J. Range Manage.
48:431–437 September 1995

Shrub preference and utilization by big game on New Mexico reclaimed mine land

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Abstract

Mined lands are reclaimed so the land can be used for other purposes after mining. At the La Plata Mine in New Mexico, post-mining land uses include livestock grazing and providing wildlife habitat. The objective of this research was to evaluate use of seeded and volunteer shrubs by mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) during the first opportune season, which occurred 7 years following reclamation. Twelve species of shrubs (10 planted and 2 volunteer) were found on 4 different topdressing treatments. Five branches of shrubs for each species were marked and lengths measured prior to and following the winter wildlife grazing season to determine amount of use. Greatest use by both deer and elk was on curlleaf mountain mahogany (*Cercocarpus ledifolius* Nutt.), followed in decreasing order by fourwing saltbush (*Atriplex canescens* [Pursh] Nutt.), rubber rabbitbrush (*Chrysothamnus nauseosus* [Pall.] Britton), common winterfat (*Ceratoides lanata* [Pursh] Moq.), shadscale (*Atriplex confertifolia* [Torr. and Frem.] Wats.), antelope bitterbrush (*Pursia tridentata* [Pursh] DC.), big sagebrush (*Artemisia tridentata* Nutt.), skunk bush sumac (*Rhus trilobata* Nutt.), Utah juniper (*Juniperus osteosperma* [Torr.] Little), fringed sagebrush (*Artemisia frigida* Willd.), service berry (*Amelanchier alnifolia* Nutt.), and pinyon pine (*Pinus edulis* Engelm.). The greatest shrub utilization was on the Jocity topdressing treatment, which is the name of the soil series from which the topdressing was obtained. The Jocity soil series was found on a flood plain site dominated by greasewood (*Sarcobatus vermiculatus* [Hook.] Torr.). Other shrub utilization, in decreasing order of use, was on topdressing that was a mixture of Jocity and Atrac topdressing, spoil topdressing, and Atrac topdressing, which is a soil series found on an upland site dominated by big sagebrush.

Key words: reclamation, browse, elk, deer, shrubs, utilization

Long periods of time, large sums of money, and much labor are often used to establish vegetation on lands that have been surface mined. The success of these efforts is ultimately reflected in their utility for the targeted post-mining land uses. The basic criteria for successful mine reclamation were established by the Surface Mining Control and Reclamation Act of 1977 (SMCRA), Pubic Law 95-87. Before a mining permit is issued, a reclamation plan must be filed that includes:

> the productivity of the land prior to mining, including appropriate classification as prime farm lands, as well as the average yield of food, fiber, forage, or wood products from such lands obtained under high levels of management (Sec. 508.(a)(2)(c)).

The affected land will be restored to:

> a condition capable of supporting the uses which it was capable of supporting prior to any mining, or to higher or better uses of which there is reasonable likelihood (Sec. 515.(a)(2)).

On all affected lands there will be established:

> a diverse, effective and permanent vegetative cover of the same seasonal variety native to the area of land to be affected and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area, except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved post mining land use plan (Sec. 515.(b)(19)).

Therefore, the coal mining permit for the La Plata Mine requires collecting data to determine the pre-mining vegetal cover, yearly plant growth, shrub density, and plant diversity. The post-mining land uses are livestock grazing and wildlife habitat. The mine land was traditionally grazed by all kinds of livestock prior to mining and is still a winter range for mule deer and elk.

In 1981, a 1.4-ha site within the La Plata mining lease was seeded with 10 shrub species, 12 grass species, and 7 forb species. A fence was placed around the site to exclude all ungulates. The site was evaluated in 1981, 1982, and 1988 to determine plant establishment success. The fence was removed in the summer of 1988. The plants, both planted and volunteer, were available for deer and elk consumption the following winter.

The objective of this research was to evaluate use of seeded and volunteer shrubs by deer and elk during the first opportune season at the La Plata Mine research site.

