CHAPTER 9

VEGETATION RESOURCES

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VEGETATION RESOURCES

Introduction

Peabody Western Coal Company (formerly Peabody Coal Company's Arizona Division) operates two surface coal mines on the Black Mesa, Navajo County, Arizona. The Black Mesa and Kayenta mines are located on contiguous leases totaling approximately 64,858 acres of Navajo and Hopi Indian Reservation land with an additional grant of easement right of way of 361 acres on Navajo land.

Peabody began an ongoing vegetation monitoring program in 1979. The program was designed in consultation with the Office of Surface Mining (OSM); the Navajo Tribe; and Espey, Huston and Associates, Inc. (EH&A). The major objectives of the program were to develop baseline vegetation information and to evaluate the progress and success of revegetation.

The initial baseline studies, completed in the fall of 1980, were conducted in the western and northeastern portions of the leasehold and included a two mile buffer area beyond the lease boundary (Figure 1). Quantitative and qualitative vegetation sampling and floristic surveys were conducted by EH&A during October, 1979, and May, July and September, 1980. Thirteen stands of vegetation were quantitatively sampled including: (1) three stands of pinyon-juniper woodland in coal resource areas (the N-7/8, N-10 and N-14 mining areas); (2) two stands of pinyon-juniper woodland on reference areas (vicinity of the N-7/8 and N-14 mining areas); (3) three stands of sagebrush shrubland on coal resource areas (the J-7, J-1/N-6 and N-14 mining areas); (4) four stands of sagebrush shrubland on reference areas (vicinity of the J-7, J-1/N-6, N-7/8 and N-14 mining areas; and (5) one stand of greasewood shrubland along the terrace at Moenkopi Wash. In addition, riparian strand, disturbed areas, aquatic vegetation and plant communities occurring adjacent to the leasehold were described in qualitative terms. The results of these studies were presented in a permit application package submitted to regulatory authorities in January of 1981 (Volume 2, Appendix 4, 1981-1985 Mining Plan).

Vegetation baseline studies were continued in 1981 by Peabody biologists (Figure 1). Additional baseline data was collected in the J-7, J-1/N-6, N-7/8, N-10 and N-14 mining areas previously sampled by EH&A. Baseline studies were started in the J-16 and J-28 mining areas. Ongoing monitoring was continued in the two pinyon-juniper woodland

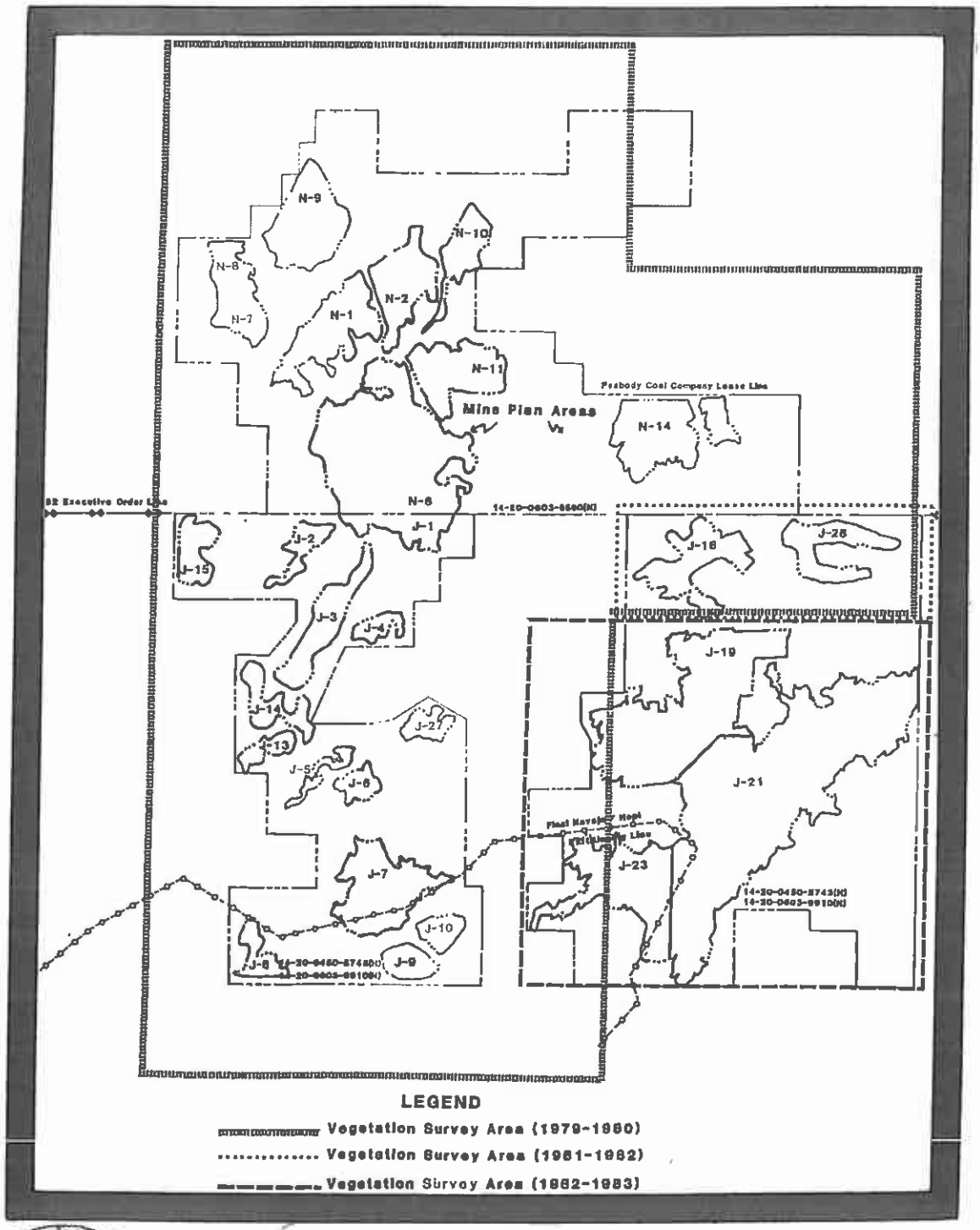

FIGURE 1

Black Mesa Leasehold and Vegetation Survey Areas

and four sagebrush shrubland reference areas. The first comprehensive studies of the reclaimed vegetation were conducted in selected portions of the J-3, J-7, J-27, J-1/N-6, N-1 and N-2 mining areas. The results of these studies were reported to regulatory authorities in the first annual vegetation and wildlife resources report (Arizona Division, Peabody Coal Company, 1982).

Vegetation baseline studies were completed in the J-16 and J-28 mining areas in the spring of 1982. In the fall of 1982, baseline studies were initiated in the then unpermitted southeastern portion of the leasehold referred to as the Mine Plan Modification Area. This area included the contiguous J-19 through J-23 mining areas (Figure 1). Ongoing monitoring was continued in the reference areas and selected reclaimed portions of the J-7, J-27, J-1/N-6, N-1 and N-2 mining areas. With the exception of the data collected in the Mine Plan Modification Area, the results of these studies were reported in the Vegetation Resources 1982 Report (Arizona Division, Peabody Coal Company, 1983).

Vegetation baseline studies in the J-19 through J-23 coal resource areas were completed during the spring of 1983. The results of these and the 1982 studies were submitted as part of a mine plan modification filed with regulatory authorities in July, 1983. A major ramification of that submittal was that sufficient baseline studies were completed to adequately characterize the pre-mining vegetation on the Black Mesa leasehold.

Six reference areas were established in 1979 and 1980 for use as revegetation success standards. Two were located in the pinyon-juniper woodland adjacent to the N-7/8 and N-14 coal resource areas. Four were located in the sagebrush shrubland adjacent to the N-7/8, N-14, J-1/N-6 and J-7 coal resource areas. The reference area at the N-7/8 area included both community types. The size of the reference areas were as follows: N-7/8 (140.8 acres), N-14 pinyon-juniper (230.2 acres), N-14 sagebrush (31.7 acres), J-1/N-6 (45.4 acres) and J-7 (91.1 acres). Within each reference areas, 0.1 acre exclosures were established to monitor livestock grazing effects.

The 0.1 acre exclosures were expanded in 1982 such that each exceeded two acres in size. These expanded exclosures became the permanent reference areas and sampling was discontinued in the larger unfenced areas. This measure was taken in response to Special Stipulation #26 attached to Permit AZ-0001. At the same time, the J-1/N-6 reference area was redesignated as a [illegible]k-up area and sampling was discontinued. Sampling in the two

pinyon-juniper reference areas was discontinued following the end of the 1982 field season. This measure was taken based upon negotiations with regulatory authorities regarding the suitability of the woodland as a standard for revegetation success. The net result was that revegetation success standards would be based upon the three remaining sagebrush shrubland reference areas. Each would represent the premining vegetation in a specific region of the leasehold unless further studies identified new plant communities.

Ongoing monitoring of the vegetation in the reference areas and selected reclaimed units was continued in 1983 and 1984. The results of these studies were reported in the respective annual resources reports (Arizona Division, Peabody Coal Company, 1984 and 1985). Since 1984, annual spring and fall monitoring of reclaimed areas and periodic spring and fall monitoring of reclaimed areas and periodic spring and fall sampling of reference areas has been conducted at the Black Mesa and Kayenta Mine. The results of these monitoring and sampling efforts are included in annual reports submitted to the requesting authority.

The objective of this chapter is to provide vegetation maps, detailed descriptions of the plant communities, and all available data to better characterize and define the spatial and temporal variability of the vegetation resources within and surrounding the Black Mesa leasehold. This necessitates consolidation of vegetation information that has been collected since 1979. The information has been variously reported to regulatory authorities in mining permit applications and annual reports designed to review the results of annual monitoring activities. Detailed vegetation survey summary reports are included as Attachment 1 to this chapter. Vegetation data summaries that were presented in annual vegetation reports submitted to regulatory authorities are not presented in detail in this chapter but may be referenced. Additionally, vegetation studies were conducted in the N12/N99 North/South and N9 portions of the leasehold in 2003. The results of these 2003 studies can be found in Attachments 4 and 5, respectively.

The following sections present: (1) a general description of the study area and review of relevant literature; (2) a description of the vegetation sampling methods; and (3) results and discussion of the vegetation studies. Appropriate sections and attachments address the significance of the pre-disturbance vegetation, important plant species, impact analysis, recommendations for feasible mitigation and enhancement and continuing monitoring activities.

General Description of the Study Area

The Black Mesa is a highland rising to approximately 8100 feet above mean sea level at its northern rim. The 2.1 million acre mesa drains into the Little Colorado River via several large washes. The Black Mesa and Kayenta Mine lease area is located toward the northern edge of the mesa at elevations ranging between 6200 feet and 7300 feet above mean sea level. The extreme north and east portion of the lease area is relatively level, breaking off into deeply incised canyons. The remainder of the area is characterized by rounded hills or dissected plains and rolling hills with gentle side slopes. The lease area drains from northeast to southwest primarily via Moenkopi Wash and its tributaries. Dinnebito Wash drains the extreme southeastern portion of the lease area.

Climatic conditions are considered arid or semiarid depending primarily on elevation. Mean annual precipitation ranges from approximately 9 to 12 inches. The majority of the precipitation occurs as brief, but intensive, convective storms during the late summer months. The remainder of the precipitation occurs primarily in the late fall and winter as both rain and snow. Temperatures rarely exceed $90^{o}F$ or fall below $15^{o}F$. The warm temperatures and low relative humidities, coupled with strong winds, contribute to high evaporation rates for most of the year. Precipitation exceeds evapotranspiration only during the winter. The growing season is approximately 20 weeks in length. Detailed climatological information is presented in Chapter 11 of this permit application package.

Soils within the lease area consist of an association of Haplargids, Camborthids, Torriorthents and Torrifluvents formed from shale and sandstone parent materials. The soils range in depth from less than 6 inches to over 60 inches. They are moderately well to well drained with slow to rapid runoff and slow to moderately rapid permeability. Plant nutrients and organic matter are limited. Erosion is moderate to severe throughout the lease area. Reference may be made to Chapter 8 of this document for a detailed description of the soils in the lease area.

The vegetation of the Black Mesa was not studied in any great detail prior to the initiation of baseline studies by Peabody. The vegetation of the Black Mesa is included on the maps presented by Kuchler (1964) and Hicks (1969) and consists of pine forest, juniper-pinyon (pinyon-juniper) woodland, Great Basin sagebrush and grama-galleta steppe. Vegetation studies of varying intensity and objectives have been conducted by Woodbury (1947), Bureau of Indian Affairs (1964 and 1978), Green and LaFevers (1975), Green (1976),

Layhe et al. (1976) and Van De-Puy (1978). Woodbury studied the relative composition of pinyon and juniper on a 0.1 acre plot in the woodland. The Bureau of Indian Affairs developed a soil and range inventory for the 1882 Executive Order Area which includes a portion of the leasehold and a range site map of the leases. Green and LaFevers discussed the biological aspects of coal mine reclamation on Black Mesa. Green conducted a biomass study on the Black Mesa. Layhe et al. conducted a reconnaissance of the northern portion of the Mesa and recognized twelve plant associations. Van De-Puy studied the Great Basin sagebrush type using a transect quadrat method.

Methods and Materials

A vegetation map of the western and northeastern portions of the leasehold and a two mile buffer zone was prepared in 1980 by EH&A. This base map is a topographic overlay on black and white photography at a scale of 1" = 2000 feet. A vegetation map of the southeastern portion of the leasehold, also prepared by EH&A, was completed in 1983. This topographic map is at a scale of 1" = 1000 feet. These base maps were prepared from color and black and white photography at scales of 1" = 1000' and 1" = 400' respectively. Supplemental information was obtained from soils maps of the areas. Visually distinct plant communities were delineated on the maps from the photography. The delineations were refined following ground inspection.

For purposes of this permit application package, an updated map was prepared from the original base maps. The updated maps were prepared because: (1) a significant amount of mining and reclamation activities have taken place since preparation of the original maps; (2) the resolution of the 1" = 2000' base maps was not appropriate for calculating disturbance acreages in the various plant communities; and (3) base maps at a single scale were felt to provide more continuity. The updated map was prepared on black and white aerial photography flown in January 1985. The scale is 1" = 1000 feet. The updated map was prepared by overlay and transcription of the original base maps. Color and black and white photography at the scales used to prepare the original maps was used to verify map delineations, along with subsequent ground-truthing.

Map unit descriptors were defined on the basis of one or more dominant plant species composing a particular vegetation type. In the process of defining the vegetation on the Black Mesa leasehold, eight vegetation types were recognized. These are: (1) pinyon-juniper woodland; (2) sagebrush shrubland; (3) saltbush shrubland; (4) greasewood

shrubland; (5) tamarix riparian strand; (6) reclaimed grassland; (7) mixed conifer woodland; and (8) a non-vegetal unit defined as disturbed lands.

The methods described in the Vegetation Sampling Program handbook for the Black Mesa and Kayenta Mines (Attachment 2) were followed for collection and analysis of the vegetation resources information. However, certain of the methods described in the handbook are modified from the methods used in the early baseline studies. These modifications resulted from experience and negotiations with regulatory authorities as the sampling program evolved. The methods in the handbook were followed with the following exceptions:

1. Shrubs in the pinyon-juniper woodland were sampled using the point-centered quarter technique prior to the fall of 1982. The methods were identical to those described for trees (Attachment 2), except that canopy covers were measured instead of basal diameters. Canopies were measured by averaging the longest and shortest canopy diameters of individual shrubs and converting the average to area.
2. In baseline studies conducted prior to the fall of 1982, the herbaceous stratum in the pinyon-juniper woodland was sampled using transects with ten, $2m^2$ circular plots spaced at 20m intervals as opposed to twenty plots spaced at 5m intervals used after that time.
3. Prior to 1981, production samples were collected in the pinyon-juniper woodland from the herbaceous stratum only. After 1980, shrub vegetation was included in production samples in accordance with Attachment 2.
4. Prior to 1981, the number of observations (Nmin) needed to obtain adequate samples was determined using the following equation:

$$Nmin = \frac{2(sz)^2}{(d\bar{x})^2}$$

Where z represents the Z statistic (z 0.02 (1), with infinite df = 0.84), s represents the sample standard deviation, d represents the amount of change in the population mean that is to be detected (0.2 for 80% confidence), and $\bar{x}$ represents the sample mean. After 1980, the sample adequacy equation was modified based upon OSM recommendations (Attachment 2).

Results and Discussion of the Vegetation Surveys

Floristics. The plant list resulting from the floristic surveys conducted within and surrounding the lease area is presented in Table 1. The table is arranged in alphabetical order by plant family. Species are identified according to scientific name, common name, growth form and occurrence in the various plant communities encountered in the surveys. Species identified as "ubiquitous" were observed in all terrestrial habitats encountered. The list includes 278 species, 178 genera and 58 families of vascular plants. For comparative purposes, 3438 species, 926 genera, and 133 families of vascular plants are recognized in Arizona by Kearney and Peebles (1960). The families represented by the most species in Table 1 include the Gramineae (45), Compositae (42), Cruciferae (18) and Chenopodiaceae (17). The largest genera include Eriogonum, Astragalus and Agropyron, with seven species each, and Chenopodium and Penstemon with six species each. Voucher specimens of each species are kept in a herbarium maintained at the mine site.

Pinyon-Juniper Woodland. Eight separate stands of pinyon-juniper woodland have been quantitatively sampled during the course of conducting baseline vegetation studies. Sampling has been conducted in six mining areas and two reference areas. Certain strata were sampled in successive years in some stands. The distribution of pinyon-juniper woodland on and adjacent to the leasehold is shown on Drawing 85320, Sheets 1 through 6.

Sampling results obtained in the pinyon-juniper woodland tree overstory are summarized in Table 2. The table summarizes the total basal area, density and species diversity in each of the stands sampled at the dates indicated. The J-16 and J-28 mining areas were sampled as a single unit in the spring and fall of 1981. These mining areas were sampled again as separate units in 1982. Vegetation survey summary reports, describing the individual species contributions to the summary values and additional sample statistics and discussion, may be found in the appropriate document referenced in the table.

The total basal area of trees ranged from 3066.8 dm^2/ha in the J-16/28 mining area in 1981, to 5551.7 dm^2/ha in the N-7/8 reference area. The mean basal area based upon the 11 samples is 3869.1 dm^2/ha. Total tree densities ranged from 198.2 individuals/ha in the J-1/N-6 mining area to 344.9 individuals/ha in the J-19/23 mining area. The overall mean tree density calculated from the 11 samples is 263.5 trees/ha. Species diversity, as expressed by the Shannon-Weiner index (H') and calculated from basal areas ranged between 0.07 and 0.30.

TABLE 1

Plant Species Observed in and Adjacent to the Black Mesa Leasehold[1]

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities[2]
ACERACEAE:		
Acer negundo (Boxelder)	tree	MC
AMARANTHACEAE:		
Amaranthus albus (Tumble pigweed)	herb	PJ
A. graecizans (Prostrate pigweed)	herb	Ubiquitous
ANACARDIACEAE:		
Rhus trilobata (Squaw bush)	shrub	PJ
ASCLEPIADACEAE:		
Asclepias asperula (Milkweed)	herb	PJ
BERBERIDACEAE:		
Berberis repens (Creeping mahonia)	shrub	MC,PJ
BORAGINACEAE:		
Cryptantha bakeri	herb	PJ
C. flava	herb	PJ
Lappula redowskii (Stickseed)	herb	Ubiquitous
Lithospermum incisum (Puccoon)	herb	PJ,SB,SA
L. multiflorum	herb	PJ
CAPRIFOLIACEAE:		
Symphoricarpus sp.	shrub	PJ
S. palmeri	shrub	MC,PJ
S. parishii	shrub	MC,PJ
CACTACEAE:		
Coryphantha vivipara var. *arizonica*	succulent	SB
Echinocereus triglochidiatus var. *melanacanthus* (Hedgehog cactus)	succulent	PJ,SB
Opuntia erinacea (Mojave prickly pear)	succulent	PJ,SB,SA,GR

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
O. fragilis var. *fragilis* (Little prickly pear)	succulent	PJ,SB
O. phaecantha	succulent	PJ,SB,SA,GR
O. polycantha (Plains prickly pear)	succulent	PJ,SB
O. whipplei (Whipple cholla)	succulent	PJ,SB
Sclerocactus parviflorus	succulent	SB
CARYOPHYLLACEAE:		
Arenaria eastwoodiae	herb	MC
A. lanuginosa	herb	MC
CHENOPODIACEAE:		
Atriplex canescens (Fourwing saltbush)	shrub	PJ,SB,SA,GR,TA,RG
A. confertifolia (Shadscale)	shrub	SB,GR,SA
A. obovata (Broadscale)	shrub	TA
A. rosea (Redscale)	herb	PJ,SB,SA,TA,DL,RG
Bassia hyssopifolia (Five hook bassia)	herb	TA
Chenopodium berlandieri (Goosefoot)	herb	PJ
C. capitatum (Strawberry blite)	herb	PJ
C. graveolens (Goosefoot)	herb	PJ
C. fremontii (Goosefoot)	herb	PJ
C. leptophyllum (Slimleaf goosefoot)	herb	PJ,SB,SA,GR,DL
C. watsoni (Goosefoot)	herb	PJ,SB
Eurotia lanata (Winterfat)	shrub	SB,RG
Kochia scoparia (Summer cypress)	herb	RG,DL
Monolepis nuttalliana (Poverty weed)	herb	SB
Salsola iberica (Russian thistle)	herb	Ubiquitous
Sarcobatus vermiculatus (Greasewood)	shrub	GR,TA
Suaeda torreyana (Desert seepweed)	herb	TA
CLEOMACEAE:		
Cleome serrulata (Rocky Mountain beeplant)	herb	SB,TA,DL

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
COMPOSITAE:		
Ambrosia acanthicarpa (Annual burweed)	herb	DL
Artemisia arbuscula spp. nova	shrub	PJ,SB
A. frigida (Prairie sagewort)	shrub	PJ,SB
A. ludoviciana	herb	PJ
A. tridentata (Big sagebrush)	shrub	PJ,SB,SA,GR,RG
Brickellia brachyphylla	shrub	PJ
Chaenactis stevioides (Esteve pincushion)	herb	SB
Chrysothamnus depressus (Rabbitbrush)	shrub	SB
C. greenei	shrub	PJ,SB,SA,GR,RG
C. nauseosus (Rayless goldenrod)	shrub	PJ,SB
C. visidiflоris (Sticky-leaved rabbitbrush)	shrub	PJ,SB,TA
Cirsium vulgare (Bull thistle)	herb	TA,DL
Erigeron concinnus (Tidy fleabane)	herb	SB
E. divergens (Spreading fleabane)	herb	PJ
E. macranthus	herb	MC,PJ
Gutierrezia sarothrae (Snakeweed)	shrub	Ubiquitous
Happlopappus armerioides	herb	PJ
H. spinulosus	herb	PJ
Helianthus petiolaris (Sunflower)	herb	PJ,TA,RG,DL
Heterotheca villosa var. hispida (Hairy goldenaster)	herb	PJ
Hymenopappus filifolius var. lugens	herb	PJ
Hymenoxys acaulis (Bitterweed)	herb	PJ,SB
Hymenoxys ivesiana (Bitterweed)	herb	PJ
Lactuca serriola (Wild lettuce)	herb	TA,RG,DL
Leucelene ericoides (White aster)	herb	PJ,SB,SA,GR,TA
Machaeranthera canescens	herb	SB,DL

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
M. grindelioides	herb	PJ
Malacothrix sonchoides var. torreyi	herb	SB
Petradoria pumila (Rock goldenrod)	herb	PJ
Psilostrophe sparsiflora (Paper flower)	herb	PJ,SB,GR,DL
Senecio douglasii var. longilobus (Threadleaf groundsel)	shrub	PJ,SB,TA,DL
Senecio neomexicanus (Groundsel)	herb	PJ
S. spartioides (Broom groundsel)	herb	PJ
Solidago sparsiflora (Goldenrod)	herb	PJ,SB
Stephanomeria exigua (Wire lettuce)	herb	SB
Taraxacum officinale (Dandelion)	herb	PJ,DL,RG, SB
Townsendia exscapa (Ground daisy)	herb	PJ,SB,SA
Tragopogon dubious (Goat's beard)	herb	SB,RG
Tetradymia canescens var. inermis (Grey feltthorn)	shrub	PJ,SB
Verbesina encelioides (Cowpen daisy)	herb	DL
Viguiera annua (Annual goldeneye)	herb	GR
Xanthium strumarium (Common cocklebur)	herb	GR,DL
CORNACEAE:		
Cornus stolonifera (Red osier dogwood)	shrub	MC
CRASSULACEAE:		
Sedum lanceolatum (Stonecrop)	herb	MC
CRUCIFERAE:		
Alyssum alyssoides	herb	PJ
Arabis perennans (Rock cress)	herb	PJ,SB,SA
Camelina microcarpa (Little pod)	herb	PJ,DL
Chorispora tenella	herb	DL
Conringia orientalis (Treacle mustard)	herb	DL
Descurainia pinnata (Yellow tansy mustard)	herb	PJ,SA,RG,DL
D. sophia (Flixweed)	herb	PJ,DL

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
Draba cuneifolia (Whitlow grass)	herb	PJ
Erysimum repandum (Wallflower)	herb	PJ
Lepidium densiflorum (Pepper grass)	herb	SB
Lesquerella arizonica (Bladder pod)	herb	PJ
L. intermedia (Bladder pod)	herb	PJ,SB
Physaria newberryi (Twin pod)	herb	PJ,SB
Sisymbrium altissimum (Tumble mustard)	herb	PJ,RG,DL
Sisymbrium irio (London rocket)	herb	PJ,SB,DL
Stanleya pinnata (Desert plume)	herb	PJ
Streptanthus cordatus (Twist flower)	herb	PJ
Thlaspi fendleri (Wild candytuft)	herb	PJ
CUPRESSACEAE:		
Juniperus monosperma (One-seed juniper)	tree	PJ
J. osteosperma (Utah juniper)	tree	PJ
J. scopulorum (Rocky Mountain juniper)	tree	MC
CYPERACEAE:		
Carex occidentalis	herb	PJ
Carex sp.	herb	PJ
Scirpus acutus (Great bulrush)	herb	A
S. pungens	herb	PJ
ELAEAGNACEAE:		
Elaeagnus angustifolia (Russian olive)	tree	RG
Shepherdia rotundifolia (Round leaf buffalo berry)	shrub	PJ
EPHEDRACEAE:		
Ephedra viridis (Green ephedra)	shrub	PJ
EUPHORBIACEAE:		
Euphorbia fendleri (Fendler spurge)	herb	PJ,SB
E. lurida	herb	PJ
E. serphyllifolia	herb	PJ,SB

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
FAGACEAE:		
Quercus gambelii (Gambel oak)	shrub	PJ,MC
Q. undulata	shrub	PJ
FUMARIACEAE:		
Corydalis aurea (Scrambled eggs)	herb	SB
GENTIANACEAE:		
Swertia radiata (Deers ears)	herb	PJ
GERANIACEAE:		
Erodium cicutarium	herb	SB,TA
GRAMINEAE:		
Agropyron cristatum (Crested wheatgrass)	herb	PJ,RG,SB, DL
A. elongatum (Wheatgrass)	herb	RG
A. intermedia (Intermediate wheatgrass)	herb	RG
A. riparian (Streambank wheatgrass)	herb	SB,RG
A. smithii (Western wheatgrass)	herb	SB,RG
A. trachycaulum (Slender wheatgrass)	herb	RG
A. trichophorum (Pubescent wheatgrass)	herb	RG
Aristida fendleriana (Fendler's threeawn)	herb	SB
Avena sativa (Oats)	herb	DL
Bouteloua barbata (Six-weeks grama)	herb	GR
B. curtipendula (Sideoats grama)	herb	PJ,MC
B. eriopoda (Black grama)	herb	RG
B. gracilis (Blue grama)	herb	PJ,SB,SA,GR,TA,RG
B. hirsuta (Hairy grama)	herb	PJ,SB
Bromus inermis (Smooth brome)	herb	RG,PJ
B. tectorum (Cheatgrass)	herb	Ubiquitous
Echinochloa crusgalli (Barnyard grass)	herb	SG,RG,DL
Elymus junceus (Russian wildrye)	herb	RG

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
Enneapogon desvauxii (Spike pappusgrass)	herb	SB
Festuca arizonica (Arizona fescue)	herb	SB,RG,MC
Hilaria jamesii (Galleta)	herb	PJ,SB,SA,RG
Hordeum jubatum (Foxtail barley)	herb	PJ,DL
H. murinum (Mouse barley)	herb	DL,PJ
H. vulgare (Common barley)	herb	RG,DL
Leptochloa fascicularis (Beaded sprangletop)	herb	DL
Muhlenbergia asperifolia (Scratchgrass)	herb	SA
M. montana	herb	MC,PJ
M. torreyi (Ring-grass)	herb	SB
Munroa squarrosa (False buffalo grass)	herb	SB,DL,RG
Oryzopsis hymenoides (Indian ricegrass)	herb	PJ,SB,SA,RG
O. micrantha (Littleseed ricegrass)	herb	PJ
Panicum capillare (Witchgrass)	herb	DL
Poa fendleriana (Mutton grass)	herb	PJ,MC
Polypogon monspelienis (Rabbitfoot grass)	herb	SG
Puccinellia distans (European alkali grass)	herb	SG
Schizachyrium scoparium (Little bluestem)	herb	MC
Setaria viridis (Green bristle grass)	herb	DL
Sitanion hystrix (Bottlebrush squirreltail)	herb	PJ,SB,SA,GR,TA,RG
Sporobolus airoides (Alkali sacaton)	herb	SB,TA,RG
S. contractus (Spike dropseed)	herb	TA,RG
S. cryptandrus (Sand dropseed)	herb	SB,TA,RG
Stipa columbiana (Columbia needlegrass)	herb	PJ
S. comata (Needle and thread)	herb	PJ,SB
S. neomexicana (New Mexican feathergrass)	herb	PJ,SB

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
Triticum aestivum (Common wheat)	herb	RG,DL
Vulpia octoflora (Six-weeks fescue)	herb	SB,SA,GR,RG
HYDROPHYLLACEAE:		
Phacelia sp. (Phacelia)	herb	PJ
JUNCACEAE:		
Juncus tenuis (Path rush)	herb	PJ,SB
LABIATAE:		
Hedeoma drummondii (Mock-pennyroyal)	herb	PJ
Moldavica parviflora	herb	PJ
LEGUMINOSAE:		
Astragalus azionis (Astragalus)	herb	PJ
A. calycosus var. *scaposus* (Torrey milkvetch)	herb	PJ,SB,RG
A. kentrophyta	herb	PJ
A. mollissima	herb	PJ
A. newberryi (Newberry milkvetch)	herb	PJ,SB
A. praelongus var. *praelongus* (Stinking milkvetch)	herb	PJ,RG
A. wingatanus (Fort wingate milkvetch)	herb	PJ
Lathyrus eucosmus (Peavine)	herb	PJ
Lotus wrightii (Short-stemmed lupine)	herb	PJ
Lupinus brevicaulis	herb	PJ,SB,RG
L. palmeri (Lupine)	herb	PJ
Medicago sativa (Alfalfa)	herb	RG
Melilotus officinalis (Yellow sweetclover)	herb	RG,DL
Oxytropis lambertii var. *bigelovii* (Lambert locoweed)	herb	PJ
Trifolium subcaulescens (Subterranean clover)	herb	PJ,MC
LILIACEAE:		
Allium macropetalum (Onion)	herb	SB,RG

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
Androstephinum breviflorum (Funnel lily)	herb	SB
Calochortus nuttallii var. aureus (Sego-lily)	herb	SB,RG
Fritillaria atropurpurea (Fritillary)	herb	MC
Yucca angustissima (Spanish bayonet)	herb	PJ
Y. baccata (Banana yucca)	herb	PJ
LINACEAE:		
Linium lewisii (Blue flax)	herb	SB
LOASACEAE:		
Mentzelia albicaulis (Small-flowered blazing star)	herb	PJ,SB
M. pumila (Blazing star)	herb	PJ,SB
LORANTHACEAE:		
Phoradendron juniperinum (Mistletoe)	epiphyte	PJ
MALVACEAE:		
Sphaeralcea ambigua (Desert mallow)	herb	RG
S. coccinea (Scarlet globemallow)	herb	PJ,SB,SA,GR,RG
S. laxa (Caliche globemallow)	herb	SB,TA
NAJADACEAE:		
Najas marina	herb	A
NYCTAGINACEAE:		
Mirabilis multiflora (Colorado four o'clock)	herb	PJ
Oxybaphus linearis	herb	SB
Tripterocalyx micranthus	herb	SB,TA
OLEACEAE:		
Forestiera neomexicana (Tanglebrush)	shrub	PJ
Menodora scoparia (Broom twinberry)	shrub	SB
ONAGRACEAE:		
Oenothera albicaulis	herb	GR

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
O. caespitosa	herb	SB
OROBANCHACEAE:		
Orobanche fasciculata	herb	SB
O. multiflorus	herb	SB
PINACEAE:		
Pinus edulis (Colorado pinyon)	tree	PJ,MC,SB
P. ponderosa (Ponderosa pine)	tree	MC
Pseudotsuga menziesii (Douglas fir)	tree	MC
PLANTAGINACEAE:		
Plantago lanceolata (Buckhorn plantain)	herb	SB
P. purshii (Pursh plantain)	herb	SB,SA,RC
POLEMONIACEAE:		
Gilia gunnisonii	herb	SB
G. leptomeria (Tooth-leaved gilia)	herb	SB
Ipomopsis aggregate (Sky rocket)	herb	PJ,SB,GR
I. longiflora (White-flowered gilia)	herb	SB
I. multiflora	herb	SB
Leptodactylon pungens (Prickly phlox)	herb	SB
Phlox longifolia (Phlox)	herb	SB,SA,PJ
POLYGONACEAE:		
Eriogonum alatum (Winged eriogonum)	herb	PJ
E. cernuum (Nodding eriogonum)	herb	PJ,SB
E. corymbosum (Wild buckwheat)	herb	PJ
E. divaricatum (Wild buckwheat)	herb	SB
E. jamesii var. flavescens	herb	PJ
E. microthecum var. foliosum (Buckwheat)	herb	PJ,SB
E. umbellatum	herb	PJ
Polygonum aviculare (Prostrate Knotweed)	herb	TA,DL
P. sawatchense (Smartweed)	herb	PJ

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
POLYPODIACEAE:		
Cheilanthus feei (Slender lip fern)	herb	MC
PORTULACACEAE:		
Portulaca oleracea (Common purslane)	herb	PJ,SB
POTAMOGETONACEAE:		
Potamogeton filiformis	herb	A
P. pectinatus (Sego pondweed)	herb	A
P. pusillus	herb	A
PRIMULACEAE:		
Androsace septentrionalis (Rock jasmine)	herb	PJ
RANUNCULACEAE:		
Clematis ligusticifolia (Virgins bower)	herb	SB
Delphinium nelsonii (Larkspur)	herb	PJ,SB
D. scaposum (Barestem larkspur)	herb	PJ,SB
Ranunculus cymbalaria	herb	SB
R. testiculatus	herb	PJ,DL
Thalictrium fendleri	herb	MC
ROSACEAE:		
Amelanchier utahensis (Service berry)	shrub	PJ
Cercocarpus intricatus (Little-leaf mountainmahogany)	shrub	MC
Cowania mexicana (Cliffrose)	shrub	PJ
Holodiscus dumosus (Rock spirea)	shrub	MC
Potentilla sp.	herb	DL
Prunis virginiana (Western chokecherry)	tree	DL
Purshia tridentata (Antelope brush)	shrub	MC,PJ
SALICACEAE:		
Populus sp.	tree	RG
Populus fremontii (Cottonwood)	tree	TA
Populus tremuloides (Quaking aspen)	tree	MC

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
SALICACEAE (Cont.)		
Salix exigua (Coyote willow)	shrub	RG,TA
SAXIFRAGACEAE:		
Fendlera rupicola (Fendlerbush)	shrub	PJ
Heuchera versicolor (Alum root)	herb	MC
Ribes cereum (Wax current)	shrub	MC
SCROPHULARIACEAE:		
Besseya arizonica (Kittentails)	herb	MC
Castilleja chromosa (Indian paintbrush)	herb	SB
C. linariaefolia (Long-leaved paintbrush)	herb	PJ
Cordylanthus wrightii (Birdbeak)	herb	PJ,SB
Pedicularis centranthera (Woodbetony)	herb	PJ
Penstemon barbatus (Scarlet penstemon)	herb	PJ
P. bridgesii (Bridges beardtongue)	herb	PJ
P. commarrhenus	herb	PJ
P. eatoni (Eaton penstemon)	herb	PJ
P. linarioides (Mat penstemon)	herb	PJ
P. strictus	herb	PJ
SOLANACEAE:		
Chamaesaracha coronopus (Small groundcherry)	herb	SB
Lycium pallidum (Wolfberry)	shrub	PJ,SB
Nicotiana attenuata	herb	PJ
Solanum rostratum (Buffalo bur)	herb	SB,DL
S. triflorum	herb	SB
TAMARICACEAE:		
Tamarix pentandra (Saltcedar)	tree	TA,DL,RG
TYPHACEAE:		
Typha sp.	herb	A

TABLE 1 (Cont.)

Family/ Scientific Name (Common Name)	Growth Form	Plant Communities
UMBELLIFERAE:		
Cymopterus purpurascens	herb	PJ,SB
C. purpureus	herb	PJ,SB
VALERIANACEAE:		
Valeriana acutiloba (Valerian)	herb	MC
Zannichelliaceae:		
Zanichellia palustris (Common poolmat)	herb	A

[1]Nomenclature follows Lehr 1978.

[2]Plant community symbols:

MC = Mixed Conifer Woodland
PJ = Pinyon-juniper Woodland
SB = Sagebrush Shrubland
SA = Saltbush Shrubland
GR = Greasewood Shrubland
RG = Reclaimed Grassland
TA = Tamarix Riparian Strand
DL = Disturbed Land
A = Aquatic

TABLE 2

Summary of the Major Vegetation Parameters From Samples

Conducted in the Pinyon-Juniper Tree Overstory

Sample Location	Sample Date	Total Basal Area (dm^2/ha)[1]	Total Density (No./ha)[2]	Species Diversity (H')	Survey Summary Report Reference
N-7/8 Mining Area	10-79	4803.8	253.7	0.16	Attachment 1
N-10 Mining Area	9-80	3894.2	215.6	0.14	Attachment 1
N-14 Mining Area	9-80	3492.4	293.0	0.26	Attachment 1
N-7/8 Reference Area	10-79	5551.7	317.8	0.15	Attachment 1
N-14 Reference Area	7-80	4453.6	275.3	0.16	Attachment 1
J-1/N-6 Mining Area	9-81	3535.8	198.2	0.07	Az. Div., PCC 1982
J-16/28 Mining Area	6-81	3066.8	232.2	0.28	Az. Div., PCC 1982
J-16/28 Mining Area	9-81	3468.4	265.1	0.26	Az. Div., PCC 1982
J-16 Mining Area	5-82	3173.5	220.9	0.24	Az. Div., PCC 1983
J-28 Mining Area	5-82	3241.5	281.9	0.30	Az. Div., PCC 1983
J-19/23 Mining Area	9-82	3877.9	344.9	0.24	Attachment 1

[1] Mean basal area ± 95% Confidence Limit ($t_{0.05\ (2),\ 10} = 2.228$) = 3869.1 ± 519.6 dm^2/ha.

[2] Mean density ± 95% Confidence Limit ($t_{0.05\ (2),\ 10} = 2.228$) = 263.5 ± 30.3 trees/ha.

Four tree species were encountered in at least one of the samples (Attachment 1; Arizona Division, Peabody Coal Company 1982 and 1983). Utah juniper (Juniperus osteosperma) and Colorado pinyon (Pinus edulis) dominated all samples. The relative density of these two species varied with elevation. As a general rule the proportion of pinyon increased with increasing elevation. For example, at the J-1/N-6 mining site (elevation approximately 6680 feet) the proportion of pinyon to juniper was 25.3 to 172.9. At the N-14 mining site (elevation approximately 6870) the proportion of pinyon to juniper was 172.5 to 120.5. Gambel oak (Quercus gambelii) was encountered in samples conducted in the N-14 reference area, J-16/28 mining area and J-19/23 mining area. An unidentified poplar (Populus sp.) was encountered in the J-16/28 and J-19/23 mining areas. The oak and poplar were found in canyon bottoms at higher elevations. They were only nominally important in the samples however, as reflected by very low densities.

Sample adequacy parameters for individual samples conducted in the pinyon-juniper tree overstory are presented in Table 3. A total of 124 transects were sampled within the leasehold. Adequate samples within individual stands were obtained in the N-10, N-14, J-1/N-6, J-16/28 and J-19/23 mining areas and the N-7/8 reference area. Additional sampling would have been needed in the N-7/8 mining area and N-14 reference area to meet the predefined sample adequacy criteria.

The results of samples conducted in the pinyon-juniper woodland shrub stratum using the point-centered quarter technique are summarized in Table 4. The table summarizes total canopy cover, total shrub density and species diversity in each of the stands sampled on the leasehold at the dates indicated. The J-16 and J-28 mining areas were sampled as a single unit in the spring and fall of 1981. These mining areas were sampled again as separate units in 1982. Shrub sampling was conducted in the two pinyon-juniper reference areas in 1979 and 1980, and again in 1982. Shrubs were included in the herbaceous stratum in baseline studies conducted at the J-19 through 23 coal resource areas.

