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Taxonomy of the Artemisia Tridentata Complex in Idaho

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ABSTRACT

Communities dominated by woody species of *Artemisia* constitute the natural vegetation of most of southern Idaho. The principal species involved is *A. tridentata*, which occurs as a complex consisting of three subspecies, one form and one additional variant not yet named. These five taxa are *A. tridentata tridentata, A. tridentata wyomingensis, A. tridentata vaseyana, A. tridentata vaseyana* form *spiciformis* and *A. tridentata* "X." They are recognizable by morphological characters and also show important ecological, phenological, cytological and chemical (chromatographic) differences. They have evolved to fit different habitats within the sagebrush region, and their recognition as distinct taxa is basic for management of sagebrush-grass ranges. Differences of management significance among the five taxa occur in kind of site occupied, reaction to depletion of understory, vegetation, livestock preference and times of seasonal growth development.

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INTRODUCTION

The name *Artemisia tridentata* was first given by Nuttall (1841) to a collection made by the Lewis and Clark expedition. Since this time it has undergone several revisions (Rydberg 1916, Hall and Clements 1923, Ward 1953, and Beetle 1960). Classification of this species has varied both in the number of subdivisions recognized and in their taxonomic rank.

This taxon in its various forms constitutes the most abundant and widespread of the woody species of *Artemisia* which characterize the extensive sagebrush-grass vegetation of Idaho and adjacent portions of the Great Basin and Columbia Plateau. Uncultivated lands presently or potentially belonging to this vegetation type occupy some 17 million acres in the southern part of the state and provide a major source of forage for domestic livestock and wildlife (Tisdale et al. 1969).

Uncertainties regarding the taxonomic status of the woody members of the genus *Artemisia* have resulted in considerable confusion regarding the nature and distribution of the various taxa involved, and have greatly handicapped studies of their ecology and response to land management practices. The present study was undertaken to clarify some of these taxonomic problems. The *A. tridentata* (big sagebrush) group was chosen for intensive study due to its great range and abundance and to its known taxonomic difficulties.

This study encompasses taxonomic units of big sagebrush as presented by Beetle (1960) and Beetle and Young (1965). These include: *Artemisia tridentata* subspecies *tridentata* (basin big sagebrush), *Artemisia tridentata* subspecies *wyomingensis* (Wyoming big sagebrush), *Artemisia tridentata* subspecies *vaseyana* (mountain big sagebrush) and *Artemisia tridentata* subspecies *vaseyana* form *spiciformis* (subalpine big sagebrush). An additional variant not recognized by the above authors has been encountered in this study. It will tentatively be referred to in this article as "X" big sagebrush.

STUDY METHODS

Recent classification systems have emphasized the use of as many attributes of organisms as possible, and include morphological, chemical, cytological, ecological and distributional data. If results of several attributes substantiate each other, the resulting classification is

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Most of the data are drawn from a thesis presented by the senior author in partial fulfillment of the Ph.D. degree in Range Resources from the University of Idaho.

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assumed to be more reliable and useful than one based on only one attribute. Information from all the above-mentioned criteria was used to substantiate the taxa described in this paper.

Numerous herbarium specimens of big sagebrush and related species were collected throughout Idaho and adjacent states. It was necessary to become familiar with all species of sagebrush in the region in order to minimize taxonomic confusion. Morphological characteristics determined on herbarium material included: leaf length; width and length-width ratio; length of vegetative shoots and flower stalks; flower head diameter; number of flowers per head; flower heads per stalk and average seed weight.

Observations were made in the field regarding the physiognomy, phenology, behavioral characteristics and distribution of each taxon. Representative specimens of all taxa were photographed both in the field and in the herbarium.

Thin-layer chromatography was used to obtain separation of fluorescent methanol-soluble compounds which form specific patterns for plants belonging to different taxa. One-half gram samples of persistent (overwintering) leaves were crushed and allowed to stand overnight in 6 ml of methanol. The solvent system consisted of 30 parts methanol to 70 parts benzene. Development was done in a glass tank (Kensco K-4096) with prepared chromatographic sheets (Eastman Chromagram Sheet 6060) on which silica-gel was the absorbent. Patterns formed by the separated compounds were observed by placing the sheets in a darkened room and exposing them to a long-wave ultraviolet light (3660 Angstroms). Each spot was recorded by location, fluorescent color and color intensity. R_Z values (Long 1961) were calculated, and each spot was assigned an identifying number. R_Z values were determined from the relationship:

$$\frac{\text{distance solute moved}}{\text{distance standard moved}}$$

A field method for determining gross fluorescence of leaf samples was also developed (Winward and Tisdale 1969).

Inflorescence samples for cytological studies were collected in the field as flower heads began to turn yellow. Collections were continued until pollen grain maturity was evident. The samples were placed in a killing solution of 95 percent ethyl alcohol, chloroform and glacial acetic acid (6:3:1). The acetocarmine smear technique (Smith 1947) was used to determine chromosome numbers. In addition, herbarium samples of material used in Ward's (1953) study of sagebrush were obtained from the Dudley Herbarium, Stanford University. These samples were separated morphologically and chromatographically into intraspecific units. Chromosome numbers previously determined by Ward for most of these specimens made it possible to relate chromosome numbers to specific taxa.

