A preliminary classification and characterization of big sagebrush, Artemisia tridentata Nutt., communities in central Montana
by Darrel Wayne Smith

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Range Management
Montana State University

Abstract:
This research was initiated in 1966 to supply basic information about sagebrush rangelands. The purpose of the study was to classify and characterize big sagebrush communities in central Montana.

Fifty-eight study locations were subjectively chosen in Petroleum and Fergus counties. Site, vegetation and soil data were taken at each location. Site data included exposure, slope, and altitude, Vegetational (Frequency) data were collected from 50 nested plots and canopy cover of big sagebrush was estimated in 50 3 by 6 decimeter plots. The soils were described by horizons including name, depth, color, texture, consistence, pH, salinity, and boundary.

Vegetational data were subjected tp three different methods of analyses, These included cluster, ordination and association techniques. Each of these techniques offered important insight into the nature of the vegetation, The cluster method grouped the vegetation into 13 units while the ordination technique displayed the study locations on a two dimensional chart. Tfye association table was used to combine the results of the first two methods into meaningful groups. These groups were related to the site and soil data, The study locations were grouped into six units including one containing two subgroups. These include: Group I (Artemisia/Poa group); Group II (Artemisia/Agropyron smithii/A. dasystachyum group); Group III subgroup a. (Artemisia/Bouteloua/Bromus). subgroup b. (Artemisia/Bouteloua/Carex); Group IV (Artemisia/Koeleria/Bouteloua group); Group V (Artemisia/Stipa/ Koeleria group); and Group VI (Artemisia/Agropyron/Poa group). The vegetation of this area appeared generally to represent a continuum with the exception of Group VI which seemed to be a discrete community.

Geological material and soil texture affected big sagebrush distribution, Big sagebrush was found on heavy soils derived from shales but was generally absent from two sandstone-derived soils.

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INTRODUCTION

Big sagebrush (Artemisia tridentata) is a shrub of low forage value for livestock. Beetle (1960) described big sagebrush as an erect, gray-green shrub. It is characterized by an aromatic smell and three toothed leaves. Big sagebrush may appear either dwarfed, shrubby or treelike. It occupies a great variety of sites in Montana and other western states. Beetle (1960) estimated 18 million acres of rangeland in Montana support big sagebrush communities.

Several methods for reducing sagebrush cover are used to increase forage productivity from heavily infested range. The economic feasibility of sagebrush control, however, often depends on rates of reinvasion and the responses of associated vegetation. Also, many ecological implications of sagebrush control such as effect on wildlife, soil stabilization, and watershed relationships need to be understood before vast sagebrush acreages are controlled. Study of these factors produced a need for basic research into the nature of sagebrush communities.

This study was initiated to classify and characterize big sagebrush communities in central Montana in an attempt to provide a basic understanding of these communities for further research work and the development of management practices. 1/

1/ This research was supported under Montana Research Station Project M.S. 132 and contributes to regional Project W-89.

REVIEW OF LITERATURE

INTRODUCTION:

The classification of vegetation should logically precede the study of vegetation-soil relationships (Smith, 1966). The necessity for designating of broad vegetation associations has been recognized and used for many years (Stoddart and Smith, 1955). As management and the study of vegetation-environment interaction becomes more specific, the need for more precise classification methods develops (Poulton and Tisdale, 1961). This literature review will be confined to (1) a brief report of two approaches commonly used in classification studies and (2) some environmental factors which may be relevant to the vegetation involved in this study.

APPROACHES TO STUDY:

Community Approach. Clements (1916) introduced the concept of the existence of discrete plant communities and the succession of vegetation toward a "climax" governed by climate. Tansley (1920) modified the "monoclimax" theory of Clements by introducing edaphic, topographic, biotic and other climax concepts, resulting in the "polyclimax" theory. This basic idea of plant communities has been very influential in forest and range ecology and has developed into the use of the "range site" and "habitat-type" concepts (Smith, 1966).

Passey and Hugie (1962a.) described a range site as a "kind of rangeland" with a given potential for producing native plants and having its own combination of environmental conditions, a part of the ultimate expression of which is a distinctive plant community. Poulton and Tisdale (1961) used the concept of the habitat-type and described it as an abstract unit that may be defined as the collective area which is capable of supporting the same relatively homogeneous climax plant association. It denotes a specific ecosystem which is the fundamental unit of the landscape classification and management purposes. They proposed that habitat types would differ not only in their climax vegetation and soils, but also in their seral vegetations which develop as a result of management treatments or disturbances such as grazing, fire, insects, and artificial revegetation. Poulton and Tisdale (1961) and Passey and Hugie (1962a.) advocate the use of a vegetational association table as the first step in the interpretation of community data. These tables enable one to see the degree to which the abstract classification units are distinct or tend to intergrade and represent a continuum. After interpreting the vegetation data the results can be related to other data such as soils data (Poulton and Tisdale, 1961).

