Appendix 3-1

Vegetation Reference Area & Species List

TABLE 1

ALPHABETICAL SPECIES LIST

Scientific Name	Common Name
Abies concolor	White Fir
Acer sp	Maple
Achillea millefolium	Yarrow
Actaea rubra	Baneberry
Agropyron cristatum	Crested Wheatgrass
Agropyron inerme	Beardless Wheatgrass
Agropyron spicatum	Bluebunch Wheatgrass
Agropyron trachycaulum	Slender Wheatgrass
Agrostis exerata	Spike Redtop
Agrostis stolonifera	Redtop
Angelica pinnata	
Antennaria parvifolia	Pussytoes
Artemisia dracunculus	Wormwood
Artemisia frigida	Fringed Sagebrush
Artemisia ludoviciana	Sage
Artemisia tridentata	Big Sagebrush
Aster chilensis	Pacific Aster
Aster glaucodes	Aster
Berula erecta	Water Parsnip
Betula occidentalis	River Birch
Bromus carinatus	Mountain Brome

TABLE 1
ALPHABETICAL SPECIES LIST
PAGE 2

Scientific Name	Common Name
Bromus ciliatus	Fringed Brome
Bromus inermis	Smooth Brome
Cardamine cordifolia	Heartleaf Bittercress
Carex aurea	Sedge
Carex microptera	Smallwing Sedge
Carex atrata	Sedge
Carex vallicola	Sedge
Castilleja linariaefolia	Wyoming Painted-cup
Castilleja miniata	Indian Paintbrush
Cercocarpus ledifolius	Curl-leaf Mahogany
Chaenactis douglasii	
Chenopodium chenopodioides	Goosefoot
Chenopodium leptophyllum	Goosefoot
Chrysothamnus nauseosus	Rubber Rabbitbrush
Chrysothamnus viscidiflorus	Low Rabbitbrush
Cirsium pulchellum	Thistle
Cornus stolonifera	Red Osier Dogwood
Cynoglossum officinale	Houndstongue
Dactylis glomerata	Orchard Grass
Descurainia Californica	California Tansy Mustard
Descurainia pinnata	Pinnate Tansy Mustard
Elymus glaucus	Blue Wildrye
Epilobium angustifolium	Fireweed

TABLE 1
ALPHABETICAL SPECIES LIST
PAGE 3

Scientific Name	Common Name
Epilobium brevistylum	Willowherb
Epilobium latifolium	Willowherb
Equisetum arvense	Horsetail
Erigeron eatonii	Fleabane
Erigeron sp	Fleabane
Erysimum asperum	Wallflower
Festuca ovina	Blue Fescue
Festuca pratensis	Fescue Grass
Fragaria americana	Wild Strawberry
Galium bifolium	Bedstraw
Gayophytum ramosissimum	
Gentianella amarella	
Geranium fremontii	Fremont Geranium
Geranium richardsonii	Richardson Geranium
Gilia aggregata	Skyrocket gilia
Hackelia floribunda	Showy stickseed
Heliomeris multiflora	
Hordeum jubatum	Foxtail Barley
Holodiscus dumosus	Rock Spiraa
Hymenoxys acaulis	Hymenoxys
Hymenoxys richardsonii	Richardsons Hymenoxys
Juncus articus	Arctic Rush
Juncus ensifolius	Swordleaf Rush

TABLE 1
ALPHABETICAL SPECIES LIST
PAGE 4

Scientific Name	Common Name
Juniperus communis	Common Juniper
Juniperus scopulorum	Rocky Mountain Juniper
Lactuca scariola	Prickly Lettuce
Lappula occidentalis	Western Waterleaf
Lonicera involucrata	Bearberry Honeysuckle
Lonicera utahensis	Utah Honeysuckle
Machaeranthera canescens	Hoary Aster
Mahonia repens	Oregon Grape
Melica bulbosa	Oriongrass
Muhlenbergia filiformis	Pullup Muhly
Opuntia sp.	Prickly Pear
Oryzopsis hymenoides	Indian Ricegrass
Pachystima myrsinites	Mountain Lover
Penstemon caespitosus	Beardtongue
Penstemon eatonii	Beardtongue
Penstemon sp.	Beardtongue
Penstemon watsonii	Watson Beardtongue
Picea pungens	Blue Spruce
Pinus edulis	Pinyon Pine
Pinus ponderosa	Ponderosa Pine
Poa compressa	Canadian Bluegrass
Poa glauca	Bluegrass
Poa palustris	Fowl Bluegrass

TABLE 1
ALPHABETICAL SPECIES LIST
PAGE 5

Scientific Name	Common Name
Populus augustifolia	Narrowleaf Cottonwood
Populus tremuloides	Aspen
Prunus virginiana melanocarpa	Chokecherry
Psuedotsuga menziesii	Douglas Fir
Puccinellia nuttaliana	Alkaligrass
Ranunculus cymbalaria	Buttercup
Ribes cereum	Squaw Currant
Ribes sp.	Currant
Rosa woodsii	Woods Rose
Rubus idaeus	Red Raspberry
Rudbeckia occidentalis	Western Coneflower
Salix bebbiana	Beak Willow
Salix drummondiana	Willow
Salix myrtillifolia	Willow
Sambucus coerulea	Blue Elderberry
Sambucus racemosa	Red Elderberry
Senecio multilobatus	Groundsel
Senecio streptanthifolius	Groundsel
Shepherdia canadensis	Russet Buffaloberry
Silene menziesii	Menzies Silene
Smilacina stellata	False Solomonsseal
Solidago spartiflora	Goldenrod

TABLE 1
ALPHABETICAL SPECIES LIST
PAGE 6

Scientific Name	Common Name
Stipa columbiana	Subalpine needlegrass
Stipa comata	Needle and Thread Grass
Stipa lettermanii	Letterman Needlegrass
Swertia radiata	Green Gentian
Symphoricarpos oreophilus	Mountain Snowberry
Thalictrum fendleri	Fendler Meadowrue
Tragopogon porrifolius	Salsify
Trisetum spicatum	Spike Trisetum
Urtica breweri	Stinging Nettle
Verbascum thapsus	Flannel Mullein
Vicia americana	American Vetch
Xanthocephalum sarothrae	

TABLE 2

SPECIES LIST BY PLANT GROUPING AND COMMUNITY TYPES:

Previously Disturbed (D), Cottonwood (CW), Sagebrush (SG), Mountain Shrub/Grassland (MSG), Mixed Mountain Shrub/Conifer/Aspen (MSCA), Spruce/Fir/Aspen (SFA), Riparian (R1 and R2).

GRASSES, SEDGES, RUSHES AND HORSETAILS

	D	CW	SG	MSG	MSCA	SFA	R1	R2
Agropyron cristatum	X							X
Agropyron inerme	X							
Agropyron spicatum	X	X	X	X	X			
Agropyron trachycaulum		X	X			X		X
Agrostis exerata							X	
Agrostis stolonifera		X					X	X
Bromus carcinatus	X							
Bromus ciliatus		X				X	X	X
Bromus inermis	X						X	X
Carex aurea							X	
Carex ai roptera							X	
Carex atrata							X	
Carex vallicola	X							
Dactylis glomerata							X	X
Elymus glaucus							X	
Equisetum arvense		X					X	X
Festuca ovina							X	
Festuca pratensis							X	
Hordeum jubatum							X	
Juncus arcticus							X	
Juncus ensifolius							X	X
Melica bulbosa					X			
Muhlenbergia filiformis			X					
Oryzopsis hymenoides				X	X			
Poa compressa		X	X	X	X	X	X	X
Poa glauca								X

TABLE 2
PAGE 2

GRASSES, SEDGES, RUSHES AND HORSETAILS

	D	CW	SG	MSG	MSCA	SFA	R1	R2
Poa palustris	X	X	X			X		
Puccinellia nuttaliana							X	
Stipa columbiana	X					X		X
Stipa comata			X		X			
Stipa lettermanii	X		X	X		X		
Trisetum spicatum							X	X
Vegetative Grass							X	X

HERBS AND FORBS

	D	CW	SG	MSG	MSCA	SFA	R1	R2
Achillea millefolium	X	X	X			X	X	X
Angelica pinnata								X
Antennaria parvifolia		X	X		X			
Artemisia dracunculus			X					
Artemisia frigida		X	X	X				
Artemisia ludoviciana							X	X
Aster chilensis		X	X			X		X
Aster glaucodes		X		X		X	X	X
Berula erecta							X	
Cardamine cordifolia								X
Castilleja linariaefolia							X	
Castilleja miniata								X
Chaenactis douglasii	X				X	X		
Chenopodium chenopodioides	X					X		
Chenopodium leptophyllum	X				X		X	
Chrysothamnus viscidiflorus			X		X			
Cirsium pulchellum	X	X	X	X	X	X	X	X
Cynoglossum officinale	X	X	X			X		X
Descurainia californica						X		
Descurainia pinnata			X					
Epilobium augustifolium							X	
Epilobium brevistylum							X	X
Epilobium latifolium							X	X
Erigeron eatonii							X	
Erigeron sp.							X	

