TEBUTHIURON TO ENHANCE RANGELAND DIVERSITY

Rich Olson, John Hansen, Tom Whitson, and Kris Johnson

Big sagebrush is the dominant shrub on more than 100 million acres of North American rangeland where livestock grazing is the primary commercial use (Vale 1974). Large expanses of dense, monotypic stands of big sagebrush have limited value for livestock grazing and wildlife habitat (Figure 1). However, when sagebrush is combined with a balanced mixture of grasses and forbs, this major rangeland habitat can provide optimum forage and cover for livestock grazing and diversified wildlife production. Resource managers across the West have consistently advocated big sagebrush management efforts to achieve a diverse mixture of forbs, grasses, and shrubs beneficial to livestock, wildlife, and other rangeland uses. The Bureau of Land Management in Farmington, New Mexico, and the University of Wyoming in Laramie, are actively investigating the use of tebuthiuron as a rangeland management tool to enhance forage production for livestock grazing, improve vegetative diversity to increase wildlife habitat quality, and promote better grazing distribution to improve range condition. When applied at reduced application rates, this soil-active herbicide results in selective thinning of big sagebrush by inhibiting photosynthetic activity (Whitson and Alley 1984). Perennial grasses and forbs produce 2-4 times as much forage following sagebrush thinning by utilizing the additional moisture available from thinned big sagebrush stands (Figure 2).

Historical Background

Historical evidence suggests that prior to European settlement, big sagebrush was an important component of western rangelands (Vale 1974). Intensive grazing during the late 1800's and early 1900's, along with recent wildfire control efforts, has allowed big sagebrush to become the dominant plant species on western rangelands (Miller 1991, Pieper 1991).

In New Mexico, vegetation within grazing exclosures on public lands administered by the BLM has shown no improvement in herbaceous production or ecological condition over the past 20 years. The dominance of big sagebrush continues within exclosures despite the absence of livestock grazing. Reduced grazing under a deferred rotation grazing system outside exclosures has likewise little effect on improving herbaceous production or ecological condition. A similar scenario exists for Wyoming's 52 million acres of sagebrush rangeland.

Big sagebrush has little forage value to cattle and competes with desirable herbaceous plant species. For this reason, sagebrush control projects traditionally included prescribed burning, mechanical methods, and chemical (2,4-D) treatments aimed at total control. Conversions of big sagebrush communities to grass/forb monocultures increases forage for livestock grazing, but also reduces wildlife populations and biodiversity (Schroeder and Sturges 1975; Swenson et. al. 1987; Zou et. al. 1989). Heavy use of the herbicide 2,4-D can eliminate many forb plant species as well as big sagebrush, which also degrades wildlife habitat quality.

Early efforts by the BLM Farmington District to improve herbaceous forage production on big sagebrush dominated rangeland included chaining, railing, rotary brush cutting, cabling, and plowing/reseeding treatments. Inadequate amounts of fine fuels and numerous archaeological sites precluded the use of prescribed burning. High costs of 2,4-D applications discouraged the use of herbicides. With few exceptions, the areas treated during the 1950's, 60's and

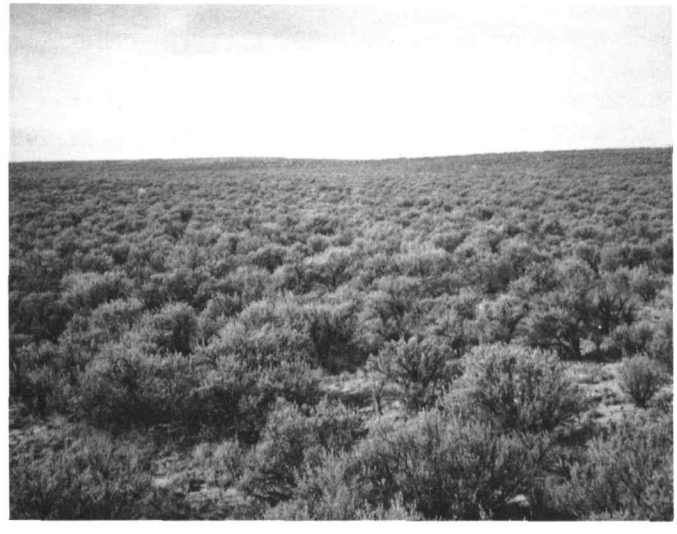

Fig. 1. *Typical unthinned Wyoming big sagebrush community of the North Kaime unit, New Mexico.*

Authors are Assistant Professor and Rangeland Wildlife Habitat Extension Specialist, Department of Range Management, University of Wyoming; Supervisory Range Conservationist, Bureau of Land Management, Farmington, New Mexico; Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming; and Graduate Research Assistant, Department of Range Management, University of Wyoming.