<u>Continuum Approach</u>. Gleason (1939) opposed the community concept and advocated an "individualistic concept" of vegetation. This concept often referred to as the "continuum concept" rejects the idea of plant communities as homogeneous units with characteristics that are fixed and repeated wherever the community occurs. This school favors the idea that vegetation changes continuously along environmental gradients according to the requirements and tolerances of the individual members of the population (Whittaker, 1953).

Analysis of vegetation using this concept usually involves the use of gradients in environmental factors, vegetational characteristics, or both (Smith, 1966). Curtis and McIntosh (1951) and Dix (1958) used the continuum concept in vegetation studies. They used the variation of the vegetation itself to order the stands into meaningful groups. Indexes were used to allow an objective, quantitative measure of the similarity between stands. Whittaker (1956) used environmental characteristics for ordination of the stands and used association tables to arrange stands along a gradient. Waring and Major (1964) described two approaches that could be used to analyze environmental characteristics affecting plant growth. One approach was to study factors such as temperature which directly affect plant growth. The other was to measure environmental characteristics such as soil texture which indirectly affect plant growth.

Comparison of the Two Approaches. One difference between these methods of study lies in a basic disagreement about natural vegetation. The extreme community concept postulates that the individuals and species within a community interact to increase each others potential for survival. This concept implies more or less sharply defined boundaries between one community and another. The other extreme holds the view that there are no discontinuities in natural vegetation except where there are discontinuities in the physical environment (Grieg-Smith, 1964). Many authors have taken an intermediate position. Webb (1954) stated that, "The fact is that the pattern of variation shown by the distribution of species among quadrats of the earth's surface chosen at random hovers in a tantalizing manner between the continuous and the discontinuous". Other authors have found vegetation to be in discrete communities in some situations and to form a continuum in others (Hyder, et al., 1966).

In using the community approach relatively undisturbed sites are selected for study. Stratification is required and ecotones and transitions are avoided (Poulton and Tisdale, 1961). This requires that the units of classification be defined to a considerable degree before actual study is begun. The continuum approach would study the relationships among soil and vegetational characteristics along gradients of these characteristics. Study locations would be selected to effectively reflect these gradients whether a given location represents a large uniform area or an ecotone (Smith, 1966).

Smith (1966) concluded that significant differences in philosophy of approach exist, but that the nature and usefulness of the results was less significant than the differences in the underlying philosophies. Grieg-Smith (1964) stated that the reality or otherwise of distinctive units of vegetation in the field remained to some extent an open question, but that this was of little importance in many fields of ecological interest.

SOME FACTORS AFFECTING ARTEMISIA TRIDENTATA DISTRIBUTION:

This review is an effort to focus attention on some of the relevant environmental factors affecting big sagebrush distribution. Poulton and Tisdale (1961) stated that, "Methods used must attempt to sample essentially all features of the vegetation and soil since at the outset, it is impossible to predict relevant or limiting factors or to identify correctly all diagnostic characteristics of each habitat-type".

Edaphic Factors. Many authors have reported that big sagebrush prefers deep to moderately deep soils where deep root penetration is possible (Beetle, 1960; Fautin, 1946; and Thatcher, 1959). Soil texture is also an important factor. Patten (1963) described most sagebrush soils in his study area as sandy loams in the surface horizon. Robertson, Nielsen and Bare (1966) found big sagebrush on soils with a sandy loam to loam surface horizon and a sandy clay loam to clay loam subsurface horizon. Houston (1961) observed big sagebrush on the clayey soils and Fautin (1946) found it on all textures but especially on a soils with high water holding capacities. Cook (1961) found that soils supporting sagebrush had significantly lower bulk densities and higher absorption rates than soils associated with desert molly (Kochia vestita). Fautin (1946) found sagebrush communities confined to permeable soils. Thatcher (1959) reported that soil permeability and structure affected big sagebrush size more than distribution, with large plants growing on well structured permeable soils.

Big sagebrush's preference for a low salt content has been reported by Fautin (1946), Gates (1956), and Thatcher (1959). Gates, Stoddart, and Cook (1956) found sagebrush soils varied widely in pH. Smith (1966) stated that most of the studies he reviewed reported a pH from about 6.5 to 7.5 in the surface horizon and 7.5 to 8.5 in the subsurface horizons.

