



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
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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.

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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 Jespersen 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	<u>C. albidus</u> (Jones ex Gray) Greene.	
	<u>C. humilis</u> Greene.	
	<u>C. linifolius</u> Greene.	
	<u>C. spathulatus</u> L. C. Anderson.	
	<u>C. greenei</u> (Gray) Greene.	
	<u>C. viscidiflorus</u> (Hook.) Nutt.	5
Gramini	<u>C. gramineus</u> Hall.	
	<u>C. eremobius</u> L.C. Anderson.	
Nauseosi	<u>C. parryi</u> (Gray) Greene.	12
	<u>C. nauseosus</u> (Pallas) Britt.	22
Pulchelli	<u>C. vaseyi</u> (Gray) Greene.	
	<u>C. molestus</u> (Blake) L.C. Anderson.	
	<u>C. depressus</u> Nutt.	
	<u>C. pulchellus</u> (Gray) Greene.	12
Punctati	<u>C. paniculatus</u> (Gray) Hall.	
	<u>C. teretifolius</u> (Dur. & Hilg.) Hall & Clem.	

^aAnderson 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 Chrysothamni.

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 involucre 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 menziesii, 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/cm² 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 Jespersen (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 appeared 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 varying 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 (Bouyoucos 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
<u>C. linifolius</u>	x	Anderson 1986a. <u>C. viscidiflorus ssp. linifolius</u> by Hall and Clements 1923.
<u>C. nauseosus</u>		
ssp. <u>albicaulis</u>	x	Anderson 1986a, Hall and Clements 1923.
ssp. <u>consimilis</u>	x	Anderson 1986a.
ssp. <u>graveolens</u>	x	Anderson 1986a, Hall and Clements 1923.

Table 2. continued.

Taxon	Located during this study	Reported in the literature
<u>C. nauseosus</u>		
ssp. <u>nauseosus</u>	x	Anderson 1986a. <u>C. n. ssp. typicus</u> by Hall and Clements 1923.
ssp. <u>speciosus</u>		Hall and Clements 1923. Included in <u>C. n. ssp. albicaulis</u> in Anderson 1986a.
<u>C. parryi</u>		
ssp. <u>glandulosus</u>	x	
<u>C. viscidiflorus</u>		
ssp. <u>lanceolatus</u>	x	Anderson 1986a, Hall and Clements 1923.
ssp. <u>puberulus</u>		Hall and Clements 1923.
ssp. <u>pumilis</u>		Hall and Clements 1923. Part of <u>C. v. ssp. viscidiflorus</u> by Anderson 1986a.
ssp. <u>stenophyllus</u>		Hall and Clements 1923. Variety of <u>C. n. ssp. viscidiflorus</u> by Anderson 1980b.
ssp. <u>viscidiflorus</u>	x	Anderson 1986a. Labeled <u>C. v. ssp. typicus</u> by Hall and Clements 1923.
var. <u>stenophyllus</u>	x	
var. <u>viscidiflorus</u>	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. glandulosus 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
<u>C. p. ssp. glandulosus</u>	1-5	1-4	stalked glands	linear-linear oblanceolate	acute	6-9	0.8-1.6	cyme	10-14
<u>C. p. ssp. asper</u>	2-5 ^b	1-3 ^b	short stalked glands ^b	oblanceolate ^a		up to 9 ^a		short raceme ^b	5-10 ^{bc}
<u>C. p. ssp. montanus</u>	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
<u>C. p. ssp. imulus</u>	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

^aAnderson 1986a.

^bHall and Clements 1923.

^cMcArthur et al. 1979a.

^dAnderson 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-oblongate, 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 involucre of C. parryi ssp. glandulosus average 1.13 cm high; bract number ranges from (9) 12 to 16. These involucre 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 involucre bracts that have no or little tomentosity whereas C. parryi ssp. glandulosus var. tomentosus has leaves and involucre 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