TABLE 2
PAGE 3

HERBS AND FORBS

	D	CW	SG	MSG	MSCA	SFA	R1	R2
Erysimum asperum						X		
Fragaria americana						X		
Galium bifolium	X					X		
Gayophytum ramosissimum			X					
Gentianella amarella								X
Geranium fremontii	X		X			X	X	
Geranium richardsonii							X	X
Gilia aggregata	X		X		X			
Hackelia floribunda	X		X			X		X
Heliomeris multiflora								X
Hymenoxys acaulis		X						
Hymenoxys richardsonii			X					
Lactuca scariola							X	X
Lappula occidentalis	X		X			X		
Machaeranthera canescens		X	X	X	X	X		X
Opuntia sp.		X						
Penstemon caespitosus					X			
Penstemon eatonii							X	
Penstemon sp.		X						
Penstemon watsonii	X	X	X		X	X		
Ranunculus cymbalaria							X	X
Rudbeckia occidentalis								X
Senecio multilobatus						X		
Senecio streptanthifolius	X					X	X	X
Silene menziesii			X			X		
Smilacina stellata					X	X		
Solidago sparsiflora			X		X	X	X	X
Swertia radiata	X							
Thalictrum fendleri							X	X
Trogopogon porrifolius								X
Urtica breweri	X							
Verbascum thapsus	X							
Vicia americana	X		X	X				X
Xanthocephalum sarothrae					X			

TABLE 2
PAGE 4

SHRUBS

	D	CW	SG	MSG	MSCA	SFA	R1	R2
Actaea rubra								X
Artemisia tridentata	X	X	X	X	X	X	X	
Chrysothamnus nauseosus	X	X	X	X	X			
Cornus stolonifera							X	X
Holodiscus dumosus		X		X				
Juniperus communis						X	X	
Lonicera involucrata							X	X
Lonicera utahensis								X
Mahonia repens				X	X	X		
Pachystima myrsinites		X		X		X	X	X
Prunus virginiana					X			X
Ribes cereum		X				X	X	
Ribes sp.						X		X
Rosa woodsii	X	X	X	X	X	X	X	X
Rubus idaeus						X		X
Salix bebbiana							X	
Salix drummondiana							X	
Salix myrtillifolia							X	X
Sambucus coerula	X							
Sambucus racemosa			X					
Shepherdia canadensis							X	X
Symphoricarpos oreophilus	X	X	X	X	X	X	X	X

TREES

Abies concolor								X
Acer sp.						X		
Betula occidentalis		X						
Cercocarpus ledifolius		X			X			
Juniperus scopulorum	X			X	X			
Picea pungens					X	X	X	X
Pinus edulis								
Pinus ponderosa								
Populus augustifolia		X						
Populus tremuloides	X	X	X			X		X
Psuedotsuga menziesii					X	X		

TABLE 3-A

PREVIOUSLY DISTURBED AREA

(Transects 1-3)

	% FREQ	% COVER	% COMP	PROD* Kg/Ha	% PROD
GRASSES AND SEDGES					
Agropyron cristatum	NC	--	--	--	--
Agropyron inerme	23	T	T	8.7	0.8
Agropyron spicatum	30	0.4	0.8	29.7	2.7
Bromus carinatus	7	T	T	5.3	0.5
Bromus inermis	17	0.9	1.8	16.0	1.4
Carex vallicola	3	T	T	0.3	T
Poa palustris	43	1.9	3.8	40.0	3.6
Stipa columbiana	3	T	T	2.3	0.2
Stipa lettermanii	20	T	T	8.0	0.7
TOTAL GRASSES AND SEDGES		3.2	6.4	110.3	10.0
HERBS AND FORBS					
Achillea millefolium	10	0.1	0.2	2.3	0.2
Chaenactis donglasii	3	T	T	0.7	0.1
Chenopodium chenopodioides	7	0.1	0.2	2.7	0.2
Chenopodium leptophyllum	3	T	T	0.7	0.1
Cirsium pulchellum	10	2.0	4.0	59.0	5.3
Cynoglossum officinale	37	1.1	2.2	58.3	5.3
Galium bifolium	3	T	T	0.7	0.1
Geranium fremontii	3	T	T	0.3	T
Gilia aggregata	3	T	T	0.3	T
Hackelia floribunda	53	1.9	3.8	86.3	7.8
Lappula occidentalis	17	T	T	3.3	0.3
Penstemon watsonii	10	0.7	1.4	13.0	1.2
Senecio streptanthifolius	3	T	T	0.3	T
Swertia radiata	NC	--	--	--	--
Urtica breweri	3	T	T	0.3	T
Verbascum thapsus	3	0.3	0.6	4.7	0.4

* Productivity is reported as dry weight in kilograms per hectare.

TABLE 3-A
Page 2

	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
HERBS AND FORBS (cont.)					
Vicia americana	3	T	T	0.3	T
Total herbs and forbs		6.2	12.3	232.2	21.1
SHRUBS					
Artemisia tridentata	37	8.3	16.5	235.4	21.4
Chrysothamnus nauseosus	43	12.7	25.2	306.2	27.8
Rosa woodsii	33	2.1	4.2	25.1	2.3
Symphoricarpos oreophilus	37	17.7	35.2	190.6	17.3
Total shrubs		40.8	81.1	757.3	68.9
TREE SEEDLINGS					
Juniperus scopulorum	3	T	T	0.4	T
Populus tremuloides	3	0.1	0.2	0.8	0.[illegible]
Total tree seedlings		0.1	0.2	1.2	0.[illegible]
Total for community		50.3	100.0	1101.0	100.[illegible]

TABLE 3-8

COTTONWOOD

(Transects 13-15)

	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
GRASSES AND HORSETAILS					
Agropyron spicatum	3	T	T	T	T
Agropyron trachycaulum	13	0.1	0.3	1.3	0.1
Agrostis stolonifera	NC	—	—	—	—
Bromus ciliatus	20	0.1	0.3	2.0	0.1
Equisetum arvense	3	T	T	T	T
Poa compressa	47	0.5	1.5	14.3	0.7
Poa palustris	20	0.2	0.6	7.0	0.3
Total Grasses		0.9	2.7	24.9	1.2
HERBS AND FORBS					
Achillea millefolium	7	T	T	0.7	T
Antennaria parvifolia	3	0.1	0.3	1.0	T
Artemisia frigida	10	0.1	0.3	1.7	0.1
Aster chilensis	13	0.2	0.5	3.3	0.2
Aster glaucodes	27	0.6	1.9	5.7	0.3
Cirsium pulchellum	23	0.9	2.8	14.7	0.7
Cynoglossum officinale	7	0.1	0.3	1.3	0.1
Hymenoxys acaulis	3	T	T	1.0	T
Machaeranthera canescens	20	0.1	0.3	2.7	0.1
Penstemon sp.	3	T	T	T	T
Penstemon watsonii	3	T	T	T	T
Opuntia sp.	NC	—	—	—	—
Total herbs and forbs		2.1	6.5	32.1	1.5
SHRUBS					
Artemisia tridentata	47	7.7	23.8	791.3	39.1
Chrysothamnus nauseosus	13	1.4	4.3	76.7	3.8
Holodiscus dumosus	7	1.4	4.3	95.7	4.7
Pachystima myrsinites	3	T	T	T	T

TABLE 3-B
Page 2

SHRUBS (cont.)	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Ribes cereum	17	4.4	13.6	281.0	13.9
Rosa woodsii	53	9.5	29.4	362.7	17.9
Symphoricarpos orephilus	27	2.1	6.5	60.7	3.0
Total Shrubs		26.5	81.9	1668.1	82.4

TREE SEEDLINGS					
Betula occidentalis	3	T	T	T	T
Cercocarpus ledifolius	10	1.8	5.6	254.7	12.6
Populus augustifolia	7	0.2	0.6	8.3	0.4
Populus tremuloides	17	0.8	2.5	35.0	1.7
Total tree seedling		2.8	8.7	298.0	14.7
Total Community		32.3	99.8	2023.1	99.8

TREES

Method = Point-centered Quarter

# of sample points = 23 (throughout area at mouth of canyon)

Average dist. = 4.89 m.