Table 1. Morphological measurements of three subspecies and one form of *Artemisia tridentata.*

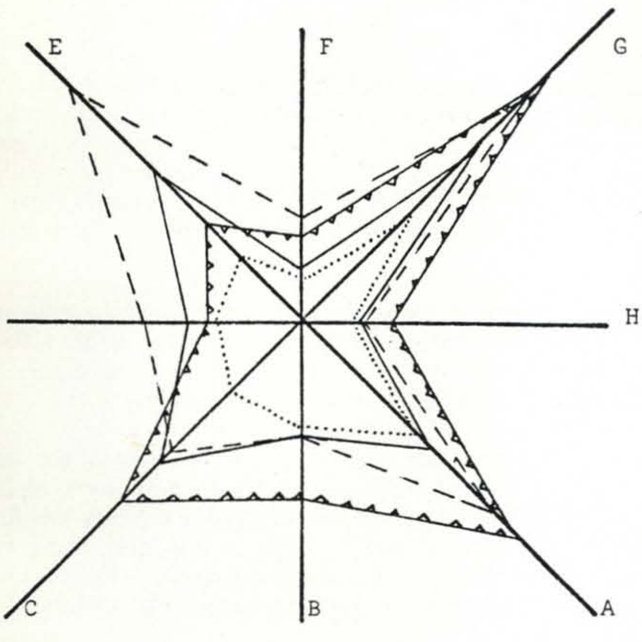
	subspecies *wyomingensis*	subspecies *tridentata*	subspecies *vaseyana*	subspecies *spiciformis*
leaf length (mm) mean ± s	8.3 ± 2.8	17.3 ± 3.1	12.0 ± 4.4	16.9 ± 6.8
leaf width (mm) mean ± s	2.7 ± .8	3.1 ± .7	3.0 ± 1.1	4.8 ± 1.6
leaf length/width ratio	3.1	5.6	4.0	3.5
flower stalk length (cm) mean ± s	10.4 ± 4.2	20.1 ± 8.5	21.4 ± 6.0	26.6 ± 6.6
vegetative shoot length (cm) mean ± s	4.7 ± 2.4	11.2 ± 6.4	6.9 ± 2.0	8.6 ± 3.5
flower/vegetative shoot ratio	2.2	1.8	3.4	3.1
flower heads per 10 cm stalk length mean ± s	82 ± 41	150 ± 74	80 ± 47	50 ± 29
flower head diameter (mm) mean ± s	1.1 ± 0.2	1.2 ± 0.1	1.2 ± 0.2	1.9 ± 0.3
flowers per head mean ± s	3.7 ± 0.9	3.8 ± 0.8	4.6 ± 0.5	7.9 ± 1.1
seed weight (mg/100 seeds)	26.0	23.0	25.8	41.6

RESULTS

Morphology

Morphological characteristics are summarized by taxonomic units in Table 1. Measurements were not made on "X" big sagebrush, as it was not recognized as a separate taxon until late in the study.

Leaf length and width were of little value as distinguishing characters when used alone, but length-width ratios proved useful in making taxonomic separations. Overlap of ratio values occurred most often between Wyoming and subalpine big sagebrush, but in this case actual leaf size differences provided separation. Leaf color, depth of lobes, and leaf shape (curved versus straight margins) also provided useful characteristics for separating these taxa.



A. flowers/head
B. flower head diameter
C. flower stalk length
D. leaf length-width ratio
E. flowering heads/stalk
F. vegetative stalk length
G. leaf length
H. leaf width

subspecies *wyomingensis* . . . .
subspecies *tridentata* - - - -
subspecies *vaseyana* ——
subspecies *vaseyana* form *spiciformis* ^^

Fig. 1. Polygonal graph comparing morphological features of three subspecies and one form of *Artemisia tridentata.*

Lengths of flowering and vegetative shoots were highly variable, both within and between intraspecific units, but the ratio of length of vegetative shoots to that of flower stalks proved to have taxonomic value. This ratio was consistently lower in Wyoming and basin big sagebrush than in mountain and subalpine big sagebrush.

Location of flower stalks in relation to vegetative shoots also showed taxonomic value. Wyoming and basin big sagebrush produced flower stalks which arose throughout the crown portion of the plant. In mountain and subalpine big sagebrush the flower stalks arose only in the upper crown portions and extended above the foliage. The combination of location of the two types of shoots and the relative length of each produced distinct growth forms. Wyoming and basin big sagebrush were uneven-topped, while mountain and subalpine big sagebrush were relatively even-topped shrubs. This difference was conspicuous in the field.

Number of flowers per head, flower head diameter and average seed weight showed only limited value in separating most of the subspecies, but were useful for distinguishing subalpine big sagebrush from the others. Number of flower heads based on equal lengths of stalk proved particularly helpful in this regard.

A polygonal diagram constructed from morphological characteristics of the four taxa listed above is shown in Fig. 1. Mean values for measurements recorded in Table 1 were scaled along the eight axes. The results show rather distinct patterns for each taxon. Noticeable overlap was attributed to the relatively great length of flower stalks in mountain and subalpine big sagebrush and the low number of flower heads per stalk in the latter.

Phenology

Marked differences in dates and rates of phenological development were recorded among the four major taxa. (See Fig. 2.) Mountain big sagebrush began growth approximately 2 weeks later and ripened seed at least 2 weeks earlier than Wyoming and basin big sagebrush. Studies by Marchand et al. (1966), and observations on sagebrush taxa transplanted into the Moscow, Idaho area, have demonstrated the genetic nature of these differences. Subalpine big sagebrush began growth later and developed seed earlier than any of the other taxa. Its phenology obviously is adapted to the higher elevational areas in which it is found. Mountain big sagebrush showed a similar but less marked pattern. No consistent phenological differences were found between basin and Wyoming big sagebrush.

Although "X" big sagebrush was found at elevations where basin and Wyoming sagebrush usually occurred, its flowering period averaged 2 weeks earlier than that of these two subspecies, and was closer to that of mountain big sagebrush.