Approved for publication by the Director of New Mexico State University Agricultural Experiment Station. Study funded by BHP–Minerals, Inc., Farmington, New Mexico.
Manuscript accepted 21 December 1994.

Methods

In 1981, the 1.4 ha-site within the La Plata mining lease was cleared of vegetation, and all topsoil (A-C horizon) was removed, leaving only exposed spoil material, the parent material for the topsoil. Four different topdressings were randomly applied in 32 × 20 m blocks (4 blocks per topdressing type) on top of the spoil to a 50 cm depth. The topdressings were derived from: 1) spoil, 2) a site in the Jocity soil series (fine-loamy, mixed calcareous, mesic Typic Torrifluvent) dominated by greasewood, 3) a site in the Atrac soil series (fine-loamy, mixed, mesic Ustollic Camborthid) dominated by big sagebrush, and 4) a 1:1 mixture of Jocity and Atrac soil (Gifford 1984). In 1988, 3 random soil samples were collected from the surface to a depth of 40 cm from each topdressing treatment. Soils from each topdressing were thoroughly mixed before laboratory analyses. These analyses included determinations of electrical conductivity, sodium absorption ratio, texture, base saturation, sodium, calcium, magnesium, nitrogen, phosphorus, potassium, boron, arsenic, and selenium (Klute 1986 and Page et al. 1982).

Each block was divided into 35 subplots (3.5 × 3.5 m) and seeded with 10 species of containerized shrubs or broadcast seeded with 12 species of grasses, 7 species of forbs, and 6 species of shrubs (one species per plot). A 2 meter high chain link fence was placed around the site to exclude all ungulates. The site was evaluated in 1981, 1982, and 1988 to determine plant establishment success (Table 1) (Samson et al. 1990). The fence was removed in the summer of 1988. The plants, both planted and volunteer, were available for deer and elk consumption the following winter. In addition to the planted species, a few volunteer species such as rubber rabbitbrush and greasewood also were present in August 1988.

Within each of the 16 blocks, a plant of each species was located, if present. Many of the blocks did not have one surviving plant of a species, such as pinyon pine. Five branches were randomly chosen on each shrub, marked with 5 different colored wires at the branch base, and measured for length (Cassady 1941; Cook and Stubbendieck 1986). In late April 1989, after deer and elk had left the area and before the start of the next season's plant growth, the same shrubs were again measured. The same shrubs and branches were measured and differences attributed to utilization. The height of each shrub was also measured. Results are reported as length of use. Within this report, the term "utilization" is synonymous with "use", which is the proportion of forage production that is consumed by grazing animals (Huss 1964). Preference refers to selection of certain plants over others by grazing animals.

Fecal counts were made at the study site in late April at the same time plants were measured. Twelve 1-meter-wide transects were systematically and equally located across the study area. Fecal counts were made for cattle (*Bos* spp.), deer, elk, and rabbits (*Lepus* spp. and *Sylvilagus* spp.).

The study represented a randomized complete block design. Data were tested for normality. Very few of the data sets were normally distributed. The data consisted of small whole numbers that followed the Poisson distribution for which the mean and standard deviation were similar. Data were subjected to a square root transformation as suggested by Steel and Torrie (1960). Data for each species and soil type were then tested for main effects and interactions with an analysis of variance, and means separated with a Fisher's Least Significant Difference test.

Table 1. Mean relative abundance (number m^{-2}) of each shrub species in each topdressing (Samson et al. 1990).