Mean area = 23.91 sq m. / tree = 418 trees per hectare.

Species List	#	% FREQ	DENSITY (trees/H.
Narrowleaf Cottonwood (Populus augustifolia)	57	62	259
Rocky Mountain Juniper (Juniperus scopulorum)	14	15	63
Blue Spruce (Picea pungens)	8	9	33
River Birch (Betula occidentalis)	7	8	33
Maple (Acer sp.)	2	2	8
Aspen (Populus tremuloides)	1	1	-
White Fir (Abies concolor)	1	1	4
Curl-leaf Mahogany (Cercocarpus ledifolius)	1	1	4
Douglas Fir (Pseudotsuga menziesii)	1	1	4
	92	100	417

TABLE 3-3
Page 3

Tree Diameters, Basal Areas

	1-10 Cm	11-25 Cm	26-50 Cm	Over 50 Cm	Ave. dia.	Basal area Sq m per hectare
Populus augustifolia	24	20	13	0	16.4	5.47
Juniperus scopulorum	11	3	0	0	8.1	0.32
Picea pungens	3	2	3	0	18.8	1.05
Betula occidentalis	7	0	0	0	4.9	0.06
Acer sp.	2	0	0	0	5.5	0.02
Populus tremuloides	1	0	0	0	5.0	0.01
Abies concolor	1	0	0	0	5.0	0.01
Cercocarpus ledifolius	1	0	0	0	3.0	0.003
Psuedotsuga menziesii	0	0	1	0	31.0	0.32
	50	25	17	0		7.26

TABLE 3-C

SAGEBRUSH

(Transects 10-12)

GRASSES	% FREQ	% COVER	% COMP	PROD Kg/ha	% PROD
Agropyron spicatum	33	0.4	0.8	9.7	1.1
Agropyron trachycaulum	13	0.1	0.2	4.7	0.5
Muhlenbergia filiformis	10	0.1	0.2	2.0	0.2
Poa compressa	13	0.4	0.8	5.3	0.6
Poa palustris	27	0.7	1.4	15.7	1.9
Stipa comata	83	7.1	14.3	125.3	14.2
Stipa lettermanii	20	0.5	1.0	16.0	1.8
TOTAL GRASSES		9.3	18.7	178.7	20.3

HERBS AND FORBS					
Achillea millefolium	7	0.1	0.2	2.0	0.2
Antennaria parvifolia	13	0.6	1.2	4.0	0.5
Artemisia dracunculus	17	1.4	2.8	95.0	10.5
Artemisia frigida	3	0.1	0.2	1.3	0.1
Aster chilensis	3	T	T	0.3	T
Chrysothamnus viscidiflorus	23	2.0	4.0	34.3	3.9
Cirsium pulchellum	3	0.1	0.2	0.7	0.1
Cynoglossum officinale	10	0.4	0.8	8.3	0.9
Descurainia pinnata	3	T	T	0.3	T
Gayophytum ramosissimum	17	T	T	1.7	0.2
Geranium fremontii	7	T	T	2.7	0.3
Gilia aggregata	23	0.3	0.6	7.7	0.9
Hackelia floribunda	7	0.1	0.2	2.7	0.3
Hymenoxys richardsonii	NC	--	--	--	--
Lappula occidentalis	27	0.2	0.4	7.0	0.8
Machaeranthera canescens	13	0.1	0.2	2.3	0.3
Penstemon watsonii	50	1.9	3.8	32.7	3.7
Silene menziesii	13	0.2	0.4	1.3	0.1

TABLE 3-C
Page 2

HERBS AND FORBS (cont.)	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Solidago sparsiflora	13	0.3	0.6	4.3	0.5
Vicia americana	3	T	T	0.3	T
TOTAL HERBS AND FORBS		7.8	15.6	208.9	23.7
SHRUBS					
Artemisia tridentata	83	22.1	44.6	333.4	37.9
Chrysothamnus nauseosus	50	7.3	14.7	120.8	13.7
Rosa woodsii	27	0.6	1.2	1.2	0.1
Sambucus racemosa	3	0.1	0.2	0.4	T
Symphoricarpos oreophilus	7	2.0	4.0	34.9	4.0
TOTAL SHRUBS		32.1	64.7	490.7	55.8
TREE SEEDLINGS					
Populus tremuloides	7	0.4	0.8	1.3	0.1
TOTAL TREE SEEDLINGS		0.4	0.8	1.3	0.1
TOTAL COMMUNITY		49.6	99.5	879.6	100.0

TABLE 3-D

MOUNTAIN SHRUB/GRASSLAND

(Transects 4-6)

	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
GRASSES					
Agropyron spicatum	90	19.3	83.5	556.7	86.3
Poa compressa	17	0.2	0.9	12.3	1.9
Stipa lettermanii	10	1.0	4.3	6.7	1.0
TOTAL GRASSES		20.5	88.7	575.7	89.2
HERBS AND FORBS					
Artemisia frigida	3	0.1	0.4	12.0	1.9
Aster glaucodes	13	0.4	1.7	3.3	0.5
Cirsium pulchellum	10	0.1	0.4	2.7	0.4
TOTAL HERBS AND FORBS		0.6	2.5	18.0	2.8
SHRUBS					
Artemisia tridentata	10	1.7	7.4	48.1	7.5
Holodiscus dumosus	NC	--	--	--	--
Mahonia repens	17	0.1	0.4	1.3	0.2
Pachystima myrsinites	3	T	T	0.2	T
Rosa woodsii	7	0.1	0.4	0.6	0.1
Sumphoricarpos oreophilus	3	0.1	0.4	1.5	0.2
TOTAL SHRUBS		2.0	8.6	51.7	8.0
TOTAL COMMUNITY		23.1	99.8	645.4	100.0

TREES

Method: Point - centered Quarter

# of sample points = 20 (taken in area above & to the west of existing portals)

Average dist. = 4.31 m.

Mean area = 18.58 sq m / tree = 538 trees / hectare.

TABLE 3-D
Page 2

Species List	#	% FREQ	DENSITY (trees/Ha)
Rocky Mountain Juniper (*Juniperus scopulorum*)	25	31	167
Curl-leaf Mahogany (*Cercocarpus ledifolius*)	44	55	296
Douglas Fir (*Pseudotsuga menziesii*)	7	9	48
Pinion Pine (*Pinus edulis*)	4	5	27
	80	100	538

Tree Diameters, Basal Areas

	1-10 Cm	11-25 Cm	26-50 Cm	50-100 Cm	Ave. dia.	Basal area Sq m per hectare
Cerocarpus ledifolius	19	25	0	0	11.7	3.18
Juniperus scopulorum	15	10	0	0	10.4	1.41
Psuedotsuga menziesii	3	2	2	0	18.1	1.25
Pinus edulis	0	1	2	1	38.0	3.05
	37	38	4	1		8.89

TABLE 3-E

MIXED MOUNTAIN SHRUB/CONIFER/ASPEN

(Transects 16-18)

GRASSES	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Agropyron spicatum	57	2.1	6.1	25.3	9.4
Melica bulbosa	27	1.6	4.7	16.3	6.1
Oryzopsis hymenoides	13	0.6	1.8	7.3	2.7
Poa compressa	37	1.0	2.9	12.3	4.6
Stipa comata	50	3.1	9.1	32.0	11.9
TOTAL GRASSES		8.4	24.6	93.2	34.8

HERBS AND FORBS					
Antennaria parvifolia	40	1.2	3.5	8.7	3.2
Chaenactis douglasii	3	T	T	T	T
Chenopodium leptophyllum	3	T	T	T	T
Chrysothamnus viscidiflorus	7	0.7	2.0	6.3	2.3
Cirsium pulchellum	17	1.8	5.3	3.3	1.2
Gilia aggregata	7	0.2	0.6	2.0	0.7
Machaeranthera canescens	10	0.5	1.5	2.7	1.0
Penstemon caespitosus	3	0.3	0.9	0.7	0.3
Penstemon watsonii	27	0.8	2.3	7.3	2.7
Smilacina stellata	13	0.5	1.5	2.7	1.0
Solidago sparsiflora	30	1.2	3.5	7.0	2.6
Xanthocephalum sarothrae	10	T	T	T	T
TOTAL HERBS AND FORBS		7.2	21.1	40.7	15.2

SHRUBS					
Artemisia tridentata	37	2.0	5.8	22.5	8.4
Chrysothamnus nauseosus	20	4.4	12.9	34.3	12.8
Mahonia repens	10	0.5	1.5	1.1	0.4
Prunus virginiana	NC	--	--	--	--
Rosa woodsii	10	0.4	1.2	0.9	0.3
Symphoricarpos oreophilus	30	6.2	18.1	37.8	14.1
TOTAL SHRUBS		13.5	39.5	96.5	36.0

TABLE 3-E
Page 2

TREE SEEDLINGS	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Cercocarpus ledifolius	40	5.0	14.6	37.5	14.0
Juniperus scopulorum	3	0.1	0.3	0.3	0.1
TOTAL TREE SEEDLINGS		5.1	14.9	37.8	14.1
TOTAL COMMUNITY		34.2	100.1	268.2	100.0

TREES

Method: Point - centered Quarter

# of samples = 20

Average dist. = 4.16 m.

