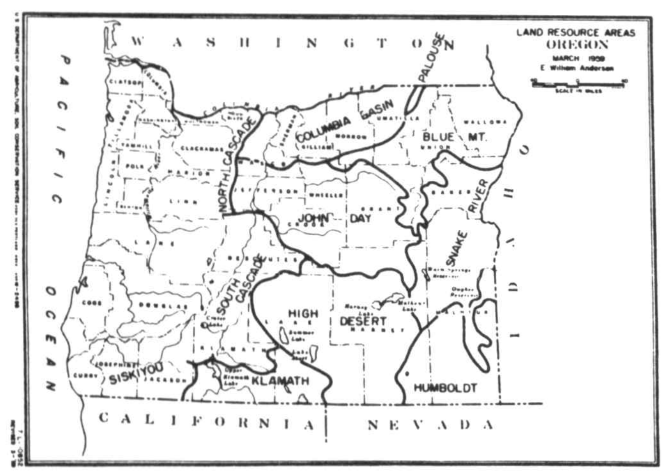
Plant Indicators of Effective Environment

E. William Anderson

Plant species have been used as indicators of various situations for many years. The purpose of this article is to (a) briefly review how climatic and land factors independently and through interaction affect the occurrence and make-up of natural plant communities; (b) present the concept that effective environment is the common denominator, albeit unquantified, of all the interacting and compensating factors; and (c) demonstrate that the effective environment can be classified for practical purposes through use of indicator species.

Background

In 1949 the Soil Conservation Service began identifying and describing the range sites in Oregon. This project continued for about 20 years and involved the rangeland and dry-forest areas of 19 counties representing ten ecological provinces (originally called Land Resource Areas), eight of which extend into other states.



The ecological provinces (originally called land resource areas) of Oregon in which ecological sites were identified and described. (SCS photo).

At an early stage it became apparent that the basic purpose of the project necessitated study of woodland and forest sites, as well as range sites, because of the interrelated forage, wood products, wildlife habitat and watershed aspects involved in conservation management of the resources. Consequently, by mid-1950's, the narrow concept of "range" site was broadened to include these other kinds of land. The term "ecological site" was substituted and defined as: "an area of land having a distinctive combination of soil, topographic, climatic and biotic (chiefly vegetation) factors which has significant management implications." This resembles the definition currently proposed by the Society for Range Management's Range Inventory Standardization Committee (RISC) which is: "Ecological site—a kind of land with a specific potential natural plant community and specific physical site characteristics, differing from other kinds of land in its ability to produce the vegetation and to respond to management."

It soon became apparent that various combinations of climatic and land factors were strongly associated with differences observed between the makeup and production of natural plant communities in a locality (Anderson 1956, 1962). Conversely, these data substantiated that similar plant communities were produced in different localities under diverse combinations of climatic and land factors. Apparently, changes in one or more factors from one location to another are compensated by changes in other factors. This suggests that the growing conditions (effective environment) are alike at the location of each similar plant community. For example, a hot south exposure or a shallow stony soil commonly offsets the effects of greater annual precipitation; the resulting plant community resembles one produced on normal soils under less precipitation. Likewise, a cool north exposure commonly produces a plant community that resembles one normally produced under greater precipitation and the degree to which this occurs can be more pronounced with increasing soil depth and slope gradient on the north exposure.

The combinations of climatic/land factors that can influence the kind of natural plant community produced at any location are almost endless. For example, climatic factors include precipitation, run-on, run-off; storm, wind and shade patterns; air and soil temperatures; elevation; latitude (photo and thermal periods); light (solar radiation); fog drip and interceptions of precipitation by plant residues and overstory plants. The effects produced by these factors vary according to the amount, kind, seasonal distribution, duration, and degree of variation of each factor. Furthermore, they are all inter-related and interact with each other and with other land factors such as soil texture, depth, structure and chemistry; slope direction, gradient and length; and ground water.

Measuring all the factors involved and their interactions in a specific location is virtually impossible. The practical solution to dealing with this extremely complex situation is to recognize that the combination of factors, interactions and compensations produces an effective environment in which certain plant species will typically occur together in the natural plant community. Other combinations of factors will produce different effective environments which are typified by certain other species. These typifying species, therefore, are reliable indicators of different classes of effective environment.

Author is Certified Range Management Consultant, 1509 Hemlock Street, Lake Oswego, Oregon 97034.

According to this concept, effective environment is the basic growing conditions resulting from the various climatic and land factors, their inter-relationships, interactions and compensations that produce a distinctive group of plant species.

