Broom Snakeweed: Toxicology, Ecology, Control and Management

Michael H. Ralphs and Kirk C. McDaniel

Rangeland Scientist, USDA/ARS Poisonous Plant Lab, Logan UT 84341; and Professor, Animal and Range Science Dept., New Mexico State Univ., Las Cruces NM 88003.

Broom snakeweed is a native weed widely distributed on rangelands of western North America. It often increases to near monocultures following disturbance from overgrazing, fire or drought. Dense snakeweed stands are a primary concern because they suppress desirable forage production, but the plant is also toxic, and can cause abortions in livestock. This paper provides a brief review of broom snakeweed toxicology, and compiles recent information on seed ecology, population cycles, control and management. Snakeweed seed germination is light sensitive, thus seeds must remain partially buried on the soil surface, and the soil surface must remain damp for several days. Propagation is usually pulse driven, allowing large expanses of even-aged stands to establish and dominate plant communities. Snakeweed can be controlled by prescribed burning or spraying with herbicides. However, a weed-resistant plant community should be established to prevent or minimize its reinvasion. Managing to maintain the dominant competitive grasses in the respective plant communities can prevent snakeweed dominance.

Nomenclature: broom snakeweed, *Gutierrezia sarothrae* (Pursh) Britt. & Rusby GUESA.

Key words: Invasive weed, poisonous plant.

Broom snakeweed is widely distributed across western North America, from Canada south through the plains to west Texas and northern Mexico, and west through the Intermountain region and into California (Figure 1, Lane 1985). It ranges in elevation between 50 and 2900 m (160 and 9500 ft) and commonly inhabits dry, well-drained, sandy, gravely or clayey loam soils. Threadleaf snakeweed (*G. microcephala* (DC) L. Benson) is similar in growth form and appearance, but differs in that it has only 1-2 florets per flowering head, compared to 3-5 in broom snakeweed. Threadleaf snakeweed occurs mainly in southern deserts, from central Texas through northern Mexico to California, and as far north as southern Utah. Most of this review pertains to broom snakeweed.

Broom snakeweed is a native plant that can increase when other more desirable plants are reduced or removed by disturbance, such as overgrazing, fire or drought. It can dominate many of the plant communities on western rangelands including: salt-desert-shrub, sagebrush, pinyon/juniper plant communities of the Intermountain region; short- and mixed-grass prairies of the plains; and mesquite, creosotebush and desert grassland communities of the southwestern deserts (US Forest Service 1937). In addition to its invasive nature, it contains toxins and can cause abortions in livestock. Platt (1959) ranked it one of the most undesirable plants on western rangelands. Previous reviews discussed the ecology and control of snakeweeds (Huddleston and Pieper 1989, McDaniel and Torell 1987, McDaniel and Sosebee 1988, McDaniel and Ross 2002, Sterling et al. 1999). This paper briefly reviews broom snakeweed toxicology, and presents recent information on its seed ecology, population cycles, control and management.

Chemistry

The toxic and abortifacient compounds in snakeweeds have not been clearly identified. Dollahite et al. (1962) extracted a crude saponin fraction that was demonstrated to induce abortions and death in cows, goats and rabbits. However, saponins are a very broad complex mixture of compounds. Roitman et al. (1994) found specific furano-diterpene acids in broom snakeweed that are structurally similar to isocupressic acid, the abortifacient compound in ponderosa pine needles. Gardner et al. (1999) speculated that whether a cow aborts or is poisoned depends on the concentration of specific diterpene acids.

Crude resins include most of the terpenes and other non-polar carbon-based secondary compounds in broom snakeweed. Crude resin concentration in the old dry stalks from the previous year ranged between 6-8% of the dry weight of the plants (Figure 2). Resins in the new growth increased over the growing season, peaking during flowering (16%), then declining slightly as seeds shattered (Ralphs et al. 2007). Apparently resins in snakeweed accumulate similar to terpenes and resins in other Compositae species, such as big sagebrush (*Artemisia tridentata* subsp. t*ridentata*) (14-25%, Kelsey et al. 1982, Cedarleaf et al. 1983) and rabbitbrush (*Chrysothamnus nauseosus* subsp. *turbinatus*) (36%, Hegerhorst et al. 1988). Like sagebrush and rabbitbrush, the high concentration of crude resins render snakeweed unpalatable to livestock and wildlife.

Toxicology

If animals are forced to eat snakeweed, it can poison the animal and cause abortions. Clinical signs of poisoning include anorexia, nasal discharge, loss of appetite and listlessness, diarrhea, then constipation and rumen stasis, which may lead to death (Mathews 1936). Consumption of snakeweed may also cause pregnant animals to abort (Dollahite and Anthony 1957). Clinical signs of the abortion include weak uterine contractions, occasional incomplete cervical dilation and excessive mucus discharge. The abortion often results in stillbirth or the birth of small weak calves, depending on the period of gestation. Cows that have aborted may retain the placenta, which can lead to uterine infection and death.

Low nutrition exacerbates fertility problems caused by broom snakeweed. Smith et al. (1991, 1994) reported that increasing amounts of snakeweed in rat diets reduced intake, which led to malnutrition and contributed to diminished fertility and increased fetal mortality. Edrington et al. (1993) confirmed that increasing amounts of snakeweed in rat diets reduced intake, but it directly impaired hormonal balance and disrupted blood flow to the uterus and developing embryos.

Livestock on a high nutritional plane experienced minor adverse effects. Ewes on high quality alfalfa (18% CP) mixed with snakeweed for up to 25% of the ration showed no adverse effects on estrus. However, ewes fed low quality blue grama hay (11% CP) would not consume rations containing more than 10% snakeweed, and 43% of these ewes did not show estrus and did not breed (Oetting et al. 1991). Heifers fed snakeweed as 15% of a balanced diet before breeding and during early gestation had no effect on progesterone levels or conception rates (Williams et al. 1993). Snakeweed added up to 30% of this same diet during the last trimester of gestation, did not cause abortion or lower calf birth weight (Martinez et al. 1993). However, cattle in lower body condition consumed more snakeweed than cows in high body condition (Ralphs et al. 2007).

