Outline for Autecological Studies of Range Grasses[1]

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Highlight

Complete autecological life history studies are necessary to overcome less obvious bottlenecks and enhance control or revegetation of important range plants. An outline of research needed for range grasses is given. This outline is guiding co-operative, multi-state studies of galleta and bluebunch wheatgrass.

In 1966, range ecologists from the states of Arizona, Nevada, New Mexico, Utah, Washington, and Wyoming[2] initiated co-operative Western Regional Project W-90, entitled "Ecological Life Histories of Selected Western Range Plants." This group was formed because of recognition that the lack of autecological knowledge on many important western range species was impeding range management progress.

Our knowledge of range plants lags considerably behind the foresters' autecological understanding of the trees they manage. Ready availability of current information to the practicing forester is now possible because of the recent publication of U.S.D.A. Agricultural Handbook 271, Silvics of Forest Trees of the United States. Here the essential information on the autecology of 125 principal tree species has been assembled through the efforts of about as many authors. The only thing comparable that range men have access to is the Range Plant Handbook, now 30 years out of date and yet recently reprinted.

I estimate that only about a dozen native range species have received study comparable to that of the commercially important trees or improved pasture plants. Summarization of all available autecological knowledge under one cover can be found for only about four species. Two of these are found only as theses, and thus are not available to a range man in the field.

Autecological research on range plants has been largely fragmentary. Problems of seed germination would be recognized and studied by someone in one state. Perhaps two decades later and half-way across the country a range scientist would follow with comprehensive studies of response to burning, but with different sample material and probable genetic variation. These one-shot studies are usually aimed at inter-relationships which are guessed to be the limiting factors for control or revegetation of the species in the investigators' neighborhood. Many times the weak link in the chain is found with the first attempt. However, many other times this approach doesn't find the weak part of the cause-effect pattern. We usually don't get to read about these negative results because of the reluctance of authors to write them up or an editor's disdain for publishing this type of information. The result is that other workers retest the same outwardly plausible hypotheses. In other cases we fail to find the limiting factors because they act indirectly and are cryptic unless a systematic study is made.

An example of these two principles is found in the attempts to explain saguaro (*Carnegiea gigantea* (Engelm.) Brit. & Rose) decline in southern Arizona. Many workers pecked away at various facets of the total problem, but none were able to explain the lack of regeneration of this species by single factor reasoning. Finally Niering et al. (1963) through a comprehensive study of the total problem were able to explain that overgrazing, as it influenced community composition, has affected rodent populations which in turn are the major factor in decimating saguaro regeneration.

It is obvious from this and other examples that the road to solution of problems is not always the short, straight or well-marked one. It is also demonstrated that arrival at a research goal is surer if one has a detailed map of the route to take. Such a check list of phenomena to be summarized or found out forces us not to detour around a facet of a plant's ecology that may well be the bottleneck we need to eliminate.

Several fine examples of outlines for autecological life history research exist. The ecological societies of both Britain and America have had committees to answer this need. In fact, the British published one in 1928 (Clapham, 1956). The first American outlines came out in 1950 (Lawrence, 1950). The British, however, have followed up with coverage of 98 of their species to date (*e.g.* Bowden, 1964). Except for a few papers (*e.g.* Pelton, 1961), Americans have largely ignored this approach and have gone sporadically chipping away at small pieces of the whole.

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[2] Members of the current W-90 committee are P. R. Ogden, University of Arizona; J. H. Robertson, University of Nevada; K. A. Valentine, New Mexico State University; G. A. Harris, Washington State University; A. A. Beetle, University of Wyoming and the author who served as chairman in 1966.

Discussion

By choosing the best features of these earlier outlines and adapting them for study of range grasses, the W-90 committee came up with the outline which follows this text. Here listed are the six kinds of information necessary to understand the autecology of a plant species: taxonomy, genecology, developmental history, ecological relationships, physiology, and economic value. The order of study would ideally follow order of presentation, as should become apparent during the following discussion.

(1) Taxonomy. To undertake such studies, one should be sure of the identity of what he is working with. Range people are prone to be superficial about their application of taxonomy. For example, we were led astray on the use of *Elymus caput-medusae* L. for what we know as medusahead rye. Not until Jack Major visited the Mediterranean area was it discovered that there was a misidentification of what is more correctly *Taeniatherum asperum* (Sim.) Nevski (McKell et al., 1962). This finding enabled the correct European literature on this grass to be used.