Total shrub canopy coverage ranged from 10508.5 dm^2/ha at the J-28 mining area in the spring of 1982, to 37002.0 dm^2/ha at the N-14 reference area in 1982. The mean total canopy coverage averaged 21446.0 based upon the 12 samples. This translates to 2.14 percent shrub cover on a per hectare basis. Total shrub densities ranged from 207.1 individual/ha at the J-16/28 mining area in the spring 1981 sample to 689.1 individuals at the N-7/8 reference area in 1982. The mean shrub density calculated from the 12 samples was 411.4 shrubs/ha. The Shannon-Weiner diversity indices ranged from 0.47 to 0.81.

TABLE 3

Sample Adequacy Parameters From Samples

Conducted in the Pinyon-Juniper Woodland Tree Overstory[1]

Sample Location	Sample Date	$\bar{d}$	s	N	Nmin[2]
N-7/8 Mining Area	10-79	0.0326	0.0134	5	6
N-10 Mining Area	9-80	0.0239	0.0060	4	3
N-14 Mining Area	9-80	0.0302	0.0044	4	1
N-7/8 Reference Area	10-79	0.0323	0.0103	4	4
N-14 Reference Area	7-80	0.0375	0.0255	5	16
J-1/N-6 Mining Area	9-81	0.0203	0.0054	11	11
J-16/28 Mining Area	1981 (Combined)	0.0306	0.0162	32	46
J-16/28 Mining Area (Combined)	1982	0.0300	0.0100	41	41
J-19/23 Mining Area	9-82	0.0375	0.0116	18	16

[1]Sample adequacy calculations are based on $\bar{d}$ tree density by transect (Attachment 2, Tables 1 and 2).

[2]The minimum number of transects required to achieve a desired confidence in sample means was calculated using the equation presented in the Methods and Materials section of this Chapter prior to 1981. After that time the equation presented in Attachment 2, Table 1 was used.

TABLE 4

Summary of the Major Vegetation Parameters From

Samples Conducted in the Pinyon-Juniper Woodland Shrub Stratum[1]

Sample Location	Sample Date	Total Canopy Cover (dm^2/ha)[2]	Total Density (No./ha)[3]	Species Diversity (H')	Survey Summary Report Reference
N-7/8 Mining Area	10-79	18786.1	270.0	0.75	Attachment 1
N-10 Mining Area	9-80	13584.0	325.2	0.47	Attachment 1
N-14 Mining Area	9-80	15239.3	550.4	0.66	Attachment 1
N-7/8 Reference Area	10-79	32881.7	659.5	0.75	Attachment 1
N-14 Reference Area	7-80	23425.8	391.8	0.65	Attachment 1
J-1/N-6 Mining Area	9-81	14450.5	242.9	0.53	Az. Div., PCC 1982
J-16/28 Mining Area	6-81	15465.6	207.1	0.77	Az. Div., PCC 1982
J-16/28 Mining Area	9-81	12711.4	244.7	0.71	Az. Div., PCC 1982
J-16 Mining Area	5-82	26966.7	404.7	0.61	Az. Div., PCC 1983
J-28 Mining Area	5-82	10508.5	300.2	0.74	Az. Div., PCC 1983
N-7/8 Reference Area	6-82	36330.4	689.1	0.66	Az. Div., PCC 1983
N-14 Reference Area	6-82	37002.0	651.8	0.81	Az. Div., PCC 1983

[1] The data was collected using the point-centered quarter technique.

[2] Mean canopy cover ± 95% Confidence Limit ($^{t}0.05(2), 11 = 2.201$) = 21446.0 ± 6108.5 dm^2/ha.

[3] Mean density ± 95% Confidence Limit ($^{t}0.05(2), 11 = 2.201$) = 411.45 ± 114.2 shrubs/ha.

Both shrub density and total canopy coverage increased in the 1982 samples from levels found in previous samples in the same areas. This increase was due to a substantial increase in sampling intensity in 1982. Many more transects were measured in the later samples in an attempt to meet sample adequacy criteria. This would indicate that less intensive samples tended to underestimate mean shrub densities to some extent.

Several shrub species were encountered in the samples (Attachment 1; Arizona Division, Peabody Coal Company 1982 and 1983). For example, 20 species of shrubs were encountered in the J-16 mining area sample conducted in 1982. Thirteen shrub species were encountered in the N-14 reference area sample in 1982. These totals included cacti and tree saplings. Cliffrose (Cowania mexicana), big sagebrush (Artemisia tridentata), fourwing saltbush (Atriplex canescens), and saplings of pinyon, juniper and oak were found to consistently rank high in terms of both total cover and density. Cliffrose had the greatest total canopy cover in 9 of the 12 samples. Less important species included squawbush (Rhus trilobata), green ephedra (Ephedra viridis), yucca (Yucca baccata and Y. angustissima), wolfberry (Lycium pallidum), Eriogonum (Eriogonum sp.) and several species of cacti.

Sample adequacy parameters for individual samples conducted in the pinyon-juniper woodland shrub stratum are presented in Table 5. A total of 212 transects were measured in the 12 samples. In no single instance was an adequate sample achieved, although if the samples were all combined it is very likely that an adequate overall sample was achieved. The great amount of variability encountered in the stands accounts for the lack of adequate samples. Shrub densities are low throughout the leasehold and a great degree of pattern exists in the shrub vegetation. This in part, was the rationale for changing the shrub sampling methods in the fall of 1982.

The results of samples conducted in the pinyon-juniper woodland herbaceous stratum are summarized in Table 6. The table presents total cover (%), total plant density (No./m^2) Shannon-Weiner indices of diversity (H') and total dry production (g/m^2) by location and date for all the samples that have been conducted. The J-16 and J-28 mining areas were sampled as a single unit in the spring and fall of 1981. These mining areas were sampled as separate units in 1982. Detailed vegetation survey summary reports showing the individual species contribution to the summary values may be found in the appropriate document referenced in the table.

TABLE 5

Sample Adequacy Parameters From Samples

Conducted in the Pinyon-Juniper Woodland Shrub Stratum[1]

Sample Location	Sample Date	$\bar{d}$	s	N	Nmin[2]
N-7/8 Mining Area	10-79	0.0456	0.0385	6	21.0
N-10 Mining Area	9-80	0.0371	0.0216	4	11.0
N-14 Mining Area	9-80	0.0748	0.0368	4	8.5
N-7/8 Reference Area	10-79	0.1430	0.1563	4	41.9
N-14 Reference Area	7-80	0.0714	0.0435	6	13.1
J-1/N-6 Mining Area	9-81	0.0944	0.0804	17	119.0
J-16/28 Mining Area	1981 (Combined)	0.0691	0.0739	31	187.0
J-16/28 Mining Area (Combined)	1982	0.0800	0.0700	80	138.0
N-7/8 Reference Area	6-82	0.1500	0.1400	30	137.0
N-14 Reference Area	6-82	0.1300	0.1900	30	326.0

[1] Sample adequacy calculations are based on shrub density by transect (Attachment 2, Tables 1 and 2.

[2] The minimum number of transects required to achieve a desired confidence in sample means was calculated using the equation presented in the Methods and Materials section of this Chapter prior to 1981. After that time the equation presented in Attachment 2, Table 1 was used.

TABLE 6

Summary of the Major Vegetation Parameters From

Samples Conducted in the Pinyon-Juniper Woodland Herbaceous Understory[1]

Sample Location	Sample Date	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)	Survey Summary Report Reference
N-7/8 Mining Area	10-79	4.05	4.43	1.29	-	Attachment 1
	7-80	-	-	-	5.80	Attachment 1
	9-80	-	-	-	5.10	Attachment 1
	5-81	0.83	3.79	1.21	-	Az. Div., PCC 1982
	9-81	0.77	3.59	1.20	-	Az. Div., PCC 1982
N-10 Mining Area	9-80	5.23	2.61	1.15	3.20	Attachment 1
	6-81	1.34	5.25	1.05	-	Az. Div., PCC 1982
	10-81	0.79	3.66	0.83	-	Az. Div., PCC 1982
N-14 Mining Area	7-80	-	-	-	2.90	Attachment 1
	9-80	5.08	3.00	1.08	2.50	Attachment 1
	5-81	0.94	5.45	1.10	-	Az. Div., PCC 1982
	10-81	0.22	2.20	0.77	-	Az. Div., PCC 1982
J-1/N-6 Mining Area	5-81	0.68	5.02	1.01	-	Az. Div., PCC 1982
	9-81	0.60	3.15	0.74	-	Az. Div., PCC 1982

TABLE 6 (Cont.)

Sample Location	Sample Date	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)	Survey Summary Report Reference
J-16/28 Mining Area	6-81	0.78	4.70	1.06	-	Az. Div., PCC 1982
	9-81	0.45	2.98	1.01	15.26	Az. Div., PCC 1982
J-16 Mining Area	5-82	0.51	3.85	1.05	8.53	Az. Div., PCC 1983
J-28 Mining Area	5-82	0.89	7.49	1.19	4.84	Az. Div., PCC 1983
J-19/23 Mining Area	*9-82	2.17	2.07	0.93	4.89	Attachment 1
	*5-83	2.44	5.25	1.07	5.42	Attachment 1
N-7/8 Reference Area	10-79	5.19	5.49	1.31	-	Attachment 1
	7-80	-	-	-	3.80	Attachment 1
	9-80	-	-	-	4.20	Attachment 1
	5-81	2.14	7.27	1.04	-	Az. Div., PCC 1982
	9-81	1.44	5.19	1.00	-	Az. Div., PCC 1982
	5-82	1.07	7.92	1.09	6.45	Az. Div., PCC 1983
	*9-82	1.40	2.68	0.96	3.69	Az. Div., PCC 1983
N-14 Reference Area	7-80	4.58	4.93	1.09	5.50	Attachment 1
	9-80	-	-	-	3.50	Attachment 1
	5-81	1.28	4.24	0.96	-	Az. Div., PCC 1982
	9-81	0.68	2.55	0.89	-	Az. Div., PCC 1982
	5-82	1.39	4.79	0.74	7.79	Az, Div., PCC 1983
	9-82	3.25	3.66	0.87	8.99	Az., Div., PCC 1983

[1]Samples collected in the N-7/8 and N-14 reference areas in 9-82, and the J-19/24 mining area in 9-82 and 9-83, included shrubs in the herbaceous stratum.

Total vegetation cover ranged from 0.22 percent at the N-14 mining area in October, 1981, to 5.23 percent at the N-10 mining area in September, 1980. Dry production ranged from 2.5 g/m^2 in the N-14 mining area in September, 1980, to 15.26 g/m^2 in the J-16/28 mining area in September, 1981. Although sparse in terms of percent cover and species density, many herbaceous species were encountered in samples conducted in the pinyon-juniper woodland understory as indicated by the relatively high species diversity indices found in all samples. Seventy-six plant species were encountered in the spring 1983 sample conducted in the J-19/23 mining area (Attachment 1).

In terms of importance percentages and relative cover figures, blue grama (Bouteloua gracilis), mutton grass (Poa fendleriana), squirrel tail (Sitanion hystrix) and Indian ricegrass (Oryzopsis hymenoides) dominated the graminoid component of the understory vegetation. Snakeweed (Gutierrizia sarothrae),(Cryptantha bakeri), rock cress (Arabis perennans) and a variety of milk vetches (Astragalus), chenopods, penstemons and composites were also frequently encountered.

Sample adequacy parameters for individual cover samples in the pinyon-juniper woodland herbaceous understory are presented in Table 7. A total of 378 cover transects were measured to quantify the vegetation in the woodland understory. Based upon the criteria used to determine sample adequacy in 1979 and 1980, adequate samples were achieved in all mining and reference areas. In 1981, using more rigorous adequacy criteria, a significant number of additional transects would have been needed to achieve the desired sampling efficiency. A great degree of variability occurs in the woodland understory which is attributable to the sparseness of the vegetation, the existence of pattern and the lack of further stratification of the vegetation. In 1982, ten additional plots spaced at a shorter sampling interval within transects were incorporated into the sampling design. This modification, coupled with combining the shrub and herbaceous stratum, reduced the variability between transects to some degree. As a result, adequate samples were obtained in most samples collected after that time using a reasonable amount of sampling effort.

Sample adequacy parameters for the production samples collected in the herbaceous understory are presented in Table 8. No calculations were made prior to 1981. The calculations made after that time indicate that a considerable number of plots were needed to achieve adequate samples. With the exceptions of production samples conducted in the J-19/23 mining area and the N-7/8 reference area in the fall of 1982, reasonably reliable samples were collected. In only one case, however, was the designed adequacy critera

TABLE 7

Sample Adequacy Parameters for Cover Samples

From the Pinyon-Juniper Woodland Herbaceous Understory

Sample Location	Sample Date	Total Cover (%) $\bar{x}$	s	N	Nmin
N-7/8 Mining Area	10-79	4.05	1.781	18	7.0
	5-81	0.83	0.373	10	33.0
	9-81	0.77	0.326	10	29.0
N-10 Mining Area	9-80	5.23	3.415	18	15.3
	6-81	1.34	0.794	5	58.0
	10-81	0.79	0.927	5	226.0
N-14 Mining Area	9-80	5.08	2.796	18	10.7
	5-81	0.94	0.399	10	30.0
	10-81	0.22	0.196	5	130.0
J-1/N-6 Mining Area	5-81	0.68	0.419	10	62.0
	9-81	0.60	0.485	10	107.0
J-16/28 Mining Area	6-81	0.78	0.498	10	67.0
	9-81	0.45	0.248	20	50.0
J-16 Mining Area	5-82	0.51	0.190	24	23.0
J-28 Mining Area	5-82	0.89	0.310	20	20.0
J-19/23 Mining Area	9-82	2.17	0.630	12	14.0
	5-83	2.44	1.300	46	46.5
N-7/8 Reference Area	10-79	5.19	2.339	18	7.2
	5-81	2.14	1.486	10	79.0
	9-81	1.44	0.585	10	27.0
	5-82	1.07	0.200	11	6.0
	9-82	1.40	0.380	11	12.1
N-14 Reference Area	7-80	4.58	2.407	15	9.8
	5-81	1.28	0.764	10	58.0
	9-81	0.68	0.319	10	36.0
	5-82	1.39	0.540	24	24.0
	9-82	3.25	0.710	8	8.0

TABLE 8

Sample Adequacy Parameters for Production Samples
From the Pinyon-Juniper Woodland Herbaceous Understory[1]

Sample Location	Sample Date	N	Nc	Production (g/M^2) $\bar{Y}$fresh	sY^2	r^2	d
N-7/8 Mining Area	7-80			None Calculated			
	9-80			None Calculated			
N-10 Mining Area	9-80			None Calculated			
N-14 Mining Area	7-80			None Calculated			
	9-80			None Calculated			
J-1/N-6 Mining Area	1981			No Sample Conducted			
J-16/28 Mining Area	9-81	200	-	27.9	728.6	0.98	0.16
J-16 Mining Area	5-82	183	58	18.9	675.3	0.99	0.13
J-28 Mining Area	5-82	112	38	13.7	374.8	0.99	0.14
J-19/23 Mining Area	9-82	66	39	9.7	1912.2	0.98	0.71
	5-83	185	65	14.8	132.6	0.96	0.07
N-7/8 Reference Area	7-80			None Calculated			
	9-80			None Calculated			
	5-82	50	17	21.0	203.4	0.99	0.12
	9-82	36	13	10.3	1028.9	0.99	0.66
N-14 Reference Area	7-80			None Calculated			
	9-80			None Calculated			
	5-82	75	27	21.0	203.4	0.93	0.15
	9-82	40	10	17.1	334.1	0.83	0.22

[1] N = Number of observations (plots) in the sample

Nc = Number of plots clipped

$\bar{Y}$fresh = Calculated mean fresh weight production

sy^2 = Sample variance

r^2 = Coefficient of determination

d = Amount of reduction detected (d = 0.1 to be within 10% of the true population mean with 80% confidence)

achieved (J-19/23, in the spring of 1983).

The pinyon-juniper woodland may be placed in the broader Great Basin Conifer Woodland Biotic Community of Brown (1982). Throughout its geographical distribution, the woodland is characterized by the unequal dominance of only a few species of the two genera Pinus and Juniperus. Colorado pinyon and Utah juniper share dominance on the Black Mesa leasehold.

The community occurs as a sparse to dense woodland on an estimated 42.6 million (Clary 1975) to 80 million acres (West et al. 1975) in the western United States. West et al. (1975) determined that 12.6 million acres of this community occur in Arizona, which represents approximately 17.3 percent of the state's land area. In terms of areal extent, it is the dominant plant community within the Black Mesa leasehold (Drawing 85320', Sheets 1 through 6. It occupies approximately 65-70 percent of the undisturbed land area.

The majority of the woodland on the Black Mesa leasehold occurs at an elevation range of approximately 6300 feet to over 7200 feet (Figure 2). At higher elevations, pinyon tends to dominate over juniper. At lower elevations, juniper predominates, and can form almost pure stands. Throughout the geographic distribution of this community, juniper is generally more prevalent than pinyon (Lowe 1964; West et al. 1975). Juniper was more common than pinyon in the majority of stands sampled on the leasehold.

Extreme variation in tree densities occur in the pinyon-juniper community throughout the southwest. Numbers per hectare of 920-1230 (Darling 1966), 316-1282 (Rand 1965) and 964 (Woodbury 1947) have been reported. On the Black Mesa leasehold, tree densities ranged between 198.2 individuals/ha to 344.9 individual/ha.

The shrub and herbaceous layer of the woodland on the leasehold is characterized by sparse, scattered graminoids, forbs, sub- and true shrubs, and extensive areas of bare soil, rock and varying thicknesses of litter underneath the trees. Herbaceous production is correspondingly low. Canopy closure ranges from open park-like circumstances on exposed xeric slopes and along vegetation type transitions to closed forest-type interlocking crowns in the most mesic situations. Shrub and herbaceous vegetation reaches its greatest development in the openings where total cover may exceed six percent (Figure 3). Total herbaceous and shrub cover decreases substantially as tree densities and canopy cover increase, often to below 0.5 percent (Figure 4). In localized areas where deeper

FIGURE 2

Pinyon-Juniper Woodland (J-21 Mining Area)

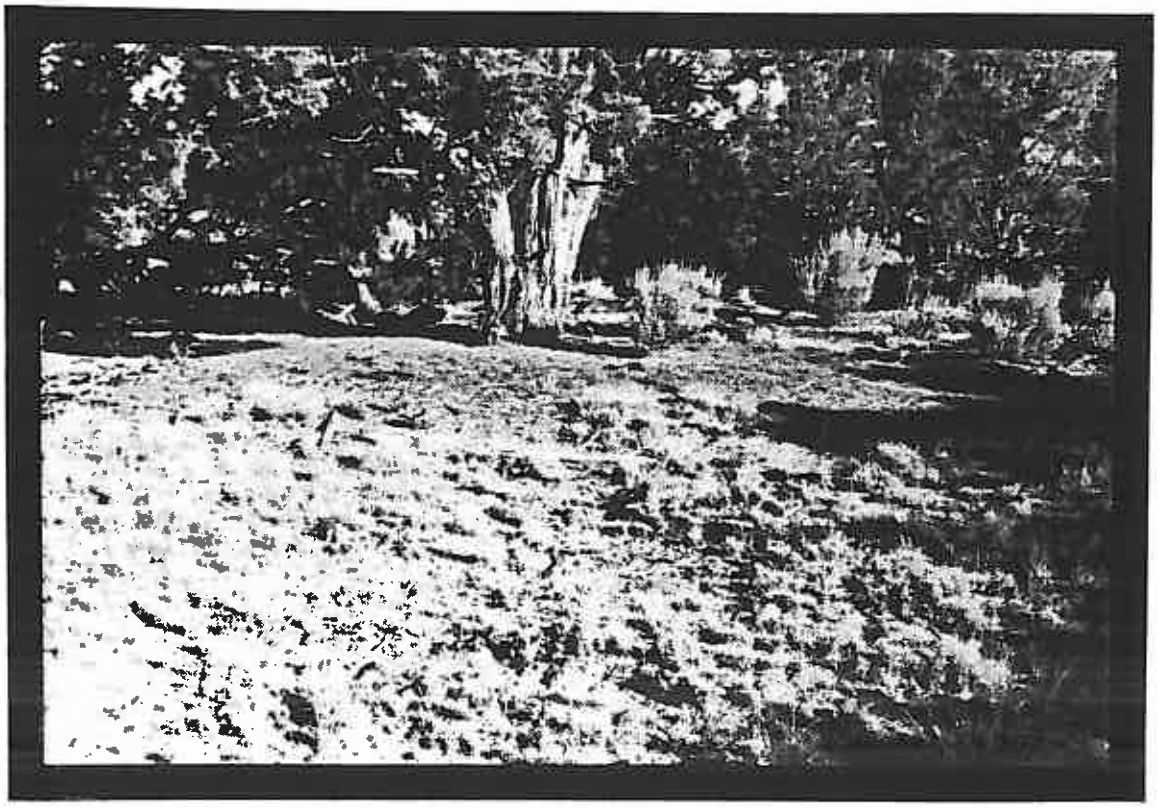

FIGURE 3

Pinyon-Juniper Woodland Understory (J-19 Mining Area)

FIGURE 4

Pinyon-Juniper Woodland Understory (J-21 Mining Area)

soils persist, big sagebrush and fourwing saltbush are subdominants. Cliffrose is the principle sub-dominant on shallower sites.

The woodland is situated on the leasehold in habitats that tend to be rocky, with steep slopes and coarse or extremely fine, shallow soils. The soils are typically severely eroded. The unproductive nature of the soils, coupled with extensive livestock utilization also contributes to the lack of understory development. The principle vegetation contact with the woodland is sagebrush shrubland.

Sagebrush Shrubland. Nine separate stands of sagebrush shrubland have been quantitatively sampled during the course of conducting baseline vegetation studies. Sampling has been conducted in five mining areas and four reference areas. The J-16/28 mining areas were sampled as a single unit in 1981 and as separate units in 1982. Most stands were sampled in more than one year. The J-7, N-7/8 and N-14 sagebrush shrubland reference areas have been sampled consistently at or near the spring and fall growth peaks since the fall of 1979. The sagebrush shrubland vegetation was sampled as a single stratum. The distribution of this plant community on and adjacent to the Black Mesa leasehold is shown on Drawing 85320, Sheets 1 through 6.

The sampling results are summarized in Table 9. The table presents total vegetation cover (%), total plant density (No./m^2), Shannon-Weiner species diversity indices (H') and total dry production (g/m^2) by location and date for all the samples that have been conducted. Detailed vegetation survey summary reports showing the individual species contribution to the values summarized in the table and additional sample statistics may be found in the appropriate document referenced.

Total vegetation cover ranged from 12.82 percent at the J-7 reference area in the spring of 1982 to 33.13 percent at the J-1/N-6 mining area in 1980. The overall mean vegetation cover, which includes stand to stand variation, sample variation and variation due to temporal cover fluctuations was 22.28 ± 1.5 percent (95% confidence limit at t 0.05(2), 37 = 2.026). As the name implies, big sagebrush dominates this community in terms of cover. Greene's rabbitbrush (Chrysothamnus greenei) is a codominate sub-shrub at lower elevations such as at the J-7 mining and reference area. The rabbitbrush all but disappears at higher elevation stands. Blue grama is the most important ground layer species.

TABLE 9

Summary of the Major Vegetation Parameters

From Samples Conducted in the Sagebrush Shrubland

Sample Location	Sample Date	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)	Survey Summary Report Reference
N-14 Mining Area	7-80	-	-	-	264.2	Attachment 1
	9-80	28.31	56.84	0.46	339.0	Attachment 1
	6-81	21.81	64.04	0.48	-	Az. Div., PCC 1982
J-7 Mining Area	5-80	23.30	212.88	0.71	-	Attachment 1
	7-80	-	-	-	105.1	Attachment 1
	9-80	-	-	-	113.9	Attachment 1
	5-81	19.34	71.35	0.62	-	Az. Div., PCC 1982
J-1/N-6 Mining Area	7-80	33.13	38.84	0.66	153.8	Attachment 1
	9-80	-	-	-	290.7	Attachment 1
	5-81	16.78	45.32	0.49	-	Az. Div., PCC 1982
J-16/28 Mining Area	5-81	17.93	67.96	0.48	-	Az. Div., PCC 1982
	9-81	18.58	81.55	0.57	182.7	Az. Div., PCC 1982
J-16 Mining Area	5-82	17.40	72.10	0.37	64.4	Az. Div., PCC 1983
J-28 Mining Area	5-82	20.86	67.44	0.33	65.2	Az. Div., PCC 1983
J-19/23 Mining Area	9-82	24.27	57.30	0.48	47.8	Attachment 1
	5-83	24.61	35.39	0.50	77.5	Attachment 1

TABLE 9 (Cont.)

Sample Location	Sample Date	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)	Survey Summary Report Reference
N-7/8 Reference Area	7-80	-	-	-	226.4	Attachment 1
	9-80	27.78	38.75	0.77	145.7	Attachment 1
	5-81	23.70	31.52	0.56	-	Az. Div., PCC 1982
	5-82	15.76	42.25	0.57	104.6	Az. Div., PCC 1983
	9-82	23.06	27.38	0.61	71.3	Az. Div., PCC 1983
	5-83	21.11	39.05	0.71	-	Az. Div., PCC 1984
	9-83	23.38	31.62	0.74	-	Az. Div., PCC 1984
	5-84	20.48	29.07	0.50	67.3	Az. Div., PCC 1985
	10-84	24.79	33.12	0.65	37.2	Az. Div., PCC 1985
N-14 Reference Area	7-80	-	-	-	435.1	Attachment 1
	9-80	32.35	72.18	0.35	348.3	Attachment 1
	5-81	19.50	62.30	0.35	-	Az. Div., PCC 1982
	5-82	21.12	98.32	0.29	85.6	Az. Div., PCC 1983
	9-82	25.61	67.28	0.35	59.7	Az. Div., PCC 1983
	5-83	25.53	49.00	0.54	61.4	Az. Div., PCC 1984
	9-83	23.95	89.95	0.40	-	Az. Div., PCC 1984

TABLE 9 (Cont.)

Sample Location	Sample Date	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)	Survey Summary Report Reference
N-14 Reference Area	5-84	19.11	80.21	0.33	55. 1	Az. Div., PCC 1985
	10-84	28.29	67.81	0.36	88.5	Az. Div., PCC 1985
J-7 Reference Area	5-80	17.98	183.69	0.97	-	Attachment 1
	7-80	-	-	-	180.5	Attachment 1
	9-80	-	-	-	111.8	Attachment 1
	5-81	17.46	108.54	0.87	-	Az. Div., PCC 1982
	5-82	12.82	310.72	0.62	82.8	Az. Div., PCC 1983
	9-82	20.45	82.84	0.73	69.8	Az. Div., PCC 1983
	5-83	25.40	280.32	0.76	-	Az. Div., PCC 1984
	9-83	22.01	69.99	0.56	-	Az. Div., PCC 1984
	5-84	15.09	98.70	0.55	59.7	Az. Div., PCC 1985
	10-84	21.99	64.16	0.59	69.4	Az. Div., PCC 1985
J-1/N-6 Reference Area	7-80	29.96	24.96	0.48	162.2	Attachment 1
	9-80	-	-	-	418.9	Attachment 1
	5-81	21.69	45.86	0.59	-	Az. Div., PCC 1982

Total plant density ranged from 24.96 individuals/m^2 at the J-1/N-6 reference area to 310.72 individuals/m^2 at the J-7 reference area in the spring of 1982. The wide range in plant densities observed is attributable to the contribution of spring annuals, primarily six-weeks fescue (Vulpia octoflora), pursh plantain (Plantago purshii) and Russian thistle (Salsola iberica).

Shannon-Weiner diversity indices (H') ranged from 0.33 at the J-28 mining area in 1982 and at the N-14 reference area in the spring of 1984 to 0.97 at the J-7 reference area in 1980. Diversity indices and total species counts tended to increase as the dominance of sagebrush decreased (Attachment 1; Arizona Division, Peabody Coal Company, 1982, 1983, 1984 and 1985). Subdominate species which consistantly occurred in most samples included blue grama, squirretail (Sitanion hystrix), Indian ricegrass, white aster (Leucelene ericoides), globemallow and prickly phlox (Phlox longiflora).

Total dry production ranged between 435.1 g/m^2 at the N-14 reference area and 105.1 g/m^2 at the J-7 mining area in the samples conducted in 1980. These figures represent total above ground biomass at the time of sampling. Stems and trunks of sagebrush and other shrubs are included. In 1981 and thereafter, only browsable portions of the shrubs or current years growth (if determinable) was sampled from shrub vegetation (Attachment 2). Consequently, a substantial drop in production figures was observed. Total dry production ranged between 37.19 g/m^2 at the N-7/8 reference area in the fall of 1984 to 182.79 in the J-16/28 mining area in 1981 after the change in sampling interpretation was made. Regardless of the sampling method used, big sagebrush, Greene's rabbitbrush or blue grama contributed substantial biomass to total production. For example, big sagebrush contributed almost 97 percent of the total fresh production in the fall and over 98% the following spring to total production in the J-19/23 mining areas (Attachment 1).

Sample adequacy parameters for the cover and production samples in the sagebrush shrubland are presented in Tables 10 and 11 respectively. In most cases, both adequate cover and production samples were collected. This is indicative of the uniformity of the sagebrush shrubland community on the Black Mesa leasehold.

The sagebrush shrubland community falls within the Great Basin Desertscrub Biotic Community described by Turner (1982). Big sagebrush dominates the vegetation to the virtual exclusion of other shrubs and herbaceous understory. At intermediate to higher elevation sites on the leasehold, the composition and structure of the sagebrush shrubland

TABLE 10

Sample Adequacy Parameters for Cover

Samples From the Sagebrush Shrubland

Sample	Sample	Total Cover (%)			
Location	Date	$\bar{x}$	s	N	Nmin
N-14 Mining Area	9-80	28.31	3.870	7	0.7
	6-81	21.81	4.460	5	7.0
J-7 Mining Area	5-80	23.30	12.300	9	19.6
	5-81	19.34	4.300	10	8.0
J-1/N-6 Mining Area	7-80	33.13	4.128	7	0.5
	5-81	16.78	2.900	10	5.0
J-16/28 Mining Area	5-81	17.93	4.640	10	11.0
	9-81	18.58	1.748	4	1.0
J-16 Mining Area	5-82	17.40	4.290	11	10.0
J-28 Mining Area	5-82	20.86	3.390	5	4.0
J-19/23 Mining Area	9-82	24.27	5.030	7	7.0
	5-83	24.61	3.410	6	3.1
N-7/8 Reference Area	9-80	27.78	11.800	7	6.4
	5-81	23.70	5.850	5	10.0
	5-82	15.76	3.570	9	8.0
	9-82	23.06	5.090	9	8.0
	5-83	21.11	1.021	4	0.4
	9-83	23.38	4.370	8	5.7
	5-84	20.48	4.407	9	7.6
	10-84	24.79	5.150	7	7.1
N-14 Reference Area	9-80	32.35	3.450	7	0.4
	5-81	19.50	1.720	6	1.0
	5-82	21.12	3.750	5	5.0
	9-82	25.61	3.620	3	3.0
	5-83	25.53	3.300	3	2.7
	9-83	23.95	2.790	4	2.2
	5-84	19.11	0.970	3	0.4
	10-84	28.29	0.370	3	0.1

TABLE 10 (Cont.)

Sample Location	Sample Date	Total Cover (%) $\bar{x}$	s	N	Nmin
J-7 Reference Area	5-80	17.98	8.878	17	8.6
	5-81	17.46	4.450	10	11.0
	5-82	12.82	2.520	7	6.0
	9-82	20.45	2.160	5	2.0
	5-83	25.40	3.940	5	4.0
	9-83	22.01	3.190	6	3.4
	5-84	15.09	1.977	4	2.8
	10-84	21.99	1.146	5	0.5
J-1/N-6 Reference Area	7-80	29.96	6.589	7	1.7
	5-81	21.69	6.510	10	15.0

TABLE 11

Sample Adequacy Parameters for Production Samples from the Sagebrush Shrubland[1]

Sample Location	Sample Date	N	Nc	Production (g/m^2) $\bar{Y}$fresh	s_Y^2	r^2	d
N-14 Mining Area	7-80			None Calculated			
	9-80			None Calculated			
J-7 Mining Area	7-80			None Calculated			
	9-80			None Calculated			
J-1/N-6 Mining Area	7-80			None Calculated			
	9-80			None Calculated			
J-16/28 Mining Area	9-81	69	-	297.6	45699.8	.97	.11
J-16 Mining Area	5-82	18	6	144.7	253.3	.96	.03
J-28 Mining Area	5-82	18	6	138.1	1049.9	.99	.07
J-19/23 Mining Area	9-82	15	5	77.6	267.7	.98	.07
	5-83	28	7	176.1	2385.0	.97	.07
N-7/8 Reference Area	7-80			None Calculated			
	9-80			None Calculated			
	5-82	18	6	259.0	4689.4	.97	.08
	9-82	15	5	142.7	2705.6	.99	.11
	5-84	30	6	133.6	1511.6	.99	.06
	10-84	30	6	72.5	229.7	.96	.05
N-14 Reference Area	7-80			None Calculated			
	9-80			None Calculated			
	5-82	18	5	199.1	1149.8	.98	.05
	9-82	18	6	118.9	593.8	.95	.06
	5-83	21	5	136.0	650.4	.99	.05
	5-84	30	5	106.0	449.8	.77	.05
	10-84	25	5	139.3	555.5	.95	.04
J-7 Reference Area	7-80			None Calculated			
	9-80			None Calculated			
	5-82	18	6	179.8	560.8	.96	.04
	9-82	18	6	134.0	364.9	.95	.04
	5-84	20	4	104.3	407.5	.99	.05

TABLE 11 (Cont.)

Sample Location	Sample Date	N	Nc	Production (g/m^2) $\bar{Y}$fresh	sY^2	r^2	d
J-7 Reference Area	10-84	25	5	117.7	2135.3	.98	.10
J-1/N-6 Reference Area	7-80			None Calculated			
	9-80			None Calculated			

[1]
N = Number of observations (plots) in the sample

Nc = Number of plots clipped

$\bar{Y}$fresh = Calculated mean fresh weight production

sY^2 = Sample variance

r^2 = Coefficient of determination

d = Amount of reduction detected (d = 0.1 to be within 10% of the true population mean with 80% confidence).

fits this observation (Figure 5). At lower elevations and shallower sites (Figure 6), big sagebrush shares dominance with rabbitbrush and, to a lesser extent, snakeweed or shadscale (Atriplex confertifolia).

Big sagebrush-dominated vegetation covers approximately 170.7 million acres in the western United States. West (1979) has determined that approximately 4.9 million acres of this community occurs in Arizona. In terms of areal extent, it is the second most dominant vegetation type on the Black Mesa leasehold, occupying approximately 30-35 percent of the undisturbed land area (Drawing 85320, Sheets 1 through 6). On the leasehold, sagebrush-dominated areas occur up to elevations of 7000 feet.

Total cover figures derived from samples on the leasehold are comparable to values found in other southern extensions of the Great Basin Desertscrub studied in Northern Arizona. For example, at Boysag Point on the Kaibab Plateau, big sagebrush comprised approximately 40% of a total cover of 22.7 percent (Schmutz et al., 1967). On another site at Fishtail Mesa, twelve miles to the northeast of Boysag Point, big sagebrush comprised 88% of a total cover of 27.7 percent (Jameson et al. 1962).

The sagebrush shrubland is situated on the leasehold in habitats that are characterized by gradual slopes and deep, loamy soils.. The soils are typically moderately eroded. The community occurs in the valley fill areas between ridges dominated by pinyon-juniper woodland at the intermediate and higher elevations. At lower elevations it occurs on rounded hills and dissected plains and rolling hills above and contacting major drainages.

Other Shrublands. Three additional shrubland communities have been recognized during the course of conducting the baseline studies. These are greasewood shrubland, saltbush shrubland and tamarix riparian strand. Quantitative samples were conducted in the greasewood and saltbush shrublands. Qualitative samples, consisting of general reconnaissance and specific traverses noting species composition were conducted in the tamarix riparian strand. The distribution of these plant communities on and adjacent to the Black Mesa leasehold is shown on Drawing 85320, Sheets 1 through 6.

The results of samples conducted in the greasewood and saltbush shrublands are summarized in Table 12. The table presents total vegetation cover (%), total plant density (No./m^2), Shannon-Weiner species diversity indices (H') and total dry production (g/m^2) by location and date for the samples that were conducted. Detailed vegetation survey summary reports

FIGURE 5

Sagebrush Shrubland (J-16 Mining Area, Elevation 6750')

FIGURE 6

Sagebrush Shrubland (J-7 Mining Area, Elevation 6400')

TABLE 12

Summary of the Major Vegetation Parameters from Samples

Conducted in the Greasewood and Saltbush Shrublands

Sample Location	Sample Date	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)	Survey Summary Report Reference
GREASEWOOD SHRUBLAND						
Moenkopi Wash	9-80	39.50	8.44	0.57	-	Attachment 1
J-16/28 Mining Area	5-82	32.93	168.81	0.41	87.82	Az. Div., PCC 1983
SALTBUSH SHRUBLAND						
J-16/28 Mining Area	5-81	16.74	47.00	0.88	-	Az. Div., PCC 1982
	5-82	24.14	224.29	0.65	61.55	Az. Div., PCC 1983
J-19 Reference Area	5-82	25.01	64.21	0.71	73.13	Az. Div., PCC 1983
	9-82	30.59	108.67	0.74	119.89	Az. Div., PCC 1983
J-19/23 Mining Area	9-82	46.58	50.13	0.46	90.85	Attachment 1
	5-83	20.33	216.50	0.81	39.14	Attachment 1

showing the individual species contribution to the values summarized in the table and additional sample statistics and discussion may be found in the appropriate document referenced.

Total vegetation cover ranged between 32.93 and 39.50 percent in the two greasewood shrubland stands sampled (Table 12). Greasewood (Sarcobatus vermiculatus) contributed 77.38 and 53.92 percent to total cover in the respective samples. The remainder of the cover consisted of understory grasses and forbs. The wide range noted in total plant density may be attributed to the contribution of annuals. At the J-16/28 mining area, summer cypress (Kochia scoparia) and stickseed (Lappula redowski) contributed 80.9 percent of the total plant density. These annuals were only nominally important in the Moenkopi Wash location, primarily due to the timing of the sample.

Total vegetation cover ranged between 16.74 and 46.58 percent in the saltbush shrubland stands (Table 12). The overall mean vegetation cover, which includes all vegetal, temporal and observer variation was 27.23 ± 11.09 percent (95% confidence limit at t 0.05 (2), 5 = 2.571). Fourwing saltbush (Atriplex canescens) dominates these stands. For example, this species contributed 57.46 percent of the total cover at the J-16/28 mining area in the spring of 1982 and 74.6 percent of the total cover at the J-19/23 mining area in the fall of 1982. Total plant densities ranged widely in the samples according to the developmental status of the annuals in relation to sample timing.

Species diversity indices tended to be slightly greater in the saltbush shrubland than in the greasewood (Table 12). Both tend to parallel those observed in the sagebrush shrubland. They were consistently less than those observed in the pinyon-juniper woodland understory.

Production sample results also tended to parallel those observed in the sagebrush shrubland (Table 12). As would be expected, greasewood and fourwing saltbush made up the bulk of the biomass sampled.

Sample adequacy parameters for cover and production samples conducted in the saltbush and greasewood shrublands are presented in Tables 13 and 14 respectively.

The tamarix riparian strand vegetation occurs intermittently along major drainageways as linear "stringers" of vegetation. These stringers range from 10 to 20 feet in width and

TABLE 13

Sample Adequacy Parameters for Cover Samples

From the Greasewood and Saltbush Shrublands

Sample Location	Sample Date	Total Cover (%) $\bar{x}$	s	N	Nmin.
GREASEWOOD SHRUBLAND:					
Moenkopi Wash	9-80	39.50	9.40	3	3.9
J-16/28 Mining Area	5-82	32.93	4.14	3	2.6
SALTBUSH SHRUBLAND:					
J-16/28 Mining Area	5-81	16.74	Not Calculated		
	5-82	24.14	2.61	3	1.9
J-19 Reference Area	5-82	25.01	4.14	5	4.5
	9-82	30.59	2.54	3	1.1
J-19/23 Mining Area	9-82	46.58	1.42	3	0.1
	5-83	20.33	8.51	4	28.7

TABLE 14

Sample Adequacy Parameters for Production

Samples from the Greasewood and Saltbush Shrublands[1]

Sample Location	Sample Date	N	Nc	$\bar{Y}$fresh	sY^2	r^2	d
GREASEWOOD SHRUBLAND:							
J-16/28 Mining Area	5-82	15	5	397.3	9564.2	0.81	0.08
SALTBUSH SHRUBLAND:							
J-16/28 Mining Area	5-82	15	5	211.9	3579.6	0.98	0.09
J-29 Reference Area	5-82	18	6	238.9	4640.9	0.99	0.09
	9-82	15	5	253.4	2577.2	0.87	0.07
J-19/23 Mining Area	9-82	15	5	194.1	1621.7	0.76	0.07
	5-83	20	4	111.1	62.7	0.97	0.02

[1] N = Number of observations (plots) in the samples

Nc = Number of plots clipped

$\bar{Y}$fresh = Calculated mean fresh weight production

sY^2 = Sample variance

r^2 = Coefficient of determination

d = Amount of reduction detected (d = 0.1 to be within 10% of the true population mean with 80% confidence).

extend from a few yards to over a half a mile in length. The community is restricted to the immediate bottoms of the washes, typically occupying agrading portions of the channel such as sandbars. It has not been found growing on the terraces above the channels.The vegetation is completely dominated by tamarix (saltcedar: Tamarix pentandra). Small amounts of greasewood, fourwing saltbush or coyote willow (Salix exigua) may be associated with the tamarix on the most stable sites. By nature of the growth form the tamarix manifests in these washes, it does not provide a great amount of cover. It can develop quite dense stands of single stemmed individuals. Stands can be completely eradicated at any given location depending upon flow conditions in the channels. New stands will develop along the channel after the flow season is over.

