# Application of Soil-Climate-Vegetation Relations to Soil Survey Interpretations for Rangelands

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Perspectives, objectives, methods and techniques employed in the appraisal and interpretation of rangeland resources during the present century reflect the gradually evolving demand for more basic knowledge. The needs of an increased population can result only in more intensive use and treatment of agricultural lands, including those devoted to production of forage for livestock and game animals. Intelligent intensification of the use and management of any resource must be based upon extensive knowledge of that resource and its wise interpretation.

Early range inventory methods were concerned primarily with the classification and interpretation of the vegetation. Little attention was given to soil and climatic influences or to the ecological aspects of range resource inventory (Dyksterhuis, 1958). The gradual shift toward recognition of the ecological aspects of range inventories and the increasing interest of soil science in the use and management of rangelands has been reviewed by Renner (1948), Dyksterhuis (1949) and, more recently, by Poulton and Tisdale (1961).

Although inventories based primarily upon present vegetation undeniably have been of considerable value to range managers, they have not provided the basis or information required for optimum management. It is not

enough to know only the kinds and amounts of plants presently growing on ranges. If management is to be directed toward the realization of sustained high production consistent with protection of the resource the range manager must know the capabilities of the different kinds of rangeland. He needs to know how much and what kinds of plants his lands can produce and must evaluate the present plant cover in relation to the potential for each kind of range. The present condition of the range provides a starting point for management. The potential plant cover represents a goal toward which management for improvement of ranges in unsatisfactory condition can be directed.

The concept of the "range site" has been developed to express differences in the inherent productive capacity of different kinds of rangelands. Simply defined, range sites are kinds of rangeland with different potentials for producing native plants. Each range site has its own combination of environmental conditions, the ultimate expression of which is a distinctive plant community. Furthermore, the range site retains its capacity to reproduce this potential plant community unless altered by physical deterioration. The range site is comparable to the capability unit for cultivated land (Hockensmith and Steele, 1943).

Several methods of determin-

ing range condition based upon comparison of the present plant cover with the normal potential for the site have been extensively reviewed by Dyksterhuis (1949). If we accept the proposal that knowledge of the nature of potential native plant communities is prerequisite to evaluation of range condition, and to providing information to guide range users in making more intelligent decisions in the use and treatment of their lands, then the question arises as to how that potential can be determined.

If all or many rangelands were presently supporting their potential native plant communities. this potential could be determined on the basis of the vegetation alone. This becomes increasingly difficult and finally impossible as the condition of the range declines. In the absence of the original or potential plant cover, a range site must be recognized on the basis of the relatively permanent (and mappable) features which are consistently associated with the potential plant cover of that site. These features normally are soil and climate.

If reliable relict areas were presently available for each representative or significant plant community within an area. it would be a comparatively simple matter to project the potential plant community characteristics to all other tracts having the same soil, climatic and topographic characteristics. The recognized lack of such relicts is to be deplored. Until relicts of potential native plant communities have been found or reestablished for all rangelands, it will be necessary for the range manager to establish assumed potential conditions for many

range sites. Assumed conditions can be most accurately determined by the careful study of available relicts and the interpolation and extrapolation of data from these points along an environmental gradient to other points for which no relicts can be found.

The practicability of extending findings from a limited number of relict environments to a larger number of environments for which no relict can be found consistent with established is procedures of soil survey interpretation as outlined by Aandahl (1958). He states that, "Similarities among soils provide a basis for extending research results and the findings of experience beyond the actual kinds of soils on which the tests or observations were made. Thus, it is possible to use observations on soil in conjunction with knowledge of the characteristics and qualities of soils as a basis for extending and applying soil survey interpretations far more widely than would otherwise be possible." Although Aandahl was referring primarily to soils on arable lands, the procedures outlined can logically be extended to interpretations of rangeland soils, topography and climatic characteristics.

The purpose of this paper is to describe the methods employed by the authors in the investigation of basic soil-vegetation-climatic relationships on relict rangelands of northern Utah, southern Idaho, northeastern Nevada and western Wyoming and the application of these relationships to soil survey interpretation.

#### Methods

#### Selection and Evaluation of Study Location

Areas of relict vegetation suitable for detailed diagnostic study are found through extensive and repeated reconnaissance as described by Clements (1934). In the present studies several hundred tracts of relict vegetation have been examined, evaluated and catalogued. Tracts which appear least disturbed and on which the present vegetation most nearly represents the potential plant community for the site are selected for study. Relicts on "key" soils have maximum value in soil survey interpretation and are utilized whenever they can be found. Key soils are those which are either (1) extensive in the area of study, or (2) if less extensive, are necessary to illustrate important variations in soil characteristics. Two or more distinctly different soils and plant communities sometimes occur within a single relict area. In such cases, each of the different communities is studied as a separate relict. Areas of obvious disturbance or unstable vegetation are avoided because of the difficulty of determining which characteristics result from disturbance and which reflect inherent site qualities.