Species	Topdressing				
	Jocity	Spoil	Mixed	Atrac	Mean
	(number /m^2)				
Curlleaf mountain mahogany	[1]	1.0	[1]	0.2	0.3
Fourwing saltbush	1.8	1.2	1.5	2.2	1.7
Rubber rabbitbrush	1.5	3.1	0.5	1.0	1.5
Common winterfat	0.8	0.2	0.2	0.8	0.5
Shadscale	1.2	0.1	0.1	0.8	0.6
Antelope bitterbrush	[1]	0.2	0.1	1.0	0.3
Fringed sagebrush	[1]	1.5	2.0	2.0	1.4
Big sagebrush	0.4	0.3	1.7	1.5	1.0
Skunk bush sumac	[1]	1.5	0.2	1.5	0.8
Utah juniper	0.5	2.5	0.1	2.2	1.3
Serviceberry	[1]	[1]	0.1	0.2	0.1
Pinyon pine	[1]	0.2	[1]	0.2	0.1

[1]No shrubs of this species were found in this topdressing.

Results and Discussion

Shrub Utilization

Species were ranked to show the mean utilization of each species in each topdressing treatment with levels of significance (Table 2). Curlleaf mountain mahogany had the greatest use and was ranked first. For this species, no significant differences existed between topdressings until the 0.20 level, where use in the spoil was significantly greatest.

As a rule, curlleaf mountain mahogany has little or no palatability for domestic livestock in the summer but is browsed to some extent by goats (*Capra* spp.), sheep (*Ovis* spp.), and cattle in the late fall, winter, and early spring (Dayton et al. 1937; Stubbendieck et al. 1992). It usually grows at elevations above that of most winter livestock ranges. Its leaves last 2 years with half being replaced annually, so both leaves and twigs are available throughout the year. Curlleaf mountain mahogany is a good winter game browse (Plummer et al. 1968), ranking as an outstanding winter forage for deer and elk, and ordinarily is grazed moderately from late fall to early spring.

Fourwing saltbush was also used extensively (Table 2) with the most use in the Jocity topdressing. Significance letters were the same at the 0.01 level of probability, but only Jocity topdressing had more use of this species at other levels of significance. This species withstands exceptionally heavy grazing and grows well the following season (Plummer et al. 1968). Livestock, big game, and rabbits graze it avidly in all seasons. Because a high proportion of its nutritious green leaves and seeds persist on bushes well into winter, all kinds of browsing animals will utilize fourwing saltbush.

Rubber rabbitbrush was used extensively in all topdressings (Table 2). Its highest use was in the Jocity topdressing, but this use was not significantly different from use in other topdressings at P=0.01 and not significantly different from use in the mixed soil type at any level. The first large animals to use this area in

Table 2. Mean twig length reduction (cm) for each species and topdressing.

Species	Soil type	Mean	Level of significance 0.01	0.05	0.10	0.20
		(cm)				
Curlleaf mountain mahogany	Jocity	[1]				
	Spoil	15.4[2]	A	A	A	B
	Mixed	[1]				
	Atrac	11.5	A	A	A	A
Fourwing saltbush	Jocity	20.5	A	A	A	A
	Spoil	10.3	A	B	B	B
	Mixed	11.0	A	B	B	B
	Atrac	8.8	A	B	B	B
Rubber rabbitbrush	Jocity	19.6	A	A	A	A
	Spoil	7.0	A	B	B	B
	Mixed	12.0	A	AB	AB	AB
	Atrac	8.3	A	AB	B	B
Common winterfat	Jocity	9.3	A	A	A	B
	Spoil	4.4	A	A	A	B
	Mixed	12.6	A	A	A	A
	Atrac	10.5	A	A	A	A
Shadscale	Jocity	12.5	A	A	A	A
	Spoil	7.0	A	A	A	B
	Mixed	8.3	A	A	A	B
	Atrac	9.2	A	A	A	B
Antelope bitterbrush	Jocity	[1]				
	Spoil	16.8	A	A	A	A
	Mixed	10.4	AB	AB	AB	A
	Atrac	0.7	B	B	B	B
Big sagebrush	Jocity	9.9	A	A	A	A
	Spoil	10.9	A	A	AB	A
	Mixed	6.3	A	A	B	B
	Atrac	[1]				
Skunk bush sumac	Jocity	[1]				
	Spoil	2.3	A	A	B	B
	Mixed	0.0	A	A	C	C
	Atrac	7.0	A	A	A	A
Utah Juniper	Jocity	3.0	A	A	A	AB
	Spoil	3.7	A	A	A	A
	Mixed	1.5	A	A	A	AB
	Atrac	1.4	A	A	A	B
Fringed sagebrush	Jocity	[1]				
	Spoil	2.3	A	A	A	A
	Mixed	0.4	A	B	B	C
	Atrac	1.2	A	B	B	B
Serviceberry	Jocity	[1]				
	Spoil	[1]				
	Mixed	0.0	A	A	A	A
	Atrac	0.0	A	A	A	A
Pinyon pine	Jocity	[1]				
	Spoil	0.0				
	Mixed	[1]				
	Atrac	0.0				

