Montana Chrysothamnus
by Gail Lynn Winkler

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
During the summers of 1985 and 1986, a study was conducted to determine what Chrysothamnus taxa occur in Montana and to record their respective distributions. Taxa found included C. linifolius. C. nauseosus ssp. nauseosus, C. n. ssp. albicaulis. C. n. ssp. graveolens. C. n. ssp. consimilis. C. viscidiflorus ssp. lanceolatus. C. v. ssp. viscidiflorus var. stenophyllus. C. v. ssp. viscidiflorus var. viscidiflorus, and the previously uncharacterized, C. parryi ssp. glandulosus. The morphology, habitat, and relationships of these taxa were discussed and their distributions described.

In 1985, a previously uncharacterized taxon of C. parryi was located in southwestern Montana. C. p. ssp. glandulosus derived its name from conspicuous stalked glands. Two varieties of this taxon were observed at 2 of 7 study sites. The typical form is named C. ssp. glandulosus var. glandulosus. The other variety is covered with tomentum, which obscures the stalked glands and is named C. ssp. glandulosus var. tomentosus.

Additional populations were located during the summer of 1986 and sites were sampled to characterize the taxon's habitat. All 7 sites sampled were found to have near-neutral, sandy loam to loam soils, and supported Artemisia tridentata/grassland communities. Aspects, slopes, elevations, and annual precipitation amounts varied among sites. An adjacent paired plot, lacking the taxon, was sampled at each site in an attempt to ascertain what factor(s) account for this taxon's occurrence. Disturbance and soil type were the only factors found that likely influence the occurrence and distribution of C. p. ssp. glandulosus. Evidence indicated this taxon is severely browsed yearly, which may be a factor limiting the expansion of this taxon.

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Master of Science

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MONTANA STATE UNIVERSITY
Bozeman, Montana

November 1987

APPROVAL

of a thesis submitted by

Gail Lynn Winkler

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date November 24, 1987

ACKNOWLEDGEMENTS

I would like to thank the efforts, time, and encouragement of several people that assisted me in this endeavor. Thanks are offered to E. D. McArthur at the USFS Shrub Science Lab in Provo, Utah for chromosome counts on C. parryi ssp. glandulosus. I extend special appreciation to all the persons around the State that took time to collect specimens of Chrysothamnus. These collections contributed significantly to this project. I'd like to thank Shelly Doyle and Rob Bray for all their help with collecting and sampling. To Carl Wambolt, my academic advisor, thank you for the many hours of work, the patience, and the encouraging words. To committee members, Jack Rumely and Jack Taylor, thanks for your guidance and suggestions. Your kind words and stories always meant so much. You both have greatly increased my understanding of the English language. Jack, the illustration of C. parryi ssp. glandulosus is beautiful! Thanks so much! Special thanks go to my parents. Your love, encouragement, and belief in me support me every day. Lastly, warm thanks to my best friend, Steve. Friends such as you are one in a million!

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ABSTRACT

During the summers of 1985 and 1986, a study was conducted to determine what Chrysothamnus taxa occur in Montana and to record their respective distributions. Taxa found included C. linifolius, C. nauseosus ssp. nauseosus, C. n. ssp. albicaulis, C. n. ssp. graveolens, C. n. ssp. consimilis, C. viscidiflorus ssp. lanceolatus, C. v. ssp. viscidiflorus var. stenophyllus, C. v. ssp. viscidiflorus var. viscidiflorus, and the previously uncharacterized, C. parryi ssp. glandulosus. The morphology, habitat, and relationships of these taxa were discussed and their distributions described.

In 1985, a previously uncharacterized taxon of C. parryi was located in southwestern Montana. C. p. ssp. glandulosus derived its name from conspicuous stalked glands. Two varieties of this taxon were observed at 2 of 7 study sites. The typical form is named C. p. ssp. glandulosus var. glandulosus. The other variety is covered with tomentum, which obscures the stalked glands and is named C. p. ssp. glandulosus var. tomentosus.

Additional populations were located during the summer of 1986 and sites were sampled to characterize the taxon's habitat. All 7 sites sampled were found to have near-neutral, sandy loam to loam soils, and supported Artemisia tridentata/grassland communities. Aspects, slopes, elevations, and annual precipitation amounts varied among sites. An adjacent paired plot, lacking the taxon, was sampled at each site in an attempt to ascertain what factor(s) account for this taxon's occurrence. Disturbance and soil type were the only factors found that likely influence the occurrence and distribution of C. p. ssp. glandulosus. Evidence indicated this taxon is severely browsed yearly, which may be a factor limiting the expansion of this taxon.

INTRODUCTION

The genus Chrysothamnus (rabbitbrush) is widely distributed across the western United States, from the Great Plains to the Pacific Coast. It is endemic to North America and occupies a variety of habitats from sea level to 3300 m (10,900 ft) (McArthur et al. 1979). This great geographical distribution is reflected in numerous diverse taxa.

Hall and Clements (1923) organized Chrysothamnus into 4 Sections, 12 species, and 40 subspecies. Since then L. C. Anderson has contributed considerable knowledge of Chrysothamnus and recently recognized 5 Sections, 16 species, and 41 subspecies (Anderson 1986a). Until the present the ecological importance of taxonomic diversity within Chrysothamnus in Montana has gone essentially unrecognized. Generally, natural resource managers have recognized only 2 taxa, C. viscidiflorus and C. nauseosus.

As a forage source, usefulness is not thoroughly documented in Montana. Traditionally Chrysothamnus taxa have been considered undesirable plants, thought to be relatively unpalatable and occupants of lands that could otherwise support more desirable forage. However, a Montana study (Eustace 1971) and a variety of reports from elsewhere (Cook and Harris 1950, Cook et al. 1954, Sampson and Jesperson 1963, Kufeld et al. 1973, McArthur et al. 1974, Hanks et al. 1975, McArthur et al. 1979) refute this popular concept.

Considerable knowledge of Chrysothamnus taxonomy, management, and uses has been gained recently in other western states. This information suggests that some Chrysothamnus taxa have many uses (Weber et al. 1985).

The lack of information regarding the diversity and value of Chrysothamnus in Montana and the knowledge gained on the importance of Chrysothamnus in the west inspired the original objective of this study. This was to determine the taxa of Chrysothamnus in Montana and their respective distributions. During the course of field work, a previously undescribed taxon was located. Thus, a second objective became to characterize this taxon, now known as C. parryi ssp. glandulosus.

LITERATURE REVIEW

Phylogeny and Classification of Chrysothamnus

The genus Chrysothamnus is a member of one of the largest and most advanced of the flowering plant families, the Asteraceae (=Compositae). Chrysothamnus, named for its relationship to Chrysocoma and its brilliant golden-yellow flower, was established by Nuttall in 1840. C. pumilus is the type species (Hall and Clements 1923). Hall and Clements (1923) described the history of the generic designation.

Chrysothamnus, meaning "goldenwood" or "goldenbush", belongs to the Astereae, the Aster tribe. This tribe was most likely derived from a Helianthoid or proto-Helianthoid ancestor (Cronquist 1955). The Helianthoid characters considered to be relatively primitive, present in some Astereae, include shrubby or suffrutescent habit, large heads, yellow corollas, and a paleaceous pappus (Cronquist 1955). Chrysothamnus is related to Section (Sec.) Macronema or Ericameria of Haplopappus and more distantly to Solidago (Anderson 1964). The numerous species and subspecies of the genus Chrysothamnus are grouped into several sections (Table 1).

Anderson and Fisher (1970) developed a specialization index (0-10), based on floral anatomy, to delineate specialization of the various taxa in Chrysothamnus. Taxa in the Sec. Nauseosi are the least specialized. C. parryi (Gray) Greene subspecies range from 1.2 to 8.3 and C. nauseosus (Pallas) Britt. subspecies from 2.3 to 6.7. C. parryi ssp. parryi was determined to be the most primitive taxon in the genus.

Cronquist (1955), reviewing phylogeny in Compositae, suggested that a feature such as few heads, each with many flowers, is primitive. This character is expressed by *C. parryi*. Subspecies of *C. parryi* and a few subspecies of *C. nauseosus* consistently have more ovarian vascular bundles than other *Chrysothamnus* taxa (Anderson 1970), indicating less specialization than other *Chrysothamnus* taxa (Anderson 1970).

Table 1. Sections, species, and numbers of subspecies of *Chrysothamnii*[a].

Section	Species	Number of subspecies
Chrysothamnus	*C. albidus* (Jones ex Gray) Greene.	
	C. humilis Greene.	
	C. linifolius Greene.	
	C. spathulatus L. C. Anderson.	
	C. greenei (Gray) Greene.	
	C. viscidiflorus (Hook.) Nutt.	5
Gramini	*C. gramineus* Hall.	
	C. eremobius L.C. Anderson.	
Nauseosi	*C. parryi* (Gray) Greene.	12
	C. nauseosus (Pallas) Britt.	22
Pulchelli	*C. vaseyi* (Gray) Greene.	
	C. molestus (Blake) L.C. Anderson.	
	C. depressus Nutt.	
	C. pulchellus (Gray) Greene.	2
Punctati	*C. paniculatus* (Gray) Hall.	
	C. teretifolius (Dur. & Hilg.) Hall & Clem.	

[a]Anderson 1986a

Karyotypes and breeding structure further indicate that *C. parryi* is one of the most primitive species of the genus (Anderson 1966). *C. p.* ssp. *parryi* has the longest chromosomes in the genus, the greatest homogeneity in chromosome length, and has chromosomes with essentially median centromeres (Anderson 1969). According to Huziwara (1962) these are primitive characters.

Hall & Clements (1923) theorized that most C. viscidiflorus subspecies and other taxa in Sec. Typici (renamed Sec. Chrysothamnus; Anderson 1986a) were the least evolutionarily advanced. Anderson (1966) presently proposes that this Section contains the most advanced taxa. In the C. viscidiflorus (Hook.) Nutt. complex (Sec. Chrysothamnus), specialization increases from C. v. ssp. viscidiflorus to C. v. ssp. lanceolatus (Nutt.) Hall & Clem. to C. v. ssp. puberulus (D. C. Eat.) Hall & Clem. (Anderson 1986b). C. v. ssp. puberulus was probably derived phylogenetically from C. v. ssp. lanceolatus (Anderson 1986b). C. paniculatus (Gray) Hall, with its specialized karyotype and narrow ecological requirements, is considered to be the most advanced species in the Chrysothamnii.

Morphology

All the taxa of Chrysothamnus are shrubs or suffrutescent shrubs. There are several trunks, coming from a single base, which are covered with loose, fibrous, brown bark which peels off in strips. The leaves are always alternately arranged and the margins are entire. The leaf blades are typically flat; however, terete leaves occur in 1 species, C. teretifolius (Dur. & Hilg.) Hall & Clem. The number of veins depends largely upon the width of leaf (Hall and Clements 1923).

Floral heads of Chrysothamnus are arranged in racemes, spikes, panicles, and cymes. This later type is the most common in the genus overall. The racemose type is characteristic of C. parryi. Involucre characteristics, such as whether the phyllaries are keeled, phyllary arrangement, and phyllary tip shapes, can be helpful in identifying taxa.

The heads of Chrysothamnus are typically discoid. Ray flowers are present in only 2 populations (southern and northern ranges) of C. spathulatus L. C. Anderson. The shape of the corolla is not diagnostic but the total length of corolla and corolla lobes are distinguishing characters (Hall and Clements 1923). The number of flowers per head is almost constantly 5 except in C. parryi and C. pyramidatus Robinson and Greenman, which have a greater number. Different environments and seasonal variations result in variability of floral features of C. viscidiflorus subspecies (Anderson 1964). Samples taken early in the season frequently average more flowers per head than samples obtained from same plant later in the season.

The pappus is nearly uniform in all Chrysothamnus taxa (Hall and Clements 1923). The pappus is important for achene orientation, wind dispersal, and possibly moisture accumulation (Stevens et al. 1986). The ratio between length of style appendage and stigmatic portion is not constant in any 1 species or perhaps even in any 1 subspecies. The overall ratio is higher for some species than for others.

Stamens are diagnostic only in C. albidus (Jones ex Gray) Greene, in which they are obtuse and shorter than in other taxa. In others, the tips are acute (Hall and Clements 1923).

The achene is of 2 forms, either: 1) obscurely 5-angled or terete, 5 nerved, and usually covered with dense pubescence; or 2) nearly terete or slightly flattened, 10 striate, and essentially glabrous (Hall and Clements 1923). The former is the common type; the latter type is found in C. vaseyi (Gray) Greene. and C. gramineus Hall.

Pubescence can be a useful diagnostic characteristic. C. nauseosus, the most complex and wide ranging species in the genus, shows much intraspecific variation with respect to this feature (Hanks et al. 1975). In C. nauseosus, 2 groups, the gray and the green, are distinguished by the presence or absence of vestiture on the involucre and the type of vestiture. This character can vary and should be used in combination with the color of tomentum on the stem. The vestiture on the involucres in the gray group is only an expression of the general tendency toward a greater amount of pubescence in the whole plant than that which occurs in the green group (Hall and Clements 1923).

Anatomy

Anderson (1970) provides a thorough account of the vascular and developmental anatomy of Chrysothamnus and of the histology of Chrysothamnus phyllaries and flowers. Taxa in the Sec. Nauseosi are characterized by presence of secretory canals and usually have trichomes on the corolla tube. Those taxa in Secs. Chrysothamnus and Puchelli lack secretory canals and only a few taxa have trichomes on the corolla tubes. In Sec. Punctati, glandular hairs are common but shorter and more clavate than the glandular hairs of Sec. Nauseosi (Anderson 1970).

The venation in Chrysothamnus flowers is relatively advanced for the Compositae (Anderson 1970). Disk flowers typically have 5 veins in the corolla, 2 in the style, and 1 in each stamen. The pappus in Chrysothamnus does not contain vasculature. Vascular trace patterns in the bracts vary at the species and subspecies levels. C. linifolius Greene, C. nauseosus ssp. albicaulis (Nutt.) Hall & Clem. and C. n. ssp. graveolens (Nutt.) Piper have a 3 trace/bract pattern. C. viscidiflorus ssp. viscidiflorus, C. v. ssp. lanceolatus, and C. v. ssp. puberulus have 3 traces in the outer bracts and 1 in the inner bracts. In most taxa of C. parryi 3 vascular traces enter each bract, but, in C. p. ssp. parryi, C. p. ssp. nevadensis (Gray) Hall & Clem., and C. p. ssp. asper (Greene) Hall & Clem., the larger (outer) bracts frequently have 5 traces/bract. In C. parryi these lateral traces usually extend half the length of the phyllaries.

Embryology

Within a head, floral maturation is synchronized (Anderson 1971). Flowers develop acropetally on the receptacle but often microsporogenesis and megasporogenesis occur simultaneously regardless of differences in individual flower size. The least synchronous species is C. linifolius, in which older flowers often have mature embryo sacs while the youngest flower is still undergoing meiosis in the ovule. Embryo sac development is the Polygonum-type in Chrysothamnus (Anderson 1983) and embryo sac size varies widely.

Typically mature sacs are long and narrow (Anderson 1971). Polyploidy has no significant bearing on embryo sac size.

Embryogeny is the Asterad type (Anderson 1971). Endosperm formation is nuclear at first then wall formation progresses to form a cellular endosperm. Meiosis results in 4 cellular megaspores. The chalazal megaspores usually produce the embryo sac. Chrysothamnus ovules are anatropous, unitegmic, and tenuinucellar. The anthers in Chrysothamnus are tetrasporangiate. In most species of Chrysothamnus, floral primordia differentiate through sequence of corolla, stamens, pappus, and pistil.

Chromosome Relationships

The basic chromosome number of Chrysothamnus is n = 9. This is the modal number in the tribe at both the specific and generic level (Solbrig et al. 1964). Chrysothamnus polyploids are mostly autopolyploids (Anderson 1986b). Polyploidy is restricted to C. viscidiflorus, with 2x and 4x found in C. v. ssp. lanceolatus and C. v. ssp. puberulus and 2x, 3x, 4x, 5x, and 6x occurring in C. v. ssp. viscidiflorus (Anderson 1986b). C. viscidiflorus polyploids are adapted to warmer, usually drier sites than diploids. Autopolyploids commonly have thicker leaves, larger flowers, larger fruits and generally flower and fruit later than diploids (Stebbins 1947). Availability of unexploited environmental resources is the chief external factor favoring the establishment of polyploidy (Stebbins 1950). The frequency of polyploid species of angiosperms appears to increase from south to north and from low to high altitudes (Grant 1971).

Reproductive Habits

Predominantly, *Chrysothamnus* is self-fertilizing, but on occasion the species crossbreed (Anderson 1980b). Autogamy (flower pollinated with own pollen) frequently occurs in every species of *Chrysothamnus* (Anderson 1980b). Chromatographic work by McArthur et al. (1978a) suggests a predominance of self-pollination in *C. viscidiflorus*. Selection pressure for inbreeding probably results from droughty environments which *Chrysothamnus* taxa typically inhabit (Anderson 1973). Self-fertilization encourages the continued genetic separation of sympatric subspecies and the formation of numerous local biotypes in a subspecies (Stebbins 1957). The success of *Chrysothamnus* at producing new forms and invading new environments is attributed to the ability to occasionally outcross (Anderson 1966). Generally within a group, primitive taxa are often outbreeders whereas specialized taxa are inbreeders (Stebbins 1957).