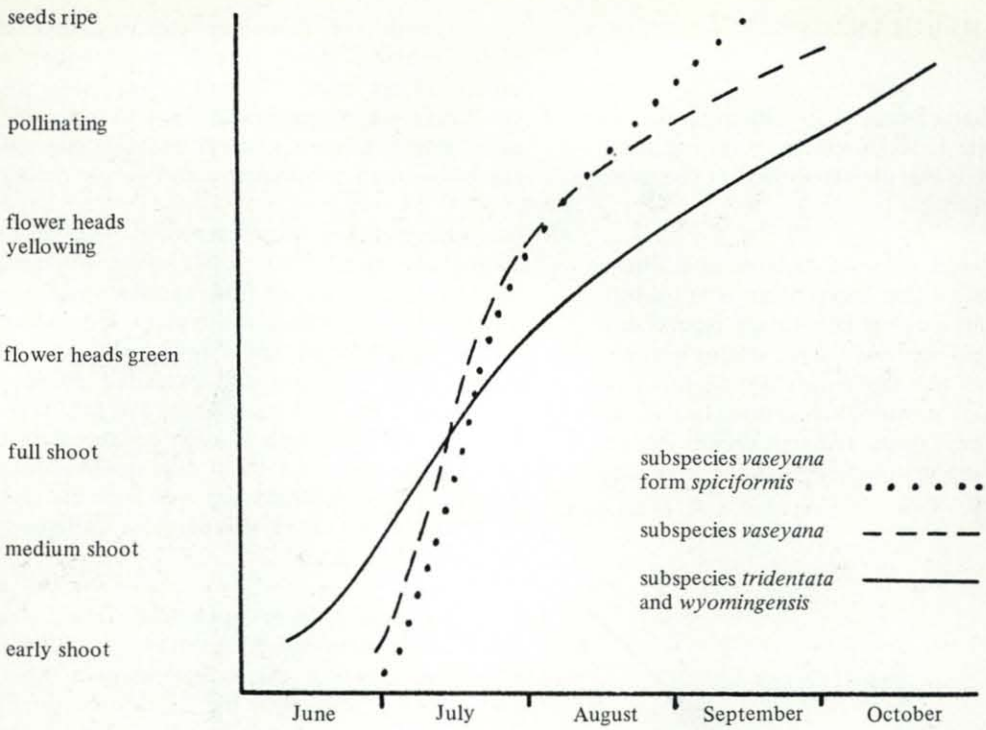


Fig. 2. Diagram of phenological development in three subspecies and one form of *Artemisia tridentata.*

Chromatography

Chromatographic patterns coincided with morphological characteristics to substantiate the presence of five taxonomic units of big sagebrush in Idaho (Fig. 3). Chlorophyll-a consistently moved farther than other compounds, and so provided a standard for location of all separated compounds. No attempt was made to identify the other compounds involved.

A relatively close relationship of basin and Wyoming big sagebrush was suggested by the chromatographic patterns, as was the grouping of the other three taxa. The presence of spot No. 5 in the pattern of "X" big sagebrush was the most noticeable sign of a relationship between this taxon and the two subspecies found at lower elevations.

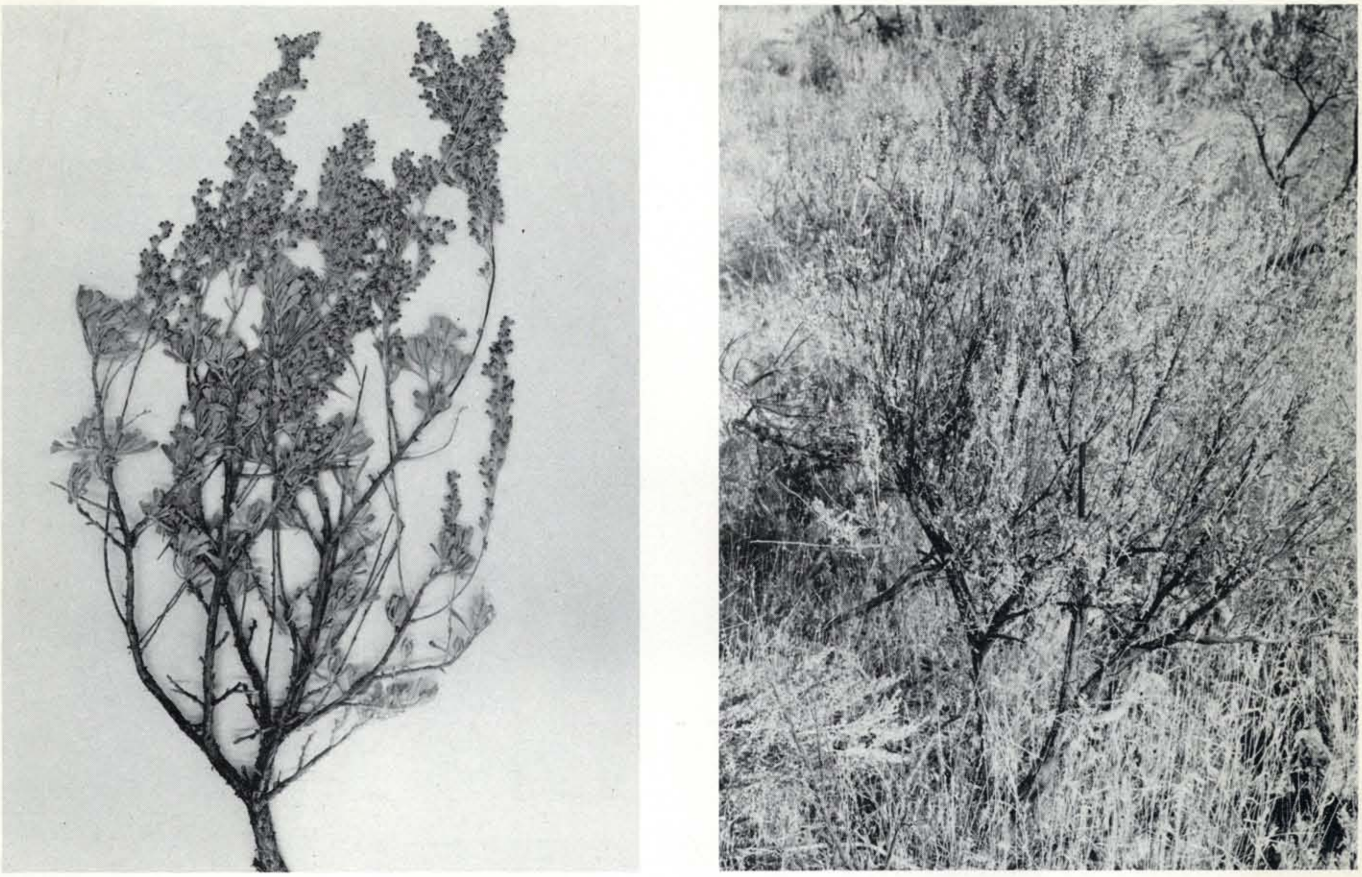
Cytology

Chromosome numbers determined in this study and those obtained by reclassifying Ward's (1953) material are shown in Table 2. Wyoming big sagebrush was found to be tetraploid (2n=36) in all cases. This is the first reported chromosome count for this subspecies. Basin big sagebrush material was both diploid and tetraploid. This is contrary to the finding of Taylor et al. (1964), in which this subspecies was found to be tetraploid only. No morphological distinctions were found between diploid and tetraploid plants of basin big sagebrush, and chromatograms of all diploid and tetraploid samples showed identical patterns.