[1]This species not found in this topdressing.
[2]Means followed by the same letter within a species and significance level are not significantly different.

1988 were deer, observed in the area in December. Some rubber rabbitbrush plants had been browsed in December. Its use is attributed to deer and elk because the used branches were higher than the rabbits could reach.

Under normal conditions, the forage value of rubber rabbitbrush is either nil or very low (Dayton et al. 1937; Stubbendieck et al. 1992). From September to November, all classes of domestic livestock graze the flower tops lightly and occasionally eat meager quantities of the herbage and more tender stems. This shrub is sometimes browsed lightly on winter ranges, and a few reports (Dayton et al. 1937) indicate localized, moderate to heavy utilization, but this probably represents an overstocked condition.

Vallentine (1980) points out that subspecies and ecotypes that have unusually high palatability or productivity are often found within plant species generally considered undesirable. Although big sagebrush and rubber rabbitbrush are generally unpalatable to cattle, certain ecotypes have been found with unusually high palatability. Apparently the rubber rabbitbrush found on this study plot is one of these highly palatable ecotypes. Rubber rabbitbrush plants outside the study site were not used, yet they probably are the parents of those inside. It is possible that the rubber rabbitbrush inside produce chemical defense mechanisms following the initial grazing (Laycock 1978). Unfortunately, the plants used in this study could not be measured again because of mining activities. We would have liked to have measured their utilization to see if it would be high over a period of several years.

Common winterfat was used in each topdressing with the most use being in the mixed topdressing (Table 2). There was no significant difference between use in the different topdressing treatments until the 0.20 level, where use in Jocity and spoil derived topdressings was less than in mixed and Atrac. Plummer et al. (1968) reported that winterfat was not highly preferred by deer, but most other big game animals and livestock seek it. Vallentine (1980) reported it has superior palatability, productivity, and adaptability. The Range Forage Handbook (Dayton et al. 1937) and North American Range Plants (Stubbendieck et al. 1992) report winterfat grazed by all classes of livestock as well as by deer and elk. Bidwell and Wooton (1925) stated that it was good goat forage, while Cotton (1904) referred to its value for horses (*Equus* spp.). This half-shrub species responds well to regulated grazing, grows luxuriantly under cultivation, and produces an abundance of viable seed. But, persistent and continuous overgrazing has measurably reduced this plant on many ranges and has completely destroyed it on others.

Scadscale had the greatest amount of use in Jocity topdressing although there was no significant difference between use on any of the topdressings until tested at the 0.20 level of probability (Table 2). At this level, use of plants in Jocity topdressing was significantly different, while use of plants in the other topdressings was not different. Close examination of shadscale plants revealed long, sharp spines that result in low palatability. However, Dayton et al. (1937) and Stubbendieck et al. (1992) report that shadscale is palatable to all classes of livestock and is grazed chiefly in the fall, winter, and spring. Although ordinarily less palatable than some of its plant associates, its abundance on winter ranges makes it very important as forage. The seeds are the most palatable part of the plant and probably the most nutritious. The leaves are also relished, often falling to the ground during the late autumn, collecting in depressions under the bushes, and thus available to animals when they enter the winter ranges. During moist weather the branches become softened and are moderately cropped. On some ranges shadscale is overused, and consumption of coarse portions causes sore mouths, especially among young lambs.