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Fig. 2. *Thinned Wyoming big sagebrush community of the North Kaime unit, New Mexico, following tebuthiuron application of 0.5 lb. ai/acre in 1986.*

70's using mechanical methods have all reverted back to a big sagebrush-dominated plant community.

Current Work

Study Areas and Methods

New Mexico: In 1982, tebuthiuron was applied at the rate of 0.5 lb. active ingredient per acre (ai/acre) to 243 acres of public land within the Rosa Community Allotment (Rosa #1) near Gobernador, New Mexico. The treatment area was a loamy range site dominated by Wyoming big sagebrush. Average annual precipitation is 12-15 inches. Following treatment, all grazing use was deferred for two growing seasons (April 1-September 30) and then grazed as part of a deferred rotation grazing system.

A subsequent tebuthiuron treatment of 0.5 lb. ai/acre was applied to an additional 629 acres within the Rosa Community Allotment (Rosa #2) in 1990. In addition to these two plots, tebuthiuron was applied at the rate of 0.5 lb. ai/acre to 1,230 acres on a different allotment, the North Kaime unit, in 1986.

In August of 1993, data was collected on vegetative production and cover from the three different aged tebuthiuron treatments and two untreated areas adjacent to the treatment plots. Vegetative production data was evaluated by using the weight estimate (Pechanec and Pickford 1937) and double sampling method (Wilm et. al. 1944), utilizing 9.6 sq. ft. sample hoops. Vegetative cover was determined by running a 100 point pace point transect adjacent to the production transects.

Wyoming: In 1978, tebuthiuron was applied at 0.94, 0.67, and 0.31 lbs. ai/acre to single, 10 acre plots in homogeneous big sagebrush stands in northcentral Wyoming near Ten Sleep. In 1992, before sampling, a control plot was established near the treatment plots. Soils on the treatment area were predominately sand and silt with a 2.3% organic matter content. Average annual precipitation is 12-15 inches.

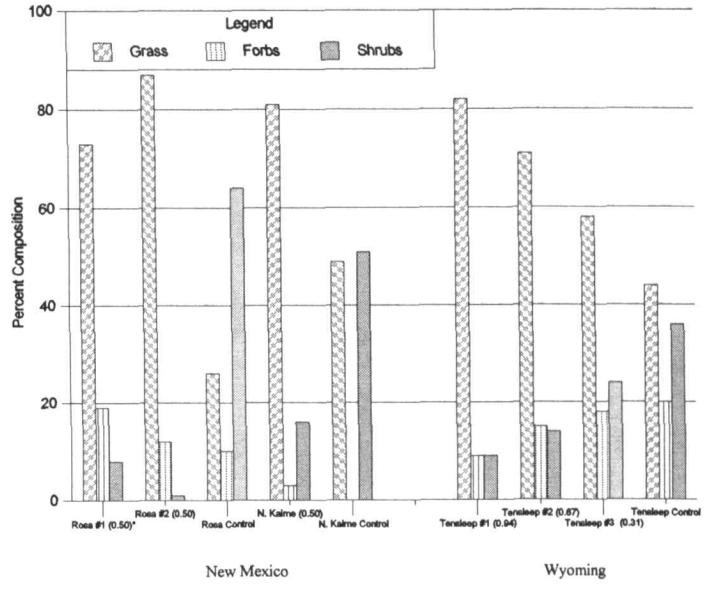
Four vegetation sampling transects 230 ft. long were randomly located in each plot. Ten 2.8 sq. ft. quadrats were sampled at even intervals along the length of each transect to assess plant density and cover. Weight estimate and double sampling methods were used to determine biomass production for each species. Importance values (Curtis and McIntosh 1951) were calculated from this data for each species to identify dominants within the plant community.

