How a Forest Affects a Forage Crop

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Forage production on forested rangelands is principally controlled by the trees making up the overstory. The trees exercise this control by modifying the complex interaction of light, heat, litter accumulation, and moisture. These environmental factors usually react within a continually changing ecosystem further influenced by fluctuations in weather, periodic logging, and grazing by livestock and wildlife.

Forest overstory and understory vegetation occupy the land somewhat independently. The same tree canopy can exist over completely different understory vegetation under normal circumstances. In the Pacific Northwest we find natural stands of ponderosa pine with an understory of needleandthread grass or natural stands of ponderosa pine with an understory of ninebark. On the other hand, similar understory stands can exist beneath a different overstory. We have stands of ponderosa pine/ninebark as indicated above, but on different sites we can find Douglas-fir as the overstory dominant with ninebark and its associated species as the understory dominants. Each of these community types responds to environmental stresses differently with respect to absolute change but similarly in the nature of change to a specific pressure. When the community type or habitat type is known, specific responses to management can be defined. Within a community type, development or management of the overstory influences production, composition, and forage value of the understory in a predictable fashion. Initial knowledge of the community type is necessary if actual predictions of response are to be made.

Light

A tree overstory has a direct influence on light received by understory vegetation. Some plant species grow and reproduce best under high light intensities and others require some degree of shading for survival. Consequently, you wouldn't expect to find a shade tolerant plant such as meadowrue in a clearcut nor would you find bull thistle under a full canopy. Most grasses grow well in full light but can tolerate varying degrees of shade.

A tree canopy reduces the total light received by understory vegetation and filters light rays selectively. A deciduous tree canopy reduces the relative proportion of red and blue light rays, which are the most photosynthetically active rays. Light penetrating the canopy has proportional enrichment of orange, yellow, green and infra-red. Yellow and orange light are related to cell elongation, which partially explains elongation often seen in shaded plants. Infra-red interacts with red to control plant hormones and subsequent induction of morphological changes such as flowering. A coniferous tree canopy affects light quality similarly to a deciduous tree canopy but filters less of the red light. Consequently, light quality under the coniferous canopy is quite similar to that received in the open on a cloudy day.

The specific ecological role of light quality is not well understood and is frequently considered of little or no importance. So little information is available that this conclusion seems premature. The change in light quality resulting from shading probably has little influence on presence or absence of most plant species but may well influence physiological and morphological characteristics of understory plants. Changes in these plant attributes could have significant bearing on nutritional value of understory forages, as will be discussed later.

Light intensity is considered ecologically important. Reactions of plants to varying levels of light intensity are well known. The rate of photosynthesis depends on intensity of light until the plant is saturated. For cool-season plants, which usually dominate the understory of a forest, this occurs at about 20% of full sunlight for plants adapted to growth in open areas and about 10% of full sunlight for plants adapted to shaded environments. Size and shape of plants or their leaves as well as orientation of leaves affect absorption of light. Under good photosynthetic conditions, products of photosynthesis accumulate and photosynthetic rate declines. Chloroplasts migrate within the leaf in relation to light intensity and will absorb varying percentages of light in relation to intensity. In general, shaded leaves are darker, thinner, lower in reflectivity, wider, oriented to light sources, have a thin cuticle and have larger chloroplasts than those in full sunlight. So it is clear that plants react to light and can adjust to maximize photosynthesis as long as a minimal amount of light of the right quality is received. When light intensity is reduced below the saturation level of the leaves, production will decline. For example, at 8% of full sunlight we would expect about 65% of full above-ground production and 25% of root growth for cool-season plants. So, if light was the only factor limiting to understory production we should see a steady state of production until light levels are reduced by about 80%. If we assume canopy cover to be uniformly proportional to light received by the understory, production would not decline until canopy coverage reached 80%. The three dimensional nature of a tree canopy would actually cause 80% reduction of light at less than 80% cover. So, in a mature forest, reduction of incoming light by 80% would probably occur at about 50% canopy coverage. Nevertheless, light intensity is probably of minimal importance for production of cool-season plants until the canopy becomes quite dense.

Moisture and Temperature

Plant growth is also limited by water and its interactions

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with temperature. As temperature increases, evapotranspiration increases as well. The short light rays of sunlight are absorbed and slowed to heat rays by soil, stems of vegetation, rocks, and so forth. In full light the ambient temperature is higher than in the shade. As a result, plants in the open are about 10° F warmer in the day and about 10° F cooler at night than those in moderately shaded areas. Of course, absolute differences vary considerably. The optimum temperature range for photosynthesis of plants commonly found in the understory of eastern Oregon forests is about 70-95° F. So, as ambient temperatures in open and shaded areas fluctuate about this range, the relative advantage for productivity would also fluctuate.

Since shaded areas are cooler with higher relative humidity, they would also provide for less evaporation than in open areas. Further, wind movement is reduced under a tree canopy which reduces wind related dessication. However, water conservation in the cooler environment can be negated by water needs of the trees. Much water is used for transpiration of trees and considerable moisture can be intercepted by the canopy and never reach the ground. Furthermore, soil moisture levels in deep shade may be more critical because of reduced root systems of the understory and competition for moisture between overstory and understory plants. Overall, it appears that moisture or competition for moisture is the dominant force governing total yield of vegetation under typical forest-range canopies in eastern Oregon. But, during seasons when moisture is abundant, light and temperature may be the controlling factors.

Changes in quantity and quality of light received by forages under a tree canopy do influence the annual growth cycle. Shaded plants tend to flower later in the growing season than those in the open. In fact, some shaded plants don't flower at all. Because of this later development, nutritional quality of shaded plants for grazers is superior to that of plants in the open when plants in these open areas begin to mature. At this time shaded plants are higher in protein, digestible energy and probably phosphorus and are thus more nutritious. Earlier in the season, plants in the open should be better sources of digestible energy and perhaps phosphorus than shaded plants but probably no differences will exist in protein levels. However, at this time plants in both environments should have sufficient nutrient levels to meet needs of lactating cows or growing steers.

Relationships of Forages to Trees

In mature stands of trees and those which have been unlogged for 15 or more years, the relationship between canopy cover and forage yield is not direct. Most forage yield reduction occurs by the time the canopy has reached 20 or 30%. However, a recently thinned forest will have a direct relationship between canopy cover and forage yield. For every percent increase in canopy cover a corresponding decrease is found in forage yield. After the roots of remaining trees establish in the interspaces left from tree removal, the relationship returns to that of a mature stand. Some shrubs will respond somewhat differently than herbaceous plants and increase with increased shading until competition for moisture and light cause reduction in these shrubs.

No relationships between yield and tree cover have been found for forages growing under aspen trees, which is probably related to both rooting patterns of aspen and the site characteristics where aspen grows. The clonal nature of aspen insures a fairly uniform distribution of roots wherever the stems appear, which coupled with fairly moist sites typical of aspen communities suggests there is little opportunity for the aforementioned relationships to occur. Other work in which no relationships are found may be because of the limited range of canopies examined. Our work indicates no relationship between canopy of ponderosa pine and understory vegetation when studies are restricted to a 20-50 percent range of canopy coverage. Further, yield of some forbs like pussytoes and goldenrod in Pacific Northwest conditions appears independent of canopy coverage.

The most important feature of overstory/understory relation is that there is no set response to all conditions. Accumulations of litter, particularly under ponderosa pine, can alter responses dramatically. If litter is not excessive, most situations should fit one of the patterns identified, even though some may intergrade with others. By deciding which pattern of response is operating, and defining the community type, management responses should become more predictable and basic ecological responses can be separated from grazing responses.