Antelope bitterbrush was used heavily in the spoil topdressing (Table 2). Only fourwing saltbush in Jocity topdressing was used

more. Antelope bitterbrush also was used heavily in the mixed topdressing but hardly at all in the Atrac topdressing. Antelope bitterbrush was not found in the Jocity topdressing. Significance levels show no differences between use of the plants found in spoil and mixed topdressings. Antelope bitterbrush and its hybrids are highly palatable to most grazing animals (Plummer et al. 1968) and are considered one of the most important browse plants on western ranges (Dayton et al. 1937; Stubbendieck et al. 1992). Leaves and younger twigs are extensively cropped by sheep, goats, and cattle, but are eaten very little by horses. It is especially important as a winter and early spring feed for deer, elk, and antelope. Some significant variations occur in its palatability: over most of its range, palatability is excellent, but in some places in the Northwest antelope bitterbrush has been found to be worthless to only fair for sheep and poor to fair for cattle. These variations are often difficult to explain. Some possibilities include fixed feeding habits of the grazing animals in certain localities; changes with different plant associations or forage combinations; the presence of certain chemicals absorbed from the soils; and genetic differences. Preference was not adversely affected by chemical uptake in the spoil, as plants in this soil had the highest use.

Big sagebrush was used relatively heavily in all topdressings except Atrac (Table 2) where no big sagebrush plants were present; therefore, use of this plant on Atrac topdressing could not be determined. There were no significant differences in use for the 3 topdressings where big sagebrush was found until the 0.10 level of probability. Big sagebrush is abundant in protein, but the foliage contains considerable aromatic oils that reduce palatability (Plummer et al. 1968). Because it grows in association with many assorted forbs, grasses, and other shrubs, in most of the West big sagebrush provides the most important winter forage on foothill areas for big game and livestock. Its value is further enhanced by its unusually rapid growth and exceptional ability to spread naturally from seed.

Skunk bush sumac was used extensively on the Atrac topdressing, but very little on the spoil and mixed topdressings (Table 2). It was not found on the Jocity topdressing. Significance levels were different for all 3 topdressings, where it was found at the 0.10 level of probability. Plummer et al. (1968) call this an unusually persistent native shrub, relatively low in palatability but valuable for wildlife cover. Winter persistent berries provide food for birds. Dayton et al. (1937) reported that in the Southwest and southwestern Colorado the species is usually fair, fairly good, or even good for cattle as well as sheep. Chapline (1915) said it was of very high palatability for goats in the Southwest.

Utah juniper was used somewhat in all topdressings (Table 2). Significant differences were only found at the 0.20 level of probability. Elias (1980) reported that the fruit is a popular food for wildlife, with ground squirrels (*Citellus* spp.), chipmunks (*Eutamias* spp.), and seed eating birds (*Aves*) consuming the largest amounts. Deer browse on the branchlets. Mahgoub et al. (1987) reported that one-seed juniper (*Juniperus monosperma* [Engelm.] Sarg.) was found in 20% of the March diet, 25% of the June diet, and 15% of the September diet of mule deer in south-central New Mexico. The 581 page proceedings of a recent conference on pinyon-juniper (Everett 1987) do not mention the use of Utah juniper foliage as a forage. From the literature and this study, it is considered quite free of grazing use by most wildlife and livestock.