In addition to plant community data, small mammal populations were sampled on each treatment plot for abundance and diversity using mark-and-recapture trapping techniques. A 10- by 10-station grid, 11 yds. between stations, with 1 aluminum livetrap per station, was established in each plot. Trapping was conducted for 5 consecutive 24-hour periods in July 1992. Captured individuals received unique toe-marking codes, using fingernail polish, for positive identification. Mark-and-recapture data were analyzed using the Schnabel estimator (Krebs 1989) to assess abundance of small nongame mammals.

Importance values for plant species and Schnabel estimates of abundance for small nongame mammal species were used to calculate a Shannon-Wiener diversity index for those communities in each plot.

Vegetative Composition

In New Mexico, a comparison of the tebuthiuron treated plots to the control plots for both the Rosa and North Kaime areas revealed a substantial increase in the percent of all grass species on treated plots (Figure 3). At an application rate of 0.5 lb. ai/acre, the percent of shrub species (primarily big sagebrush) was reduced significantly while the percent of forbs increased only slightly. Tebuthiuron-treated



*Application rate (lb. ai/acre)

Fig. 3. *Percent composition of grasses, forbs, and shrubs on New Mexico and Wyoming sites treated with tebuthiuron at different application rates.*

plots in New Mexico changed from a plant community dominated by big sagebrush to one dominated by grasses. There was little effect on the forbs.

In Wyoming, a similar change in vegetative composition occurred when tebuthiuron-treated plots were compared to the untreated plot (Figure 3). Percent shrub composition was greatest on the control plot and reflected progressively decreased percent composition with increasing rates of tebuthiuron application. Likewise, percent grass composition was lowest on the control plot and increased with heavier tebuthiuron application rates. Forbs displayed small declines in percent composition with increased tebuthiuron rates.

When evaluating dominant plant species only, as identified from importance values, big sagebrush comprised 35% of the composition on the untreated plot, and correspondingly decreased to 5% composition on the plot of heaviest tebuthiuron application (Table 1). Likewise, among dominant grasses, western wheatgrass increased significantly in percent vegetative composition with increasing application rates of tebuthiuron. The lowest percent composition of western wheatgrass occurred on the untreated plot. Other dominant grass species showed little response to different tebuthiuron rates. The overall number of species present was lowest in the untreated plot.

Table 1. Percent composition of dominant plant species on Tensleep, Wyoming sites treated with various levels of tebuthiuron (lb. ai/acre) in 1978.

Species	Composition Of Dominant Plants Site #1 (0.94)	Site #2 (0.67)	Site #3 (0.31)	Control
			(%)	
Western wheatgrass	64	51	39	23
Sandberg bluegrass	9	7	9	6
Prairie junegrass	7	9	7	11
Woolly loco	2	4	6	4
Big sagebrush	5	12	18	35
Number Species Present	23	23	24	20

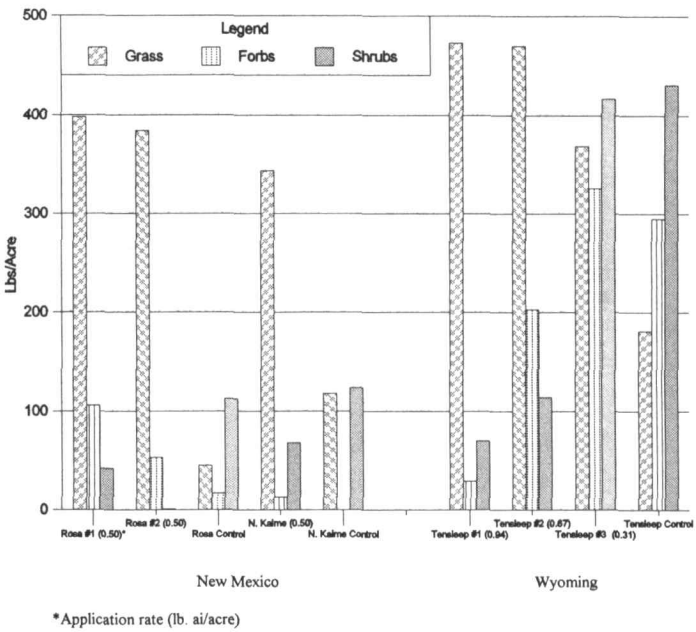
In both New Mexico and Wyoming, tebuthiuron is an effective management tool to reduce big sagebrush dominance and enhance grasses, with little effect on forbs.