In addition to problems of misidentification, there are those of synonomy—use of different scientific names by different people at different times applying to the same biological entity. For instance, take the case of creosote bush. The most current, correct name is *Larrea tridentata* (S. & M.) Cov. (Porter, 1963). Many know this plant as *Larrea divaricata* Cov., others as *Covillea tridentata* (S. & M.) Vail or *C. glutinosa* (Engelm.) Rydb. In the earliest American literature this shrub was designated *Zygophyllum californicum* Torr. & Frem. Nine other scientific names have been used by other authors at various times. Knowledge of these different scientific names and their sequence of use is necessary to take full advantage of available literature and to be able to synthesize it. The same principle holds for common names.

Other aspects of a complete biosystematic study include distribution patterns, breeding patterns (whether inbreeding, outcrossing, etc.), and hybridization. This information along with understanding of present and past ecological patterns will allow consideration of a plant's evolutionary history. Modern chemical taxonomic methods will aid in confirming other lines of evidence (*e.g.* Young, 1965).

(2) Genecology. Although one or a few individual plants serve as study samples, what we usually hope to find are characteristics which are common to the species population. However, we must consider the possibility of genetic variation over portions of the species range (Tisdale, 1962). Such ecotypic (if discrete) or ecoclinal (if continuous) variation can only be discovered through experimentation. The W-90 committee is exchanging clonal material of galleta grass (*Hilaria jamesii* (Torr.) Benth.) and bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. and Smith) from all the participating states and planting it in nurseries in the home states to allow separation of the effects of genetics and environment. Such studies are similar to the "provenance" research that has so greatly enhanced reforestation (Callaham, 1963).

(3) Developmental History. When autecology or life history studies are mentioned, many bring to mind study of a plant's life cycle. Indeed, this phase should be a major area of effort. However, it is unwise to proceed on these studies without an adequate understanding of the taxonomy and at least provision for incorporating knowledge of ecotypic variation. Likewise, it is foolhardy to study ecological, physiological, and economic characteristics of a plant without understanding its life cycle. Such studies are best organized around the seed, seedling, juvenile, reproductive, and senescent stages of the life cycle (Pelton, 1953; Steven and Rock, 1952).

(4) Ecological Relationships. Autecology involves the study of the inter-relationships of individual plants or species populations to their environment. In addition to the commonly recognized factors of the physical environment such as temperature, soil moisture, light, etc. we should not overlook the biotic side of a plants environment. Habitat factors may not directly determine a plant's distribution and importance but rather they may act indirectly to influence competitive abilities (Walter, 1960). This is why it is to be emphasized that an autecologist does not work in isolation of a synecologist or the information he generates. In fact, it is best that autecological and synecological studies progress concomitantly. The synecologist provides understanding of patterns of vegetation in relation to environment. In the process of arriving at this understanding, first approximations of a species distribution, importance and reaction to the environmental complex are gained. The synecologist's observations of reactions to soils, flooding, fires, grazing, etc. by at least the dominant species gives the autecologist many working hypotheses. The autecologist in turn follows these up with experiments sharpening knowledge of species indicator values, thus enhancing the use of synecological data for comparing environmental contexts. So both kinds of ecologists contribute to range management in a manner analogous to the way physicists contribute to progress by engineers.

(5) Physiological Relationships. Range management is developing to the extent that it can no longer progress without a better understanding of the physiology of at least the principal species we

manage. We have understood the importance of food reserve patterns and nutrient content for several decades but perhaps we have overlooked other eco-physiological phenomena that may be of great importance. For instance, we may be able to best evaluate vigor by measurement of photosynthetic-respiratory balances (Polster, 1962). Perhaps pigment content in different environments will help explain environmental compensations (McNaughton, 1966). All of these internal functions that respond to external environmental change merit inclusion in a total autecological study.