Fringed sagebrush was used most in the spoil topdressing (Table 2). This plant is low-growing, with foliage reaching only a few centimeters in height although the seed heads reach some 40 cm high. Use was measured on the foliar parts, and 2.3 cm of use represents most of the plant. No plants were found on Jocity topdressing. Significant differences in use occurred for all topdressing treatments at the 0.20 level of probability. Fringed sagebrush varies considerably in forage value in different locations. In the Southwest, it rates as fairly good for cattle and very good for sheep and goats, especially during the winter and spring. It is fair for deer and elk, especially for late fall, winter, and early spring use.

Serviceberry was found on 2 topdressings (Table 2), but was not utilized on either. There was no sign of use on either tagged or untagged branches. Plummer et al. (1968) reported that big game and livestock use the new growth as forage throughout the year. The berries provide food for mammals (*Mammalia*) and birds, and the shrubs serve as cover. Dayton (1931) and Stubbendieck et al. (1992) reported it is grazed principally in the spring, when it provides fairly good forage for cattle and good to excellent browse for sheep and goats. Plummer et al. (1968) said it was not readily used in Utah. This study showed it was not used in the study area.

Pinyon pine was found on 2 topdressings (Table 2), but only 2 pinyon pines were found on the entire research site. They were probably grazed by rodents or rabbits prior to tagging in December. Numerous accounts cite losses of pine seedlings to rodents, squirrels, rabbits, cattle, deer, elk, and birds (Heidmann et al. 1977; Larson 1961; Radvanyi 1973; Schubert 1974; and White 1981).

Mean utilization and standard deviation for each species in each topdressing and all topdressings combined are shown in Table 3. Curlleaf mountain mahogany had the highest utilization

Table 3. Mean utilization (cm) and standard deviations from each species with all topdressings combined.

Species	Standard mean	deviation	Level of significance 0.01	0.05	0.10	0.20
	-(cm)-					
Curlleaf mountain mahogany	13.5[1]	7.2	A	A	A	A
Fourwing saltbush	13.3	14.3	A	A	A	A
Rubber rabbitbrush	11.7	18.9	A	A	AB	AB
Common winterfat	9.9	13.7	A	AB	AB	BC
Shadscale	9.3	9.4	A	AB	AB	BC
Antelope bitterbrush	8.8	13.0	AB	AB	ABC	BC
Big sagebrush	8.5	6.6	AB	AB	BC	C
Skunk bush sumac	3.5	6.9	AB	BC	C	D
Utah juniper	2.2	4.4	AB	C	C	D
Fringed sagebrush	1.4	2.1	B	C	C	D
Serviceberry	0.0	0.0	B	C	C	D
Pinyon pine	0.0	0.0	B	C	C	D

[1]Means followed by the same letter within a significance level are not significantly different.

while serviceberry and pinyon pine had none. The letters showing significant differences at various levels of probability tend to lump the species into 3 overlapping groups. The first group includes species with utilization from 8.5 to 13.5 cm (big sagebrush, antelope bitterbrush, shadscale, common winterfat, rubber

rabbitbrush, fourwing saltbush, and curlleaf mountain mahogany). The second group includes those species from 2.2 to 9.9 cm (Utah juniper, skunk bush sumac, big sagebrush, antelope bitterbrush, shadscale, and common winterfat). The third group include species from 0.0 to 3.5 cm (pinyon pine, serviceberry, fringed sagebrush, Utah juniper, and skunk bush sumac). The groups get much narrower at the 0.20 level and wider at the 0.01 level of probability.

Mean utilization and standard deviation for each topdressing treatment with all species combined are shown in Table 4. The most utilization occurred on shrubs in the Jocity topdressing, and this level of use was significantly greater than use on other topdressings. Lowest use was on the Atrac topdressing. The reasons why use on the Jocity topdressing is highest and lowest on the Atrac topdressing are not clear. Factors effecting palatability are not completely understood (Heady 1975), for example, nutritive and chemical contents correlate with palatability in many instances but not in others. Chemical content of the 4 topdressing materials show higher values in the Jocity for several variables (Table 5), especially sodium. Salt has not been placed in the area for livestock for many years, and deer and elk may be seeking sodium-rich plants as part of their winter diets. Nitrogen was also higher in the Jocity topdressing material.