Biomass Production

Vegetative production on New Mexico sites was significantly greater among grass species on tebuthiuron-treated areas compared to the control areas (Figure 4). There was some increase in forb production following treatment, although the production increases were not as great compared to grasses.

An interesting observation is the uniformity of grass production among the treated areas regardless of differences in treatment years. This would imply that tebuthiuron promotes long-lasting effects in maintaining production.

On Wyoming sites, production of all grasses combined also increased significantly as big sagebrush was thinned with tebuthiuron (Figure 4). Grass production increased progressively with heavier tebuthiuron application rates while forbs and shrubs decreased.



*Application rate (lb. ai/acre)

Fig. 4. *Biomass production (lbs./acre) on New Mexico and Wyoming sites treated with tebuthiuron at different application rates.*

An evaluation of biomass production changes among dominant grass species reveals that western wheatgrass was the primary species that consistently responded to increased levels of big sagebrush thinning (Table 2). The two other predominate grass species, prairie junegrass and sandberg bluegrass, were inconsistent in biomass production changes with different levels of tebuthiuron application.

There is a direct relationship in both New Mexico and

Table 2. Biomass production (lbs./acre) of major grass species on Tensleep, Wyoming sites following different tebuthiuron application rates in 1978.

Sample Sites	Application Rate (lb ai/ac)	Biomass Production Western Wheatgrass	Prairie Junegrass	Sandberg Bluegrass
		(lbs./ac)		
Tensleep #1	0.94	730	41	48
Tensleep #2	0.67	656	89	28
Tensleep #3	0.31	409	71	102
Tensleep Control		272	83	16

Wyoming sites between the amount of grass biomass production and level of big sagebrush thinning. On the New Mexico sites, blue grama and galleta were the primary species accounting for the increased biomass production among grass species. In Wyoming, the increased biomass production was primarily from western wheatgrass. This observation indicates that tebuthiuron enhances biomass production of both warm and cool season grasses. Personnel from the BLM Farmington District estimated that a four-fold increase in stocking rates occurred on the tebuthiuron-treated areas compared to the control sites.

Small Mammal Relationships

Small mammals are particularly sensitive to habitat alterations (Frischknecht and Baker 1972; Zou et. al. 1989) and can be used as a barometer for assessing overall biodiversity of an area. For this reason, small mammal populations were evaluated on the Wyoming sites to determine the relationship between vegetative diversity and small mammal abundance and diversity.

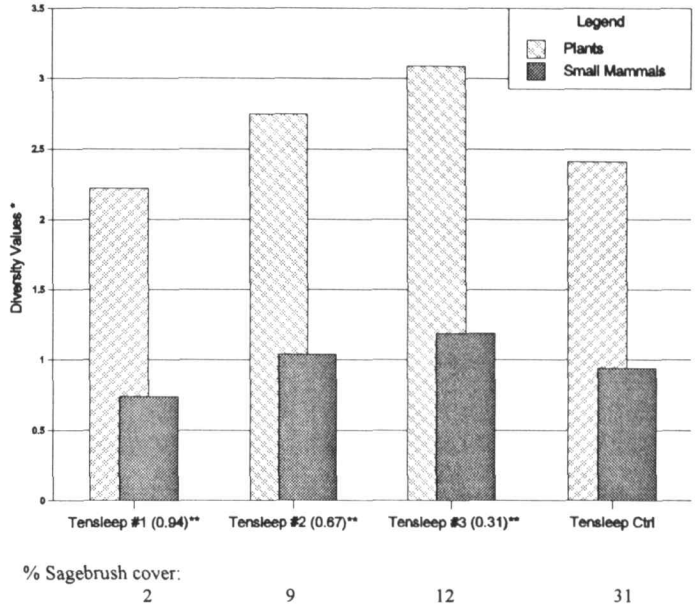
Estimates of small mammal populations from mark-and-recapture efforts showed that the Wyoming ground squirrel increased in abundance as the level of big sagebrush thinning increased (Table 3). Conversely, the white-footed deer mouse was least abundant in the heavy treatment (0.94 lbs. ai/acre) area. Overall, the number of small mammal species was lowest in the untreated plot.