Mountain big sagebrush was found to be consistently diploid (2n=18), as reported by Taylor et al. (1964). Material of the higher elevational form, subalpine big sagebrush, was both diploid and tetraploid.

Chromosome numbers were determined for only two samples of "X" big sagebrush. Both were diploid (2n=18), but more samples are needed to verify this finding. The apparent diploid status of this form, along with its phenological and chromatographic characteristics, suggests a close relationship to mountain big sagebrush.

Specimens of big sagebrush with recurved inflorescences were found, especially in the lower elevations of the species range. The inflorescence branches in these plants began to curve downward in the late flower or early seed stages of development and were quite noticeable in the field. This apparently is a genetically controlled characteristic found in isolated individuals. Some previous classifications assigned specific or subspecific ranking to such specimens. Beetle (1960) grouped them in the form *parishii* of subspecies *tridentata*. We found this characteristic, usually associated with relatively long slender branches and leaves, in both basin and Wyoming big sagebrush. Two of Ward's three samples of this nature proved to belong to basin big sagebrush (both tetraploid), and one to Wyoming big sagebrush (chromosome number not determined). Samples checked by the authors for chromosome number included one with a recurved inflorescence.



(a) herbarium sample (b) full shrub

Fig. 10. *Artemisia tridentata* ("X" big sagebrush).

Artemisia tridentata ("X" big sagebrush)

Chromatographically, cytologically and phenologically, this variant is closely allied to mountain big sagebrush. It is found in a zone of moderate precipitation, 400-500 mm (16-18 inches) annually, where summer temperatures are higher than those occurring at similar elevations in other parts of the state. It has an uneven-topped growth form, which resembles that of basin big sagebrush (Fig. 10). It is best distinguished from basin big sagebrush by its shorter and relatively broader leaves, earlier phenology and creamish-blue fluorescence when placed in alcohol.

In Idaho, this form has been found only in the west-central portion of the state, where it occurs at elevations from 760 to 1370 m (2500 to 4500 ft) above sea level, and merges gradually into mountain big sagebrush. Limited cytological sampling indicates it to be diploid (2n=18). It shows only moderate increases in density and cover when associated herbaceous vegetation is disturbed.

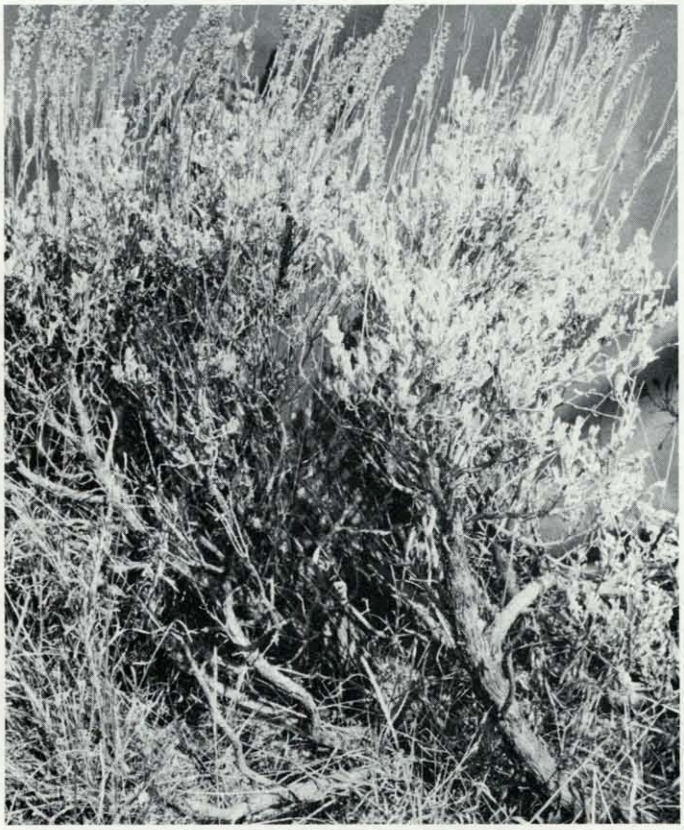
Separation in the field of "X" big sagebrush from mountain big sagebrush is not easy in areas where the two taxa meet. All big sagebrush material collected below 1370 m (4500 ft) elevation in Idaho and fluorescing creamish-blue in alcohol has been found to belong to the "X" form. This elevational limit may be different in other portions of the sagebrush region.

Artemisia tridentata subspecies *vaseyana* form *spiciformis*
(Osterhout) Beetle (subalpine big sagebrush)

This taxon is distinguished by its large flower heads and leaves (Fig. 9). It has a smaller number of flower heads per length of flower stalk and the inflorescence is closer to a spicate/raceme than to the panicle characteristic of other members of the big sagebrush group. There are commonly more than 6 flowers per head, and the stems frequently layer. Both diploid (2n=18) and tetraploid (2n=36) plants occur. It is similar to mountain big sagebrush in having a flat-topped growth form and in fluorescing creamish-blue in alcohol.

Subalpine big sagebrush, as its name implies, is definitely a high altitude form, and rarely occurs below 2140 m (7000 ft) above sea level. Even at high elevations it tends to be restricted to more mesic sites, while drier habitats at the same elevation are occupied by mountain big sagebrush. Like the latter, subalpine big sagebrush tends to increase in both density and foliage cover when the associated herbaceous vegetation is depleted.