Palatability of a given plant species changes, sometimes for unknown reasons, but probably because of changes in characteristics that an animal can recognize by its senses of touch, taste, and smell (Cowlishaw and Alder 1960). Cook (1959) found soil affected plant palatability and animal food preferences. A plant species on different sites will vary in chemical composition, succulence, proportion of leaf, and harshness of the foliage–all palatability factors.

Tables 3 and 4 contain the standard deviations for each mean, representing a measure of dispersion of use values. Standard deviations associated with the shrub populations in this study are near the mean in size. This is not the result of inadequate sample size, but rather reflects conditions at the study site. Within a species, some shrubs had the majority of its branches eaten, while some shrubs had very few eaten and still others had some branches that were heavily used and some that were used very little. Much of this variation is probably due to random use by animals and not plant morphology. Based on methods of estimating twig or branch weight based on leader length and diameter (Mahgoub et al. 1988), a rubber rabbitbrush twig grazed for 57 cm (which actually happened) would represent about 570 g or about 1.25 lbs. Mature cattle each eat about 11,800 g or about 26 lbs each day. A deer eats about a sixth as much as a cow (2,000 g or 4.3 lbs) and an elk eats about half as much (5,900 g or 13 lbs) (Rasmussen et al. 1941). Therefore, the consumption of a 57 cm long twig by a deer would represent about a quarter to a third of its daily intake. Deer usually do not eat their entire day's need at one time, but spread it out throughout a 24-hour day (Moen 1973).

Table 4. Mean utilization (cm) and standard deviations for each topdressing with all species combined.

Species	Standard mean	deviation	Level of significance 0.01	0.05	0.10	0.20
	(cm)					
Jocity	14.6[1]	15.2	A	A	A	A
Spoil	7.3	10.4	B	B	B	B
Mixed	8.7	12.9	B	BC	BC	B
Atrac	5.7	11.2	B	B	C	C

[1]Means followed by the same letter within a significance level are not significantly different.

Table 5. Soil Analysis (1988)[1].

Chemical analysis	Jocity	Spoil	Mixed	Atrac
pH	8.0	7.4	7.6	7.7
Electrical conductivity (mmhos cm^{-1})	2.2	3.3	1.2	0.7
Sodium Absorption Ratio (SAR)	13.4	3.8	3.3	0.7
Texture[2]	l	cl	scl+	scl
Base saturation (%)	40.0	65.0	41.6	41.8
Sodium (meq $liter^{-1}$)	17.1	13.1	5.3	1.2
Calcium (meq $liter^{-1}$)	3.4	9.0	5.1	4.1
Magnesium (meq $liter^{-1}$)	1.2	12.8	2.2	1.6
Nitrogen NO_3-N (meq $liter^{-1}$)	14.4	6.5	9.8	7.4
Phosphorus (μg g^{-1})	5.8	3.0	6.6	3.2
Potassium (μg g^{-1})	171	76	184	198
Boron (μg g^{-1})	≤0.1	0.1	≤0.1	≤0.1
Arsenic (μg g^{-1})	≤0.05	≤0.05	≤0.05	≤0.05
Selenium (μg g^{-1})	≤0.01	≤0.01	≤0.01	≤0.01

[1]Soil samples were collected and analyzed in August 1988. Each mean represents a composite sample from 0-10, 15-25, and 30-40 cm depth.
[2]l = loam, cl = clay loam, scl = sandy clay loam.

Shrub Height

Mean plant height for each shrub species in all topdressings is shown in Table 6. Behind the protection of an excluding fence, all shrubs grew quite tall considering the climate, soil type, and shrub genetic potential. The biggest disappointments were pinyon

Table 6. Mean plant height (cm) for each shrub species in each topdressing and all topdressings combined.