The undisturbed margins and corners of nonirrigated farm fields, fenced highway and railroad rights of way, grazing lands remote from stockwater, and areas isolated by steep slopes, ledges or lava flows have provided the most suitable relicts located to date. Rangeland relicts are not always strategically located from the standpoint of geography and soils. For this reason, considerable interpolation and extrapolation of data must be anticipated.

#### Vegetation

Both soil and vegetation on each relict selected for study are examined for homogeneity. Studies are confined to that portion of stratified stands where soils and vegetation are uniform. The size and shape of each study location are determined by its homogeneity. At a central or "modal" point within the study location, three closely spaced square plots of 9.6 sq. ft. area are established to provide a convenient means of determining herbage weight on an acreage basis (Frischknecht and Plummer, 1949).

Green weight of each plant species and of mulch are estimated on each plot. Herbaceous plants are then clipped at ground level and are collected separately by species for each plot. Clip-



FIGURE 1. Method of clipping and sorting herbage from 9.6 square foot plot. Herbage of each plant species and the mulch from each plot were placed in separate paper bags.

ping is confined to the current year's growth of shrubby species. Fresh and humic mulch are separated from the herbage and are collected. Clipped herbage and the mulch are placed in paper bags which are labeled by species and plot number, (Figure 1). Herbage, by species, and mulch are weighed on a gram scale immediately after clipping. Estimates of green weight of each plant species and the weight of mulch are made on an additional 20 plots of 9.6 sq. ft. area located at random on each study location.

Clipped herbage and mulch samples from the three central plots are air-dried and reweighed. Herbage and mulch weight estimates for the 20 random plots are converted to airdry weight on the basis of shrink recorded for the clipped samples. Estimated weights for the random plots are adjusted in line with error incurred on the central plots on which estimates of herbage weight were made prior to clipping.

Clipping is done only after all major plant species have completed growth but before early maturing species have begun to shatter. If clipping is begun on the lower, dryer locations and extended progressively to the higher or more humid locations, the period within which accurate studies can be made is extended to approximately six weeks in the area of study.

Productivity of each study location is expressed in terms of total air-dry weight of herbage per acre. Species composition is expressed by the percent of the total herbage weight contributed by each plant species.

Records are made of the size, form, habit of growth, number of stems, presence of rhizomes or stolons, presence of dead plant centers, and other characteristics of the more important plant species. A list of species on the study location provides constancy data. Frequency of individual



FIGURE 2. Typical soil pit prepared for detailed soil profile studies.

plant species is determined from the number of random plots in which they occur. The number of shrubby species by maturity classes is recorded by classifying and counting all shrubs within a 100 by 5 foot belt bisected by the central plots. Age of the oldest shrubs is determined by counting the annual growth rings of their stems.

Herbage production studies are repeated annually on representative locations to assess the extent of annual and periodic fluctuations in production and species composition. Methods employed in the original studies are applied to the repeated studies except that clipping is done on plots other than those previously clipped.

## Soil

On each study location a soil pit is dug within the area covered by the three central plots from which vegetation was clipped. The pits are dug by hand to bedrock or to a depth beyond any indication of soil development, (Figure 2).

Each soil profile is described in detail in accord with the procedures outlined in the *Soil Sur*- vey Manual (Soil Survey Staff, 1951). Detailed descriptions of each genetic soil horizon are recorded in narrative form.

Bulk density and pH are determined and bulk, envelope and micro-monolith samples are taken from each soil horizon. Records are made of the depth, size, kind and extent of plant roots, kind and number of soil fauna, extent of rodent disturbance and any special or unusual soil features.

Soils from selected study locations are subjected to laboratory analysis. This includes particle size distribution, pH (1:1), organic carbon, nitrogen, conductivity, calcium carbonate equivalent, moisture tensions at 1/10, 1/3 and 15 atmospheres, cation exchange capacity, extractable cations, soluble saturation extract analysis and moisture at saturation. Kinds of clay and mineralogy determinations are made for some soils.

All soils are evaluated and correlated to soil type and series in accord with standards of the Soil Conservation Service.