Mean area = 17.31 sq m / tree = 578 trees / hectare.

Species List	#	% FREQ	DENSITY (trees/Ha)
Aspen (Populus tremuloides)	23	29	168
Rocky Mountain Juniper (Juniperus scopulorum)	30	37	214
Ponderosa Pine (Pinus ponderosa)	10	12	69
Curl-leaf Mahogany (Cerocarpus ledifolius)	7	9	52
Blue Spruce (Picea pungens)	2	3	17
White Fir (Abies concolor)	1	1	6
Douglas Fir (Psuedotsuga menziesii)	6	8	46
Choke Cherry (Prunus virginiana)	1	1	6
	80	100	578

Tree Diameters, Basal Areas

	1-10 Cm	11-25 Cm	26-50 Cm	51-100 Cm	Ave. dia. (Cm)	Basal ar Sq m per hect
Populus tremuloides	16	7	0	0	8.7	1.00
Juniperus scopulorum	15	14	1	0	11.3	2.14
Pinus ponderosa	1	1	5	3	45.5	11.33

Tree Diameters, Basal Areas (continued)

	1-10 Cm	11-25 Cm	26-50 Cm	51-100 Cm	Ave. dia. (Cm)	Basal are Sq m per hect
Cercocarpus ledifolius	3	4	0	0	11.3	0.52
Picea pungens	1	1	0	0	12.0	0.20
Abies concolor	0	0	1	0	29.0	0.38
Psuedotsuga menziesii	1	2	3	0	27.0	2.64
Prunus virginiana	1	0	0	0	3.0	0.004
	38	29	10	3		18.21

TABLE 3-F

SPRUCE/FIR/ASPEN
(Transects 7-9)

GRASSES	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Agropyron trachycaulum	27	0.3	0.7	11.0	1.6
Bromus ciliatus	23	0.5	1.1	6.7	1.0
Poa compressa	17	0.3	0.7	5.7	0.8
Poa palustris	67	2.2	4.9	44.0	6.5
Stipa columbiana	3	T	T	0.3	T
Stipa lettermanii	27	0.2	0.4	8.0	1.2
TOTAL GRASSES		3.5	7.7	75.7	11.3
HERBS AND FORBS					
Achillea millefolium	37	0.1	0.2	8.0	1.2
Aster chilensis	3	T	T	0.7	0.1
Chaenactis douglasii	7	T	T	2.0	0.3
Chenopodium chenopodioides	3	T	T	0.3	T
Cirsium pulchellum	17	1.3	2.9	9.7	1.4
Cynoglossum officinale	53	1.4	3.1	30.0	4.5
Descurainia californica	3	T	T	0.3	T
Erysimum asperum	NC	-	-	-	-
Frageria americana	10	0.4	0.9	3.3	0.5
Galium bifolium	30	0.4	0.9	5.7	0.8
Geranium fremontii	40	0.9	2.0	12.7	1.9
Hackelia floribunda	40	2.1	4.6	56.3	8.4
Lappula occidentalis	17	0.1	0.2	5.0	0.7
Machaeranthera canescens	30	0.5	1.1	9.0	1.3
Penstemon watsonii	17	0.4	0.9	10.3	1.5
Senecio multilobatus	NC	-	-	-	-
Senecio streptanthifolius	10	T	T	2.0	0.3
Silene menziesii	23	0.3	0.7	4.7	0.7

TABLE 3-F
Page 2

HERBS AND FORBS (cont)	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Smilacina stellata	7	0.2	0.4	2.0	0.3
Solidago sparsiflora	10	0.2	0.4	3.3	0.5
TOTAL HERBS AND FORBS		8.3	18.4	165.3	24.6
SHRUBS					
Artemisia tridentata	13	0.3	0.7	2.1	0.3
Juniperus communis	NC	--	--	--	--
Mahonia repens	3	0.3	0.7	0.8	0.1
Pachystima myrsinites	30	2.0	4.4	17.9	2.7
Ribes cereum	13	1.5	3.3	24.3	3.6
Ribes sp	3	0.6	1.3	6.8	1.0
Rosa woodsii	43	4.5	10.0	44.1	6.6
Rubus idaeus	3	0.3	0.7	1.2	0.2
Symphoricarpos oreophilus	80	22.4	49.6	322.2	47.9
TOTAL SHRUBS		31.9	70.6	419.4	62.4
TREE SEEDLINGS					
Acer sp	3	T	T	0.1	T
Populus tremuloides	33	1.5	3.3	11.7	1.7
TOTAL TREE SEEDLINGS		1.5	3.3	11.8	1.7
TOTAL COMMUNITY		45.2	100.0	672.2	100.0

TREES

Method: Point - centered Quarter

# of sample = 20

Average dist. = 3.02 m.

Mean area = 9.12 sq m / tree = 1096 trees / Hectare

TABLE 3-F
Page 3

Species List	#	% FREQ	DENSITY (trees/Ha
Blue Spruce (*Picea pungens*)	36	45	493
Douglas Fir (*Psuedotsuga menziesii*)	16	20	219
Aspen (*Populus tremuloides*)	21	26	285
Rocky Mountain Juniper (*Juniperus scopulorum*)	5	6	66
White Fir (*Abies concolor*)	2	3	33
	80	100	578

Tree Diameters, Basal Areas

	1-10 Cm	11-25 Cm	26-50 Cm	51-100 Cm	Ave. dia.	Basal Sq m per he
Picea pungens	7	22	6	1	19.0	13.9
Psuedotsuga menziesii	4	8	4	0	19.1	6.2
Populus tremuloides	7	13	1	0	12.6	3.5
Juniperus scopulorum	3	2	0	0	9.4	0.4
Abies concolor	0	2	0	0	19.5	0.9
	21	47	11	1		25.2

TABLE 3-G

RIPARIAN #1

(Transect R-1)

GRASSES, SEDGES, RUSHES & HORSETAILS	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Agrostis exerata	1	T		T	
Agrostis stolonifera	17	1.4	8.1	46.7	3.4
Bromus ciliatus	7	0.1	0.6	7.5	0.6
Bromus inermis	1	T	T	0.4	T
Carex aurea	2	T	T	0.4	T
Carex microptera	2	T	T	1.7	0.1
Carex atrata	4	0.1	0.6	6.7	0.5
Dactylis glomerata	1	T	T	1.3	0.1
Elymus glaucus	1	T	T	1.3	0.1
Equisetum arvense	5	0.1	0.6	5.0	0.4
Festuca ovina	1	T	T	0.4	T
Festuca pratensis	3	0.6	3.5	12.5	0.9
Hordeum jubatum	1	T	T	1.3	0.1
Juncus arcticus	3	0.1	0.6	4.6	0.3
Juncus ensifolius	9	0.1	0.6	15.0	1.1
Poa compressa	7	0.2	1.2	12.5	0.9
Puccinellia nuttaliana	2	0.1	0.6	2.5	0.2
Trisetum spicatum	4	0.1	0.6	7.5	0.6
Vegetative grass	4	0.4	2.3	6.3	0.5
TOTAL GRASSES, SEDGES AND RUSHES		3.3	19.1	133.6	9.8

HERBS AND FORBS					
Achillea millefolium	20	0.2	1.2	12.1	0.9
Artemisia ludoviciana	2	T	T	3.8	0.3
Aster glaucodes	16	0.6	3.5	23.3	1.7
Berula erecta	8	T	T	4.2	0.3
Castilleja linariaefolia	1	T	T	0.4	T
Chenopodium leptophyllum	1	T	T	0.4	T
Cirsium pulchellum	10	1.6	9.2	12.9	[illegible]