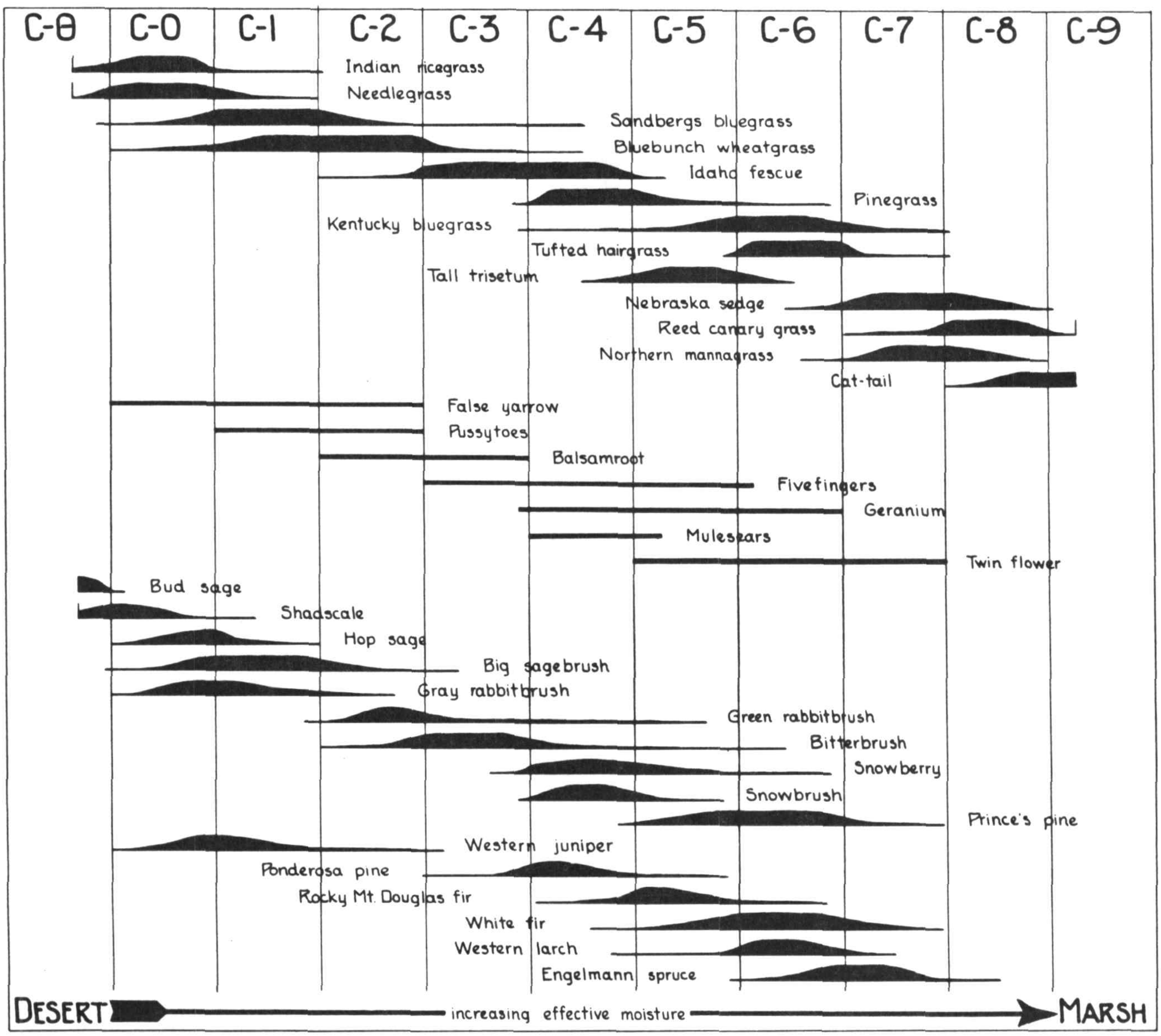
Classes of Effective Environment

As the effective environment changes from the most xeric to the most moist ecological sites, additional species occur in the natural plant communities, others disappear, and/or certain species change markedly in amount.

To clarify this concept and devise a practical grouping of indicator species into classes, a 10-segment chart was developed by 1957 representing classes of increasing effective moisture spanning from Desert to Marsh. Classes were numbered from Zero through Nine. Soon thereafter the narrow concept of effective "moisture" as a basis for classification was corrected to be effective "environment" for reasons which have been explained.

The chart began with the selection of three major grasses—*Sandberg bluegrass, bluebunch wheatgrass and Idaho fescue*—which are basic components of many natural plant communities in Oregon, both rangeland and woodland. These three species were plotted according to their relative *occurrence on the moisture scale based on data represent*ing reasonably undisturbed plant communities located on nearly level topography which represent the climatic potential of the site (climatic climax). Likewise, other species that *occur together under such natural conditions were added.* As the chart expanded it was apparent that an additional class was needed to represent the most xeric environment in Oregon. This eleventh class was numbered with the Greek letter *Theta because it conveniently looks like a minus Zero.*

Data is truncated in class C-Theta because only the upper portion of this very arid class occurs in a small portion of southeastern Oregon; additional out-of-state data were needed to show relationships with other indicator species of this class. Truncated data in class C-9 indicates that different



Occurrence of selected indicator species in natural plant communities relative to eleven effective environment classes spanning from Desert to Marsh in Oregon.

degrees of marsh exist, which was not sampled. Since 1957, several minor adjustments have been made in the relationships of species shown.

