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Review of Research Studies on Vegetation Response to California Annual Range Improvement Practices.

Introduction

A variety of range improvement practices have been looked at in the past as means of increasing livestock production. Most of the reports reviewed in this technical note quantified range vegetation responses to improvement practices in terms of yield and composition. Important types of improvement practices include mulch management, grazing systems, reseeding, burning, and fertilization. Often multiple combinations of treatments have been evaluated. The majority of research studies were conducted on herbaceous annual vegetation, but some were found to document foothill shrub range improvements in terms of yield and seedling production. This technical note is intended to assist SCS range conservationists in making management recommendations to landowners with quantitative estimates of potential responses.

Mulch Residues in Relation to Grazing or Fire

A fair volume of literature has developed over the years concerning the effects of differential forage utilization on range productivity. Hormay (1944) recommended moderate use as the key to proper maximum sustained yield of forage and livestock. Light, moderate, and excessive grazing were illustrated and described in relation to soil fertility, erosion, plant composition and range improvement. Moderately grazed ranges were purported to support better forage plants, evidence little erosion, grow more total forage and reach range readiness earlier in the season.

Hedrick (1948) reported many benefits associated with leaving adequate mulch on California annual ranges. Sufficient mulch increased germination and early growth, total yield, improved soil conditions and contributed to the health of livestock in the fall and early winter by providing bulk to the diet. This study examined not only changes in surface residues but also differences in soil bulk density and "humic" mulch (soil organic matter) in relation to grazing intensity.

An interesting study on the effects of fire on vegetation in pastures grazed at different intensities was done by Hervey (1949). The study area in Contra Costa County was on Los Osos adobe and clay loams. It burned in July after the forage had dried, removing most of the plant residues, although unburned areas remained and served as controls. Burning decreased yield from 25 to 40 percent and shifted the composition in favor of forbs in light and moderately grazed sites, but heavy grazing masked these effects. Height growth was

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significantly reduced for both grasses and forbs. The author recommends altering management practices to compensate for reduced forage yield and changes in the length of the grazeable season.

Grazing Management, Seeding, and Fertilization

One of the classic publications on tailoring livestock production to the growth characteristics of California annual ranges was by Bentley and Talbot (1951). They report over 14 years of well-designed research on cattle production at the San Joaquin Experimental Range. Forage growth and quality over the annual cycle is fitted into three key periods according to the energy and nutrient content of the forage: the inadequate green season after fall rains have started through early winter, the adequate green season in the spring, and the inadequate dry season in summer and early fall. Energy supplementation is the principal necessity for livestock during the inadequate green season, while protein and vitamins are deficient in the range forage in the inadequate dry season. The timing of these seasons varied over the years but averages showed the typical pattern. Yields were reported in detail by different range sites, and variations in relation to weather parameters are described. Methods for adjusting herd numbers to compensate for annual fluctuations in forage production are presented, and the crucial goal was again determined to be a moderate degree of grazing for greatest red meat production and resource protection in the long term.

Biswell, Schultz, Hedrick, and Mallory (1953) examined frost heaving effects on seeded areas of burned chaparral near Clear Lake in Lake County. By uprooting young plants frost heaving often caused 75 percent or more seedling mortality, and was found to be worst in areas that alternately froze and thawed in early season than where freezing temperatures were maintained for long periods of time. A good cover of mulch effectively reduced this phenomenon by buffering the temperature extremes at the soil surface, and fertilization resulting in rapid early growth of seedlings also lessened mortality. Thus, the value of adequate mulch was re-emphasized, at least in regions where fall freezing is common.

Heady (1956, 1966) has published definitive results of experiments with varying levels of mulch done at Hopland Field Station. The trials were made with statistically elaborate design and conducted over a number of years to determine plant composition and yield by treatment. Weather patterns were found to cause fluctuations in vegetation independently of mulch in some years, but general trends were evident. Important conclusions were that absolute amounts of mulch in pounds/acre were indicative of the vegetation the following year much more than the percent utilization of annual yield, positioning of mulch (upright vs. flattened) influenced potential yield, and the resiliency of the annual plant community allowed rapid recovery from overgrazing of short duration. In a later study, Hooper and Heady (1970) demonstrated by an economic analysis of the relative opportunity costs of light vs. heavy grazing that light grazing is a more desirable management strategy for the rancher in order to minimize the potential of disastrous financial loss.