The herbaceous understory is composed primarily of cheatgrass (Bromus tectorum), European alkali grass (Puccinellia distans), stickseed and desert seepweed (Sauda torreyana). The ground cover can be quite variable depending on the stability of the sites.

The saltbush and greasewood shrublands ean be placed as series in the broader Great Basin Desertscrub described by Turner (1982). The appearance of fourwing saltbush or greasewood as the dominate (or other members of the Chenopodiaceae or Compositae) in the more widespread sagebrush series is apparently dependent upon edaphic conditions rather than broader climatic conditions (Turner 1982). This is the case on the Black Mesa leasehold. The communities are situated along the margins of terraces associated with the primary, secondary and occasionally tertiary drainages. The terraces are normally 5 to 20 feet above the drainage channel floodplains where alluvial soil materials may be as much as 30 feet deep. Soil materials may or may not be saline.

As the names imply, fourwing saltbush (Figure 7) and greasewood (Figure 8) dominate the respective communities, with sparse to dense understories of annual forbs and grasses present. An intergrade can occur in the relative dominance of the two shrubs, or with big sagebrush. The three may be equally represented in some stands. The primary vegetation contact with these communities is sagebrush shrubland.

The tamarix riparian strand community which occurs on the Black Mesa leasehold may be best described as a component in the broader Plains and Great Basin Riparian Wetland Biotic Community (Minckley and Brown 1982). It has been characterized as a disclimax riparian strand populated almost exclusively by tamarix (Figure 9). Coyote willow is often associated with it. Stands of varying age are not uncommon due to the flood successional

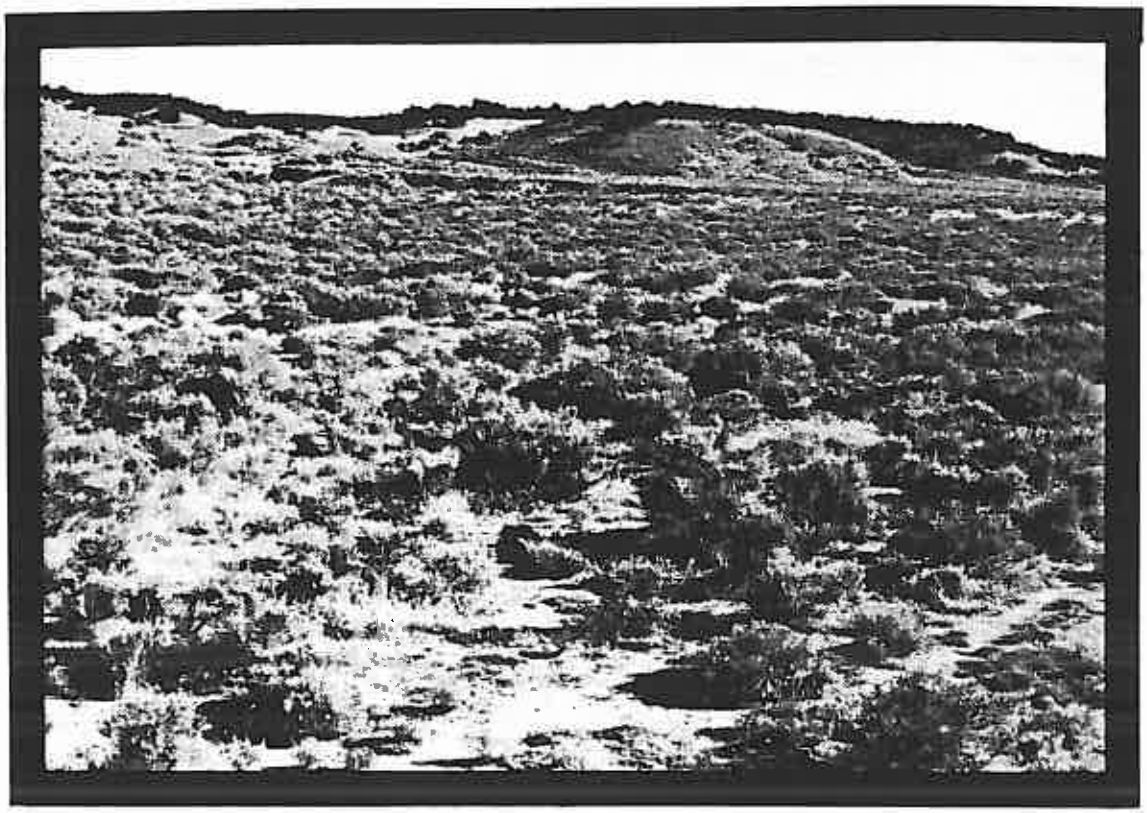

FIGURE 7

Saltbush Shrubland (Dinnebito Wash)

FIGURE 8

Greasewood Shrubland (Moenkopi Wash)

FIGURE 9

Tamarix Riparian Strand (Moenkopi Wash)

nature of the community.

The greasewood, saltbush and tamarix riparian strand vegetation comprise less than three percent of the areal surface of the leasehold.

Reclaimed Grasslands. Reclaimed units of grassland in seven mining areas have been sampled intermittently since 1981. Several units have been sampled seasonally for four years. The reclaimed grassland is obviously not a natural vegetation community. However, a significant amount of both post- and pre-law reclaimed grassland exists; enough so, that stratification as a vegetation map unit is warranted. Well over 3000 acres of the grassland has been reclaimed and much of it has developed sufficiently to sample and describe. The distribution of this community on the Black Mesa leasehold is shown on Drawing 85320, Sheets 1 through 6.

The sampling results are summarized in Table 15. The table presents total vegetation cover (%), total plant density (No./m^2), Shannon-Weiner diversity indices (H') and total dry production (g/m^2). All parameters shown represent pooled (by sub-unit) and averaged (by season through years) values, except the diversity indices. Ranges of diversity indices are presented by season. Detailed vegetation survey summary reports showing the individual samples, and individual species contribution to those samples summarized in the table may be found in Arizona Division, Peabody Coal Company (1982; 1983; 1984; 1985).

The reclaimed grassland is an artificial plant community consisting of a mixture of cool season bunch and sod-forming grasses and at some sites, four-wing saltbush (Figure 10). The foreground and middle-ground constitute the reclaimed area in the figure. Crested wheatgrass dominates most stands in terms of cover and biomass, although other wheatgrasses, Russian wildrye (Elymus junceus) and smooth brome (Bromus inermis) are well represented. Forbs consist primarily of Russian thistle, summer cypress, alfalfa (Medicago sativa) and yellow sweetclover (Melilotus officinalus). Occasionally, warm season grasses are encountered in the samples.

Samples are conducted in the reclaimed grasslands to evaluate the progress and results of reclamation practices. Considerable discussion of these samples, including sample adequacy, is made in the annual resources reports previously mentioned. For this reason, further discussion and presentation of results will not be made. The reader is encouraged to consult the appropriate document for further reference.

TABLE 15

Summary of the Major Vegetation Parameters

From Samples Conducted in the Reclaimed Grassland

Sample Location	Season	Total Cover (%)	Total Density (No./m^2)	Species Diversity (H')	Total Dry Production (g/m^2)
J-7 Mining Area	Spring	16.88	260.1	0.40 - 0.86	54.0
	Fall	19.93	67.1	0.28 - 0.81	56.9
J-27 Mining Area	Spring	14.13	270.6	0.55 - 0.85	31.5
	Fall	18.43	105.1	0.55 - 0.74	38.8
J-3 Mining Area	Spring	10.10	131.9	0.41 - 0.76	35.4
	Fall	9.15	36.6	0.44 - 0.77	27.2
J-1/N-6 Mining Area	Spring	20.57	124.4	0.17 - 0.65	65.2
	Fall	23.05	60.8	0.20 - 0.74	46.8
N-1 Mining Area	Spring	10.88	104.8	0.38 - 0.56	49.2
	Fall	17.40	63.4	0.36 - 0.63	29.3
N-2 Mining Area	Spring	14.88	115.8	0.39 - 0.74	38.1
	Fall	15.08	42.0	0.41 - 0.71	28.3
N-7/8 Mining Area	Spring	22.20	291.0	0.63	59.6
	Fall	32.32	39.7	0.74	70.6

FIGURE 10

Reclaimed Grassland (J-7 Mining Area)

Aquatic Resources. Aquatic resources occur at many permanent and semi-permanent impoundments constructed on the leasehold. These impoundments include freshwater ponds, sediment ponds and internally draining ponds in reclaimed areas. The age, size and water stability within these impoundments dictates the degree of development of aquatic vegetation. Qualitative studies of the aquatic resources in impoundments have been made at several generic sites.

The J-7 pond is used for sediment control and as a back-up water supply for the coal slurry pipeline at the Black Mesa Mine. It is the largest and one of the oldest impoundments on the leasehold (Drawing 85320, Sheet 1). Aquatic macrophyte vegetation includes common poolmat (Zanichellia palustric) and pond weeds (Potamogeton filiformis and P. pectinatus). The former species occurs in the shallow areas and is prominant in the spring. The latter species prefer deeper zones and reach their greatest development in the summer and fall. Tamarix, coyote willow, bulrush (Scirpus acutus) and cattail (Typha sp.) occur along the margins of the pond (Figure 11).

The freshwater pond located south of the J-1/N-6 mining area is dominated by holly-leafed water numph (Najas marina) and pondweed. Blue green algae are also present. The shoreline contains tamarix and rabbitbrush (Chrysothamnus nauseosus).

Three small, internally draining impoundments in the pre-law J-3 reclaimed mining area contained common poolmat and pondweeds. Tamarix, coyote willow, bulrush and cattails occur along the pond margins (Figure 12).

Qualitative assessment of the aquatic vegetation in the smaller sediment ponds revealed that, in most cases, the only aquatic macrophyte present was a blue-green alga (Chara sp.). The aquatic pondweeds and poolmat were not found, due to the small size of the ponds and the extreme fluctuations in water levels. However, because water fowl infrequently visit these ponds, aquatic vegetation could occur if water levels remained stable for extended periods of time. Fluctuating water levels and heavy livestock use contribute to the complete lack of riparian or shoreline vegetation at the ponds.

Disturbed Lands. Disturbed lands are considered a miscellaneous, non-vegetal mapping unit for the purpose of describing the vegetation resources on the Black Mesa leasehold.

FIGURE 11

Aquatic Resources (J-7 Pond)

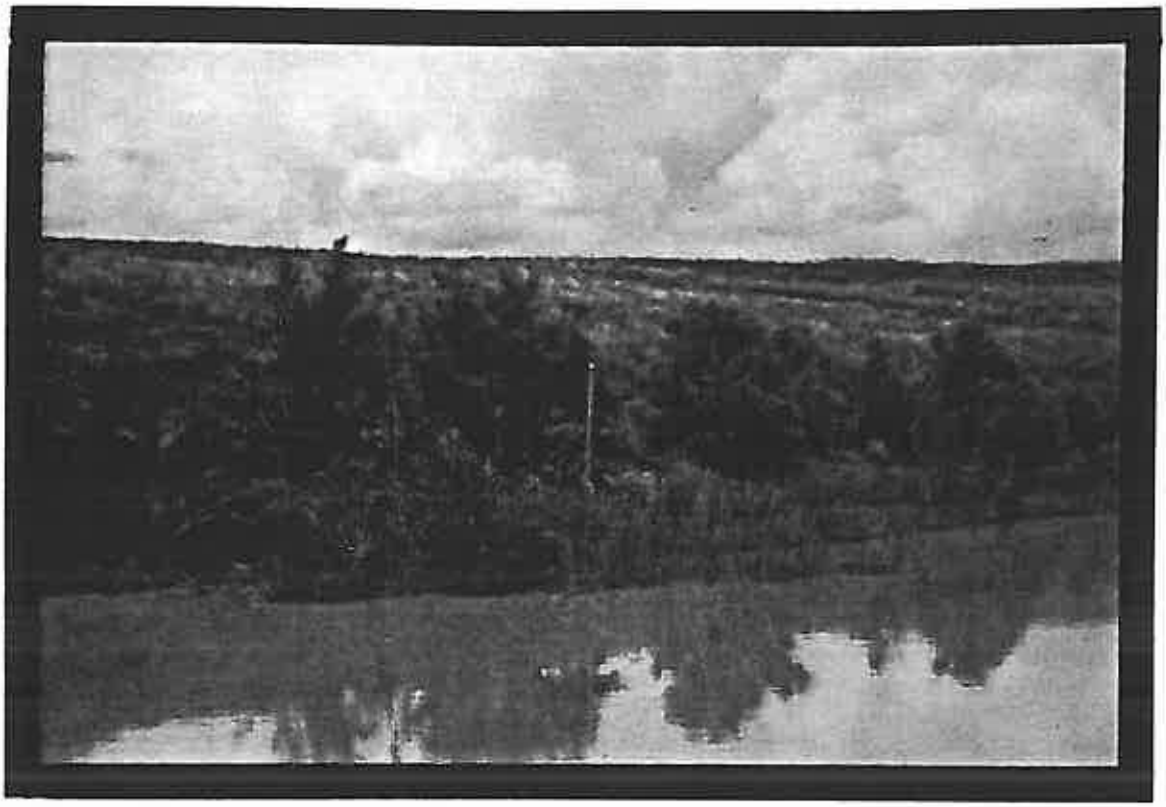

FIGURE 12

Aquatic Resources (J-3 Reclaimed Mining Area)

Classified under this heading are: (1) mining related disturbances such as pits, spoil banks, areas stripped of topsoil material, topsoil stockpiles, graded spoils and developing revegetated reclamation; (2) facilities such as coal processing equipment, shops and mine support buildings; and (3) coal transportation facilities and roads. The extent of this mapping unit is shown on Drawing 85320, Sheets 1 through 6.

Plant Communities of Adjacent Areas. The plant species observed adjacent to the Black Mesa leasehold are listed in Table 1. At the higher elevations near the Black Mesa leasehold to the northeast occurs a mixed conifer woodland dominated by Colorado pinyon pine, ponderosa pine (Pinus ponderosa), and Douglas-fir (Pseudotsuga mensiezii). The mesa rises to an elevation of 8110 feet here before dropping abruptly to the plain below near Kayenta. The mesa tilts downward to the southwest and is dissected by a large number of wash systems, which drain the mesa. At these high elevations the washes have formed deep canyons, some with vertical drops of hundreds of feet. The areas between the wash systems are relatively level. The vegetation on the level areas between drainage areas is dominated by Colorado pinyon and ponderesa pine. The latter species sometimes dominates. Associated species are Utah juniper and gambel oak. A number of these areas have been cleared and planted with wheat and rye grasses.

The vegetation of the steep canyon slopes is dominated by Douglas-fir on the northern exposure and ponderosa and Colorado pinyon pines on the southern exposure (Figure 13). A common ground layer plant at the top of the slopes is Oregon grape (Mahonia repens). On the steep north-facing slopes, thickets of shrubs such as Gambels oak, rock spirea (Holodiscus dumosus), little-leaf mountain mahogany, (Cercocarpus intricatus), and wax currant (Ribes cereum) occur. In the wooded canyon bottoms occur a few, small, dense stands of quaking aspen (Populus tremuloides). Other tree species scattered throughout these wooded areas include rocky mountain juniper (Juniperus scopularum), box elder (Acer negundo), and chokecherry (Prunus virginiana). Common shrubs include wax currant, snowberry and red oiser dogwood (Cornus stolonifera). Ground plants in shaded areas include Geranium caespitosum, Thalictrum fendleri, and kittentails (Besseya arizonica). Occurring on rocky, open areas are Arenaria eastwoodiae and valerian (Valeriana acutiloba).

As the canyon bottoms flatten out downstream, dense stands of big sagebrush dominate these sandy bottom areas. Broomrape (Orobanche multiflorus), a parasite on sagebrush, was abundant in some of these stands. Along the wash bottom, dense stands of Ranunculus

FIGURE 13

Mixed Conifer Woodland

cymbalaria, a stoloniferous perennial, occur.

At the lower elevations off the Peabody lease area to the south and southwest occur pinyon-juniper, sagebrush, greasewood, and grassland community types. A large number of sagebrush areas south of the vegetation study area have been chained to remove the sagebrush. These areas were reseeded with wheat and rye grasses.

Important Species

For the purpose of this discussion, important plant species are defined as those which: (1) are threatened or endangered; (2) are valuable for commercial or cultural reasons; (3) affect the well-being of some important species within criteria (1) or (2); or (4) are critical to the structure and function of the ecological system or land use objectives.

Currently, 15 federally-listed threatened or endangered plant species have distributions encompassing Arizona (USDI, Fish and Wildlife Service, 1992). No federally-listed threatened or endangered plant species have been observed on the Black Mesa leasehold. None of these species have known geographic ranges that include the leasehold.

The Navajo sedge (Carex specuicola) was listed as a threatened species by the U.S. Fish and Wildlife Service on July 7, 1985 (50 FR 19370). The Resources Committee of the Navajo Nation Council, by Resolution RCF-014-91 which approved the Endangered Species List for the Navajo Nation, placed the Navajo sedge in Group 3 of their list. Group 3 of the Navajo Nation list identifies species or subspecies which are likely to become endangered species within the foreseeable future throughout all or a significant portion of their range on the Navajo Nation. Representatives of the Navajo Natural Heritage Program (NNHP) have expressed concern that the Navajo sedge may have the potential to occur within or adjacent to the permit area. The presence of Navajo sedge within the permit area was determined to be "unlikely" by the U.S. Fish and Wildlife Service (Sue Rutman, oral communication, January 12, 1989. In Final Environmental Impact Statement, Proposed Permit Application, Black Mesa-Kayenta Mine, Navajo and Hopi Indian Reservations, Arizona. OSM-EIS-25, USDI, Office of Surface Mining Reclamation and Enforcement, 1990).

Navajo sedge was originally known only from a restricted location near Inscription House, Coconino County, Arizona (Kearney and Peebles, 1960; House, 1987). It is thought to be

endemic to the Navajo Nation (House, 1987). Additional survey work has revealed populations of Navajo sedge in several localities in northeastern Arizona (Coconino and Navajo Counties) and in southeastern Utah (Bill Hevron, NNHP, pers. comm., March 24, 1993).

Navajo sedge is a riparian plant occurring in hanging gardens within the Great Basin Conifer Woodland (House, 1987). The seep/spring habitats are on Navajo Sandstone Formation bedrock at an elevation of 5710 to 5980 feet above mean sea level (House, 1987), although recent work has revealed populations near springs and seeps associated with outcrops of the Wingate Formation (Bill Hevron, NNHP, pers. comm., March 24, 1993). The species grows in a variety of situations on Navajo Sandstone, from sheer cliff faces to alcoves.

Surface mining and reclamation activities will not affect the Navajo sedge or its designated habitat. This species, or habitat that would support a population, was not found during the coarse of conducting baseline studies in support of the permit application, nor does the geology within the permit area suggest the potential for its occurrence. As previously stated, the U.S. Fish and Wildlife Service has determined that the occurrence of this species in the permit area is "unlikely". Although this species occurs within six miles of the permit boundary, no ground water N-aquifer impacts will affect the seep spring situations where this species grows. This is because, to the north and northwest, PWCC wellfield pumpage drawdowns are not occurring beyond the confined/unconfined aquifer boundary (Brown and Eychaner 1988). Also, it is likely that the majority of the seeps where this species grows are above the saturated (baseflow) portion of the washes. To the southwest, both Brown and Eychaner (1988) and Papadopulos et al. (1993) concluded that any drawdowns due to PWCC ground withdrawals are negligible at the confined/unconfined N-aquifer boundary along Moenkopi Wash.

Potential impacts to the Navajo sedge associated with N-aquifer withdrawals associated only with the Kayenta Mine are extremely remote. Kayenta Mine usage of water withdrawn from the N-aquifer represents approximately 9.5 percent of total usage. Kayenta Mine usage consists of sanitary and potable uses, dust suppression, public supply, construction, wash water, and other miscellaneous uses. Based upon historical usage information, annual usage at Kayenta Mine ranges between approximately 239.2 acre-feet (1985 total pumpage 2517.9 ac-ft.) and 450.7 acre-feet (1982 total pumpage 4744.2 ac-ft.). The range is based on water statistics compiled from 1972 through 1993.

The U.S. Forest Service classification system categorizes forested lands into either commercial or non-commercial groups. Pinyon-juniper woodlands are placed in the non-commercial category. Johnson (1975) indicated that this puts the woodlands into a general "no value" bracket. LeBaron (1968) suggested that commercial exploitation of the dominant trees is feasible to some extent. Colorado pinyon could be utilized for Christmas trees, firewood and charcoal, and Utah juniper could be used for firewood, charcoal and fenceposts. On the Black Mesa leasehold, both trees are utilized for firewood and fenceposts. Pinyon nuts are harvested in years when crops are produced. Attachment 3 presents ethnobotanical information on many of the plants which occur on the Black Mesa. The primary plant list was compiled by the Navajo Health Authority for use by Peabody. A supplemental list, compiled by Peabody, presents additional species having probable ethnobotanical significance (Kearney and Peebles, 1960). From a cultural standpoint, these species may be considered important, although they are not commercially exploited. The list indicates that many plants are utilized for one purpose or another. Primary uses include medicines, dyes, food, and ceremonial and construction materials.

Table 16 summarizes range and wildlife habitat characteristics of a number of plants which occur on the leasehold. The table includes all species which had an importance percentage of one percent or greater in any vegetation sample, plus additional species which are considered valuable as range plants. In some cases, characteristics are taken from several sources. The tabled values represent the average or consensus interpretation. These are relative factors, which vary with livestock and wildlife species, seasonality, climatic and edaphic conditions and locality.

TABLE 16

Range and Habitat Characteristics of Species Occurring on the Black Mesa Leasehold[1,2]

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
	N = Native I = Introduced	B = Bunch S = Sod E = Evergreen D = Deciduous	C = Cool W = Warm	D = Decreaser I = Increaser IN = Invader		G = Good F = Fair P = Poor		H = High M = Moderate L = Low
TREE:								
Juniperus osteosperma*	N	E	C	I	P	G	G	M
Pinus edulis*	N	E	C	I	P	G	G	M
Quercus gambelii*	N	D	W	I	F	G	G	M
Tamarix pentandra*	I	D	-	IN	P	G	-	M
SHRUBS:								
Artemisia frigida	N	E,D	C	I	P,F,G	P	P,F,G	-
A. tridentata*	N	E,D	W	I,IN	P,F	G	-	L,M
Atriplex canescens*	N	E	C,W	D	G	G	G	M

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
SHRUBS (Cont.):								
A. confertifolia*	N	E	W	D,I	F	F	F	L
Chrysothamnos greenei*	N	D	C	I,IN	P	-	-	L
C. nauseosus*	N	D	C	I,IN	P	P,F	P,F	M
Cowania mexicana*	N	E	C	I	F	G	F	M
Ephedra viridis*	N	D	C	I	F	P,F	F	M
Eurotia lanata	N	E	C	D	G	F	G	-
Fendlera rupicola*	N	-	-	-	P	-	-	-
Foresteria neomexicana*	N	D	-	-	P	-	-	-
Gutierrizia sarothrae*	N	D	W	IN	P	-	-	L
Lycium pallidum*	N	D	-	-	F	-	-	-
Opuntia sp.*	N	E	-	-	P	-	-	-
O. whipplei*	N	E	-	-	P	-	-	L
Rhus trilobata*	N	D	C	I	P,F	F	P,F	M
Sarcobatus vermiculatus*	N	D	W	I	-	F,G	P,F	M
Shepherdia rotundiflora*	N	E	-	-	-	G	G	-

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
SHRUBS (Cont.)								
Yucca angustissima*	N	E	-	-	-	-	G	-
Y. baccata*	N	E	-	-	-	-	G	-
GRASSES:								
Agropyron cristatum*	I	B	C	-	F,G	F	F	M
A. smithii*	N	S	C	-	G	G	F,G	H
A. trachycaulum*	N	B	C	-	G	G	F,G	M,H
A. trichophorum*	I	S	C	-	G	-	-	M,H
Aristida fendleriana	N	B	C,W	I,IN	P,F,G	-	-	-
Bouteloua gracilis*	N	S	W	I	G	P	P	H
Bromus inermis*	I	S	C	-	G	F	F	H
B. tectorum*	I	B	-	IN	P,F	-	-	-
Carex sp.*	N	B	-	-	F	F	F	M
Elymus junceus*	I	B	C	I	G	F,G	P	M
Hilaria jamesii*	N	S	W	I	F,G	-	-	H

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
GRASSES (Cont.):								
Hordeum sp.*	N	-	C	I	P	-	-	-
Muhlenbergia torreyi	N	S	W	I	P,F	-	-	H
*Munroa squarrosa**	N	S	-	I	-	-	-	-
*Oryzopsis hymenoides**	N	B	C	D	F,G	P,F	F,G	M
*Poa fendleriana**	N	B	C	I	G	R,F	F,G	L,H
*Sitanion hystrix**	N	B	C	I	F	P,G	P,F	L
*Sporobolus airoides**	N	B	W,C	-	F	F	G	M
*S. cryptantha**	N	B	W	I	F	P,F	G	M
*Stipa columbiana**	N	B	C	D	P,F,G	-	-	-
S. comata	N	B	C	D	P,G	-	-	-
*S. neomexicana**	N	B	C	D	P,F,G	-	-	-
*Vulpia octoflora**	N	B	-	I,IN	P,F	-	-	L
FORBS:								
*Allium macropetalum**	N	B	C	-	G	-	-	-
*Arabis perennans**	N	B	C	-	P	-	-	-

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
FORBS (Cont.):								
Astragalus calycosus*	N	B	C	-	P	-	-	-
A. newberryi*	N	B	C	-	P	-	-	-
A. wingatanus*	N	B	W	-	P	-	-	-
Chenopodium sp.*	N,I	B	-	-	P,F,G	-	-	-
Calochortus nuttalii*	N	B	C	-	F	-	-	-
Cordylanthus wrightii*	N	B	-	-	P	-	-	-
Cryptantha sp.*	N	B	-	-	P	-	-	-
Cymopterus sp.*	N	S	-	-	P	-	-	-
Descurainia sophia*	I	B	C	IN	P	-	-	-
D. pinnata*	N	B	C	IN	P	-	-	-
Draba cuneifolia*	N	B	-	-	P	-	-	-
Erigeron concinnus*	N	B	-	-	P	-	-	-
Eriogonum imballatum	N	B	W	I	P	-	-	-
Eriogonum sp.*	N	-	-	-	P,F,G	-	-	-
Erodium cicutarium	I	B	C	IN	G	-	-	-
Euphorbia fendleri*	N	1B	W	-	P	-	-	-

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
FORBS (Cont.):								
Gilia sp.*	N	B	-	-	P	-	-	-
Happlopappus filifolius*	N	B	-	-	P	-	-	-
Hymenoxys acaulis*	N	B	C	-	P	-	-	-
Ipomopsis sp.*	N	B	C	-	F,G	-	-	M,L
Kochia scoparia*	I	B	-	IN	F,G	F,G	P	L
Lactuca serriola*	I	B	W	-	-	-	-	-
Lappula redowski*	N	B	C	IN	P	-	-	L
Lepidium densiflorum*	N	B	-	-	P	-	-	-
Lesquerella intermedia*	N	B	C	-	P	-	-	-
Leucelene ericoides*	N	B	-	-	P	-	-	-
Lupinus brevicaulus*	N	B	-	-	P	-	-	-
Machaeranthera grindeloides*	N	B	-	-	P	-	-	-
Medicago sativa*	I	S	C,W	-	G	G	G	M,H
Melilotus officinalis*	I	B	-	-	G	G	G	M,H
Mentzelia albicaulis*	N	B	-	-	-	-	-	-
Oxytropis lambertii*	N	B	-	-	P	-	-	-

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
FORBS (Cont.):								
Pedicularis centranthera*	N	B	-	-	P	-	-	-
Penstemon barbatus*	N	B	-	-	P,F	-	-	-
P. eatoni*	N	B	-	D	F,G	-	-	M
P. linarioides*	N	B	-	-	G	-	-	M
Petradoria pumila*	N	B	-	-	P	-	-	L
Phlox longiflora*	N	B	-	-	P	P	F,G	L
Plantago purshii*	N	B	C	I	F,G	P	F,G	-
Salsola iberica*	I	B	C	IN	F	P,F	F,G	L
Senecio neomexicana*	N	B	-	-	P	-	-	-
Solidago sparsiflora*	N	B	-	-	P	-	-	-
Sphaeralcea coccinnea*	N	B	-	-	F	P	F	M
Stephanomeria exigua*	N	B	-	-	-	-	-	-
Streptanthus cordatus*	N	B	-	-	-	-	-	-
Suaeda torreyana*	N	B	-	-	-	-	-	-
Thlaspi montanum*	N	B	-	-	-	-	-	-
Townsendia exscapa*	N	B	-	-	P	-	-	-

TABLE 16 (Cont.)

Species	Origin	Growth Character	Growth Season	Grazing Response	Forage Value	Wildlife Cover Value	Wildlife Food Value	Erosion Control Potential
FORBS (Cont.):								
Tragopogon dubius	I	B	C	IN	F	-	-	-
Trifolium subcaulescens*	N	S	-	D	F,G	P,F	G	L

[1] Asterisked species are species that had an Importance Percentage greater than or equal to one in any specific sample.

[2] The data was compiled from Parker (no date); Sampson (1924); Dayton (1931); USDA, Forest Service (1937); Dayton (1960); Judd (1962); Kearney and Peebles (1960); Plummer, et al. (1968); Schmutz, et al. (1968); Humphrey (1970); Vallentine (1971); Vories and Sims (1977); Long (1978); Wasser (1982); Thornburg (1982).

occur on the leasehold. The table includes all species which had an importance percentage of one percent or greater in any vegetation sample, plus additional species which are considered valuable as range plants. In some cases, characteristics are taken from several sources. The tabled values represent the average or consensus interpretation. These are relative factors, which vary with livestock and wildlife species, seasonality, climatic and edaphic conditions and locality.

Plants with high ratings in Table 16 may be considered important to the structure and function of the ecosystem and/or land use objectives because land uses include range and wildlife habitat. Several species are valuable for forage, wildlife food and cover, and erosion control. The proportion of valuable plants to less desirable or undesirable plants is low. For example, 24 increasers, 15 invaders and 9 decreasers (grazing responses of particular species vary under certain conditions) are identified. The proportion of increasers and invaders to decreasers is indicative of deteriorating range condition. This observation is supported by the relative abundance of the less desirable and undesirable plants found from quantitative samples and the degree of active soil erosion observed on site.

Known or suspected noxious or toxic plant species encountered during the course of conducting baseline studies are listed in Table 17. Forty species have been so identified on the basis of their effect on lifestock. Eight of the species are considered to be major contributors to poisoning problems and may be considered dangerous depending upon seasonality and quantity consumed. The majority of plants are poisonous only when consumed in very large quantities, or under very special circumstances. The abundance and speciation of poisonous plants are indicative of poor range condition.

Significance of the Vegetation Communities

No naturally occurring unique or ecologically sensitive areas have been identified on the Black Mesa leasehold. The vegetation resources that are present are well represented throughout the Great Basin and Colorado Plateau regions of the western and southwestern United States.

As previously indicated, the pinyon-juniper woodland community found on the leasehold can be placed in the broader Great Basin Conifer Woodland Biotic Community. It is one of the most extensive communities in the southwest, occupying an estimated 42.6 million (Clary

TABLE 17

Known or Suspected Noxious and Poisonous

Range Plants Which Occur on the Black Mesa Leasehold

Species	Importance	Agent or Mechanism	Reference[1]
Agropyron spp.	minor	Ergot (fungi)	1
Artemisia tridentata	minor	Not specified	2
Ascelpias asperula	minor	Glycosides	3,4
Astragalus praelongus	major	Selenium accumulator (primary)	5
Atriplex canescens	minor	Selenium accumulator (secondary)	2
Atriplex confertifolia	minor	Selenium accumulator (secondary?)	5
Boutelous gracilis	minor	Not specified	2
Bromus tectorum	minor	Mechanical (awns)	4
Castilleja chromosa	minor	Selenium accumulator (secondary)	5
Corydalis wrightii	minor	Alkaloids, Selenium	5,6
Chrysothamnus nauseosus	minor	Not specified	6
Delphinium spp.	major	Alkaloids	3,4
Descurainia pinnata	?	Unknown	6
Ephedra viridis	suspect	Unknown	2
Eurotia lanata	minor	Not specified	2
Gutierrezia sarothrae	minor	Selenium (?)	2,5,6
Hordeum spp.	minor	Mechanical (awns)	4
Juniperus osteosperma	minor	Not specified	2
Kochia scoparia	minor	Not specified	2
Lupinus spp.	major	Alkaloids	4
Macaranthera grindelioides	minor	Selenium accumulator (secondary)	3,5
Medicago sativa	minor	Not specified	2
Melilotus officinalis	minor	Not specified	2
Monolepis nuttalliana	minor	Nitrates	6
Opuntia spp.	minor	Mechanical (spines)	2,4
Oxytropis lambertii	major	Not specified or unknown	1,3,4,6,7
Penstemon barbatus	minor	Selenium accumulator (secondary)	7
Prunus virginiana	minor	Hydrocyanic acid	3,4
Psilostrophe sparsiflora	minor	Not specified	4
Quercus gambelii	major	Tannic acid	1,2,6

TABLE 17 (Cont.)

Species	Importance	Agent or Mechanism	Reference[1]
Salsola iberica	minor	Nitrate accumulation	2,6
Sarcobatus vermiculatus	major	Oxalic acid	2,4
Senecio douglasii	minor	Alkaloids	4,6
Sitanion hystrix	minor	Mechanical (awns)	4
Solanum rostratum	?	Alkaloid (solanine)	6
Solidago sparsiflora	?	Not specified	3,7
Stanleya pinnata	major	Selenium accumulator (primary)	3,5
Stipa spp.	minor	Mechanical (awns)	2,4
Tetradymia canescens	major	Photosensitization	4
Xanthium strumarium	minor	Mechanical, Unknown chemical	4,6

[1] 1 = Kingsbury (1964)
2 = Vories and Sims (1977)
3 = Kearney and Peebles (1960)
4 = Stoddard and Smith (1955)
5 = Beath et al. (1940)
6 = Parker (1972)
7 = Schmutz et al. (1968)

1975) to 80 million acres (West et al. 1975). Approximately 12.6 million acres occur in Arizona (West et al. 1975). Brown (1982) identifies the Great Basin Conifer woodland as structurally among the simplest communities in the southwest.

Relative to other communities studied on the Black Mesa leasehold, the pinyon-juniper woodland is perhaps the most important wildlife habitat. The results of wildlife surveys (Chapter 14) in the leasehold indicate that it is the most diverse habitat in terms of the number of species which live and breed in it. The woodland provides nest sites for raptors, cover for numerous mammals and seasonal habitat for a number of migratory species. The woodland is also relatively diverse in terms of the plant species which occur.

Sagebrush dominated lands are estimated to occupy 422,000 square miles in the western United States (Beetle 1960). This estimate includes all biotic communities in which Artemisia species are important components, and therefore includes a considerably larger area than just Great Basin Desertscrub. In Arizona, approximately 4.9 million acres of sagebrush dominated lands occur (West 1979). This community characteristically exhibits low plant species diversity with a single shrub species usually dominating the landscape to the virtual exclusion of other woody species and understory grasses and forbs. Large ungulates are poorly represented in the sagebrush community, as are reptiles. As some of their names imply, certain birds are characteristic of the community; e.g., sage sparrow and sage thrasher. Most of the common medium statured mammals (coyotes, black-tailed jackrabbits and desert cottontails) are, for the most part, found throughout most of the western biomes.

The greasewood and saltbush shrublands are classified as minor series within the broader Great Basin Desertscrub. Structurally, they are similar to the sagebrush series with a single shrub species dominating the landscape. In terms of vegetal and faunal diversity, these shrublands are considered relatively simple as well.

The tamarix riparian strand is considered a disclimax riparian series in the Greater Plains and Great Basin Riparian Wetlands. This series comprises many miles of river and stream channels, including ephemeral tributaries, in the warmer, western portions of the Great Basin biotic province. On the Black Mesa leasehold, the community is structurally similar to the shrublands. In terms of vegetal and faunal diversity, it is relatively simple. This is due as much to the lack of structure in the community as it is to its

intermittent distribution and flood successional nature.

The communities represented on the Black Mesa leasehold are used extensively throughout the west as rangeland. Stoddard and Smith (1955) described the grazing utility of the pinyon-juniper woodland as "ideally suited for spring range, especially lambing range". However, the woodland is relatively unproductive, even when in excellent condition, due unfavorable growing conditions. An estimated 60 percent depletion in the productivity of this range region has occurred in the western United States.

Stoddard and Smith (1955) describe the intermountain shrub region (big sagebrush type) as "essentially a spring and fall range". A large part of the region appears to have once been dominated by cool season bunchgrasses, with sagebrush or other shrub series dominants, occurring as subdominants. Heavy overgrazing on the type has been almost universal (Stoddard and Smith 1955) resulting in a substantial loss in productivity as increased warm season grasses and shrubs become dominant.

Table 18 presents carrying capacity figures for the plant communities occurring on the leasehold. The acres required to support one animal unit for one month for each season are based on production samples collected in all sampling areas and all years. The woodland is the least productive of the communities followed by the sagebrush and greasewood shrublands. The saltbush shrubland and reclaimed grassland exhibit much better livestock carrying capacity. The saltbush capacity is due to the presence of fourwing saltbush, an important range plant. The reclaimed grassland capacity is due to the presence of productive cool season bunch grasses. The figures for reclaimed grasslands would be much better, except production values from years before some units had completely developed were included in the calculations. Overgrazing by sheep and cattle appears to contribute significantly to the lack of productivity in the natural plant communities, although most are relatively unproductive for livestock utilization even when in excellent range condition.

The impact of heavy grazing partially accounts for the relatively sparse wildlife populations found on the leasehold (Chapter 10). The Black Mesa has been closed to all big game hunting. Small game hunting, commercial trapping and other forms of outdoor recreation are available in the natural vegetation communities. The lands on the leasehold have received a negative determination as prime farmland by the Soil Conservation Service.

TABLE 18

Seasonal Livestock Carrying Capacity Figures for the

Plant Communities Occurring on the Leasehold[1]

Vegetation Community	Season	Livestock Carrying Capacity (ac./AUM)[2]
Pinyon-Juniper Woodland	Spring	119.0 ± 95.2 (Confidence Limit: t0.05(2), 4 = 2.776)
	Fall	189.2 ± 229.4 (as above)
Sagebrush Shrubland	Spring	10.5 ± 1.7 (Confidence Limit: t0.05(2), 8 = 2.306)
	Fall	13.0 ± 7.7 (as above)
Greasewood Shrubland	Spring	9.6 (n = 1)
Saltbush Shrubland	Spring	5.7 (n = 3: s = 2.01)
	Fall	2.5 (n = 2)
Reclaimed Land[3]	Spring	4.2
	Fall	4.2

[1] Total usable forage is derived from Proper Use Factors for sheep (Attachment 2).

[2] Livestock carrying capacity is expressed as acres required to support one animal unit for one month (Attachment 2).

[3] Based on averaged historic reclaimed area monitoring data.

Impact Analysis

The scope of this analysis is limited to direct and indirect impacts on the biotic components of vegetation and wildlife. The approximate remaining acreages of each vegetation community to be disturbed by mining activities on the Black Mesa leasehold are shown in Table 19.

Approximately 10,992 acres will be disturbed or redisturbed during the remaining life of mining activities on the leasehold. The breakdown by native vegetation community type is 7,940 acres of pinyon-juniper woodland, 1,306 acres of sagebrush shrubland, and 146 acres of saltbush shrubland. An additional 1600 acres of land disturbed prior to 2005 will be redisturbed, including an estimated 713 acres of reclaimed land in the N-6 areas.

The loss of wildlife habitat may have varied impacts on wildlife populations. The impacts may be direct or indirect. Removal of the vegetation will result in the direct loss of food, cover and breeding habitat. Noise and related impacts associated with concentrated industrial activities will disturb sensitive wildlife in surrounding areas. Disturbance of the land surface and subsurface creates the potential for impacting surface and ground water quality and quantity, and may affect natural physical shelters.

Mobile wildlife species will not be as severely influenced by the disturbance as less mobile small mammals, strongly territorial birds, reptiles and amphibians. The restricted species can be expected to be extirpated in the disturbance area. The larger and more mobile species will be displaced into surrounding areas, temporarily creating increased competition for the available resources. If the surrounding areas are at or near carrying capacity, populations will be stressed until a new equilibrium is reached. Displaced species which have the capacity to exploit the habitat created by reclamation activities will repopulate developing reclaimed areas, particularly those species adapted to grass/shrubland habitats.

Overall, the fauna in the lease area must be described as relatively sparse; apparently attributable to habitat availability, quality, and condition. The areas that will be disturbed exhibit less value to wildlife in their present state than what would be expected under more pristine conditions. There are extensive tracts of the plant communities throughout the southwestern United States, and since few, if any, vertebrates are wholly dependent upon them, the impact or manipulation of a small percentage can be viewed as negligible. No unique habitats or habitats of high quality will be disturbed.

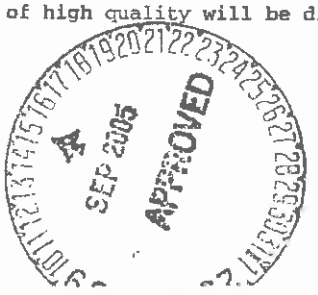

Table 19

Estimated Life of Mine Disturbance Acreages for Native Vegetation Communities and Other Types and Reclamation Status of Active Pit Coal Resource Areas as of 11/01/03 for the Black Mesa Mining Complex.

