DEPARTMENT OF ENVIRONMENTAL QUALITY

LAND QUALITY DIVISION

CHAPTER 4, APPENDIX 4B

A. Evaluation of Shrub Density

Introduction

All "eligible lands", as defined in Chapter 1, Section 2(am), shall be ~~All land affected after August 6, 1996, excluding cropland, pastureland or treated grazingland as defined in Chapter 1 shall be considered eligible land~~ subject to the standard. Except where a lesser density is justified by premining conditions, at least 20 percent of the eligible land shall be restored to shrub patches supporting an average density of one shrub per square meter ~~(Chapter 4, Section 2(d)(x)(E))~~.

The postmining areal extent of shrub patches and specific shrub density(ies) shall be based on the original premining shrub densities in each vegetation community and the percentage each community contributes to the total eligible land existing in the original permit area and any lands added to the permit area through the amendment process.

Premine community(ies) identified and sampled during the baseline studies shall serve as the target for bond release unless otherwise approved by the Administrator.

For bond release purposes, the average postmine total density and species specific density(ies) shall be at least 90 percent of the calculated criteria for the applicable standard.

CALCULATING THE REQUIRED POSTMINE DENSITY AND SPECIES COMPOSTION

In order to calculate density and composition, the following must be identified:

1. Areal extent and premining total density of eligible land by vegetation community;

2. Relative density for each species;

3. Dominant premine species which then becomes the target postmine species;

4. Density of target postmine species using the formula $D[1/(N+1)]$;

5. Allowable density of postmining residual species; and

6. Acceptable residual species.

* D is the postmining total shrub density. When D is less than 1.00, the density of the target postmining species is reduced proportionately. N is the number of primary premining shrub and subshrub species.

~~Table 3:~~ Identification of available options

Option	Identification	Premine
I	Reduced permit-wide full shrub standard	$\prec 20\%@\geq 1/M^2$
II	Permit-wide full shrub standard	$\geq 20\%@\geq 1/M^2$
III	Community-specific full shrub standard	No restrictions
IV	Community-specific full and subshrub standard	No restriction – add subshrubs

The operator shall select one option only for bond release purposes within each permit or amendment area.

Option I: Permit-wide full shrub density standard; reduction in areal extent; composition based on premining full shrub density only (see Figure 1 for an illustration of this Option). For bond release purposes, no more than two separate acreage/density standards shall be used.

1. Reductions in areal extent and shrub density shall be appropriate when the premining vegetation community(ies) supporting at least one shrub per square meter comprised less than 20 percent of the eligible land. The percentage this community contributed to the total eligible land would then become the percentage of the postmining landscape that is required to support one shrub per square meter. The remainder of the postmining 20 percent areal extent of shrub patches shall be required to support shrubs at a density equaling the next highest density existing in a premining community.

2. Compute the relative premining dominance of full shrub species based on a weighted average of the percent areal extent of all vegetation communities and their associated full shrub species present within the eligible land. In this instance, one shrub patch seed mixture will be developed for the entire 20 percent areal extent.

3. From the information calculated in step 2. above, identify the dominant premine full shrub species. This species then becomes the target postmine species within the postmine shrub patches.

4. Compute the minimum density that the postmining target shrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

$$D[1/(N+1)]$$

D is the postmining total shrub density (D is always ≤ 1.00). N is the number of primary shrub species existing in the premining communities as identified in step 2. above. Primary shrub species shall be defined as full shrub species which comprise at least 10 percent of the relative density of full shrubs.

All primary shrub species shall be included in the shrub patch seed mixture.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species from the total required density.

6. Residual density may be comprised of any premining primary species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

FIGURE 1

OPTION I: PERMIT-WIDE SHRUB DENSITY, REDUCTION OF DENSITY POSSIBLE COMPOSITION BASED ON FULL SHRUBS

Note: No reduction of density is possible when 20 percent or more of the eligible acreage supports a premining total shrub density of over 1 shrub per square meter.