(a) herbarium sample



(b) full shrub

Fig. 9. *Artemisia tridentata* subspecies *vaseyana* form *spiciformis*.

Artemisia tridentata subspecies *vaseyana* (Rydberg) Beetle
(mountain big sagebrush)

Mountain big sagebrush is distinguished from the other two subspecies by its characteristic flat topped appearance and early seed maturity. Flower stalks arise only at the upper crown portion of the plant and extend above the foliage (Fig. 8). Leaves tend to be wider in relation to their length than those of basin big sagebrush, and are usually widest just below the leaf lobes. Vegetative shoots in the upper crown are less than half as long as the nearest flower stalks. Fluorescence in alcohol is creamish-blue, and the taxon is consistently diploid (2n=18). This subspecies is found throughout the upper foothill and mountain areas of the state, at elevations ranging from 1370 to 2740 m (4500 to 9000 ft) above sea level. It shows a strong tendency to increase in plant density and foliage cover in stands where the herbaceous vegetation has been disturbed.

(a) herbarium sample

(b) full shrub

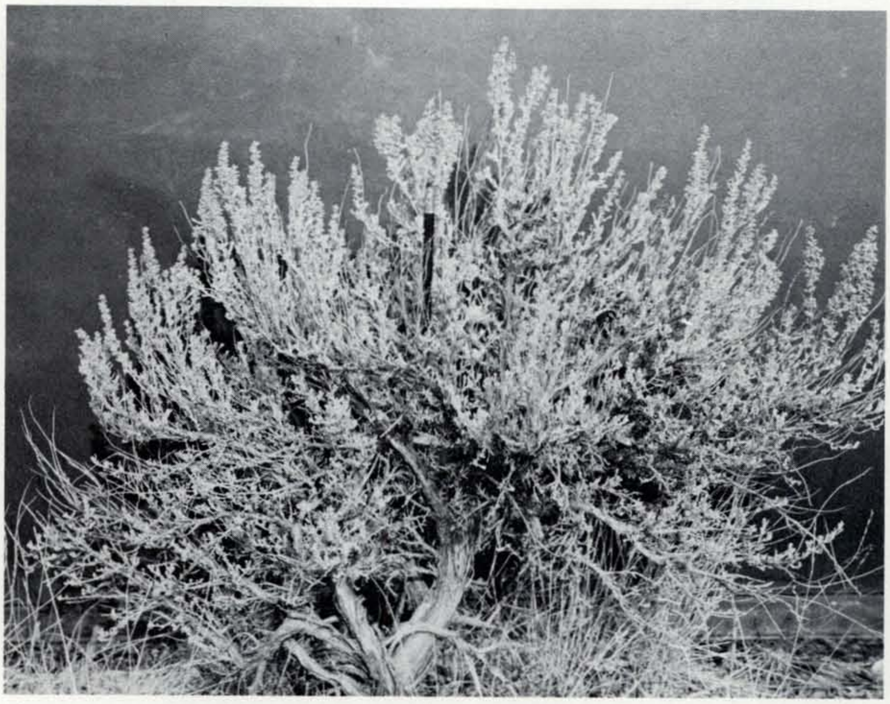
Fig. 8. *Artemisia tridentata* subspecies *vaseyana*.

Artemisia tridentata subspecies *wyomingensis* Beetle
(Wyoming big sagebrush)

Wyoming big sagebrush is a relatively low-growing subspecies, 45-100 cm (18-40 inches) in height (Fig. 7). Flower stalks arise throughout the crown of the plant, providing a rounded, irregular top. Its leaves are relatively short and wide and more deeply lobed than those of other big sagebrush taxa. The leaf margins curve outward from the base, forming bell-shaped leaves. The main stem is often separated into 2 to 3 twisted portions at ground level.

Wyoming big sagebrush fluoresces brownish-red in alcohol and is consistently tetraploid (2n=36). It grows in relatively shallow soils in the hotter and drier portions of the sagebrush region, and is common on the lower slopes of major drainages. In Idaho it is found at elevations from 700 to 1980 m (2500 to 6500 ft) above sea level. This subspecies shows only a moderate tendency to increase in density with disturbance of the associated vegetation. It tends to produce more lateral roots in the upper soil horizons than other big sagebrush taxa. Consequently, it may compete more with associated herbaceous species than do other taxa in the big sagebrush group.

(a) herbarium sample



(b) full shrub

Fig. 7. *Artemisia tridentata* subspecies *wyomingensis.*

(a) herbarium sample (b) full shrub

Fig. 6. *Artemisia tridentata* subspecies *tridentata.*

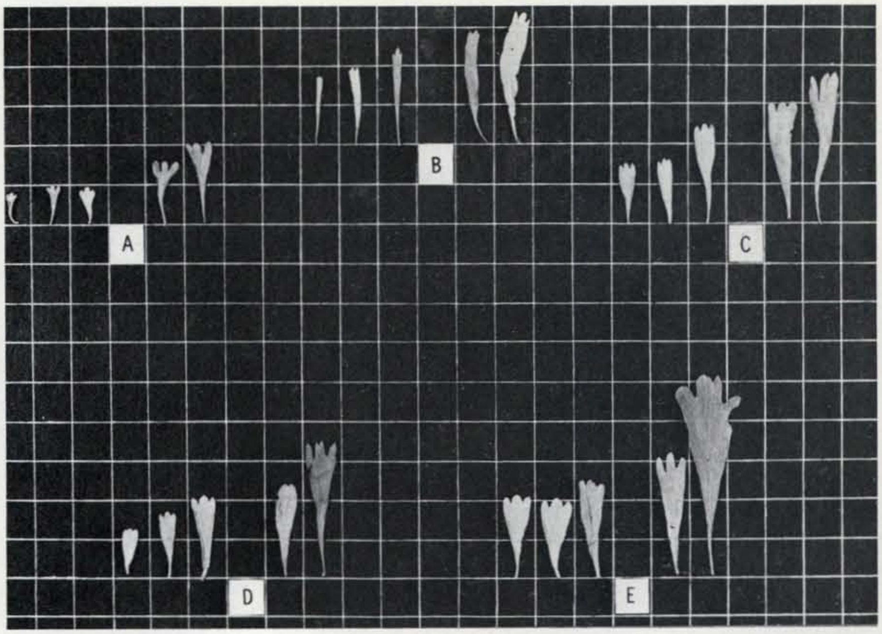
Artemisia tridentata subspecies *tridentata* Nuttall