		Affected Vegetation Communities or Type[1]								Reclamation Status[2]			
LOM/Pit Area	Years	PJ	SB	SA	GR	TA	REV	DIS	Total	FGR	TSD	REV	FAC/DIS
J7	2000-2005		21						21	65	38	688	567
J16	Mining Complete - Final Reclamation									25	11	1221	227
J19/J19 West	2000-2005	1874	434	20				121	2449	240	148	784	978
	2006-2010	70	124	3				9	206				
	Beyond 2010	16	1						17				
J21	2000-2005	685	225	35				33	978	185	172	2087	1002
	Beyond 2005	455	125	4					584				
N6	2000-2005	64	67						131	198	141	1470	1389
N11	2000-2005	173	29						202	195	50	139	658
N9	2005-2011	1964	134	84			191	154	2527				

Table 19 (Cont.)

Estimated Life of Mine Disturbance Acreages for Native Vegetation Communities and Other Types and Reclamation Status of Active Pit Coal Resource Areas as of 11/01/03 for the Black Mesa Mining Complex.

		Affected Vegetation Communities or Type[1]								Reclamation Status[2]			
LOM/Pit Area	Years	PJ	SB	SA	GR	TA	REV	DIS	Total	FGR	TSD	REV	FAC/DIS
N99 North	2000-2005	4					3	133	140				
	2006-2010	44	1				1	10	56				
	Beyond 2010	945	36				1	12	994				
N12/N99 South	2000-2005	1135	37				317	281	1770				
	2006-2010	511	72				200	134	917				
N14	Mining Complete - Final Reclamation									28	1	1490	498
Total Affected		7940	1306	146	0	0	713	887	10,992				

[1] Estimated maximum disturbance acreages for vegetation communities for life of mine (LOM) or remaining maximum disturbance acreages in the active mining areas J7, J19, J21, N6, or N11. PJ = pinyon-juniper; SB = sagebrush shrubland; SA = saltbush shrubland; GR = greasewood shrubland; TA = Tamarix riparian strand; REV = revegetated areas which may be reaffected by LOM activities; DIS = roads, facilities, or other currently affected lands which may be reaffected by LOM activities.

[2] Reclamation status for active mining areas and former mining areas in final reclamation as of 11/01/03.

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The remaining life-of-mine vegetation disturbance will result in the temporary loss of approximately 7,732 acres of native and reclaimed rangeland. On the basis of the carrying capacity figures presented in the previous section, the remaining vegetation disturbance will result in the potential loss of approximately 94 animal unit months (AUMs) of grazing. Revegetation and release of successfully reclaimed lands will compensate for the acreage loss during the life-of-mine. As of 11/01/03, 13,063 pre- and postlaw acres have been reclaimed at the Black Mesa and Kayenta Mines. Based on this acreage and an average reclaimed land stocking rate of 4.2 ac/AUM, there are approximately 3,110 AUMs of grazing available in a normal precipitation year.

The list of plant species resulting from comprehensive floristic surveys conducted on and adjacent to the Black Mesa leasehold is presented in Table 1. The list includes 278 species. The importance of some of these species as cultural resources of the Navajo and Hopi (medicines, food, building materials, tools, ceremonial items, etc.) has been previously discussed. Culturally significant plants are identified in plant lists that can be found in Attachment 3. Ninety-nine species, genera, or families are listed in the ethnobotanical information compiled by the Navajo Health Authority (79 listed species or genera plus an additional 20 species, genera, or families referenced in the narrative). A supplemental list, prepared by Peabody (Attachment 3), lists 19 additional species or genera that are known to have or are suspected to have ethnobotanical significance. See also Chapter 23 and Appendix B to Chapter 23 for additional discussion regarding culturally significant plants.

Appendix 3 contains 118 species, genera, or families of vascular plants that are of ethnobotanical importance. Several of these species, genera, and families need not be considered in an impact analysis for reasons given in the following paragraphs. The result is a total of 77 species or genera, or approximately 28 percent of the plants found in the floristic surveys which could potentially be impacted by surface mining activities.

It is extremely unlikely that several of the species or genera contained in Attachment 3 will be impacted by surface mining activities on the basis that their regional distribution does not encompass the disturbance areas or they were not present in the comprehensive floristic surveys. These species or genera may include:

Mirabilis oxybaphoides	Gaura coccinea	Chenopodium album
Melilotus indica	Tribulus terrestris	Senecio multicapitatus
Salix laevigata (S. bonplandiana)	Eriogonum rotundifolium	Echinocereus spp.
Lupinus kingii	Mammillaria spp.	

Salix laevigata (S. bonplandiana)	Eriogonum rotundifolium
Lupinus kingii	Mammillaria spp.
Senecio multicapitatus	Echinocereus spp.
Chenopodium album	

Several genera or species contained in Attachment 3 are not of concern in the analysis of impacts because no ethnobotanical uses are indicated or listed, or they are only mentioned in the narrative in disparaging terms. They are:

Symphoricarpus spp.	Tamarix pentandra
Salsola kali (= S. iberica)	Opuntia phaecantha
Atriplex nuttallii	Echinocereus triglochidiates
Calochortus nuttallii	Sitanion hystrix
Oxytropis spp.	Agropyron smithii

Two species contained in Attachment 3 are not of concern in the analysis of impacts because the scientific names cannot be traced to any known synonyms in the Taxonomy of Arizona (Kearney and Peebles 1960; Lehr 1978). These species are Silene douglasii and Artemisia trifida.

Several species which occur on the leasehold are not of concern although the genera or one family to which they belong are listed as significant in Attachment 3. This assessment is based on notations in the literature which mention ethnobotanical uses of certain species in the genera or family, but do not include the species found on the leasehold (Kearney and Peebles 1960). These include (species represented on the leasehold are in parenthesis):

Labiatae (Hedeoma drummondii; Moldavica parviflora)
Asclepias spp. (A. asperula)
Crypthantha spp. (C. bakeri; C. flavus)
Panicum spp. (P. capillare)

It is highly unlikely that several of the species or genera contained in Attachment 3 will be impacted by surface mining activities because they are associated primarily or exclusively with plant communities that will not be disturbed. These plants include (plant communities in which they occur are in parenthesis and correspond to the community codes in Table 1):

Berberis repens (MC)	Quercus gambelii (MC)

Pinus ponderosa (MC)

Pseudotsuga taxifolia (= *P. menziesii*; MC)

Purshia tridentata (MC)

Populus tremuloides (MC)

Populus freemontii (TA)

Ribes cereum (MC)

Typha spp. (A)

Scirpus acutus (A)

Prunus demissa (= *P. virginiana*; DL)

Zea mays (cultivated)

The impact of surface mining on the majority of the remaining 77 species or genera of concern can be viewed as negligible. The rationale for this assessment is that these species and genera are of such common local and/or regional occurrence that the disturbance of the specified acreages on which they occur will not substantially affect the supply (see the Vegetation Survey Summary Reports referenced or included herein). In some cases, the abundance of a species lost to the mining disturbance is offset by its inclusion in the seed mixes and/or plantings used for revegetation purposes (see Chapter 23), its use in revegetation trials with provisions for inclusion in the revegetation plan if successful, or its noted ability to reinvade the reclaimed lands. These species and genera include (asterisked species are used in the revegetation seed mixes and/or plantings):

Chrysothamnus spp.

*C. nauseosus**

Aster leuceline (= *Leuceline ericoides*)

*Artemisia tridentata**

Senecio spp.

S. longilobus (= *S. douglasii* var. *longilobus*)

Gutierrezia sarothrae

Sarcobatus vermiculatus

Chenopodium spp.

*Atriplex confertifolia**

*A. canescens**

*Medicago falcata**

Eriogonum spp.

*Cowania mexicana**

Penstemon barbatus

Lycium pallidum

Cleome serrulata

Sphaeralcea coccinea

Allium deserticola (= *A. macropetalum*)

Opuntia spp.

O. whipplei

Lappula redowski

Amaranthus spp.

*Pinus edulis**

Plantago purshii

Gilia (= *Ipomopsis*) *aggregata*

*Sporobolus cryptandrus**

S. airoides

*Oryzopsis hymenoides**

Munroa squarrosa

*Hilaria jamesii**

Bromus tectorum

*Boutelona gracilis**

Stipa comata

Juniperus spp.*

Lesquerella intermedia

Phorandendron spp.

Cymopterus glomerata (= *C. purpereus*)

Penstemon eatoni	Rhus trilobata*
Yucca spp.	Lupinus spp.
Y. angustissima	Descurainia spp.
Y. baccata	Ephedra viridis
Hymenoxys acaulis	Oxytropis lambertii
Suaeda torreyana	

The impact of surface mining activities on the remaining 28 species or genera of ethnobotanical concern is somewhat difficult to assess. Impacts could range from slight to substantial depending upon: 1) the local supply and demand for a given species; 2) the proximity of substantial populations of a given species surrounding the leasehold that could not be quantified due to the scope of the vegetation baseline studies; 3) the willingness of residents to travel to obtain materials; 4) the emphasis placed on ethnobotanical plant materials in view of cultural changes occurring on the reservation; 5) substitution of functionally similar species when one is in short supply; and 6) the success of mitigation measures developed for the resource. A discussion of mitigation for the loss of these cultural resources is included in the following section.

Mitigation, Enhancement and Monitoring

Direct and indirect measures for protecting vegetation and wildlife values with regard to the impact mechanisms discussed in the previous section are incorporated into all pertinent aspects of the permit application package. These measures include procedures for identifying, reducing and/or preventing air and surface or groundwater contamination, vegetation and soil loss, solid waste contamination, vegetation and soil loss, solid waste contamination, range and coal fires and noise. These activities are the best currently available practices for protecting wildlife and vegetation values.

The Western Division of Peabody Coal Company has stressed the importance of an effective revegetation plan to minimize the impact to wildlife from the land surface disturbances. The revegetation plan is outlined in Chapter 23. The plan is designed to optimize revegetation for the postmining land uses of livestock grazing and wildlife habitat (refer to Chapter 14 for a complete discussion of Land Use). Proposed habitat protection and enhancement procedures which are designed to mitigate unavoidable disturbances are also incorporated into the plan.

In order to better understand the effects of surface mining on the biota within the lease boundary and to evaluate the effectiveness of enhancement procedures, the Arizona Division has instituted an annual biologic monitoring program. Biological data is collected on an annual basis and presented to the regulatory authority during the first quarter following the completion of the annual studies. The methods for collecting the data follow those used to collect the current baseline information.

Possible impacts to specified ethnobotanical resources were identified in the previous section. A portion of these impacts will be mitigated through the use of selected culturally significant species in the revegetation seed mixes and plantings (Chapter 23). These species were selected for use in the revegetation program because of a high likelihood of successful establishment, compatibility with the postmining land use, benefits to wildlife, and cultural benefits. They represent approximately 46 percent of the species in the mixes and include:

Boutelona gracilis (Blue Grama)
Hilaria gamesii (Galleta)
Sporobolus crystandra (Sand Dropseed)
Sphaerlacea ambigua (Desert Globemallow)
Linum lewisii (Lewis Flax)
Medicago falcata (Alfalfa-prostrate)
Oryzopsis hymenoides (Indian Ricegrass)
Atriplex canescens (Fourwing Saltbush)
Atriplex confertifolia (Shadscale)
Eurotia lanata (Winterfat)
Chrysothamnus nauseosus (Rubber Rabbitbrush)
Artemisia tridentata (Big Sagebrush)
Juniperus spp. (Juniper species)
Pinus edulis (Colorado Pinyon)
Cowania mexicana (Cliffrose)

Additional mitigation for the impacts on ethnobotanical resources will be partially accomplished by the direct respreading of topsoil materials ("live" topsoiling) and the natural reinvasion of the reclaimed areas by species native to the leasehold. Peabody intends to direct haul plant growth materials as often as is feasible (Chapter 22). Care is taken to redistribute surface lifts back on the surface of regraded spoils to conserve the seed bank that exists near the surface of the natural soils. This practice and the probable reinvasion of certain species is contributing to the reintroduction of species which are or are not intentionally seeded. Species of ethnobotanical significance that have occurred in quantitative vegetation samples in the reclaimed areas or were noted as incidentals include:

Chrysothamnus nauseosus
Sphaeralcea coccinea

Luecelene ericoides	Opuntia spp.
Artemisia tridentata	Bromus tectorum
Senecio douglasii var. longilobus	Descurainia spp.
Gutierrizia sarothrae	Setaria viridis
Sarcobatus vermiculatus	Amaranthus spp.
Circium vulgare	Helianthus petiolaris
Echinochloa crusgalli	Munroa squarrosa
Sporobolus airoides	Lupinus brevicaulis
Plantago purshii	Allium macropetalum

Several additional ethnobotanically significant species have been or will be used in revegetation trials (Chapter 23). For example, successful plantings of barnyard grass (Echinochloa crusgalli), Fremont cottonwood (Populus fremontii), and Typha have been made around approved internally draining ponds. In addition, the Revegetation Plan contains provisions to screen the following ethnobotanically significant species: Chrysothamnus spp., Sarcobatus vermiculatus, Ephedra viridis, Lycium pallidum, Purshia tridentata, Tamarix pentandra, Berberis repens, Quercus gambelli, Eriogonum spp., and Symphoricarpus spp. These trials will be continued depending upon the availability of commercial sources of improved plant materials. Provisions are included in the revegetation trials to incorporate successfully screened species into the revegetation plan either for general or site-specific use.

Certain important factors preclude the mitigation for certain culturally significant plants. First, a large number of species are not adapted to the reclaimed environment. For example, several plants that occur in the pinyon-juniper woodland require shallow, rocky soils. These conditions are typically not present on reclaimed sites by virtue of the reclamation methods employed. Second, commercial sources of improved plant materials are lacking for most of the culturally significant plants discussed herein. Many undoubtedly possess difficult dormancy or morphological problems which have precluded their selection for improvement or development. Third, several of the culturally significant plants that have been discussed are undesirable for use in the revegetation process because of direct conflicts with postmining land uses. Plants in this last category include weeds (e.g., Cirsium spp.) and poisonous plants (e.g., Stanleya pinnata; Castilleja chromosa). Finally, information regarding the degree of utilization (if any) and the specific species used by residents on the leasehold has not been made available to Peabody.

Peabody believes that the overall impacts of surface mining on culturally significant plants must be viewed as negligible in relation to the number of species actually affected and the potentially beneficial economic and cultural impact of substantially improved livestock grazing capability on reclaimed lands. In addition, the mitigation measures and problems associated with restoration indicate that satisfactory measures have been taken to sustain this culturally significant plant resource.

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ATTACHMENT 1

VEGETATION SURVEY SUMMARY REPORTS

LIST OF VEGETATION SURVEY SUMMARY REPORTS

LIST OF VEGETATION SURVEY SUMMARY REPORTS (CONT.)

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-7/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: TREE

UTMN(1): 4044293.91 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4044000.00 SLOPE: 0-5%
UTME(1): 549634.40 ASPECT: ALL
UTME(2): 551000.00 ELEVATION RANGE: 6490 - 6900

SPECIES NAME	MEAN BASAL AREA (CM2)	TOT. BASAL AREA (D2/HA)	RELATIVE BASAL AREA (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2761.70	4203.58	87.50	152.21	60.00	92.00	54.76	67.42
PINUS EDULIS COLORADO PINYON	591.43	600.24	12.50	101.48	40.00	76.00	45.24	32.58

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
39.42	253.69	0.16

*** NOTES ***

REPORT GENERATED FROM ORIGINAL SH&A FIELD SHEETS

Report 1

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-7/8
MONTH: 11
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: SHRUB

UTMN(1): 4046298.91
UTMN(2): 4044000.00
UTME(1): 549634.40
UTME(2): 551000.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6680 - 6900

SPECIES NAME	MEAN CANOPY COVERAGE (CM2)	TOT. CAN. COVERAGE (CM2/HA)	RELATIVE CAN. COVERAGE (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	8024.23	7041.88	37.49	87.75	32.50	73.33	27.85	32.61
COWANIA MEXICANA CLIFF ROSE	9384.89	1645.52	24.73	49.50	18.33	43.33	16.46	19.84
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	1111.34	125.03	0.67	11.25	4.17	13.33	5.06	3.30
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	10565.38	2614.93	13.92	24.75	9.17	30.00	11.39	11.49
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	7064.13	1430.49	7.61	20.25	7.50	30.00	11.39	8.84
LYCIUM PALLIDUM RABBIT THORN	284.71	12.91	0.07	4.50	1.67	3.33	1.26	1.00
YUCCA BACCATA BANANA YUCCA	1267.74	199.67	1.06	15.75	5.83	13.33	5.06	3.99
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	4228.06	1141.58	6.08	27.00	10.00	23.33	8.86	8.31
ECHINOCEREUS TRIGLOCHIDIATUS VAR. MELANACANTHUS HEDGEHOG CACTUS	176.71	3.98	0.02	2.25	0.83	3.33	1.26	0.71
YUCCA ANGUSTISSIMA SPANISH BAYONET	1389.76	125.08	0.67	9.00	3.33	6.67	2.53	2.18
OPUNTIA SPP.	613.59	55.22	0.29	9.00	3.33	13.33	5.06	2.90
FORESTIERA NEOMEXICANA DESERT OLIVE	49087.34	1104.47	5.88	2.25	0.83	3.33	1.26	2.66
QUERCUS GAMBELII GAMBEL OAK	1590.43	71.57	0.38	4.50	1.67	3.33	1.26	1.11
FENDLERA RUPICOLA FENDLER BUSH	9503.31	213.82	1.14	2.25	0.33	3.33	1.26	1.08

Report 2

PEABODY COAL [illegible]Y
ARIZONA DIV.
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 2

MINE: KAYENTA
MINE AREA: N-1/3
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: SHRUB

UTMN(1): 4044293.91 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4044000.00 SLOPE: 0-50%
UTME(1): 549634.40 ASPECT: ALL
UTME(2): 551000.00 ELEVATION RANGE: 6690 - 6800

SPECIES NAME	MEAN CANOPY COVERAGE (CM2)	TOT. CAN. COVERAGE (CM2/HA)	RELATIVE CAN. COVERAGE (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
37.04	259.99	0.75

*** NOTES ***

REPORT GENERATED FROM ORIGINAL FIRA FIELD SHEETS

Report 2 (Cont.)

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: H-7/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4044299.91
UTMN(2): 4044001.00
UTME(1): 549631.40
UTME(2): 551001.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 5590 - 6800

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARABIS PERENNANS ROCK CRESS	0.07	1.73	0.07	1.58	10.00	3.54	2.28
CHENOPODIUM CAPITATUM STRAWBERRY BLITHE	0.06	1.48	0.24	5.42	6.11	2.16	3.02
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.61	15.06	0.26	5.87	25.00	8.86	9.93
PENSTEMON LINARIOIDES MAT PENSTEMON	0.87	21.48	0.85	19.19	44.44	15.74	18.80
UNIDENTIFIED FORB SPECIES 1	0.02	0.49	0.05	1.13	4.44	1.57	1.07
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.18	4.44	0.17	3.84	12.22	4.33	4.20
BOUTELOUA GRACILIS BLUE GRAMA	0.04	0.99	0.12	2.71	2.22	0.79	1.49
CRYPTANTHA BAKERI	0.11	2.72	0.18	4.06	18.33	6.49	4.42
HILARIA JAMESII GALLETA	0.02	0.49	0.01	0.23	1.67	0.59	0.44
IPOMOPSIS AGGREGATA SKY ROCKET	0.05	1.23	0.11	2.48	9.44	3.34	2.35
LESQUERELLA INTERMEDIA BLADDER POD	0.04	0.99	0.06	1.35	7.78	2.76	1.70
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.12	2.96	0.15	3.39	8.89	3.15	3.17
PENSTEMON EATONII EATON PENSTEMON	0.13	3.21	0.09	2.03	7.78	2.76	2.67
UNIDENTIFIED FORB SPECIES 2	0.01	0.25	0.01	0.23	1.11	0.39	0.29
COMPOSITAE UNIDENTIFIED COMPOSITE	0.02	0.49	0.02	0.45	3.33	1.18	0.71
HYMENOXYS ACAULIS BITTERWEED	0.01	0.25	0.01	0.23	1.11	0.39	0.29

Report 3

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: 2-77B
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4046298.91
UTMN(2): 4044000.00
UTME(1): 549634.40
UTME(2): 551000.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6680 - 6800

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
SITANION HYSTRIX	SQUIRREL TAIL	0.16	3.95	0.16	3.61	12.78	4.53	4.03
GRAMINEAE	UNIDENTIFIED GRASS SEEDLING	0.04	0.99	0.05	1.13	1.67	0.59	0.90
EUPHORBIA SERPYLLIFOLIA	RATTLESNAKE WEED	0.01	0.25	0.01	0.23	1.11	0.39	0.29
LEUCELENE ERICOIDES	WHITE ASTER	0.14	3.46	0.24	5.42	6.11	2.16	3.68
CYMOPTERUS PURPUREUS	CYMOPTERUS	0.22	5.43	0.32	7.22	18.33	6.49	6.38
DESCURAINIA SOPHIA	FLIXWEED	0.14	3.46	0.23	5.19	10.56	3.74	4.13
DRABA CUNEIFOLIA	WHITTOW-GRASS	0.07	1.73	0.13	2.93	3.33	1.18	1.95
LAPPULA REDOWSKI	STICKSEED	0.06	1.48	0.09	2.03	4.44	1.57	1.70
PHLOX LONGIFOLIA	PHLOX	0.01	0.25	0.04	0.90	1.67	0.59	0.58
SPHAERALCEA COCCINEA	SCARLET GLOBEMALLOW	0.07	1.73	0.08	1.81	1.67	0.59	1.38
CRUCIFERAE SPP.		0.00	0.00	0.01	0.23	1.11	0.39	0.21
JUNIPERUS OSTEOSPERMA	UTAH JUNIPER	0.00	0.00	0.00	0.00	0.56	0.20	0.07
OPUNTIA SPP.		0.00	0.00	0.00	0.00	0.56	0.20	0.07
STREPTANTHUS CORDATUS	TWIST FLOWER	0.02	0.49	0.02	0.45	3.89	1.38	0.77
TOWNSENDIA EXSCAPA	GROUND DAISY	0.01	0.25	0.01	0.23	2.78	0.98	0.49
UNIDENTIFIED FORB SPECIES 3		0.00	0.00	0.01	0.23	0.56	0.20	0.14

Report 3 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-7/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4044293.91
UTMN(2): 4044000.00
UTME(1): 549634.40
UTME(2): 551000.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6630 - 6800

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
COWANIA MEXICANA CLIFF ROSE	0.00	0.00	0.04	0.99	0.56	0.20	0.37
PEDICULARIS CENTRANTHERA WOOD BETONY	0.29	7.16	0.12	2.71	13.89	4.92	4.93
POA FENDLERIANA MUTTON GRASS	0.16	3.95	0.22	4.97	9.44	3.34	4.09
ASTRAGALUS SPP.	0.05	1.23	0.03	0.68	3.33	1.18	1.03
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	0.01	0.25	0.04	0.90	2.22	0.79	0.65
LEPIDIUM DENSIFLORUM PEPPERGRASS	0.00	0.00	0.01	0.23	1.11	0.39	0.21
SENECIO NEOMEXICANA GROUNDSEL	0.00	0.00	0.01	0.23	1.67	0.59	0.27
THLASPI MONTANUM VAR. FENDLERI WILD CANDYTUFT	0.05	1.23	0.07	1.58	1.11	0.39	1.07
ALLIUM MACROPETALUM WILD ONION	0.00	0.00	0.00	0.00	0.56	0.20	0.07
ASTRAGALUS NEWBERRYI NEWBERRY MILK-VETCH	0.01	0.25	0.01	0.23	0.56	0.20	0.22
BROMUS TECTORUM CHEATGRASS	0.01	0.25	0.00	0.00	0.56	0.20	0.15
HAPLOPAPPUS ARMERIOIDES GOLDENWEED	0.04	0.99	0.01	0.23	2.22	0.79	0.67
CAREX SPP. SEDGE	0.01	0.25	0.01	0.23	1.11	0.39	0.29
LUPINUS BREVICAULUS	0.00	0.00	0.00	0.00	0.56	0.20	0.07
MACHAERANTHERA GRINDELIOIDES	0.04	0.99	0.03	0.68	1.67	0.59	0.75
TRIFOLIUM SUBCAULESCENS	0.00	0.00	0.01	0.23	0.56	0.20	0.14

Report 3 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 4

MINE: KAYENTA
MINE AREA: N-1/3
SOUTH: 10
YEAR: 79

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4046293.91 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4044000.00 SLOPE: 0-50%
UTME(1): 549631.40 ASPECT: ALL
UTME(2): 551000.00 ELEVATION RANGE: 6490 - 6800

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
LITHOSPERMUM INCISUM	PUCCOON	0.01	0.25	0.00	0.00	0.56	0.20	0.15
MIRABILIS MULTIFLORA	COLORADO FOUR O'CLOCK	0.01	0.25	0.00	0.00	0.56	0.20	0.15
ERIOGONUM SPP.		0.03	0.74	0.01	0.23	1.67	0.59	0.52
HYMENOXYS IVESIANA	BITTERWEED	0.01	0.25	0.01	0.23	1.67	0.59	0.35
PHYSARIA NEWBERRYI	TWINPOD	0.00	0.00	0.00	0.00	0.56	0.20	0.07
HYMENOPAPPUS FILIFOLIUS		0.01	0.25	0.00	0.00	0.56	0.20	0.15
PINUS EDULIS	COLORADO PINYON	0.00	0.00	0.00	0.00	0.56	0.20	0.07

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
4.05	4.43	1.29

*** NOTES ***

LITTER COVERAGE = 10.99% ROCK COVERAGE = 3.62% LICHEN/MOSS COVERAGE = 0.60%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

Report 3 (Cont.)

PEABODY COAL CO.
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-10
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: TREE

UTMN(1): 4047366.00
UTMN(2): 4045488.00
UTME(1): 556359.00
UTME(2): 556336.50

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-60%
ASPECT: ALL
ELEVATION RANGE: 6730 - 7000

SPECIES NAME	MEAN BASAL AREA (CM2)	TOT. BASAL AREA (M2/HA)	RELATIVE BASAL AREA (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	529.89	399.15	10.25	75.47	35.00	75.00	44.12	29.79
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2493.81	3495.07	89.75	140.15	65.00	95.00	55.88	70.21

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
46.38	215.62	0.14

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

Report 4

PEABODY COAL CO
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-10
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: SHRUB

UTMN(1): 4047366.00
UTMN(2): 4045484.00
UTME(1): 556359.90
UTME(2): 556336.50

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-60%
ASPECT: ALL
ELEVATION RANGE: 6780 - 7000

SPECIES NAME	MEAN CANOPY COVERAGE (CM2)	TOT. CAN. COVERAGE (CM2/HA)	RELATIVE CAN. COVERAGE (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
COWANIA MEXICANA CLIFF ROSE	8050.75	7199.79	53.00	89.43	27.50	40.00	17.39	32.63
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	609.69	98.27	0.73	16.24	5.00	20.00	8.70	4.81
PINUS EDULIS COLORADO PINYON	4347.41	4771.28	35.12	109.75	33.75	70.00	30.43	33.10
YUCCA BACCATA BANANA YUCCA	661.04	80.58	0.59	12.19	3.75	15.00	6.52	3.62
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	4830.19	1178.08	8.67	24.39	7.50	25.00	10.87	9.01
OPUNTIA SPP.	219.26	105.96	0.79	48.78	15.00	35.00	15.22	10.33
LYCIUM PALLIDUM RABBIT THORN	1256.64	51.02	0.38	4.06	1.25	5.00	2.17	1.27
YUCCA ANGUSTISSIMA SPANISH BAYONET	176.71	7.17	0.05	4.06	1.25	5.00	2.17	1.16
OPUNTIA WHIPPLEI WHIPPLE CHOLLA	575.96	70.21	0.52	12.19	3.75	10.00	4.35	2.87
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	490.87	19.93	0.15	4.06	1.25	5.00	2.17	1.19

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
30.75	325.19	0.47

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

Report 5

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-10
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4047365.00
UTMN(2): 4045483.00
UTME(1): 556352.90
UTME(2): 556335.50

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-60%
ASPECT: ALL
ELEVATION RANGE: 5730 - 7000

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
CHENOPODIUM CAPITATUM STRAWBERRY BLITHE	0.09	1.72	0.17	6.51	10.56	5.78	4.67
CRYPTANTHA BAKERI	0.14	2.68	0.12	4.69	10.56	5.78	4.35
EUPHORBIA SERPYLLIFOLIA RATTLESNAKE WEED	0.03	0.57	0.01	0.38	1.67	0.91	0.62
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	1.02	19.50	0.17	6.51	23.33	12.76	12.93
LEUCELENE ERICOIDES WHITE ASTER	0.20	3.82	0.12	4.69	4.44	2.43	3.62
PENSTEMON LINARIOIDES BAT PENSTEMON	0.97	18.55	0.45	17.24	32.78	17.93	17.91
PETRADORIA PUMILA ROCK GOLDENROD	0.22	4.21	0.06	2.30	2.22	1.21	2.57
PHYSARIA NEWBERRYI TWINPOD	0.02	0.38	0.01	0.38	1.67	0.91	0.56
SALSOLA IBERICA RUSSIAN THISTLE	0.02	0.38	0.03	1.15	1.67	0.91	0.82
STANLEYA PINNATA DESERT PLUME	0.08	1.53	0.00	0.00	0.56	0.31	0.61
ARABIS PERENNANS ROCK CRESS	0.06	1.15	0.05	1.92	8.33	4.56	2.54
ASTRAGALUS NEWBERRYI NEWBERRY MILK-VETCH	0.04	0.76	0.03	1.15	3.89	2.13	1.35
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.10	1.91	0.05	1.92	6.67	3.65	2.49
BOUTELOUA GRACILIS BLUE GRAMA	0.95	18.16	0.79	30.27	17.22	9.42	19.28
ERIOGONUM SPP.	0.08	1.53	0.01	0.38	2.22	1.21	1.04
HAPLOPAPPUS ARMERIOIDES GOLDENWEED	0.11	2.10	0.06	2.30	3.89	2.13	2.18

PEABODY COAL CO
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 2

MINE: KAYENTA
MINE AREA: 9-10
MONTH: 09
YEAR: 90

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4047366.00 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4045488.00 SLOPE: 0-60%
UTME(1): 556359.90 ASPECT: ALL
UTME(2): 556336.50 ELEVATION RANGE: 6790 - 7000

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
IPOMOPSIS AGGREGATA SKY ROCKET	0.14	2.68	0.11	4.21	9.44	5.16	4.02
LACTUCA SERRIOLA WILD LETTUCE	0.01	0.19	0.01	0.38	0.56	0.31	0.29
SITANION HYSTRIX SQUIRREL TAIL	0.11	2.10	0.06	2.30	5.00	2.73	2.38
HILARIA JAMESII GALLETA	0.01	0.19	0.01	0.38	1.11	0.61	0.39
LESQUERELLA INTERMEDIA BLADDER POD	0.04	0.76	0.03	1.15	5.00	2.73	1.55
LITHOSPERMUM MULTIFLORUM	0.02	0.38	0.00	0.00	0.56	0.31	0.23
TOWNSENDIA EXSCAPA GROUND DAISY	0.04	0.76	0.02	0.77	4.44	2.43	1.32
UNIDENTIFIED FORB SPECIES 1	0.01	0.19	0.00	0.00	0.56	0.31	0.17
STIPA COLUMBIANA COLUMBIA NEEDLEGRASS	0.01	0.19	0.01	0.38	0.56	0.31	0.29
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.19	3.63	0.07	2.68	8.33	4.56	3.62
STREPTANTHUS CORDATUS TWIST FLOWER	0.01	0.19	0.01	0.38	1.67	0.91	0.50
CORYPHANTHA VIVIPARA	0.02	0.38	0.00	0.00	0.56	0.31	0.23
ERIOGONUM CERNUUM NODDING ERIOGONUM	0.01	0.19	0.00	0.00	0.56	0.31	0.17
PENSTEMON EATONI EATON PENSTEMON	0.02	0.38	0.01	0.38	1.11	0.61	0.46
CORDYLANTHUS WRIGHTII BIRD BEAK	0.16	3.06	0.04	1.53	5.00	2.73	2.44
MACHAERANTHERA GRINDELIOIDES	0.22	4.21	0.03	1.15	2.22	1.21	2.19

Report 6 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: B-10
MONTH: 09
YEAR: 90

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4047365.00
UTMN(2): 4045489.00
UTME(1): 556359.90
UTME(2): 556339.50

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-60%
ASPECT: ALL
ELEVATION RANGE: 6780 - 7000

SPECIES NAME

		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
POA FENDLERIANA	MUTTON GRASS	0.02	0.38	0.01	0.33	0.56	0.31	0.36
PINUS EDULIS	COLORADO PINYON	0.00	0.00	0.00	0.00	0.56	0.31	0.10
ERIOGONUM JAMESII		0.01	0.19	0.00	0.00	0.56	0.31	0.17
ERIOGONUM ALATUM	WINGED ERIOGONUM	0.01	0.19	0.01	0.33	0.56	0.31	0.29
STIPA NEOMEXICANA	NEW MEXICAN FEATHERGRASS	0.02	0.38	0.05	1.92	1.11	0.61	0.97
OPUNTIA WHIPPLEI	WHIPPLE CHOLLA	0.01	0.19	0.00	0.00	0.56	0.31	0.17
ERIGERON CONCINNUS	TIDY FLEABANE	0.01	0.19	0.00	0.00	0.56	0.31	0.17

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
5.23	2.61	1.15

*** NOTES ***

LITTER COVERAGE = 7.44% ROCK COVERAGE = 2.81% LICHEN/MOSS COVERAGE = 0.25%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: TREE

UTMN(1): 4041500.19
UTMN(2): 4041414.81
UTME(1): 559835.70
UTME(2): 563610.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-55%
ASPECT: ALL
ELEVATION RANGE: 6700 - 6900

SPECIES NAME	MEAN BASAL AREA (CM2)	TOT. BASAL AREA (CM2/HA)	RELATIVE BASAL AREA (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	588.17	1012.30	28.99	172.11	58.75	95.00	54.29	47.34
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2052.37	2430.08	71.01	120.84	41.25	80.00	45.71	52.66

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
34.14	292.95	0.26

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: SHRUB

UTMN(1): 4041500.12
UTMN(2): 4041414.81
UTME(1): 559835.70
UTME(2): 563611.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-55%
ASPECT: ALL
ELEVATION RANGE: 6700 - 6900

SPECIES NAME	MEAN CANOPY COVERAGE (CM2)	TOT. CAN. COVERAGE (CM2/HA)	RELATIVE CAN. COVERAGE (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	2925.61	4429.37	29.07	151.40	27.50	60.00	26.67	27.74
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	2400.14	3468.68	22.76	144.52	26.25	45.00	20.00	23.00
COWANIA MEXICANA CLIFF ROSE	3445.46	4979.38	32.67	144.52	26.25	50.00	22.22	27.05
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2720.94	1310.63	8.60	49.17	8.75	30.00	13.33	10.23
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	2061.67	567.58	3.72	27.53	5.00	20.00	8.89	5.87
OPUNTIA SPP.	873.75	120.23	0.79	13.76	2.50	10.00	4.44	2.58
QUERCUS GAMBELII GAMBEL OAK	2601.63	357.98	2.35	13.76	2.50	5.00	2.22	2.36
YUCCA ANGUSTISSIMA SPANISH BAYONET	78.54	5.40	0.04	6.88	1.25	5.00	2.22	1.17

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
18.16	550.54	0.66

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

Report 8

PEABODY COAL CO.
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041500.19
UTMN(2): 4041414.81
UTME(1): 559835.70
UTME(2): 563610.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-55%
ASPECT: ALL
ELEVATION RANGE: 6700 - 6900

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
BOUTELOUA GRACILIS	BLUE GRAMA	0.90	17.72	1.09	36.33	21.67	13.09	22.38
CORDYLANTHUS WRIGHTII	BIRD BEAK	1.50	29.53	0.51	17.00	30.56	18.45	21.66
CRYPTANTHA BAKERI		0.06	1.18	0.04	1.33	5.00	3.02	1.84
ORYZOPSIS HYMENOIDES	INDIAN RICEGRASS	0.18	3.54	0.08	2.67	10.56	6.38	4.20
PENSTEMON LINARIOIDES	MAT PENSTEMON	0.51	10.04	0.13	4.33	7.78	4.70	6.36
ASTRAGALUS WINGATANUS	FORT WINGATE MILK-VETCH	0.13	2.56	0.05	1.67	7.78	4.70	2.97
HAPLOPAPPUS ARMERIOIDES	GOLDENWEED	0.02	0.39	0.02	0.67	1.11	0.67	0.58
LEUCELENE ERICOIDES	WHITE ASTER	0.04	0.79	0.07	2.33	3.89	2.35	1.82
POA FENDLERIANA	MUTTON GRASS	0.12	2.36	0.03	1.00	2.78	1.68	1.68
GUTIERREZIA SAROTHRAE	BROOM SNAKEWEED	0.25	4.92	0.11	3.67	11.11	6.71	5.10
HILARIA JAMESII	GALLETA	0.32	6.30	0.22	7.33	8.33	5.03	6.22
IPOMOPSIS AGGREGATA	SKY ROCKET	0.04	0.79	0.04	1.33	6.11	3.69	1.94
SITANION HYSTRIX	SQUIRREL TAIL	0.19	3.74	0.09	3.00	11.67	7.05	4.60
STREPTANTHUS CORDATUS	TWIST FLOWER	0.02	0.39	0.02	0.67	2.22	1.34	0.80
PENSTEMON EATONI	EATON PENSTEMON	0.01	0.20	0.00	0.00	0.56	0.34	0.18
PETRADORIA PUMILA	ROCK GOLDENROD	0.14	2.76	0.02	0.67	1.11	0.67	1.36

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041500.19 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4041414.81 SLOPE: 0-55%
UTME(1): 559835.70 ASPECT: ALL
UTME(2): 563611.00 ELEVATION RANGE: 5700 - 6900

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ASTRAGALUS CALYCOSUS VAR. SCAPIOSUS TORREY MILK-VETCH	0.02	0.39	0.01	0.33	1.67	1.01	0.58
ERIOGONUM MICROTHECUM WILD BUCKWHEAT	0.02	0.39	0.01	0.33	1.11	0.67	0.47
ASTRAGALUS SPP.	0.13	2.56	0.05	1.67	6.67	4.03	2.75
ERIOGONUM JAMESII	0.10	1.97	0.01	0.33	1.11	0.67	0.99
STIPA COLUMBIANA COLUMBIA NEEDLEGRASS	0.09	1.77	0.12	4.00	3.33	2.01	2.59
TRAGOPOGON DUBIUS GOAT'S BEARD	0.01	0.20	0.00	0.00	0.56	0.34	0.18
TOWNSENDIA EXSCAPA GROUND DAISY	0.00	0.00	0.00	0.00	0.56	0.34	0.11
ARABIS PERENNANS ROCK CRESS	0.04	0.79	0.03	1.00	4.44	2.68	1.49
ASTRAGALUS NEWBERRYI NEWBERRY MILK-VETCH	0.01	0.20	0.01	0.33	1.11	0.67	0.40
CHENOPODIUM CAPITATUM STRAWBERRY BLITE	0.03	0.59	0.11	3.67	3.89	2.35	2.20
COWANIA MEXICANA CLIFF ROSE	0.01	0.20	0.06	2.00	1.11	0.67	0.96
PINUS EDULIS COLORADO PINYON	0.00	0.00	0.00	0.00	0.56	0.34	0.11
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	0.00	0.00	0.00	0.00	0.56	0.34	0.11
STANLEYA PINNATA DESERT PLUME	0.11	2.17	0.00	0.00	0.56	0.34	0.83
ERIOGONUM SPP.	0.01	0.20	0.01	0.33	1.11	0.67	0.40
HYMENOPAPPUS FILIFOLIUS	0.02	0.39	0.02	0.67	1.11	0.67	0.58

Report 9 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 3

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041500.19
UTMN(2): 4041414.81
UTME(1): 559135.70
UTME(2): 563610.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-5%
ASPECT: ALL
ELEVATION RANGE: 6700 - 6900

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
LESQUERELLA INTERMEDIA	BLADDER POD	0.03	0.59	0.02	0.67	2.78	1.68	0.98
COMPOSITAE	UNIDENTIFIED COMPOSITE	0.01	0.20	0.01	0.33	0.56	0.34	0.29
ERIOGONUM UMBELLATUM	WILD BUCKWHEAT	0.01	0.20	0.01	0.33	0.56	0.34	0.29

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
5.08	3.00	1.08

*** NOTES ***

LITTER COVERAGE = 5.39% ROCK COVERAGE = 2.49% LICHEN/MOSS COVERAGE = 0.44%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EMRA FIELD SHEETS

Report 9 (Cont.)