For each species, amplitude of occurrence along the Desert-Marsh scale is represented by the length of line as the species spans several classes. Some species have narrow, others wide distribution across several natural habitats. This is often called ecological amplitude. The portion of the effective environment class in which a species makes its strongest contribution to the natural plant community, as indicated by percent cover, is represented by the thickest segment of the line and each species is treated independently in this respect. It is important to note that the thickness of line is not based on a uniform scale on this chart. Therefore, where species have the same thickness of line does not mean that they occur in equal amounts in the plant community. Rather, the thick-line segment merely indicates where that particular species seems to perform its best—produces the greatest cover—in its amplitude of occurrence under natural conditions.

Species occurring in the same effective environment class column grow within that environmental range but all of them do not necessarily occur together in the same plant community. For example, in class C-3, Idaho fescue can contribute a strong cover component in the plant community of a ponderosa pine woodland, a bitterbrush shrub-grassland, and a natural grassland. In class C-4, it can constitute the major cover component of a dry meadow plant community in company with such forbs as fivefingers, geranium and mulesears. Therefore, some plant indicators of effective environment can occur on a variety of ecological sites.

Individual forb species contribute such a small cover component in the plant communities studied that thickness of line seemed irrelevant. However, the presence or absence of certain perennial forbs species constitutes some of the most important, sensitive indicators of effective environment.

Theoretically, these indicator species will not move to the left of their current position on the chart, i.e., invade a more arid effective environment, because they cannot successfully establish and/or grow—survive—in a more arid situation. On the other hand, the amplitude of occurrence of these indicator species in more moist environments is limited under natural conditions mainly because of competition from species which are better adapted to those environments, and not because of restrictive growing conditions. An obvious exception would be standing water and alpine environments which constitute restrictive growing conditions for many species. Therefore, if the competitive or dominant species in a natural plant community are significantly reduced in vigor and/or abundance through plant community deterioration due to such factors as overgrazing, fire, logging and drought, some species that typify more arid classes of effective environment will increase or move into the more-moist plant community as increasers or invaders. This is a function in the dynamics of site deterioration.

Indicator Species

Long-lived perennials are more reliable as indicator species than are most annuals which flourish when ephemeral spring moisture temporarily overpowers all other environmental factors. Each species has its own geographic range of occurrence and this plant geography causes the list of indicator species to vary from one general area to another. Experience has shown that the limitations or extensiveness of a species' geographical distribution is clarified by relating it to the ecological province(s) in which it occurs.

In some cases, plant identification at the subspecies level is required to obtain good indicators of effective environment because the taxonomy at the species level is too general. For example, basin big sagebrush grows sparsely in effective environment class C-Theta and its amplitude extends into class C-3 under natural conditions. Wyoming big sagebrush grows in classes C-1 and C-2. Mountain big sagebrush grows in class C-2 but appears to perform its best in classes C-3 and C-4.[1]

Application

Ecological Sites: Due to the complex climatic/land factor situation dealt with at the field inventory level, the primary reason for the origination of the effective environment class concept is to facilitate interpretations of data representing plant communities so they can be properly differentiated according to ecological sites. Knowing which species are indicators of various classes of effective environment helps clarify vegetational likenesses and differences between sites thereby contributing to meaningful differentiation and providing information for description.

Ecological Status: Not all indicator species are palatable to herbivores. Those that are not palatable have special indicator value since they persist in low-seral ecological status. Their presence helps verify the effective environment class of the potential plant community which, together with basic land data, helps to correctly identify the ecological site on which the deteriorated plant community exists. This, in turn, provides the basis for judging ecological status of the present plant community.

Resource Management: Once the class of effective environment is established for a location, the identification of climatic/land factors and explanation of their probable causative and compensating interactions is enhanced. This aids resource managers to judge site potential for establishing practical management objectives and determine if anything can be done to offset those factors that appear to be limiting.

Training: One of the most important aspects of effective environment classes and their indicator species has been in the training of resource workers. The indicator species concept accentuates the importance of the total plant community. Focus is on all species instead of merely focusing on those species having commercial value.