Supplemental protein and energy may enhance degradation and elimination of terpenes. Strickland et al. (1998) reported that a protein supplement improved tolerance to snakeweed toxicosis in cows in low body condition. Cows receiving protein had greater elimination of bromosulphthalein (BSP), indicating an increased capacity of the liver to conjugate and eliminate xenobiotics in Phase II biotransformation. They also had lower bilirubin and alkaline phosphatase levels, indicating less liver damage. In contrast, Ralphs et al. (2007) reported no effect of a special supplement formulated to provide bypass protein high in sulfur-containing and glucogenic amino acids and additional energy for detoxification of terpenes. It remains unclear whether protein or energy supplements will prevent snakeweed poisoning or abortions.

Ecology and Propagation

Broom snakeweed is a suffrutescent sub-shrub, having many unbranched woody stems growing upwards from a basal crown. These stems die back each winter and new growth is initiated from the crown in early spring. Douglas rabbitbrush (*Chrysothamnus viscidiflorus* (Hook) Nutt.) is similar in appearance and often confused with snakeweed, but is distinguished by its multi-branched stems, linear twisted leaves, and it does not die back each year.

Snakeweed is a short-lived perennial, typically surviving 4-7 years (Dittberner 1971). Seedlings establish in years with optimal environmental conditions (Mayeux and Leotta 1981, Mayeux 1989, Wood et al. 1997). It is a prolific a seed producer with 2036-3928 seeds/plant (Wood et al. 1997). Seeds are held in the dried flower heads and are gradually dispersed over winter, mainly during high wind and snowfall events. They have no specialized structures such as wings to aid in long range dispersal, thus they usually drop directly beneath or close to the parent plant. Germination is light-stimulated, therefore seeds must remain partially exposed on the soil surface (Mayeux 1983). Buried seed remain viable and germinate when moved to the soil surface by disturbance (Mayeux and Leotta 1981). To imbibe and successfully germinate, the soil surface moisture must remain near saturation for at least 4 days (Wood et al. 1997).

Pulse Establishment

The fluctuating resource availability theory of invasibility (Davis et al. 2000) suggests plant communities are more susceptible to weed invasion whenever there are unused resources. This occurs when there is either an increase in resource supply or a decrease in resource use. Snakeweed populations often establish in years with above average precipitation following disturbance that reduces competition from other vegetation. McDaniel et al. (2000) monitored snakeweed germination and establishment in permanent m^2 plots from 1990-1998 following burning and herbicide treatments applied on shortgrass prairies in central New Mexico. A total of 394 snakeweed seedlings / m^2 established in the wet years of 1991 and 1992. Most of the seedlings established within the first or second year after burning events (92%), which exposed soil and reduced grass cover, compared to herbicide spraying (4%). The majority of the seedlings (64%) germinated in spring of 1992 when precipitation was 224% above average, and most establishment occurred in open spaces (71%) between grass plants.

Ralphs and Banks (2009) reported a new crop of snakeweed plants ($30/m^2$) established in a crested wheatgrass seeding (*Agropyron cristatum* (L.) Gaertner) after an intensive spring grazing trial when spring precipitation was 65% above average. A heavy late spring snow storm occurred during the study and saturated the soil for several days. Intense grazing reduced grass standing crop (which reduced use of soil moisture) and trampling disturbed the soil surface, thus providing ideal soil and environmental conditions for establishment.

In a companion defoliation study (Ralphs 2009), density of snakeweed seedlings was higher in clipped plots in both the crested wheatgrass seeding and in a native bluebunch wheatgrass (*Pseudoroegneria spicata* Pursh) stand. Clipping reduced competition for soil moisture from grass and mature snakeweed plants, allowing new snakeweed seedlings to establish (57/m^2 vs 16/m^2 in the unclipped control plot in the crested wheatgrass seeding, and 7.9/m^2 vs 1.5/m^2 in the bluebunch wheatgrass stand). This study showed that in wet years, snakeweed can establish even in healthy stands of native bluebunch wheatgrass or seeded crested wheatgrass, when defoliation reduces competition for soil moisture.

Population cycles

Pulse establishment allows massive even aged stands of snakeweed to establish. There is little intraspecific competition among snakeweed seedlings (Thacker et al. 2009), thus large expanses of even-aged stands establish in wet years. As these stands mature, they become susceptible to die-off, mainly from insect damage or drought stress. Although snakeweed is highly competitive for soil moisture, it is not particularly drought tolerant (Piper and McDaniel 1989; Wan et al. 1993b). In southern New Mexico, broom snakeweed populations died out during droughts in 1970-71, 1978, 1982, and 1994, but rapidly reestablished within a year or two when wet winters or springs followed (Pieper and McDaniel, 1989, Beck et al. 1996, 1999; McDaniel 1989a, McDaniel et al. 2000). In central New Mexico, most mature snakeweed plants died in 1994 from drought stress and thereafter only occurred at minimal levels for the next 15 years because spring precipitation remained below normal (Torell et al. 2010). Ralphs and Sanders (2002) reported snakeweed populations in a salt desert shrub community on the Colorado Plateau died out in 1990, reestablished in 1994, declined in 1996, completely died out in 2000, and has not established during the current region-wide drought (Figure 3). In a crested wheatgrass seeding on the Snake River plain, snakeweed established during the wet years of 1983-6, died back in the drought of 1992, and completely died out in 2000 and has not reestablished (Ralphs and Sanders 2002).

Competition

Once established, snakeweed is very competitive with other vegetation. McDaniel et al. (1993) reported a negative exponential relationship between snakeweed overstory and grass understory that implies snakeweed's presence, even in minor amounts, suppresses grass growth. Partial removal of snakeweed allowed remaining plants to increase in size and continue to dominate the plant community (Ueckert 1979). Total removal allowed grass production to increase >400% on blue grama grasslands (McDaniel et al. 1982, McDaniel and Duncan 1987). Control strategies should strive for total snakeweed control.

