The Rimrock Report

The effects of global warming and rotational grazing on wolf predation of feral horses.

Not really. But now that I have your attention, let’s talk about photosynthesis. Yes, I know that was a cheap trick. The university wants me to be more creative and use modern communication techniques. You know, try and appeal to pop culture.... So there I was in the checkout line at the grocery store and it just came to me. Ok that’s enough of that. Photosynthesis. Simply put, the process by which green plants convert light energy, carbon dioxide, and water into oxygen and sugar. Sugar that provides energy and structure for plant growth, and to shelter or nourish herbivores. Sounds simple enough and we do take it for granted (or else why would I think I need some tabloid title for this article?), but obviously a process that is critical to life as we know it. I am sure a lot of this will be review for most of you Rimrock Regulars, but keep reading anyway. You never know when you might learn something new.

To begin, let’s outline the subject matter. The process of photosynthesis has several main categories: 1) light energy, 2) plant morphology, 3) plant cell anatomy, 4) and plant chemistry. Photosynthesis can be divided into light and dark reactions. There are 3 different chemical pathways of photosynthesis: C₃, C₄, and CAM (crassulacean acid metabolism). We will also look at some of the practical range and animal, science and management applications that are affected by this important basic biological function. Applications such as plant nutrient quality, carbon sequestration, and remote sensing.

The energy for photosynthesis comes from the sun in the form of visible light. White light is made up of the various colors in the rainbow. Did you learn the acrostic ROY G BIV in school to help remember in order the colors of the rainbow? From longer to shorter wavelengths they are: red, orange, yellow, green, blue, indigo, violet.

Yak grazing near Ikh Tamir, Mongolia in July 2009.
The Rimrock Report

The effects of global warming ...continued

So here is a pop quiz. True or false: Green light is used by plants in the process of photosynthesis…. Give up? The answer is false. Sort of a trick question. We know that it is the green pigment, chlorophyll, that is involved in photosynthesis but think about that a little harder. Remember another lesson from freshman biology. We see the plant as green because chlorophyll absorbs red and blue light and reflects green. More correctly, wavelengths that we detect with our eyes as green. So it is actually the other wavelengths, primarily red and blue, not green that provide the energy for photosynthesis. Knowing this, it must be the “greenest” parts of the plant that are the most photosynthetic.

The basic structure of vascular plants is illustrated in Figure 2. The four major parts are roots, stems, leaves, and reproductive structures (flowers). Photosynthesis takes place above ground and primarily in leaves, less so in stems. There are certain plants such as cactus species which also conduct significant amounts of photosynthesis in stems (pads) and drought deciduous species like the Blue Palo Verde tree (*Parkinsonia florida*) have chlorophyll in their bark. Both of these adaptations involve water conserving mechanisms. More on that later.

Regardless of morphological structure, the biochemical machinery of photosynthesis is found within plant cells (Figure 3) and specifically, in organelles known as chloroplasts (Figure 4). These structures within the cytoplasm, or liquid center of plant cells, have inner and outer membranes, an intermembrane space, and a liquid matrix or stroma. Within the stroma are structures known as thylakoids. Stacked like coins, the thylakoid structures are collectively referred to as “grana”. Chlorophyll is found in the membranes of the thylakoids. Young, new, growing cells with thinner cell walls, i.e. less fiber (cellulose) in leaves will have the greatest photosynthetic rates.
The Rimrock Report

The effects of global warming ...continued

The chemical formula for photosynthesis is: \(6\text{CO}_2 + 6\text{H}_2\text{O} (+ \text{light energy}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\). As we said earlier, carbon dioxide plus water and light yields sugar and oxygen. Remember we mentioned light and dark reactions of photosynthesis earlier? Light reactions are those taking place only in daylight hours. Absorption of light causes transfer of hydrogen and electrons within the pigments, generating energy in the form of phosphorus bonds, and oxygen. Dark reactions can actually take place in day or night, they just do not require light. This is the carbon fixation part of the process, when carbohydrates are constructed. The enzyme which catalyzes the first major step of carbon fixation is ribulose 1,5 bisphosphate carboxylase oxygenase or RuBisCo. RuBisCo is thought to be the most abundant protein on Earth. Another pop quiz: Anybody remember the most abundant carbohydrate (actually the most abundant organic compound) on Earth ... Give up? Cellulose. Cellulose is a polysaccharide, i.e. a chain of simple sugars (glucose) from photosynthesis, held together by Beta 1-4 bonds. It is the main structural fiber in plant cell walls. One more quiz, True or False: Cows have digestive enzymes that can break Beta 1-4 bonds, but humans do not... Give up? False. Microbes in the rumen of cows have this capability, not the cows.