Williams, Love, and Conrad (1956) experimented with seeding rose, crimson, and subclovers in conjunction with fertilization and grazing management near Lincoln in Placer County. The soil was reported to be an upland terrace Placentia gravelly loam, producing approximately 1,300 pounds/acre on an average without improvement. When seeded to the clover mixture and fertilized at a rate of about 200 pounds/acre superphosphate, yields nearly tripled to some 3,700 pounds/acre on an average. In addition, the forage was higher in protein content, resulting in over a threefold increase in protein production per acre. The result was a tripled carrying capacity, and exclosure studies showed this increase in grazing was desirable and necessary to maintain a good stand of clovers by reducing competition from other plants.

Grazing management has been found to influence composition and yield in many studies. Smith and Williams (1973) developed a computer simulation model which contrasted the effects of continuous and deferred grazing on a subclover pasture. Considerable literature review was used to estimate the values of model parameters, such as inputs of solar radiation, rainfall, evaporation, soil moisture storage, etc., and outputs of forage growth and livestock production agreed closely with field conditions measured in the experiment. Generally, by deferring grazing to some 40 days after germination, the vegetation was able to establish itself better and produce more forage and livestock over the season than when continuously grazed. It is important to note that very little mulch was present before germination in the live experiment, since this factor could have improved the growth of young seedlings by providing protection from grazing and buffering the microenvironment.

MacLauchlan, Miller, and Hoglund (1970) reported that deferral of early season grazing in conjunction with overseeding of Lana vetch resulted in good control of medusahead infestations on foothill rangeland. On rough terrain where tillage was impossible, Lana vetch and grazing management proved useful in controlling this undesirable grass. Lana was adapted to a wide range of soils and environmental conditions, but often required superphosphate fertilization to grow well. However, it resulted in better protein content and doubled or tripled forage production.

Fertility problems in California range soils are not uncommon, with nitrogen, phosphorus, and sulfur in various combinations of deficiency usually the limiting plant nutrients (M. B. Jones, pers. comm.). Nitrogen is easily lost from the organic portions of annual ecosystems by leaching or the formation of gases, sulfur is intermediate in its ability to remain, and phosphorus has fair stability within annual ecosystems (Jones and Woodmansee, 1979). The result of these properties is that nitrogen fertilization lasts only a short period of time (usually one year or less), while phosphorus and sulfur usually affect plant growth for longer periods of time (3 to 10 years). Nitrogen usually favors the growth of grasses in a stand while P and S may enhance the legumes, at least where soils are naturally deficient. Because of the high energy costs required in the manufacture of nitrogenous fertilizers, many experts now consider the best practice on rangelands to be P and S fertilization to enhance the growth of seeded and native legumes which are able to fix atmospheric nitrogen biologically.

Bentley, Green, and Wagnon (1951) reported increased forage yields and livestock capacity in pastures fertilized with sulfur for a number of years at the San Joaquin Experimental Range. The greatest response occurred in the better sites if sulfur was deficient, and fertilization could also be used to shift the distribution of livestock from heavily used swale areas to rolling upland areas. Fertilization with sulfur and phosphorous shifted the botanical composition towards desirable legumes which cured well and held nutritive quality well into the dry season. Judicious use of rotational grazing was necessary to utilize increased forage quality and quantity throughout the year.

Duncan (1974) followed vegetation and livestock responses to combinations of sulfur, sulfur and nitrogen, and grazing in different seasons at the San Joaquin Experimental Range. Herbage production and composition fluctuated considerably between years, but consistently N + S followed by S fertilization increased growth above the unfertilized controls. Interestingly, livestock gains were fairly similar regardless of treatment in the dry season, but the cattle did much better on fertilized ranges in the green season. One key conclusion drawn from the experiment was that sulfur fertilization alone appeared to give more return per unit investment cost than N + S did. It is important to realize that inflation of energy costs has far out distanced increases in livestock value since 1968, when these experiments were concluded, placing far greater merit on such a recommendation today than when devised.

Shrub Management

Gibbens and Pieper (1962) studied the effects of various combinations of fertilization on shrub production and utilization by deer in the Sierra Nevada foothills in Madera County. By increasing forage quality, fertilization caused increased use by deer and showed potential as a management practice to influence the density and growth of shrubs, either positively or negatively. Another examination of shrub reproduction and growth following fire was presented in detail by Biswell and Gilman (1961). For a twelve year period, the herbaceous composition and shrub seedling characteristics in unburned annual grassland, burned grassland, and burned shrubland were followed in Tehama County foothill ranges. Soil characteristics and species adaptations were discussed in relation to the distribution of plant communities, and plant competition and browsing by deer also affected vegetation distribution. The authors used thorough analyses of these ecological factors to implicate possible manipulation practices which would achieve desired goals, and suggested fruitful areas for future research. Other publications addressing the management of foothill chaparral in terms of quantified responses of shrubs for deer winter range improvement were published by Gibbens and Schultz (1962, 1963).

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