Snakeweed's root structure and depth provide a competitive advantage over associated grasses for soil moisture (Torell et al. 2010). In the southwest, its deeper roots enable greater soil water extraction between 30-60 cm depth, compared sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray) (Wan et al. 1993c). Snakeweed populations in the northern Great Basin have shallower roots of smaller diameter than plants growing on southern plains and prairie (Wan et al. 1995). In its northern range, snakeweed is acclimated to a saturated soil profile from snowmelt and spring rains to sustain rapid growth. When soil water stress increases seasonally or during drought, leaf stomates do not close completely (Wan et al. 1993a, DePuitt and Caldwell 1975), allowing snakeweed to continue transpiring. This depletes soil moisture to the detriment of associated grasses. If drought persists, leaf growth declines and leaves are eventually shed to cope with water stress, but stems continue photosynthesis to enable it to complete flowering and seed production (DePuitt and Caldwell 1975). However, as drought stress increases, tissues dehydrate and mortality occurs rapidly (< 10 days) when soil water potential drops below -7.5 MPa and leaf water content declines to 50% (Wan et al. 1993b).

Succession Patterns

In the southwest, early researchers suggested broom snakeweed was originally found on rocky ridges, gravelly slopes and infertile soils (Parker 1939). Overgrazing allowed snakeweed invasion and resulted in a decline in the successional condition of many plant communities (Costello and Turner 1941, Dayton 1931; Green 1951; Talbot 1926; and Wooton 1915). Campbell and Bomberger (1934), for example, reported overgrazed black grama range almost always results in an increase in broom snakeweed establishment. Allison (1989) reviewed literature pertaining to snakeweed response to grazing in New Mexico and concluded that heavy stocking contributes to heavy broom snakeweed stands; grazing systems, both four-pasture one-herd and short duration grazing tend to have lower snakeweed populations over time; and that non-use does not reduce or prevent snakeweed infestations.

Snakeweed was commonly considered an indicator of poor range condition caused by overgrazing. However, Jameson (1970) showed its populations fluctuated with climatic patterns, and concluded it was not a reliable indicator of range condition. It has even increased in good condition plant communities in the absence of grazing (Chew 1982, Hennessy et al. 1983).

In sagebrush / bunchgrass plant communities of the Intermountain region, snakeweed was a minor component of plant communities, averaging 1.9 % foliar cover on undisturbed sites (Christensen 1964a). It increased with disturbance from overgrazing and when fire removed sagebrush overstory, to 5.9% cover (31% of perennial cover) on foothill ranges in Utah (Christensen 1964b, Pickford 1932). Snakeweed also increased following fire in the sagebrush steppe in Idaho (Pechanec and Blaisdell, 1954), and the Pinyon / Juniper type in Arizona (Arnold et al. 1964). Once established, snakeweed often dominates for several years until sagebrush or juniper reestablish. The successional pattern begins with a few snakeweed plants that survive or establish rapidly after a fire, they produce abundant seed, and increase rapidly in the open niches. Snakeweed increased in varying aged burns in the pinyon/juniper type of west-central Utah from 11% frequency three years after burning, to a maximum frequency of 46 - 52% from 11 to 22 yrs following a fire (Barney and Frischknecht 1974). After 22 years, sagebrush increased and suppressed snakeweed, and finally juniper dominated the community at about 70 years.

Healthy sagebrush/bunchgrass communities can suppress snakeweed. Thacker et al. (2008) described a fence line contrast between a Wyoming big sagebrush / bluebunch wheatgrass community and a degraded sagebrush / Sandberg bluegrass community in northern Utah. A 2001 wildfire removed the sagebrush in both communities. Snakeweed established on the degraded side of the fence and increased to 30% cover and dominated the site by 2005. Bunchgrasses on the other side of the fence prevented establishment of snakeweed.

From this research, a new broom snakeweed phase was added to the Upland Gravelly Loam (Wyoming big sagebrush) ecological site description (Figure 4, Thacker et al. 2008). Two driving mechanisms lead to snakeweed invasion. Heavy spring grazing almost eliminated the bunchgrass component of the plant community, transitioning from the Current Potential State (2.2) over a threshold to a dense Wyoming Sagebrush State (4). Fire removed the sagebrush, allowing snakeweed to increase and dominate the Snakeweed / Sandberg bluegrass phase (4.2). Subsequent fires will remove snakeweed and the site will likely transition over another threshold to a cheatgrass community in the Invasive Plant State (5). The research suggests that if robust perennial bunchgrasses can be maintained in the community, they will resist snakeweed invasion or expansion, recover from fire or drought, and produce more forage for wildlife and livestock.

Control

Snakeweed can be controlled by herbicides and prescribed burning. McDaniel and Ross (2002) recommended prescribed burning during the early stages of a snakeweed infestation or when mature plants are sparse and there is sufficient grass to carry a fire. Summer fires are more intense than at other seasons and kill most mature snakeweed plants (Dwyer 1967). However, weather conditions to meet the prescription for a safe and successful burn are difficult to come by in summer, thus spring burning (which also results in less grass damage) is the preferred time to burn in the southwest (McDaniel et al. 1997).