Achene formation in *Chrysothamnus* results from fertilization. Apomixis is not known to occur in *Chrysothamnus* taxa (Anderson 1971). Hybridization in *Chrysothamnus* occurs infrequently (Anderson 1970). All known hybrids in the genus have involved *C. nauseosus* (Anderson 1980c). *C. bolanderi*, an uncertain taxon, has been redefined as an intergeneric hybrid between *Haplopappus macronema* and *C. n.* ssp. *albicaulis* (Anderson and Reveal 1966). Additional types of hybrids are known. For example, interspecific hybrids have been reported (Anderson 1966, Anderson 1983, Anderson 1984) and hybrids from Ash Meadows, Nevada represent the first naturally occurring intersectional hybrids found in the genus (Anderson 1973). The known hybrids studied were found at the geographical or ecological edge of one or both of the parents' ranges (Anderson 1973). Intergradation occurs between some of the subspecies of *C. viscidiflorus* and some subspecies of *C. nauseosus*. *C. v.* ssp. *lanceolatus* intergrades extensively with *C. v.* ssp. *viscidiflorus* (Letter from L. C. Anderson 5/20/86). *C. n.* ssp. *nauseosus* seemingly intergrades only with *C. n.* ssp. *albicaulis*. *C. n.* ssp. *albicaulis* intergrades occasionally with *C. n.* ssp. *consimilis* (Greene) Hall & Clem., *C. n.* ssp. *nauseosus*, and particularly *C. n.* ssp. *hololeucus* (Gray) Hall & Clem. where their ranges overlap (Anderson 1986c). Little or no integration occurs between *C. n.* ssp. *nauseosus* and *C. n.* ssp. *graveolens* even though they are sympatric over about half their respective ranges (Anderson 1986c).

Distribution and Site Characteristics

Chrysothamnus occurs on open plains, valleys, foothills, and mountains from British Columbia and Saskatchewan, south to west Texas and Baja California. It ranges from sea level to 3,300 m (10,900 ft) in elevation (Hall and Clements 1923, McArthur et al. 1974, McArthur and Welch 1986). *Chrysothamnus* is most abundant in the Intermountain Region (McArthur et al. 1979a). Most *Chrysothamnus* taxa have great ecological amplitude; they express the ability to inhabit a wide range of edaphic conditions, latitudes, and elevations (Anderson 1981).

The many subspecies and ecotypes of C. nauseosus (rubber rabbitbrush) inhabit a wide variety of soils and sites. Soils include heavy clays and alkali soils in salty lowlands (Hanks et al. 1975) and sandy, gravelly, and clayey, neutral to acid soils at higher elevations (Hanks et al. 1975, McArthur et al. 1978b, McArthur et al. 1979a). Elevations range from 150 to 2750 m (500-9000 ft) in A. tridentata, Pinus edulis - Juniperus spp., and Pinus ponderosa zones (McArthur et al. 1978b). Some types of C. nauseosus are thought to be subclimax in the A. tridentata climax. Often they result if A. tridentata is disturbed by fire, trampling, or washout (Hall and Goodspeed 1919). C. n. ssp. albicaulis, C. n. ssp. hololeucus, C. n. ssp. nauseosus, C. n. ssp. consimilis, and C. n. ssp. graveolens are more widespread than the other subspecies of C. nauseosus (Weber et al. 1985).

C. n. ssp. albicaulis (white rubber rabbitbrush), a foothill type, occurs at elevations between 610 and 2135 m (2000-7000 ft) (McArthur et al. 1974, Anderson 1986c) from British Columbia and Montana, south to New Mexico, Colorado, Utah, Nevada, and eastern California (McArthur et al. 1979a). In Utah, C. n. ssp. albicaulis is found in Distichlis stricta, A. tridentata, Pinus edulis - Juniperus spp., and Pinus ponderosa communities, 1310 to 2290 m (4300-7500 ft) in elevation (Welsh 1983).

C. n. ssp. graveolens, (green rubber rabbitbrush), occurring in the eastern half of the species range, is found in foothills and valleys, 915 to 1830 m (3000-6000 ft) from North Dakota to Idaho (McArthur et al. 1979a). It is a component of the western foothills of the Black

Hills Pine Forest plant association, defined by Kuchler (1964). This plant association occurs in the Black Hills of South Dakota and Wyoming.

In Utah, C. n. ssp. consimilis (threadleaf rubber rabbitbrush) inhabits saline meadows, riparian zones, and terraces in Distichlis stricta - Sporobolus airoides, Atriplex confertifolia, Artemisia tridentata, Cercocarpus - Quercus, Pinus edulis - Juniper spp., and Pinus ponderosa communities from 1280 to 3000 m (4200-9800 ft) in elevation (Welsh 1983). In Nevada, it occurs on sites receiving as little as 250 mm (10 in) precipitation annually (Rosentreter 1986).

C. viscidiflorus (low rabbitbrush) is one of the most widely distributed shrubs on rangelands throughout western North America. C. viscidiflorus has great ecological amplitude (Anderson 1986b), but is not very salt tolerant (McArthur et al. 1978a). It occupies open, dry plains and mountains on poor soils from British Columbia, Montana, North Dakota, south to New Mexico and eastern California (Hall and Clements 1923). C. viscidiflorus grows at elevations of 790 to 3350 m (2600-11,000 ft) (McArthur et al. 1978a). Other common names of C. viscidiflorus include yellowbrush, yellow rabbitbrush, yellowsage, rabbitsage, sticky-leaved rabbitbrush, Douglas rabbitbrush, and sticky-flowered Irishman.

The subspecies of C. viscidiflorus are split into 2 morphological types, glabrous and pubescent. C. v. ssp. lanceolatus (mountain low rabbitbrush), a pubescent type, ranges between southern British Columbia and northern New Mexico (Anderson 1986b). In the Intermountain Region it occurs at mid and high elevations, from 1525 to

3200 m (5000-10,500 ft) (McArthur et al. 1978a). In Utah, C. v. ssp. lanceolatus inhabits Artemisia tridentata, Pinus ponderosa, Populus tremuloides, Pseudotsuga menzesii, Pinus contorta, Picea - Abies, and alpine meadow communities (Welsh 1983). Another pubescent type, C. v. ssp. puberulus (hairy low rabbitbrush) occurs between Montana and Colorado, east to California, and in British Columbia at low elevations. It is abundant on dry hills and in dry stream ways of western Nevada (Hall and Clements 1923).

A glabrous type, C. v. ssp. viscidiflorus (stickyleaf low rabbitbrush) is 1 of the most widespread taxa in the genus (Anderson 1986b) and is the most common subspecies of C. viscidiflorus. C. v. ssp. viscidiflorus occurs in northern Washington, western Montana, northwestern Nevada, southern California and northern Arizona. It grows at low and high elevations, 244 to 3965 m (800-13,000 ft) on a variety of soil textures and pHs (McArthur et al. 1978a, Anderson 1981). C. v. ssp. viscidiflorus is present in Atriplex confertifolia, Artemisia tridentata, Pinus edulis - Juniperus spp., Cercocarpus-Quercus, Abies concolor, Pinus ponderosa, and Populus tremuloides communities between 1460-2900 m (4800-9500 ft) (Welsh 1983).

C. linifolius (spreading rabbitbrush) is a tall, robust shrub up to 2.4 m in height. C. linifolius was originally described as a subspecies of C. viscidiflorus by Hall and Clements (1923). Anderson (1964) has since established it as a species. Chromatographic data collected by McArthur et al. (1978a) support the species status of C. linifolius. It occurs in Wyoming, Colorado, Montana, New Mexico, Utah, and Nevada. In Utah it is found on stream banks and terraces, irrigation canals, seeps and springs in riparian communities at elevations ranging from 1130 to 2535 m (3700-8300 ft) (Welsh 1983). Anderson (1964) reports that C. linifolius often occurs in sandy soils.

C. greenei (Gray) Greene (green rabbitbrush) resembles C. viscidiflorus ssp. stenophyllus Gray (considered C. v. ssp. viscidiflorus var. stenophyllus; Anderson 1980a) (narrowleaf low rabbitbrush) (McArthur et al. 1979a). It occurs on plains, valleys, and foothills in Colorado, New Mexico, Nevada, and Utah (Hall and Clements 1923). C. vaseyii (Vasey rabbitbrush) grows on plains, hillsides, mountains, and valleys at elevations of 1700 to 2600 m (5570-8525 ft) in Utah, Wyoming, Colorado, New Mexico, and Arizona (McArthur et al. 1979a).

C. parryi (Parry rabbitbrush), a mountain and foothill type, is found from Wyoming to western Nevada, west to California and south to New Mexico and Arizona (McArthur et al. 1979a). C. albidus (alkali rabbitbrush) is the only taxon with white flowers. It is a halophyte and successfully invades alkaline areas. It is most commonly found on the west side of the Great Salt Lake Desert, through Nevada to east central California (McArthur et al. 1979a). C. depressus Nutt. (dwarf rabbitbrush) grows on dry plains, hills, and rocky mountain slopes from 1000 to 2100 m (3300-6900 ft) in western Colorado, New Mexico, Utah, Nevada, and southeastern California (Hall and Clements 1923).

Life History

Chrysothamnus is a relatively short lived shrub (Young and Evans 1974b, Daubenmire 1975). It reproduces primarily by seed. Initial establishment of C. nauseosus by seed is fair to good. Stevens et al. (1986) reported a startling increase of C. n. ssp. albicaulis by natural spread from 10 to 622 plants in 9 years. In a study examining the effect of the pappus on germination and survival, seedling establishment was more successful with uncleaned seed planted upright and half buried than other positions and depths (Stevens et al. 1986). C. n. ssp. albicaulis seedling success was augmented by seed placement and positioning. In the field the pappus acts as a parachute, thereby helping to position the seed (scar down) and acts as an anchor.

Once Chrysothamnus is established, growth is rapid if conditions are favorable (McArthur et al. 1974). When transplanted, Chrysothamnus grows vigorously due to basal sprouting (Hall and Clements 1923). Seedlings as young as 3 months have been found to resprout following extreme drought (McKell and Chilcote 1957). Schlatterer and Tisdale (1969) suggested that C. nauseosus contains fewer inhibitory substances and leachates than other common arid zone species. They suggested that germination and increased growth of Elymus elymoides and Pseudoroegneria spicata (nomenclature according to Barkworth and Dewey 1985) under the influence of Chrysothamnus might be due to growth stimulatory substances in Chrysothamnus.

Flowering time in Chrysothamnus varies with taxon and habitat. C. nauseosus blooms a few to several weeks later than C. viscidiflorus when they occur together (Winward and Anderson 1986). C. humilis Greene is the earliest blooming species of the genus (Anderson 1986a). Plants at high elevations bloom earlier than those at low elevations (McArthur et al. 1979a).

Some Chrysothamnus taxa often colonize disturbed plant communities (McArthur et al. 1978b, McArthur and Welch 1986). Chrysothamnus taxa express the following characteristics that Baker (1965) lists as contributing to the success of colonizing species: facultative self compatibility, high seed production in favorable environmental conditions, seeds equipped for long and short distance dispersal, phenotypic plasticity to climatic and edaphic variation, vigorous vegetative reproduction, and rapid seedling establishment. Self-fertilization is a mechanism insuring continued fertility in plants inhabiting environments of periodic drought (Stebbins 1957). Lowest seral species produce many, very small seeds and have dispersal mechanisms which shower surrounding areas with them (Young et al. 1972). Young and Evans (1974a) estimated that if C. v. ssp. viscidiflorus canopies were shaped in a perfect hemisphere the average plant would produce 30,000 achenes (6 achenes/cm^2 of canopy surface with a mean shrub canopy height and diameter of 55 cm). The pappus is important for wind dispersal (Stevens et al. 1986). C. v. ssp. viscidiflorus plants failed to flower at a site that experienced a severe drought (Young and Evans 1974a). This is an example of phenotypic plasticity in Chrysothamnus. Chrysothamnus seed establishes rapidly; with cool nights and warm days it can germinate within 2 days

(Weber et al. 1985). Once established, growth is rapid if conditions are favorable (McArthur et al. 1974).

Plant competition is very important in controlling the growth and reproduction of Chrysothamnus on the open range. McKell (1956), measuring the effects of competition on Chrysothamnus growth, found flower production and stem growth to be significantly reduced by competition. Chrysothamnus, when controlled, reinvades slowly, particularly where understory herbaceous vegetation is abundant (Frischknecht et al. 1953). Still, the viability of seeds from plants with and without competition is the same (McKell and Chilcote 1957).

Chrysothamnus resprouts in response to topkill. Young and Evans (1974b) found that C. viscidiflorus dominated an Artemisia tridentata community after fire by resprouting and by seedling establishment. They found that fire enhanced achene production. C. viscidiflorus dominated the site and periodically reestablished itself for 15 years at this site.

Chrysothamnus has a C3 photosynthetic pathway. In C. nauseosus the rate of photosynthesis is high for a woody C3 plant. It does not become light-saturated at full sun. Weber et al. (1985) suggest that this might be due to tomentose vestiture on the leaf surface shading the chloroplasts. They cite other authors suggesting that pubescence is an adaptive feature, reducing heat loads by lowering internal temperatures.

Uses and Management Opportunities

The taxa of Chrysothamnus tend to form resins and oils. This is associated with the xerophytic habitat of the plants (Hall and Clements 1923). C. nauseosus is rich in the secondary metabolite, rubber (McArthur and Welch 1986). Hall & Goodspeed (1919) concluded that if extractable over 150,000 tons of rubber were available in native stands of Chrysothamnus. The rubber in Chrysothamnus is present in the individual cells; it is not a latex rubber. The percent in each plant is too small to warrant harvest (Hall and Goodspeed 1919), but no genetic selections have been made (Ostler et al. 1986). Ostler et al. (1986) noted that potential for rubber production by C. nauseosus is enhanced because of the following characteristics: 1) it is widely distributed throughout western North America where winter temperatures are often below -20 F; thus its potential range exceeds that of any other known rubber-producing plant; 2) it grows on marginal land and alkaline soils; and 3) its ability to resprout makes it resistant to mowing and harvesting.

Many Chrysothamnus taxa have been noted as useful soil stabilizers. C. linifolius is valuable for stabilizing disturbed soil due to a strong underground spreading characteristic (McArthur et al. 1974). C. nauseosus is useful for erosion control because of its deep roots, heavy litter, ability to establish on severe sites (McArthur et al. 1978b), easy establishment, and rapid spread (McArthur et al. 1974).

There is some controversy over the value of Chrysothamnus taxa as a forage resource. According to McKell and Chilcote (1957), C.

viscidiflorus and *C. nauseosus* are relatively unpalatable shrubs. Several situations have been reported where *Chrysothamnus* has contributed to both livestock and wildlife diets. Cook and Harris (1950) reported that *C. stenophyllus* (*C. v.* ssp. *viscidiflorus* var. *stenophyllus* Anderson 1980a) contributed 11.31% and 8.2% by weight of diet of sheep on winter range in Utah during 1946-47 and 1947-48, respectively. Severson (1966) estimated that *Chrysothamnus* comprised 30% of the pronghorn diet in the Red Desert of Wyoming. Leach (1956) found that Great Basin deer utilized *Chrysothamnus* taxa during severe winters in California. Yoakum (1986) suggests *Chrysothamnus* should be managed as a needed component on pronghorn rangelands since it is a highly preferred forage species for pronghorn and provides needed cover. In Montana, *Chrysothamnus*, along with *Artemisia* and *Juniper*, was found to comprise 60% of mule deer diets in Garfield and Rosebud counties, MT (Eustace 1971).

The use of *Chrysothamnus* taxa may be partially determined by type and abundance of associated forage. In a study on the nutritive value of winter range plants in the Great Basin (Cook et al. 1954), use of *C. stenophyllus* comprised 8% of the diet on sagebrush range, 6% on saltbush range, and 2% on grass range. *Chrysothamnus* species are used on depleted game ranges (McArthur et al. 1974) and in the fall and winter when more desirable forages are unavailable (McArthur et al. 1978b, Leach 1956).

McArthur et al. (1974) suggest that the forage value of *C. nauseosus* varies with subspecies, ecotype, and season of the year. This is likely true of all the *Chrysothamnus* taxa. In *C. nauseosus* the gray group subspecies generally are more palatable to game and livestock than those subspecies in the green group. In Utah, C. n. ssp. consimilis and C. n. ssp. graveolens (green group subspecies) are less palatable to game and livestock than gray group taxa, C. n. ssp. albicaulis and C. n. ssp. salicifolius Rydberg (mountain rubber rabbitbrush) (McArthur et al. 1974). Dittberner and Olson (1983) report palatability ratings of Chrysothamnus taxa in several western states by subspecies. For example, in Montana several subspecies of C. nauseosus are rated good in palatability for white-tail deer as is C. viscidiflorus for mule deer.

Sampson and Jesperson (1963) noted that the crude protein of C. nauseosus was 9% during dormant months and 11.8% in spring after new leaves are formed. In an analysis of C. stenophyllus, carotene was found to be relatively high (2.1 mg/lb), but phosphorus and protein relatively low (digestible protein value = 4% October 31 and 2.2% December 11) (Cook et al. 1954).

Frischknecht (1963) determined the effects of C. nauseosus on Agropyron cristatum production and found herbage yield of seedheads, and average culm height of A. cristatum were all greater where Chrysothamnus had not been removed. Chrysothamnus seemed to enhance the growth of A. cristatum by providing shade, hence decreasing evaporation, and by not competing for water. Competition for water was minimized because A. cristatum and C. nauseosus do not actively grow at the same times and secondary laterals of C. nauseosus seemingly offer little competition to grass. Thus C. nauseosus can increase the value of A. cristatum range for fall grazing by allowing understory plants to remain succulent.

Chrysothamnus taxa have several other possible uses. Weber et al. (1985) suggest that C. nauseosus has many current and potential uses such as landscaping, production of natural rubber, potential hydrocarbon crop, and potential source of natural insecticides and fungicides. When Chrysothamnus is included in a herbaceous seeding, it can increase total production, enhance grass yields, improve the nutritive value of the seeding, increase available winter forage, enhance snow entrapment, improve the aesthetics of the seeding, and reduce the chances of destructive insect infestations (Stevens 1986). Often the landscapes dominated by Chrysothamnus spp. have been disturbed. Chrysothamnus can be useful as habitat indicator (Dayton 1931). Flowers and inner bark of Chrysothamnus make yellow and green dye (Kearney and Peebles in McArthur et al. 1979a), and Booth (in McArthur et al. 1979a) recommended Chrysothamnus for late season honey.

Control of Chrysothamnus is difficult because of its resprouting habit and great reproductive capacity (McKell and Chilcote 1957). Robertson and Cords (1957) found 2,4-D superior to 2,4,5-T in controlling Chrysothamnus. Evans and Young (1973) got 97% control of C. viscidiflorus with 2.4 kg/ha 2,4-D + 0.6 kg/ha picloram. Paulsen and Miller (1968) determined Tordon 22-K at 2.4 kg/ha later in the growing season was most effective in eradicating C. parryi compared with 2,4-D and low applications of Tordon. C. nauseosus was not controlled at any rate between 1.28 to 1.68 kg/ha of Tebuthiuron (Marion et al. 1986). The optimum time to apply 2,4-D to Chrysothamnus is when the current annual shoots are 7.6 cm long (Evans and Young 1973). Range improvement practices may give Chrysothamnus taxa an advantage because its growth and seed production are enhanced when competing vegetation is removed.