(basin big sagebrush)

This subspecies represents the tallest form of big sagebrush (Fig. 6). Mature plants are commonly 120-180 cm (4-6 ft) in height, and individuals may reach 240 cm or more. Flower stalks arise throughout the crown of the plant, providing a rounded, irregular top. Vegetative shoots originating in the upper crown portion of the plant are more than half the length of immediately adjacent flower stalks. The leaves are relatively long and narrow and the persistent leaves are shallow-lobed. Leaf margins are straight, providing a narrow wedge-shaped leaf which is widest at the lobe tips. The main stem normally remains trunk-like.

Basin big sagebrush fluoresces brownish-red in alcohol and has both diploid (2n=18) and tetraploid (2n=36) plants. We were not able to separate plants of the two ploidy levels by chromatographic patterns, morphological characteristics or ecological distribution. This subspecies grows in deep, well drained soils of valley bottoms and lower foothill regions. In Idaho its range is from 700 to 2140 m (2500 to 7000 ft) above sea level. It shows only moderate increases in density with disturbance of the associated vegetation, but may increase greatly in foliage cover due to enlargement of crowns. Much of the area once dominated by this subspecies is presently under cultivation.

A subspecies *wyomingensis*
B subspecies *tridentata*
C subspecies *vaseyana*
D "X"
E form *spiciformis*



Note: The three leaves on the left of each group are persistent, and the two in the right of each group are ephemeral. The background is lined into 0.5 cm squares.

Fig. 4. Shapes and sizes of representative leaves of five big sagebrush taxa.

even topped shrubs (flower stalks from upper crown area only)

uneven topped shrubs (flower stalks throughout crown)

leaf margins curved outward (bell shape)

leaf margins straight (wedge shape)

leaves widest at lobe tips

leaves widest just below lobes

Fig. 5. Diagramatic sketch of important morphological characteristics used in the taxonomic key of *Artemisia tridentata.*

Table 2. Summary of chromosome numbers determined for subspecies and forms of *Artemisia tridentata.*

TAXA	*wyomingensis*		*tridentata*		*vaseyana*		*spiciformis*		"*X*"	
	2n=18	2n=36	2n=18	2n=36	2n=18	2n=36	2n=18	2n=36	2n=18	2n=36
Number of observations (Ward 1953)	0	9	4	5	17	0	1	2	–	–
Number of our observations	0	4	2	1	4	0	2	2	2	0
TOTAL	0	13	6	6	21	0	3	4	2	0

This proved to be Wyoming big sagebrush and was tetraploid. Taxonomic rank on the basis of a recurved inflorescence does not seem justified. Discovery of this character in two subspecies obviates the form ranking assigned by Beetle (1960).

Big sagebrush plants intermediate in morphology were found in areas where boundaries of two taxa met. These intermediates presumably represented hybrids and/or environmental modifications, and periodically presented taxonomic problems. These problems were minimized by concentrating on characteristics of populations and not on individuals of intermediate form.

TAXONOMIC KEY AND DESCRIPTIONS

Three important features of the big sagebrush group must be recognized for identification purposes:

1. Leaves from the flowering branches are not always reliable for taxonomic separation.
2. Leaves of the vegetative shoots are of two types, ephemeral or persistent. Ephemeral leaves are larger and often irregularly lobed. They are among the earliest to develop, and are shed as the season advances. Persistent leaves are typically 3-lobed, and over-winter on all big sagebrush taxa. Differences between ephemeral and persistent leaves, and leaf variation among taxa of big sagebrush are shown in Fig. 4.
3. Leaf and growth form characteristics are most easily distinguished after plants have flowered.

The following key is designed for separations based on persistent leaves only. Additional characteristics are provided under the individual plant descriptions. Illustrations of some characters used in the key are presented in Fig. 5.

Artemisia Tridentata Key

1 Uneven topped shrubs, flower stalks arising throughout the crown

2 Mature plants usually more than 100 cm (40 inches) in height, leaf margins straight

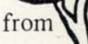
3 Leaves relatively long-narrow, L/W ratio 4.0 or greater, fluoresces reddish brown in alcohol (See Winward and Tisdale 1969.)

A. tridentata subspecies *tridentata*

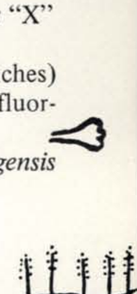
3 Leaves relatively long-broad, L/W ratio less than 4.0, fluoresces bluish-cream in alcohol

A. tridentata "X"

2 Mature plants less than 100 cm (40 inches) in height, leaf margins curved outward, fluoresces reddish brown in alcohol



A. tridentata subspecies *wyomingensis*



1 Even-topped shrubs, flower stalks arising from upper crown and extending above foliage

4 Flower heads less than 1.5 mm wide, 4-6 flowers per head, plants not layered, fluoresces bluish-cream in alcohol

A. tridentata subspecies *vaseyana*

4 Flower heads more than 1.5 mm wide, more than 6 flowers per head, plants often layered, fluoresces bluish-cream in alcohol