Herbicide control is recommended on dense snakeweed stands, particularly where fine fuels are suppressed and fire is not an option. Picloram at 0.28 kg ae/ha (0.25 lb/ac) or metsulfuron at 0.03 kg ai/ha (0.43 oz/ac) applied in the fall provided consistent control in New

Mexico (McDaniel and Duncan 1987, McDaniel 1989b). Sosebee et al. (1982) suggested fall applications were more effective than spring in the southwest because carbohydrate translocation was going down to the crown and roots, thus carrying the herbicides down to the perennating structures. Whitson (1989) recommended picloram at 0.56 kg ae/ha (0.5 lb/ac) and metsulfuron at 0.04 kg ai/ha (0.6 oz/ac) applied in the spring on shortgrass rangelands in Wyoming. In big sagebrush sites in Utah, the new herbicide aminopyralid at 0.12 kg ae/ac (0.11 lb/ac) was effective when applied during the flower stage in fall, as was metsulfuron 0.115 kg ai /ha (1.67 oz/ac) and picloram + 2,4-D 1.42 kg ae/ha (1.25 lb/ac). Picloram by itself at 0.56 kg ae/ha (0.5 lb/ac) was most effective and eliminated snakeweed when applied in either spring or fall (Keyes et al. 2010). Residual control was obtained with tebuthiuron (80% wettable powder) at 1.1-1.7 kg ai/ha (1 – 1.5 lb/ac) on mixed grass prairies in west Texas (Sosebee et al. 1979).

After snakeweed control, a weed resistant plant community should be established to prevent its reinvasion. Thacker et al. (2009) reported competition from cool season grasses prevented establishment of snakeweed seedlings in both potted-plant and field studies. Snakeweed seedlings appear to be sensitive to competition from all established vegetation, including cheatgrass. Hycrest crested wheatgrass (*Agropyron cristatum* (L.) Gaertner x *A. desertorum* (Fisch. Ex Link) Schultes) was the most reliable grass to establish on semi-arid rangelands, thus was most effective in suppressing snakeweed establishment and growth. There appears to be a window of opportunity for grasses to suppress snakeweed in its seedling stage, if the grasses can be established. Once established, snakeweed is very competitive and will likely remain in the plant community.

Conclusion

Snakeweed is more destructive as an invasive weed than a poisonous plant. Its invasive nature and competitive ability allow it to increase and dominate plant communities. It establishes in years of above average precipitation, particularly following disturbance by fire, drought or overgrazing. This allows widespread even-aged stands to develop that can dominate plant communities. Although its populations cycle with climatic patterns, it can be a major factor impeding succession of plant communities. Snakeweed can be controlled with prescribed burning and herbicides, however a weed-resistant plant community should be established and/or maintained to prevent its reinvasion. Proper grazing and management to maintain competitive grasses is essential for suppression of this invasive weed.

Literature Cited

Allison, C.D. 1989. Influence of livestock grazing on broom snakeweed populations. pp 141-146 *in*: E.W. Huddleston and R.D. Pieper (eds), Snakeweed: Problems and Perspectives. New Mexico Agr. Exp. Sta. Bull. 751.

Arnold, J.F., D.A. Jameson, and E.H. Reid. 1964. The pinyon - juniper type of Arizona: effects of grazing fire and tree control. USDA/FS Prod. Res. Rep 84.

Barney, M.A., and N.C. Frischknecht. 1974. Vegetation changes following fire in the pinyon-juniper type of west-central Utah. J. Range Manage. 24:91-96.

Beck, R.F., R.P. NcNeeley, and S.J. Muir. 1996. Effects of goats and drought on snakeweed. p.7 *in*: Abstracts, 49th Annual Meeting, Society for Range Management, Wichita KA.

Beck, R.F., M. Nsinamwa, R. Santos, and R.D. Pieper. 1999. Dynamics of *Gutierrezia sarothrae* with drought and grazing. pp. 502-503 *in:* Eldridge and Freudenberger (Eds), Proc. VI International Rangeland Congress, Townsville Aust.

Campbell, R.S. and E. H Bomberger. 1934. The occurrence of Gutierrezia sarothrae on Bouteloua eriopda range in southern New Mexico. Ecol. 15:49-51.

Cedarleaf, J.D., B.L. Welch and J.D. Brotherson. 1983. Seasonal variation of monoterpenoids in big sagebrush (*Artemesia tridentate*). J. Range Manage. 36:492-494.

Chew, R.M. 1982. Changes in herbaceous and suffrutescent perennials in grazed and ungrazed desertified grassland in south eastern Arizona USA, 1958-1978. Am. Midl. Nat. 108:159-169.

Christensen, E.M. 1964a. Changes in composition of *Bromus tectorum - Sporabolus cryptandus-Aristida longiseta* community following fire. Utah Academy Sci. Proc. 41:53-57.

Christensen, E.M. 1964b. The foothill bunchgrass vegetation of central Utah. Ecol. 44:156-158.

Costello, D. F. and G. T. Turner. 1941. Vegetation changes following exclusion of livestock from grazed ranges. J. For. 39:310-314.

Davis, M.A., J.Ph Grime, and K. Thompson. 2000. Fluctuating resources in plant communities: a general theory of invisibility. J. Ecology. 88:528-534.

Dayton, W. A. 1931. Important western browse plants. USDA Misc. Pub. 101.163pp.

DePuit, E.J. and M.M. Caldwell. 1975. Stem and leaf gas eschange of two arid land shrubs. Am. J. Bot. 62:954-961.

Dittberner, D.L. 1971. A demographic study of some semi-desert grassland plants. M.S. Thesis, New Mexico State Univ., Las Cruces NM.

Dollahite, J.W. and W.V. Anthony 1957. Poisoning of cattle with *Gutierrezia microcephala,* a perennial broomweed. J. Am. Vet. Med. Assoc. 130:525-530.

Dollahite, J.W., T. Shaver, and B.J. Camp. 1962. Injected saponins as abortifacient. J. Am. Vet Res. 23:1261-1263.

Dwyer, D.D. 1967. Fertilization and burning of blue grama grass. J. Anim. Sci. 26:943 (Abstract).

Edrington, T.S., G.S. Smith, T.T. Ross, D.M. Hallford, M.D. Samford and J.P. Thilsted. 1993. Embryonic mortality in Sprague-dawley rats induced by snakeweed (*Gutierrezia microcephala*) J. Anim. Sci. 71:2193-2198.

Gardner, D.R. and L.F. James. 1999. Ponderosa pine and broom snakeweed: poisonous plants that affect livestock. J. Natural Toxins 8:27-34.

Green, L. R. 1951. Utilization of winter forage by sheep. J Range Manage. 4:233-235.