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: TREE

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	MEAN BASAL AREA (CM2)	TOT. BASAL AREA (DM2/HA)	RELATIVE BASAL AREA (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2000.81	2932.79	75.63	146.58	42.50	87.78	47.88	55.34
PINUS EDULIS COLORADO PINYON	482.26	942.53	24.30	195.44	56.67	92.22	50.30	43.76
QUERCUS GAMBELII GAMBEL OAK	92.23	2.65	0.07	2.87	0.83	3.33	1.82	0.90

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
28.99	344.89	0.24

*** NOTES ***

--- SAMPLE ADEQUACY (DENSITY) ---
SAMPLE SIZE = 18 MEAN DENSITY = 0.03758 ST. DEV. = 0.01164
*MINIMUM SAMPLE REQUIRED = 15.7

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
ARABIS PERENNANS ROCK CRESS	0.01	0.46	0.13	6.28	9.58	5.81	4.18	0.03	0.01	0.97
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	0.26	11.98	0.10	4.83	10.00	6.06	7.62	0.06	0.03	
ASTRAGALUS CALYCOSUS VAR. SCAPIOSUS TORREY MILK-VETCH	0.00	0.00	0.03	1.45	4.17	2.53	1.33	0.01	0.01	
ASTRAGALUS NEWBERRYI NEWBERRY MILK-VETCH	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.02	0.01	1.00
ASTRAGALUS SPP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.02	
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.19	1.00
BOUTELOUA GRACILIS BLUE GRAMA	0.10	4.61	0.60	28.99	14.17	8.59	14.06	0.01	0.00	
CHENOPODIUM FREMONTII GOOSEFOOT	0.00	0.00	0.01	0.48	1.25	0.76	0.41	0.02	0.00	1.00
CHRYSOTHAMNUS GREENEI RABBIT BRUSH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
CHENOPODIUM LEPTOPHYLUM GOOSEFOOT	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.01	0.00	
COWANIA MEXICANA CLIFF ROSE	0.36	16.59	0.04	1.93	8.33	5.05	7.86	1.73	0.94	1.00
CORDYLANTHUS WRIGHTII BIRD BEAK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.09	
CRYPTANTHA BAKERI	0.01	0.46	0.05	2.42	5.42	3.28	2.05	0.00	0.00	0.96
DESCURAINIA PINNATA TANSY MUSTARD	0.00	0.00	0.02	0.97	0.83	0.50	0.49	0.15	0.05	
ERODIUM CICUTARIUM FILAREE	0.00	0.00	0.01	0.48	1.25	0.76	0.41	0.62	0.48	0.93
ERIGERON DIVERGENS SPREADING FLEABANE	0.00	0.00	0.00	0.00	0.42	0.25	0.08	1.12	0.55	1.00

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
ERIOGONUM JAMESII	0.01	0.46	0.01	0.48	1.67	1.01	0.65	0.00	0.00	1.00
ERIOGONUM SPP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.13	5.99	0.28	13.53	17.92	10.86	10.13	3.04	1.50	0.98
HILARIA JAMESII GALLETA	0.02	0.92	0.08	3.86	2.08	1.26	2.02	0.38	0.15	
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	0.25	11.52	0.00	0.00	2.50	1.51	4.35	0.05	0.03	
LACTUCA SERRIOLA WILD LETTUCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	
LEUCELENE ERICOIDES WHITE ASTER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	
LESQUERELLA INTERMEDIA BLADDER POD	0.01	0.46	0.05	2.42	5.83	3.53	2.14	0.01	0.00	
LYCIUM PALLIDUM RABBIT THORN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.05	2.30	0.08	3.86	7.50	4.54	3.57	0.14	0.06	0.99
PENSTEMON BARBATUS BEARD TONGUE	0.01	0.46	0.01	0.48	1.67	1.01	0.65	0.09	0.03	0.94
PENSTEMON LINARIOIDES MAT PENSTEMON	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.00	0.00	0.99
PETRADORIA PUMILA ROCK GOLDENROD	0.06	2.76	0.07	3.38	7.50	4.54	3.56	0.40	0.20	0.97
PINUS EDULIS COLORADO PINYON	0.72	33.18	0.06	2.90	18.75	11.36	15.81	0.11	0.04	0.98
POA FENDLERIANA MUTTON GRASS	0.00	0.00	0.02	0.97	3.33	2.02	0.99	0.37	0.12	1.00
PORTULACA OLERACEA COMMON PURSLANE	0.00	0.00	0.02	0.97	1.25	0.76	0.57	0.04	0.00	1.00

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACECUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
QUERCUS GAMBELII GAMBEL OAK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.24	
SALSOLA IBERICA RUSSIAN THISTLE	0.01	0.46	0.03	1.45	1.25	0.76	0.89	0.00	0.00	
SENECIO NEOMEXICANA GROUNDSEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SITANION HYSTRIX SQUIRREL TAIL	0.02	0.92	0.13	6.28	16.25	9.85	5.68	0.21	0.11	1.00
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
TOWNSENDIA EXSCAPA GROUND DAISY	0.00	0.00	0.02	0.97	3.33	2.02	0.99	0.00	0.00	
UNIDENTIFIED FORB SPECIES 1	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.00	0.00	
OPUNTIA FRAGILIS VAR. FRAGILIS LITTLE PRICKLY PEAR	0.10	4.61	0.04	1.93	1.67	1.01	2.52	0.00	0.00	
OPUNTIA PHAEACANTHA	0.01	0.46	0.01	0.48	1.67	1.01	0.65	0.00	0.00	
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	0.01	0.46	0.01	0.48	1.25	0.76	0.57	0.00	0.00	
HYMENOXYS ACAULIS BITTERWEED	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.00	0.00	
THLASPI MONTANUM VAR. FENDLERI WILD CANDYTUFT	0.00	0.00	0.04	1.93	0.42	0.25	0.73	0.00	0.00	
CHENOPODIUM GRAVEOLENS	0.00	0.00	0.03	1.45	2.92	1.77	1.07	0.00	0.00	
STREPTANTHUS CORDATUS TWIST FLOWER	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.00	0.00	
UNIDENTIFIED FORB SPECIES 2	0.00	0.00	0.04	1.93	0.83	0.50	0.81	0.00	0.00	
CHENOPODIUM BERLANDIERI GOOSEFOOT	0.00	0.00	0.02	0.97	2.08	1.26	0.74	0.00	0.00	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

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ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
EUPHORBIA FENDLERI FENDLER SPURGE	0.00	0.00	0.02	0.97	2.08	1.26	0.74	0.00	0.00	
SCLEROCACTUS PARVIFLORUS	0.00	0.00	0.00	0.00	0.42	0.25	0.08	0.00	0.00	
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.00	0.00	0.01	0.48	2.08	1.26	0.58	0.00	0.00	
YUCCA ANGUSTISSIMA SPANISH BAYONET	0.02	0.92	0.00	0.00	0.83	0.50	0.47	0.00	0.00	

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY	TOT. FRESH PRODUCTION	TOT. DRY PRODUCTION
2.17	2.07	0.93	9.70	4.89

*** NOTES ***

TOTAL NON-OVERLAPPING COVERAGE = 2.00%
LITTER COVERAGE = 34.22% ROCK COVERAGE = 3.50% LICHEN/MOSS COVERAGE = 0.68%
SPECIES WITH COVER VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO TOTAL COVER

--- SAMPLE ADEQUACY (COVER) ---
SAMPLE SIZE = 12 ST. DEV. = 0.63
*MINIMUM SAMPLE REQUIRED = 14.0

--- SAMPLE ADEQUACY (PRODUCTION) ---
SAMPLE SIZE (EST/CLP) = 66/39 VARIANCE = 1912.20
COEF. OF DET.(R**2) = 0.98 REDUCTION(D) = 0.710
*AMOUNT OF REDUCTION DESIRED = 0.1

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

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ARABIS PERENNANS ROCK CRESS	0.01	0.41	0.14	2.67	14.67	5.63	2.90	0.10	0.02	0.96
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	0.30	12.30	0.05	0.95	6.52	2.50	5.25	0.00	0.00	0.99
ASTRAGALUS CALYCOSUS VAR. SCAPICSUS TORREY MILK-VETCH	0.01	0.41	0.02	0.38	1.96	0.75	0.51	0.01	0.00	
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.01	0.41	0.04	0.76	3.70	1.42	0.86	0.05	0.01	1.00
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	0.15	6.15	0.01	0.19	1.96	0.75	2.36	0.48	0.20	0.99
BOUTELOUA GRACILIS BLUE GRAMA	0.16	6.56	0.73	13.90	12.72	4.88	8.45	0.09	0.04	
BROMUS TECTORUM CHEATGRASS	0.00	0.00	0.02	0.38	3.04	1.17	0.52	0.08	0.00	1.00
CHRYSOTHAMNUS GREENEI RABBIT BRUSH	0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.01	0.01	
CHENOPODIUM LEPTOPHYLUM GOOSEFOOT	0.00	0.00	0.00	0.00	0.22	0.08	0.03	0.00	0.00	
COWANIA MEXICANA CLIFF ROSE	0.88	36.07	0.31	5.90	20.43	7.84	16.60	3.95	2.16	0.87
CRYPTANTHA BAKERI	0.01	0.41	0.06	1.14	7.83	3.01	1.52	1.02	0.23	1.00
CYMOPTERUS PURPUREUS CYMOPTERUS	0.04	1.64	0.35	6.67	10.87	4.17	4.16	0.09	0.02	0.99
DESCURAINIA PINNATA TANSY MUSTARD	0.03	1.23	0.57	10.86	13.48	5.17	5.75	0.00	0.00	0.97
DRABA CUNEIFOLIA WHITLOW-GRASS	0.01	0.41	0.45	8.57	11.30	4.34	4.44	0.02	0.01	1.00
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.00	0.00	
ERIGERON CONCINNUS TIDY FLEABANE	0.02	0.82	0.01	0.19	1.20	0.46	0.49	0.01	0.01	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

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ERIOGONUM JAMESII	0.03	1.23	0.06	1.14	6.09	2.34	1.57	0.76	0.26	0.80
GILIA LEPTOMERIA GILIA	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.11	4.51	0.51	9.71	26.96	10.35	8.19	1.08	0.48	0.87
HILARIA JAMESII GALLETA	0.08	3.28	0.16	3.05	2.83	1.09	2.47	0.05	0.02	
LAPPULA REDOWSKI STICKSEED	0.00	0.00	0.02	0.38	1.96	0.75	0.38	0.01	0.00	1.00
LEUCELENE ERICOIDES WHITE ASTER	0.02	0.82	0.21	4.00	5.54	2.13	2.32	0.10	0.03	0.96
LESQUERELLA INTERMEDIA BLADDER POD	0.00	0.00	0.08	1.52	5.11	1.96	1.16	0.00	0.00	0.68
LUPINUS BREVICAULUS	0.00	0.00	0.05	0.95	3.04	1.17	0.71	0.00	0.00	
MENTHA ARVENSIS FIELD MINT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	
OPUNTIA PHAEACANTHA	0.01	0.41	0.01	0.19	0.98	0.38	0.33	0.00	0.00	1.00
OPUNTIA WHIPPLEI WHIPPLE CHOLLA	0.00	0.00	0.00	0.00	0.22	0.08	0.03	0.01	0.00	
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.10	4.10	0.23	4.38	20.98	8.05	5.51	0.09	0.03	0.97
PENSTEMON BARBATUS BEARD TONGUE	0.00	0.00	0.03	0.57	2.17	0.83	0.47	0.01	0.00	
PENSTEMON LINARIOIDES MAT PENSTEMON	0.05	2.05	0.18	3.43	8.70	3.34	2.94	0.04	0.01	1.00
PETRADORIA PUMILA ROCK GOLDENROD	0.05	2.05	0.07	1.33	3.70	1.42	1.60	0.00	0.00	0.99
PHLOX LONGIFOLIA PHLOX	0.00	0.00	0.02	0.38	1.30	0.50	0.29	0.00	0.00	1.00

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

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VEGETATIVE COMMUNITY: PINYON-JUNIPER
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PINUS EDULIS	COLORADO PINYON	0.18	7.38	0.05	0.95	8.91	3.42	3.92	1.42	0.77	0.91
POA FENDLERIANA	MUTTON GRASS	0.02	0.82	0.05	0.95	3.37	1.29	1.02	0.26	0.09	0.98
QUERCUS GAMBELII	GAMBEL OAK	0.03	1.23	0.01	0.19	0.43	0.17	0.53	0.02	0.01	
SITANION HYSTRIX	SQUIRREL TAIL	0.04	1.64	0.40	7.62	24.89	9.56	6.27	0.22	0.07	0.58
SPHAERALCEA COCCINEA	SCARLET GLOBEMALLOW	0.01	0.41	0.13	2.48	2.17	0.83	1.24	0.08	0.04	
STANLEYA PINNATA	DESERT PLUME	0.00	0.00	0.01	0.19	0.65	0.25	0.15	4.68	0.87	1.00
TOWNSENDIA EXSCAPA	GROUND DAISY	0.00	0.00	0.01	0.19	1.74	0.67	0.29	0.00	0.00	
CHENOPODIUM FREMONTII	GOOSEFOOT	0.00	0.00	0.02	0.38	1.74	0.67	0.35	0.00	0.00	
JUNIPERUS OSTEOSPERMA	UTAH JUNIPER	0.01	0.41	0.01	0.19	2.28	0.88	0.49	0.00	0.00	
MALACOTHRIX SONCHOIDES VAR.TORREYI	MALACOTHRIX	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
HAPLOPAPPUS SPP.	GOLDENWEED	0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.00	0.00	
LYCIUM PALLIDUM	RABBIT THORN	0.01	0.41	0.01	0.19	0.98	0.38	0.33	0.00	0.00	
SALSOLA IBERICA	RUSSIAN THISTLE	0.00	0.00	0.04	0.76	1.41	0.54	0.43	0.00	0.00	
HYMENOPAPPUS FILIFOLIUS		0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.00	0.00	
HAPLOPAPPUS ARMERIOIDES	GOLDENWEED	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
PENSTEMON SPP.	PENSTEMON	0.01	0.41	0.04	0.76	2.61	1.00	0.72	0.00	0.00	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
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CRUCIFERAE SPP.	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
IPOMOPSIS AGGREGATA SKY ROCKET	0.00	0.00	0.01	0.19	1.52	0.58	0.26	0.00	0.00	
CHRYSOTHAMNUS NAUSEOSUS RAYLESS GOLDENROD	0.02	0.82	0.01	0.19	0.43	0.17	0.39	0.00	0.00	
ECHINOCEREUS TRIGLOCHIDIATUS VAR. MELANACANTHUS HEDGEHOG CACTUS	0.00	0.00	0.00	0.00	0.22	0.08	0.03	0.00	0.00	
AGROPYRON TRACHYCAULUM SLENDER WHEATGRASS	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
HYMENOXYS ACAULIS BITTERWEED	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
ASTRAGALUS ZIONIS MILK-VETCH	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
ERIGERON DIVERGENS SPREADING FLEABANE	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
CALOCHORTUS NUTTALLII SEGO LILY	0.00	0.00	0.00	0.00	0.22	0.08	0.03	0.00	0.00	
MACHAERANTHERA GRINDELIOIDES	0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.00	0.00	
STREPTANTHUS CORDATUS TWIST FLOWER	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
ALLIUM MACROPETALUM WILD ONION	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
UNIDENTIFIED FORB SPECIES 2	0.00	0.00	0.01	0.19	0.43	0.17	0.12	0.00	0.00	
CAREX SPP. SEDGE	0.00	0.00	0.00	0.00	0.22	0.08	0.03	0.00	0.00	
PEDICULARIS CENTRANTHERA WOOD BETONY	0.01	0.41	0.02	0.38	0.87	0.33	0.37	0.00	0.00	
PLANTAGO PURSHII PURSH PLAINTAIN	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

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MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

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VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
TRIFOLIUM SUBCAULESCENS	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
YUCCA ANGUSTISSIMA SPANISH BAYONET	0.01	0.41	0.00	0.00	0.22	0.08	0.16	0.00	0.00	
OXYTROPIS LAMBERTII VAR. BIGELOVII AMBERT LOCOWEED	0.01	0.41	0.00	0.00	0.22	0.08	0.16	0.00	0.00	
ARISTIDA FENDLERIANA FENDLER'S THREE-AWN	0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.00	0.00	
LITHOSPERMUM INCISUM PUCCOON	0.00	0.00	0.00	0.00	0.33	0.13	0.04	0.00	0.00	
OPUNTIA FRAGILIS VAR. FRAGILIS LITTLE PRICKLY PEAR	0.00	0.00	0.00	0.00	0.43	0.17	0.06	0.00	0.00	
UNIDENTIFIED FORB SPECIES 1	0.00	0.00	0.00	0.00	0.22	0.08	0.03	0.00	0.00	
PHYSARIA NEWBERRYI TWINPOD	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
MENTZELIA ALBICAULIS BLAZING STAR	0.00	0.00	0.02	0.38	0.22	0.08	0.16	0.00	0.00	
ASTRAGALUS NEWBERRYI NEWBERRY MILK-VETCH	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	
PENSTEMON EATONI EATON PENSTEMON	0.00	0.00	0.01	0.19	0.65	0.25	0.15	0.00	0.00	
EUPHORBIA FENDLERI FENDLER SPURGE	0.00	0.00	0.00	0.00	0.11	0.04	0.01	0.00	0.00	

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY	TOT. FRESH PRODUCTION	TOT. DRY PRODUCTION
2.44	5.25	1.07	14.75	5.42

Report 12 (Cont.)

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7200

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED

*** NOTES ***

TOTAL NON-OVERLAPPING COVERAGE = 2.43%
LITTER COVERAGE = 31.25% ROCK COVERAGE = 3.94% LICHEN/MOSS COVERAGE = 1.12%
SPECIES WITH COVER VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO TOTAL COVER

--- SAMPLE ADEQUACY (COVER) ---
SAMPLE SIZE = 46 ST. DEV. = 1.30
*MINIMUM SAMPLE REQUIRED = 46.5

--- SAMPLE ADEQUACY (PRODUCTION) ---
SAMPLE SIZE (EST/CLP) = 185/65 VARIANCE = 132.56
COEF. OF DET.(R**2) = 0.96 REDUCTION(D) = 0.073
*AMOUNT OF REDUCTION DESIRED = 0.1

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-7/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: TREE

UTMN(1): 4043465.00
UTMN(2): 4043497.50
UTME(1): 550027.00
UTME(2): 550066.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6690 - 6800

SPECIES NAME	MEAN BASAL AREA (CM2)	TOT. BASAL AREA (CM2/HA)	RELATIVE BASAL AREA (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	199.73	635.21	11.44	127.11	40.00	75.00	44.12	31.95
JUNIPERUS OSTEOSPERMA JTAH JUNIPER	2578.55	1916.52	88.56	190.67	60.00	95.00	55.88	68.15

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
31.47	317.78	0.15

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-1/2
PERMIT: 10
YEAR: 79

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: SHRUB

UTMN(1): 4043666.00 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4043497.50 SLOPE: 0-5%
UTME(1): 550027.00 ASPECT: ALL
UTME(2): 550066.00 ELEVATION RANGE: 6490 - 6800

SPECIES NAME	MEAN CANOPY COVERAGE (CM2)	TOT. CAN. COVERAGE (CM2/HA)	RELATIVE CAN. COVERAGE (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
OPUNTIA SPP.	615.23	152.15	0.46	24.73	3.75	15.00	6.00	3.40
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2251.02	930.76	2.83	41.22	6.25	25.00	10.00	6.36
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	4247.62	3151.79	9.59	74.20	11.25	25.00	10.00	10.28
LYCIUM PALLIDUM RABBIT THORN	148.92	71.23	0.22	49.47	7.50	15.00	6.00	4.57
YUCCA BACCATA BANANA YUCCA	1963.49	161.79	0.49	8.24	1.25	5.00	2.00	1.25
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	7090.39	5261.07	16.00	74.20	11.25	25.00	10.00	12.42
PINUS EDULIS COLORADO PINYON	5430.79	7611.25	23.15	140.15	21.25	55.00	22.00	22.13
YUCCA ANGUSTISSIMA SPANISH BAYONET	1747.51	288.16	0.88	16.49	2.50	10.00	4.00	2.46
COWANIA MEXICANA CLIFF ROSE	6641.28	11493.05	34.97	173.13	26.25	50.00	20.00	27.07
FENDLERA RUPICOLA FENDLER BUSH	6531.89	3231.33	9.83	49.47	7.50	20.00	8.00	8.44
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	6361.72	524.21	1.59	8.24	1.25	5.00	2.00	1.61

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
15.16	659.54	0.75

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-7/8
SOUTH: 10
YEAR: 79

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4043665.00 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4043497.50 SLOPE: 0-50%
UTME(1): 550027.00 ASPECT: ALL
UTME(2): 550066.00 ELEVATION RANGE: 6610 - 6800

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARABIS PERENNANS ROCK CRESS	0.04	0.77	0.03	0.55	4.44	1.41	0.91
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.07	1.35	0.06	1.09	5.00	1.59	1.34
COMPOSITAE UNIDENTIFIED COMPOSITE	0.04	0.77	0.03	0.55	4.44	1.41	0.91
CRYPTANTHA BAKERI	0.03	0.58	0.08	1.46	8.31	2.65	1.56
CYMOPTERUS PURPUREUS CYMOPTERUS	0.11	2.12	0.13	2.37	7.22	2.30	2.26
DRABA CUNEIFOLIA WHITLOW-GRASS	0.00	0.00	0.00	0.00	0.56	0.18	0.06
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.95	18.30	0.46	8.38	43.33	13.78	13.49
LEUCELENE ERICOIDES WHITE ASTER	0.18	3.47	0.39	7.10	10.00	3.18	4.58
PEDICULARIS CENTRANTHERA WOOD BETONY	0.16	3.08	0.08	1.46	4.44	1.41	1.98
PENSTEMON LINARIOIDES MAT PENSTEMON	0.24	4.62	0.21	3.83	17.22	5.48	4.64
SITANION HYSTRIX SQUIRREL TAIL	0.37	7.13	0.48	8.74	30.00	9.54	8.47
STREPTANTHUS CORDATUS TWIST FLOWER	0.02	0.39	0.03	0.55	3.33	1.06	0.66
GRAMINEAE UNIDENTIFIED GRASS SEEDLING	0.37	7.13	0.53	9.65	9.44	3.00	6.59
BROMUS TECTORUM CHEATGRASS	0.00	0.00	0.00	0.00	0.56	0.18	0.06
CYMOPTERUS PURPURASCENS	0.00	0.00	0.01	0.19	0.56	0.18	0.12
DESCURAINIA SPP. TANSY MUSTARD	0.00	0.00	0.01	0.01	0.56	0.18	0.06

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-7/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041665.00
UTMN(2): 4043497.50
UTME(1): 550027.00
UTME(2): 550065.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-50%
ASPECT: ALL
ELEVATION RANGE: 6680 - 6800

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
JUNIPERUS OSTEOSPERMA — UTAH JUNIPER	0.01	0.19	0.01	0.18	1.67	0.53	0.30
ORYZOPSIS HYMENOIDES — INDIAN RICEGRASS	0.43	8.29	0.52	9.47	35.56	11.31	9.69
BOUTELOUA GRACILIS — BLUE GRAMA	0.66	12.72	0.74	13.48	18.89	6.01	10.73
DESCURAINIA SOPHIA — FLIXWEED	0.01	0.19	0.04	0.73	5.00	1.59	0.84
LESQUERELLA INTERMEDIA — BLADDER POD	0.08	1.54	0.13	2.37	11.67	3.71	2.54
MACHAERANTHERA GRINDELIOIDES	0.02	0.39	0.02	0.36	1.67	0.53	0.43
POA FENDLERIANA — MUTTON GRASS	0.29	5.59	0.22	4.01	11.11	3.53	4.38
SOLIDAGO SPARSIFLORA — GOLDENROD	0.06	1.16	0.03	0.55	2.78	0.88	0.86
CRUCIFERAE SPP.	0.01	0.19	0.02	0.36	2.22	0.71	0.42
ERIOGONUM SPP.	0.07	1.35	0.05	0.91	6.11	1.94	1.40
PENSTEMON BARBATUS — BEARD TONGUE	0.07	1.35	0.05	0.91	4.44	1.41	1.22
STIPA NEOMEXICANA — NEW MEXICAN FEATHERGRASS	0.04	0.77	0.05	0.91	4.44	1.41	1.03
IPOMOPSIS AGGREGATA — SKY ROCKET	0.02	0.39	0.06	1.09	6.67	2.12	1.20
LUPINUS BREVICAULUS	0.00	0.00	0.01	0.18	1.67	0.53	0.24
PHYSARIA NEWBERRYI — TWINPOD	0.01	0.19	0.01	0.18	2.22	0.71	0.36
SPHAERALCEA COCCINEA — SCARLET GLOBEMALLOW	0.15	2.99	0.24	4.37	5.56	1.77	3.01

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 3

MINE: KAYENTA
MINE AREA: N-1/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4043655.00 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4043497.50 SLOPE: 0-50%
UTME(1): 560027.00 ASPECT: ALL
UTME(2): 560046.00 ELEVATION RANGE: 6680 - 6800

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
UNIDENTIFIED FORB SPECIES 3	0.00	0.00	0.00	0.00	0.56	0.18	0.06
ALLIUM MACROPETALUM WILD ONION	0.00	0.00	0.01	0.18	0.56	0.18	0.12
GRAMINEAE UNIDENTIFIED GRASS 2	0.02	0.39	0.03	0.55	1.11	0.35	0.43
CHENOPODIUM SPP.	0.05	0.96	0.16	2.91	6.67	2.12	2.00
LAPPULA REDOWSKI STICKSEED	0.04	0.77	0.09	1.64	3.33	1.06	1.16
PENSTEMON EATONII EATON PENSTEMON	0.05	0.96	0.04	0.73	2.78	0.88	0.86
UNIDENTIFIED FORB SPECIES 1	0.01	0.19	0.03	0.55	1.11	0.35	0.36
UNIDENTIFIED FORB SPECIES 2	0.03	0.58	0.03	0.55	3.33	1.06	0.73
CRYPTANTHA SPP. CRYPTANTHA	0.00	0.00	0.00	0.00	1.11	0.35	0.12
GILIA LEPTOMERIA GILIA	0.03	0.58	0.06	1.09	3.33	1.06	0.91
HYMENOPAPPUS FILIFOLIUS	0.14	2.70	0.02	0.36	0.56	0.18	1.08
GRAMINEAE UNIDENTIFIED GRASS 3	0.03	0.58	0.02	0.36	1.11	0.35	0.43
PETRADORIA PUMILA ROCK GOLDENROD	0.01	0.19	0.01	0.18	0.56	0.18	0.18
HAPLOPAPPUS ARBERIOIDES GOLDENWEED	0.08	1.54	0.06	1.09	3.89	1.24	1.29
PINUS EDULIS COLORADO PINYON	0.01	0.19	0.01	0.18	1.11	0.35	0.24
UNIDENTIFIED FORB SPECIES 4	0.03	0.58	0.02	1.45	1.67	0.53	0.82

Report 15 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-1/8
MONTH: 10
YEAR: 79

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4043665.00
UTMN(2): 4043497.50
UTME(1): 550027.00
UTME(2): 550066.00

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-5%
ASPECT: ALL
ELEVATION RANGE: 6680 - 6800

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
HILARIA JAMESII	GALLETA	0.08	1.54	0.10	1.82	7.78	2.47	1.95
ASCLEPIAS ASPERULA	MILKWEED	0.02	0.39	0.00	0.00	0.56	0.18	0.19
EUPHORBIA SERPYLLIFOLIA	RATTLESNAKE WEED	0.01	0.19	0.00	0.00	0.56	0.18	0.12
SENECIO NEOMEXICANA	GROUNDSEL	0.01	0.19	0.00	0.00	0.56	0.18	0.12
ERIOGONUM UMBELLATUM	WILD BUCKWHEAT	0.03	0.58	0.01	0.18	1.11	0.35	0.37

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
5.19	5.49	1.31

*** NOTES ***

LITTER COVERAGE = 5.51% ROCK COVERAGE = 9.05% LICHEN/MOSS COVERAGE = 0.02%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL C
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-14
MONTH: 07
YEAR: 90

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: TREE

UTMN(1): 4042115.69 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4041984.81 SLOPE: 0-55%
UTME(1): 559386.80 ASPECT: ALL
UTME(2): 559517.80 ELEVATION RANGE: 6750 - 6830

SPECIES NAME	MEAN BASAL AREA (CM2)	TOT. BASAL AREA (CM2/HA)	RELATIVE BASAL AREA (%)	DENSITY (SP/HA)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	511.72	907.22	11.39	99.12	36.00	80.00	43.48	30.29
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	2308.53	3940.98	81.49	170.71	62.00	100.00	54.35	68.28
QUERCUS GAMBELII GAMBEL OAK	97.27	5.36	0.12	5.51	2.00	4.00	2.17	1.43

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
36.32	275.34	0.16

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-14
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: SHRUB

UTMN(1): 4042115.69
UTMN(2): 4041984.81
UTME(1): 559385.80
UTME(2): 559517.90

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-55%
ASPECT: ALL
ELEVATION RANGE: 6750 - 6810

SPECIES NAME	MEAN CANOPY COVERAGE (CM2)	TOT. CAN. COVERAGE (CM2/1A)	RELATIVE CAN. COVERAGE (%)	DENSITY (SP/1A)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PINUS EDULIS COLORADO PINYON	6206.74	7497.77	32.01	120.80	30.83	63.33	26.39	29.74
COWANIA MEXICANA CLIFF ROSE	7281.26	7556.56	32.26	94.68	24.17	60.00	25.00	27.14
EPHEDRA VIRIDIS MOUNTAIN JOINT-FIR	1154.53	492.98	2.09	42.44	10.83	26.67	11.11	8.01
ECHINOCEREUS TRIGLOCHIDIATUS VAR. MELANACANTHUS HEDGEHOG CACTUS	132.73	4.33	0.02	3.26	0.83	3.33	1.39	0.75
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	7291.62	3095.41	13.21	42.44	10.83	30.00	12.50	12.18
OPUNTIA WHIPPLEI WHIPPLE CHOLLA	1590.43	51.85	0.22	3.26	0.83	3.33	1.39	0.81
QUERCUS GAMBELII GAMBEL OAK	8964.70	4097.76	17.49	45.71	11.67	20.00	8.33	12.50
OPUNTIA SPP.	405.79	39.73	0.17	9.79	2.50	10.00	4.17	2.28
YUCCA ANGUSTISSIMA SPANISH BAYONET	373.06	36.52	0.16	9.79	2.50	10.00	4.17	2.27
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	2837.25	555.82	2.37	19.59	5.00	13.33	5.55	4.31

MEAN AREA	TOTAL DENSITY	SPECIES DIVERSITY
25.52	391.79	0.65

*** NOTES ***

REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-14
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4042115.69 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4041984.81 SLOPE: 0-55%
UTME(1): 559385.80 ASPECT: ALL
UTME(2): 559517.80 ELEVATION RANGE: 6750 - 6380

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
BOUTELOUA GRACILIS BLUE GRAMA	0.97	19.00	1.26	25.56	14.00	6.98	17.18
CHENOPODIUM CAPITATUM STRAWBERRY BLITHE	0.13	2.84	1.42	28.80	19.33	9.63	13.76
CRYPTANTHA BAKERI	0.06	1.31	0.14	2.84	9.33	4.65	2.93
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	1.22	26.64	0.36	7.30	31.33	15.61	16.52
HILARIA JAMESII GALLETA	0.16	3.49	0.09	1.83	4.67	2.33	2.55
LESQUERELLA INTERMEDIA BLADDER POD	0.05	1.09	0.08	1.62	9.33	4.65	2.45
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.41	8.95	0.20	4.06	16.67	8.31	7.10
PENSTEMON LINARIOIDES MAT PENSTEMON	0.60	13.10	0.31	6.29	25.33	12.62	10.67
PINUS EDULIS COLORADO PINYON	0.01	0.22	0.01	0.20	1.33	0.66	0.36
SITANION HYSTRIX SQUIRREL TAIL	0.15	3.28	0.09	1.83	8.67	4.32	3.14
UNIDENTIFIED FORB SPECIES 1	0.01	0.22	0.01	0.20	1.33	0.66	0.36
CYMOPTERUS PURPUREUS CYMOPTERUS	0.04	0.87	0.06	1.22	4.67	2.33	1.47
ERIOGONUM ALATUM WINGED ERIOGONUM	0.04	0.87	0.03	0.61	4.00	1.99	1.16
IPOMOPSIS AGGREGATA SKY ROCKET	0.02	0.44	0.05	1.01	5.33	2.66	1.37
LACTUCA SERRIOLA WILD LETTUCE	0.00	0.00	0.00	0.00	0.67	0.33	0.11
PEDICULARIS CENTRANTHERA WOOD BETONY	0.01	0.22	0.01	0.20	2.00	1.00	0.47

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-14
NORTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4042115.69
UTMN(2): 4041984.81
UTME(1): 559386.80
UTME(2): 559517.80

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-5%
ASPECT: ALL
ELEVATION RANGE: 6750 - 6980

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PHYSARIA NEWBERRYI TWINPOD	0.00	0.00	0.01	0.20	1.33	0.66	0.29
TOWNSENDIA EXSCAPA GROUND DAISY	0.01	0.22	0.03	0.61	2.67	1.33	0.72
ARABIS PERENNANS ROCK CRESS	0.04	0.87	0.05	1.01	4.67	2.33	1.40
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.09	1.97	0.04	0.81	2.67	1.33	1.37
CAREX SPP. SEDGE	0.12	2.62	0.05	1.01	2.67	1.33	1.65
LUPINUS BREVICAULUS	0.00	0.00	0.00	0.00	0.67	0.33	0.11
POA FENDLERIANA MUTTON GRASS	0.15	3.28	0.11	2.23	6.00	2.99	2.83
ASTRAGALUS CALYCOSUS VAR. SCAPIOSUS TORREY MILK-VETCH	0.01	0.22	0.01	0.20	1.33	0.66	0.36
MACHAERANTHERA GRINDELIOIDES	0.02	0.44	0.02	0.41	0.67	0.33	0.39
STIPA NEOMEXICANA NEW MEXICAN FEATHERGRASS	0.04	0.87	0.02	0.41	0.67	0.33	0.54
DESCURAINIA SOPHIA FLIXWEED	0.00	0.00	0.01	0.20	0.67	0.33	0.18
OPUNTIA SPP.	0.02	0.44	0.00	0.00	0.67	0.33	0.26
SPOROBOLUS AIROIDES ALKALI SACATON	0.01	0.22	0.00	0.00	0.67	0.33	0.18
STIPA COLUMBIANA COLUMBIA NEEDLEGRASS	0.03	0.66	0.07	1.42	3.33	1.66	1.24
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	0.00	0.00	0.00	0.00	0.67	0.33	0.11
LAPPULA REDOWSKI STICKSEED	0.00	0.00	0.02	0.41	0.67	0.33	0.25

PEABODY COAL C
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 3

MINE: KAYENTA
MINE AREA: 3-14
MONTH: 07
YEAR: 90

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4042115.69 SOIL SERIES: CLAYSPRINGS
UTMN(2): 4041984.81 SLOPE: 0-55%
UTME(1): 559396.80 ASPECT: ALL
UTME(2): 559517.80 ELEVATION RANGE: 6750 - 6830

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PENSTEMON EATONII EATON PENSTEMON	0.01	0.22	0.00	0.00	0.67	0.33	0.18
LEUCELENE ERICOIDES WHITE ASTER	0.10	2.18	0.05	1.01	0.67	0.33	1.18
STREPTANTHUS CORDATUS TWIST FLOWER	0.01	0.22	0.02	0.41	1.33	0.66	0.43
TRIFOLIUM SUBCAULESCENS	0.04	0.87	0.22	4.46	2.67	1.33	2.22
ERIOGONUM JAMESII	0.01	0.22	0.02	0.41	1.33	0.66	0.43
HAPLOPAPPUS ARMERIOIDES GOLDENWEED	0.03	0.66	0.03	0.61	2.00	1.00	0.75
HYMENOPAPPUS FILIFOLIUS	0.01	0.22	0.01	0.20	0.67	0.33	0.25
OPUNTIA WHIPPLEI WHIPPLE CHOLLA	0.01	0.22	0.01	0.20	0.67	0.33	0.25
PENSTEMON BARBATUS BEARD TONGUE	0.01	0.22	0.00	0.00	0.67	0.33	0.18
PETRADORIA PUMILA ROCK GOLDENROD	0.01	0.22	0.01	0.20	0.67	0.33	0.25
QUERCUS GAMBELII GAMBEL OAK	0.01	0.22	0.00	0.00	0.67	0.33	0.18
CYMOPTERUS PURPURASCENS	0.01	0.22	0.00	0.00	0.67	0.33	0.18

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
4.58	4.93	1.09

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 4

MINE: KAYENTA
MINE AREA: 1-14
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: PINYON-JUNIPER
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4042115.69
UTMN(2): 4041984.81
UTME(1): 559385.80
UTME(2): 559517.80

SOIL SERIES: CLAYSPRINGS
SLOPE: 0-55%
ASPECT: ALL
ELEVATION RANGE: 6750 - 6980

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)

*** NOTES ***

LITTER COVERAGE = 9.60% ROCK COVERAGE = 3.23% LICHEN/MOSS COVERAGE = 0.43%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EHRA FIELD SHEETS

PEABODY COAL C
ARIZONA DIVI
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-14
PERIOD: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041509.19
UTMN(2): 4041414.81
UTME(1): 559835.70
UTME(2): 563611.00

SOIL SERIES: CLOVIS
SLOPE: 0-3%
ASPECT: ALL
ELEVATION RANGE: 6720 - 6730

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	20.66	73.98	1.83	3.23	52.57	27.26	34.48
BOUTELOUA GRACILIS BLUE GRAMA	1.23	14.94	45.09	79.33	69.71	36.14	43.47
CORDYLANTHUS WRIGHTII BIRD BEAK	0.37	1.31	0.37	0.65	4.86	2.52	1.49
ELYMUS JUNCEUS RUSSIAN WILDRYE	0.01	0.04	0.03	0.05	0.86	0.45	0.18
ERIGERON CONCINNUS TINY FLEABANE	0.11	0.39	0.49	0.86	4.86	2.52	1.26
LEUCELENE ERICOIDES WHITE ASTER	0.38	1.34	2.86	5.03	12.36	6.47	4.35
OPUNTIA SPP.	0.07	0.25	0.11	0.19	1.14	0.59	0.34
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.27	0.95	0.74	1.30	7.43	3.85	2.04
PHLOX LONGIFOLIA PHLOX	0.01	0.04	0.14	0.25	0.86	0.45	0.24
PINUS EDULIS COLORADO PINYON	0.55	1.94	0.11	0.19	3.14	1.63	1.25
SITANION HYSTRIX SQUIRREL TAIL	0.38	1.34	1.29	2.27	12.00	6.22	3.28
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	0.19	0.67	0.00	0.00	1.14	0.59	0.42
HILARIA JAMESII GALLETA	0.70	2.47	2.80	4.93	12.00	6.22	4.54
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.10	0.35	0.14	0.25	2.57	1.33	0.64
STIPA NEOMEXICANA NEW MEXICAN FEATHERGRASS	0.20	0.71	0.49	0.86	3.43	1.78	1.12
ARABIS PERENNANS ROCK CRESS	0.01	0.04	0.06	0.11	0.86	0.45	0.20

Report 19 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041500.19
UTMN(2): 4041411.81
UTME(1): 559835.70
UTME(2): 563610.00

SOIL SERIES: CLOVIS
SLOPE: 0-3%
ASPECT: ALL
ELEVATION RANGE: 6720 - 6930

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ASTRAGALUS SPP.	0.00	0.00	0.01	0.05	0.29	0.15	0.07
CORYPHANTHA VIVIPARA	0.01	0.04	0.03	0.05	0.29	0.15	0.08
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.02	0.07	0.14	0.25	1.14	0.59	0.30
TOWNSENDIA EXSCAPA GROUND DAISY	0.01	0.04	0.06	0.11	0.57	0.30	0.15
ECHINOCEREUS TRIGLOCHIDIATUS VAR. MELANACANTHUS HEDGEHOG CACTUS	0.03	0.11	0.03	0.05	0.29	0.15	0.10

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
28.31	56.84	0.46

*** NOTES ***

LITTER COVERAGE = 4.81% ROCK COVERAGE = 0.00% LICHEN/MOSS COVERAGE = 0.56%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EHSA FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: BLACK MESA
MINE AREA: J-1/0-6
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041742.50 SOIL SERIES: IVES
UTMN(2): 4040966.19 SLOPE: 1-10%
UTME(1): 551543.00 ASPECT: ALL
UTME(2): 556854.00 ELEVATION RANGE: 6500 - 6910

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARTEMISIA TRIDENTATA	BIG SAGEBRUSH	18.65	56.29	2.46	6.33	46.57	27.86	30.16
BOUTELOUA GRACILIS	BLUE GRAMA	1.51	4.56	15.11	38.90	25.43	15.21	19.56
EUROTIA LANATA	WINTER FAT	0.03	0.09	0.20	0.51	0.86	0.51	0.37
GUTIERREZIA SAROTHRAE	BROOM SNAKEWEED	4.22	12.74	1.69	4.35	22.29	13.34	10.14
LEUCELENE ERICOIDES	WHITE ASTER	0.85	2.57	1.97	5.07	8.57	5.13	4.25
ORYZOPSIS HYMENOIDES	INDIAN RICEGRASS	0.48	1.45	1.66	4.27	12.29	7.35	4.36
PINUS EDULIS	COLORADO PINYON	3.42	10.32	0.40	1.03	5.71	3.42	4.92
SITANION HYSTRIX	SQUIRREL TAIL	0.25	0.75	1.23	3.17	5.14	3.08	2.33
SPHAERALCEA COCCINEA	SCARLET GLOBEMALLOW	0.35	1.06	2.29	5.90	16.57	9.91	5.62
ATRIPLEX CANESCENS	FOUR-WING SALTBUSH	1.66	5.01	0.00	0.00	2.57	1.54	2.18
ERIGERON DIVERGENS	SPREADING FLEABANE	0.00	0.00	0.17	0.44	1.71	1.02	0.49
ERIOGONUM MICROTHECUM	WILD BUCKWHEAT	0.01	0.03	0.03	0.03	0.29	0.17	0.09
HILARIA JAMESII	GALLETA	1.67	5.04	11.26	28.99	18.00	10.77	14.93
CASTILLEJA CHROMOSA	INDIAN PAINT BRUSH	0.00	0.00	0.03	0.09	0.29	0.17	0.08
ARABIS PERENNANS	ROCK CRESS	0.03	0.09	0.34	0.89	0.76	0.51	0.49

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT

MINE: BLACK MESA
MINE AREA: J-17/1-6
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4041762.50
UTMN(2): 4040865.19
UTME(1): 551542.00
UTME(2): 556854.00

SOIL SERIES: IVES
SLOPE: 1-10%
ASPECT: ALL
ELEVATION RANGE: 6500 - 6880

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
33.13	38.84	0.66

*** NOTES ***

LITTER COVERAGE = 7.18% ROCK COVERAGE = 0.77% LICHEN/MOSS COVERAGE = 0.71%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

AREA: BLACK MESA
MINE AREA: I-7
MONTH: 05
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4022274.50 SOIL SERIES: IVES
UTMN(2): 4028451.41 SLOPE: 0-7%
UTME(1): 553241.00 ASPECT: ALL
UTME(2): 556612.00 ELEVATION RANGE: 6360 - 6510

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARTEMISIA TRIDENTATA	BIG SAGEBRUSH	6.50	27.90	1.80	0.85	27.78	9.57	12.77
ATRIPLEX CANESCENS	FOUR-WING SALTBUSH	0.20	0.86	0.04	0.02	1.33	0.46	0.45
BOUTELOUA GRACILIS	BLUE GRAMA	3.20	13.73	63.00	29.59	53.11	18.30	20.54
CALOCHORTUS NUTTALLII	SEGO LILY	0.00	0.00	0.04	0.02	0.44	0.15	0.06
CHENOPODIUM SPP.		0.10	0.43	2.09	0.98	9.33	3.22	1.54
CYMOPTERUS PURPUREUS	CYMOPTERUS	0.00	0.00	0.04	0.02	0.22	0.08	0.03
GILIA LEPTOMERIA	GILIA	0.00	0.00	0.04	0.02	0.44	0.15	0.06
GUTIERREZIA SAROTHRAE	BROOM SNAKEWEED	8.80	37.77	8.20	3.85	62.44	21.52	21.05
HILARIA JAMESII	GALLETA	0.70	3.00	0.69	0.32	27.56	9.50	4.28
LAPPULA REDOWSKI	STICKSEED	0.10	0.43	4.00	1.88	10.44	3.60	1.97
LEUCELENE ERICOIDES	WHITE ASTER	0.00	0.00	0.04	0.02	0.22	0.08	0.03
MENTZELIA ALBICAULIS	BLAZING STAR	0.00	0.00	0.04	0.02	0.44	0.15	0.06
MUHLENBERGIA TORREYI	RING MUHLY	0.10	0.43	0.09	0.04	4.89	1.69	0.72
OPUNTIA SPP.		0.10	0.43	0.20	0.09	1.56	0.54	0.35
ORYZOPSIS HYMENOIDES	INDIAN RICEGRASS	0.20	0.86	0.69	0.32	4.22	1.45	0.88
PLANTAGO PURSHII	PURSH PLANTAIN	0.00	0.00	0.00	0.00	4.00	1.38	0.69

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 2

SITE: BLACK MESA
MINE AREA: J-7
MONTH: 05
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SURJOLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4029271.50 SOIL SERIES: IVLS
UTMN(2): 4029451.41 SLOPE: 0-7%
UTME(1): 551241.09 ASPECT: ALL
UTME(2): 555410.09 ELEVATION RANGE: 6360 - 6540

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
SALSOLA IBERICA	RUSSIAN THISTLE	0.00	0.00	0.20	0.09	1.33	0.46	0.18
SITANION HYSTRIX	SQUIRREL TAIL	0.40	1.72	1.00	0.47	7.56	2.61	1.60
SPHAERALCEA COCCINEA	SCARLET GLOBEMALLOW	0.20	0.86	1.40	0.65	11.34	3.90	1.91
SPHAERALCEA LAXA	CALICOE GLOBE MALLOW	0.00	0.00	0.20	0.09	0.22	0.08	0.06
STIPA NEOMEXICANA	NEW MEXICAN FEATHERGRASS	0.00	0.00	0.04	0.02	0.22	0.08	0.03
TOWNSENDIA EXSCAPA	GROUND DAISY	0.00	0.00	0.04	0.02	0.22	0.08	0.03
VULPIA OCTOFLORA	SIX-WEEKS FESCUE	2.70	11.59	128.20	60.22	60.89	20.98	30.93

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
23.30	212.88	0.71

*** NOTES ***

LITTER COVERAGE = 1.50% ROCK COVERAGE = 0.00% LICHEN/MOSS COVERAGE = 0.00%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM SUMMARY TABLES IN EH&A FINAL REPORT TO PCC

Report 21 (Cont.)