TABLE 1

Vegetation Community	Number of Acres Affected Following Rule Approval	Percent Eligible Acreage	Premining Total Shrub Density per m^2 (1)	Premining Total Shrub Number
Mixed Shrubland	**364.00**	**18.2**	**1.20**	**1,767,730**
Upland Grassland	**1506.00**	**75.3**	**0.80**	**4,875,826**
Scoria Grassland	**80.00**	**4.0**	**0.30**	**97,128**
Drainage Bottomland	**50.00**	**2.5**	**0.20**	**40,470**
Pastureland (2)	**300.00**	**n/a**	**n/a**	**n/a**
Total Eligible Acreage	**2000.00**			
Total Acreage	**2300.00**		**Premining No. of Shrubs**	**6,781,153**
% Eligible/Total	**86.96**			

(1) When the permit-wide standard is applied, premining density may be calculated from full shrubs only.
(2) Pastureland excluded by regulation

TABLE 2

Relative Premining Density for Primary Shrubs (≥ 10% Relative Density)			Postmining Total Shrub Density m^2 D*	N	D* (1/N+1) Density of Dominant per m^2	Density of Residual Shrubs per m^2	Density of Approved Subshrubs per m^2	20% Acreage Reclaimed with Shrubs	Number of Shrubs Established
Big Sagebrush	**Rubber Rabbitbrush**	**Douglas Rabbitbrush**							
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
0.43	**0.13**	**0.21**	**← Numbers are weighted average relative density from Table 3**						
Dominant Species for this Option:			**BIG SAGEBRUSH**						
Reduced Permit-wide Standard									
18.2% at 1/m^2			**1.00**	**3**	**0.25**	**0.375**	**0.375**	**364.00**	**1,473,108**
1.8% at 0.8/m^2			**0.80**	**3**	**0.20**	**0.300**	**0.300**	**36.00**	**116,554**
						20 percent of eligible lands		**400.00**	
							Postmining No. of Shrubs		**1,589,662**

*** D = Postmining Total Shrub Density (e.g. 0.8 * [1/(3+1)] = 0.20)**

TABLE 3 – Option I, Figure 1 continued

Relative Density Information for Species

Note: Relative density is calculated by number of individuals of each species divided by total number of individuals.

The value of the dominant species for each type is shaded

	Mixed Shrubland	Upland Grassland	Scoria Grassland	Drainage Bottomland	Weighted Average Relative Density**
Silver sagebrush	0.06			0.28	0.02
Big sagebrush	0.63	0.39	0.35	0.11	0.43
Fourwing saltbush		0.03			0.02
Black sagebrush		0.06	0.18		0.05
Rubber rabbitbrush	0.19	0.13			0.13
Douglas rabbitbrush		0.27	0.18		0.21
Wax currant			0.05		0.00
Skunkbrush sumac	0.12		0.20		0.03
Greasewood				0.61	0.02
Common snowberry		0.12	0.04		0.09
Full Shrub Total	1.00	1.00	1.00	1.00	1.00
Fringed sagewort*	0.21	0.03			0.06
Gardner's saltbush*		0.28			0.21
Winterfat*				0.08	0.00
All Full Shrubs/m^2*	1.20	0.80	0.30	0.20	

* excludes these subshrubs, which are not allowed to be included in Option I, II or III.

** Calculated by summing across communities the individual species density times the percent eligible acreage of each community divided by 100

Option II: Permit-wide full shrub density standard, no reduction in areal extent or density, composition based on premining full shrub density only (see Figure 2 for an illustration of ~~this~~ Option II).

1. If 20 percent or more of the premine eligible land supports at least 1 shrub per square meter, no reduction in shrub density or areal extent shall be permitted.

2. Compute the relative premining density of full shrub species based on a weighted average of the percent areal extent of all vegetation communities and their associated full shrub species present on eligible land. In this instance, one shrub patch seed mixture will be developed for the entire 20 percent areal extent.