Hennessy, J.T., R.P. Gibbens, J.M. Tramble, and M. Cardenas. 1983. Vegetation changes from 1935-1980 in mesquite (*Prosopis glandulosa*) dune lands and former grasslands of southern New Mexico USA. J. Range Manage. 36:370-374.

Hegerhorst, D.F., R.B. Bhat, D.J. Weber and E.D. McArthur. 1988. Seasonal changes of selected secondary plant products in *Chrysothamnus nauseosus* ssp. *turbinatus*. Great Basin Naturalist 48:1-8.

Huddleston, E.W. and R.D. Pieper. 1989. Snakeweed: Problems and Perspectives. New Mexico Agr. Exp. Sta. Bull. 751.

Kelsey, R.G., J.R. Stephens, and F. Shafizadeh. 1982. The chemical constituents of sagebrush foliage and their isolation. J. Range. Manage. 35:617-622.

Jameson, D.A. 1970. Value of broom snakeweed as a range condition indicator. J. Range Manage. 23:302-304.

Keyes, J., C. Ransom, and M.H. Ralphs. 2010. Herbicide control of broom snakeweed on the Colorado Plateau and Great Basin. Range. Ecol. Manage. (in review).

Lane, J. 1985. Taxonomy of *Gutierrezia* Lag. (Compositae: Asteraceae) in North America. Systemic Botany 10:1-28.

Martinez, J.H., T.T. Ross, K.A. Becker, J.L. Williams, D. Campos and G.S. Smith. 1993. Injested dry snakeweed foliage did not impair reproduction in ewes and heifers in late gestation. Proc. Wes. Sec. Amer. Soc. ANim. Sci. 44:32-35.

Mathews, F.P. 1936. The toxicity of broomweed (*Guterrezia microcephala*) for sheep, cattle and goats. J. Am. Vet. Med. Assoc. 88:55-61

Mayeux, H.S. Jr. 1983. Effects of soil texture and seed placement on emergence of four sub shrubs. Weed Sci. 31:380-384.

Mayeux, H.S. Jr. 1989. Snakeweed seed characteristics and germination requirements. Pp. 39-50 *in*: E.L. Huddleston and R.D. Pieper (eds), Snakeweed : Problems and Perspectives. New Mexico Agr. Exp. Sta. Bull. 751.

Mayeux, H.S. Jr., and L.Leotta. 1981. Germination of broom snakeweed (*Gutierrezia sarothrae*) and threadleaf snakeweed (*G. microcephala*) seed. Weed Sci. 29:530-534.

McDaniel. K.C. 1989a. Snakeweed populations in New Mexico, 1979-1989. pp. 13-25 *in:* E.W. Huddleston and R. D. Pieper (eds), Snakeweed: Problems and Perspectives, New Mexico Agr. Exp. Sta. Bull. 751.

McDaniel. K.C. 1989b. Use of herbicides in snakeweed management. pp. 85-100, *in*: E.W. Huddleston and R. D. Pieper (eds), Snakeweed: Problems and Perspectives, New Mexico Agr. Exp. Sta. Bull. 751.

McDaniel, K.C., D.B. Carrol, and C.R. Hart. 2000. Broom snakeweed establishment on blue grama grasslands after fire and herbicide treatments. J. Range Manage. 53:239-245.

McDaniel, K.C., C.R. Hart, and D.B. Carroll. 1997. Broom snakeweed control with fire on New Mexico blue grama rangeland. J. Range. Manage. 50:652-659.

McDaniel, K.C. and K.W. Duncan. 1987. Broom snakeweed (*Guterrezia sarothrae*) control with picloram and metsulfuron. Weed Sce. 35:837-841.

McDaniel, K.C., R.D. Pieper and G.B. Donart. 1982. Grass response following thinning of broom snakeweed. J. Range Manage. 35:219-222.

McDaniel, K.C. and T.T. Ross. 2002. Snakeweed: poisonous properties, livestock loss, and management considerations. J. Range Manage. 55:277-284.

McDaniel, K.C. and R.E. Sosebee. 1988. Ecology, management and poisonous properties associated with perennial snakeweeds. pp 43-69 *in*: L.F. James, M.H. Ralphs and D.B. Nielsen (eds), The Ecology and Economic Impact of Poisonous Plants on Livestock Production. Westview Press, Boulder CO.

McDaniel, K.C. and L.A. Torell. 1987. Ecology and management of broom snakeweed. pp. 101-115 *in:* J.L. Capinera (ed.), Integrated Pest Management on Rangeland, A Shortgrass Prairie Perspective. Westview Press, Boulder CO.

McDaniel, K.C., L.A. Torell, and J.W. Bain. 1993. Overstory-understory relationships for broom snakeweed-blue grama grasslands. J. Range Manage. 46:506-511.

Oetting. B.C., T.T. Ross, K. Walraven, P. Kloppenburg, G.S. Smith and D.M. Hallford. 1990. Effects of ingested snakeweed herbage on estrual activity, blood progesterone and serum clinical profiles of fine-wool ewes. Proc. West. Sec. Am. Soc. Anim. Scio. 41:23-26.

Parker, K.W. 1939. The control of snakeweed in the southwest. Southwest Forest and Range Exp. Sta. Res. Note 76.

Pechanec, J.F. and J.P. Blaisdell. 1954. Sagebrush burning, good and bad. USDA Farmers Bull. 1948.

Pickford, G.D.1932. The influence of continued heavy grazing and promiscuous burning on spring-fall ranges in Utah. Ecol. 13:159-171.

Pieper, R.D. and K.C. McDaniel. 1989. Ecology and management of broom snakeweed. pp. 1-2 *in*: E.W. Huddleston and R. D. Pieper (eds), Snakeweed: Problems and Perspectives, New Mexico Agr. Exp. Sta. Bull. 751.

Platt, K.B. 1959. Plant control – some possibilities and limitations. II Vital statistics for range management. J. Range Manage. 12:194-200.