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLOVIS
SLOPE: 0-10%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7000

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
AGROPYRON SMITHII WESTERN WHEATGRASS	0.39	1.61	5.37	9.37	13.43	6.18	5.72	0.15	0.13	
ARTEMISIA TRICENTATA BIG SAGEBRUSH	16.95	69.84	4.89	8.53	68.86	31.71	36.69	64.79	37.65	0.99
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	0.19	0.78	0.00	0.00	0.29	0.13	0.31	0.20	0.10	
BOUTELOUA GRACILIS BLUE GRAMA	4.15	17.10	32.83	57.29	56.57	26.05	33.48	10.30	8.21	0.89
CHRYSOTHAMNUS GREENEI RABBIT BRUSH	0.61	2.51	0.89	1.55	7.43	3.42	2.50	0.05	0.03	
LEUCELENE ERICOIDES WHITE ASTER	0.71	2.93	6.77	11.82	26.57	12.23	8.99	1.30	1.09	0.90
OPUNTIA PHAEACANTHA	0.00	0.00	0.03	0.05	0.29	0.13	0.06	0.13	0.07	
SITANION HYSTRIX SQUIRREL TAIL	0.36	1.48	1.37	2.39	11.43	5.26	3.05	0.13	0.11	
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.32	1.32	3.17	5.53	20.57	9.47	5.44	0.51	0.36	0.95
AMARANTHUS GRAECIZANS PROSTRATE PIGWEED	0.00	0.00	0.03	0.05	0.29	0.13	0.06	0.00	0.00	
EUROTIA LANATA WINTER FAT	0.01	0.04	0.06	0.10	0.86	0.40	0.18	0.00	0.00	
PHLOX LONGIFOLIA PHLOX	0.01	0.04	0.54	0.94	2.57	1.18	0.72	0.00	0.00	
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	0.06	0.25	0.00	0.00	0.29	0.13	0.13	0.00	0.00	
UNIDENTIFIED FORB SPECIES 1	0.01	0.04	0.03	0.05	0.29	0.13	0.08	0.00	0.00	
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.26	1.07	0.11	0.19	1.71	0.79	0.68	0.00	0.00	
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.06	0.25	0.03	0.05	0.29	0.13	0.14	0.00	0.00	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 2

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLOVIS
SLOPE: 0-10%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7000

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
SALSOLA IBERICA	RUSSIAN THISTLE	0.01	0.04	0.06	0.10	0.57	0.26	0.14	0.00	0.00	
PINUS EDULIS	COLORADO PINYON	0.04	0.16	0.03	0.05	0.29	0.13	0.12	0.00	0.00	
HILARIA JAMESII	GALLETA	0.13	0.54	1.03	1.80	3.71	1.71	1.35	0.00	0.00	
STREPTANTHUS CORDATUS	TWIST FLOWER	0.00	0.00	0.03	0.05	0.57	0.26	0.10	0.00	0.00	
TOWNSENDIA EXSCAPA	GROUND DAISY	0.00	0.00	0.03	0.05	0.29	0.13	0.06	0.00	0.00	

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY	TOT. FRESH PRODUCTION	TOT. DRY PRODUCTION
24.27	57.30	0.48	77.56	47.75

*** NOTES ***

TOTAL NON-OVERLAPPING COVERAGE =23.7%
LITTER COVERAGE = 14.49% ROCK COVERAGE = 0.0% LICHEN/MOSS COVERAGE = 0.24%
SPECIES WITH COVER VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO TOTAL COVER

--- SAMPLE ADEQUACY (COVER) ---
SAMPLE SIZE = 7 ST. DEV. = 5.03
*MINIMUM SAMPLE REQUIRED = 7.0

--- SAMPLE ADEQUACY (PRODUCTION) ---
SAMPLE SIZE (EST/CLP) = 15/5 VARIANCE = 267.66
COEF. OF DET.(R**2) = 0.98 REDUCTION(D) = 0.068
*AMOUNT OF REDUCTION DESIRED = 0.1

Report 22 (Cont.)

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 93

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLOVIS
SLOPE: 0-10%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7000

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
AGROPYRON SMITHII WESTERN WHEATGRASS	0.16	0.65	1.60	4.52	6.33	3.08	2.75	0.00	0.00	1.00
ALLIUM MACROPETALUM WILD ONION	0.01	0.04	0.10	0.28	1.00	0.49	0.27	0.00	0.00	
ARTEMESIA FRIGIDA PRAIRIE SAGEWORT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	17.00	65.08	1.53	4.32	53.67	26.10	33.17	171.43	75.81	0.97
ASTRAGALUS WINGATANUS FORT WINGATE MILK-VETCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	0.06	0.24	0.03	0.08	0.67	0.33	0.22	0.14	0.07	
BOUTELOUA GRACILIS BLUE GRAMA	3.07	12.47	19.27	54.45	48.33	23.50	30.14	2.36	0.96	1.00
CHRYSOTHAMNUS GREENEI RABBIT BRUSH	1.02	4.14	2.10	5.93	16.67	8.11	6.06	1.01	0.25	1.00
CYMOPTERUS PURPURASCENS	0.04	0.16	0.27	0.76	2.33	1.13	0.69	0.02	0.00	
DESCURAINIA PINNATA TANSY MUSTARD	0.01	0.04	0.10	0.28	0.67	0.33	0.22	0.00	0.00	
EUROTIA LANATA WINTER FAT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	
GILIA GUNNISONI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	
LAPPULA REDOWSKI STICKSEED	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	
LEUCELENE ERICOIDES WHITE ASTER	0.12	0.49	1.10	3.11	5.33	2.59	2.06	0.01	0.01	
LUPINUS BREVICAULUS	0.05	0.20	0.47	1.33	4.00	1.95	1.16	0.01	0.00	
PHLOX LONGIFOLIA PHLOX	0.17	0.69	1.83	5.17	13.33	6.48	4.11	0.23	0.05	0.99

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLOVIS
SLOPE: 0-10%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7000

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
PINUS EDULIS COLORADO PINYON	0.03	0.12	0.10	0.28	1.33	0.65	0.35	0.16	0.09	
SITANION HYSTRIX SQUIRREL TAIL	0.09	0.37	0.27	0.76	1.67	0.81	0.65	0.36	0.17	1.00
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.19	0.77	2.20	6.22	13.33	6.48	4.49	0.15	0.06	1.00
TOWNSENDIA EXSCAPA GROUND DAISY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	
UNIDENTIFIED FORB SPECIES 1	0.01	0.04	0.07	0.20	0.33	0.16	0.13	0.04	0.02	
ARTEMISIA TRIDENTATA BIG SAGE (HALF-SHRUB)	2.32	9.43	2.00	5.65	24.33	11.83	8.97	0.00	0.00	
UNIDENTIFIED FORB SPECIES 2	0.09	0.37	1.03	2.91	6.33	3.08	2.12	0.00	0.00	
AMARANTHUS GRAECIZANS PROSTRATE PIGWEED	0.01	0.04	0.03	0.08	0.33	0.16	0.10	0.00	0.00	
HILARIA JAMESII GALLETA	0.03	0.12	0.10	0.28	1.00	0.49	0.30	0.00	0.00	
ARISTIDA FENDLERIANA FENDLER'S THREE-AWN	0.03	0.12	0.20	0.57	1.33	0.65	0.44	0.00	0.00	
UNIDENTIFIED FORB SPECIES 3	0.01	0.04	0.10	0.28	0.33	0.16	0.16	0.00	0.00	
VULPIA OCTOFLORA SIX-WEEKS FESCUE	0.04	0.16	0.83	2.35	2.33	1.13	1.21	0.00	0.00	
OPUNTIA PHAEACANTHA	0.05	0.20	0.03	0.08	0.33	0.16	0.15	0.00	0.00	
ASTER SPINOSUS SPINY ASTER	0.00	0.00	0.03	0.08	0.33	0.16	0.08	0.00	0.00	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 3

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: CLOVIS
SLOPE: 0-10%
ASPECT: ALL
ELEVATION RANGE: 6700 - 7000

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY	TOT. FRESH PRODUCTION	TOT. DRY PRODUCTION
24.61	35.39	0.50	176.07	17.54

*** NOTES ***

TOTAL NON-OVERLAPPING COVERAGE = 23.90%
LITTER COVERAGE = 17.08% ROCK COVERAGE = 0.12% LICHEN/MOSS COVERAGE = 0.08%
SPECIES WITH COVER VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO TOTAL COVER

--- SAMPLE ADEQUACY (COVER) ---
SAMPLE SIZE = 6 ST. DEV. = 3.41
MINIMUM SAMPLE REQUIRED = 3.1

--- SAMPLE ADEQUACY (PRODUCTION) ---
SAMPLE SIZE (EST/CLP) = 28/7 VARIANCE = 2385.0
COEF. OF DET.(R**2) = 0.97 REDUCTION(D) = 0.067
*AMOUNT OF REDUCTION DESIRED = 0.1

PEABODY COAL C
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-1/8
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4043665.00 SOIL SERIES: FRUITLAND
UTMN(2): 4043497.50 SLOPE: 0-15%
UTME(1): 550065.00 ASPECT: SSW
UTME(2): 550027.00 ELEVATION RANGE: 6550 - 6600

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	11.27	40.57	1.69	4.36	36.57	16.41	20.45
ASTRAGALUS CALYCOSUS VAR. SCAPIOSUS TORREY MILK-VETCH	0.03	0.11	0.09	0.23	0.57	0.26	0.20
ASTRAGALUS SPP.	0.01	0.04	0.06	0.15	0.57	0.26	0.15
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	1.90	6.84	0.25	0.67	6.86	3.08	3.53
BOUTELOUA GRACILIS BLUE GRAMA	1.25	4.50	11.77	30.37	29.71	13.33	16.07
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	7.42	26.71	2.57	6.63	34.29	15.39	16.24
HILARIA JAMESII GALLETA	0.51	1.84	3.31	8.54	17.43	7.82	6.07
LAPPULA REDOWSKI STICKSEED	0.08	0.29	3.23	8.34	7.14	3.20	3.94
LEUCELENE ERICOIDES WHITE ASTER	2.19	7.88	8.00	20.65	31.43	14.10	14.21
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.59	2.12	1.71	4.41	14.86	6.67	4.40
PHLOX LONGIFOLIA PHLOX	0.10	0.36	1.37	3.54	8.29	3.72	2.54
PINUS EDULIS COLORADO PINYON	1.44	5.18	0.06	0.15	4.29	1.92	2.42
PSILOSTROPHE SPARSIFLORA PAPER FLOWER	0.01	0.04	0.00	0.00	0.57	0.26	0.10
SITANION HYSTRIX SQUIRREL TAIL	0.17	0.61	0.46	1.19	4.86	2.18	1.33
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.35	1.26	2.69	6.94	16.00	7.18	5.13
UNIDENTIFIED FORB SPECIES 2	0.00	0.00	0.03	0.03	0.29	0.13	0.07

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: N-1/8
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4043665.00
UTMN(2): 4043497.50
UTME(1): 550066.00
UTME(2): 550027.00

SOIL SERIES: FRUITLAND
SLOPE: 0-15%
ASPECT: SSW
ELEVATION RANGE: 6550 - 6600

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
JUNIPERUS OSTEOSPERMA UTAH JUNIPER	0.35	1.26	0.00	0.00	1.14	0.51	0.59
SHEPHERDIA ROTUNDIFOLIA ROUND-LEAF BUFFALO BERRY	0.02	0.07	0.00	0.00	0.29	0.13	0.07
CHENOPODIUM SPP.	0.04	0.14	0.77	1.99	3.71	1.66	1.27
LESQUERELLA INTERMEDIA BLADDER POD	0.00	0.00	0.00	0.00	0.29	0.13	0.04
SALSOLA IBERICA RUSSIAN THISTLE	0.02	0.07	0.40	1.03	1.71	0.77	0.62
STIPA NEOMEXICANA NEW MEXICAN FEATHERGRASS	0.02	0.07	0.14	0.36	1.14	0.51	0.31
UNIDENTIFIED FORB SPECIES 1	0.01	0.04	0.11	0.28	0.57	0.26	0.19
GRAMINEAE UNIDENTIFIED GRASS SEEDLING	0.00	0.00	0.03	0.09	0.29	0.13	0.07

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
27.78	38.75	0.77

*** NOTES ***

LITTER COVERAGE = 10.31% ROCK COVERAGE = 21.58% LICHEN/MOSS COVERAGE = 0.07%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4017872.41 SOIL SERIES: CLOVIS
UTMN(2): 4037753.09 SLOPE: 0-2%
UTME(1): 563777.70 ASPECT: ENE
UTME(2): 563909.50 ELEVATION RANGE: 5750 - 5800

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	24.54	75.96	3.31	4.59	66.29	33.77	38.07
BOUTELOUA GRACILIS BLUE GRAMA	5.44	16.82	41.43	85.11	77.43	39.44	47.12
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.14	0.43	0.09	0.12	1.71	0.87	0.48
HILARIA JAMESII GALLETA	0.03	0.09	0.23	0.32	1.71	0.87	0.43
LEUCELENE ERICOIDES WHITE ASTER	0.41	1.27	2.69	3.73	15.71	8.00	4.33
PINUS EDULIS COLORADO PINYON	1.03	3.18	0.14	0.19	4.29	2.19	1.85
SITANION HYSTRIX SQUIRREL TAIL	0.59	1.82	2.23	3.09	15.71	8.00	4.31
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.16	0.49	1.91	2.65	11.14	5.67	2.94
STIPA NEOMEXICANA NEW MEXICAN FEATHERGRASS	0.00	0.00	0.03	0.04	0.29	0.15	0.06
TOWNSENDIA EXSCAPA GROUND DAISY	0.00	0.00	0.03	0.04	0.29	0.15	0.06
CHENOPODIUM SPP.	0.00	0.00	0.03	0.04	0.29	0.15	0.06
OPUNTIA SPP.	0.00	0.00	0.00	0.00	0.29	0.15	0.05
LUPINUS BREVICAULUS	0.01	0.03	0.00	0.00	0.57	0.29	0.11
ERIGERON CONCINNUS TIDY FLEABANE	0.00	0.00	0.03	0.04	0.29	0.15	0.06
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.00	0.00	0.03	0.04	0.29	0.15	0.06

PEABODY COAL C
ARIZONIA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 2

MINE: KAYENTA
MINE AREA: N-14
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 403872.41
UTMN(2): 403753.09
UTME(1): 563777.70
UTME(2): 563900.50

SOIL SERIES: CLOVIS
SLOPE: 0-2%
ASPECT: ENE
ELEVATION RANGE: 6750 - 6300

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
32.35	72.18	0.35

*** NOTES ***

LITTER COVERAGE = 11.04% ROCK COVERAGE = 0.01% LICHEN/MOSS COVERAGE = 1.11%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

Report 25 (Cont.)

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT

MINE: BLACK MESA
MINE AREA: J-1/4-6
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4037896.60
UTMN(2): 4037913.40
UTME(1): 554445.30
UTME(2): 555115.90

SOIL SERIES: IVES
SLOPE: 0-20%
ASPECT: ALL
ELEVATION RANGE: 6570 - 6670

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ALLIUM MACROPETALUM WILD ONION	0.00	0.00	0.03	0.12	0.29	0.19	0.10
ARTEMISIA TRIDENTATA BIG SAGEBRUSH	18.53	61.95	3.20	12.82	42.00	27.17	33.94
BOUTELOUA GRACILIS BLUE GRAMA	1.01	3.37	12.29	49.24	40.29	26.06	26.22
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	8.05	26.87	2.31	9.25	30.00	19.40	18.51
HILARIA JAMESII GALLETA	0.49	1.64	3.34	13.38	11.43	7.39	7.47
OROBANCHE FASCICULATA BROOM RAPE	0.00	0.00	0.03	0.12	0.29	0.19	0.10
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.05	0.17	0.29	1.16	2.00	1.29	0.87
PINUS EDULIS COLORADO PINYON	0.87	2.90	0.09	0.36	2.29	1.48	1.58
SITANION HYSTRIX SQUIRREL TAIL	0.35	1.17	1.14	4.57	8.57	5.54	3.76
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.21	0.70	1.34	5.37	10.57	6.84	4.30
COMPOSITAE UNIDENTIFIED COMPOSITE	0.03	0.10	0.06	0.24	0.57	0.37	0.24
LEUCELENE ERICOIDES WHITE ASTER	0.12	0.40	0.57	2.28	3.14	2.03	1.57
CYCU (NAME NOT FOUND)	0.00	0.00	0.00	0.00	0.29	0.19	0.06
ERIGERON DIVERGENS SPREADING FLEABANE	0.03	0.10	0.00	0.00	0.29	0.19	0.10
LEPTODACTYLON PUNGENS PRICKLY PHLOX	0.04	0.13	0.03	0.12	0.57	0.37	0.21
ATRIPLEX CONFERTIFOLIA SHAD-SCALE	0.06	0.20	0.00	0.00	0.29	0.19	0.13

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: BLACK MESA
MINE AREA: J-17N-6
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4037896.69
UTMN(2): 4037933.40
UTME(1): 554445.30
UTME(2): 555113.90

SOIL SERIES: IVES
SLOPE: 0-20%
ASPECT: ALL
ELEVATION RANGE: 6570 - 6670

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
SCLEROCACTUS PARVIFLORUS		0.02	0.07	0.03	0.12	0.29	0.19	0.12
ERIGERON CONCINNUS	TINY FLEABANE	0.00	0.00	0.09	0.36	0.57	0.37	0.24
CRYPTANTHA BAKERI		0.00	0.00	0.03	0.12	0.29	0.19	0.10
ATRIPLEX CANESCENS	FOUR-WING SALTBUSH	0.09	0.30	0.03	0.12	0.29	0.19	0.20
TOWNSENDIA EXSCAPA	GROUND DAISY	0.01	0.03	0.06	0.24	0.29	0.19	0.15

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
29.96	24.96	0.48

*** NOTES ***

LITTER COVERAGE = 4.88% ROCK COVERAGE = 0.26% LICHEN/MOSS COVERAGE = 0.72%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EI&A FIELD SHEETS

PEABODY COAL CO
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 1

MINE: BLACK MESA
MINE AREA: J-7
MONTH: 05
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4030339.09 SOIL SERIES: IVES
UTMN(2): 4030233.50 SLOPE: 0-5%
UTME(1): 563014.10 ASPECT: SW
UTME(2): 563001.50 ELEVATION RANGE: 6340 - 6350

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ARTEMISIA TRIDENTATA	BIG SAGEBRUSH						
	2.97	16.52	10.42	5.67	20.00	6.77	9.65
BOUTELOUA GRACILIS	BLUE GRAMA						
	1.96	10.90	27.91	15.19	47.41	16.05	14.05
CRYPTANTHA BAKERI							
	0.06	0.33	1.13	0.62	2.12	0.72	0.56
GUTIERREZIA SAROTHRAE	BROOM SNAKEWEED						
	5.57	30.98	8.31	4.52	49.65	16.80	17.44
LAPPULA REDOWSKI	STICKSEED						
	0.37	2.06	13.72	7.47	11.98	4.02	4.52
LEUCELENE ERICOIDES	WHITE ASTER						
	0.21	1.17	2.62	1.43	8.12	2.75	1.78
OPUNTIA SPP.							
	0.03	0.17	0.01	0.01	0.12	0.04	0.07
ORYZOPSIS HYMENOIDES	INDIAN RICEGRASS						
	0.38	2.11	1.66	0.90	12.59	4.26	2.43
SALSOLA IBERICA	RUSSIAN THISTLE						
	0.09	0.50	4.14	2.25	9.53	3.23	1.99
SPHAERALCEA COCCINEA	SCARLET GLOBEMALLOW						
	0.41	2.28	2.08	1.13	15.53	5.26	2.99
STIPA NEOMEXICANA	NEW MEXICAN FEATHERGRASS						
	1.02	5.67	9.00	4.90	23.18	7.85	6.14
VULPIA OCTOFLORA	SIX-WEEKS FESCUE						
	2.00	11.12	85.71	46.66	22.59	7.65	21.81
ATRIPLEX CANESCENS	FOUR-WING SALTBUSH						
	1.73	9.62	0.72	0.39	6.12	2.07	4.03
BROMUS TECTORUM	CHEATGRASS						
	0.02	0.11	0.12	0.07	0.59	0.20	0.13
CHENOPODIUM SPP.							
	0.05	0.28	2.74	1.49	18.35	6.21	2.66
CHRYSOTHAMNUS GRIFFINI	RABBIT BRUSH						
	0.35	1.98	0.11	0.06	1.06	0.36	0.13

PEABODY COAL C
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 2

MINE: BLACK MESA
MINE AREA: J-7
MONTH: 09
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4030339.00 SOIL SERIES: IVES
UTMN(2): 4030233.50 SLOPE: 0-5%
UTME(1): 553014.10 ASPECT: SW
UTME(2): 553001.50 ELEVATION RANGE: 6340 - 6360

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
SITANION HYSTRIX SQUIRREL TAIL	0.31	1.72	1.11	0.60	9.41	3.18	1.84
ARABIS PERENNANS ROCK CRESS	0.01	0.06	0.05	0.03	0.35	0.12	0.07
ASTRAGALUS SPP.	0.06	0.33	0.25	0.14	2.12	0.72	0.40
CYMOPTERUS PURPURASCENS	0.03	0.17	0.32	0.17	2.59	0.98	0.41
CYMOPTERUS PURPUREUS CYMOPTERUS	0.02	0.11	0.15	0.08	1.65	0.56	0.25
EUROTIA LANATA WINTER FAT	0.02	0.11	0.09	0.05	0.71	0.24	0.13
PHLOX LONGIFOLIA PHLOX	0.05	0.28	0.81	0.44	4.94	1.67	0.90
ARISTIDA FENDLERIANA FENDLER'S THREE-AWN	0.00	0.00	0.05	0.03	0.12	0.04	0.02
CALOCHORTUS NUTTALLII SEGO LILY	0.00	0.00	0.04	0.02	0.47	0.16	0.06
LESQUERELLA INTERMEDIA BLADDER POD	0.05	0.28	0.25	0.14	2.24	0.76	0.39
TOWNSENDIA EXSCAPA GROUND DAISY	0.00	0.00	0.02	0.01	0.24	0.08	0.03
UNIDENTIFIED FORB SPECIES 1	0.01	0.06	0.19	0.10	1.29	0.44	0.20
UNIDENTIFIED FORB SPECIES 2	0.00	0.00	0.11	0.06	0.94	0.32	0.13
LEPTODACTYLON PUNGENS PRICKLY PHLOX	0.03	0.17	0.12	0.07	0.94	0.32	0.18
ALLIUM MACROPETALUM WILD ONION	0.01	0.06	0.07	0.04	0.71	0.24	0.11
GILIA LEPTOMERIA GILIA	0.07	0.39	1.27	0.69	2.47	0.84	0.64

Report 27 (Cont.)

PEABODY COAL C
ARIZONA DIVIS
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 3

MINE: BLACK MESA
MINE AREA: J-7
MONTH: 05
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4030332.00 SOIL SERIES: IVES
UTMN(2): 4030233.50 SLOPE: 0-5%
UTME(1): 553014.10 ASPECT: SW
UTME(2): 553001.50 ELEVATION RANGE: 6340 - 6360

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
PLANTAGO PURSHII PURSH PLANTAIN	0.12	0.67	5.41	2.95	6.71	2.27	1.96
GRAMINEAE UNIDENTIFIED GRASS SEEDLING	0.07	0.39	0.32	0.17	1.06	0.36	0.31
DELPHINIUM NELSONII LARKSPUR	0.01	0.06	0.12	0.07	0.59	0.20	0.11
OPUNTIA WHIPPLEI WHIPPLE CHOLLA	0.01	0.06	0.01	0.01	0.12	0.04	0.03
CASTILLEJA CHROMOSA INDIAN PAINT BRUSH	0.00	0.00	0.01	0.01	0.24	0.08	0.03
ATRIPLEX CONFERTIFOLIA SHAD-SCALE	0.04	0.22	0.09	0.05	1.06	0.36	0.21
UNIDENTIFIED FORB SPECIES 5	0.00	0.00	0.01	0.01	0.12	0.04	0.02
HILARIA JAMESII GALLETA	0.10	0.56	1.93	1.05	3.41	1.15	0.92
UNIDENTIFIED FORB SPECIES 3	0.02	0.11	0.12	0.07	0.35	0.12	0.10
SCLEROCACTUS PARVIFLORUS	0.00	0.00	0.02	0.01	0.35	0.12	0.04
UNIDENTIFIED FORB SPECIES 6	0.00	0.00	0.12	0.07	0.47	0.16	0.07
UNIDENTIFIED FORB SPECIES 7	0.01	0.06	0.07	0.04	0.12	0.04	0.04
ARTEMISIA ARBUSCULA SSP. NOVA SAGEBRUSH	0.01	0.06	0.00	0.00	0.12	0.04	0.03
MUHLENBERGIA TORREYI RING MUHLY	0.00	0.00	0.09	0.05	0.12	0.04	0.03
MENTZELIA ALBICAULIS BLAZING STAR	0.00	0.00	0.01	0.01	0.24	0.08	0.03
STREPTANTHUS CORDATUS TWIST FLOWER	0.00	0.00	0.04	0.02	0.24	0.08	0.03

Report 27 (Cont.)

PEABODY COAL CO
ARIZONA DIVISI
VEGETATIVE SURVEY SUMMARY REPORT

MINE: BLACK MESA
MINE AREA: J-7
MONTH: 05
YEAR: 80

SAMPLING AREA TYPE: REFERENCE AREA
VEGETATIVE COMMUNITY: SAGEBRUSH-SHRUBLAND
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4030339.09
UTMN(2): 4030233.50
UTME(1): 553014.10
UTME(2): 553001.50

SOIL SERIES: IVES
SLOPE: 0-5%
ASPECT: SW
ELEVATION RANGE: 6340 - 6360

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
CHAMAESARACHA CORONOPUS SMALL GROUND CHERRY	0.00	0.00	0.02	0.01	0.12	0.04	0.02

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
17.98	183.69	0.97

*** NOTES ***

LITTER COVERAGE = 0.96% ROCK COVERAGE = 1.41% LICHEN/MOSS COVERAGE = 0.07%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM ORIGINAL EH&A FIELD SHEETS

Report 27 (Cont.)

PEABODY COAL C
ARIZONA DIVI
VEGETATIVE SURVEY SUMMARY REPORT

MINE: BLACK MESA
MINE AREA: KOENKOPI
MONTH: 07
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: GREASEWOOD
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 0.00
UTMN(2): 0.00
UTME(1): 0.00
UTME(2): 0.00

SOIL SERIES: YOUNGSTON
SLOPE: 1%
ASPECT: NONE
ELEVATION RANGE: 6350 - 6500

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	2.40	6.08	0.47	5.57	10.00	5.30	5.65
BOUTELOUA GRACILIS BLUE GRAMA	0.00	0.00	0.40	4.74	2.00	1.06	1.93
BROMUS TECTORUM CHEATGRASS	0.00	0.00	0.00	0.00	2.67	1.41	0.47
CHENOPODIUM SPP.	0.10	0.25	1.27	15.05	8.00	4.24	6.51
CRYPTANTHA SPP. CRYPTANTHA	0.00	0.00	0.07	0.83	12.00	6.36	2.40
DESCURAINIA SOPHIA FLIXWEED	0.00	0.00	0.00	0.00	2.00	1.06	0.35
ELYMUS JUNCEUS RUSSIAN WILDRYE	0.00	0.00	0.00	0.00	0.67	0.36	0.12
ERIGERON DIVERGENS SPREADING FLEABANE	0.00	0.00	0.07	0.83	0.67	0.36	0.39
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.70	1.77	0.47	5.57	4.67	2.47	3.27
KOCHIA SCOPARIA SUMMER CYPRESS	0.10	0.25	0.27	3.20	2.00	1.06	1.50
LAPPULA REDOWSKI STICKSEED	0.00	0.00	0.00	0.00	14.00	7.42	2.47
LYCIUM PALLIDUM RABBIT THORN	1.30	3.29	0.07	0.83	4.00	2.12	2.08
ORYZOPSIS HYMENOIDES INDIAN RICEGRASS	0.10	0.25	0.07	0.83	0.67	0.36	0.48
SALSOLA IBERICA RUSSIAN THISTLE	2.00	5.06	0.87	10.31	12.00	6.36	7.24
SARCOBATUS VERMICULATUS BLACK GREASEWOOD	21.30	53.92	1.07	12.69	46.00	24.38	30.33
SITANION HYSTRIX SQUIRREL TAIL	0.10	0.25	0.20	2.37	2.67	1.41	1.35

PEABODY COAL CO
ARIZONA DIVIS.
VEGETATIVE SURVEY SUMMARY REPORT

MINE: BLACK MESA
MINE AREA: MOENKOPI
SOUTH: 09
YEAR: 80

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: GREASEWOOD
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 0.00
UTMN(2): 0.00
UTME(1): 0.00
UTME(2): 0.00

SOIL SERIES: YOUNGSTON
SLOPE: 1%
ASPECT: NONE
ELEVATION RANGE: 6350 - 6500

SPECIES NAME		COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)
SPOROBOLUS AIROIDES	ALKALI SACATON	0.50	1.27	0.20	2.37	2.67	1.41	1.68
SUAEDA TORREYANA	DESERT SEEPWEED	10.90	27.59	2.87	34.00	38.67	20.49	27.36
TRIPTEROCALYX MICRANTHUS		0.00	0.00	0.07	0.83	0.67	0.36	0.39
VULPIA OCTOFLORA	SIX-WEEKS FESCUE	0.00	0.00	0.00	0.00	22.67	12.01	4.00

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY
39.50	8.44	0.57

*** NOTES ***

LITTER COVERAGE = 0.00% ROCK COVERAGE = 0.30% LICHEN/MOSS COVERAGE = 0.01%
SPECIES WITH COVER OR PRODUCTION VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO THESE PARAMETERS
REPORT GENERATED FROM SUMMARY TABLES IN EH&A FINAL REPORT TO PCC

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SALTBUSH
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: YOUNGSTON
SLOPE: 0-2%
ASPECT: ALL
ELEVATION RANGE: 6500 - 6900

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
AGROPYRON SMITHII WESTERN WHEATGRASS	1.06	2.28	9.60	19.15	19.33	8.28	9.90	9.25	6.17	1.00
AMARANTHUS GRAECIZANS PROSTRATE PIGWEED	0.09	0.19	0.53	1.06	2.67	1.14	0.80	0.13	0.07	
ARTEMISIA TRICENTATA BIG SAGEBRUSH	3.45	7.41	1.53	3.05	14.67	6.29	5.58	0.02	0.01	
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	34.75	74.60	5.87	11.71	81.33	34.85	40.39	143.60	60.65	0.78
BOUTELOUA GRACILIS BLUE GRAMA	0.79	1.70	1.93	3.85	14.00	6.00	3.85	0.27	0.13	
BROMUS TECTORUM CHEATGRASS	0.65	1.40	4.27	8.52	8.00	3.43	4.45	1.00	0.50	
CHENOPODIUM SPP.	0.03	0.06	0.20	0.40	2.00	0.86	0.44	0.31	0.10	1.00
CHRYSOTHAMNUS GREENEI RABBIT BRUSH	0.33	0.71	0.13	0.26	2.67	1.14	0.70	7.00	3.50	
MUNROA SQUARROSA FALSE BUFFALOGRASS	0.13	0.28	0.13	0.26	0.67	0.29	0.28	0.13	0.07	
SALSOLA IBERICA RUSSIAN THISTLE	3.33	7.15	11.27	22.48	41.33	17.71	15.78	27.91	16.67	0.97
SITANION HYSTRIX SQUIRREL TAIL	0.17	0.36	0.40	0.80	3.33	1.43	0.86	0.40	0.20	
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.14	0.30	0.93	1.86	4.00	1.71	1.29	3.21	2.32	1.00
SPOROBOLUS CRYPTANDRUS SAND DROPSEED	0.17	0.36	0.87	1.74	6.67	2.86	1.65	0.58	0.37	1.00
GRAMINEAE UNIDENTIFIED GRASS SEEDLING	1.41	3.03	12.13	24.20	29.33	12.57	13.26	0.27	0.10	
MENTHA ARVENSIS FIELD MINT	0.03	0.06	0.13	0.26	1.33	0.57	0.30	0.00	0.00	
ASTER SPINOSUS SPINY ASTER	0.03	0.06	0.07	0.14	0.67	0.29	0.16	0.00	0.00	

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 09
YEAR: 82

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SALTBUSH
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: YOUNGSTON
SLOPE: 0-2%
ASPECT: ALL
ELEVATION RANGE: 6500 - 6900

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
LEUCELENE ERICOIDES WHITE ASTER	0.01	0.02	0.07	0.14	0.67	0.29	0.15	0.00	0.00	
UNIDENTIFIED FORB SPECIES 1	0.01	0.02	0.07	0.14	0.67	0.29	0.15	0.00	0.00	

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY	TOT. FRESH PRODUCTION	TOT. DRY PRODUCTION
46.58	50.13	0.46	194.09	90.85

*** NOTES ***

TOTAL NON-OVERLAPPING COVERAGE = 45.85%
LITTER COVERAGE = 19.63% ROCK COVERAGE = 0.0% LICHEN/MOSS COVERAGE = 0.01%
SPECIES WITH COVER VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO TOTAL COVER

--- SAMPLE ADEQUACY (COVER) ---
SAMPLE SIZE = 3 ST. DEV. = 1.42
*MINIMUM SAMPLE REQUIRED = 0.1

--- SAMPLE ADEQUACY (PRODUCTION) ---
SAMPLE SIZE (EST/CLP) = 15/5 VARIANCE = 1621.68
COEF. OF DET.(R**2) = 0.76 REDUCTION(D) = 0.069
*AMOUNT OF REDUCTION DESIRED = 0.1

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SALTBUSH
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: YOUNGSTON
SLOPE: 0-2%
ASPECT: ALL
ELEVATION RANGE: 6500 - 6900

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
AGROPYRON SMITHII WESTERN WHEATGRASS	0.24	1.18	4.90	2.26	17.00	5.20	2.88	2.44	0.76	1.00
AMARANTHUS SPP. PIGWEED	0.09	0.44	1.15	0.53	7.00	2.14	1.04	0.21	0.11	
ARTEMESIA FRIGIDA PRAIRIE SAGEWORT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	
ARTEMISIA TRICENTATA BIG SAGEBRUSH	1.90	9.35	0.55	0.25	7.00	2.14	3.91	5.85	2.93	
ATRIPLEX CANESCENS FOUR-WING SALTBUSH	5.41	26.61	2.25	1.04	51.50	15.75	14.47	42.74	17.39	0.78
ATRIPLEX ROSEA REDSCALE	0.01	0.05	0.85	0.39	1.50	0.46	0.30	0.73	0.15	
BOUTELOUA GRACILIS BLUE GRAMA	0.96	4.72	3.50	1.62	17.50	5.35	3.90	1.26	0.63	1.00
BROMUS TECTORUM CHEATGRASS	6.88	33.84	53.40	24.67	49.00	14.98	24.50	28.90	9.45	1.00
CHRYSOTHAMNUS GREENEI RABBIT BRUSH	0.03	0.15	0.75	0.35	4.00	1.22	0.57	0.55	0.27	
CYMOPTERUS PURPURASCENS	0.02	0.10	0.65	0.30	3.00	0.92	0.44	0.05	0.02	
CYMOPTERUS PURPUREUS CYMOPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
DESCURAINIA PINNATA TANSY MUSTARD	0.01	0.05	0.05	0.02	0.50	0.15	0.08	0.32	0.07	
ERIGERON DIVERGENS SPREADING FLEABANE	0.99	4.87	40.45	18.68	22.50	6.88	10.14	5.05	1.33	1.00
GUTIERREZIA SAROTHRAE BROOM SNAKEWEED	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.05	
LAPPULA REDOWSKI STICKSEED	2.69	13.23	71.40	32.98	72.50	22.17	22.79	16.63	4.11	1.00
MENTZELIA ALBICAULIS BLAZING STAR	0.50	2.46	8.60	3.97	13.50	4.13	3.52	3.15	0.74	0.66

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SALTBUSH
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00
UTMN(2): 4027300.00
UTME(1): 558330.00
UTME(2): 568270.00

SOIL SERIES: YOUNGSTON
SLOPE: 0-2%
ASPECT: ALL
ELEVATION RANGE: 6500 - 6900

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED
MENTHA ARVENSIS FIELD MINT	0.02	0.10	0.10	0.05	1.00	0.31	0.15	0.62	0.31	
PHLOX LONGIFOLIA PHLOX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	
PLANTAGC PURSHII PURSH PLAINTAIN	0.09	0.44	1.70	0.79	2.00	0.61	0.61	0.05	0.02	
SALSOLA IBERICA RUSSIAN THISTLE	0.07	0.34	17.60	8.13	33.00	10.09	6.19	0.91	0.21	1.00
SITANION HYSTRIX SQUIRREL TAIL	0.10	0.49	0.55	0.25	2.50	0.76	0.50	0.11	0.05	
SPHAERALCEA COCCINEA SCARLET GLOBEMALLOW	0.07	0.34	0.60	0.28	3.50	1.07	0.56	0.67	0.18	
TOWNSENDIA EXSCAPA GROUND DAISY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.18	
UNIDENTIFIED FORB SPECIES 2	0.04	0.20	2.65	1.22	11.00	3.36	1.59	0.04	0.02	
VULPIA OCTOFLORA SIX-WEEKS FESCUE	0.04	0.20	2.25	1.04	3.00	0.92	0.72	0.25	0.12	
UNIDENTIFIED FORB SPECIES 1	0.08	0.39	2.45	1.13	3.50	1.07	0.87	0.00	0.00	
OPUNTIA PHAEACANTHA	0.08	0.39	0.05	0.02	0.50	0.15	0.19	0.00	0.00	
ASTER SPINOSUS SPINY ASTER	0.01	0.05	0.05	0.02	0.50	0.15	0.08	0.00	0.00	

TOTAL COVERAGE	TOTAL DENSITY	SPECIES DIVERSITY	TOT. FRESH PRODUCTION	TOT. DRY PRODUCTION
20.33	216.50	0.81	111.09	39.14

Report 30 (Cont.)