11/25/88

TABLE 3-G
Page 2

HERBS AND FORBS (cont)	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Epilobium augustifolium	1	T	T	2.5	0.2
Epilobium brevistylum	10	0.2	1.2	5.4	0.4
Epilobium latifolium	1	0.1	0.6	2.9	0.2
Erigeron eatonii	1	T	T	0.4	T
Erigeron sp	1	T	T	0.4	T
Geranium fremontii	3	0.2	1.2	5.0	0.4
Geranium richardsonii	8	0.4	2.3	8.3	0.6
Lactuca scariola	10	T	T	4.6	0.3
Penstemon eatonii	1	T	T	1.3	0.1
Ranunculus cymbalaria	5	0.3	1.7	4.2	0.3
Senecio streptanthifolius	4	0.1	0.6	3.3	0.2
Solidago sparsiflora	10	0.1	0.6	7.5	0.6
Thalictrum fendleri	10	0.1	0.6	5.8	0.4
TOTAL HERBS AND FORBS		3.9	22.5	108.7	8.0
SHRUBS					
Artemisia tridentata	2	T	T	4.6	0.3
Cornus stolonifera	10	2.8	16.2	312.9	23.1
Juniperus communis	3	1.6	9.2	200.4	14.8
Lonicera involucrata	2	0.1	0.6	11.3	0.8
Pachystima myrsinites	2	0.2	1.2	9.6	0.7
Ribes cereum	3	1.3	7.5	109.6	8.1
Rosa woodsii	8	1.2	6.9	20.8	1.5
Salix bebbiana	1	T	T	2.1	0.2
Salix drummondiana	2	0.5	2.9	60.4	4.5
Salix myrtillifolio	17	1.8	10.4	251.3	18.5
Shepherdia canadensis	1	0.1	0.6	30.4	2.2
Symphoricarpos oreophilus	2	0.1	0.6	7.5	0.6
TOTAL SHRUBS		9.7	56.1	1020.9	75.3
TREE SEEDLINGS					
Picea pungens	4	0.4	2.3	92.1	6.8
TOTAL TREE SEEDLINGS		0.4	2.3	92.1	6.8
TOTAL COMMUNITY		17.3	100.0	1355.3	100.0

TABLE 3-H

RIPARIAN #2
(Transect R-2)

GRASSES, RUSHES AND HORSETAILS	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Agropyron cristatum	1	T	T	0.5	T
Agropyron trachycaulum	8	0.1	0.2	6.3	0.6
Agrostis stolonifera	10	0.7	1.5	30.6	2.7
Bromus ciliatus	5	T	T	2.3	0.2
Bromus inermis	18	2.2	4.8	77.5	7.0
Dactylis glomerata	1	T	T	2.7	0.2
Equisetum arvense	18	1.8	3.9	33.3	3.0
Juncus ensifolius	3	0.2	0.4	14.9	1.3
Poa compressa	2	T	T	1.8	0.2
Poa glauca	1	T	T	0.9	0.1
Stipa columbiana	1	T	T	0.5	T
Trisetum spicatum	1	T	T	0.5	T
Vegetative grass	21	0.9	2.0	31.1	2.8
TOTAL GRASSES, RUSHES AND HORSETAILS		5.9	12.8	202.9	18.2

HERBS AND FORBS					
Achillea millefolium	20	0.3	0.7	14.9	1.3
Angelica pinnata	3	0.2	0.4	5.9	0.5
Artemisia ludoviciana	7	0.2	0.4	52.3	4.7
Aster chilensis	1	T	T	0.9	0.1
Aster glaucodes	34	3.7	8.0	39.2	3.5
Cardamine cordifolia	6	0.6	1.3	12.2	1.1
Castilleja miniata	1	T	T	0.9	0.1
Cirsium pulchellum	3	0.6	1.3	32.0	2.9
Cynoglossum officinale	4	0.2	0.4	7.7	0.7
Epilobium brevistylum	2	T	T	1.4	0.1
Epilobium latifolium	4	0.2	0.4	4.5	0.4
Gentianella amarella	1	T	T	0.5	T

TABLE 3-H

Riparian #2
Page 2

HERBS AND FORBS (cont)	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Geranium richardsonii	31	2.2	4.8	47.7	4.3
Hackelia floribunda	1	T	T	1.4	0.1
Heliomeris multiflora	1	T	T	0.5	T
Lactuca scariola	4	T	T	1.8	0.2
Machaeranthera canescens	1	0.1	0.2	1.4	0.1
Ranunculus cymbalaria	1	T	T	0.5	T
Rudbeckia occidentalis	2	0.1	0.2	9.0	0.8
Senecio streptanthifolius	1	T	T	1.4	0.1
Solidago sparsiflora	10	0.1	0.2	5.9	0.5
Thalictrum fendleri	5	0.1	0.2	3.2	0.3
Trogopogon porrifolius	1	T	T	1.4	0.1
Vicia americana	7	0.1	0.2	4.1	0.4
Vegetative herb	6	0.3	0.7	5.4	0.5
TOTAL HERBS AND FORBS		9.0	19.6	306.1	27.5

SHRUBS					
Actaea rubra	1	0.3	0.7	3.2	0.3
Cornus stolonifera	5	0.4	0.9	3.7	0.3
Lonicera involucrata	1	0.2	0.4	3.2	0.3
Lonicera utahensis	1	T	T	0.5	T
Pachystima myrsinites	1	0.1	0.2	0.9	0.1
Prunus virginiana	1	0.1	0.2	0.4	T
Ribes sp.	3	0.4	0.9	8.1	0.7
Rosa woodsii	41	13.1	28.5	252.0	22.6
Rubus idaeus	5	0.3	0.7	5.7	0.5
Salix myrtillifolio	15	7.3	15.9	119.0	10.7
Shepherdia canadensis	5	1.5	3.3	48.9	4.4
Symphoricarpos oreophilus	15	5.7	12.4	114.8	10.3
TOTAL SHRUBS		29.4	63.9	560.4	50.3

TABLE 3-H

Riparian #2
Page 3

TREE SEEDLINGS	% FREQ	% COVER	% COMP	PROD Kg/Ha	% PROD
Abies concolor	3	0.1	0.2	2.4	0.2
Picea pungens	7	1.4	3.0	38.3	3.4
Populus tremuloides	2	0.2	0.4	3.2	0.3
TOTAL TREE SEEDLINGS		1.7	3.7	43.9	3.9
TOTAL COMMUNITY		46.0	100.0	1113.3	100.0

TABLE 4

Plant communities of the Genwal Coal Co. Permit Area by percent of area covered:

Type	Hectares	% Area
Previously Disturbed	0.64	1.9
Mountain Shrub/Grassland	29.87	88.2
Mixed Mtn. Shrub/Conifer/Aspen	1.04	3.1
Spruce/Fir/Aspen	1.92	5.7
Riparian	0.38	1.1
	33.85	100.0
	(83.65 acres)	

Plant communities to be disturbed by percent of area covered:

Type	Hectares	% Area
Mountain Shrub/Grassland	1.58	41.1
Mixed Mtn. Shrub/Conifer/Aspen	0.34	8.9
Spruce/Fir/Aspen	1.32	34.4
Previously Disturbed	0.60	15.6
	3.84	100.0

PRODUCTIVITY ADJUSTMENT FACTORS, TABLE 5

Species name	Common name	Estimated Adjustment Factor
Abies concolor	White Fir, seedling	-0.80
Acer sp.	Maple	-0.75
Actaea rubra	Baneberry	-0.80
Artemisia tridentata	Big Sage Brush	-0.80
Cercocarpus ledifolius	Curl-leaf mahogany, seedling	-0.75
Chrysothamnus nauseosus	Rabbit Brush	-0.70
Chrysothamnus viscidiflorus	Rabbit Brush	-0.70
Cornus stolonifera	Red Osier Dogwood	-0.90
Juniperus communis	Common Juniper	-0.90
Lonicera involucrata	Bearberry Honeysuckle	-0.80
Lonicera utahensis	Utah Honeysuckle	-0.80
Mahonia repens	Oregon Grape	-0.60
Pachystima myrsinites	Mountain Lover	-0.75
Populus tremuloides	Aspen, seedling	-0.80
Prunus virginiana	Chokecherry	-0.90
Picea pungens	Blue spruce, seedling	-0.30
Rosa woodsii	Wood's Rose	-0.70
Ribes cereum	Squaw currant	-0.75
Ribes sp.	Currant	-0.75
Rubus idaeus	Red raspberry	-0.80
Sambucus racemosa	Red Elderberry	-0.90
Symphoricarpos oreophilus	Mountain Snowberry	-0.75
Salix myrtillifolia	Willow	-0.90
Shepherdia canadensis	Russet Buffaloberry	-0.70

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Item F

VEGETATION REFERENCE AREA

Vegetation Reference Areas are established primarily to monitor revegetation success after mining operations have ended. Reference areas must be located outside the area of possible disturbance.