3. From the information calculated in step 2. above, identify the dominant premine full shrub species. This species then becomes the target postmine species within the postmine shrub patches.

4. Compute the minimum density that the postmining target shrub (identified in step 3. above) must meet I order to achieve bond release under the standard. This is accomplished by applying the following equation:

$$D[1/(N+1)]$$

D is the postmining total shrub density (D is always ≤ 1.00). N is the number of primary shrub species existing in the premining communities as identified in step 2. above. Primary shrub species shall be defined as full shrub species which comprise at least 10 percent of the relative density of full shrubs.

All primary shrub species shall be included in the shrub patch seed mixture.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species from 1.00.

6. Residual density may be comprised of any premining primary species and other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

FIGURE 2

OPTION II: PERMIT-WIDE SHRUB DENSITY, NO DENSITY REDUCTION POSSIBLE COMPOSITION BASED ON FULL SHRUBS

Note: No reduction of density is possible when 20 percent or more of the eligible acreage supports a premining total shrub density of over 1 shrub per square meter

TABLE 1

Vegetation Community	Number of Acres Affected Following Rule Approval	Percent Eligible Acreage	Premining Total Shrub Density per m^2 (1)	Premining Total Shrub Number
Mixed Shrubland	**444.00**	**22.2**	**1.20**	**2,156,242**
Upland Grassland	**1426.00**	**71.3**	**0.80**	**4,616,818**
Scoria Grassland	**80.00**	**4.0**	**0.30**	**97,128**
Drainage Bottomland	**50.00**	**2.5**	**0.20**	**40,470**
Pastureland (2)	**300.00**	**n/a**	**n/a**	**n/a**

Total Eligible Acreage	**2000.00**	**Premining No. of Shrubs**	**6,910,657**
Total Acreage	**2300.00**		
% Eligible/Total	**86.96**		

(1) When the permit-wide standard is applied, premining density may be calculated from full shrubs only.
(2) Pastureland excluded by regulation

TABLE 2

Relative Premining Density for Primary Shrubs (≥ 10% Relative Density)			Postmining Total Shrub Density m^2 D*	N	D* (1/N+1) Density of Dominant per m^2	Density of Residual Shrubs per m^2	Density of Approved Subshrubs per m^2	20% Acreage Reclaimed with Shrubs	Number of Shrubs Established
Big Sagebrush	**Rubber Rabbitbrush**	**Douglas Rabbitbrush**							
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
0.43	**0.13**	**0.21**	**← Numbers are weighted average relative density from Table 3**						

Dominant Species for this Option: **BIG SAGEBRUSH**

Reduced Permit-wide Standard							
100% at 1/m^2	**1.00**	**3**	**0.25**	**0.375**	**0.375**	**400.00**	**1,618,800**

20 percent of eligible lands	**400.00**	
Postmining No. of Shrubs		**1,618,800**

*** D = Postmining Total Shrub Density (e.g. 1.0 * [1/(3+1)] = 0.25)**

TABLE 3 – Option II, Figure 2 continued

Relative Density Information for Species

Note: Relative density is calculated by number of individuals of each species divided by total number of individuals.

The value of the dominant species for each type is shaded

	Mixed Shrubland	Upland Grassland	Scoria Grassland	Drainage Bottomland	Weighted Average Relative Density**
Silver sagebrush	0.06			0.28	0.02
Big sagebrush	0.63	0.39	0.35	0.11	0.43
Fourwing saltbush		0.03			0.02
Black sagebrush		0.06	0.18		0.05
Rubber rabbitbrush	0.19	0.13			0.13
Douglas rabbitbrush		0.27	0.18		0.21
Wax currant			0.05		0.00
Skunkbrush sumac	0.12		0.20		0.03
Greasewood				0.61	0.02
Common snowberry		0.12	0.04		0.09
Full Shrub Total	1.00	1.00	1.00	1.00	1.00
Fringed sagewort*	0.21	0.03			0.07
Gardner's saltbush*		0.28			0.20
Winterfat*				0.08	0.00
All Full Shrubs/m^2*	1.20	0.80	0.30	0.20	

* excludes these subshrubs, which are not allowed to be included in Option I, II or III.