PEABODY COAL COMPANY
ARIZONA DIVISION
VEGETATIVE SURVEY SUMMARY REPORT PAGE: 3

MINE: KAYENTA
MINE AREA: J-19 THRU 23
MONTH: 05
YEAR: 83

SAMPLING AREA TYPE: MINE PLAN AREA
VEGETATIVE COMMUNITY: SALTBUSH
SPECIES GROWTH STRATA: HERBACEOUS

UTMN(1): 4036640.00 SOIL SERIES: YOUNGSTON
UTMN(2): 4027300.00 SLOPE: 0-2%
UTME(1): 558330.00 ASPECT: ALL
UTME(2): 568270.00 ELEVATION RANGE: 6500 - 6900

SPECIES NAME	COVERAGE (%)	RELATIVE COVERAGE (%)	DENSITY (SP/M2)	RELATIVE DENSITY (%)	FREQUENCY (%)	RELATIVE FREQUENCY (%)	IMPORTANCE PERCENTAGE (%)	PRODUCTION (FRESH) (GM/M2)	PRODUCTION (DRY) (GM/M2)	R SQUARED

*** NOTES ***

TOTAL NON-OVERLAPPING COVERAGE = 18.96%
LITTER COVERAGE = 17.75% ROCK COVERAGE = 0.0% LICHEN/MOSS COVERAGE = 0.0%
SPECIES WITH COVER VALUES OF ZERO CONTRIBUTE TRACE AMOUNTS TO TOTAL COVER

--- SAMPLE ADEQUACY (COVER) ---
SAMPLE SIZE = 4 ST. DEV. = 8.51
MINIMUM SAMPLE REQUIRED = 28.7

--- SAMPLE ADEQUACY (PRODUCTION) ---
SAMPLE SIZE (EST/CLP) = 20/4 VARIANCE = 62.69
COEF. OF DET.(R**2) = 0.97 REDUCTION = 0.020
*AMOUNT OF REDUCTION DESIRED = 0.1

Report 30 (Cont.)

ATTACHMENT 2

Vegetation Sampling Program

Black Mesa and Kayenta Mines

Environmental Affairs Department

Peabody Western Coal Company

November 8, 1993

Attachment 2

Index

List of Tables

List of Exhibits

Vegetation Sampling Program

Black Mesa and Kayenta Mines

Peabody Western Coal Company

Introduction

The vegetation sampling methods utilized at the Black Mesa and Kayenta Mines are described in the following sections. The methods provide for the collection of quantitative and qualitative data needed to describe the native and reclaimed vegetation that occurs on the Black Mesa leasehold. The methods were developed in consultation with the Navajo Tribe, the Office of Surface Mining Reclamation and Enforcement (OSMRE), and various consulting firms that have been retained to assist Peabody Western Coal Company (PWCC) in conducting vegetation studies at the Black Mesa leasehold.

Quantitative vegetation studies were started in the fall of 1979 by PWCC (then the Arizona Division of Peabody Coal Company) and Espey, Huston and Associates, Inc. (EH&A) of Austin, Texas. The original sampling methods, used primarily to describe the premining plant communities, were presented in Appendix 16 of the Permit AZ-0001 1981-1985 Mining and Reclamation Plan. Since that time, several modifications have been made in the program as a result of experience and negotiations with the regulatory authority. The modifications were described in several different documents submitted for regulatory review (Arizona Division, Peabody Coal Company (PCC), 1982; Arizona Division, PCC, 1983; Arizona Division, PCC, 1986).

In 1989, PWCC made a major change in the methods used to conduct vegetation samples at the Black Mesa leasehold. The point intercept method was adopted as the preferred method for collecting vegetation cover samples. Previously, vegetation cover samples were collected primarily using ocular estimates.

The OSMRE completed the first midterm permit review (MPR) of Federal Permit No. AZ-0001C on February 16, 1993. Certain deficiencies in the permit application package (PAP) were identified in the MPR, prompting the OSMRE to order several revisions to the PAP. Revision Order No. 5 required, in part, submitting a revised presentation of the vegetation sampling methods to reflect the current methodologies in use at the minesite, and correct certain discrepancies pertaining to sample adequacy and production sampling. This document describes the sampling methods used on permanent program lands at the minesite.

Sampling Design

All vegetation sampling is conducted in a random manner in order to allow all species and individuals an equal opportunity of occurring in a given sample. Such randomization insures unbiased estimates of sample means and variances (N-1) so that valid statistical comparisons of samples can be made (Uniscale and Bonham, 1980).

Sample points are selected using x and y coordinates generated using a random numbers table, electronic calculator, or computer algorithm. Sample points are plotted on topographic maps, aerial photos, or orthophotoquad coverages (depending on media availability) using a grid overlain on the media, or by computer. Media scales vary depending upon the size of the sampling unit. A sufficient number of potential sample points are plotted prior to entering the field to accommodate sample adequacy needs. The sample points are located in the field by pacing the desired distances along compass bearings, from pre-determined origins. The origins may consist of corner fence posts or other identifiable landmarks in the field. Upon reaching the immediate vicinity of a sample point, a blind throw of a stake is made to set the precise point. Random numbers are also used to determine compass directions in cases where transects or belts will be run.

Independent vegetation samples are obtained twice annually; once in the spring and again in the fall. An attempt is made to time sampling activities with the "peak of green" to insure both cool and warm season species are adequately described.

Four general types of samples are, or have been, conducted on the Black Mesa leasehold; reference areas, reclaimed areas, coal resource areas (baseline studies), and floristic surveys. Reclaimed areas are sampled on a periodic basis to measure the progress of the vegetation and to demonstrate revegetation success. Reference areas are sampled to provide quantitative information needed to make revegetation success comparisons. Floristic surveys are qualitative in nature, utilized primarily to list species occurrence.

Floristics

Floristic surveys are conducted by a walking reconnaissance of the study area and adjacent areas noting species occurrence and distribution in the various communities during a given sampling period. The purpose of the surveys is to determine and list the plant species in

each community and identify any species that may occur on the lease area that are rare, endangered or protected, are noxious, or have unique economic or aesthetic value. A herbarium collection is maintained at the mine site which consists of mounted voucher specimens of each species in the floristic surveys.

Cover Samples

For purposes of this sampling program, total ground cover means the area of ground covered by the combined aerial parts of vegetation and the litter that is produced on-site (non-stratified), expressed as a percentage of the total area of measurement (30 CFR 701.5).

Cover is sampled using the point intercept method in which data are tabulated as interceptions of a point with plant species, soil, litter, or rock (Buckner, 1985). Point intercepts will be measured using a Model 2 or Model 3 optical point bar developed by Dr. David Buckner of ESCO Associates, Inc. The optical point bar consists of an optical sighting device mounted on a bar which is 0.5 meter long. This bar is attached to a tripod that can be adjusted (leveled) to accommodate terrain variation. The sighting device incorporates a microscope reticle with a set of extremely fine cross hairs that project a nearly dimensionless point where they intersect. A large diameter objective and microscope optics with magnification improve image and identification. The system eliminates parallax and allows the observer to make a clear and objective decision as to where to attribute the point hit. A rotating mirror set 0.5 meter from the tripod attachment point allows projection of points up into the overstory canopy, as well as down into the understory canopy. The bar attachment to the tripod allows the bar to swing freely and places the point projection 0.5 meter from the tripod center. At regular intervals along a predetermined transect length, the tripod is centered over the transect line and the bar is oriented perpendicular to the line and the first observation is made. The arm is swung 180° and the second cover reading for the transect interval is taken. This is repeated for the length of the transect until the total number of desired points are taken.

At the Black Mesa complex, point intercept cover samples are taken at randomly located and randomly oriented 50m transects. After field determination of random sample point origins is completed, a 50-meter transect tape will be laid out in a randomly selected direction. At each meter along the line, two points will be read (one on each side of the

line) for a total of 100 points per transect. Non-stratified and stratified cover will be recorded by sighting down and up (if needed) in a vertical projection of the point. Cover data will be collected by species and will also include measurements of rock, litter, lichen and moss, and bare ground. Data will be recorded in a manner that allows segregation of canopy cover (intercepts above one meter of the ground surface) and ground cover (intercepts within one meter of the ground surface).

First hit interceptions are used to calculate absolute non-stratified vegetation cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit (non-stratified) relative vegetation cover is calculated by dividing first hit vegetation cover for each species by the total first hit vegetation cover and converting to percentage. Stratified vegetation cover is calculated by dividing all hits (1st, 2nd, etc.) for a particular species by the total number of points taken (100). Stratified relative vegetation cover is calculated using all hits for a particular species divided by the total hits accumulated during sampling of a transect.

Production Sampling

Production sampling is accomplished using circular quadrats located at random points along the 50m transects utilized for cover sampling. The complete harvest method is used in which all current years growth in a vertical projection above the plot boundary is clipped in each plot. Within production plots, all herbaceous growth is clipped, sorted by species, and placed in labeled paper bags. Current year's growth of shrubs is also clipped, sorted, and bagged. Clipped samples are transported to the laboratory for drying at 30° C in a forced-draft oven until a constant weight is obtained. The 30° C drying temperature corresponds to air dry weight which is the weight used in the technical success standard derived for production (see Chapter 23). Dried samples are weighed to the nearest 0.1 gram. For purposes of statistical analysis, each plot constitutes an observation.

An appropriate plot size ($0.25m^2$ to $1.0m^2$) and the number of plots sampled per transect (3 to 5 plots/50m transect) will be selected on a study area basis each season. Larger plots and greater numbers of plots per transect will be used in areas where vegetation is sparse and/or non-uniform. Smaller plots will be utilized in combination with lesser numbers of plots per transect in areas where the vegetation is dense, uniform, and has a great amount of biomass. In no case will the plot size or plot numbers be lesser or greater than the

ranges specified above without prior approval of the regulatory authority. Plot size and numbers will not be changed during a particular sampling episode at a particular study area.

Density Samples

Density samples are collected in the reclaimed areas to evaluate seedling emergence and establishment of herbaceous species, and to quantify woody plant density (tree or shrub). Two methods are used.

Seeded stands in logical reclamation units are evaluated to determine the need for reseeding. Stands are evaluated by the end of the second growing season after the seeding treatments are completed. Stands are evaluated on the basis of the number of established perennial plants per square foot as follows: excellent (0.75 or more); good (0.5 to 0.75); fair (0.25 to 0.5); and poor (less than 0.25). Stands that fail to meet at least the fair category must be retreated. The density data is collected using randomly placed circular plots. The plots vary in size from $0.5m^2$ to $2m^2$, depending upon visual assessments of stand uniformity and the number of plants per unit area. Larger plots are used in sparse stands. Results are always converted to numbers per square foot to assess seeding success, and mean perennial plant species density constitutes the sample mean. Sample sizes range between 50 and 500 observations depending upon the size of the area being evaluated. In some cases, more samples may be collected in areas where the stand exhibits a great degree of variability, or the sample adequacy equation indicates additional samples are needed to accurately appraise the seeding.

Woody plant density samples are collected using belt transects (2 x 50m quadrats) oriented along the cover transects. The sample unit extends 1m on each side of the 50m transect. Density is measured by direct counts, by species, of all shrubs encountered in the $100m^2$ quadrat. Individuals with more than 50 percent of the root crowns inside the plot are counted. Shrubs are tabulated by life stages as follows: seedling, mature, or dead. Shrubs may also be tabulated by height classes. Each quadrat is considered an observation for statistical purposes.

Species Frequency/Density Samples

During the course of cover sampling, all plant species occurring within one meter on either side of the cover sample transect are noted as present within each sample.

Frequency for each plant species observed during sampling is calculated by dividing the number of sample transects in which the species was observed by the total number of samples. As such, this value is probably more correctly known as "constancy".

The total number of species (within each lifeform) observed in each sample provide a measure of "species density", indicating relative species richness of different areas. These measures reflect progress toward return of diverse species composition in the reclaimed areas from a different perspective than is available from examination of cover data alone.

Photographic Record

Within each sampling area, representative color photographs are taken to document the appearance of the vegetation unless equipment problems are experienced or field conditions preclude photography.

Sample Adequacy

For the purpose of making revegetation success determinations or developing a revegetation success standard based upon historical records, adequate samples will be collected. Sample adequacy will be defined using Equation 1:

$$\text{(Eq. 1)} \quad N(\text{min}) = \frac{(st)^2}{(d\bar{x})^2} \quad \text{where;}$$

N(min) = the minimum sample size required

s = the sample standard deviation (N-1)

t = the t-statistic (t 0.10(2), df = N-1)

d = the detection limit (0.1 for the sample mean to fall within 10% of the population area

$\bar{x}$ = the sample mean

The sample adequacy equation shown above will be used on cover samples, production samples, and woody plant density samples (trees or shrubs). Sample adequacy will be assessed in the field after a minimum of ten observations have been collected in a given study area. The number of initial samples collected will be based upon experience. If

sample adequacy has not been achieved (N is less than N(min)) using the initial sample size, additional samples will be collected until N is greater than or equal to N(min). The mean ground cover of perennial plants measured on individual transects will constitute observations for purposes of assessing the adequacy of cover samples. The total perennial plant production (wet weight) from each individual plot will constitute an observation for purposes of assessing the adequacy of production samples. The total woody plant density from each belt transect will constitute an observation for purposes of assessing the adequacy of shrub or tree density samples.

In cases where premining pinyon/juniper woodland cover data and woody plant density data from reclaimed communities display severe departures from the assumptions for using the t-statistic, a data transformation may be performed to improve the shape of data distributions. The arcsine transformation (Equation 2) will be used on data sets which form biomodal distributions, and the square root transformation will be used on data sets which form Poisson distributions (Equation 3). These transformations are commonly recommended for the distributions expected (Steele and Torrie, 1960; Zar, 1974).

(Eq. 2) $X^1 = \text{arcsine} \quad x+1$

(Eq. 3) $X^1 = \quad x+.05$

Sample adequacy will be reassessed using the transformed data sets using Equation 1. When sample adequacy has not been achieved, additional samples will be collected until the criteria are met or the sampling design will be re-evaluated.

Data transformations will only be used in extreme cases, since the t-statistic applied in Equation 1 is considered to be rather robust with regard to deviations from the underlying assumptions. A minimum of 30 observations will be collected and tested using Equation 1 before considering a transformation. If the initial 30 observations fail to meet sample adequacy, pinyon/juniper cover sample data and reclaimed area shrub density sample data will be checked for normality and symmetry using visual assessments of the graphed data and calculated values for symmetry and kurtosis. Following the initial assessment, up to 20 more observations will be collected. If the additional data does not improve the distribution and significantly reduce the values for symmetry and kurtosis, the data set will be transformed. If the transformed data does not meet sample adequacy using Equation 1, sampling will continue until the transformed sample data is adequate.

Carrying Capacity

The carrying or grazing capacity for a given area is determined using the production data obtained from harvest sampling. Carrying capacities are calculated using the equations outlined in Table 1. Although production data are measured in grams/m^2 for each species, the data are converted to lbs/acre to calculate grazing capacity, since lbs/acre is the commonly accepted mode for expressing these figures.

A proper use factor is an index of the grazing use that may be made of forage species based on a system of range management that will maintain the economically important forage species or achieve other management objectives. Values of 40 to 50 indicates high preference by certain animals for specific species. Values of 20 or less suggest low palatability. The use factors of some plant species are listed in Exhibit A. Since sheep and cattle are the major livestock on Black Mesa, the average of the use factor for each animal can be used in the calculations.

The forage requirement of 2270 lbs per sheep unit year long (SUYL) is roughly equivalent to a 3 lbs per day requirement for 100 pounds body weight as determined on the Central Plains Experimental Range (Table 1). This constant has traditionally been employed for calculating stocking rates on the Navajo Reservation. Four sheep units equal one animal unit instead of five as is reported elsewhere. The stocking rate as suggested by the BIA (1980) and Stoddard and Smith (1975) can be based on 65 percent of the total forage production if Proper Use Factors are not used.

TABLE 1

Equations for Carrying Capacity Calculations (BIA 1980)

$$\text{Acres/SUYL} = \frac{2270}{\text{Total Useable Forage}}$$

$$\text{Acres/AUYL} = (\text{Acres/SUYL}) \times 4.0$$

$$\text{Acres/AUM} = (\text{Acres/AUYL}) / 12$$

where,

Total Useable Forage = sum of the useable forage for all species in a given sample (lb/acre x Proper Use Factor)[1]

Proper Use Factor = grazing use index for a given forage species[2]

Acres/SUYL = Acres required per sheep unit year long

Acres/AUYL = Acres required per animal unit year long (4 sheep/animal unit)

Acres/AUM = Acres required per animal unit growth

2270 = a constant based upon sheep forage requirements that is equivalent to 3 lb/day per 100 lb body weight consumed plus trampling (traditionally used for calculating carrying capacity on the Navajo Indian Reservation)

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[1] Stocking rates can be based upon 65% of the total forage production (BIA 1980; Stoddard and Smith 1975)

[2] Grazing use indices for many of the forage species found in the lease area may be found in Exhibit A.

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EXHIBIT A

PROPER USE FACTOR FOR SELECTED

FORAGE SPECIES FOUND ON THE BLACK MESA LEASES

This list is a partial printing of Plants Found in the Navajo Land Selection Areas supplied by BIA (1980). The original list is based on the publication Intermountain Range Plant Symbols (U.S.F.S., Intermountain Forest and Range Experimental Station, Ogden, Utah, 1966), and lists provided by Hovenweep and Petrified Forest National Monuments. The numbers indicate, in order, use factors for cattle and sheep (values of 40 to 50 indicate high preference.

GRASSES	
Agropyron cristatum (Crested Wheatgrass)	50-35
A. smithii (Western Wheatgrass)	50-35
A. trachycaulum (Slender Wheatgrass)	50-35
A. trachycaulum var. unilaterale (Bearded Wheatgrass)	50-35
Bouteloua gracilis (Blue Grama)	50-40
Bromus inermis (Smooth Brome)	40-35
B. tectorum (Cheatgrass)	10-10
Hilaria jamesii (Galleta)	50-40
Hordeum jubatum (Foxtail Barley)	0-0
Muhlenbergia asperifolia (Alkali Muhly)	5-5
M. pungens (Sandhill Muhly)	10-10
M. torreyi (Ring Muhly)	0-0
Munroa squarrosa (False Buffalograss)	0-0
Oryzopsis hymenoides (Indian Ricegrass)	50-35
Poa fendleriana (Muttongrass)	40-30
Polypogon monspeliensis (Rabbitfoot)	10-10
Puccinellia distans (Weeping Alkaligrass)	10-10
Secale cereale (Winter Rye)	50-40
Setaria viridis (Green Bristlegrass)	0-0
Sitanion hystrix (Squirreltail)	30-35
Sporobolus airoides (Alkali Sacaton)	30-20
S. cryptandrus (Sand Dropseed)	30-30
Stipa neomexicana (New Mexico Feathergrass)	30-25
Vulpia octoflora (Sixweeks Fescue)	10-10
GRASS-LIKE PLANTS	
Carex sp. (Sedge)	30-20
Juncus Tenuis (Poverty Rush)	30-30
Scirpus acutus (Tule Bulrush)	20-20

FORBS

Allium macropetalum (Wild Onion)	0-10
Amaranthus graecizans (Tumble Pigweed)	0-0
Arenaria eastwoodiae	0-0
Artemisia ludoviciana (Silverking Sagebrush)	10-20
Asclepias sp. (Milkweed)	0-0
Astragalus praelongus (Stinking Mile-vetch)	0-0
Artiplex rosea (Redscale)	0-0
Calochortus aureus (Sego Lily)	0-10
Castilleja chromosa (Indian Paintbrush)	5-10
C. linariaefolia (Long-leaved Paintbrush)	5-10
Chaenactis stevioides (Esteve Pin Cushion)	5-10
Chamaesarcha coronopus (Small Ground Cherry)	0-0
Chenopodium sp. (Pigweed)	10-20
Chorispora tenella (Chorispora)	0-0
Cirsium sp. (Thistle)	0-0
Cleome serrulata (Rocky Mountain Beeplant)	0-5
Cordylanthus wrightii (Birdbeak)	0-10
Cordalis aurea (Scrambled Eggs)	0-0
Cryptantha bakeri	0-0
C. flava	0-0
Cymopterus purpurascens	0-0
C. purpureus	0-0
Delphinium nelsonii (Larkspur)	0-0
Descurainia pinnata (Tansy Mustard)	0-0
D. sophia (Flixweed)	0-0
Draba sp.	0-0
Erigeron divergens (Spreading Fleabane)	5-10
Eriogonum alatum (Winged Eriogonum)	20-20
E. cernuum (Nodding Eriogonum)	20-20
E. divaricatum (Wild Buckwheat)	0-0
E. jamesii (James Eriogonum)	20-20
Erodium cicutarium (Filaree)	10-10
Erysimum sp. (Erysimum)	10-10
Euphorbia sp. (Euphorbia)	5-10
Gilia sp. (Gilia)	5-5

FORBS (Cont.)

Happlopappus armerioides (Goldenweed)	0-10
H. Spinulosus (Goldenweed)	0-10
Helianthus petiolaris (Prairie Sunflower)	5-20
Hymenopappus filifolius	0-0
Hymenoxys acaulis (Bitterweed)	0-0
H. ivesiana (Bitterweed)	0-0
Ipomopsis aggregata (Sky Rocket)	5-5
Lactuca serriola (Wild Lettuce)	0-0
Lappula redowski (Stickseed)	0-0
Leptodactylon pungens (Prickly Phlox)	0-0
Lesquerella intermedia (Bladder Pod)	0-10
Leuceline ericoides (White Aster)	5-10
Linum Lewisii (Blue Flax)	0-10
Lithospermum incisum (Puccoon)	0-0
Lotus sp. (Deervetch)	30-40
Lupinus brevicaulis (Short-stemmed Lupine)	0-0
Machaeranthera canescens (Hoary Aster)	5-10
Malacothrix sonchoides	0-10
Medicago sativa (Alfalfa)	30-30
Melilotus officinalis (Yellow Sweetclover)	20-20
Mentzelia albicaulis (Small-flowered Blazing Star)	5-10
M. pumila (Blazing Star)	5-10
Mirabilis multiflora (Colorado Four O'clock)	5-10
Nicotiana attenuata (Coyote Tobacco)	0-0
Oenothera albicaulis (Prairie Evening Primrose)	0-10
O. caespitosa (Sun Drops)	0-10
Orobanche fasciculata (Broom Rope)	0-0
Oxybaphus linearis	0-0
Penstemon barbatus (Scarlet Penstemon)	0-10
P. linarioides (Mat Penstemon)	5-10
P. strictus (Rocky Mountain Penstemon)	0-10
Petradoria pumila (Rock Goldenrod)	5-10
Phlox longifolia (Phlox)	5-10
Plantago purshii (Indian Wheat)	10-10
Polygonum aviculare (Prostrate Knotweed)	0-0

FORBS (Cont.)	
Salsola iberica (Russian Thistle)	10-10
Senecio douglasii var. longilobus (Thread Leaf Groundsel)	0-0
Sisymbrium altissimum (Tumble Mustard)	0-0
Solonum rostratum (Buffalo Bur)	0-0
S. triflorum	0-0
Sphaeralcea coccinea (Scarlet Globe Mallow)	10-30
Stanleya pinnata (Desert Plume)	0-0
Suaeda torreyana (Desert Seepweed)	10-20
Tragopogon dubius (Goat's Beard)	0-10
Verbesina enceloides (Cowpen Daisy)	0-0
Viguiera annua (Annual Goldeneye)	5-10
TREES AND SHRUBS	
Amelanchier utahensis (Utah Serviceberry)	20-40
Artemisia arbusculas sp. nova (Black Sagebrush)	15-20
A. frigida (Prairie Sagewort)	10-20
A. tridentata (Big Sagebrush)	10-15
Atriplex canescens (Fourwing Saltbush)	40-50
A. confertifolia (Shadscale)	20-20
A. obovata (Broadscale)	20-40
Chrysothammus depressus (Dwarf Rabbitbrush)	10-20
C. greenei (Greene's Rabbitbrush)	5-10
C. nauseosus (Rayless Goldenrod)	5-10
C. viscidiflorus (Douglas Rabbitbrush)	5-10
Clematis ligusticifolia (Virgin's Bower)	5-10
Corypantha vivipara	0-0
Cowania mexicana (Cliffrose)	20-40
Echinocereus triglochidiatus (Hedgehod Cactus)	0-0
Ephedra viridis (Green Ephedra)	10-15
Eriogonum corymbosum (Wild Buckwheat)	10-10
Eurotia lanata (Winterfat)	30-40
Fendlera rupicola (Fendler Bush)	20-30
Foresteria meomexicana (Tangle Bush)	10-10
Gutierrezia sarothrae (Snakeweed)	0-0
Juniperus osteosperma (Utah Juniper)	0-0
Lycium pallidum (Rabbit Thorn)	0-0

TREES AND SHRUBS (Cont.)

Opuntia erinacea (Mohave Prickly Pear)	0-0
O. fragilis (Little Prickly Pear)	0-0
O. phaeacantha (Prickly Pear)	0-0
O. whipplei (Whipple Cholla)	0-0
Pinus edulis (Pinyon)	0-0
Populus sp. (Cottonwood)	10-10
Quercus gambelii (Gamble Oak)	10-10
Q. Undulata (Wavyleak Oak)	10-10
Rhus trilobata (Squawbush)	0-5
Salix exigua (Coyota Willow)	30-30
Sarcobatus vermiculatus (Greasewood)	10-10
Shepherdia rotundifolia (Roundleaf Buffaloberry)	20-20
Symphoricarpos sp. (Snowberry)	20-30
Tamarix pentandra (Salt-cedar)	0-10
Tetradymia canescens (Gray Felt Thorn)	0-0
Yucca angustissima (Spanish Bayonet)	10-10
Y. baccata (Banana Yucca)	10-10

ATTACHMENT 3

ETHNOBOTANICAL INFORMATION

Information on Plants Grown on Black Mesa

Information collected for the use of Peabody Coal Co.

by the

Ethnobotany Project of Native Healing Sciences
Navajo Health Authority
Window Rock, Arizona 86515

Researched by Sharon Benay
Navajo Translations by Ella Ashley

1.) FAMILY

Compositae

SPECIES

Chrysothamnus Spp.

COMMON NAMES

Rabbit Brush
Chamisa

NAVAJO NAMES

Ts'iilyésiitso - yellow stem

HOPI NAMES

Siva'pi
Masi'siva'pi

NAVAJO USES

A number of unidentified species of Chrysothamnus are used as yellow dyes.

HOPI USES

It is commonly used in wind breaks and similiar constructions where brush is needed. Name of a clan of the Water-Corn phratry. Associated with the northwest (siva'pi) and the northeast (masi'siva'pi) in the povamu altar and with the zenith (siva'pi) and the nadir ("small" siva'pi) in the Oagol ceremony. Used in weaving the wedding belt.

2.) FAMILY

Compositae

SPECIES

Chrysothamnus viscidiflorus (Hook) Nutt. var. Pumilus (Nutt) H & C
Bigelovia douglas; A. Gray var. pumila A. Gray
Chrysothamnus pumilus Nutt.

COMMON NAMES

Douglas Rabbit Brush

NAVAJO NAMES

Tc'iltiilyéesiitshoh - big plant which is used as a refuge by small animals.

NAVAJO USES

This plant is mixed with the pollens of five different trees in the five night sings to make a sick person vomit.

3.) FAMILY

Compositae

SPECIES

Aster Spp.

COMMON NAMES

Aster

NAVAJO NAMES

Atsá halchinii - plant smells like an eagle.

3.) NAVAJO USES

Liniment for the Bead Chant consists of aster, tumbleweed (Amaranthus graecizans) and an unidentified species of Artemisia. The Bead Chant tobacco consists of the following plants: gila (Gilia longiflora) Four-O'clock (Mirabilis oxybaphoides) bread root (Psoralea tenuiflora) catchfly (Silene douglasii) and caltrop, (Tribulus terrestris).

4.) FAMILY

Compositae

COMMON NAMES

Broadscale Rabbit Brush
Rubber Rabbitbrush
Chamiso

SPECIES

Chrysothamnus latisquameus (A. Gray) Greene
Chrysothamnus nauseosus graveolens
Bigelovia graveolens A. Gray var. latisquamea A. Gray

NAVAJO NAMES

K'iiɁtsoi - yellow stem

NAVAJO USES

Navajo Indians make yellow dye from the blossoms. A green dye is made from the inner bark. The twigs and flowers of this species are used to color wool.

5.) FAMILY

Compositae

COMMON NAMES

Health Aster
White Aster

SPECIES

Aster leuceline
Aster leuceline Blake
Aster ericaefolius Rothr.

HOPI NAMES

to:'tim - boys The plant is not generally recognized and there is a confusion of names.
ho'n'ngapi - the Bear Charm

HOPI USES

It is used to aid a sore nose and to quiet the baby.

6.) FAMILY

Compositae

COMMON NAMES

SPECIES

Artemisia tridentata Nutt.

Three toothed sagebrush - Basin Sagebrush - Big Sagebrush
Rocky Mountain Sagebrush
Black Sagebrush - Blue Sagebrush
Chamiso hedionda (stinking sagebrush)
Estafiata

6.) NAVAJO NAMES

Gah biłakani - plant which rabbits eats like candy.
Ts'ah - sage (botanical name)
Tse'eziih - rock sage
Tsetah ts'ah - sage among rocks
Ma'iiłizhin natoh - black coyote tobacco

HOPI NAMES

Wi:'kwapi

NAVAJO USES

Coyote gave this "tobacco" to the water monster to calm her after he had stolen her baby. Waterway medicine - Eagleway medicine. This plant is mixed with Artemisia trifida as a medicine for headaches, which are supposed to be cured by odor alone. It is also used for colds and fevers. This plant is taken before long hikes and athletic contests and is supposed to rid the body of undesirable things that are lingering in the body. A drink made from this same plant is used as an aid in childbirth. When this plant is boiled and drunk, it is supposed to act like epsom salts and cure stomachache, constipation and watersnake bite.

HOPI USES

For digestive disorders.

.) FAMILY

Asclepiadaceae

SPECIES

Asclepias spp.

COMMON NAMES

Milkweed

NAVAJO NAMES

Ch'il abe'étsoh - plant which has pods which resemble snake winder snake's horn.

NAVAJO USES

These plants are used for stomach trouble in general by crushing the dried leaves between the fingers and stirring the resulting powder into a bowl of water. Because the juice of the milkweed resembles milk, it is held to be useful in treating a mother who cannot nurse her infant. One of the plants used to treat boils or abscesses. Sheep get blown up if they eat milkweed in the spring even without water.

8.) FAMILY

Caprifoliaceae

SPECIES

Symphoricarpos orbiculatus Moench
Symphoricarpos (L.) MacMillan
Symphoricarpos vulgaris Michx.

8.) COMMON NAMES

Snowberry
Indian Currant
Stag Berry
Waxberry
Coral Berry
Wolf Berry

NAVAJO NAMES

Tshetshohk'ii - twig plant which grows among the boulders.

NO NAVAJO USES IN OUR LITERATURE.

9.) FAMILY

Chenopodiaceae

SPECIES

Sarcobatus vermincultus (Hook) Torr.
Batis vermiculata Hook.

COMMON NAMES

Black greasewood
Chico

NAVAJO NAMES

Díwózhii - the greasewood
Díwózhii/zhiin - black greasewood

HOPI NAMES

te:'ve

NAVAJO USES

This plant is used as firewood by the Navajo and in winter it is used as forage for sheep, who eat it for the salt. Planting sticks, Navajo dice, knitting needles, heald sticks, the handle of the distaff used in weaving and war bows are all made of greasewood because it is so hard. The plant is sometimes chewed and applied to ant, bee and wasp stings, and as a lotion applied to a mad coyote's bite.

HOPI USES

The strong wood is used for rabbit sticks, planting sticks, stirring rods, musical rasps, lease rods, clothes hooks in houses, arrows, and construction generally. The Kiva fuel; when dry it burns with a bright sparkling flame. Name of clan sometimes associated with the Eagle-Sun phratry and sometimes with the water-corn phratry.

10.) FAMILY

Chenopodiaceae

SPECIES

Salsola Kai L.

NAVAJO NAMES

Ch'il deeníní - sharp plant

NO NAVAJO USES.

11.) FAMILY

Chenopodiaceae

SPECIES

Eurotia lanata (Pursh) Moq.
Diotis lanata Pursh

11.) COMMON NAMES

Winter Fat, White Sage
Winter Sage
Lambs Tail
Sweet Sage

NAVAJO NAMES

Gahtsohdą́ą́' - jack rabbits food

HOPI NAMES

wuta'kvala
tavo'tka

NAVAJO USES

This plant is used to relieve blood spitting by slightly boiling the leaves and eating them, and to cure Datura poisoning by drinking a cold infusion. It is used with other plants as mixed charcoal for blackening. Plants are dried, burnt to ashes on a hot plate and mixed with a mixed salve.

HOPI USES

An ingredient of fever medicine. For sore muscles, the plant is pounded with hot rocks and smeared on the sore muscles.

12.) FAMILY

Chenopodiaceae

SPEICES

Chenopodium spp.

COMMON NAMES

Goosefoot
Pigweed
Lamb's Quarter's

NAVAJO NAMES

TX'ohdeii - upper grass

NAVAJO USES

One species is chopped up finely and spread on the face and arms to keep the flies and mosquitoes from biting. Also said to be like soap when crushed up. Another species is usually eaten as a stiff porridge. Pigweed is also used with other plants as a liniment in the Mountain Chant.

13.) FAMILY

Chenopodiaceae

SPECIES

Chenopodium album L.

COMMON NAMES

Quelite
Lamb's Quarters
White Goosefoot
White Pigweed

NAVAJO NAMES

tl'oh deii - upper grass
tl'oh deii tsoh - big seed grass
tl'oh deii nááXgai - white eyed grass
dikǫǫzh - like salt weed

HOPI NAMES

si'swa
hzhz'la

13.) NAVAJO USES

The young tender plants are collected by the Navajo and boiled as herbs alone or with other foods. Large quanities are eaten in the raw state.
Food: Seeds, not used now as much as formerly; seeds of dried plants threshed on a blanket, winnowed in a blanket, ground lightly to loosen perianths, winnowed again, washed, dried ground with maize (if used alone they have a bitter taste). In 1936, Kluckhohn saw a stack of lambsquarters as high as a hogan being threshed and the seeds saved for winter; and in four different families he saw the seeds being made into bread. It is also used for ceremonial food in Nightway.

HOPI USES

Boiled and eaten with a number of foods. Packed around the fruits of Yucca angustissima when they are baked in the earth oven.

14.) FAMILY SPECIES

Chenopodiaceae Atriplex nuttallii Wats.

NAVAJO NAMES

díkǫ́ǫ́zh - bitter saltweed

NO NAVAJO USES.

15.) FAMILY SPECIES

Chenopodiaceae Atriplex confertifolia (Torr. & (Frem.) S. Wats
Obione confertifolia Torr. & Frem.

COMMON NAMES

Spiny Saltbrush
Sheep Fat
Saltbush

NAVAJO NAMES

Díkǫ́ǫ́zh - bitter salt weed
Díkǫ́ǫ́zh sízílinii - standing salt weed
Díkǫ́ǫ́zh bihosh ɣání - salt weed having many spines

HOPI NAMES

znga'toki
ki'tsvi

NAVAJO USES

Salt substitute for human and livestock.
This plant is used in the winter to provide salt for the sheep.

15.) HOPI USES

Young tender leaves cooked and eaten as greens.

16.) FAMILY

Chenopodiaceae

SPECIES

Atriplex canescens (Pursh) Nutt.
Calligonum cancescens Pursh.

COMMON NAMES

Chamiso
Four-wing Saltbush
Shadscale Saltbush
Orache

NAVAJO NAMES

Díwózhii Ɣbáí - greasewood, gray
Díwózhii Ɣbáí - chamiso, gray

HOPI NAMES

su'ovi

NAVAJO USES

Sheep feed. In warm weather it may cause sheep to bloat if they over eat, but a decoction of chamiso and juniper leaves will relieve them if administered quickly, enough. Evilway and Navajo Windway emetic. Warts are treated by cutting them or tying horse hairs around them and appling certain plants. Atriplex canescens is recommended for this purpose. (Another treatment is to burn some powdered pith of Helianthus annuus upon a wart).

HOPI USES

Burned and ashes used as alkali necessary to maintain the blue coloring present in the blue corn meal used in making blue piki (wafer bread).

17.) FAMILY

Capparidaceae

SPECIES

Cleome serrulata Pursh
Cleome integrifolia T & G
Peritoma serrulatum DC

COMMON NAMES

Rocky Mountain Bee Weed
Blue Colorado Bee Plant
Clammy weed stink weed
Cleome spider plant

HOPI NAMES

tu'mi

NAVAJO USES

When plants get about four inches high they are picked and boiled like spinach. The plants are also made into a stew with wild onion (Allium deserticola), wild celery (Cymopterus glomeratus) and a little tallow or bits of meat. Morsels of bread are dipped into the stew and eaten. When any of the plants are left over they are sometimes allowed to dry and are cooked in the form of dumplings with

17.) meat or tallow. The young plants are boiled and pressed out three times, after which they are rolled into balls and eaten, or dried and stored for the winter. When these balls are to be used they are soaked and boiled with or without tallow. The Navajo say that guaco has saved them from starvation on several occasions.

HOPI USES

The young plants are gathered and boiled for food; frequently plants are allowed to mature and seed in the cornfields, insuring a supply for the following spring. This plant is used in the preparation of pottery paint among the Tewa of the Rio Grande.

18.) FAMILY SPECIES

Cactaceae Opuntia whipplei Engelm & Bigel

COMMON NAMES HOPI NAMES

Cholla Cactus ZSZ'
Pi:'nga - refers to milk

HOPI USES

The fruit is boiled and eaten with squash.
March is sometimes called the cactus moon because "in early times food was often scarce at this season," and this cactus was practically the only vegetable food obtainable.

.) FAMILY SPECIES

Cactaceae Opuntia spp.

COMMON NAMES

Cane Cactus
Prickly Pear
Candelabrum Cactus
Coyote Candles
Nopales
Cholla

NAVAJO NAMES

Tit chin pixwoc - cactus which does not satisfy hungar - it produces no edible fruit.
Hosh - Cactus
Hosh'atiniit'oo iih - cactus whose awls are hard to extract.
Hosh'íneecbijeeh - cactus which resembles a food preparation called broken braids.
Hosh líbaíí - cactus, grey

19.) NAVAJO USES

Plants used to treat boils or abscesses may be designated by the Navajo family name "boil medicine" (c'oz ?aze?). Boils may be attributed to eagle infection, and treated by Eagle Way or Bead Way, with "eagle plants". Boiled eagle meat may be eaten. Life medicine also is an appropriate treatment. Preparations include poultices, dusting powders, and lotions. Boils are lanced with cactus spines.
The fruits of a number of species of prickly pears are eaten by the Navajos. They gather the fruits with a cactus picker made of a forked stick, and after the spines are removed the tunas are split and dried in the sun and served in much the same manner as we serve dried fruit.

20.) FAMILY SPECIES

Cactaceae Opuntia phaeacantha Engelm

NAVAJO NAMES

hosh níteelí - wide cactus

NO NAVAJO USES.

21.) FAMILY SPECIES

Cactaceae Mammillaria spp.

COMMON NAMES

Ball Cactus
Pincushion Cactus
Fishhook Cactus

NAVAJO USES

The flesh is eaten as food.

22.) FAMILY SPECIES

Cactaceae Echinocereus coccineus Engelm
Cereus aggregatus Coult.
Cereus coccineus Engelm.
Cereus phoenicius Engelm.
Echinocereus aggregatus (Engelm) Rydb.
Echinocereus triglochidiatus var. melanacanthus

COMMON NAMES

Crimson Hedgehog Cereus
Crimson Hedgehog Cactus
Crimson Barrel Cactus
Spinemound
Mound Cactus
Claretcup

22.) NAVAJO NAMES

Jéinályoogisíí - plant, which if eaten makes the heart feel as if it were twisted.

NAVAJO USES

The yellow-green fruits are edible but are believed by the Navajo to cause internal pains; hence the name "heart twister". The Navajo eat the fresh fruits of several species of this genus but this particular species is supposed to be poisonous. The name is probably derived from the effects produced after eating it, since the Navajo say that it makes your heart feel as if it were twisted.