Ralphs, M.H. 2009. Response of broom snakeweed (*Gutierrezia sarothrae*) to defoliation. Invasive Plant Science and Management. 2:28-35.

Ralphs, M.H. and J.E. Banks. 2009. Cattle grazing broom snakeweed as a biological control: vegetation response. Range Ecol. Manage. 62:38-43.

Ralphs, M.H., R.D. Wiedmeier and J.E. Banks. 2007. Decreasing forage allowance can force cattle to graze broom snakeweed (*Gutierrezia sarothrae*) as a biological control. Range Ecol. Manage. 60:487-497.

Ralphs, M.H. and K.D. Sanders. 2002. Population cycles of broom snakeweed in the Colorado Plateau and Snake River Plains. J. Range Manage. 55:406-411.

Roitman, J.N., L.F. James and K.E. Panter. 1994. Constituents of broom snakeweed (*Gutierrezia sarothrae*), an abortifacient rangeland plant. pp. 345-350 *in*: S.M. Colegate and P.R. Dorling (eds) Plant-Associated Toxins: Agricultural, Phytochemical and Ecological Aspects. CABI, Wallingford Oxon, UK.

Smith, G.S., T.T. Ross, G.I. Flores-Rodriguez, B.C. Oetting and T.S. Edrington. 1991. Toxicology of snakeweeds, (*Gutierrezia sarothrae* and *G. microcephala*). pp. 236-246 *in*: L.F. James, J.O. Evans, M.H. Ralphs and R. D. Child (eds), Noxious Range Weeds. Westview Press, Boulder CO.

Smith, G.S., T.T. Ross, D.M. Hallford, J.P. Thilsted, E.C. Staley, J.A. Greenberg and R.J. Miller. 1994. Toxicology of snakeweeds (*Gutierrezia sarothrae* and *G. microcephala*). Proc. West. Sec. Am. Soc. Anim. Sci. 45:98-102.

Sosebee, R.E., W.E. Boyd and C.S. Brumley. 1979. Broom snakeweed control with tebuthiuron. J. Range Manage. 32:179-182.

Sosebee, R.E., W.W. Seip and J. Alliney. 1982. Effect of timing of herbicide application on broom snakeweed control. Noxious Brush and Weed Control Research Highlights, Range and Wildlife dept. Texas Tech Univ. Vol 13:19.

Sterling, T. M., D. C. Thompson and K. C. McDaniel. 1999. Snakeweeds, p. 323-335 in: Biology and Management of Noxious Rangeland Weeds. R. L. Sheley and J. K. Petroff (eds). Oregon State Univ. Press. Corvalis OR.

Strickland, J.R., L.F. Gulino-Klein, T.T. Ross, S.Slate, M.K. Peterson, T.May, and J.B. Taylor. 1998. Effects of nutrient supplementation in beef cows of poor body condition fed snakeweed (*Gutierrezia* spp.). Vet. Human Toxicol. 40 (5): 278-284.

Talbot, M. V. 1926. Indicators of southwestern range conditions. USDA Farmers Bul. 1782. 36pp.

Thacker, E.T., M.H. Ralphs, C.A. Call, B. Benson and S. Green. 2008. Using an ecological site description to evaluate broom snakeweed (*Gutierrezia sarothrae*) invasion in a sagebrush steppe. Range Ecol. Manage. 61:263-268.

Thacker, E., M.H. Ralphs, and T.A. Monaco. 2009. A comparison of inter- and intraspecific interference on broom snakeweed (*Gutierrezia sarothrae*) seedling growth. Invasive Plant Sci. Manage. (in press).

Torell, L. A., K. C. McDaniel, and V. Koren. 2010. Estimating grass yield on blue grama range from seasonal rainfall and soil moisture measurements. Range Ecol. Manage. (in press)

US Forest Service. 1937. Range Plant Handbook. U.S. Gov. Printing Office. Washington D.C.

Ueckert, D.N. 1979. Broom snakeweed: effect on shortgrass forage production and soil water depletion. J. Range Manage. 32:216-220.

Wan, C., R.E. Sosebee and B.L. McMichael. 1993a. Broom snakeweed responses to drought: I. photosynthesis, conductance, and water-use efficiency. J. Range Manage. 46:355-359.

Wan, C., R.E. Sosebee and B.L. McMichael. 1993b. Broom snakeweed responses to drought: II. root growth, carbon allocation, and mortality. J. Range Manage. 46:360-363.

Wan, C., R.E. Sosebee and B.L. McMichael. 1993c. Soil water extraction and photosynthesis in (*Guterrezia sarothrae*) and *Sporobolus cryptandrus*. J. Range Manage. 46:425-430.

Wan, C., R.E. Sosebee and B.L. McMichael. 1995. Water acquisition and rooting characteristics in northern and southern populations of *Guterrezia sarothrae*. Environmental and Experimental Botany 535:1-7.

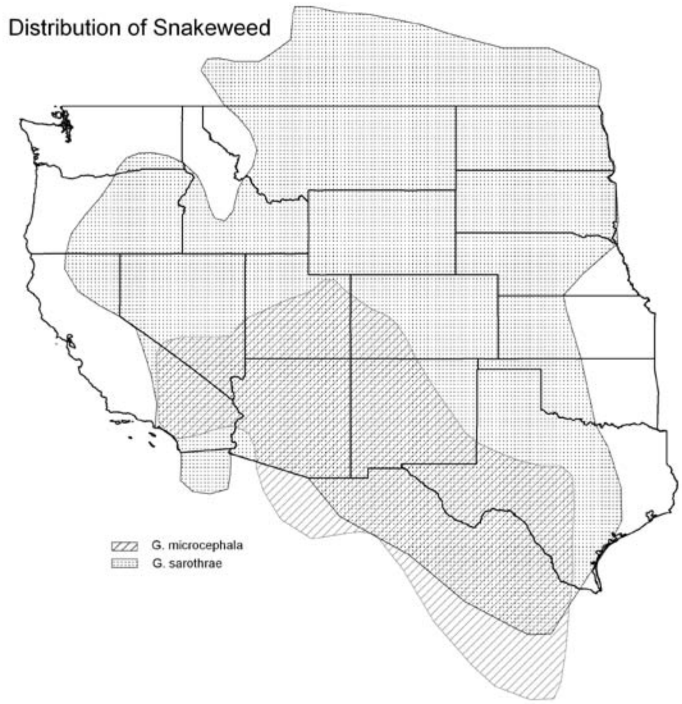
Whitson, T.D. and J.W. Freeburn. 1989. Broom snakeweed control in two rangeland locations. West. Soc. Weed Sci. Res. Prog. Rep. p.37.