STUDY AREAS AND METHODS

General Survey Methods

Chrysothamnus specimens were collected throughout Montana during the summers of 1985 and 1986 to inventory Montana taxa and to determine their distributions. All collected specimens were determined to the subspecies level using Anderson's (1986a) diagnostic key. Specimens annotated by L. C. Anderson, obtained on loan from the following herbaria; University of Montana, Missoula (MONTU); University of Idaho, Moscow (ID); Washington State University, Pullman (WS); and University of Wyoming, Laramie (RM) (Holmgren and Keuken 1974), aided in verification.

Each plant collection site was noted on a Montana highway map and general habitat information was recorded. Soil texture was determined by the hand estimation method (USDA 1975). Soil depth was assigned to 1 of 3 categories; very shallow (0-2 in), shallow (2-6 in), and normal (6+ in). A compass was employed to determine aspect and percent slope was estimated. Browsing on Chrysothamnus plants was noted as light (<15% leaders browsed), moderate (15-40% leaders browsed), or heavy (40+% leaders browsed). Dominant associates and disturbance indicators, if present, were noted.

In addition, herbarium specimens previously collected in Montana, from Montana State University (MONT) and the University of Montana, were verified to subspecies. Any available habitat information was noted and locations were recorded separately on distribution maps.

Unknown Taxon Study Area and Methods

During 1985, a previously uncharacterized taxon of C. parryi was discovered in southwestern Montana. Thus, in the summer of 1986 additional localities of the new taxon were sought. Once likely site characteristics were known, similar areas were surveyed for the new taxon.

At 2 localities, Jerry Creek and Quartz Hill (description of these sites located in the Results and Discussion section, Tables 5,6), the undescribed taxon apppeared to have 2 forms, 1 with tomentum on the leaves and 1 without tomentum. Plants with mature flowers of each form were collected at these sites. Leaves and heads from these pressed plants were soaked in 50% ethyl alcohol to restore them to original size (Anderson 1964). Vegetative and floral measurements were taken for comparative and descriptive information. Following Anderson (1964) 10 mature heads (occasionally fewer due to the lack of mature heads) from each sample were measured for involucre features and 1 flower from each head was measured for floral features. Seventeen plants (10 of tomentum form and 7 of form without tomentum) were measured from the Jerry Creek site and 20 (10 of each form) were measured from the Quartz Hill site. All together 298 heads and flowers were measured. Measurements were made on 10 leaves from each plant.

Flower buds, at the stage of anthers-enlarged, but not yellow, were collected, preserved in acetic acid and later transferred to 50% ethyl alcohol for meiotic chromosome counts. Chromosome counts were made by

Dr. E. D. McArthur at the United States Forest Service Shrub Science Laboratory in Provo, Utah.

Seven sites with the new taxon were studied to describe habitat features. All 7 locations were silty range sites (Ross and Hunter 1976) but they received varing amounts of annual precipitation. Precipitation amounts ranged from 356 to 588 mm (14-23 in) and elevations ranged from 1708 to 2227 m (5600-7300 ft). All sites supported Artemisia tridentata - grass communities. Slopes were variable and all aspects except north were encountered. For more complete descriptions of these sites see the Results and Discussion section (Table 5,6).

The following procedure was employed at each site to determine the area of the sampling plots. First, the region containing the highest density of C. parryi was ocularly estimated and the area was measured. Then, within this area, the "closest neighbor" inter-plant distances were measured from a sample of 10 randomly chosen plants. Twice the mean "closest neighbor" distance was added to each side of the ocularly estimated area, thereby establishing a plot which included some outlying plants.

The following measurements were taken of the C. parryi plants: 1) density; 2) crown coverage; 3) average plant height (cm); and 4) average leader length (cm). To simplify counts, plots were divided into subplots. In each subplot all C. parryi plants were counted. This included only individuals with all basal stems within the plot. For the remaining measurements, a proportion of plants were sampled so that 300 leaders were measured per plot. The number of plants needed to insure this number of leaders was determined by estimating the average number of leaders per plant at each plot. This was necessary because the number of leaders per plant varied between plots and within plots. The number of plants measured per subplot was determined by estimating the proportion of the total count present in each subplot. The first plant measured was arbitrarily chosen and following plants were measured at random intervals by choosing a number between 1 and 10 for each subplot. Use was noted on each plant measured. Ten percent (but not <15) of the leaders were counted per individual. The percent canopy coverage of C. parryi was determined by measuring the shortest and the longest dimensions of each plant.

To determine what environmental factors might favor the new taxon, an adjacent paired plot without the taxon present was chosen by matching slope, aspect, and vegetation as closely as possible to the plot containing C. parryi. This plot, as in the C. parryi plot, was divided into subplots. A line transect was placed in each subplot in both the paired plots. To measure basal coverage of grasses and forbs, by species, a 2 x 5 dm rectangular quadrat was placed every other meter along a tape stretched the length of the subplot. The top left corner of the quadrat was placed on the meter mark. By the use of a plumb bob, canopy cover of shrubs other than C. parryi was measured by recording the distance each plant spanned along the tape. Only live crown was recorded as coverage.

Density of shrubs other than C. parryi was measured by counting individuals of each species within 1 m of each line transect.

Soil samples were taken in each quarter of the paired plots. In the taxon plot, samples were taken close to a C. parryi plant. Three depths: 0 to 5 cm (0-2 in), 5 to 15 cm (2-6 in), and 15 to 30.5 cm (6-12 in) were separated and stored in bags. Texture analysis (Bouyoucous 1936), electrical conductivity (USDA 1954), and pH (USDA 1954) were analyzed.

Additional information was recorded at each site such as disturbance, associated species, aspect, and slope. Elevations and annual precipitations at each study site were estimated from Montana climatological records (National Oceanic and Atmospheric Administration 1984).

RESULTS AND DISCUSSION

During the summers of 1985 and 1986, 8 previously described *Chrysothamnus* taxa were found to occur in Montana (Table 2). Additionally, in August, 1985 a previously uncharacterized subspecific taxon of *Chrysothamnus parryi* was located in southwestern Montana. Until now, 12 subspecies of *C. parryi* had been described (Anderson 1986a). None of this subspecies have been noted to occur in Montana. Conspicuous stalked glands differentiate the new taxon from other *C. parryi* taxa with the exception of *C. p.* ssp. *asper* (Greene) Hall & Clem., known only from California and Nevada. Based on these stalked glands it is proposed that this new taxon be known as *C. parryi* ssp. *glandulosus* Winkler and Wambolt. Two varieties are proposed, *C. p.* ssp. *glandulosus* var. *glandulosus* and *C. p.* ssp. *glandulosus* var. *tomentosus*.

Table 2. Occurrence of *Chrysothamnus* taxa in Montana.

Taxon	Located during this study	Reported in the literature
C. linifolius	x	Anderson 1986a. *C. viscidiflorus* ssp. *linifolius* by Hall and Clements 1923.
C. nauseosus		
ssp. *albicaulis*	x	Anderson 1986a, Hall and Clements 1923.
ssp. *consimilis*	x	Anderson 1986a.
ssp. *graveolens*	x	Anderson 1986a, Hall and Clements 1923.

Table 2. continued.

Taxon	Located during this study	Reported in the literature
C. nauseosus		
ssp. nauseosus	x	Anderson 1986a. C. n. ssp. typicus by Hall and Clements 1923.
ssp. speciosus		Hall and Clements 1923. Included in C. n. ssp. albicaulis in Anderson 1986a.
C. parryi		
ssp. glandulosus	x	
C. viscidiflorus		
ssp. lanceolatus	x	Anderson 1986a, Hall and Clements 1923.
ssp. puberulus		Hall and Clements 1923.
ssp. pumilis		Hall and Clements 1923. Part of C. v. ssp. viscidiflorus by Anderson 1986a.
ssp. stenophyllus		Hall and Clements 1923. Variety of C. n. ssp. viscidiflorus by Anderson 1980b.
ssp. viscidiflorus	x	Anderson 1986a. Labeled C. v. ssp. typicus by Hall and Clements 1923.
var. stenophyllus	x	
var. viscidiflorus	x	Anderson 1980b.

Phylogeny and classification of Chrysothamnus parryi ssp. glandulosus

The reproductive strategy of facultative self-fertilization with the capacity to occasionally outcross, as occurs in Chrysothamnus, often promotes the development of new varieties. These varieties include new ecotypes, subspecies, and species. However, this trait is not conducive to evolution of new genera and families (Stebbins 1957). A species is a population entity maintained by the inability or great restriction of gene exchange by physiological or genetic isolation barriers (Stebbins 1950). Seventy to 80% of the species of higher plants conform well to this biological species definition and consequently show morphological discontinuity based on reproductive isolation (Stebbins 1965). No reproductive tests were performed to determine if C. p. ssp. glandulosus is reproductively isolated from other C. parryi taxa.

Subspecies are series of populations resembling each other in certain morphological and physiological characteristics, each inhabiting a geographic subdivision of the species range or a series of similar habitats. They are different in several characteristics from typical members of other subspecies, yet are connected with 1 or more of them by a series of intergrading forms (Stebbins 1950). Two subspecies can coexist over the same area, but are likely to be at least partly isolated from each other by habitat preferences (Stebbins 1950). Muller (1940) states that subspecies establishment is evolutionarily significant in that it promotes allopatric speciation.

He suggests that the segregation of a previously interbreeding population system into 2 or more reproductively isolated populations tends to restrict the supply of genes available to each of these populations and channels them into certain paths of adaptation. Ecotypes, an ecological and adaptational concept, are distinguished primarily by their reaction to the environment and may possess defined morphological differences (Stebbins 1950). C. p. ssp. glandulosus is morphologically and apparently geographically separated from other subspecies and thus is proposed as a subspecies rather than an ecotype.

Anderson (1978) inferred that C. p. ssp. montanus, a local endemic, is related to C. p. ssp. parryi because of its many-flowered heads. If this is so, then C. p. ssp. glandulosus is likely derived from the same lineage, since it likewise has many flowers per head. These taxa are similar morphologically, yet differ primarily in that C. p. ssp. glandulosus has stalked glands and a greater number of flowers per head than C. p. ssp. montanus (Table 3). The type location of C. p. ssp. montanus is Clark Co., Idaho on exposed rocky slopes of the Red Conglomerate Peaks, located in the Irving Creek drainage, 28 air miles northwest of Dubois, Idaho (Anderson 1978). This lies close to the southwest border of Montana where a few populations of C. p. ssp. glandulosus are known to occur.

It is speculated that C. p. ssp. glandulosus var. tomentosus arose from C. p. ssp. glandulosus var. glandulosus. C. p. ssp. glandulosus var. glandulosus has a wider range, occurs more frequently, and occurs independently of C. p. ssp. glandulosus var. tomentosus. C. p. ssp. glandulous var. tomentosus was found at only 2 of the 7 sampling sites

Table 3. Comparison of *Chrysothamnus parryi* ssp. *glandulosus* with 3 morphologically similar *C. parryi* taxa.

Taxon	Leaf length (cm)	Leaf width (mm)	Leaf surface	Leaf shape	Tip shape	Flower length (mm)	Flower lobe length (mm)	Inflorescence arrangement	No. flowers per head
C. p. ssp. *glandulosus*	1-5	1-4	stalked glands	linear-linear oblanceolate	acute	6-9	0.8-1.6	cyme	10-14
C. *p.* ssp. *asper*	2-5[b]	1-3[b]	short stalked glands[b]	oblanceolate[a]		up to 9[a]		short raceme[b]	5-10[bc]
C. p. ssp. *montanus*	2-3.5[ad]	1-2[d]	viscidulous	linear[d]		9-10[ad]	1.4-1.7[d]	few-headed, cymose[d]	5-11[d]
C. p. ssp. *imulus*	1-1.5[ab]	2-3[b]	gray with dense tomentum[b]	spatulate-linear spatulate[b]	obtuse[b]	9-10[b]	1-1.5[b]	reduced raceme[b]	11-15[b]

[a]Anderson 1986a.
[b]Hall and Clements 1923.
[c]McArthur et al. 1979a.
[d]Anderson 1978.

and was always intermixed with C. p. ssp. glandulosus var. glandulosus.

Morphology of Chrysothamnus parryi ssp. glandulosus

Chrysothamnus parryi ssp. glandulosus is a low shrub, 1-3 dm tall, much branched from a woody caudex. This taxon, like other C. parryi taxa (Paulsen and Miller 1968, McArthur et al. 1979b), spreads by underground shoots. The stems are leafy and covered with loose white tomentum. Characteristically, C. parryi taxa have felt-like white to green tomentum which is not as dense or resinous as that on stems of C. nauseosus (McArthur et al. 1979a). Stems of C. parryi ssp. glandulosus are mostly erect, although some are found spreading on the ground. Branching occurs only in the inflorescence. The leaves are alternate, sessile, narrow to broadly linear-oblanceolate, with acute tips. The leaves measure (1) 2 to 4 (5) cm long and 1.5 to 4 mm wide. They have 1 prominent nerve, yet occasionally there are 2 or 4 additional nerves. Hall and Clements (1923) note that nerve number is variable and dependent on leaf width. The leaves are roughened, with numerous stalked resin glands. The margins are entire and the upper leaves occasionally barely surpass the inflorescence.

The flower heads of C. parryi ssp. glandulosus are arranged in leafy terminal cymes (Fig. 1), differing from other C. parryi inflorescences, which are typically racemes (Hall and Clements 1923). The involucres of C. parryi ssp. glandulosus average 1.13 cm high; bract number ranges from (9) 12 to 16. These involucral bracts are somewhat ranked, not keeled, have narrowly acuminate tips and are 1 nerved, occasionally with 2 additional nerves. There are (9) 10 to 14 (16) flowers/head. The disk flowers, tubular shaped, are (6) 7 to 8 (9) mm long; lobes are 1 to 1.3 mm long. The style branch ranges from 2 to 3.5 mm. The stigmatic lines are usually shorter than the style appendages (35 to 57%). The pappus length is 7 to 8 mm. The achene is 2 to 5 mm long. The chromosome number is 2n=18. This is the modal number throughout the genus (Solbrig et al. 1969). C. parryi ssp. glandulosus blooms from July to August. C. parryi ssp. glandulosus var. glandulosus has leaves and involucral bracts that have no or little tomentosity whereas C. parryi ssp. glandulosus var. tomentosus has leaves and involucral bracts covered with dense tomentum which makes the stalked glands inconspicuous (Fig. 1).

The Relationship of Chrysothamnus parryi ssp. glandulosus to other Chrysothamnus Taxa

C. p. ssp. glandulosus is morphologically close to 3 other C. parryi taxa: C. p. ssp. imulus Hall & Clem., C. p. ssp. asper, and C. p. ssp. montanus L. C. Anderson. Intraspecifically, only C. p. ssp. glandulosus and C. p. ssp. asper have conspicuous stalked glands. Typically, C. p. ssp. glandulosus, C. p. ssp. imulus, and C. p. ssp. montanus have more than 7 flowers per head and are 1 to 2 dm tall. Leaf length, leaf width, flower number per head, and other morphological characteristics distinguish C. p. ssp. glandulosus (Table 3). C. p. ssp. asper occurs on slopes bordering the desert of eastern California and western Nevada from 2100 to 2600 m (6885-8525 ft) in

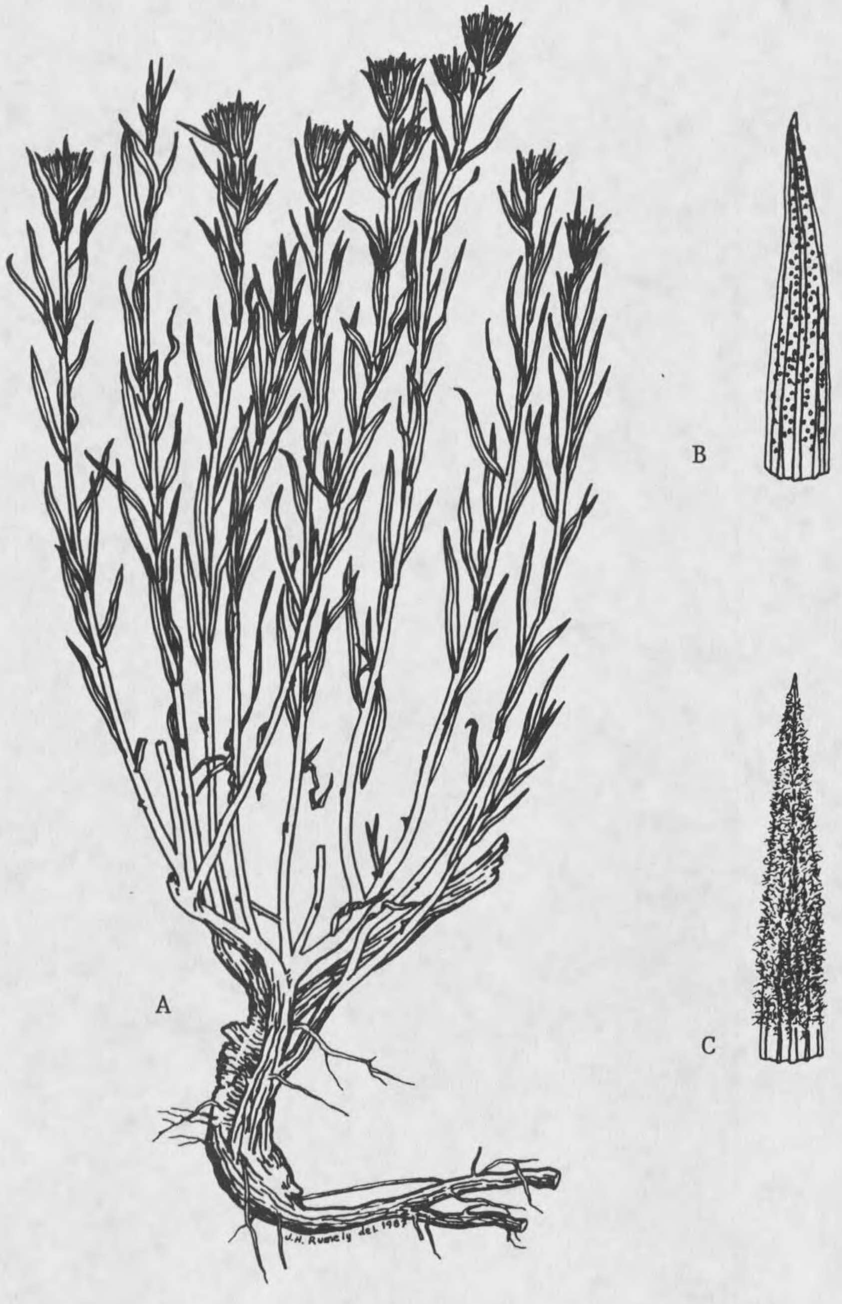

Figure 1. Illustrations of *Chrysothamnus parryi* ssp. *glandulosus*. A. Habit x 2/3. B. Involucral bract of *C. p.* ssp. *glandulosus* var. *glandulosus*, showing stalked glands x 4. C. Involucral bract of *C. p.* ssp. *glandulosus* var. *tomentosus*, showing tomentum x 4.

elevation (Hall and Clements 1923); C. p. ssp. imulus is found only in the San Bernardino Mountains of southern California (Hall and Clements 1923); and C. p. ssp. montanus has been located only in the Red Conglomerate peaks at the Montana - Idaho border (Anderson 1978).

