The Art of Land Management - Understanding Plant Competition

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It is hard to have a field trip to rangelands or forest lands without the subject of competition between plants coming up. This is probably because competition is a widespread process whose effects are often readily apparent to even the casual observer. Our conceptual models of how biology works tend to parallel our social models. The idea of plants battling it out to obtain their share of scarce resources is a comfortable extension of the Darwinian "survival of the fittest" view of nature. This view of competition, by which plants divide up a set of finite resources, is so prevalent in forestry that it has its own law, the "self thinning rule". You can see the self thinning rule in action in open canopied semi-arid forests such as Ponderosa pine or western juniper stands. It assumes that once live tree basal area is sufficient to support a canopy that is potentially capable of using all of a site resource, such as water or light, plant basal area can only increase by a counterbalancing reduction in live basal area of other plants. In juniper stands, this often is seen as a reduction in associated shrubs and grass as the trees grow beyond a certain size. In order for juniper to continue to grow, it must take resources from its neighbors. Obviously, this situation occurs sooner and is most pronounced on drier, thinner soiled sites. We also see this process going on in dense forest stands, such as the oak forest in Figure 1, where large dominant trees eventually overtop and kill smaller trees as the forest ages. Once a critical amount of live tree basal area is reached, thinning out the smaller trees does not really change the total amount of stand growth, it merely concentrates it into the larger remaining trees. This "dividing up the pie" model of relations between individual plants is a useful but simplistic view of nature. Nature is much more interesting than that. To fully understand competition, one must consider three fundamental properties. First, competition only occurs for resources that are in inadequate supply compared to potential demand. This suggests that plants only compete for limited resources that they both need and they are both accessing from the same place at the same time. So, **there are both time and space dimensions to competition**. For example, Douglas-fir trees in western Oregon silvopastures only compete with pasture plants for moisture during about a one month period in late spring-early summer when they are both rapidly growing and soil moisture is inadequate to meet the needs of both plants. Plant growth is restricted by low temperature rather than moisture during the winter – early spring. Mid-spring rainfall is adequate to meet the needs of both pasture and trees. Pasture plants such as perennial ryegrass and subclover are dormant during summer-early fall. They have shallow roots and stop growing once the weather becomes hot and moisture in the top 6 inches (15 cm) of soil is used up. Trees such as Douglas-fir and weeds such as poison oak and Canada

Figure 1. Overstocked stand of Oregon white oak trees. Trees are dying so that others may grow…This is the self-thinning rule in action.

thistle grow on through the summer by tapping deeper layers of soil moisture, without competing with the pasture.

Figure 2. Conifer trees grow on into the summer after pasture plants have gone dormant.

The deeper rooting habits of trees/shrubs compared to herbaceous plants is often cited as a factor reducing competition for soil resources. To some extent, this opinion is based upon the mental image of tap rooted plants looking like a big carrot. In fact, deep tap rooted trees do have large woody feeder roots that extend downwards. They also maintain a very active and extensive net of surface roots within the top foot or so of soil. They do this for a simple reason – soil organic matter from leaf fall and shedding of fine surface roots of pasture and other understory plants occurs within the top layer of soil, so that is where the nutrients are. Which brings up the second fundamental property **– the nature and intensity of competition varies with the resource being competed for**. So, while competition for soil moisture may occur throughout the soil profile, competition for nutrients is mostly confined to the soil surface. Having a deep root system is great for extracting soil moisture, but is not nearly as helpful in obtaining soil nutrients. To go a bit further, most inorganic nitrogen compounds enter the root dissolved in water. Phosphorous (P) is rather insoluble in water, so roots get most of their P by direct contact with soil particles where P is attached. This means that within the surface soil, competition for water and competition for nitrogen occur together while competition for P is separate. It takes a much more extensive system of fine roots to get P by direct contact than it does to get N which will flow to the root with water from some distance away. That is where enhancers such as symbiotic soil fungi come in. Endomycorrhizal fungi are common partners with trees and shrubs. These fungi actually invade the root tissue of host plants where they receive sustenance in return for connecting the host to the hair-like mass of fungal hyphae that forms its body. This effectively enlarge the surface for contact exchange to extract P for the host plant whose roots it has penetrated, thus providing a competitive advantage over uninfected plants, and allowing host plants to grow faster on fairly low phosphorous sites.

Third, but perhaps most important, **competition is a process**. Processes are mechanisms by which things change over time. We actually don't observe processes. We see the resulting change. For example, we do not really see plants competing. What we see is some plants prospering while others nearby are declining. This is usually the net effect of several interacting processes. Plants may interfere with each others growth by competing for scarce resources. But competition is only one of many forms of interference. Plants may also interfere with each other each other by accumulating salts, producing toxic chemicals (allelopathy), serving as habitat for diseases/insects or encouraging the growth of other competitors. For example, walnut trees produce a toxin (jugulone) that selectively damages growth of broad-leafed plants but does not affect grasses, current bushes are an alternative host for rusts that attack cereal crops such as wheat, and peach trees can be very effective over wintering sites for aphids. Plants may also facilitate each others growth through microclimate modification, accumulation of soil nutrients near themselves, fixing nitrogen, encouraging pollinators, or discouraging grazers/diseases etc.

What we observe in the field is the net balance of interference and facilitation. This often produces zones (rings) of influence around widely spaced trees or large shrubs with interference reducing understory plant growth nearest to trees while facilitation increases understory growth near the canopy edge. It is not uncommon to see more grass growing under widely spaced juniper or oak trees than in the open away from trees on productive sites while less grows under trees on less productive sites. This shows that under some conditions, facilitation is at least temporarily exceeding interference near the trees. The challenge to land managers is to recognize and manipulate the balance of these two forces so that facilitation is emphasized over interference. Nature accomplishes this by combining plants that share resources well in time and space and which support each others growth through nutrient cycling, maintaining soil organic matter, discouraging the build up of diseases and pests, and other support functions.

Figure 3. More grass grows near a Juniper tree growing on a productive site in Eastern Oregon.