(6) Economic Considerations. It is in these matters that the range conservationist has the most interest. However, attempts to short-circuit the progression of knowledge usually result in some mistakes. Attempts to revegetate with a species before its strengths or weaknesses are known is putting the cart before the horse. The seed source used may not have the genetic potential to flourish in the environment in which it is planted. Other ecotypes could be well suited to the technician's needs. Perhaps there isn't a long enough growing season for carbohydrate reserves to be replenished or for seed to mature. Knowledge of each of these things increases the chances of success and reduces the waste of already scarce dollars for range improvements.

An understanding of every item on the outline is needed to do the best possible job of managing a given species. But this isn't to say we can't move until research is completed. It simply means we will be able to successively do a better job as more and more of the question marks are erased.

Obviously, the lack of co-ordinated autecological information on range plants is a problem of major proportions. Therefore, no one man in even a lifetime can make much of a contribution. However, a group of men pooling their various abilities, facilities and experiences have a better chance of coming up with more information in a shorter period of time. The W-90 committee hopes to set a good example for subsequent studies of other species. It is hoped that other range scientists will be encouraged to follow with efforts on the autecology of other range plant species.

Outline for Ecological Life History Studies of a Range Grass

- I. Taxonomy
  - A. Nomenclature—synonymy, description, common names
  - B. Distribution—geographical, altitudinal, topographical, history of introduction, if introduced
  - C. Chromosome patterns
  - D. Breeding System
  - E. Hybridization
    - 1. Natural
    - 2. Artificial
  - F. Evolutionary History
  - G. Chemotaxonomic definition—chromatography, serological
- II. Genecological Variation
  - A. Ecotypic or ecoclinal variation
  - B. Reciprocal transplants
    - 1. Field
    - 2. Greenhouse
    - 3. Growth chamber
- III. Developmental History
  - A. Seed Stage
    - 1. Seed dispersal
    - 2. Pre-conditioning requirements (dormancy)
      - a. temperature
      - b. moisture
      - c. after-ripening
      - d. aeration
      - e. seed coat
        - (1) scarification
        - (2) biotic breakdown
        - (3) inhibitors
        - (4) longevity
  - B. Seedling stage—germination
    - 1. Under natural conditions
    - 2. Under controlled conditions
  - C. Juvenile stage—establishment
    - 1. Under natural conditions
    - 2. Under controlled conditions
  - D. Reproductive stage
    - 1. Roots and rhizome
      - a. growth rate
      - b. pattern
    - 2. Tillering, stolen, and bud development
    - 3. Leaf development
    - 4. Culm development
    - 5. Flowering
      - a. micro-sporogenesis
      - b. pollination
      - c. mega-sporogenesis
      - d. fertilization
      - e. seed development
    - 6. Seed production (fruiting)
  - E. Senescent stage—decline and death
- IV. Ecological Relationships
  - A. Climatic Relationships
    - 1. Light
      - a. qualitative effects (wavelengths)
      - b. quantitative effects (intensity)
      - c. periodicity effects (photoperiod)
    - 2. Temperature
      - a. quantity
      - b. periodicity
      - c. frost resistance
    - 3. Precipitation
      - a. quantity
      - b. quality
      - c. seasonal distribution
      - d. drought resistance

B. Edaphic Relationships
1. Soil physical characters
a. texture
b. structure
Soil moisture
3. Nutrient uptake
a. requirements
b. tolerances
(1) toxic elements
(2) salinity
C. Response to fire
D. Response to biotic factors
1. Parasites
a. macro-
b. micro-
c. plant
d. animal
2. Pathogens
3. Symbionts—mychorrizal
E. Synecological Content—community occurrence
F. Competitive ability—dispersion patterns

V. Physiological Relationships
A. Pigment production
B. Photosynthetic efficiency
C. Respiration
D. Food Reserves
1. Carbohydrate pattern
a. aerial portions
b. underground portions
E. Other chemical constituents
1. Resins
2. Essential oils
3. Saponifiable oils
4. Rubber
5. Total N
6. Total protein
7. Pentosans
8. Reducing sugars
9. Starch
10. Lignin (crude fiber)
11. Ash

VI. Economic Characteristics
A. Forage Value
1. Herbage yield (grazing capacity)
2. Palatability
3. Nutritional value
4. Response to grazing
a. natural
b. simulated
B. Watershed protection value
C. Potential and means for revegetation (desirable species)
D. Response to fertilization
E. Control methods (undesirable species)
1. Mechanical
2. Chemical
3. Biological

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