Biotic Factors. Man has had a profound effect on vegetation through the use of grazing livestock. Lommasson (1946) after a 31 year study in Montana concluded that sagebrush was extending its range as a result of heavy grazing. Thatcher (1959) referring to big sagebrush stated that, "Changes in local distribution occur primarily through reduction of competition from herbaceous species through grazing. Local distribution undoubtedly has been affected more than outside limits of total range, but the extent of these modifications could not be determined". After a review of the literature Johnson (1966) stated that there seems to be a general concensus that sagebrush is increasing in both range and density.

Pyric Factors. Man has also altered natural fire patterns. Passey and Hugie (1962b.) cited fire as a factor causing sagebrush fluctuations. Fire is often used as a sagebrush control (Blaisdell, 1953; and Pechanec, Stewart, and Blaisdell, 1954), but Quinnild and Cosby (1958) after ring count studies found that many big sagebrush plants became established following disturbance by fire.

Topographic Factors. Many authors have reported differences in production and composition associated with slope position, slope gradient, and aspect (Thatcher, 1959; Dix, 1958; and Smith, 1966). Dix (1958) further stated that slope will strongly influence vegetational cover and that it is impossible to separate the effects of slope from other factors.

DESCRIPTION OF THE STUDY AREA

LOCATION AND HISTORY:

The area studied is located in central Montana within Petroleum and Fergus counties. This region has been heavily grazed since the early 1880's. During the hot, dry summer of 1886, the range was overstocked and the vegetation was grazed down to its roots by fall (Burlingame, 1942). Since this early history of over-use, the range has been generally exploited up to the present time.

GEOLOGY, TOPOGRAPHY AND SOILS:

The central Montana geology is composed predominantly of Cretaceous sedimentary deposits belonging to the Montana and Colorado groups (Lawlor, 1956). Most of the study locations are on Colorado shale, which is composed primarily of dark gray shale and siltstone with many sandy units included. Soil and vegetation on the Bearpaw shale (a dark gray and brownish clay shale) and the Hell Creek formation (containing sandstone, clay shale and mudstone) were studied. Other locations are on Quaternary alluvium consisting of silt, sand, and gravel valley fills (Ross, Andrews, and Witkind, 1955).

The landscape is of relatively even rolling uplands with creeks and gullies forming a well-developed drainage pattern. The study locations range from 2700 to 3500 feet above sea level with slopes from one to 39 percent.

Wide variations in soil depth, texture, structure, pH and salinity were encountered. Site and soil data for the 58 study locations are presented in Appendix I.

CLIMATE:

Central Montana has a typical Northern Great Plains climate. Four seasons are evident with cold winters, often reaching -30° F, and hot summers, usually approaching 100° F. Extreme climatic variation is characteristic. Forty year records from a station near Flatwillow, Petroleum County, show a record low of -48° F and a high of 108° F (U. S. Department of Commerce, 1965). Most of the average annual 12.6 inches of precipitation comes in the spring and summer. Wind and high temperatures reduce the effectiveness of summer rains. Annual precipitation extremes of 7.0 to 19.5 inches were recorded at the Flatwillow station in 1952 and 1962, respectively. In 1967 the area received almost 3 inches more than the average amount of precipitation (U. S. Department of Commerce, Annually) with a very wet spring and fall and a dry summer. Temperature and precipitation data from the Flatwillow station are presented in Table I.

VEGETATION:

All the study locations were placed in areas where mountain big sagebrush (*Artemisia tridentata* subspecies *vaseyana*) was present. Fringed sagewort (*Artemisia frigida*) is a common half-shrub. The wheatgrasses (*Agropyron* spp.) dominate the herbaceous cover. These include western wheatgrass (*A. smithii*), thickspike wheatgrass (*A. dasystachyum*), and bluebunch wheatgrass (*A. spicatum*). Needleandthread (*Stipa comata*) and green needlegrass (*Stipa viridula*) also are common. Blue grama (*Bouteloua gracilis*), prairie junegrass (*Koeleria cristata*) and Sandberg bluegrass (*Poa secunda*) are ubiquitous understory grasses. Common forbs include American vetch (*Vicia americana*), scarlet globemallow (*Sphaeralcea*

Table I. Precipitation and temperature records from a station 4 miles ENE of Flatwillow, Petroleum County; Elevation 3140 (U.S. Department of Commerce--Weather Bureau, 1965).

Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
					NORMAL TOTAL PRECIPITATION								
1931-1960	.31	.38	.64	.85	1.94	3.17	1.40	1.19	.98	.88	.44	.39	12.57
					MEAN TEMPERATURE								
1931-1960	20.8	23.6	30.9	44.2	54.6	61.9	71.5	69.2	58.9	48.0	34.2	26.7	45.4
					MEAN DAILY MAXIMUM TEMPERATURE								
1915-1960	33.0	36.1	43.8	57.7	68.4	76.1	87.7	85.8	73.6	61.3	46.4	37.4	58.9
					MEAN DAILY MINIMUM TEMPERATURE								
1915-1960	8.2	11.5	19.1	30.2	39.2	47.6	53.8	51.3	42.2	32.5	21.0	12.9	30.8
					HIGHEST TEMPERATURE								
1915-1960	69	76	79	91	98	107	108	108	104	90	81	70	108
					LOWEST TEMPERATURE								
1915-1960	-40	-46	-30	-14	8	30	34	31	8	-18	-29	-48	-48
			MEAN NUMBER OF DAYS WITH TEMPERATURES $\geq$ 90° or $\leq$ 32° F										
1951-1960													
$\geq$ 90° F	0	0	0	T	1	2	18	13	4	0	0	0	38
$\leq$ 32° F	30	28	28	19	4	0	0	0	3	16	26	30	184

coccinea), spindle plantain (*Plantago spinulosa*), and prairie pepperweed (*Lepidium densiflorum*). A comprehensive species list is found in Appendix II.

METHODS AND PROCEDURES

FIELD METHODS:

Selection of Study Locations. The central Montana area was selected for study because it represents the eastern edge of big sagebrush distribution. Here big sagebrush is associated with vegetational communities far different from those occurring to the west and south. It was felt that an understanding of these communities would help complete the knowledge of the total environment supporting big sagebrush.

Within this grass area 58 study locations were selected (Figure 1). These locations were subjectively chosen to represent the apparent variation in sagebrush rangeland.

Several criteria were used in choosing these areas. The presence of big sagebrush on public land was a prerequisite. Locations were chosen to represent the greatest possible range in density and cover of big sagebrush, associated vegetation, topography, geologic material, and soils. A visual reconnaissance was conducted to find all the various combinations of these factors. Many apparently similar sites were sampled so that the accuracy of field observations could be checked later by more detailed data analyses.

Recording Study Locations. After selecting a study location its position was indicated on large scale (1:63,360) maps. Each location was recorded using bearings and distances from prominent landmarks. Four to seven landmarks were used for most locations. A steel post was driven in the ground and used as a landmark if natural reference points were not adequate. Posts were placed 60-70 yards from the study locations to minimize the effects of attracted livestock. The center of each location was

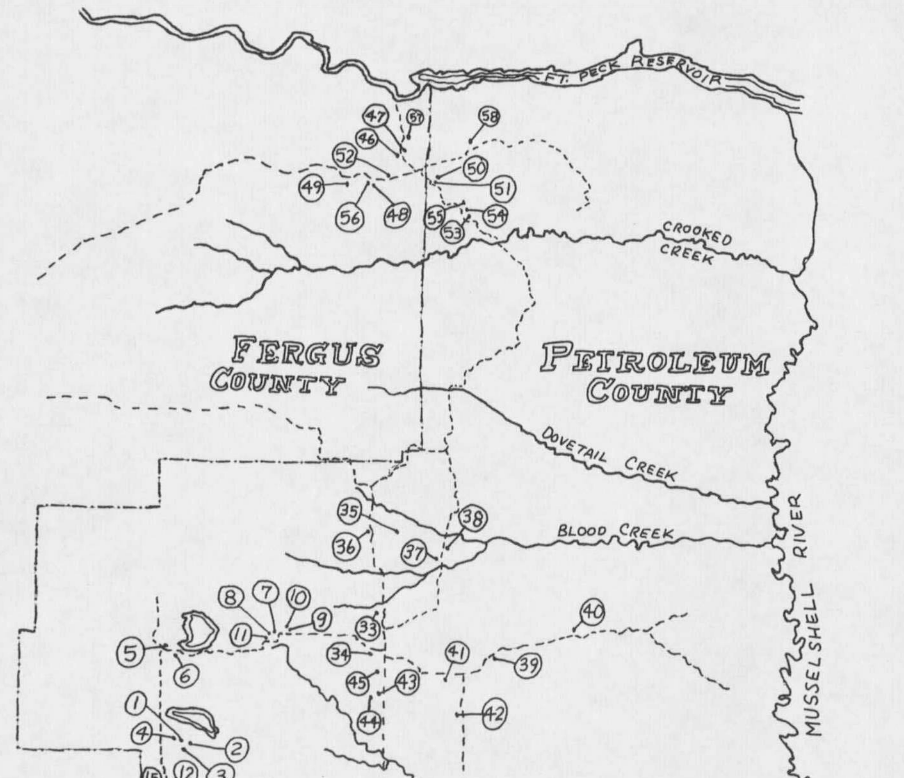

Figure 1. Map of central Montana showing the 58 study locations.