Now let’s talk about the three different photosynthetic pathways; C\(_3\), C\(_4\) and CAM. Most plants have the C\(_3\) pathway of photosynthesis. The name comes from the fact that carbon is first incorporated into a 3 carbon intermediate (3 phosphoglycerate). Cool season grasses, shrubs and forbs typically have this pathway. This pathway is considered more efficient in cooler, wetter environments, requires fewer enzymes (proteins which must also be made by the plant) and no special anatomical features. In the C\(_4\) pathway, the 4 carbon intermediates are either malate or aspartate. Warm season grasses are examples of plants with this pathway. In C\(_4\) photosynthesis, the plant uses phosphoenolpyruvate carboxylase to quickly incorporate CO\(_2\) from the atmosphere. This allows the plant to regulate its’ stomata (pores on the plant surface) and keep them closed more often to conserve water. Fourwing saltbush (Atriplex canescens) is a shrub with the C\(_4\) pathway. The third pathway is found in many desert species such as cacti and other succulents such as the agave. First observed in the family Crassulacea and so named, CAM plants are more efficient users of water due to the fact that they close their stomata during the day to further conserve water and then use CO\(_2\) stored as malate. So cactus with spines instead of leaves (Figure 5), the CAM photosynthetic pathway and the
The Rimrock Report

The effects of global warming ...continued

ability to shed leaves in drought but still conduct photosynthesis in green bark (i.e. Palo Verde), are all survival adaptations of desert plants.

Now for the “so what”. First, forage quality due to the amount and relationship of carbon (cellulose, fiber) to nitrogen (protein, mainly Rubisco) is related to amount and activity of photosynthetic tissue. New, live, leaf is the most nutritious as compared to old, dead, stem. You have heard this in the Rimrock Report before. Leaves with greater surface area will absorb more light and be more productive. Actively growing plants will have larger healthier root systems, deposit higher quality litter for soil microbes, promote greater organic matter and sequester more carbon. All important ecosystem goods and services brought to you by photosynthesis.

Normalized Difference Vegetation Index (NDVI) is a remote sensing measurement that is used to monitor plants from space. As we discussed earlier, chlorophyll reflects green light and absorbs red and blue. So if we apply the formula ($NDVI = (NIR - Red)/(NIR + Red)$) from visible and near infrared light detected by satellites, we can determine the level of “greenness” or abundance of vegetation at landscape scales. For instance the University of Arizona is working on the release of a website called Drought View that uses this technology. Images of Arizona from an older version of the website, Range View, are illustrated in Figure 6.

So, photosynthesis may not be as provocative as global warming, may not start as many fist-fights at SRM meetings as rotational grazing, may not involve the attention of as many celebrities as wolves, or inspire as many impassioned activists as feral horses... but without it we wouldn’t have enough oxygen or energy to fight, cry, ruminate, or bloviate...
Plant of the “week” by guest writer Doug Whitbeck

Mexican Jumping Bean

*Sebastiania bilocularis*, also known as the Mexican Jumping Bean, is a medium to large shrub native to southern Arizona and northwestern Mexico. This many-stemmed shrub is widespread in the lowlands of the Sonoran Desert, reaching down to more tropical areas of Mexico where it can grow up to 5 meters tall. In the US, its range is limited to southern Arizona between Interstate 8 and the US/Mexico border in rocky washes and rocky mountain slopes.

The broad leaves of the Mexican Jumping Bean often catch one’s eye when it is spotted amongst common species of the lower Sonoran Desert such as Palo Verde and Ironwood trees.

From a distance the Mexican Jumping Bean can be mistaken for a flowerless Oleander but upon closer inspection the simple alternate dark green leaves growing off the reddish twigs appear to be lance shaped with slight serrations around the perimeter. During colder months the leaves will turn bright orange-red which can really make it stand-out against its desert environment.