As a species C. parryi is most closely related to C. nauseosus. Hall and Clements (1923) state that there can be no doubt as to the common origin of these 2 species. They share characteristics such as tomentum on the stems and similar shapes of corollas and style branches.

In the past, natural resource managers have recognized only 2 Chrysothamnus taxa in Montana, C. nauseosus and C. viscidiflorus (Booth and Wright 1966). Recently Dorn (1984) cited a third taxon, C. linifolius. Table 4 illustrates some of the morphological characteristics differentiating C. p. ssp. glandulosus from other taxa in the State.

Morphology of other Chrysothamnus Taxa in Montana

Chrysothamnus nauseosus

Morphologically C. nauseosus subspecies fall into 2 groups, gray and green, based on stem color and presence or absence of hairs on the involucre (Anderson 1986c). The gray group typically has gray stems and pubescence to tomentum on the involucres and includes Montana taxa C. n. ssp. nauseosus and C. n. ssp. albicaulis. The pubescence on the

Table 4. Diagnostic characteristics of Montana *Chrysothamnus*.[a]

Stems Tomentose							Stems Not Tomentose glabrous to puberulent			
Phyllaries attenuate, rather membranous Inflorescence racemose 5-20 flowers/head *Chrysothamnus parryi*			Phyllaries obtuse to acute, chartaceous Inflorescence mostly cymose Usually 5 flowers/head *Chrysothamnus nauseosus*				Leaves often twisted, linear to oblong - lanceolate Smaller plant *Chrysothamnus viscidiflorus*			Leaves never twisted, lanceolate Soboliferous Tall plant > 7 dm *Chrysothamnus linifolius*
Leaves with stalked glands	Leaves without stalked glands Leaves overtop inflorescence		Involucres pubescent to tomentose (rarely nearly nearly glabrous) Stems whitish		Involucres glabrous Stems greenish		Upper stems hairy Leaves > 2 mm wide, hairy to glabrous	Upper stems glabrous Leaves 1-10 mm wide, ciliate margins otherwise glabrous		
	5-7 flowers/head. Corolla pale yellow, 8-10 mm long. Leaves 1-3 mm wide.	8-20 flowers/head. Leaves 2-3.5 cm long. Shrub 1-2 dm tall.	Corolla 6 - 8.5 mm long. Involucre 7-9.5 mm long. Shrub 2-7 dm tall.	Corolla (8) 9-10 mm long. Involucre 9-11 mm long. Shrub 4-15 dm tall.	Leaves 1-3 mm wide, 1-5 nerved. Involucre 6.7-9.5 mm long. Corolla 7-9 mm long. Corolla lobes .6-1.5 mm long. Often tall, robust.	Leaves 1 mm wide or less, 1 nerved. Involucre 7-8 mm long. Corolla 7 - 9.5 mm long. Corolla lobes 1-2.5 mm long Often bright green stem.				
ssp. *glandulosus*	ssp. *salmonensis*	ssp. *montanus*	ssp. *nauseosus*	ssp. *albicaulis*	ssp. *graveolens*	ssp. *consimilis*	ssp. *lanceolatus*	ssp. *viscidiflorus*		
foliage with tomentum var. *tomentosus*	foliage without tomentum var. *glandulosus*							Leaves > 1.5 mm wide; up to 1 m tall var. *viscidiflorus*	Leaves 1-1.5 mm wide; mostly < 3 dm tall var. *stenophyllus*	

[a]includes two *C. parryi* taxa from Idaho. These taxa were not found in Montana but might occur.

involucre is an expression of the tendency toward abundant pubescence in the whole plant (Hall and Clements 1923).

The specimens of C. n. ssp. nauseosus collected during this study ranged in height from 1.6-10 dm. The following collections illustrate the intrasubspecific variation in stem color of this taxon: 8/16/4b, 8/16/5e, and 8/27/14a had bright green stems; 8/27/9b had a dark green stem; and 8/26/2b had a cottony white stem. Specimens of C. n. ssp. albicaulis collected ranged in height from 2.5-11 dm. Stem color characteristics of this taxon varied considerably. Collections 8/29/1a, 8/29/1b, 8/31/3b, 8/31/3c, and 8/31/3d had bright green stems, however, collection 8/31/2c had white stems. Typically stem pubescence in C. n. ssp. albicaulis ranges from light green to white varying with ecotype (Hanks et al. 1975).

The green group, composed of C. n. ssp. consimilis and C. n. ssp. graveolens, has green stems and glabrous involucres. The height of collected specimens of C. n. ssp. graveolens ranged from 3.1 to 12 dm. Most specimens of this taxon were fairly typical, yet, some plants had narrower leaves. Specimens of C. n. ssp. consimilis ranged from 2.4 to 7 dm in height.

Variation in the above taxa may be explained by intergradation that occurs between parapatric and sympatric subspecies of C. nauseosus (Fig. 2). In areas where 2 Aciurina species (fruit fly) concur and C. nauseosus subspecies are sympatric, 1 fly species (Aciurina bigeloviae) induces cotton galls on the green group of C. nauseosus whereas another fly species (A. trixa) induces callus galls on the white group. Galls in areas of sympatry can aid in identification of subspecies of *C. nauseosus* (McArthur et al. 1979b, Weber et al. 1985).

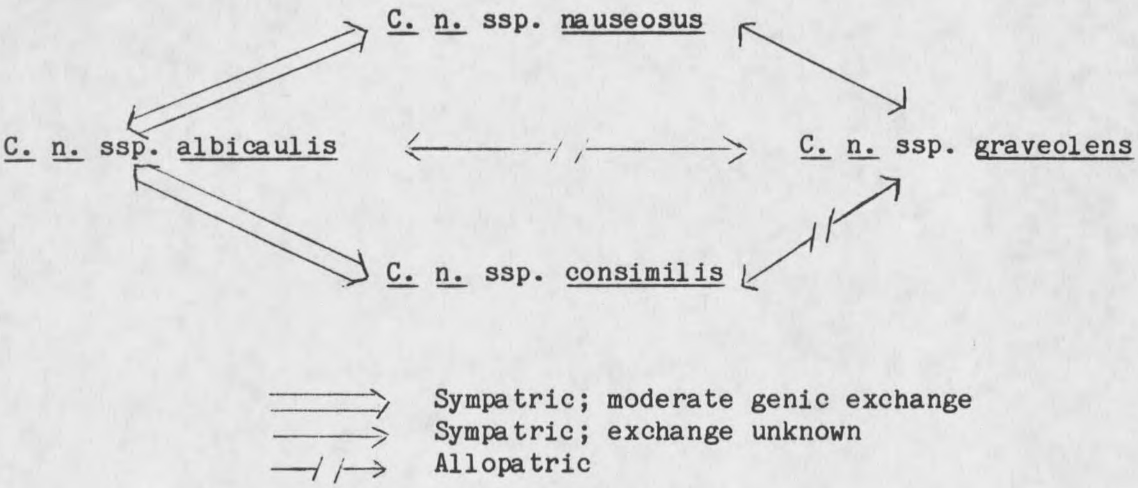

Figure 2. Relationships among Montana *Chrysothamnus nauseosus* subspecies. Adapted for Montana from Anderson 1986c.

Chrysothamnus viscidiflorus

Intraspecific variants of *C. viscidiflorus*, separated from *C. nauseosus* primarily by the lack of tomentose vestiture on the stems, are difficult to classify due to the lack of sufficient floral distinctions (Anderson 1980a). The floral features vary with different environments (Anderson 1964). The amount and type of vestiture on leaves and stems, if present, aids in determining *C. viscidiflorus* subspecies in Montana. According to a diagnostic key by Anderson (1986a), *C. v.* ssp. *lanceolatus* has hispid hair on the stems near the inflorescence and the leaves are hirsute to glabrous. *C. v.* ssp. *lanceolatus* collections ranged in height from 1.4 to 3 dm. All collections made during this study had flat leaves which agrees with McArthur et al. (1978a), who reported that C. v. ssp. lanceolatus has leaves 2.5-6mm wide, 1.5-4cm long, and flat. However, collection 8/20/1b had twisting leaves. Also, several narrow leaved specimens of C. v. ssp. lanceolatus were found. The leaves of collections 8/16/2a, 8/20/2c, 8/20/3d, and 8/31/5a all measured less than 1.7 mm. These are examples of phenotypic variation, which may reflect different ecotypes and environments.

The stems of C. v. ssp. viscidiflorus usually are glabrous, although, McArthur et al. (1978a) notes the stems are sometimes sparsely puberulent. The leaves often have ciliate margins, otherwise they are glabrous and range in width from 1 to 10 mm. No Montana specimens of C. v. ssp. viscidiflorus were found with leaves wider than 3.5 mm.

Anderson (1980a) describes 2 varieties of C. v. ssp. viscidiflorus: C. v. ssp. viscidiflorus var. viscidiflorus and C. v. ssp. viscidiflorus var. stenophyllus, which are distinguished by leaf width and plant height. The principal characteristic used to distinguish between these 2 varieties in the collections made for this study was leaf width. C. v. ssp. viscidiflorus var. viscidiflorus has leaves greater than 1.5 mm and C. v. ssp. viscidiflorus var. stenophyllus has leaves 1 to 1.5 mm wide. Reported plant heights for C. v. ssp. viscidiflorus var. viscidiflorus range up to 1 m while C. v. ssp. viscidiflorus var. stenophyllus is usually less than 3 dm (Anderson 1980a). Collected specimens of C. v. ssp. viscidiflorus var.

viscidiflorus ranged in height from 1.5 to 5.5 dm. All specimens of C. v. ssp. viscidiflorus var. stenophyllus were less than 3 dm with the exception of 8/16/1b (6.6 dm) and 8/24/1a (5.6 dm).

Although, C. v. ssp. viscidiflorus is reported to have glabrous stems, C. v. ssp. viscidiflorus var. viscidiflorus specimens 8/16/2b and 8/17/4d had some hair on the stems. Collections of C. v. ssp. viscidiflorus var. stenophyllus (8/16/4d and Bannack 8/V11/85) had some hispid hairs on the stems. These specimens may express vestiture due to intergradation between C. v. ssp. lanceolatus and C. v. ssp. viscidiflorus (Letter from L. C. Anderson 5/20/86), which are sympatric over part of their ranges in Montana (Figs. 9,10).

Chrysothamnus linifolius

C. linifolius has broad, smooth, dark green leaves (Winward and Anderson 1986). Some specimens of C. linifolius grow 3.66 m tall in southern Utah (Winward and Anderson 1986). The few specimens collected in Montana averaged 1.83 m tall. C. linifolius spreads by lateral roots that form adventious shoots (McArthur et al. 1979a). It is this characteristic that gives C. linifolius its large round form.

Distribution of Montana Chrysothamnus

The only known populations of C. p. ssp. glandulosus occur in southwestern Montana (Fig. 3). Table 2 lists the other Chrysothamnus taxa occurring in Montana; Figures 4-11 show their respective

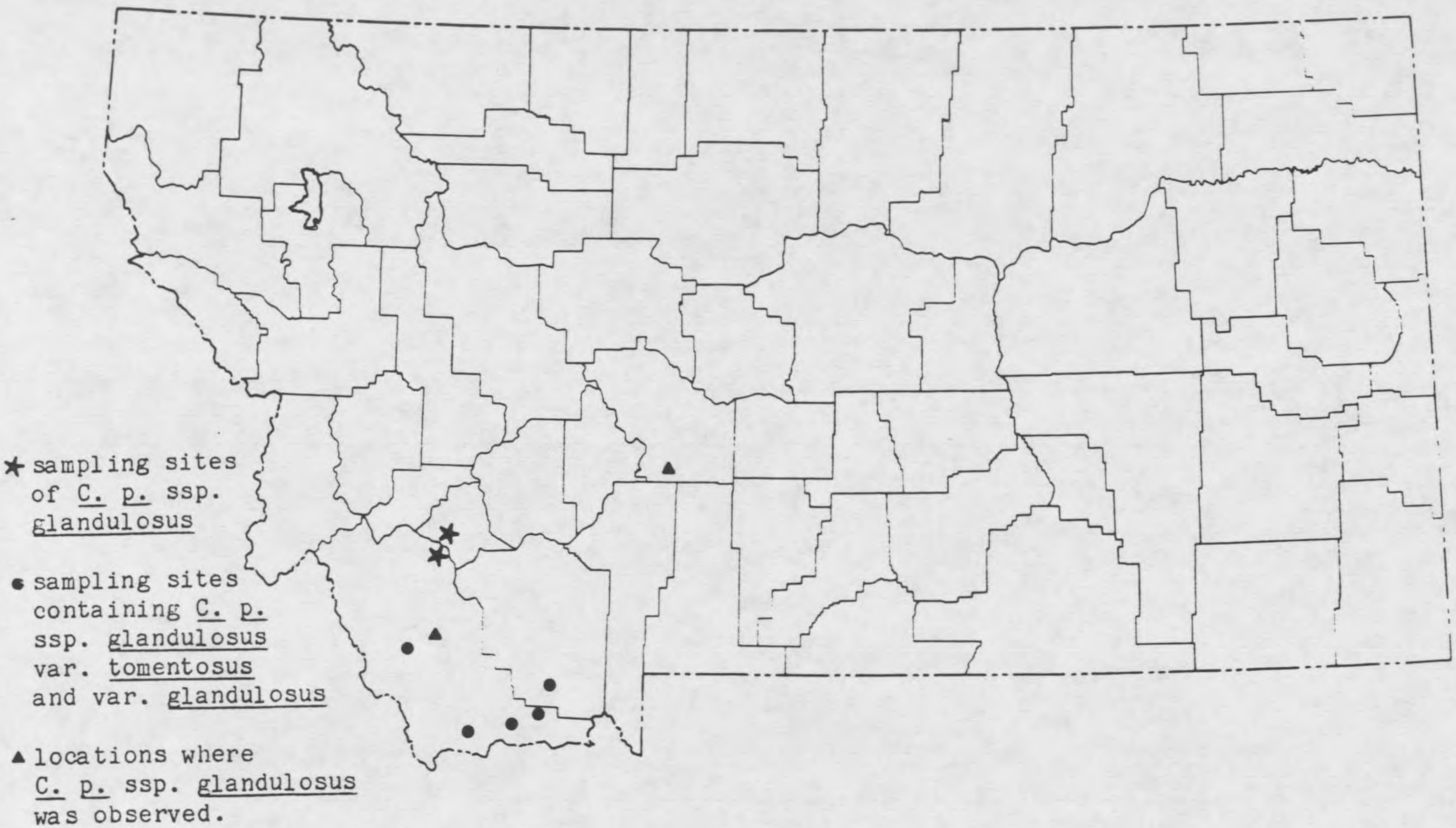

Figure 3. Locations of *Chrysothamnus parryi* ssp. *glandulosus* found in Montana.