A. tridentata subspecies *vaseyana* form *spiciformis*

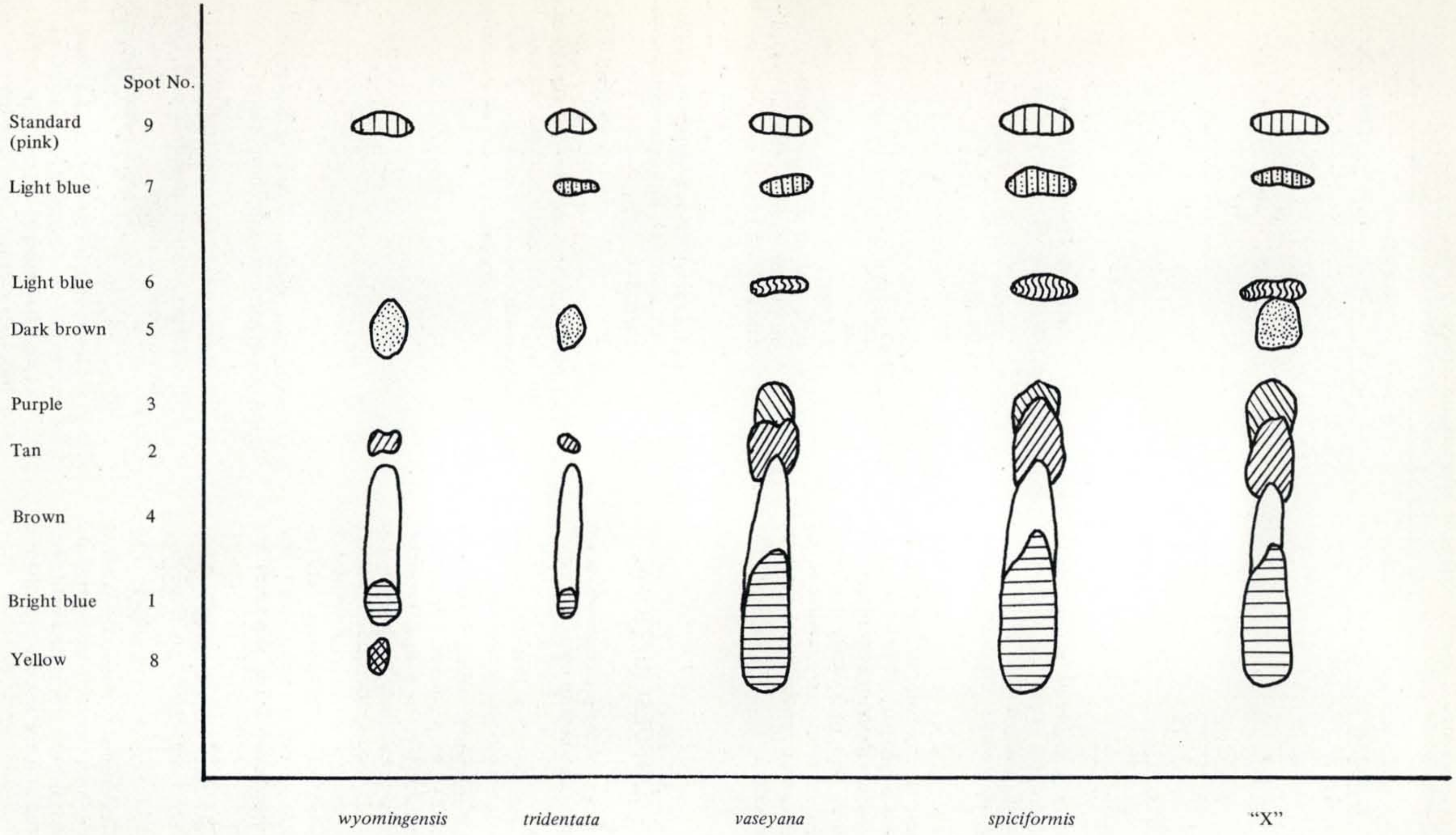


Fig. 3. Variation in patterns of methanol soluable extracts in five big sagebrush taxa.

DISCUSSION

The *A. tridentata* complex is a difficult one to resolve taxonomically, and the subdivisions described in this paper are not necessarily the only ones which may be found in Idaho. They are, however, taxa which can be recognized in the field by their morphology, and show important ecological, phenological, cytological and chemical differences.

Our treatment of this group is generally consistent with that of other investigators. It differs from Beetle's views mainly in the ecological status of Wyoming big sagebrush. We found this subspecies confined to the drier portions of the sagebrush region of the state, characterized by low precipitation and relatively shallow soils. Beetle and Young (1965) described *A. wyomingensis* as intermediate in ecology and distribution between *A. vaseyana* and *A. tridentata.*

Hanks et al. (1973) described seven subdivisions of *A. tridentata*, based largely on chromatographic separations and phenology, but these are not established as taxonomic entities beyond their grouping under the three subspecies recognized in the present study. Much ecotypic variation is likely to occur in a species as widely distributed as *A. tridentata*, but unless these races can be shown to be morphologically distinct they cannot be assigned taxonomic status.

Despite the reluctance of some land managers, it appears highly desirable to recognize subspecific units of *A. tridentata*. Morphological differences permit separation of these taxa in the field. Although the critical differences may appear unclear at times on an individual plant basis, due to environmental modification or sporadic crossing, identification of populations is always feasible. Reasons for recognizing these subspecific units follow:

1. The *A. tridentata* subunits described have evolved in response to different environmental pressures in various parts of the sagebrush region in Idaho. For this reason, they possess high indicator value in the areas where they occur. A much more valuable classification of sagebrush-grass vegetation can be made by recognizing the particular taxon of big sagebrush present rather than lumping all under the heading of *A. tridentata.* Dominance or even the presence of one of these subspecific taxa of big sagebrush can provide information regarding climate, soil and other site factors. In the case of depleted range vegetation, much can be learned about the potential composition and productivity of a site from the kind of big sagebrush that it supports.

2. Differences in growth habits and reproduction among the big sagebrush taxa are evident in their reaction to disturbance of associated species. Slight to moderate density increases were found in basin and Wyoming big sagebrush when the associated herbaceous vegetation was depleted, although total foliage cover usually increased due to greater crown size of individual sagebrush plants (Tisdale et al. 1969). On the other hand, subalpine and especially mountain big sagebrush increased sharply in both density and crown cover when associated vegetation was reduced (Winward 1970). Under such conditions, these two taxa were found to form stands three to five times more dense than those of the other big sagebrush taxa. Subalpine big sagebrush is aided in this respect by its ability to propagate by layering of basal branches as well as by seed. Since sagebrush cover is a major criterion for determining range condition, it follows that correct identification of the kind of big sagebrush present is highly important.