Another unique characteristic of the Mexican Jumping Bean and other plants in the Euphorbiaceae (spurge) family is the clear toxic resin, which happens to fluoresce strongly under black light, and oozes out when the twigs are broken. The resin produced by the Mexican Jumping Bean was commonly used by the Apache Indians to poison their arrows which were often made from the straight branches of the plant. Appropriately, another name for the plant is “arrow poison plant” or hierba de la fleche in Mexico.


http://cabezaprieta.org/plant_page.php?id=1189s2136

http://plants.usda.gov/core/profile?symbol=SEBI9

Photo by Doug Whitbeck
“Plant of the Week”…..continued

The Mexican Jumping Bean is monoecious, where both female and male flowers occur on the same plant, with small greenish-red flowers on a spike without petals. The fruit from these spike flowers are three-valved capsules born with a large seed in each capsule. This plant is a favored host plant for some moth species. Therefore, some of the seeds may contain a moth larva that can cause the “bean” to move or jump, hence the name “jumping bean”. These “beans” are often sold as novelties in Mexico.

Some of the best places to observe the Mexican Jumping Bean would be in the Organ Pipe National Monument, where it can be seen growing alongside the magnificent Organ Pipe cactus, and the slightly less accessible Barry M. Goldwater Air Force Range, where it can be seen growing alongside beautiful bonsai-like Elephant trees.

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Before I graduated from the University of Idaho I had to go through an exit interview with the department head of forestry. Why forestry instead of rangeland? Well, that can be a long story, but the quick and dirty is that budget cuts caused a merger and forestry was a very large department. The exit interview was about what you would expect, but one question stuck in my mind. I was asked, “What’s so bad about junipers.” I’m not sure what brought on that question, but I suppose we in the range world do sometimes carry on after junipers with a vengeful passion. Perhaps we do come off a bit strong on a topic that can be viewed as simple afforestation.

Of course the answer depends on where you are, your management goals, and the junipers you are talking about. In general there’s nothing particularly bad about junipers. They are native trees ranging over 74 million acres across the Western United States. In much of that area they form pigmy forests that become nesting habitat for dozens of species of birds, winter shelter for large mammals, and provide food for a variety of animals. In fact juniper berries are often available when other sources of food are scarce; making the trees even more valuable to the critters that can utilize them. Junipers are also some of the longest living organisms on the planet, capable of living longer than 1500 years with record holding junipers somewhere in the 3000 year old range.

That last bit of knowledge is particularly interesting considering that over 90% of all junipers germinated after the 1870’s.

Today we are witnessing a massive expansion of junipers both in extent and density (Figure 2). Paleobotanical analysis of macrofossils in packrat middens and lake bed cores have found that though juniper distribution has changed throughout geologic time, today’s density is unprecedented over the last 10,000 years. The exact cause of this expansion is hard to say since several different events occurred somewhat simultaneously. The little ice age ended just before the 1870’s, ushering in a warmer trend that may be more conducive to juniper germination. The ranching industry ran some of the highest densities
of livestock at that time, reducing grass competition against junipers. That heavy grazing also fireproofed the landscape, reducing fires which have historically restricted juniper growth to rocky outcrops, shallow soils, and other fire resistant landscapes. And the industrial revolution was in full swing at that time, changing the chemical composition of the atmosphere and potentially impacting global temperatures in favor of junipers. The exponential increase in atmospheric CO$_2$ does not coincide with the initial expansion, but it does act like fertilizer on the photosynthetically C$_3$ junipers, accelerating its growth and giving it a competitive boost against C$_4$ plants (see Doug Tolleson’s topic on Photosynthesis).

As junipers expand they invade adjacent vegetation types. This includes the sagebrush steppe, desert scrub, grasslands, ponderosa savannas, riparian corridors, and aspen groves. The initial stages of the invasion is followed by a small increase in biodiversity as the vegetation types merge, but as the juniper matures it starts to reduce the understory vegetation, eventually reducing biodiversity and creating large barren interspaces (Figure 3). Mature ponderosa pines can compete with juniper, but the problem here isn’t competition, it’s fire. Junipers create ladder fuels within ponderosa savannas, which often lead to a crown fire that kills the fire resistant ponderosas. The expansion thus far has increased the extent of junipers tenfold since the 1870’s, with many potential areas left to be invaded.

Those invaded vegetation types are typically more charismatic than juniper woodlands, and can have rather vocal groups calling for their restoration. Calls for restoration which can get rather loud when threatened or endangered animals like the pygmy rabbit or sage grouse are involved. There are also large economic considerations as the forage available for wildlife and livestock dramatically decreases. The financial cost can be staggering, adding voices to the call to restore the landscape. Other considerations include the air quality and health issues involved in excessive juniper pollen, and the increase in high severity fires and threat to houses as junipers add more heavy fuel to the landscape. Fish are also impacted as the erosion increases in the barren innerspaces, the hydrologic systems of the watershed degrades, and the water quality of the streams and rivers decreases. Even old growth juniper stands, those several centuries old and older, are at risk. These trees have historically established themselves in fire resistant areas, but now the young junipers are closing canopy gaps which result in catastrophic fires that
destroy the old growth stands.