During the lifetime of the mine the only changes which should occur within the reference areas are those resulting from natural causes such as climatological changes, variations in grazing pressure due to normal fluctuations of animal populations, and vegetative succession. Unusually high or unnatural grazing pressures should be protected against by exclosing the reference area.

Within the Genwal Coal Company lease area four of the baseline study communities will be disturbed by mining activities. They are: Previously disturbed (D); Spruce/Fir/Aspen (SFA); Mixed Mountain Shrub/Conifer/Aspen (MSCA); Mountain Shrub/Grassland (MSG). Revegetation plans call for uniform treatment of the disturbed areas with grasses and some forbs. A single 0.607 hectare (1.50 acres) reference area was established in a Mountain Shrub/Grassland area 60 meters above the existing portals and 40 meters above the limits of disturbance. The corners are marked by green and white steel fence posts. An aluminum tag identifying the corners is attached to each fence post. The dimensions of the area are 121.92 m(400 ft.) by 49.79 m (163.35 ft).

A single reference area in a MSG area was chosen because it most closely resembles the disturbed areas as they will be when revegetated. No attempt will be made to immediately return SFA and MSCA or even MSG areas to their original condition. The purpose of revegetation will be

to restore the land to its predisturbance usefullness as range land and to stabilize slopes against erosion. Natural vegetative succession will hopefully restore the various areas to their predisturbance condition. That, of course, will take a rather long and undetermined amount of time.

Although range cattle roam Crandall Canyon during the summer months, they will not impact the reference area. They stay in the bottom and don't climb very far up the mountainside. There are no recent or old cattle signs near or in the reference area. Sheep are grazed at higher elevations above the cliffs, migrating along the ridge tops from the west. Since the only significant impact on the reference area will be normal deer and elk feeding, it was decided that the area will not need to be exclosed.

SAMPLING METHODS:

Vegetation was sampled during the days of August 10 and 11, 1981 which corresponds to the late July and early August 1980 sampling dates for the baseline data. 1981 had a much wetter spring than 1980 and consequently grass and herb growth was visibly greater in 1981.

Vegetation was sampled for cover by two methods. Grasses, herbs and small shrubs were sampled by means of four 1 meter by 30 meter transects from each of which 10 square meters were randomly chosen by means of a random numbers table generated by computer. The total area sampled was 40 square meters. Tree cover was sampled by means of four 30 meter line-intercept transects. Total length sampled was 120 meters.

Trees were sampled for density and basal area by means of the point-centered quarter method. Twenty-five centers were sampled for a total of 100 samples.

The results of the vegetation sampling in the reference area is summarized in tables VRA-1 through VRA-3.

SIMILARITY:

Similarity between the reference area and the corresponding area (MSG) from the baseline studies is calculated by the following formula:

$$s = \frac{2w}{a+b}$$

where s = similarity fraction

w = number of species common to both areas

a = total number of species in reference area

b = total number of species in baseline area.

When applied to these studies the formula works out as follows:

$$s = \frac{2 \times 16}{24 + 20} = 0.73$$

The reference area included three species with single unsampled occurances. If they are neglected the similarity calcuates to be 0.78.

SAMPLE ADEQUACY:

Adequacy of sampling for cover is demonstrated statiscally by means of a formula developed by COOK and BONHAM (1977). Their test determines the minimum number of samples needed to achieve a desired level of confidence in detecting a certain percentage change in the population mean.

$$n_{min} = \frac{t^2 2s^2}{(\bar{x}c)^2}$$

where n_{min} = minimum number of samples needed

$\bar{x}$ = sample mean

s = standard deviation of the sample

t = two-tailed t valve for the desired confidence level, with appropriate degrees of freedom.

c = percent change to be detected

The mean of the 40 cover samples equaled 20.45% . The standard deviation equaled 20.78. The t value for 80% confidence with 39 degrees freedom is 1.304. The percent change desired to be detected is variable as listed in the table below:

% confidence	percent change	n_{min}
80	10	351
80	20	88
80	30	39

Since 40 samples were taken it can be concluded that a 30% change in the sample mean has an 80% chance of being detected.

Table VRA-1

Mountain Shrub/Grassland

Vegetation Reference Area

Scientific Name	Common Name	% Frequency	% Cover	% Composition
GRASSES				
Agropyron spicatum	bluebunch wheatgrass	100	18.1	91.9
Oryzopsis hymenoides	indian ricegrass	N.C.	Neg.	Neg.
Poa compressa	Canadian bluegrass	N.C.	Neg.	Neg.
	vegetative grass (unidentifiable)	17.5	0.4	2.0
	TOTAL GRASSES		18.5	93.9
HERB AND FORBS				
Artemesia frigida	fringed sagebrush	5.0	0.1	0.5
Artemesia ludovisiana	sagebrush	2.5	Neg.	Neg.
Aster glaucodes	aster	5.0	Neg.	Neg.
Cirsium pulchellum	thistle	5.0	0.2	1.0
Cynoglossum officinale	houndstongue	N.C.	Neg.	Neg.
Machaeranthera canescens	hoary aster	2.5	Neg.	Neg.
Smilacina stellata	false solomonsseal	N.C.	Neg.	Neg.
	TOTAL HERB & FORBS		0.3	1.5
SHRUBS				
Cercocarpus ledifolius	curl leaf mahogany (seedling)	7.5	0.1	0.5
Chrysothamnus nauseosus	rubber rabbit brush	2.5	0.2	1.0
Holodisus dumosus	rock spirea	7.5	Neg.	Neg.
Mahonia repens	Oregon grape	12.5	0.2	1.0
Pachystima myrsinites	mountain lover	N.C.	Neg.	Neg.
Prunus verginiana melanocarpa	choke cherry	N.C.	Neg.	Neg.
Sambucus racemosa	red elderberry	2.5	0.1	0.5
Symphoricarpos oreophilus	mountain snowberry	N.C.	Neg.	Neg.
Xanthocephalum sarothrae		5.0	0.3	1.5
	TOTAL SHRUBS		0.9	4.5
	TOTAL COMMUNITY (UNDERSTORY)		19.7	99.9

Table VRA-2

TREES (% Cover)

Line-intercept transect 4 x 30 meters = 120 meters

Scientific Name	Common Name	Intercept Length	% Cover
Abies concolor	white fir	0.0 m	N.C.
Cercocarpus ledifolius	curl leaf mahogany	18.6 m	15.5
Juniperus scopulorum	Rocky mtn. juniper	2.6 m	2.2
Pinus edulis	pinyon pine	7.3 m.	6.1
Psuedotsuga menziesii	Douglas fir	0.0 m.	N.C.

Table VRA-3

TREES (density and basal area)

Method: Point-centered quarter

centers: 25 # samples : 100

Average distance: 5.08 m.

mean area: 25.81 sq.m./tree = 387.5 trees/hectare

Tree densities

Scientific Name	Common Name	#	% Frequency	(trees/hectare)
Abies concolor	White fir	2	2	8
Cercocarpus ledifolius	curl leaf mahogany	55	55	213
Juniperus scopulorum	Rocky mtn. juniper	23	23	89
Pinus edulis	pinyon pine	16	16	62
Psuedotsuga menziesii	Douglas fir	4	4	15.5
		100	100	387.5

Tree diameters, Basal area

Scientific Name	1-10(cm)	10-25	25-50	50-100	Av. dia. (cm)	Basal Area $m.^2$/hectare
Abies concolor	0	1	1	0	33.5	0.71
Cercocarpus ledifolius	22	31	2	0	12.9	2.78
Juniperus scopulorum	13	9	1	0	10.0	0.70
Pinus edulis	6	5	4	1	20.3	2.01
Psuedotsuga menziesii	2	0	1	1	24.5	0.73
	43	46	9	2		6.94

SAMPLE ADEQUACY

Sample adequacy for the vegetation data has been calculated using the formula suggested in the latest DOGM Guidelines:

$n_{min} = (t^2 s^2)/(d\bar{x})^2$ where:

n_{min} = minimum number of sample units needed

t = two-tailed t value

s = standard deviation of sample mean

d = 0.1

$\bar{x}$ = sample mean

The affected and reference area vegetation types are classified as shrublands, for which an 80% two-tailed confidence level value for t can be used (t = 1.282).

The results of the calculations are shown in Table 2, Revised.

The following consideration should be noted:

The parameter of interest for shrub density sample adequacy calculations is the average distance, in feet, to shrubs in 4 quadrants at each randomly selected station (point-centered Quarter Method). From the average distance density can be calculated.