** Calculated by summing across communities the individual species density times the percent eligible acreage of each community divided by 100

Option III: Community-specific full shrub density standard (see Figure 3 for an illustration of this Option).

1. Each eligible premining vegetation community serves as the basis for developing the required postmine density and areal extent. The percentage each community contributes to the total eligible land is multiplied by 20 percent to establish the number of acres required on the postmining landscape. The average number of full shrubs each community supported premine serves as the postmine average density for that particular community.

2. Compute the relative premining dominance of all full shrub species within each eligible vegetation community. In this instance, one shrub patch seed mixture will be developed for each eligible vegetation community.

3. From the information calculated in step 2. above, identify the dominant premine full shrub species within each eligible vegetation community. This species then becomes the target postmine species within a particular shrub patch corresponding to a specific vegetation community.

4. Compute the minimum density that the postmining target shrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

$$D[1/(N+1)]$$

D is the postmining total shrub density (D is always ≤ 1.00). N is the number of primary shrub species existing in the premining communities as identified in step 2. above. Primary shrub species shall be defined as full shrub species which comprise at least 10 percent of the relative density of full shrubs.

All primary shrub species shall be included I the respective shrub patch seed mixtures.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species with each vegetation community from the total required density for that community.

6. Residual density may be comprised of any premining primary species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density with each community.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

OPTION III: COMMUNITY SPECIFIC SHRUB DENSITY – COMPOSITION BASED ON FULL SHRUBS ONLY

TABLE 1

Vegetation Community	Number of Acres Affected Following Rule Approval	Percent Eligible Acreage	Premining Total Shrub Density per m^2	Premining Total Shrub Number	Postmining Total Shrub Density m^2 "D"	N	Dominant Species	D x (1/N+1) Density of Dominant per m^2	Density of Residual Shrubs per m^2	Approved Subshrubs per m^2	20% Acreage Reclaimed with Shrubs	Number of Shrubs Established
Mixed Shrubland	364	18.2	1.20	1,767,730	1.00	3	Big Sagebrush	0.25	0.38	0.38	72.80	294,622
Upland Grassland	1506	75.3	0.80	4,875,826	0.80	4	Big Sagebrush	0.16	0.32	0.32	301.20	975,165
Scoria Grassland	80	4.0	0.30	97,128	0.30	4	Big Sagebrush	0.06	0.12	0.12	16.00	19,426
Drainage Bottomland	50	2.5	0.20	40,470	0.20	3	Greasewood	0.05	0.08	0.08	10.00	8,094
Pastureland (1)	300	n/a	n/a									
										Total Postmining Shrub Acres	400.00	
Total Eligible Acreage	2000	Premining No. of Shrubs		6,781,153						Postmining No. of Shrubs		1,297,306
Total Acreage	2300											
% Eligible/Total	87.0											

(1) pastureland excluded by regulation
* D = Postmining Total Shrub Density (e.g. 0.8 x [1(4+1)] = 0.16)

TABLE 2 – Option 3, Figure 3 continued

Relative Density Information for Species – Full Shrub Only The value of the dominant species for each type is shaded.	Mixed Shrubland	Upland Grassland	Scoria Grassland	Drainage Bottomland
Silver sagebrush	**0.06**			**0.38**
Big sagebrush	**0.63**	**0.39**	**0.35**	**0.11**
Fourwing saltbrush		0.03		
Black sagebrush		0.06	0.18	
Rubber rabbitbrush	0.19	0.13		
Douglas rabbitbrush		0.27	0.18	
Wax currant			0.05	
Skunkbrush sumac	0.12		0.20	
Greasewood				0.51
Common snowberry		0.12	0.04	
Full Shrub Total	1.00	1.00	1.00	1.00
Fringed sagewort*	0.21	0.03		
Gardner's saltbush*		0.28		
Winterfat*				0.08
Number shrubs ≥ .1	3	4	4	3
All Full Shrubs/m^2	1.20	0.80	0.30	0.20
*excludes these subshrubs, which are not allowed to be included in Option I, II or III.				