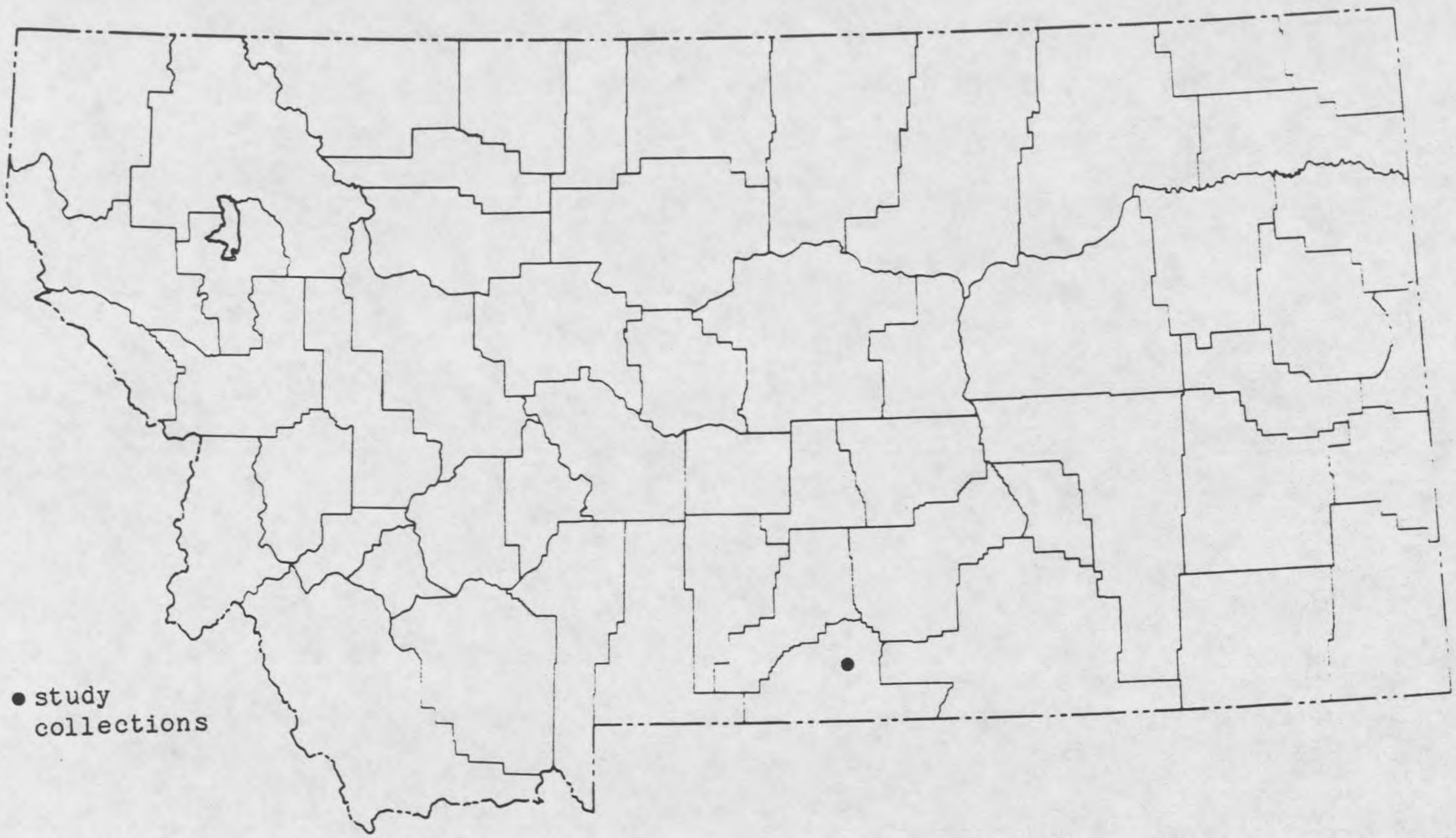

Figure 4. Location of collections of C. linifolius.

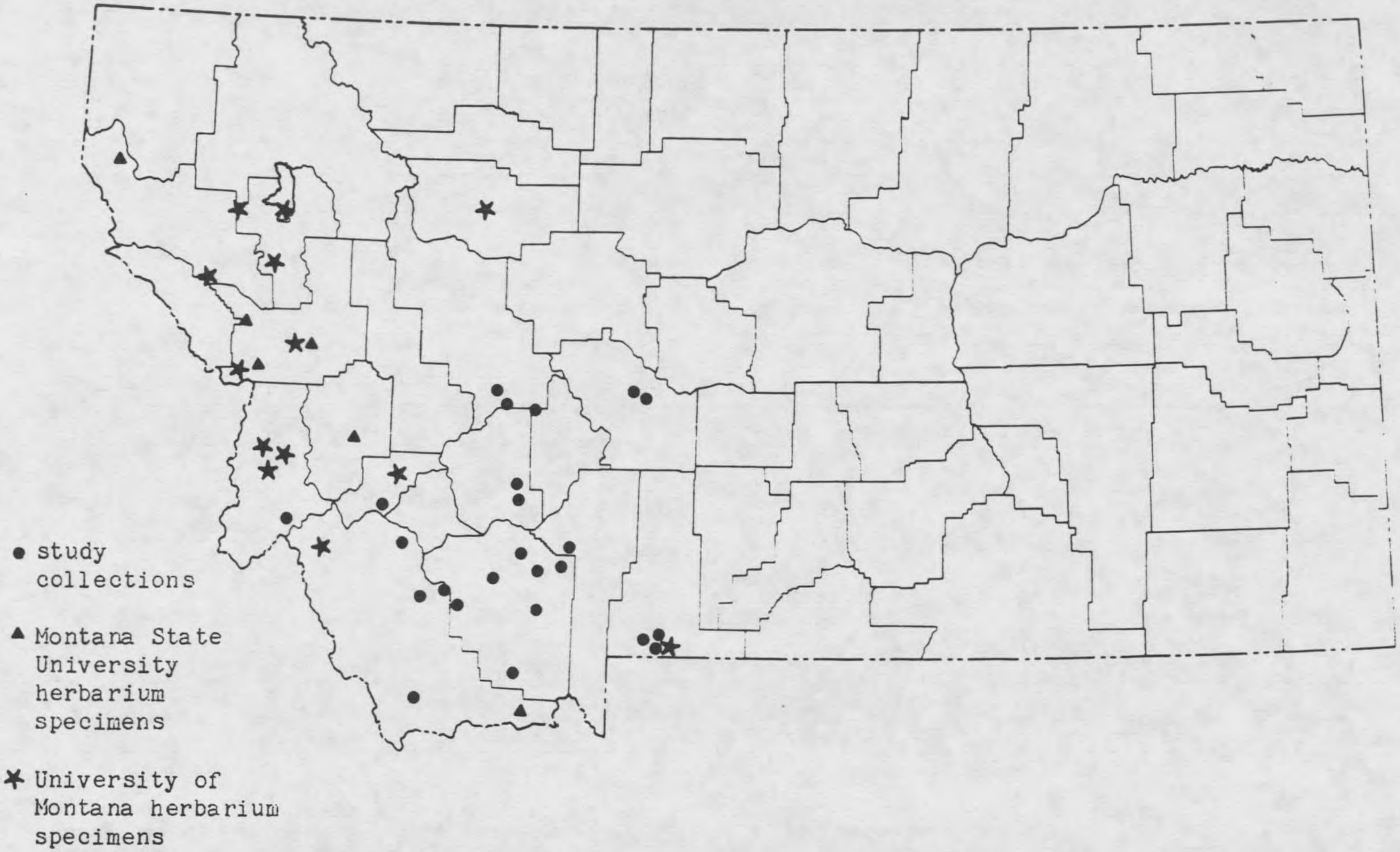

Figure 5. Location of collections and herbarium specimens of C. n. ssp. albicaulis.

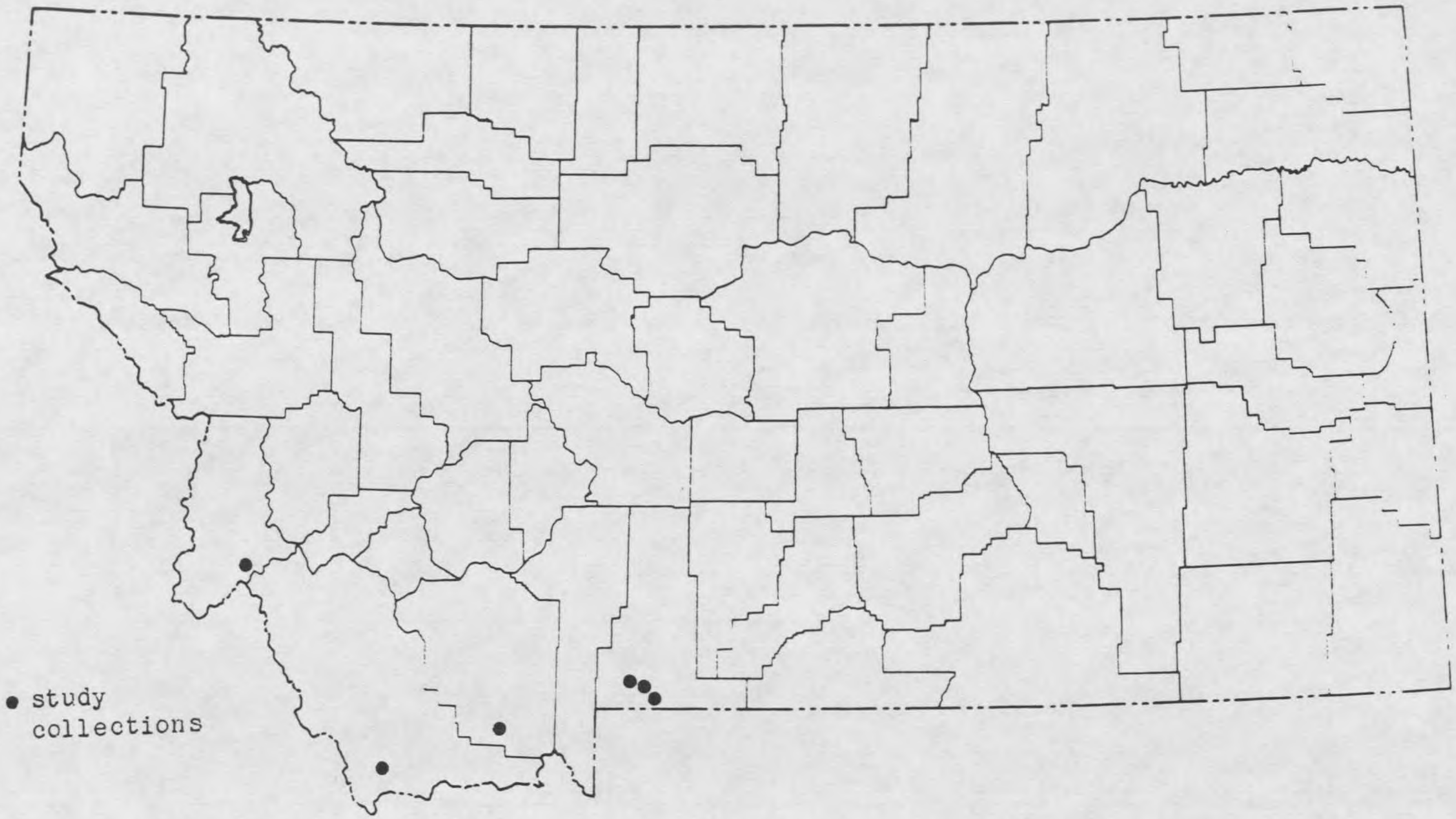

Figure 6. Location of collections and herbarium specimens of C. n. ssp. consimilis.

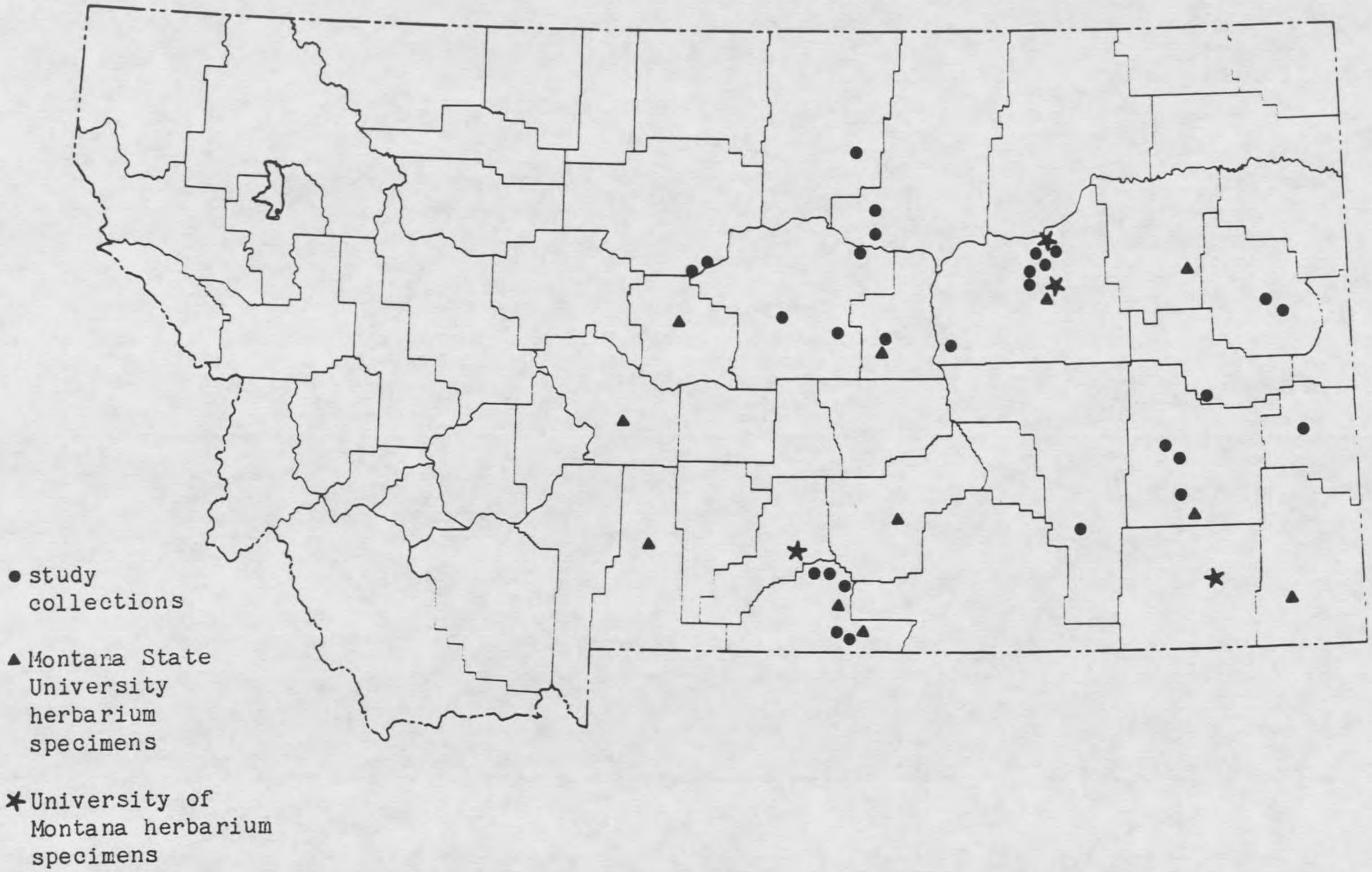

Figure 7. Location of collections and herbarium specimens of C. n. ssp. graveolens.

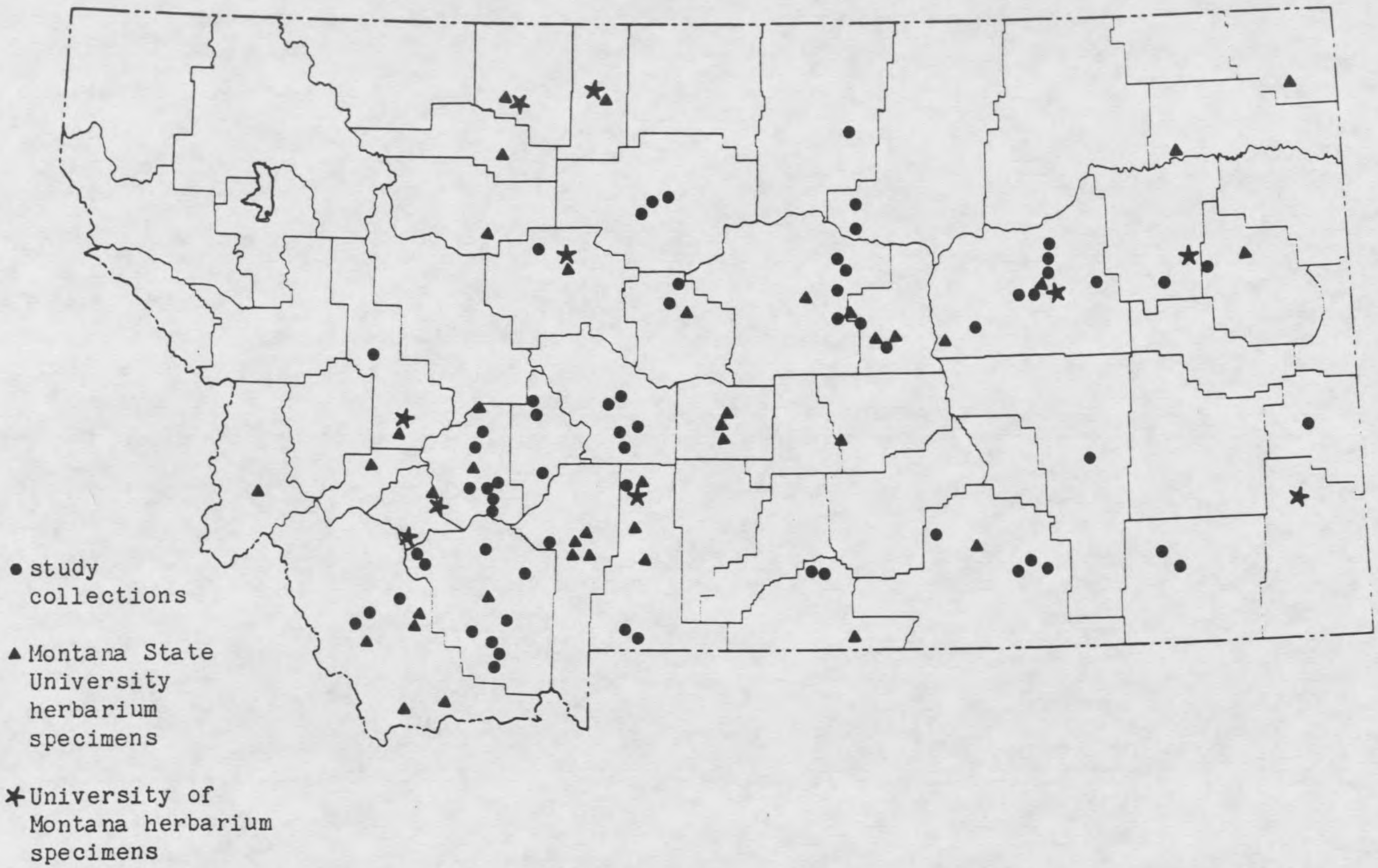

Figure 8. Location of collections and herbarium specimens of C. n. ssp. nauseosus.