Species	Soil derivation Jocity	Spoil	Mixed	Atrac	All
	(cm)				
Curlleaf mountain mahogany	[1]	81	[1]	42	65
Fourwing saltbush	104	73	94	106	94
Rubber rabbitbrush	106	121	108	115	112
Common winterfat	37	28	36	71	46
Shadscale	39	25	43	38	36
Antelope bitterbrush	[1]	74	60	48	61
Fringed sagebrush	[1]	23	41	40	35
Big sagebrush	97	80	77	42	80
Skunkbush sumac	[1]	78	83	97	87
Utah juniper	57	46	23	62	49
Serviceberry	[1]	[1]	[1]	68	68
Pinyon pine	[1]	10	[1]	21	15
All	79	63	66	66	

[1]This species not found in this topdressing.

pine and juniper. These plants had experienced 8 growing seasons and were only 15 and 49 cm tall, respectively. All shrubs were considered to be within reach of deer, elk, and cattle. Many were probably too tall and out of reach for rabbits. Plant height for each topdressing with all shrubs combined shows the tallest plants were growing in the Jocity topdressing. Heights in the other topdressings were quite similar. Apparently the Jocity topdressing had the most nutrients or water-holding capacity.

Table 7 shows mean utilization as a percentage of plant height. Shadscale, a relatively low-growing shrub, had the highest percentage use compared to height. Others with high percentages in decreasing order were common winterfat, curlleaf mountain mahogany, antelope bitterbrush, fourwing saltbush, big sagebrush, and rubber rabbitbrush. The other species had less than 5% utilization.

Table 7. Mean utilization divided by plant height for each species across all topdressings.

Species	Utilization/height
Curlleaf mountain mahogany	20.8
Fourwing saltbush	14.1
Rubber rabbitbrush	10.4
Common winterfat	21.5
Shadscale	25.8
Antelope bitterbrush	14.4
Fringed sagebrush	4.0
Big sagebrush	10.6
Skunkbush sumac	4.0
Utah juniper	4.5
Serviceberry	0.0
Pinyon pine	0.0

Fecal Numbers

The research plot was also sampled for fecal numbers. Mean number of cattle piles was 176 per hectare. Cattle were not supposed to be in the study area, but some trespassed onto the mine while the soil was wet. Their tracks were evident and grass plots showed use. Tracks were not found near shrubs, and it is believed that cattle did not use any of the shrubs. Mean number of deer pellet groups was 547 per hectare, while elk left 137 pellet groups, and rabbits left 1367 pellet groups. Rabbits were in the study area before the fence was removed in the summer of 1988. Most of the use of the tall shrubs is attributed to deer with a lesser portion to elk. The small shrubs were probably used by deer, elk, and rabbits. No attempt was made to differentiate fecal groups by age.

Conclusions

This study shows that 10 of the 12 shrub species that were evaluated showed some signs of use. Use is not considered excessively high on any of the species. The use could be extremely high if animal numbers were much greater, based on reports relating these species to use in other areas. Species of high palatability may not be desirable if other goals such as soil utilization and aesthetics are important to management. It would be useful to continue monitoring these shrubs for several more years. Unfortunately, due to mining activities, they were not available after 1989. A long-term study would be even more meaningful, but the present study gives indicators of expected responses for a short time.

A large array of species offers protection from potential climatic or biological abuse of a site. For example, serviceberry may be immune to large animal grazing, it may stabilize a site, and be aesthetically pleasing, but an insect attack restricted to that plant species may leave an ecological disaster. A wide array of highly palatable plants might perpetuate a wildlife herd whose population is increasing to the point of being a real problem in maintaining a protective cover on reclaimed sites. Therefore, the goals of land management can indicate if it is more desirable to have a majority of highly palatable plants, a mixture of species that have various degrees of palatability, or mostly a majority of plants that will not be eaten by wildlife and livestock. The results of this study make it possible to choose any of the 3 alternatives.

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