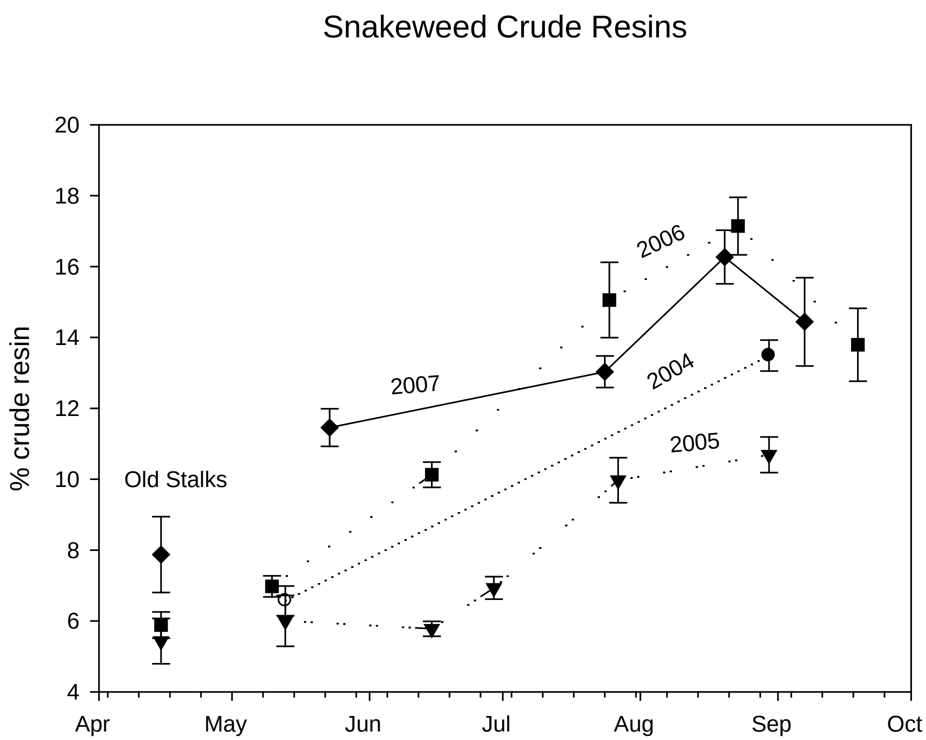
Williams, J.L., D. Campos, T.T. Ross, K.A. Becker, J.M. Martinez, B.C. Oetting, G.S. Smith. 1992. Snakeweed (*Gutierrezia* spp.) toxicosis in beef heifers. Proc. Wes. Sec. Amer. Soc. Anim. Sci. 43:43:67-69.

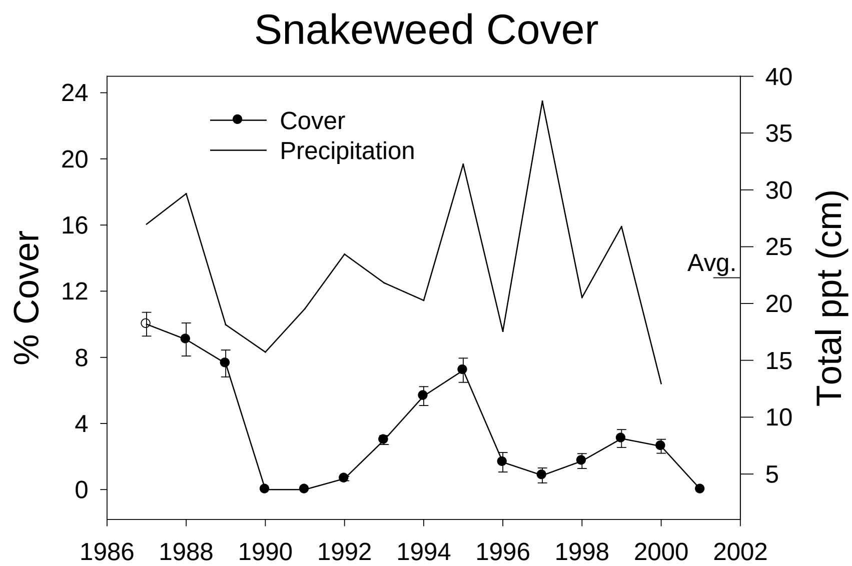
Wood, B.L., K.C. McDaniel, and D. Clason. 1997. Broom snakeweed (*Guterrezia sarothrae*) dispersal, viability, and germination. Weed Sci. 45:77-84.