SAMPLING METHODS

Cover and Compisition

Sample plots were selected at random throughout the mountain shrub/grassland areas and vegetation reference area. Twenty-two plots were sampled in the M.S.G. and ten in the VRA using a steel hoop with a circumference of 11.0 feet and an area of 9.6 square feet, which is equivalent to 0.89 square meters.

Shrub Density

Point-centered quarter plots were sampled.

SHRUB DENSITY

VRA

Average distance to shrub from sample data = 9.27 feet. This value squared = 85.93 square feet per shrub which is equivalent to a density of 507 shrubs per acre.

MSG

Average distance = 5.71. 5.71 squared = 32.60 sq. ft./shrub which is equivalent to a density of 1336 shrubs/acre.

SIMILARITY

The following formula was used to test similarity of the reference area to its affected vegetational counterpart with respect to cover and shrub density.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}, \quad df = n_1 + n_2 - 2 \quad \text{where:}$$

t = t value to be applied to a table for test of significance between two sample means. From the table is obtained a value P, which is the probability of having a t of the calculated value, or larger.

$\bar{x}_1$ and $\bar{x}_2$ = means of samples 1 and 2.

s_1^2 and s_2^2 = variance (standard deviation squared) of sample means 1 and 2.

n_1 and n_2 = sizes of samples 1 and 2

df = degrees of freedom

The table below lists the values to be applied to the tests:

Vegetation Reference Area	n	$\bar{x}$	s	s^2
% Cover	10	23.70	6.00	36.00
Shrub density (average distance in feet)	30	9.27	3.26	10.63
Mountain Shrub/Grassland				
% Cover	22	20.73	6.57	43.16
Shrub density (average distance in feet)	30	5.71	2.54	6.45

Similarity t-test for % cover:

$$t = \frac{23.70 - 20.73}{\sqrt{\frac{36.00}{10} + \frac{43.16}{3}}} = 1.259, \text{ df} = 10+22-2=30 : \text{ confidence } 90\%$$

(90% confidence = 1.697)

Similarity t-test for shrub density: (parameter being tested is average distance in feet, obtained from Point-centered Quarter Method)

$$t = \frac{9.27 - 5.71}{\sqrt{\frac{10.63}{30} + \frac{6.45}{30}}} = 4.718, \text{ df} = 30+30-2=58: \text{ confidence } 90\%$$

SAMPLE ADEQUACY, TABLE 2, REVISED

Community	n	$\bar{x}$	s	n(min)
Vegetation Reference Area				
% Cover	10	23.70	6.00	10.5
Shrub Density	30	9.27	3.26	20.3
Mountain Shrub/Grassland				
% Cover	22	20.73	6.57	16.5
Shrub Denisty	30	5.71	2.54	32.5

At confidence level of 89.5% (d=.105) n_{min} for shrub density = 29.5

We felt that where our sampling was adequate at 89.5% confidence the expense of additional sampling to achieve 90% confidence was not warrented.

VRA

OF PLOTS = 10

	% Freq	% Cover	% Complete
Grasses and Sedges –			
Agropyron spicatum	10	T	T
Carex geyeri	40	0.3	1.1
Elymus salinus	100	21.7	91.7
Oryzopsis hymenoides	10	0.1	0.2
Poa compressa	20	0.2	1.0
Stipa lettermania	10	0.1	0.6
Total Grasses and Sedges		22.4	94.6
Forbs			
Artemisia ludoviciana	10	T	T
Aster glaucodes	30	0.1	0.3
Cirsium pulchellum	10	0.1	0.3
Machaerauthera canescens	10	T	0.1
Penstemon watsonii	10	T	T
Total Forbs		0.2	0.7
Shrubs			
Amelanchier alnifolia	10	T	T
Artemisia frigider	40	0.1	0.2
Artemisia tridentata	10.	T	T
Cercocarpus ledifolius	20	0.1	0.4
Chrysothamnus viscidiflorus	20	0.3	1.1
Holodiscus dumosus	20	T	T
Mahonia repens	60	0.6	2.7
Sambucus coerulea	20	0.1	0.3
Symphoricarpos oreophilus	20	T	T
Total Shrubs		1.2	4.7
TOTAL PLANT COMMUNITY		23.8	100.0

Percent of Cover:

Vegetative density	24
Bare ground	26
Surface rock	31
Litter	19
	100 %

MSG

OF PLOTS = 22

Grasses and Sedges	% Freq.	% Cover	% Composition
Agropyron scicatum	52	0.3	1.6
Carex geyeri	23	0.4	1.9
Elymus salinas	100	18.1	87.2
Oryzopsis hymenoides	9	T	0.1
Poa compressa	27	0.1	0.4
Poa nevadensis	9	T	T
Poa secunda	5	T	T
Sitanion hystrix	5	T	0.2
Stipa lettermanii	5	0.2	1.0
Total Grasses and Sedges		19.1	92.4
Forbs			
Antennaria parvifolia	5	T	T
Artemisia dracunculus	5	T	T
Aster glaucodes	23	0.2	1.1
Chaenactus douglasii	5	T	T
Cirsium pulchellum	23	0.3	1.3
Enysimum asperum	9	T	T
Penstemon watsonii	9	T	T
Total Forbs		0.5	2.4

	% Freq.	% Cover	% Composition
Shrubs			
Artemisia frigida	36	0.2	1.0
Artemisia tridentata	36	0.3	1.3
Cercocarpus ledifolius	9	T	0.1
Chrysothamnus nauseosus	14	T	0.1
Chrysothamnus viscidiflorus	18	0.1	0.3
Coryphantha vivipia	5	0.1	0.5
Gatierrezia sarathrae	14	0.1	0.3
Holodisius dumosus	5	T	T
Juniperus communis	5	T	T
Mahonia repens	27	0.2	0.7
Pachystima myrsinites	5	T	T
Rosa woodsii	9	0.1	0.5
Symphoricarpos oreophilus	32	0.1	0.3
Total Shrubs		1.2	5.1
Total Plant Community		20.8	100.0

Percent of Cover:

Vegetative density	21%
Bare ground	31%
Surface Rock	28%
Litter	20%
Total Plot	100%

Re: Shrub Density Placement Standard

Vegetation Reference Area:

Vegetation Reference Area site was inspected by personnel from Utah State Division of Oil, Gas and Mining in July 1981. At that time they agreed that the only practical site for a Reference Area was that chosen by the applicant's biologist, immediately up slope from the area of disturbance. Subsequent sampling has shown that the reference area can be used for monitoring revegetation success for productivity and cover, but that there is a significant difference between the affected area and reference area with regards to shrub density. Where sample adequacy was met for shrub density sampling in the affected area, the baseline density of 1280 shrubs per acre will be used as the standard (as taken from Sample Adequacy Table).

SAMPLE ADEQUACY

In MSG area 22 plots were sampled. Vegetative cover was as listed below:

	%		%
# 1	25	# 12	18
# 2	20	# 13	20
# 3	10	# 14	20
# 4	15	# 15	18
# 5	25	# 16	28
# 6	20	# 17	20
# 7	30	# 18	10
# 8	15	# 19	10
# 9	29	# 20	30
# 10	26	# 21	22
# 11	15	# 22	30

$\bar{x}$ (cover) = 20.73

s (cover) = 6.57

$$n_{min} = \frac{(1.282^2 \times 6.57^2)}{(0.1 \times 20.73)^2} = 16.5 \text{ plots}$$

In vegetation Reference Area 10 plots were sampled. Cover is listed below:

	%		%
# 1	20	# 6	29
# 2	20	# 7	21
# 3	25	# 8	22
# 4	35	# 9	15
# 5	20	# 10	30

$\bar{x}$ (cover) = 23.70

s (cover) = 6.00

$$n_{min} = \frac{(1.282^2 \times 6.00^2)}{(0.1 \times 23.70)^2} = 10.5 \text{ plots}$$

SAMPLE ADEQUACY

Sample adequacy for the vegetation data has been recalculated using the latest agency supplied formula; in this case the Office of Surface Mining.

$n_{min} = (t^2 s^2)/(d\bar{x})^2$ where:

n_{min} = minimum number of sample units needed

t = two-tailed t value from table

s = standard deviation of sample mean.

d = percentage departure from the mean (1.00 minus two-tailed confidence level)

$\bar{x}$ = sample mean

The affected and reference area vegetation types are classified as shrublands, for which an 80% two-tailed confidence level value for t can be used. In the formula then, d = 0.20 and t = 1.28 where n is greater than 30. In the language of the OSM recommendations it is unclear whether t = 1.28 should be used regardless of the size of n or whether t values should be selected from the tables using the appropriate degrees of freedom. To eliminate any chance of misunderstanding the calculations have been done both ways and the results are tabulated for comparison in Sample Adequacy Table 2, Revised.