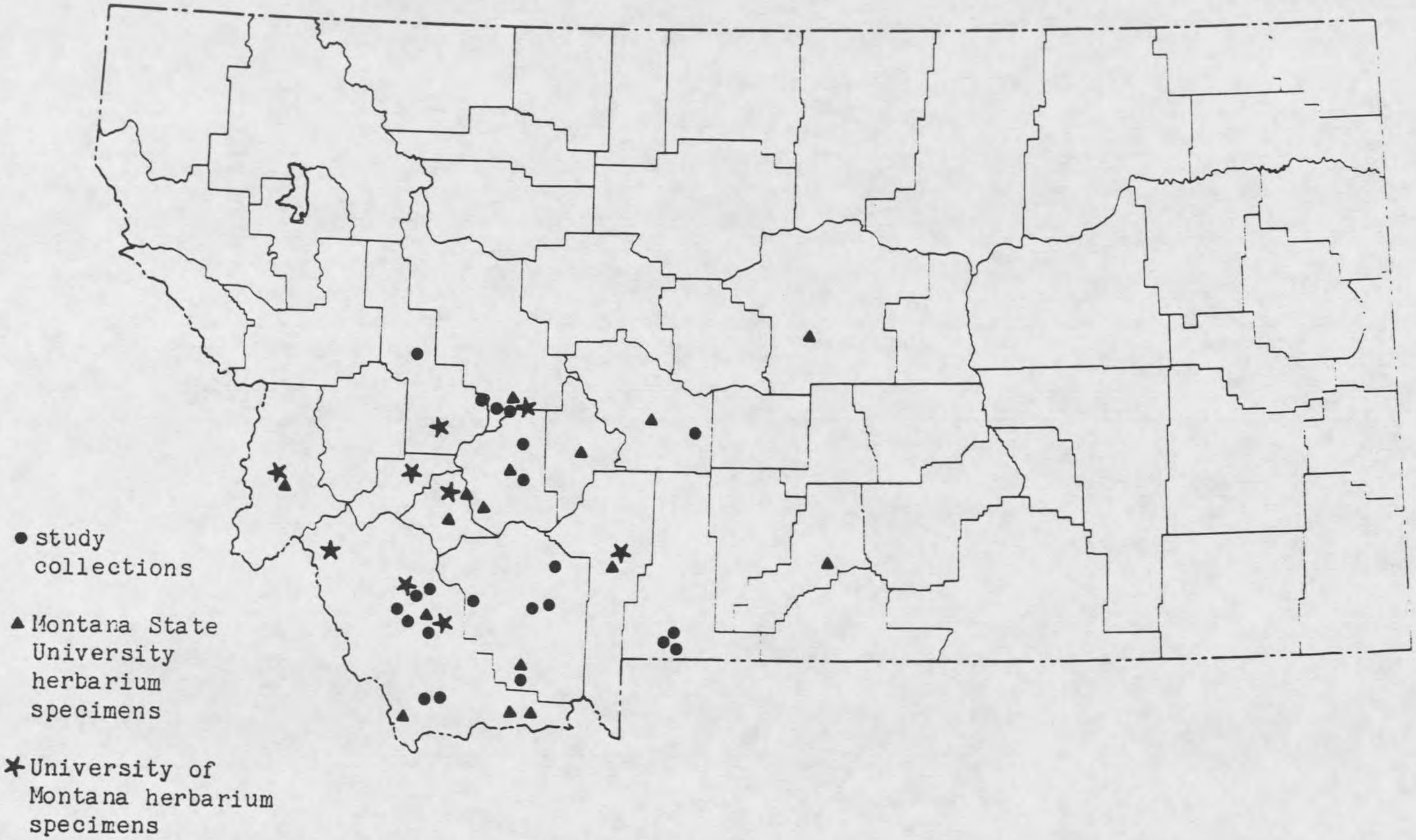

Figure 9. Location of collections and herbarium specimens of C. v. ssp. lanceolatus.

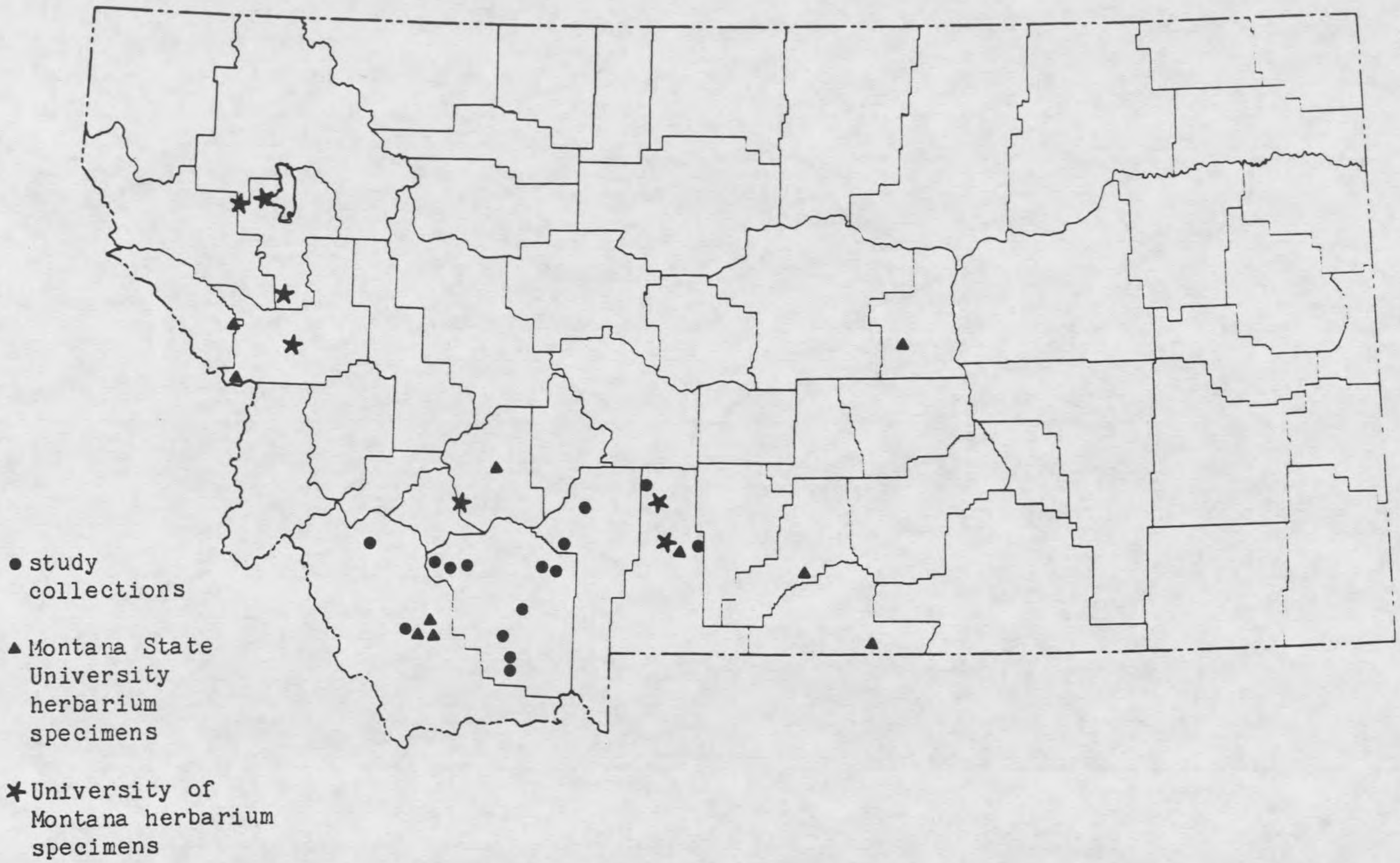

Figure 10. Location of collections and herbarium specimens of C. v. ssp. viscidiflorus.

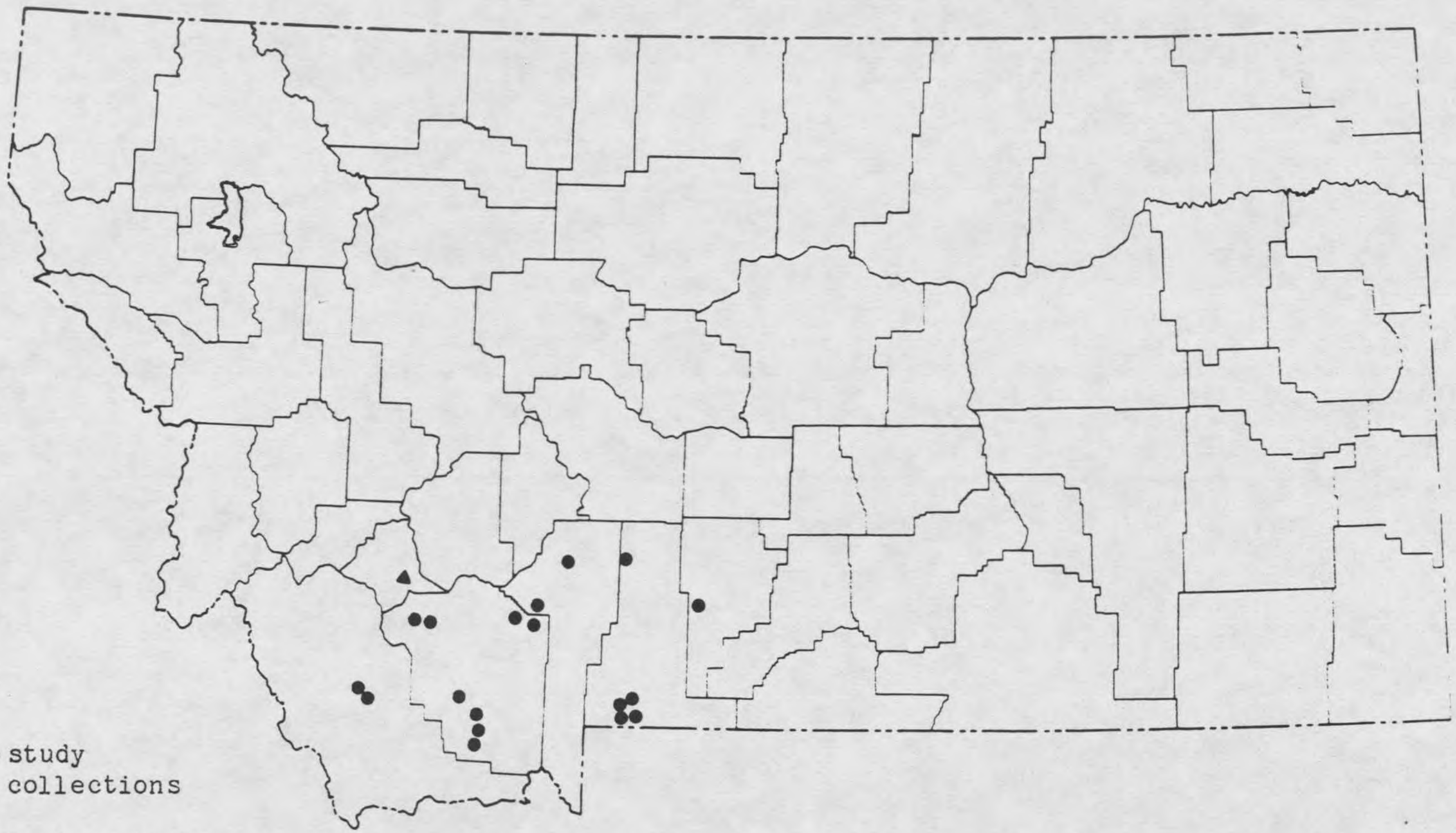

Figure 11. Location of collections of C. v. ssp. viscidiflorus var. stenophyllus.

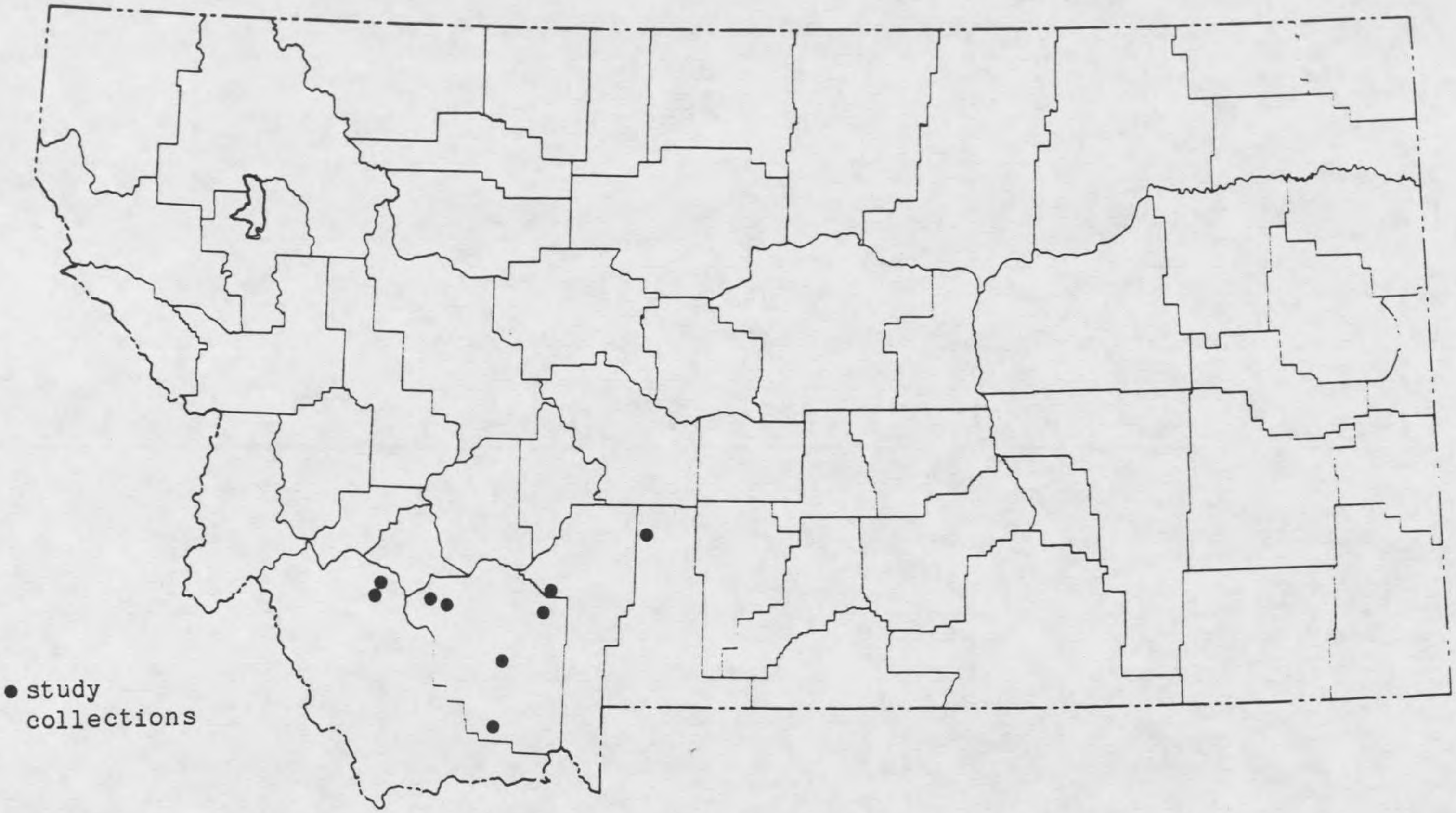

Figure 12. Location of collections of C. v. ssp. viscidiflorus var. viscidiflorus.

distributions. Herbarium specimens with insufficient information on location have been noted at the county seat.

C. n. ssp. nauseosus is the most widespread taxon in Montana (Fig. 8). C. linifolius is limited to a small area in the south central part of the State (Fig 4). Although Hall and Clements (1923) listed C. v. ssp. puberulus as occurring in Montana (Table 5), no specimens of C. v. ssp. puberulus were found. According to a map of distribution by Anderson (1986a), C. v. ssp. puberulus does not occur as far north as Montana. Anderson (1980b) illustrated that the distribution of C. v. ssp. viscidiflorus var. stenophyllus did not extend into Montana. However, C. v. ssp. viscidiflorus var. stenophyllus was found and collected more frequently than C. v. ssp. viscidiflorus var. viscidiflorus.

The majority of Chrysothamnus taxa are sympatric over all or part of their range in Montana, particularly in the western half (Figs. 3-11). C. n. ssp. graveolens appears sympatric with only C. n. ssp. nauseosus and C. linifolius (Fig. 4,7,8). Additionally, C. linifolius is sympatric over part of the range of C. n. ssp. nauseosus (Fig. 4,8).

Habitat of Montana Chrysothamnus

Chrysothamnus parryi ssp. glandulosus

Characteristically C. p. ssp. glandulosus was found in small populations. The 7 sites sampled averaging 85 m^2 in size (Table 5). Sites were grassy openings among Artemisia tridentata - grassland type

Table 5. Legal descriptions and range sites[a] for 7 <u>Chrysothamnus parryi</u> ssp. <u>glandulosus</u> and sample plot size.

Site	County	Legal description	Range site	Plot size (m)
Bureau of Land Management	Beaverhead	NW 1/4, Sec.1, T1S, R11W	silty range site 15-19" P. Z.	4.0x10.5
Coal Creek	Madison	NE 1/4, Sec.29, T11S, R3W	silty range site 20-24" P. Z.	5.8x6.8
Centennial Valley	Beaverhead	SW 1/4, Sec. 5, T13S, R4W	silty range site 10-14" P. Z.	5.0x8.5
Helen Larson	Beaverhead	SW 1/4, Sec.6 T6S, R14W	silty range site 15-19" P. Z.	6.0x10
Jerry Creek	Silverbow	NW 1/4, Sec.30 T1N, R10W	silty range site 15-19" P. Z. bordering on subalpine fir, Douglas-fir climax forests on deep soils with cryic temperature regimes and pale brown or light brownish gray surfaces on moderately steep to very steep slopes 20-45" P. Z.	4.0x13.7

Table 5. continued

Site	County	Legal description	Range site	Plot size (m)
Quartz Hill	Beaverhead	NE 1/4, Sec.8 T1S, R10W	silty range site 15-19" P. Z. bordering on subalpine fir, Douglas-fir climax forests on deep soils with cryic temperature regimes and pale brown or light brownish gray surfaces on moderately steep to very steep slopes 20-45" P. Z.	8.0x10
Riverside	Beaverhead	NW 1/4, Sec.1 T1S, R11W	silty range site 15-19" P. Z.	8.0x16.4

Table 6. Habitat description for 7 *Chrysothamnus parryi* ssp. *glandulosus* sampling sites.