Option IV: Community-specific full shrub and approved subshrub density standard (see Figure 4 for an illustration of this Option)

1. Each eligible premining vegetation community serves as the basis for developing the required postmine density and areal extent. The percentage each community contributes to the total eligible land is multiplied by 20 percent to establish the number of acres required on the postmining landscape. The average number of full shrubs and approved subshrubs each community supported premine serves as the postmine average density for that particular community.

The following are the approved subshrubs which shall be included in calculating the premining density within each community:

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat

2. Compare the relative premining dominance of full shrub and approved subshrub species within each eligible vegetation community. In this instance, one shrub patch seed mixture will be developed for each eligible vegetation community.

3. From the information calculated in step 2. above, identify the dominant premine full shrub or approved subshrub species with each eligible vegetation community. This species then becomes the target postmine species within a particular shrub patch corresponding to a specific vegetation community.

4. Compute the minimum density that the postmining target shrub/approved subshrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

$$D[1/(N+1)]$$

D is the postmining total shrub density (D is always ≤ 1.00). N is the number of primary shrub/approved subshrub species existing in the premining communities as identified in step 2. above. Primary shrub/approved subshrub species shall be defined as full shrub/approved subshrub species which comprise at least 10 percent of the relative density of full shrubs. However, in order to be considered primary species, fringed sagewort must comprise at least 20 percent of the relative shrub/approved subshrub composition.

All primary shrub/approved subshrub species shall be included in the respective shrub patch seed mixtures.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species within each vegetation community from the total required density for that community.

6. Residual density may be comprised of any premining primary full shrub/approved subshrub species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density within each community.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

OPTION IV: COMMUNITY SPECIFIC SHRUB DENSITY – COMPOSITION BASED ON FULL SHRUBS AND APPROVED SUBSHRUBS

TABLE 1

Vegetation Community	Number of Acres Affected Following Rule Approval	Percent Eligible Acreage	Premining Total Shrub Density per m^2	Premining Total Shrub Number	Postmining Total Shrub Density m^2 "D"	N	Dominant Species	D x (1/N+1) Density of Dominant per m^2	Density of Residual Shrubs per m^2	Approved Subshrubs per m^2	20% Acreage Reclaimed with Shrubs	Number of Shrubs Established
Mixed Shrubland	364	18.2	1.40	2,062,351	1.00	3	Big Sagebrush	0.25	0.38	0.38	72.80	294,622
Upland Grassland	1506	75.3	1.10	6,704,260	1.00	3	Big Sagebrush	0.16	0.32	0.32	301.20	975,165
Scoria Grassland	80	4.0	0.30	97,128	0.30	4	Big Sagebrush	0.06	0.12	0.12	16.00	19,426
Drainage Bottomland	50	2.5	0.20	40,470	0.20	3	Greasewood	0.05	0.08	0.08	10.00	8,094
Pastureland (1)	300	n/a	n/a									

				Total Postmining Shrub Acres	400.00
Total Eligible Acreage	2000	Premining Number of Shrubs	8,904,209	Postmining No. of Shrubs	1,297,306
Total Acreage	2300				
% Eligible/Total	87.0				

(1) pastureland excluded by regulation
*** D = Postmining Total Shrub Density (e.g. 0.3 x [1(4+1)] = 0.06)**

A complete proposal for evaluation of postmining shrub density should include:

1. A commitment to provide a brief history of the methods employed to implant shrubs and the husbandry practices specifically related to shrub establishment and maintenance.

2. Methods to identify shrub patches and to determine their areal distribution and extent.

3. Proposed sampling methods for the determination of shrub density within the patches. This discussion should include number of samples.

4. Proposed methods for documenting the presence and distribution of shrub species on all other lands jointly used by livestock and wildlife.