The following considerations should be noted:

a. Previously submitted adequacy calculations used individual plots as the sample units. Present calculations use the transect as the sample unit.

b. In the Vegetation Reference Area 4 randomly located transects were sampled, each 30 meters long with ten $1m^2$ plots selected from a random numbers table generated by computer. Analysis, with the transects as sample units, reveals the mean percent cover for transect # 2 to be radically lower than the other three transects, indicating that transect # 2 is untypical. The adequacy calculation results for the Vegetation Reference Area are presented both with transect #2 and without it.

c. Productivity values previously reported included woody stem weights for shrubs and tree seedlings. For the present calculations their productivity has been adjusted downward by the factors listed in Productivity Adjustment Factors, Table 5. The Factor values are estimates of the proportion of woody stem weight to total weight. Previously submitted tables of productivity have also been revised and are included with this report.

d. The parameter of interest for tree density sample adequacy calculations is the average distance, in meters, to trees in 4 quadrants at each randomly selected station (point-centered Quarter Method). From the average distance density can be calculated.

SAMPLING METHODS

At the time baseline data sampling was being performed Engineering plans showing the extent and limits of disturbance were not available. In all cases for all vegetation types the area subject to random sampling included all of the areas now earmarked for disturbance.

Tree cover information is supplied for information only and will not be used for establishing a success standard for cover.

Previously submitted tabulations of cover include a percent cover total for the community. For example: Table 3-A, Previously Disturbed Area gives a total cover for the community of 50.3%. None of the communities had significant amounts of rock. Only the Spruce/Fir/Aspen type had appreciable amounts of litter on the ground.

REFERENCE AREA

The following formula was used to test similarity of the proposed reference area to its affected vegetational counterpart with respect to cover and woody plant density.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{s_1^2}{n_1}\right) + \left(\frac{s_2^2}{n_2}\right)}}, \quad df = n_1 + n_2 - 2 \text{ where:}$$

t = t value to be applied to a table for test of significance between two sample means. From the table is obtained a value P, which is the probability of having a t of the calculated value, or larger.

$\bar{x}_1$ and $\bar{x}_2$ = means of samples 1 and 2.

s_1^2 and s_2^2 = variance (standard deviation squared) of sample means 1 and 2.

n_1 and n_2 = sizes of samples 1 and 2.

df = degress of freedom

The table below lists the values to be applied to the tests:

Vegetation Reference Area	n	$\bar{x}$	s	s^2
% Cover	3	23.90	4.04	16.32
tree density (average dist. in meters)	25	5.08	1.70	2.89
Mountain Shrub/Grassland				
% Cover	3	23.27	7.51	56.40
tree density (average dist. in meters)	20	4.31	1.01	1.02

Similarity t-test for % cover:

$$t = \frac{23.90 - 23.27}{\sqrt{\left(\frac{16.32}{3}\right)+\left(\frac{56.40}{3}\right)}} = 0.128, df = 3+3-2=4 \; : \; P > 0.90$$

Similarity t-test for tree density: (parameter being tested is average dist. in meters, obtained from Point-centered Quarter Method)

$$t = \frac{5.08 - 4.31}{\sqrt{\left(\frac{2.89}{25}\right)+\left(\frac{1.02}{20}\right)}} = 1.887, \; df = 25+20-2 = 43 \; : \; 0.10 > P > 0.05$$

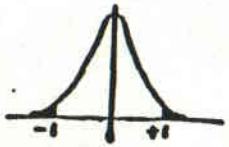
VEGETATION MAPPING

Although the contour lines on the previously submitted Vegetative Community Study Map do not extend to the limits of the permit area (lease area) the labeled vegetation community does extend to the permit area limits.

RIPARIAN VEGETATION TYPE

At the time Table 4 was last submitted, only rough preliminary grading and facility plans were available. Since it was not known for certain whether the riparian zone would be affected by construction or operations, its area was included in the table. Final plans are now available and the Riparian Vegetation Zone will not be disturbed. A revised Table 4 is herewith submitted.

TABLE FOR t TEST OF SIGNIFICANCE BETWEEN TWO SAMPLE MEANS ($\bar{x}_1$ AND $\bar{x}_2$)



Degrees of freedom	*P = 0.9	0.8	0.7	0.6	0.4	0.2
1	0.158	0.325	0.510	0.727	1.000	1.376
2	0.142	0.289	0.445	0.617	0.816	1.061
3	0.137	0.277	0.424	0.584	0.765	0.978
4	0.134	0.271	0.414	0.569	0.741	0.941
5	0.132	0.267	0.408	0.559	0.727	0.920
6	0.131	0.265	0.404	0.553	0.718	0.906
7	0.130	0.263	0.402	0.549	0.711	0.896
8	0.130	0.262	0.399	0.546	0.706	0.889
9	0.129	0.261	0.398	0.543	0.703	0.883
10	0.129	0.260	0.397	0.542	0.700	0.879
11	0.129	0.260	0.396	0.540	0.697	0.876
12	0.128	0.259	0.395	0.539	0.695	0.873
13	0.128	0.259	0.394	0.538	0.694	0.870
14	0.128	0.258	0.393	0.537	0.692	0.868
15	0.128	0.258	0.393	0.536	0.691	0.866
16	0.128	0.258	0.392	0.535	0.690	0.865
17	0.128	0.257	0.392	0.534	0.689	0.863
18	0.127	0.257	0.392	0.534	0.688	0.862
19	0.127	0.257	0.391	0.533	0.688	0.861
20	0.127	0.257	0.391	0.533	0.687	0.860
21	0.127	0.257	0.391	0.532	0.686	0.859
22	0.127	0.256	0.390	0.532	0.686	0.858
23	0.127	0.256	0.390	0.532	0.685	0.858
24	0.127	0.256	0.390	0.531	0.685	0.857
25	0.127	0.256	0.390	0.531	0.684	0.856
26	0.127	0.256	0.390	0.531	0.684	0.856
27	0.127	0.256	0.389	0.531	0.684	0.855
28	0.127	0.256	0.389	0.530	0.683	0.855
29	0.127	0.256	0.389	0.530	0.683	0.854
30	0.127	0.256	0.389	0.530	0.683	0.854
∞	0.12566	0.25335	0.38532	0.52440	0.67449	0.84162

Degrees of freedom	0.1	0.2	0.1	0.05	0.02	0.01
1	1.963	3.078	6.314	12.706	31.821	63.657
2	1.386	1.886	2.920	4.303	6.965	9.925
3	1.250	1.638	2.353	3.182	4.541	5.841
4	1.190	1.533	2.132	2.776	3.747	4.604
5	1.156	1.476	2.015	2.571	3.365	4.032
6	1.134	1.440	1.943	2.447	3.143	3.707
7	1.119	1.415	1.895	2.365	2.998	3.499
8	1.108	1.397	1.860	2.306	2.896	3.355
9	1.100	1.383	1.833	2.262	2.821	3.250
10	1.093	1.372	1.812	2.228	2.764	3.169
11	1.088	1.363	1.796	2.201	2.718	3.106
12	1.083	1.356	1.782	2.179	2.681	3.055
13	1.079	1.350	1.771	2.160	2.650	3.012
14	1.076	1.345	1.761	2.145	2.624	2.977
15	1.074	1.341	1.753	2.131	2.602	2.947
16	1.071	1.337	1.746	2.120	2.583	2.921
17	1.069	1.333	1.740	2.110	2.567	2.898
18	1.067	1.330	1.734	2.101	2.552	2.878
19	1.066	1.328	1.729	2.093	2.539	2.861
20	1.064	1.325	1.725	2.086	2.528	2.845
21	1.063	1.323	1.721	2.080	2.518	2.831
22	1.061	1.321	1.717	2.074	2.508	2.819
23	1.060	1.319	1.714	2.069	2.500	2.807
24	1.059	1.318	1.711	2.064	2.492	2.797
25	1.058	1.316	1.708	2.060	2.485	2.787
26	1.058	1.315	1.706	2.056	2.479	2.779
27	1.057	1.314	1.703	2.052	2.473	2.771
28	1.056	1.313	1.701	2.048	2.467	2.763
29	1.055	1.311	1.699	2.045	2.462	2.756
30	1.055	1.310	1.697	2.042	2.457	2.750
∞	1.03663	1.28155	1.64485	1.95996	2.32634	2.57582

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* P is the probability of having t this large or larger in size by chance.