Site	Elevation (m)	Annual Ppt	Soil Texture	Soil Depth	Aspect	Slope (%)	Type of disturbance[a]
Riverside	1708	406			east	6-10	r,f,ds
taxon plot			sandy-loam	shallow			
paired plot			sandy-loam	shallow			
Quartz Hill	1739	419			level	0-2	r
taxon plot			loam	normal			
paired plot			sandy-loam	normal			
Jerry Creek	1769	432			level	0-2	r
taxon plot			loam	normal			
paired plot			loam	normal			
Centennial Valley	1830	356			level	0-2	r
taxon plot			sandy-loam	normal			
paired plot			sandy-loam	normal			

Table 6. continued

Site	Elevation (m)	Annual Ppt	Soil Texture	Soil Depth	Aspect	Slope (%)	Type of disturbance[a]
Bureau of Land Management	1983	406			south-west	3-5	g
taxon plot			sandy-loam	normal			
paired plot			loam-sandy-loam	normal			
Coal Creek	2135	588			west	10-20	wr
taxon plot			sandy-loam	normal			
paired plot			loam-sandy-loam	normal			
Helen Larson	2227	483			west	3-5	g
taxon plot			sandy-loam	shallow			
paired plot			sandy-loam	shallow			

[a] r=road, f=fire, ds=dump site, g=grazing, wr=wind erosion

communities. Elevations at the 7 sites ranged from 1788 to 2227 m (5862-7300 ft) and annual precipitation varied from 356 to 588 mm (14-23 in) (Table 6). Slopes ranged from 0-20% and aspects varied (Table 6).

Soil pH averaged between 7 and 8, increasing slightly with depth (Table 7). There was no difference in pH between the taxon plots and the paired plots. Electrical conductivities were all very low, indicating low content of soluble salts. There was no real difference in soluble salt content between the taxon and paired plots (Table 8). All sites were loamy to sandy loam in texture throughout their profile with 2 exceptions (Table 6). At 2 sites, Jerry Creek and Bureau of Land Management, textures were silt loam at the 6-12" depths on the taxon plots. Soil characteristics measured provided little insight as to what edaphic factor(s) might be determining occurrence of C. p. ssp. glandulosus.

Table 7. pH means (ranges) of soils from 7 Chrysothamnus parryi ssp. glandulosus collection sites.

Soil Depth	C. p. ssp. glandulosus plot	paired plot
0 - 2 in	7.13 (6.01 - 8.17)	7.28 (6.06 - 8.34)
2 - 6 in	7.53 (6.22 - 8.87)	7.73 (6.30 - 8.78)
6 - 12 in	7.82 (6.39 - 8.87)	7.83 (6.39 - 9.20)

Table 8. Soil electrical conductivity (mmhos) means (range) from 7 *Chrysothmnus parryi* ssp. *glandulosus* collection sites.

Soil Depth	*C. p.* ssp. *glandulosus* plot	paired plot
0 -2 in	0.72 (0.2 - 1.7)	0.51 (0.3 - 1.1)
2 - 6 in	0.31 (0.1 - 0.7)	0.30 (0.1 - 0.5)
6 - 12 in	0.34 (0.1 - 0.7)	0.30 (0.1 - 0.5)

Communities with *C. p.* ssp. *glandulosus* averaged 13% grass basal coverage, 9% shrub canopy coverage, and 17% bare ground. The most common associated woody species included *Artemisia frigida*, *A. tridentata*, *A. tripartita*, *C. nauseosus*, and *C. viscidiflorus*. All 7 collection sites were silty range sites located in the foothills and mountains geographical area, but had varying amounts of precipitation (Table 5). As with soil parameters, plant parameters of grass basal coverage, shrub canopy coverage and bare ground also failed to explain differences.

Disturbance had occurred at all 7 sites on the *C. p.* ssp. *glandulosus* plots and the associated paired plots (Table 6). All sites except for the Coal Creek site were found close to a road. Four of these sites, Quartz Hill, Jerry Creek, Centennial Valley, and Riverside, appeared disturbed as a result of mechanical means, possibly parking lots for heavy equipment. The 2 other road site locations, Helen Larson Ranch and Bureau of Land Management, were heavily used by cattle. The remaining location, Coal Creek, was a blowout site near the summit of a ridge.

A colonizer is any taxon having an ability to establish and spread as a result of human or natural disturbance (Stebbins 1965). This appears to be a strategy of C. p. ssp. glandulosus. Disturbance is a factor involved in its occurrence and distribution. Other Chrysothamnus taxa are recognized colonizers of disturbed plant communities (McArthur et al. 1978b, McArthur and Welch 1986). Known members of the Chrysothamnus genus express the following characteristics that Baker (1965) lists as contributing to the success of colonizing species: facultative self compatibility; high seed production in favorable environmental conditions; seeds equipped for long and short distance dispersal; phenotypic plasticity to climatic and edaphic variation; vigorous vegetative reproduction; and rapid seedling establishment. The rate of seedling establishment and seed production strategies of C. p. ssp. glandulosus are not yet known, however, this taxon does express the other characteristics.

An explanation for the occurrence of C. p. ssp. glandulosus in small isolated populations, but its absence on similar adjacent sites, might be that it has strong colonizing ability, but is sensitive to extreme grazing. C. p. ssp. glandulosus appears to require medium to lighter textured, near-neutral soils, that are low in soluble salts (Tables 6-8). Perhaps it is able to exploit these sites when they are opened up by disturbances such as compaction and vegetation removal due to heavy machinery traffic, heavy grazing and browsing with accompanying trampling, or by soil layer removal by wind. Once it is established, it spreads vigorously by underground roots. Evidence was apparent at each study site that the taxon is browsed heavily (near 100% of current years growth) each year (Table 9). This may explain why this taxon has not been previously recognized. Severe browsing of this taxon might be limiting further expansion and/or eliminating it from adjacent disturbed sites.

It is possible that the site parameters measured or perhaps the sampling techniques employed did not isolate the factor or combination of factors determining the location of this taxon. Since it is a successful colonizer it may lack the ability to compete with higher successional species. The sampling employed did not detect advanced successional development on the associated paired plots compared to the new taxon plots.

Table 9. Percent of _Chrysothamnus parryi_ ssp. _glandulosus_ plants browsed at 7 sampling sites.

	site						
	1[a]	2[b]	3[c]	4[d]	5[e]	6[f]	7[g]
Plants browsed (includes past and this season)	100	100	97	100	91	80	98
Plants browsed by mid-summer, 1986	40	--	3	86	5	--	7

[a]Bureau of Land Management
[b]Coal Creek
[c]Centennial Valley
[d]Helen Larson Ranch
[e]Jerry Creek
[f]Quartz Hill
[g]Riverside

Chrysothamnus nauseosus

In Montana C. nauseosus subspecies were found widely distributed (Figs. 5-8) on a variety of habitats. The type specimen of C. n. ssp. nauseosus is in Montana on the banks of the Missouri River (Hall and Clements 1923). Specimens of C. n. ssp. nauseosus were collected on soils ranging from clay to sandy loam on a variety of slopes and aspects. Estimated annual precipitation on collection sites ranged from 280 to 510 mm (11-20 in) and elevations ranged from 700 to 2300 m (2300-7500 ft). C. n. ssp. nauseosus was found in Artemisia tridentata - Pseudoroegneria spicata and A. tridentata - Bouteloua gracilis dominated communities. On occasion it was found with Distichlis stricta. In southeastern Montana, C. n. ssp. nauseosus was found associated with Schizachyrium scoparium and Calamovilfa longifolia. Specimens were often collected in severely overgrazed pastures and along roadsides. It was found on many range sites in all 5 geographical areas of Montana (Table 10).

C. n. ssp. graveolens was found on sites with a variety of slopes and aspects, at elevations from 640 to 1500 m (2100-5000 ft). Annual precipitation on these sites ranged from 280 to 380 mm (11-15 in). It was often associated with Sarcobatus vermiculatus and Atriplex spp., and in the southeastern part of the State with Artemisia tridentata and Bouteloua gracilis. Although the range of C. n. ssp. nauseosus overlaps that of C. n. ssp. graveolens, rarely was C. n. ssp. nauseosus found with Sarcobatus vermiculatus. This suggests that C. n. ssp. graveolens is more salt tolerant than C. n. ssp. nauseosus.

Table 10. Range sites[a] of *Chrysothamnus* taxa in Montana.

Geographical area and range site	Occurring taxa
Eastern Glaciated Plains	
silty-clayey range site complex 10-14" P. Z.	*C. n.* ssp. *graveolens* *C. n.* ssp. *nauseosus*
Western Glaciated Plains	
silty range site, 10-14" P. Z.	*C. n.* ssp. *nauseosus*
silty-clayey range site complex, 10-14" P. Z.	*C. n.* ssp. *nauseosus*
clayey and shallow clay range site association, 10-14" P. Z.	*C. n.* ssp. *nauseosus*
Eastern Sedimentary Plains	
silty range site, 10-14" P. Z.	*C. n.* ssp. *graveolens* *C. n.* ssp. *nauseosus*
silty-clayey range site complex, 15-19" P. Z.	*C. n.* ssp. *nauseosus*
clayey and shallow range site association, 10-14" P. Z.	*C. n.* ssp. *graveolens* *C. n.* ssp. *nauseosus*
riverbreaks, 10-14" P. Z.	*C. n.* ssp. *graveolens* *C. n.* ssp. *nauseosus*
badlands, 10-14" P. Z.	*C. n.* ssp. *graveolens*

Table 10. continued

Geographical area and range site	Occurring taxa
Western Sedimentary Plains	
clayey and shallow clay range site association 10-14" P. Z.	C. n. ssp. graveolens C. n. ssp. nauseosus
clayey and shallow clay range site association 15-19" P. Z.	C. n. ssp. nauseosus
dense clay-clayey-saline upland range site complex, 5-9" P. Z.	C. linifolius C. n. ssp. graveolens
river breaks 10-14" P. Z.	C. n. ssp. graveolens
Foothills and Mountains	
silty range site 10-14" P. Z.	C. n. ssp. albicaulis C. n. ssp. consimilis C. n. ssp. nauseosus C. p. ssp. glandulosus C. v. ssp. lanceolatus C. v. ssp. viscidiflorus var. stenophyllus var. viscidflorus
silty range site 15-19" P. Z.	C. n. ssp. albicaulis C. n. ssp. consimilis C. n. ssp. nauseosus C. p. ssp. glandulosus C. v. ssp. lanceolatus

Table 10. continued

Geographical area and range site	Occurring taxa
Foothills and Mountains	
silty range site 15-19" P. Z.	*C. v.* ssp. *viscidiflorus* var. *stenophyllus* var. *viscidflorus*
silty range site 20-24" P. Z.	*C. n.* ssp. *nauseosus* *C. p.* ssp. *parryi* *C. v.* ssp. *viscidiflorus* var. *stenophyllus*
silty-clayey range site complex, 10-14" P. Z.	*C. n.* ssp. *albicaulis* *C. n.* ssp. *nauseosus* *C. v.* ssp. *viscidiflorus* var. *stenophyllus* var. *viscidiflorus*
silty-clayey range site complex, 15-19" P. Z.	*C. n.* ssp. *albicaulis* *C. n.* ssp. *graveolens* *C. n.* ssp. *nauseosus* *C. v.* ssp. *viscidiflorus* var. *viscidiflorus*
limy-shallow-very shallow range site 10-14" P. Z.	*C. n.* ssp. *albicaulis* *C. n.* ssp. *nauseosus* *C. v.* ssp. *lanceolatus* *C. v.* ssp. *viscidiflorus* var. *stenophyllus*

Table 10. continued.

Geographical area and range site	Occurring taxa
Foothills and Mountains	
subalpine fir, douglas-fir,and ponderosa pine climax forests on deep soils with cryic or frigid temperature regimes and grayish brown, light brownish gray, or light yellowish brown surfaces on moderately steep to very steep mountain slopes west of the continential divide 16-70" P. Z.	_C._ _n._ ssp. _albicaulis_ _C._ _n._ ssp. _consimilis_

Ross and Hunter 1976.

The type locality of C. n. ssp. graveolens is on the banks of the Missouri River in denuded soil (Hall and Clements 1923). C. n. ssp. graveolens was most often found on sites with highly eroded or poorly developed soils, clay to sand in texture. Examples of such sites include highly erodible badland soils, drainages, and roadcuts. However, it was also found in deeper soils such as clay breaks of the Missouri river and receded shore lines of Fort Peck lake. C. n. ssp. graveolens was found on several range sites in the western and eastern sedimentary plains and locally in the southwestern eastern glaciated plains (Table 10).

C. n. ssp. albicaulis is a foothill and mountain type (Hanks et al. 1975, Anderson 1986c). Herbarium specimens and collections from Montana were found at sites ranging from 732 to 2440 m (2400-8000 ft) in elevation and from 290 to 710 mm (11-28 in) annual precipitation. Most Chrysothamnus grow in basic soils, but C. n. ssp. albicaulis may occur on acid soils (Plummer 1977). All the specimens of C. n. ssp. albicaulis collected were found on medium to light textured soils (silt to sand). One herbarium specimen noted a collection site with a clay loam soil.

C. n. ssp. albicaulis occurred in association with such taxa as Pseudoroegneria spicata, A. tridentata, Festuca idahoensis, Artemisia cana, Stipa comata, and Oryzopsis hymenoides. On more mesic sites it was collected with Rhus trilobata, Purshia tridentata, and Prunus virginiana. C. n. ssp. albicaulis was found on several range sites but was limited to the foothills and mountains geographical area (Table 10).

Few specimens of C. n. ssp. consimilis were collected and no herbarium mounts of this taxon were located. In Utah, C. n. ssp. consimilis characteristically grows on dry lowlands where drought and alkali might be restrictive to C. n. ssp. albicaulis and C. n. ssp. graveolens (Hanks et al. 1975). Often C. n. ssp. consimilis occurs in association with Sarcobatus vermiculatus on alkaline flats (Weber et al. 1985). However, this was not the case in Montana. C. n. ssp. consimilis was most commonly found associated with Artemisia tridentata and Pseudoroegneria spicata.

C. n. ssp. consimilis sites ranged from 280 to 420 mm (11-16.5 in) annual precipitation and from 1373 to 1912 m (4500-6270 ft) in elevation. It was found on silt to loam soils with variable slopes and aspects. Anderson (1981) reported that soils of C. n. ssp. consimilis had pHs ranging from 5.6 to 8.6 and electrical conductivity ranging from 0.2 to 250 mmhos/cm. (Anderson 1981). C. n. ssp. consimilis was found on a few range sites in the foothills and mountains geographic area (Table 10).

Chrysothamnus viscidiflorus

C. viscidiflorus is one of the most widely distributed shrubs on rangelands throughout North America and has great ecological amplitude (Anderson 1986b). In western Montana it inhabits a wide range of habitats. Herbarium mounts and collections of C. v. ssp. lanceolatus from Montana have been found from 1190 to 2380 m (3900-7800 ft) in elevation. Often this type was found in heavily grazed pastures with

Artemisia tridentata - Poa spp., Artemisia frigida - Artemisia filifolia - Pseudoroegneria spicata, and Koeleria pyramidata - Festuca idahoensis - Stipa spp. Precipitation on these sites ranged from 300 to 510 mm (12-20 in). Collections during this study were made only on light textured soils ranging from silt to sand. Mounted specimens acc. # 14391 (MONTU) and acc. # 45706 (MONT) reported clay loam soils. This taxon was limited to a few range sites in the foothills and mountains geographical region (Table 10).

C. v. ssp. viscidiflorus is one of the most widespread taxa in the genus (Anderson 1986b). It is reported to be well suited on moist to arid disturbed sites (Anderson 1986b), dry plains and hillsides among rocks (Hall and Clements 1923), and from low to high elevations (McArthur et al. 1978a). Anderson (1986b) reports the few soils of C. v. ssp. viscidiflorus tested ranged in pH from 6 to 8.4 (Anderson 1986b). Herbarium specimens of C. v. ssp. viscidiflorus from Montana were keyed only to the subspecies level. Most specimens that had soil information reported silty to sandy textured soils with a few exceptions, acc. # 20053 (MONT), acc. # 44715 (MONT) (noted as having broader leaves like C. v. ssp. viscidiflorus var. viscidiflorus), acc. # 45107 (MONT), and acc. # 44726 (MONT), which were noted to be found on clayey soils.

Collected specimens of C. v. ssp. viscidiflorus from Montana were further keyed to the variety. C. v. ssp. viscidiflorus var. viscidiflorus was collected on sites with silt to sandy loam soils with a variety of slopes and aspects. Precipitation ranged on these sites from 330 to 460 mm (13-18 in) and elevation ranged from 1403 to 2104 m

(4600-6900 ft). C. v. ssp. viscidiflorus var. viscidiflorus was found associated with Rosa spp., Artemisia tridentata, Poa spp., and Leymus cinereus. It was found to occur in foothill and mountains geographical area (Table 10). C. v. ssp. viscidiflorus var. stenophyllus specimens were collected on variable slopes and aspects of light textured soils. This taxon was found occurring with Artemisia tridentata-Pseudoroegneria spicata, Stipa comata, and Pascopyrum smithii at elevations from 1220 to 2196 m (4000-7200 ft) and precipitation zones from 310 to 510 mm (13-20 in) yearly. It was located on several range sites in the foothills and mountains geographical region (Table 10).

Chrysothamnus linifolius

In Montana, specimens of C. linifolius were collected at only 1 location. This location was disturbed and lies in a part of Carbon County inhabited by salt desert shrub species. This taxon is known in other states as growing in alkaline and sandy soils. It appears to favor similar sites in Montana. It was found in only 1 range site in the western sedimentary plains (Table 10).

Overlapping taxa

Several Chrysothamnus taxa in Montana appear to have overlapping habitat requirements (Table 11). And, as evidenced above, several express the ability to inhabit and adapt to a variety of conditions. This ability enables these taxa to disperse to new sites when competition from higher successional species occurs. It reinforces the notion that the ecological role of several Chrysothamnus taxa is one of colonization.

Table 11. Range sites[a] at which multiple Chrysothamnus taxa were collected.