Being able to catalogue plant communities according to classes of effective environment provides an initial structural hypothesis that can be tested with further study. It contributes to the uniformity of judgement between resource workers and it improves one's consistency of judgement from day to day because it provides a strong basis for reasoning in the process of analyzing ecological relationships. Species which formerly may have been thought of merely as

[1]A list of 71 gramineae, 86 forb, 68 shrub and 34 tree species tentatively ranked according to the most xeric effective environment class in which they grow in Oregon can be obtained from the author by sending a self-addressed, stamped envelope.

botanical specimens become meaningful indicators of one of the most complex and least understood components of the autecology and synecology of our rangeland and forest resources.

References Cited

Anderson, E. William. 1956. Some soil-plant relationships in Eastern Oregon. Journal Range Manage. 9:171-175 July.

Anderson, E. William. 1962. Behavior of forage yields on some range sites in Oregon. Journal Range Manage. 15:245-252. September.

Viewpoint: Crop or Range?

E.J. Dyksterhuis

The noun "crop" is defined as "The cultivated produce of the ground." The *transitive verb "crop" means "To cause to* bear a crop or crops." In contrast "range" is uncultivated ground, and we do not cause it to produce forage as in the case of a tame pasture. Accordingly, planted tame pastures whether annual, in crop rotation, or long term, would seem to be a part of cropland acreage—as distinct from rangeland and forestland acreages.

Apart from dictionary reasons, there are compelling ecological reasons for distinguishing between range and crop. These are brought sharply into focus in the book, *Grain Yields and the American Food Supply,* Univ. Chicago Press. The introduction by Dr. Paul B. Sears, eminent ecologist of Yale University and past president of the American Association for the Advancement of Science, states:

> "Environment is of course complex, but the limiting factors may be grouped into those which are climatic, edaphic, and biotic. In the instance of crop plants a fourth set of factors, the cultural, must be added. This last represents man's efforts to control the other three for his own purposes.
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> "Productivity is one of the central problems of the field of biological science known as ecology, and one of the most vital to mankind. The best indicator of *natural* productivity is the characteristic plant and animal life of the area, properly studied and measured over a long enough time to cancel out the effects of climatic and other fluctuations. It then becomes the role of land-use planning and management to preserve and enhance, so far as possible, the natural potential."

The No. 1 definition of "culture" is usually "action or practice of cultivating the soil; tillage." This clearly places crop scientists as fostering culture, which should be appreciated. Nonetheless, what is good under one set of conditions may be bad under another. Therefore, cultural elements must be listed among limiting factors of the environment for crops but not for range.

Many areas, of course, have been put into cultivated crops where experience now shows that natural forest or natural pasture would have been better land use. In the past, various Homestead Acts were the cause of such mistakes. Legislators through tax and subsidy laws still make such mistakes, sometimes abetted by real estate promoters and others. Much natural rangeland was environmentally well suited to crops. We have only to think of the state of Iowa. In the *Yearbooks of Agriculture,* of a little over a century ago, there are references to Illinois, Iowa, and parts of Minnesota as the rangelands of the Northwest. There is still rangeland on many ranches being used as range that is suitable for cropland. Some could well be converted to feed crops (including tame hay) or tame pasture to supplement range, but then should be managed as such instead of as range. Nonetheless, in land use planning, our first concern should be use of land *within* capability. Use of land up to capability is nationally less urgent.

If rangeland is native pasture on natural grazing land, then cultivation and seeding of introduced or domesticated-native forage plants is in fact a *conversion in land use* from rangeland to cropland. This has too frequently been termed *"range improvement."*

Ecologically, this change is of the utmost significance and must therefore be recognized in our terminology. We must recognize the conversion to avoid misleading land owners and operators. Secondary succession tends to restore ranges but tends to destroy tame pastures. Natural tendencies in the development of vegetation on the planted tame pasture must be offset as surely as we still regularly have to control weeds in our cotton and corn fields, even after a century of clean cultivation. Nature will continue to show that the natural law of secondary succession hasn't been repealed, whether in cotton field or planted tame pasture.

Perhaps needing separate consideration is *unplanted* permanent "pastureland" of corn belt farms and of forestlands, but the latter are outside the scope of the title. An article in the July-August 1984 issue of the *Journal of Soil and Water Conservation* shows that *all* rangeland was included in pastureland acreage in the 1967 National Resources Inventory (NRI) on use of nonfederal rural land. However, it also shows that in the NRI's of 1977 and 1982, they were segregated. This is progress for range science. An adjacent table shows estimated average wind erosion in tons/per acre/per year as 1.5 for rangeland and 0.0 for pastureland. From this it seems safe to conclude that little pastureland is now tallied in rangeland climates, except possibly in the corn belt or where irrigated. On corn belt farms of the Dakotas and Nebraska, tracts of nonarable land used for pasture may be termed range, but in adjacent Minnesota and Iowa they are regularly termed pastureland as distinguished from cropland. They may be regarded by owners as either native or tame pasture but seldom as range. They may

Dr. Dyksterhuis may be contacted at 3807 Oaklawn, Bryan, Texas 77801.