Table 3. Estimates of small mammal abundance on Tensleep, Wyoming sites treated with tebuthiuron at different application rates (lb. ai/acre) in 1978.

Species	Site #1 (0.94)	Site #2 (0.67)	Site #3 (0.31)	Control
	- - - - - - (no./acre) - - - - - - -			
Wyoming ground squirrel	26	25	24	12
White-footed deer mouse	4	7	5	6
Northern grasshopper mouse	1	2	5	0
Total All Species	31	34	34	18

Diversity indices, calculated for both plant communities and small mammal populations, reflect higher values at lower thinning rates of big sagebrush (Figure 5). There is a progressive decrease in plant and animal diversity as thinning levels increase. Plant community and small mammal diversity was lowest in areas treated with the heaviest tebuthiuron application rates. Conversely, plant and animal diversity was highest in the plot receiving the lowest tebuthiuron application rate.

A comparison of the relationship between vegetative diversity and small mammal diversity illustrates a close association between these factors (Figure 5). As plant community diversity increases, small mammal population diversity also increases, indicating the importance of habitat quality for wildlife.



*Shannon-Wiener index. Larger numbers signify higher diversity.
** Application rate (lb. ai/acre)

Fig. 5. *Plant community and small mammal population diversity on Wyoming sites treated with tebuthiuron at different application rates in 1978.*

Management Implications

Information from the work in New Mexico and Wyoming illustrates that thinning big sagebrush with tebuthiuron can increase herbaceous forage production for the benefit of livestock and wildlife, while also increasing plant and animal diversity. The increase in dominance of grasses in both New Mexico and Wyoming sites supports the suggestions by Vale (1974) and Frischknecht and Baker (1972) that big sagebrush competes with cattle-preferred herbaceous forage, and big sagebrush control improves desirable forage production. Resource managers from the BLM Farmington District strive to maintain an overall composition of 65% perennial grasses, 15% forbs, and 20% shrubs in big sagebrush dominated areas. This ratio is not a uniform mix on every acre, but rather a mosaic of various communities. They believe this diverse plant community composition will provide optimum conditions for livestock grazing, wildlife habitat, and protection of watershed systems.

Resource managers generally recognize that ideal habitat for antelope and sage grouse consist of big sagebrush with associated stands of other shrubs, grasses, and forbs comprising a variety of cover types from dense brush to grassy openings. In New Mexico, Hooley (1991) reported that antelope heavily used tebuthiuron-treated areas, especially during non-winter periods, to take advantage of the available grasses and forbs. The BLM purposely leaves large tracts of untreated big sagebrush for wintering use by antelope when browse demands are higher.

Elk populations in the BLM Farmington District have also increased dramatically since tebuthiuron treatments were implemented 11 years ago. In 1982, the first year of tebuthiuron treatments, 284 elk licenses were issued for the game management area encompassing the BLM Farmington District. The number of elk licenses issued in 1993, 11 years later, was 1,130[1]. Since the initiation of tebuthiuron treatments, BLM resource managers have observed reduced runoff, erosion, and sedimentation from watersheds due to higher absorption of precipitation from increased vegetative cover. The percent vegetative cover on Rosa and North Kaime tebuthiuron-treated areas averaged 78.5% and 67%, respectively, compared to 44% and 43%, respectively, on adjacent untreated areas (Table 4).

Table 4. Percent ground cover on New Mexico sites treated with tebuthiuron (0.50 lb. ai/acre) compared to control sites in 1993.

	Ground Cover						
Sample Sites	Bare Ground	Forbs	Shrubs	Rock	Litter	Ground	Trees
				(%)			
Rosa #1	57	20	3	0	14	5	1
Rosa #2	66	9	2	0	14	9	0
Rosa Control	24	5	15	1	24	31	0
North Kaime	61	2	4	0	10	23	0
North Kaime Control	23	0	20	0	15	42	0

In addition to increasing forage production for herbivore grazing, enhancing wildlife habitat, and protecting against watershed erosion, thinned big sagebrush areas attract livestock away from riparian habitat. Several ranchers already using tebuthiuron report that livestock spend less time in riparian areas, preferring to graze the more palatable and nutrient-rich herbaceous forage produced on thinned big sagebrush uplands This management technique offers a promising tool to protect and improve valuable riparian areas across the West.