Geographical area and range site	Taxa collected at same site
Foothills and Mountains	
silty range site 10-14" P. Z.	C. n. ssp. nauseosus C. v. ssp. lanceolatus
silty range site 15-19" P. Z.	C. n. ssp. albicaulis C. n. ssp. nauseosus C. v. ssp. viscidiflorus var. stenophyllus
	C. n. ssp. albicaulis C. n. ssp. nauseosus
	C. n. ssp. nauseosus C. v. ssp. lanceolatus
silty range site 20-24" P. Z.	C. n. ssp. albicaulis C. n. ssp. nauseosus C. v. ssp. lanceolatus
silty-clayey range site complex 10-14" P. Z.	C. n. ssp. albicaulis C. n. ssp. nauseosus C. v. ssp. viscidiflorus var. viscidiflorus
	C. v. ssp. viscidiflorus var. stenophyllus var. viscidiflorus
	C. n. ssp. albicaulis C. v. ssp. viscidiflorus var. stenophyllus
	C. n. ssp. nauseosus C. v. ssp. lanceolatus

Table 11. continued

Geographical area and range site	Taxa collected at same site
silty-clayey range site complex 10-14" P. Z.	C. n. ssp. nauseosus C. v. ssp. viscidiflorus var. stenophyllus var. viscidiflorus
silty-clayey range site complex 15-19 P. Z.	
	C. v. ssp. viscidiflorus var. stenophyllus var. viscidiflorus C. n. ssp. nauseosus C. v. ssp. viscidiflorus
	C. n. ssp. nauseosus C. v. ssp. viscidiflorus var. viscidiflorus
	C. n. ssp. albicaulis C. n. ssp. nauseosus
subalpine fir, douglas-fir climax	C. n. ssp. nauseosus
forests on deep soils with cryic temperature regimes and pale brown or ligh brownish gray surfaces on moderately steep to very steep mountain slopes 20-45" P. Z.	C. v. ssp. lanceolatus
subalpine fir, douglas-fir, ponderosa pine climax forests on deep soils with cryic or frigid temperature regimes on and grayish brown, light brownish gray, or light yellowish brown surfaces on moderately steep to very steep mountain slopes west of the continential divide 16-70" P. Z.	C. n. ssp. albicaulis C. n. ssp. consimilis
Eastern Glaciated Plains	
silty-clayey range site complex 10-14" P. Z.	C. n. ssp. graveolens C. n. ssp. nauseosus

Table 11. continued

Geographical area and range site	Taxa collected at same site
Western Sedimentary Plains	
clayey and shallow clay range site association 10-14" P. Z.	C. n. ssp. graveolens C. n. ssp. nauseosus
river breaks 10-14" P. Z.	C. n. ssp. graveolens C. n. ssp. nauseosus

Browsing of Montana Chrysothamnus Taxa

C. p. ssp. glandulosus appears to be palatable to wildlife and livestock. Past evidence of browsing indicates that the current year's growth is generally browsed to the ground annually (Table 9). On 2 sites, which were actively stocked with cattle at the time of sampling, 86% and 40% use had been reached by midsummer (Table 9). C. p. ssp. glandulosus occurs so infrequently and in such small quantities that it is unlikely to be a major component of wildlife diets in southwestern Montana.

C. n. ssp. nauseosus and C. n. ssp. graveolens were the other 2 types of Chrysothamnus taxa observed to be browsed significantly in Montana. Often plants of C. n. ssp. nauseosus were severely grazed. Plants of C. n. ssp. nauseosus collected at site 8/26/2 were browsed to dwarf forms. One collection (8/26/2a) was hedged so severely that little of the base remained, making it appear deformed.

The use of C. n. ssp. nauseosus agrees with the observations of McArthur et al. (1979b) that the gray group, containing C. n. ssp.

nauseosus, is more palatable than the green group. However, C. n. ssp. graveolens (belonging to the green group) was found to be browsed often also, occasionally quite heavily (site 8/27/2). Current use of this taxon was observed in May of 1986 on the banks of the Missouri river.

Browsing was most often observed in the eastern half of Montana. This is the extent of the range of C. n. ssp. graveolens (Fig. 7), yet, C. n. ssp. nauseosus extends over to the western half of Montana (Fig. 8). Notable use on plants of C. n. ssp. consimilis and C. viscidiflorus was observed in areas north of Yellowstone National Park near Gardiner, MT.

Pronghorn and mule deer are likely consumers of Chrysothamnus taxa in Montana. In Rosebud and Garfield counties, Montana, Chrysothamnus was found to be an important winter browse of mule deer. Along with Artemisia species and Juniperus species, it made up greater than 60% of the diet at both sites (Eustace 1971). In Rosebud county Chrysothamnus accounted for 36.8% of the winter diet, the largest single component.

Hall and Clements (1923) suggested the palatablity of Chrysothamnus taxa is dependent on the species in which they are associated. Perhaps this is the case in Montana. Little literature was found regarding Chrysothamnus taxa contributions to wildlife in Montana.

Additional Uses for Chrysothamnus Taxa in Montana

There are several additional contributions Chrysothamnus taxa make to Montana. Chrysothamnus taxa were often found on sites in Montana with soils that were severely eroded. Several taxa could be very useful in reclaiming mine spoils, roadsides, and other disturbed soils in their respective ranges. Plummer (1977) rated all *Chrysothamnus* taxa high for reclamation purposes based on factors such as establishment, spread, growth rate, soil stabilization, and adaptation to disturbance. McArthur (1983) recommended several *Chrysothamnus* taxa for stabilizing disturbed soils in the Intermountain Area. Some of these taxa occur in Montana and might be similarly employed. *C. n.* ssp. *consimilis* is recommended for stabilizing disturbed soils that are poorly drained or heavy textured. *C. linifolius* can stabilize intermittent drainage canals. It is valuable for stabilizing disturbed soil due to a strong underground spreading characteristic (McArthur et al. 1974). *C. n.* ssp. *albicaulis* and *C. viscidiflorus* will provide similar stabilization on well drained, dry, rocky soils (McArthur 1983).

Chrysothamnus taxa in Montana flower late in the summer generally after other bright flowered plants have finished blooming. *Chrysothamnus* taxa, particularly *C. nauseosus* subspecies, can be used in landscaping to add color to parks, yards, and roadsides. *C. n.* ssp. *albicaulis*, with yellow, very showy flowers, is suitable as an ornamental (McArthur et al. 1979a).

In addition to providing browse, *Chrysothamnus* provides cover for pronghorn. Yoakum (1986) suggests that *Chrysothamnus* should be managed as a needed component on pronghorn rangelands.

Laycock and Shoop (1982) reported that *C. linifolius* and *C. nauseosus* make excellent living snow fences in northeastern Colorado. Similarly *Chrysothamnus* taxa could be employed as natural snow fence in

Montana especially C. n. ssp. graveolens. It has a wide range in the eastern half of the State and it grows to 12 dm.

SUMMARY

During the summers 1985 and 1986, 8 previously described taxa and 1 uncharacterized taxon of *Chrysothamnus* were located in Montana. This new taxon, *Chrysothamnus parryi* ssp. *glandulosus* is differentiated from other *C. parryi* taxa, with the exception of *C. p.* ssp. *asper*, by conspicuous stalked glands. It differs from *C. p.* ssp. *asper* by inflorescence arrangement, number of flowers per head, and location. The inflorescence of *C. p.* ssp. *glandulosus* is arranged in a cyme while *C. p.* ssp. *asper* has an inflorescence arranged in a raceme. *C. p.* ssp. *glandulosus* has 10 to 14 flowers per head. *C. p.* ssp. *asper* has 5 to 10 flowers per head. *C. p.* ssp. *asper* is located in Nevada and California. *C. p.* ssp. *glandulosus* is similar to *C. p.* ssp. *imulus* and *C. p.* ssp. *montanus*, but differs by characteristics such as leaf length, leaf width, and the number of flowers per head.

C. p. ssp. *glandulosus* expresses 2 varieties. *C. p.* ssp. *glandulosus* var. *tomentosus* is covered with tomentum which obscures the stalked glands. The typical form, *C. p.* ssp. *glandulosus* ssp. *glandulosus* lacks tomentum.

Four subspecies of *C. nauseosus* were found to occur in Montana. Two, *C. n.* ssp. *nauseosus* and *C. n.* ssp. *albicaulis*, fall into the gray group, which typically have gray stems and pubescence to tomentum on the involucres. Variants in stem color, ranging from bright green to cottony white, were found in both taxa. *C. n.* ssp. *consimilis* and *C. n.* ssp. *graveolens* belong to the green group, which have green stems and glabrous involucres.

Three taxa of C. viscidiflorus were found. Two subspecies, C. v. ssp. lanceolatus and C. v. ssp. viscidiflorus, are differentiated by the presence and type of vestiture on the stems and leaves. Two varieties of C. v. ssp. viscidiflorus occur in Montana. These were differentiated primarily by leaf width. C. v. ssp. viscidiflorus var. viscidiflorus has leaves greater than 1.5 mm wide and the leaves of C. v. ssp. viscidiflorus var. stenophyllus range between 1 and 1.5 mm wide. Many variants were found of these 3 taxa. This variation might be explained by intergradation, which frequently happens in C. viscidiflorus taxa.

Also C. linifolius, originally described by Hall and Clements as a subspecies of C. viscidiflorus, occurs in Montana. Like C. viscidiflorus, it lacks tomentum characteristic of C. nauseosus. It differs from C. viscidiflorus taxa by its tallness and by its ability to spread by lateral roots.

C. p. ssp. glandulosus was characteristically found in small populations in grassy openings among Artemisia tridentata - grassland type communities. The sites sampled to characterize this taxon's habitat ranged in elevation from 1788 to 2227 m (5862-7300 ft) and annual precipitation varied from 356 to 588 mm (14-23 in). Slopes and aspects were variable. All sites had loam to sandy loam textured soils with pH values between 7 and 8. The communities averaged 13% coverage, 9% shrub canopy coverage, and 17% bare ground. All 7 sites sampled were silty range sites located in the foothills and mountains geographic area, but had varying amounts of precipitation. Disturbance had occurred on all sites.

Adjacent plots without the C. p. ssp. glandulosus were sampled to determine what factor(s) were responsible for this taxon's occurrence. Although disturbance had also occurred on the adjacent plots, this factor, along with soil type, seemed to influence occurrence and distribution of C. p. ssp. glandulosus. It seems able to colonize near neutral, loam to sandy loam soils, low in soluble salts, however, it was absent on adjacent sites with similar characteristics. Sensitivity to extreme grazing may explain absence of C. p. ssp. glandulosus on adjacent sites and the small size of populations in which it occurs. Past evidence of browsing indicates that the current year's growth of C. p. ssp. glandulosus is generally browsed to the ground. Use was found to be 40 and 86% by mid-summer on 2 sites that were actively stocked at the time of sampling.

Chrysothamnus taxa were distributed throughout the State. C. p. ssp. glandulosus was found only in southwestern Montana. C. n. ssp. nauseosus, the most widespread taxon, was found over the entire State. C. n. ssp. albicaulis was limited to the western half of Montana and C. n. ssp. graveolens was distributed in the eastern half. C. n. ssp. consimilis occurred only in the southern portions of the State. C. v. ssp. lanceolatus ranged in the lower half of central to southwestern Montana. C. v. ssp. viscidiflorus shared the same range as C. v. ssp. lanceolatus but extended into northwestern Montana. C. linifolius was found only in Carbon County located in the lower half of central Montana.

C. nauseosus subspecies were distributed on a wide variety of habitats. C. n. ssp. nauseosus was collected on clay to sandy loam soils. Collection sites varied in annual precipitation amounts from 280 to 510 mm (11-20 in) with elevations ranging from 700 to 2300 m (2300-7500 ft). As with _C. n._ ssp. _nauseosus_, _C. n._ ssp. _graveolens_ was often found on disturbed sites. It was commonly associated with _Sarcobatus vermiculatus_ and _Atriplex_ spp.

C. viscidiflorus taxa were also often found on areas where disturbance was evident. Collections of _C. v._ ssp. _lanceolatus_ were made on soils ranging from silt to sand. The 2 varieties of _C. v._ ssp. _viscidiflorus_ were also collected primarily on light textured soils. _C. linifolius_ was found in communities dominated by salt desert shrub species.

Chrysothamnus taxa seem to be important locally to wildlife in Montana. _C. p._ ssp. _glandulosus_ appears to be palatable, but contributes little to wildlife diets because it occurs in such small quantities. However, _Chrysothamnus_ taxa such as _C. n._ ssp. _nauseosus_ and _C. n._ ssp. _graveolens_, are more abundant and widely distributed. These taxa were found severely grazed in several locations and appear to contribute to wildlife diets, particularly in eastern Montana.

Chrysothamnus taxa make additional contributions to Montana. They readily establish on disturbed and depleted areas making them useful for reclamation purposes. They offer color to landscapes after other bright flowered plants have dried up, particularly _C. n._ ssp. _albicaulis_. In addition, _Chrysothamnus_ taxa provide needed cover for wildlife and can be used for live snow fences.

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APPENDIX

Table 12. Summary of vegetation parameters measured at 7 *C. parryi* ssp. *glandulosus* sampling sites.

	Riverside		Jerry Creek		Quartz Hill		Helen Larson Ranch	
	taxon plot	paired plot	taxon plot	paired plot	taxon plot	paired plot	taxon plot	paired plot
% total grass cover	8.5	9.0	13.2	21.2	10.5	8.1	16.3	9.7
% shrub canopy cover total	6.04	4.3	9.89	9.6	5.2	24.7	6.19	5.1
C. parryi	3.54		8.29		2.62		2.59	
other *Chrysothamnus* taxa	1.0	3.5	----	----	----	----	2.2	3.7
Artemisia taxa	1.5	0.5	1.6	1.5	1.5	0.5	2.9	1.4
C. parryi ssp. *glandulosus* density/m^2	0.98		3.28		3.26		1.58	
% Bare ground	5.4	2.2	7.5	1.8	3.7	5.7	3.2	11.2

Table 12. continued

	Coal Creek		BLM		Centennial	
	taxon plot	paired plot	taxon plot	paired plot	taxon plot	paired plot
% total grass cover	12.5	11.0	11.3	14.0	11.7	7.2
% shrub canopy cover						
total	16.94	5.8	10.46	9.1	7.3	18.2
C. parryi	11.64		7.76		2.6	
other *Chrysothamnus* taxa	1.1	1.5	0.9	0.5	1.1	----
Artemisia taxa	4.2	0.2	1.8	5.9	3.6	18.1
C. parryi ssp. *glandulosus* density/m^2	3.04		6.05		1.11	
% Bare ground	33.4	38.7	36.3	22.8	30.7	34.3

Table 13. Habitat notes and locations of specimens of Chrysothamnus and sites noted in the Results and Discussion section.

Taxon and specimen	Soil texture	Aspect	Slope %	Dominant associated plants	Grazing at site	Location description
C. nauseosus ssp. nauseosus						
8/16/4b	silty	east	10-20	Pseudoregneria spicata Artemisia arbuscula	yes	38.1 miles from Alder on Ruby River Reservoir road, Madison County
8/16/5e	silty, gravel		0-2	Artemisia tridentata A. frigida Pseudoregneria spicata	moderate	34.1 miles from Alder on Ruby River Reservoir road, Madison County
8/27/9b	loam		0-2	Artemisia tridentata Bouteloua gracilis	yes	West side of highway 19, 7.45 miles south of junction 191 north, Fergus County
8/26/2b	clayey	west	6-10	Pseudoregneria spicata Grindelia squarrosa	yes	South side of 200s, 15.6 miles southeast of Circle, Dawson County
ssp. albicaulis						
8/29/1a and 1b	loam	east	3-5	Artemisia tridentata	heavy	West side of 89, 9.15 miles north of junction
8/31/3b and 3c	loam	south	3-5	Elymus canadensis Poa spp. Stipa comata	moderate	East side of Bear Trap Recreation road, 2.1 miles south of 84, Gallatin County 12 East, Meagher County

Table 13. continued.

Taxon and specimen	Soil texture	Aspect	Slope %	Dominant associated plants	Grazing at site	Location description
8/31/2c	loam		0-2	*Pseudoregneria spicata*	heavy	North side of 84, 7.55 miles where 86 meets the Madison River on the east side of 84, Madison County
8/26/2a	clayey	west	6-10	*Pseudoregneria spicata* *Grindelia squarrosa*	yes	South side of 200s, 15.6 miles southeast of Circle, Dawson County
C. viscidiflorus ssp. *lanceolatus* 8/16/2a		south	6-10	*Artemisia tridentata*	yes	1.6 miles east of Virginia City southwest of 287, Madison County
8/20/1b		west	0-2	*Artemisia tridentata* *Juniperus scopulorum*	heavy	1.05 miles north of Helmville on 141, Powell County
8/20/2a		south	6-10	*Koeleria cristata* *Festuca idahoensis* *Stipa* spp.	moderate	Priest's Pass road 6.4 miles northwest of 12, 8.3 miles west of Helena, Lewis and Clark County
ssp. *lanceolatus* 8/20/3d		south	6-10	*Koeleria cristata* *Festuca idahoensis* *Stipa* spp.	moderate	Priest's Pass road 6.2 miles northwest of 12, Helena, Lewis and Clark County

Table 13. continued.

Taxon and specimen	Soil texture	Aspect	Slope %	Dominant associated plants	Grazing at site	Location description
ssp. *lanceolatus* 8/31/5a	sandy-loam	west	20+	*Pseudoregneria spicata* *Artemisia cana* *Koeleria cristata* *Poa* spp.	yes	West side of 287, 4.1 miles south of Norris, Madison County
C. v. ssp. *viscidiflorus* var. *stenophyllus* 8/16/4d	silty	east	10-20	*Pseudoregneria spicata* *Artemisia arbuscula*	yes	38.1 miles west from Alder on Ruby River Reservoir road, Madison County
8/24/1a	sandy-loam	north	20+	*Pseudoregneria spicata* *Artemisia cana* *Artemisia frigida* *Artemisia tridentata*	no	On I-90, 0.6 miles west of Springdale exit, Park County
C. v. ssp. *viscidiflorus* var. *viscidiflorus* 8/16/2b		south-west	6-10	*Artemisia tridentata* *Juniperus* spp.	yes	1.6 miles east of Virginia City southwest of 287, Madison County
var. *viscidiflorus* 8/17/4d	silty		0-2	*Artemisia tridentata*	heavy	4.6 miles east of Twin Bridges - Melrose road, Madison County