3. Differences in preference among subspecific units of big sagebrush by both domestic livestock and wildlife have been observed (Winward 1970, Hanks et al. 1971 and 1973, Brunner 1972, and Sheehy 1975). This is a factor to be considered for management of big sagebrush ranges. Grazing systems, schemes for sagebrush control, and reseeding on big game ranges are some of the practices in which relative animal preference values of subunits of big sagebrush are an important consideration.

4. Differences in phenology of 2 to 5 weeks exist among the various taxa, with mountain big sagebrush and its close relatives flowering and producing seed earlier than basin and Wyoming big sagebrush. Since effectiveness of herbicide treatment depends largely on the stage of development in sagebrush, it is vital to know which subdivision of the species is being treated, especially if stands of two different taxa occur in close proximity. Differences in degree of susceptibility to herbicides may also occur among the various taxa. Differences in growth development rate may be important for other management measures also, but to date the herbicide situation is the best known.

Distribution

Distribution of the subdivisions of big sagebrush in Idaho is shown in Fig. 11, a considerable revision of the distributional picture presented by Beetle (1960). Wyoming big sagebrush, unrecognized at the time of Beetle's publication, is shown as the predominant form over large areas, extending into the valleys as far north as Salmon. Basin big sagebrush occupies a proportionally smaller area than shown by Beetle. The other important difference is made in reference to *A. vaseyana* and related taxa. Mountain big sagebrush itself occurs over a much larger area than shown by Beetle, while subalpine and "X" big sagebrush occupy distinctive areas.

The areas outlined in Fig. 11 are those in which the various taxa occur in noticeable amounts, but are not necessarily dominant throughout the entire area indicated for each. The large area shown for Wyoming big sagebrush contains numerous patches of basin big sagebrush too small to depict on this map. The latter subspecies occurs throughout this dry area, on sites favored by pockets of deep, moisture-holding soils or by run-off from adjacent slopes. The actual extent of these stands of basin big sagebrush is difficult to estimate, but it is probably less than five percent of the total area shown for Wyoming big sagebrush. Similarly, mountain and subalpine big sagebrush occur in numerous openings in the coniferous forest, but these patches constitute less than half the total area shown for these two taxa.

Big sagebrush "X" occupies a distinctive position along the western border of the state and has not been found elsewhere in Idaho. It occurs in eastern Oregon also, but may be restricted to an area within 40 to 50 miles of the Idaho border.

Samples of sagebrush collected from higher elevations in the extreme southeastern portion of the state are presently being assigned to *Artemisia rothrockii* (Rothrock sagebrush) by some authors. Recent work has suggested that this material does not belong in *A. rothrockii*, but is instead a hitherto unrecognized variant of *A. tridentata* (Winward 1975). More work is needed to establish the status of this variant.

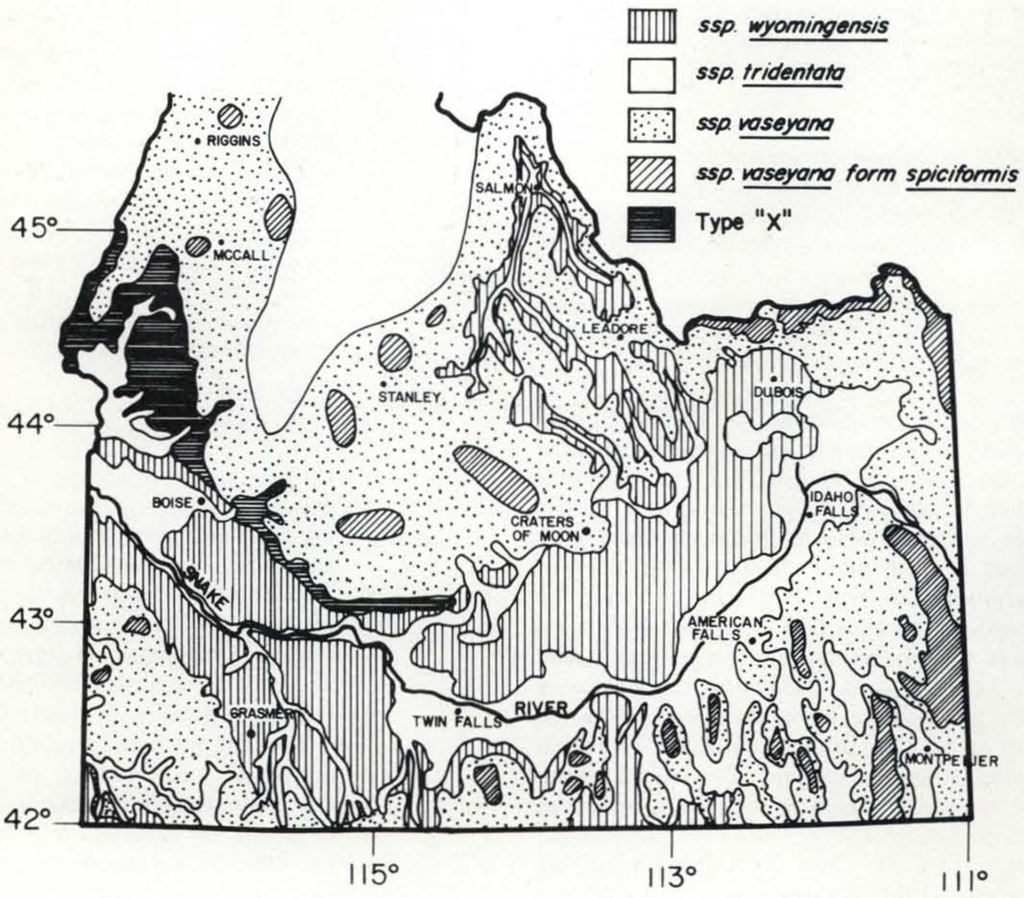


Fig. 11. Outline map showing distribution of five *Artemisia tridentata* taxa in Idaho.

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