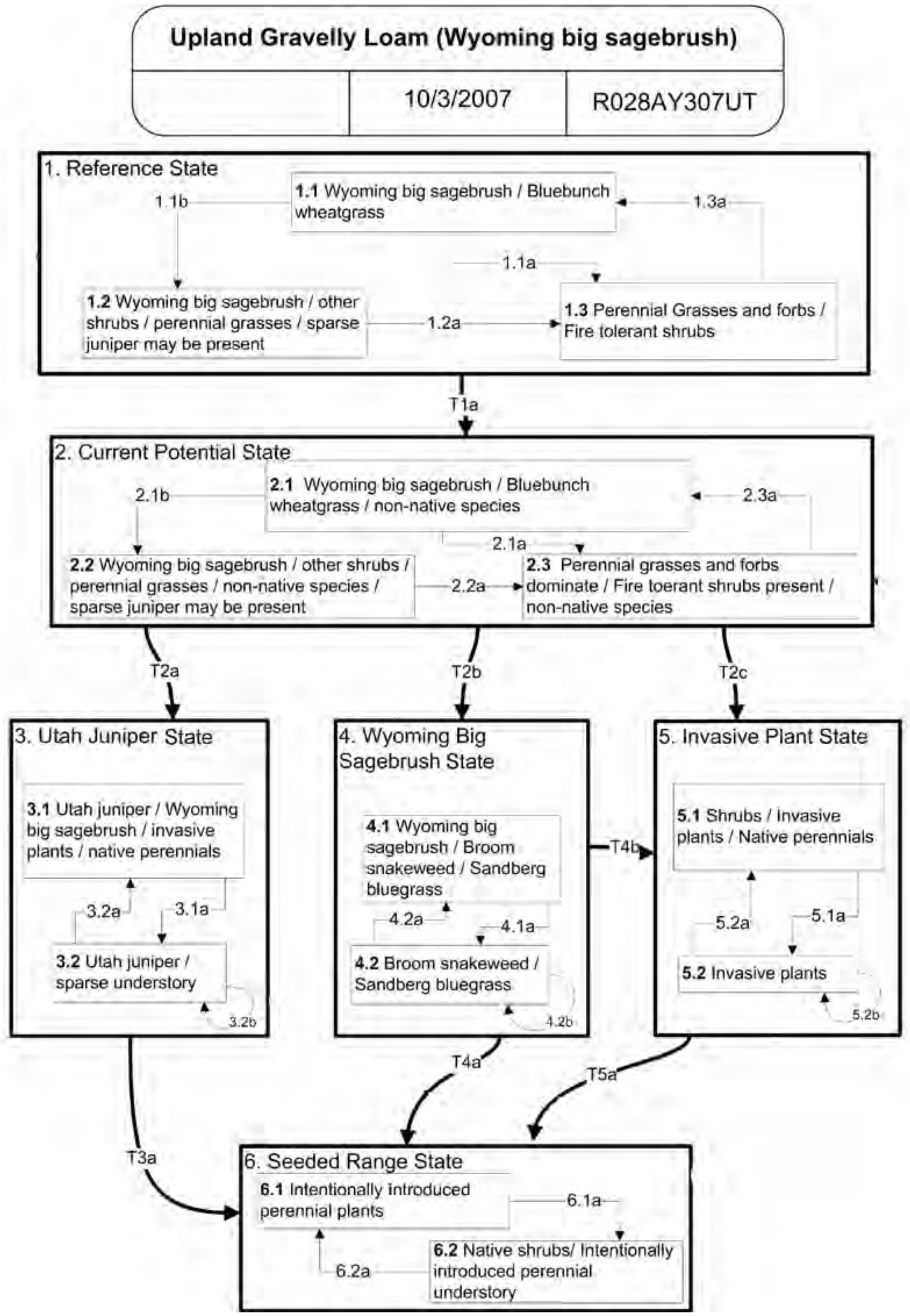
Wooton, E. O. 1915. Factors affecting range management in New Mexico. USDA Bul. 211. 39pp.

List of Figures


Distribution of Snakeweed
G. microcephala
G. sarothrae


Snakeweed Crude Resins
% crude resin
20
18
16
14
12
10
8
6
4
Apr
May
Jun
Jul
Aug
Sep
Oct
Old Stalks
2007
2006
2004
2005


Snakeweed Cover
Cover
Precipitation
Avg.
% Cover
Total ppt (cm)
24
20
16
12
8
4
0
40
35
30
25
20
15
10
5
1986
1988
1990
1992
1994
1996
1998
2000
2002


Upland Gravelly Loam (Wyoming big sagebrush)
10/3/2007
R028AY307UT
1. Reference State
1.1 Wyoming big sagebrush / Bluebunch wheatgrass
1.1b
1.3a
1.1a
1.2 Wyoming big sagebrush / other shrubs / perennial grasses / sparse juniper may be present
1.2a
1.3 Perennial Grasses and forbs / Fire tolerant shrubs
T1a
2. Current Potential State
2.1 Wyoming big sagebrush / Bluebunch wheatgrass / non-native species
2.1b
2.3a
2.1a
2.2 Wyoming big sagebrush / other shrubs / perennial grasses / non-native species / sparse juniper may be present
2.2a
2.3 Perennial grasses and forbs dominate / Fire toerant shrubs present / non-native species
T2a
T2b
T2c
3. Utah Juniper State
3.1 Utah juniper / Wyoming big sagebrush / invasive plants / native perennials
3.2a
3.1a
3.2 Utah juniper / sparse understory
3.2b
4. Wyoming Big Sagebrush State
4.1 Wyoming big sagebrush / Broom snakeweed / Sandberg bluegrass
4.2a
4.1a
4.2 Broom snakeweed / Sandberg bluegrass
4.2b
T4b
5. Invasive Plant State
5.1 Shrubs / Invasive plants / Native perennials
5.2a
5.1a
5.2 Invasive plants
5.2b
T4a
T5a
T3a
6. Seeded Range State
6.1 Intentionally introduced perennial plants
6.1a
6.2a
6.2 Native shrubs/ Intentionally introduced perennial understory

Interpretive Summary

Broom snakeweed is an invasive native sub-shrub that is widely distributed across rangelands of western North America. In addition to its invasive nature, it contains toxins that can cause death and abortions in livestock. It establishes in years of above average precipitation following disturbance by fire, drought or overgrazing. This allows widespread even-aged stands to develop that can dominate plant communities. Although its populations cycle with climatic patterns, it can be a major factor impeding succession of plant communities. Snakeweed can be controlled with prescribed burning and herbicides, however a weed-resistant plant community should be established and/or maintained to prevent its reinvasion. Proper grazing and management to maintain competitive grasses is essential for suppression of this invasive weed.