#### Climate

Climatic data are secured from monthly and annual summaries

from all Weather Bureau recording stations within the area of study. To aid in the direct interpolation of Weather Bureau data, standard rain gauges are installed on key study locations. These gauges are read at intervals throughout the year. Soil moisture samples are taken in triplicate from each soil horizon at the beginning and at the end of the growing season on each of the locations where herbage production data are collected annually to provide an additional means of determining the moisture available for plant growth.

# Supplemental Data

Notes are made of the amount and orientation of mulch, soil surface features (presence, absence or extent of soil movement, soil pedestals, hummocks and crusting) and the percent of the soil surface occupied by living vegetation, mulch, stones, cryptogammic plants, or by bare soil.

Elevation, physiographic features, percent slope, direction of slope, position on the slope, and opportunities for run-on or runoff of water or drifting of snow are recorded for each study location.

The history of the study locations is compiled from interviews with stockmen and farmers and from evidences of grazing, fire, cultivation or other disturbance. The current activity of insects, rodents or game animals is evaluated.

Both monochrome and color photographs are made to show general and detailed features of soil and vegetation.

## Analysis of Data

As the first step in analysis of data, the relicts studied are segregated on the basis of similarities or differences in species composition. For example, stands in which Idaho fescue (*Festuca idahoensis Elmer.*) is a significant species are separated from those in which it occurs sparingly or not at all. Similar separations and groupings are made for other major species and for groups of species which commonly occur in association. Minor variations in the amount of one species usually associated with a specific plant community are reconciled with the consistency of other species of that community. Association tables similar to that described by Poulton and Tisdale (1961) have been useful in the initial analysis of data.

Stands are further segregated, if necessary, on the basis of total herbage production. Stands are considered to be distinct if there is a significant difference in either species composition or total herbage production.

Distinct individual stands and groups of similar stands are associated with the taxonomic soil units on which they occur. Thus, the range in soil taxonomic units associated with distinct plant communities is revealed.

Individual soil factors (such as texture, structure, permeability, depth, bulk density, stoniness, geologic parent material, etc.), climatic factors (including total and seasonal precipitation, annual and monthly mean temperatures, etc.), and secondary factors such as elevation, slope, aspect and exposure, are compared with total herbage production and with species composition of each relict stand through the use of association tables and scatter diagrams (Waugh, 1938). Vegetative values and environmental factors which appear to be related are subjected to statistical testing to determine their significance. In this manner, the range in specific soil, climatic and topographic characteristics associated with specific plant communities is recognized.

Relationships between climatic factors and plant responses are also tested in a manner patterned after the work of Thornthwaite (1948) and Arkley and Ulrich (1961). Scatter diagrams are employed to determine if relationships exist between herbage production and total available moisture as measured in rain gauges, as interpolated from Weather Bureau data, and as calculated from soil moisture samples. Relationships between herbage production and available moisture aid in assessing the range in production to be expected on specific sites over a period of years and also indicate the relative productive capacity of specific soils.

As soil-vegetation-climate relationships become evident, they are tested by applying these relationships to other stands of both relict and disturbed vegetation and with rangelands having similar as well as those with different soils. As relicts are studied they are oriented along a gradient and interpretations are made for other points along these gradients for which no representative relict has been studied.

The validity of specific diagnostic characteristics in soil survey interpretation on rangelands can be finally proven only through the successful application of these findings in practical rangeland evaluation and subsequent management.

## Summary

The trend toward intensification in the use and management of rangelands requires more basic knowledge of their potential plant communities. In the absence of the potential plant community, range sites can be identified and their potential approximated through the interpretation of soil and climatic influences known to be associated with specific natural plant communities.

Methods are described for selection of areas of relict vegetation and the detailed concurrent study of soil-plant-climatic relationships on such areas. Vegetation is evaluated in terms of herbage production and species composition by weight as determined by a combination of clipping and estimation and by nu-

merical and adjective classification of important vegetational features. Soils are classified and described according to accepted standard procedures. Specific soil characteristics are revealed through laboratory analysis. Climatic data from Weather Bureau records are supplemented by soil moisture sampling and rain gauge records on representative study locations. Topographic features, history, and other factors influencing vegetation on each study location are recorded

Relationships between environmental influences and associated quantitative and qualitative plant community characteristics are recognized by use of association tables, scatter diagrams and statistical analysis.

Soil, plant and climatic relationships from reliable relicts is finally tested by interpreting such relationships for other range areas for which no relicts of potential plant communities are available.

It is suggested that the methods outlined will provide information useful to the intelligent interpretation of soil survey data and the identification of range sites. Such interpretations are essential to the planning and application of optimum programs of management and treatment for rangelands.

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