All this brings us back to the initial question, “What’s so bad about junipers?” Well, a lot if your preferred habitat is being invaded, your favored wildlife is at risk, or your livelihood is at stake. The expansion and the problems associated with it are a lot more complicated than simple afforestation. The end result is that junipers are frequently highlighted in a negative light, often labeled as invasive, and there is a lot of support for removing junipers from invaded landscapes (see YouTube video of juniper removal). We in the range world are particularly enthusiastic and vocal about juniper removal mainly because it degrades most rangeland vegetation types.

References and Additional Reading:

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AZ SRM Winter Meeting

Dates: January 8-9, 2014
Place: Holiday Inn & Suites Tucson Airport North, 4550 S. Palo Verde Boulevard, Tucson, AZ
Theme: “Managing rangelands with federally listed species & opportunities in rangeland consulting”
The agendas and registration forms are below.

Registration Form

The AzSRM General Membership meeting begins Wednesday evening, January 8 and will conclude Thursday January 9, following the banquet and awards.
Friday morning will be a Board of Directors meeting to discuss and plan activities for 2014.

Arizona Section SRM Winter Meeting Agenda

A block of 60 rooms has been reserved at the Holiday Inn & Suites at the rate of $79.00 per night.
For lodging reservations at the Holiday Inn Tucson Airport North, you may phone (520)746-1161 or make reservations on-line at: http://www.ihg.com/holidayinn/hotels/us/en/tucson/tusap/hoteldetail

For on-line registration for the Arizona Section SRM meeting, follow the instructions below:
Step 1. Go to: http://srm.allenmm.com
Step 2. Click on Sections on left hand menu
Step 3. Click on Arizona Section Meeting

P.S. Please consider bringing an item for the auction! While you are out shopping…think SRM 😊

Society for Range Management
Arizona Section

See the Top Ten pictures for 2013!
http://cals.arizona.edu/vbarv/rangeprogram/sites/cals.arizona.edu.vbarv.rangeprogram/files/Top%2010%20Pictures%202013.pdf
Wouldn’t it be interesting if Will Rogers were around today? Here are a few of his sayings to start the year off right...

“There are three kinds of men; the one that learns by reading, the few who learn by observation, and the rest of them have to pee on the electric fence for themselves.”

“If you want to be successful it’s just this simple; know what you are doing, love what you are doing, and believe in what you are doing.”

“Diplomacy is the art of saying ‘nice doggie’ till you find a rock.”

Six years and counting... another one in the books. This fall has flown by. Since the last issue, we here at the V Bar V range program have participated in collaborative range monitoring on several northern Arizona ranches, toured the Willow Springs Ranch near Oracle with the Arizona SRM Young Professionals, helped with the V Bar V Ranch Research Field Day, shot video for Range Rocks! in Tucson and at the ranch, submitted a few grant proposals and journal papers, spoke at the Colorado Section SRM meeting and, I lost count of other meetings, etc... So, hopefully yall are getting your money’s worth out of us. One big milestone was acceptance of our nutritional monitoring paper in Journal of Animal Science. We started work on that in fall of 2007 and it represents 3 years of field work as well as data analysis, writing, and revision. It is the first full refereed journal article the range program has published from a project conducted at the V Bar V since I arrived. We did have the Rangelands article on cattle and elk diets from the V Bar V a couple years ago but Larry Howery and I had actually began collaborating on that project several years before when I was still at the Gan Lab. We have a couple more on tap for the coming year; dealing with landscape scale vegetation modeling, and soil carbon:nitrogen. Facebook has been an interesting development this year, Chris is doing a great job with that. Just after the first we have the Range Animal Nutrition 101 Workshop and the Arizona Section SRM meetings in Tucson. I am looking forward to the national SRM meetings in Orlando in February. We have a poster on Blue Collar Plants and the Native Range Symposium there. Christmas was good, Marshall was back from TAMU and Ross was here from Fort Hood with his fiancé Mallory. And I have to say that New Years Eve was not bad either. It is not that often that an old Aggie/new Wildcat gets to celebrate 2 bowl victories on the same day. Enjoy the top “10” pictures for 2013, we will go get more. Well, I hope y’all get some rain or snow in your country and I look forward to seeing you out on the range this year.

Till next time,

Doug