Skeletons of big sagebrush remaining after treatment with tebuthiuron provide perch sites for a variety of avian wildlife and trap blowing snow thereby further improving moisture availability for plant production. In some areas of heavy herbivore grazing, skeletons of big sagebrush offer some protection to herbaceous understory vegetation normally subjected to intensive utilization. The increase in grasses and forbs associated with sagebrush thinning also reduces the amount of wind-caused soil erosion.

[1](Personal communication from R. Culp, Conservation Officer, New Mexico Game and Fish Department).

Treatment Costs

In 1993, the BLM treated 6,550 acres of big sagebrush-dominated rangeland with tebuthiuron. The average cost per acre using a fixed wing aircraft to apply 0.4 lb. ai/acre was $12.39. Based on an estimated 20-year expected benefit, tebuthiuron treatments cost only $0.62 per acre per year. Considering the limited beneficial period from past mechanical treatments in New Mexico, tebuthiuron applications offer an attractive cost-benefit range improvement alternative.

Summary

Determining the appropriate prescribed application rate of tebuthiuron to achieve optimal multiple-use benefits on western rangelands dominated by big sagebrush has been an evolutionary process to this point. However, applications ranging from 0.3 to 0.5 lb. ai/acre are cost effective prescriptions to achieve a mixed plant community. This range of application appears to provide maximum benefits to herbivores and a wide variety of wildlife, as well as additional benefits to the watershed.

Literature Cited

Curtis, J.T. and R.P. McIntosh. 1951. An upland forest continuumin the prairie-forest border region of Wisconsin. Ecology 32:476-496.

Frischknecht, N.C. and M.F. Baker. 1972. Voles can improve sagebrush rangelands. J. Range Manage. 25(2):466-468.

Hooley, C. 1991. Pronghorn antelope use of tebuthiuron treated areas in northwestern New Mexico. Paper presentation, 15th Biennial Pronghorn Antelope Workshop, Rock Springs, Wyo.

Krebs, C.J. 1989. Ecological methodology. Harper and Row, Publishers, New York, N.Y. 645 p.

Miller, R.F. 1991. Effects of livestock grazing the sagebrush steppe. In: Ecological Implications Of Livestock Herbivory In The West. Symposium presented at the 42nd AIBS Annual Mtg. of Scientific Societies, San Antonio, Tx., August 4-8. Abstract.

Pechanec, J.F. and G.D. Pickford. 1937. A weight estimate method for determination of range or pasture production. J. Agron. 29:894-904.

Pieper, R.D. 1991. Ecological implications of herbivory. In: Ecological Implications Of Livestock Herbivory In The West. Symposium presented at the 42nd AIBS Annual Mtg. of Scientific Societies, San Antonio, Tx., August 4-8. Abstract.

Schroeder, M.H. and D.L. Sturges. 1975. The effect on Brewer's sparrow of spraying big sagebrush. J. Range Manage. 28(4):294-297.

Swenson, J.E., C.A. Simmons, and C.D. Eustace. 1987. Decrease in sage grouse (*Centrocercus urophasianus*) after ploughing of sagebrush steppe. Bio. Conserv. 41:125-132.

Vale, T.R. 1974. Sagebrush conversion projects: An element of contemporary environmental change in the Western United States. Bio. Conserv. 6(4):274-284.

Whitson, T.D. and H.P. Alley. 1984. Tebuthiuron effects on Artemisia spp. and associated grasses. Weed Sci. 32:180-184.

Wilm, H.G., D.F. Costello, and G.E. Klipple. 1944. Estimating forage yield by the double sampling method. J. Agron. 36:194-203.

Zou, J., J.T. Flinders, H.L. Black, and S.G. Whisenant. 1989. Influence of experimental habitat manipulations on a desert rodent population in southern Utah. Great Basin Nat. 49(3):435-448.