23.) FAMILY

Cactaceae

SPECIES

Echinocereus spp.

COMMON NAMES

Hedgehog Cactus
Barrel Cactus

NAVAJO USES

The fruits of several species of this genus are eaten by the Navajo. They are said to be a little bit sweet and taste something like avocado.

( ) FAMILY

Borginaceae

SPECIES

Lappula occidentalis (S. Wats) Greene
Echinospermum redowskii Lehm
Echinospermum redowdkii Lehm var. occidentalis S. Wats.
Lappula redowskii (Hornem.) Greene
Lappula redowskii (Hornem.) var. occidentalis (S. Wats) Rydb.

COMMON NAMES

Western Stickseed

NAVAJO NAMES

'Iitjiihih - plant whose seeds are sticky
Ch'il bohoshí - spiny plant

NAVAJO USES

To heal sores caused by insects, a poultice if the plant is applied.

25.) FAMILY

Boraginaceae

SPECIES

Cryptantha spp.

NAVAJO NAMES

'Azee'łibáíí - gray medicine

25.) NAVAJO USES

Coyote infection; used with a plant called ma'ii'iilcee' - like a coyote's tail. Life medicine.

26.) FAMILY SPECIES

Amaranthaceae Amaranthus spp.

COMMON NAMES NAVAJO NAMES

Red root pigweed Naazkaadii

NAVAJO USES

Medicines to relieve itching of the skin are usually prepared as infusions and applied locally as lotions, but poultices or ointments (with red ochre in mixed salve) maybe used. Among the conditions for which such medicines are appropriate, informants mentioned chicken pox, small pox, measles, erythema mulforme, scabs, cold sores, sunburn, chapping, frozen feet, corns, poisoning from poison ivy or other plants, and mosquito or other insect bites. Dusting powders are used as deodorants and for itching.

27.) FAMILY SPECIES

Pinaceae Pinus ponderosa Dougl.

COMMON NAMES NAVAJO NAMES

Western yellow pine Nídíshchíí' - pine
Ponderosa pine

HOPI NAMES

lzqz

NAVAJO USES

One part of the Night Chant medicine consists of pollen from this tree, and (Pinus edulis), Juniperus virginiana and Juniperus occidentalis.
Evil Way Chant arrow - Male and Female Shooting Evil Way equipment, Big Starway, Red Antway equipment.

HOPI USES

Large roof timbers. The Kiva ladders are invariably made of pine.

28.) FAMILY SPEICES

Pinaceae Pinus edulis Engelm
Pinus monophylla Torr. & Frém

28.) COMMON NAMES

Two-leaf pinon
Pinon, Pinyon
Nut Pine

NAVAJO NAMES

Deestsiin - dry logs
Bijeeh - pinon gum
Cha'oł - pinon

HOPI NAMES

Tuve"e
Ho:ga"z
Na'shz - branch
Sa'na - gum

NAVAJO USES

Pinon has many uses. Medicine, ceremonials, building, firewood, and household items.
Pinon nuts! Gather in large quanties, sold & traded. Roasted in pots or skillets, sometimes mashed and made into a butter similiar to peanut butter. Nuts crushed between stones to remove shells than made into a paste which is spread on hot corn cakes.
Sap is used for chewing gum.
Medicinally, pinon gum, tallow and red clay make a salve which is smeared on open cuts and sores.
Pinon needles are one of the ingredients in a medicine drunk in the War Dance.
After a death of family or friends, Navajos smear their body with pinon pitch before burying the body, and while mourning. Spots of pitch are smeared on the forehead and under the eyes.
In the War Dance, a mixture of pinon and willow pitch is painted on the patient.
An incense, which is burned during the Night Chant, is made of dried pinon gum and the parts of several birds. On the fourth day of the Night Chant, Talking God carries a sapling of pinon, if the patient is male, and juniper, if the patient is female. On the Ninth Day of the Night Chant, the Slayer of Alien Gods and the Child of Water deposit their cigarettes in the shade of a tree, preferrable a pinon.
On the last Night of the Mountain Chant, the dancers carry wand inserted in bunches of pinon needles, in each hand.
Hogans for ordinary as well as ceremonial usage are usually built of pinon logs which are about eight to ten inches in diameter, and from 10 to 12 feet long. Loom poles, beams and uprights used in construction of looms, ceremonial pokers, ceremonial wands.
Parts of the Navajo cradle are made of pinon wood because it is so easily carved.
It is used extensively for firewood.
The best black for sand paintings is obtained from the charcoal of the pinon tree.
The corral which is built for public exhibitous at the close of a ceremonial, especially the Night Chant, is built of juinper & pinon boughs.
Pinon & juniper are used to make the circle of branches for the Mountain Chant.

28.) A black dye is made from pinon gum, the leaves and twigs of sumac (Rhus trilobata) and a native yellow ocher (teetchoh - earth, yellow). The sumac leaves are put in water and allowed to boil until mixture becomes strong. While this is boiling the ocher is powdered and roasted again.
As the roasting proceeds, the gum melts and finally the mixture is reduced to a black powder. This is cooled and thrown into the sumac mixture forming a rich blue-black fluid which is essentially an ink.
Water bottles are covered with pinon gum to make them watertight. The gum is heated and poured into the jar and by turning the jar, the melted gum is brought into contact with the entire inner surface, after which the surplus is poured off. The outside is covered with the gum to which a red clay has been added so that the bottle has a reddish hue when finished.

HOPI USES

The nuts are eaten.

29.) FAMILY

Pinaceae

COMMON NAMES

Douglas Fir
Douglas Spruce
Red Fir
Yellow Fir
Oregon Pine
False Spruce
Pino Real

SPECIES

Pseudotsuga taxifolia (poir.) Britt.
Abies douglasii Lindl.
Abies mucronata Raf.
Pseudotsuga douglasii (Linl) Carr.
Pseudotsuga mucronata (Raf.) Sudw.

NAVAJO NAMES

'Azee ts'óóz - slender medicine
Ch'óh deeníní - the spruce

HOPI NAMES

sala vi

NAVAJO USES

Used for stomach disease, and headache by fumigation. Ground with a certain rock and put with corn seed to insure a good crop. "Navajos do not observe this very closely now: that is why the wind kills corn and worms eat it". Mountain-Top Way, Beauty Way, Beadway, Nightway, Evilway, Starway medicine; in the Shooting Chant, many branches of the Douglas Fir are used.

HOPI USES

Important in many of the ceremonies, though juniper is occassionally substituted. Associated with the northwest direction. Name of a clan of the Kachina-cottonwood phratry.

) FAMILY

Plantaginaceae

30.) COMMON NAMES

Pursh Plantain
Pursh Ribgrass
Woolly Indian Wheat
Plantain

SPECIES

Plantago purshii R & S
Plantago gnaphaloides Nutt.
Plantago patagonica Jacq. var. gnaphaloides A. Gray

HOPI NAMES

Hahai'nga - from the Kachina haha''i

NAVAJO NAMES

'Azee'it'iɣ - medicine
Yiitjih - it catches hold of it
Ts'aa'xalts'aa' - bowl shaped (seeds hollowed like a basket)

NAVAJO USES

Food, seeds made mush. (Navajo name implies medicinal uses)

HOPI USES

Given to a person to make him more agreeable.

31.) FAMILY

Polemoniaceae

SPECIES

Gilia aggregata (Pursh) Spreng
Gilia attenuata (A. Gray) A. Nels
Gilia aggregata (Pursh) Spreng var. attenuata A. Gray

COMMON NAMES

Scarlet Gilia
Sky Rocket
Scarlet Trumpet
Gilia

NAVAJO NAMES

Dahyiiłįhídąą - hummingbird food
Dloziłgai bich'il - white pine squirrel's plant

HOPI NAMES

pala'ka'tsi

NAVAJO USES

The dried leaves crushed between the fingers and stirred in a bowl of water are used as a remedy for stomach troubles in general. Blessing pollen, flowers mixed with corn pollen, Enemyway emetic.

HOPI USES

The flowers are ground with meal for the hunters petition before setting out on an antelope hunt, because that animal is very fond of the plant.

32.) FAMILY

Polygonaceae

SPECIES

Eriogonum spp.

COMMON NAMES

Wild Buckwheat

NAVAJO NAMES

Xóchǫ́ǫ́dzí ch'il łíbáí - gray evil way plant
Wóláchíí'dą́ą́' - red ant food

HOPI NAMES

powa'wi

NAVAJO USES

One of the plants used for wounds. Preparations used for infected wounds (used when castrating stock animals) include poultices, dusting powders and infusions for lotions or to drink. Wounds may be sultured with bison or deer sinew.
Used for Mountain Top Way, Eagle Way, Bead Way or Plume Way. May be used to treat sore throat, Decoctions are drunk and applied as lotions, and poultices of the plant are applied to the throat.
Used for stomach disease caused by ghost infection or Evilway infection.

HOPI USES

A menstruation medicine and to help with childbirth.

33.) FAMILY

Polygonaceae

SPECIES

Eriogonum rotundifolium Benth.

COMMON NAMES

Wild Buckwheat

NAVAJO NAMES

Wóláchíí'dą́ą́'- red ant food

NAVAJO USES

This plant is taken when ants are swallowed to make one vomit.

34.) FAMILY

Polygonaceae

SPECIES

Eriogonum umbellatum Torr.

NAVAJO NAMES

[illegible] - mountain tobacco
[illegible] - wood worm's tobacco

NAVAJO USES

Used with fog tobacco, cloud tobacco, and water tobacco, in the emetic and fumigant of Waterway. Biliousness, emetic.

35.) FAMILY

Rosaceae

SPECIES

Cowania stansburiana Torr.
Cowania Mexicana Don.

35.) COMMON NAMES

Cliff Rose
Buck Brush
Quinnie Bush

NAVAJO NAMES

awéétś'áál - plant whose bark is used in making the backing for the baby's cradle.

HOPI NAMES

hu:'nvi

NAVAJO USES

The bark is stripped form the shrub, softened by applying between the hands and used as a backing for cradle boards and as stuffing for pillows. It is spread out in the sun everyday to take the odor off. It is also used to stuff the Navajo baseball, which is covered with the hide of any animal that can be eaten with impunity, such as horsehide, goatskin or buckskin.
Used in place of Fendlera rupicola if the patient is a woman in certain ceremonies. Also used for Navajo Windway, Nightway, Shooting Way, and Plume Way mush..

HOPI USES

Hopi Indians made arrows from the wood.

36.) FAMILY

Rosaceae

SPECIES

Purshia tridentata (Pursh) DC
Tigarea tridentata Pursh

COMMON NAMES

Antelope Brush
Buck Brush
Bitter Brush

NAVAJO NAMES

'Awéétś'áál - baby mat
K'ínijił'ahí - skinned from the tree

NAVAJO USES

One of the plants used as emetic. Arrows are made of this plant.

37.) FAMILY

Salicaceae

SPECIES

Populus fremontii S. Wats

COMMON NAMES

Fremont Popular
Fremont Cottonwood

NAVAJO NAMES

T'iis - the cottonwood tree

HOPI USES

Hopi Indians use the wood in carving Kachina dolls.

37.) NAVAJO USES

Used in all types of building.

38.) FAMILY

Salicaceae

SPECIES

Populus tremuloides Michx.
Populus aurea Tidestrom
Populus tremuloides Aurea Daniels

COMMON NAMES

Quaking Aspen
American Aspen
Rocky Mountain Aspen

NAVAJO NAMES

T'iis báí - gray cottonwood

HOPI NAMES

tzvo'vi

NAVAJO USES

This tree, according to legend, has the distinction of being the first tree against which the bear rubs his back in the Sun's House Chant. The others are red willow (Salix laevigata), fir (Pseudotsuga taxifolia); and chokecherry (Prunus demissa).

HOPI USES

Associated with the northeast direction: ritually smoked.

39.) FAMILY

Scrophulariaceae

SPECIES

Castilleja chromosa A. Nels

NAVAJO NAMES

Dahiitʃhídą́ą́'- humming bird's food (female)
Na'ashjé'iidą́ą́'- spider food

NAVAJO USES

Used for spider bite, with Penstemon eatoni and Gilia aggregata.

40.) FAMILY

Scrophulariaceae

SPECIES

Castilleja spp.

COMMON NAMES

Indian Paintbrush

NAVAJO NAMES

Dahiitʃhídą́ą́'- hummingbird's food

NAVAJO USES

"Baby Medicine" (used post partum to expedite recovery).

41.) FAMILY

Scrophulariaceae

SPECIES

Penstemon barbartus (cav.) Roth

COMMON NAMES

Scarlet Bugler

HOPI NAMES

pala'katsi

NAVAJO USES

In earlier days a sweet drink was made by boiling the whole plant.

42.) FAMILY

Tamariacaceae

SPECIES

Tamarix pentandra

COMMON NAMES

Five Stamen pentandra

NAVAJO USES

Woman in Tuba City used branches in weaving, but because plant is not a native it has fewer uses than most native plants.

43.) FAMILY

Solanaceae

SPECIES

Lycium pallidum Miers.

COMMON NAMES

Rabbit thorn
Box thorn
Matrimony vine
Tomatillo

NAVAJO NAMES

Haashch'éédą́ą́'- supernatural's food

HOPI NAMES

ke: 've
keve'fsi

NAVAJO USES

The fruits are eaten as they come off the bush or they are boiled into a soup. They are picked in the summer and boiled to the right consistency and spread on the rocks to dry. When dry they are stored until winter, then eaten dried or made into a soup. The flavor is rather flat. The fruit is also sacrificed to the gods.
To stop a toothache, put the ground root in cavity.

HOPI USES

Berries are boiled, the water drained off and the berries ground. A double handful of potato clay is soaked in water until it is the consistency of thick cream. It is then mixed with a large bowlful of the ground berries and eaten. This it is said was the principal fruit eaten during the famine of 1863, but is rarely eaten now, as there are many other fruits available.

44.) FAMILY

Malvaceae

COMMON NAMES

Scarlet False Mallow
Red False Mallow

SPECIES

Malvastrum coccineum (Pursh) A. Gray
Cristaria coccinea Pursh
Sphaeralcea coccinea (Pursh) Rydb. var. elata (Baker) Kearney

NAVAJO NAMES

'Azéé'hókánii

NAVAJO USES

An infusion of this plant is supposed to be a remedy for disease produced by witchcraft. It is also used to stop bleeding. Skin disease,-lotion, sores, dusting powder. Tonic to improve appetite. Ceremonial tobacco, beverage; medicine to give singer strength.

45.) FAMILY

Malvaceae

COMMON NAMES

Globe Mallow

SPECIES

Spaeralcea spp.

HOPI NAMES

Kopo'na

NAVAJO USES

Disease attributed to ceremonially improper sexual intercourse (sore eyes, headache, pain in bones) or to intercourse too soon after childbirth (pus in stomach in females) is treated by infusions of Globe Mallow, or more commonly, the plants are used as ingredients of bison fumigant which is administered by hole fumigantion (sprinkled on hot coals in a hole over which the patients sits, covered by a blanket). This treatment may be added to a Life Way and other ceremonials.
Lung trouble may be treated by Shooting Way or Navajo Wind Way. Infusions or decoctions of the plants are drunk.

HOPI USES

Root is chewed or boiled for broken bones. When defecation is difficult or accompanied by blood, the roots are chewed with cactus roots or boiled together. Also used for bowel trouble in babies.

46.) FAMILY

Liliaceae

SPECIES

Yucca spp.

46.) COMMON NAMES

Soaproot
Amole
Soapweed
Spanish Bayonet
Bare Grass

NAVAJO NAMES

Tsá'ászí' - Yucca
Tsá'ászí'niteelí - banana yucca
Tsá'ászi'ts'óóz - soapweed yucca

NAVAJO USES

Boys and girls have their hair washed with yucca suds in a short initiation ceremony on the next to last night of the Nightway. In the Blessingway, there are a few songs one night, a ritual bath in yucca suds with prayers and songs the next day. The ceremonial bath in Yucca suds are common to most chants. In all chants there is great stress on the idea of purification; there is an insistence on "clean thinking" and serious demeanor. The suds bath is based upon this idea which is one of the most central notions in Navajo thinking.
The sweatbath and the yucca root bath probably have effects on the nervous system in some ways similiar to those of hydrotherapy.

47.) FAMILY

Nyctaginaceae

SPECIES

Mirabilis multiflora A. Gray
Quamoclidion multiflorum Torr.

COMMON NAMES

Many-flowered Four-O'clock
Colorado Four O'clock

NAVAJO NAMES

K'íneetlíciidą́ą́' - stinkbug food
Tł'éé'yigáahii - white at nignt
Tsé dídéėh - rock tea
Tsé dídéėh tsoh - big rock tea

NAVAJO USES

Kluckhohn has eleven references to a tea being made from this species. The root is used as a poultice for dwellings.

HOPI USES

Hopi Indians are said to eat the root to stimulate visions.
It is also placed on a child's head to induce sleep.

48.) FAMILY

Onagraceae

SPECIES

Gaura coccinea Pursh

NAVAJO NAMES

'Azee'bilátah łichíí'ígí - red flowers
'Azee'líbáí - grey medicine
na'ashje'iidą́ą́'- spider food
iiníziin ch'il - witchcraft plant

48.) NAVAJO USES

Most ceremonials require a chant lotion which is applied to the patients body in a ceremonial order, after which he bathes in it and drinks some. The ingredients are mostly member of the Labiatae, although other fragrant plants may be used. Certain plants may be specific for given ceremonies. They may be designated by some combination of the Navajo family name "chant lotion". Chant lotion is used to relieve headache, fever, lameness and general body aches and pains and coughs, colds and chills. Cold infusions are employed. Rheumatism or swollen, painful joints, is sometimes treated by Beautyway or ascribed to "witchcraft" so Beautyway decoction or "witchcraft plants" may be used to treat it as well as other plants. It is usually prepared by decoction, to drink or for lotions. (This is one of the plants used in burns or scalds. Preparations include dusting powder, poultices, ointments (with sheep grease and red ocher) and infusions for lotions. These are also used for sores. Warm infusions of this plant and other plants are drunk for internal pain).

49.) FAMILY

Onagraceae

SPECIES

Oenothera grandiflora S. Wats
Oenothera caespitosa Nutt. var. marginata (Nutt) Munz
Oenothera caespitosa Nutt.
Oenothera marginata Nutt.

COMMON NAMES

Large-flowered Evening Primrose
Evening Primrose

NAVAJO NAMES

Tł'éé'ii gahí - white at night
'Azee'łitsoi - yellow medicine
'Azee'łabáhí - gray medicine
Tł'éé'yigáahii tsoh - big white at night

NAVAJO USES

Prolapse of the uterus, grind and apply. Mixed with cornmeal placed on Nightway sandpainting figures used by singer to improve his performance, to insure pain, or for a child who has seen forbidden sandpaintings.

50.) FAMILY

Onagraceae

SPECIES

Oenothera spp.

COMMON NAMES

Evening Primrose

NAVAJO NAMES

Tł'éé'yigáahii tsoh - big plant which blooms at night
'Azee'łaatilt'ihíh - medicine which grows alone.

50.) NAVAJO USES

For sores caused by a snake or an insect touching the skin, some of the leaves are ground with fuller's earth, mixed with corn (Zea Mays) pollen and water and mixture is put on the sore. Lifeway medicine.

51.) FAMILY

Liliaceae

SPECIES

Yucca glauca Nutt.
Yucca angustifolia Pursh
Yucca angustissima Engelm

COMMON NAMES

Narrow-Leaved Yucca
"Bear Grass"
Narrow-Leaved Soaproot
Indian Cabbage
Pamilla
Mesa Yucca Narrow-Leaved Soapweed

NAVAJO NAMES

Tsá'ászi'ts'óóz - slender standing awl, narrow yucca
Tsa'laguoc - water suds, name for roots
Ni doodlóhii - no meaning, the green fruit
Nteestijiin - stalk when it first comes out of the ground is a very dark green color and is called stalk, black. The stalk grows a little taller and begins to look whitish and is call Nteeskaih (stalk, white)

HOPI NAMES

mo'hu - refers to the top of the plant, while mo:vi refers to the roots.

NAVAJO USES

The fruits of this plant are either eaten as they are found, baked in ashes, or they are sliced and dried for winter use. They are not as palatable as the fruits of Yucca baccata, yet taste similiar to a banana.
Soaproot is used to make a shampoo. It prevents dandruff, and keeps hair from falling out.

HOPI USES

Roots are crushed with stones and used for soap. In the ceremonial washing of hair as a purification rite, the suds are associated with clouds for baldness, which is very rare, wash the hair with yucca root and rub with duck grease, because ducks have such heavy feathers. The yucca has many uses, but the only medicinal use seems to be as a laxative.

52.) FAMILY

Liliaceae

SPECIES

Calochortus nuttallii T & G
Calochortus nuttallii

COMMON NAMES

Nuttall Mariposa
Nuttall Sego Lily
Nuttall Mariposa Lily
Nuttall Mariposa Tulip
Nuttall Butterfly Tulip
Nuttall Butterfly Lily
Sego Lily
Mariposa
Star Tulip
Butterfly Lily
Sego - is a Shoshonean origin

NAVAJO NAMES

K'íłtsíniih - the mariposa lily

NO NAVAJO USES.

53.) FAMILY

Leguminosae

SPECIES

Oxytropis spp.

COMMON NAMES

Loco weed

NAVAJO NAMES

dibé haich'iidii - sheep scratch
dibé nát'oh - sheep tobacco
dibédą́ą́' - sheep food
Txá'iiltchóc iits'óoz - slender plant which has pods that can be popped on the forehead.
Mą'ɬina'ooltjil'azee' - medicine for coyote rabies.

NO NAVAJO USES.

54.) FAMILY

Leguminosae

SPECIES

Melilotus indica (L.) All.

NAVAJO NAMES

'Azee'bílátah hal tsoi - yellow flowers

NAVAJO USES

Navajo word "azee" implies medicinal use.

55.) FAMILY

Leguminosae

SPECIES

Oxytropis lambertii Pursh
Aragallus lambertii (Pursh) Greene
Oxytropis lambertii sericea Nutt.
Spiesia lambertii (Pursh) kuntze

55.) COMMON NAMES

Locoweed
Lambert Locoweed

NAVAJO NAMES

Dibé'nát'oh - sheep tobacco
Dibe'haich'iidii - sheep scratch
tádídíín dootl'izh nitsaá gíí - .blue pollen large

HOPI NAMES

sita'ngwi

NAVAJO USES

Plumeway infusion specific, to treat deer infection caused by deer's breath, Ravenway infusion specific. To treat constipation, use as a food, made into mush or parched. To protect corn from grasshoppers, steep plant with coal, yellow orchre, and sheeps' milk, and spray the corn with it. This plant is offered to the Bighorn at the Night Chant.

HOPI USES

The Hopi's recognize that it is poisonous to cattle.

56.) FAMILY

Leguminosae

SPECIES

Medicago sativa L.

COMMON NAMES

Cultivated alfalfa
Lucerne
Medick

NAVAJO NAMES

Tł'oh waa'í - hay which looks like the bee weed.
Dine'é ch'il - game way plant

NAVAJO USES

Diseases of the head and neck may be treated by chants of the God-Impersonators, Wind Chant, or Eagle Trapping sub- groups, so certain plants (Lupinus kingii and Lotus wrightii) pertaining to these chants (including gameway plant may be remedies for such condition: sore aching eyes).

57.) FAMILY

Leguminosae

SPECIES

Lupinus spp.

COMMON NAMES

Lupine

NAVAJO NAMES

Azeediilch'íłii - medicine, male

NAVAJO USES

This unidentified species of lupine is used in the male shooting chant. (Navajo name suggests some medicinal use).

58.) FAMILY

Hydrophyllaceae

SPECIES

Phacelia crenulata Torr. var. ambiqua (Jones) Macbe.

NAVAJO NAMES

'Azee'nichįi'íi - irritating medicine

NAVAJO USES

A mixture of Rhus toxicoddndron, Phacelia crenulata Torr. var. ambigua, charcoal from a lightening struck tree and deer's blood make an arrow poison, name implies medicinal use.

59.) FAMILY

Gramineae

SPECIES

Stipa comata Trin & Rupr.

COMMON NAMES

Needlegrass
Speargrass
Needle and Thread grass

NAVAJO NAMES

tl'ohdeí'chíní - bony seed grass

HOPI NAMES

Ho:'ki - name also applied to several other grasses.

NAVAJO USES

Used as play arrows by adults and children.

60.) FAMILY

Gramineae

SPECIES

Sporobolus cryptandrus (Torr) A. Gray
Agrostis cryptandra

COMMON NAMES

Rush Grass, Poverty Grass, Wire Grass, Sacaton Grass, Sand Dropseed

NAVAJO NAMES

tł'ohts'óozíh - grass, slender

NAVAJO USES

The chaff is removed from the seeds which are then ground to make dumplings, rolls, gridle-cakes and tortillas.

61.) FAMILY

Gramineae

SPECIES

Sporobolus airoides Torr.

61.) COMMON NAMES

Alkali Sacaton

NAVAJO NAMES

tl'oh tsahii - awl grass
tł'ohtsózhitso

HOPI NAMES

Nx:'na

HOPI USES

The grain, which falls free from the chaff when ripe, was collected in quanity for food, particularly in times of famine, occasionally used today.

62.) FAMILY

Gramineae

SPECIES

Sitanion hystrix (Nutt) J.G. Smith
Aegilops hystrix Nutt.

COMMON NAMES

Wild Rye, Foxtail, Squirreltail

NAVAJO NAMES

'Azee'iilwo'í - runs into the mouth

HOPI NAMES

pe'sru - for the tail of the rat (sz'rz, tail)

NAVAJO USES

Mature awls considered dangerous. (The mature beard may cause mouth or nose injuries in stock animals and if they get into the hair or wool they may penetrate the skin and cause sores.

63.) FAMILY

Gramineae

SPECIES

Oryzopsis hymenoides (Roem & Shult) Ricker
Eriocoma cuspidata Nutt.
Eriocoma nymenoides Rydb.
Oryzopsis cuspidata Benth
Stipa hymenoides Roem. & Schult
Eriocoma membranaceae (Pursh) Beal

63.) COMMON NAMES

Indian Millet
Sand Bunch Grass
Indian Rice Grass
Mountain Grass
Mountain Rice

NAVAJO NAMES

ntitłitih - seed, toasted

HOPI NAMES

le:'hu

NAVAJO USES

The Navajo use the seeds of this plant for food. In collecting the seeds, a bunch of the grass is held near the fire, allowing the seeds to fall out of the base of a flat stone place obliquely near by. The seeds are then ground and made into cakes.

HOPI USES

The seeds, which fall tree form the chaff when ripe have excellent food value and were collected in quanity, particularly in times in famine.

64.) FAMILY

Gramineae

SPECIES

Munroa squarrosa (Nutt) Torr.
Munroa squarrosa

COMMON NAMES

False Buffalo grass

NAVAJO NAMES

tl'oh shoh dak'áá nii - pulverized frost grass

HOPI NAMES

kwai'pz'hz - refers to the downy feathers of a hawk or eagle, kw'hz.

NAVAJO USES

Pollen for some of the sacred ceremonies is gathered from this plant. The roots have a somewhat sweetish taste when put into cold water and drunk.

65.) FAMILY

Gramineae

SPECIES

Hilaria jamesii (Torr) Benth
Pleuraphis jamesii Torr.

COMMON NAMES

Galleta Grass

NAVAJO NAMES

tl'oh łichíí' - red grass
tł'ohtshá híh - grass whose leaves are like awl

HOPI NAMES

sz hz

65.) NAVAJO USES

Horse and sheep feed, second in importance to Bouteloua gracilis, although not as palatable, it is better able to withstand trampling & close grazing. Appetizer for babies: cold infusion, makes them "want to eat a lot" when they grow up, thus they become strong.

HOPI USES

The fill of the coiled basketry made on the Second Mesa and the artificial arm worn by the manipulator of the serpent effigy. Attached to prayersticks for deer and antelope.

66.) FAMILY

Gramineae

SPECIES

Brommus tectorum L.

COMMON NAMES

Cheatgrass

NAVAJO NAMES

ghe'iats'osii - God impersonators plume

NAVAJO USES

Sheep and horse feed.
Lotion to bathe faces of God Impersonators before they put on the masks, Plume-Way infusion specific, Nightway infusion.

) FAMILY

Gramineae

SPECIES

Bouteloua gracilis (HBK) Lag.
Chondrosium gracile HBK

COMMON NAMES

Grama grass
Blue grama
Mesquite grass

NAVAJO NAMES

tł'oh nástasí - bent grass

HOPI NAMES

haru shu - refers to the curling of the mature spike.

NAVAJO USES

Important forage grass, Enemyway blackening: ashes of stem and leaves. Evil Way mixed charcoal for blackening: dry the plants, burn to ashes on a hot plate and mix with mixed salve. This species of grass is one of the plants that is tied to the end of the wand carried by the girl in the squaw dance.

HOPI USES

A important forage grass. Sometimes used in a fill of the second mesa coiled booketry.

68.) FAMILY

Graminaceae

SPECIES

Agropyron smithii Rydb.

COMMON NAMES

Colorado Bluestem

NAVAJO NAMES

pa shu
pa shz - grass growing near water

NO HOPI OR NAVAJO USES.

69.) FAMILY

Fagaceae

SPECIES

Quercus spp.

COMMON NAMES

Oak

NAVAJO NAMES

tsé ch'il - oak

HOPI NAMES

kwi:'ngvi

NAVAJO USES

The acorns of the various oaks are used by the Navajos as food. They are boiled like beans, roasted over coals or they are sometimes dried and ground into flour. A medicine, whose use is unknown is made and placed in thirty-two acorn shells and humming bird made to sip from each.

HOPI USES

The wood is used in making rabbit sticks, arrows, bows, digging sticks, clubs, weft battons, axe handles, and other utensils. Name of a clan of the mustard phratry. Associated with the northwest direction in the Oagol ceremony.

70.) FAMILY

Fagaceae

SPECIES

Quercus gambelii Nutt.
Quercus douglasii H & A var. gambelia D.C.
Quercus undulata Torr. var. gambelii Engelm.

COMMON NAMES

Gambel Oak
Blue Oak
Rocky Mountain White Oak

70.) NAVAJO NAMES

tséch'il - oak

NAVAJO USES

Acorns: eaten raw, boiled, roasted in ashes or dried & ground and cooked like corn meal; not gathered every year or by all families. Also, Evilway big hoop made of oak.

71.) FAMILY

Cupressaceae

SPECIES

Juniperus monosperma (Engelm) Sarq.
Juniperus occidentalis Hook. var. monosperma Engelm.
Sabina monosperma

NAVAJO USES

Berries eaten in fall or winter when they are ripe. Said to be a "little bit sweet when ripe".
One of the plants used as emetic. Used for firewood, building cradleboard, shade house.
Berry like cones may be roasted or boiled. Bark is chewed for flavor. In times of food shortage, Navajos chewed the inner bark. When snow is deep, Navajos cut branches for sheep to eat. Special hogans for Enemyway Ceremonies were made from juniper.
Prayersticks. Bath purification of burial party. Bark used as tinder for ceremonial fire.
Stick carried in War Dance is made of a piece of juniper from which all of the twigs except a small bunch at the tip have been trimmed. To the leaves left at the top is added a bunch of rabbit weed, (Chrysothamnus) or snake weed (Gutierrezia sarothrae) gramma grass (Bouteloua gracilis) and several other articles.
Bows for canopy, from of cradle and a canopy to bed & coverlet for baby to make him strong, protect newly-born child from sparks of fire.
Lining of moccasins in winter to absorb moisture.
Bark & berries color wool green, ashes of needles, an ingredient in dye for buckskin.
Wood used for firewood, fence posts, shade house, hogan roofs, ordinary and ceremonial because it does not readily decay.
Charcoal for smelting silver.
Bow carried in war, torch used in Fire Dance.
At times the leaves of the juniper are chewed and spit out-as in the face of a bulky burro. Lining for sweat house. Used in making Yucca suds. Platform for sundry roasted corn. Lining of storage pit for corn.
And now for a story:
Navajos claim that the finishing to ashes on their baskets are their own. In ancient days, four men were standing in a hogan trying to decide how things should be. When all of a sudden coyote threw the branch of a juniper in. The men looked at the branch as it occurred to them that the peciular folds of the juniper leaves would make a finishing touch.

71.) Medicinal:
Post partum pain, highly prized as a medicine for burns, menstrual pains, stomach ache, fever, a decoction for cough is from pinyon needles, often salt is added to improve taste.
Bloating in sheep is often from eating "chamiso".
Ingredient of sweat bath medicine.
Post partum pain or prolonged labor-patient placed on a bed of heated jumiper boughs and more hot boughs placed over her legs, thighs and abdomen by the women present-never the singer-especially in the winter.
Post partum fainting-wet twigs, or puliverized needles placed on patients face or given to her to smell.
Emetic for new born babies-to clean out all impurities, infusion of inner bark of juniper or pinyon-a tablespoonful for the first four days of life.

72.) FAMILY

Cruciferae

SPECIES

Stanleya pinnata (Pursh) Britt.
Stanleya pinnatifida Nutt.
Cleome pinnata Pursh
Stanleya integri folia James

COMMON NAMES

Prince's Plume
Desert Plume

HOPI NAMES

'i'shz
kwi:'vi - proud

NAVAJO NAMES

'Azee'haagaií - medicine, white
Tshetc'oc'azee' - rock, worm medicine
Ts'ahbi̧i̧h - deer sage
'Azéé'ta'iitsóhii - squash blossom medicine
Tsé'éya hataał - sings under rock

NAVAJO USES

Food, greens. This plant is used as a medicine for glandular swellings.

HOPI USES

Eaten as greens in the spring.

73.) FAMILY

Cruciferae

SPECIES

Lesquerella intermedia (S. Wats) Heller L. Cinerea Wats.

COMMON NAMES

Bladderpod

NAVAJO NAMES

tóneinilii binákee'ati̧i̧ - water sprinkler's eye wash

73.) HOPI NAMES

hohoi'yáwnga - name for the black beetle (Elepdes sp.) which disturbed is said to flatulate in the same fashion as a man who has chewed the root.

NAVAJO USES

One of the main Nightway medicines.

HOPI USES

The bitter root is chewed and causes flatulation. In describing the famous Snake Dance. Each man carries some of this while hunting the snakes. If one bites him he eats a little of the root, chews it a little and lays it on the wound, and no harm insures. An infusion of the same root is drunk and then acts as an emetic, as a purfication at the end of the public ceremony. A little of this snake medicine, which is composed chiefly of hohoi'ya'wnga and the black beetle is considered a good medicine and is sometimes drunk by others than those taking part.

74.) FAMILY SPECIES

Compositae Senecio spp.

NAVAJO USES

(Word medicine 'azee' in name implies medicinal usage)

75.) FAMILY SPECIES

Compositae Senecio multicapitatus Greenm.

COMMON NAMES HOPI NAMES

Groundsel Muyi'tka - suggestions that the name means "mole corn" is in error.

HOPI USES

The tip of this plant is used as a brush to remove the hair spines from prickly pear.

76.) FAMILY SPECIES

Compositae Senecio longilobus Benth.

COMMON NAMES

Groundsel

76.) NAVAJO NAMES

'Azee'hááldzidí - rotten medicine

HOPI NAMES

Masi'muyi'tka - masi' - gray
Muyi'tka, S. multicapitatus

NAVAJO USES

Boils, poultice.

HOPI USES

Pound with a hot rock and smear over a sore muscle. Grind leaves and put them on pimples. This plant seems to be generally recognized as having medicinal properties and is preferred to S. multicapitatus.

77.) FAMILY

Compositae

COMMON NAMES

Sunflower
Common Sunflower
Annual Sunflower

SPECIES

Helianthus annuus L.
Helianthus anomalus Blake
Helianthus petiolaris Nutt.

NAVAJO NAMES

dz'o'xonaa'ai bina toh - sun tobacco
nídíyílii tsoh - sunflower

NAVAJO USES

Prenatal infection from an eclipse of the sun. Sun sand painting ceremony. Warts are treated by buring some powdered pith of Helianthus annuus upon a wart. Liniment for the War Dance consists of Physaria sp., Wild Sunflower, sumac (Rhus trilobata), and mistletoe (Phorandendron sp.).

HOPI USES

Hopi Indians make from the seeds purple and black dye for coloring cloth, basket fibers and their bodies, in preparation for ceremonial rites. Seeds are eaten out of hand. The seeds are recognized as an important source of food for summer birds.

78.) FAMILY

Compositae

COMMON NAMES

Snake weed

SPECIES

Gutierrezia sarothrae (Pursh) Britt. & Rusby

NAVAJO NAMES

ch'ildiilyésii - snakeweed

HOPI NAMES

ma:"zvi - all species
tcatca'kma:"zvi
tcatca'k - small or fine refers in general to the species of Gutierrazia

HOPI USES

Important as paho (prayerstick) decorations. Wrapped with the mother ear of corn. Used medicinally for "gastric disturbances" at Hano.

79.) FAMILY

Compositae

SPECIES

Cirsium spp.

COMMON NAMES

Thistle

NAVAJO NAMES

Azeehókánii

NAVAJO USE

Life Medicine.

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SUPPLEMENT TO THE INFORMATION ON PLANTS GROWN

ON BLACK MESA (NHA ETHNOBOTANICAL PROJECT)[1]

SPECIES	NAVAJO/HOPI USE(S)
Amelanchier spp.	Food
Berberis repens	Food
Clematis ligusticifolia	Medicinal
Descurainia spp.	Food
Echinochloa crusgalli	Food
Ephedra viridis	Medicinal, Food
Foresteria neomexicana	Functional (Hopi digging sticks)
Hymenoxys acaulis	Medicinal
Linum lewisii	Functional (cordage)
Lithospermum incisum	Functional (dyes), Medicinal
Monolepis nuttalliana	Food
Orobanche spp.	Medicinal
Panicum spp.	Food
Portulaca spp.	Food
Ribes cereum	Medicinal
Scirpus acutus	Food
Setaria viridis	Food
Suaeda torreyana	Medicinal
Typha spp.	Food

[1] Source: Kearney and Peebles (1960)

Attachment 4

2003 Baseline Vegetation Sampling Report
N12/N99 North/South Study Area

Black Mesa Mining Complex

N12/N99 North/South
VEGETATION BASELINE SAMPLING REPORT
2003

Black Mesa Mining Complex

November 2003

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INTRODUCTION

In late May and early June 2003, ESCO Associates conducted a baseline vegetation study of the N12/N99 North/South area within Peabody Western Coal Company's (PWCC) Black Mesa Mining Complex leasehold. The purpose of this sampling was to describe species composition, woody plant density, and diversity in the study area prior to disturbance by mining. Both quantitative and qualitative data were collected in the study area; methods, sample areas, and sample sizes were those specified by PWCC.

The vegetation resources in the project areas were similar to those described in previous baseline studies (Peabody Coal Company 1985 and ESCO Associates 2000), consisting of a mosaic of sagebrush and pinyon-juniper vegetation communities. Sampled areas were classified as either sagebrush or pinyon-juniper using aerial photos and previous baseline vegetation maps.

METHODS

Sensitive Plant Surveys

A list of sensitive plant species was compiled from the following sources under the following definitions:

USFWS THREATENED AND ENDANGERED SPECIES (50CFR 17.11 AND 17.12, DEC. 1999)

Endangered species: any species which is in danger of extinction throughout all or a significant portion of its range (other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under the provisions of The Endangered Species Act of 1973 would present an overwhelming and overriding risk to man).

Threatened species: any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, as determined by the Secretary.

NAVAJO ENDANGERED SPECIES LIST (NESL)

The following definitions are taken from the Navajo Endangered Species List (NESL) issued by the Navajo Nation Department of Fish and Wildlife-NNDFWL (2001)

Group 1: Those species or subspecies that no longer occur on the Navajo Nation

Group 2 (**G2**) & Group 3 (**G3**): "Endangered" – Any species or subspecies whose prospects of survival or recruitment within the Navajo Nation are in jeopardy or are likely within the foreseeable future to become so.

G2: A species or subspecies whose prospects of survival or recruitment are in jeopardy.

G3: A species or subspecies whose prospects of survival or recruitment are likely to be in jeopardy in the foreseeable future.

Group 4: Any species or subspecies for which the Navajo Nation Department of Fish & Wildlife (NNDFWL) does not currently have sufficient information to support their listing as G2 or G3 but has reason to consider them. The NNDFWL will actively seek information on these species to determine if they warrant inclusion in a different group or removal from the list.

The final sensitive plant species list (Appendix 3 – *Field Guide to Potentially Occurring Rare Plants, Black Mesa Mining Complex*) was organized by species growth habit and habitat preferences, and included detailed descriptions and drawings of morphological traits, mention of look-alikes and distinguishing characteristics, habitat requirements, and phenology. A literature review was conducted on those species listed in the above sources to compile this information (see Kearny and Peebles 1960, McDougall 1973, Arizona Rare Plant Committee 2000, Ecosphere 1995, Great Plains Flora Association 1986, Utah TES Plant Interagency Committee 1991, Spahr 1991, Welsh et al. 1993).

The inner boundary (blue) areas shown on Map 1 were traversed on foot to ascertain the presence of the target species. This pedestrian survey took place between May 20 and

June 1, 2003. As of September 2003, the areas to be included in baseline study increased [see outer (red) boundaries]. Inasmuch as the target species were all most reliably to be identified in the early season, the additional areas could not be inventoried for species presence. Rather, they were visited in September and early October 2003 to determine the comparability of habitats of the outer areas to those of the inner areas that were surveyed in detail in the blooming season. This knowledge of the habitats of the outer areas was used to assess the likelihood of the occurrence there of each target species.

Qualitative Data Collection

The N12/N99 North/South study area was surveyed on the Black Mesa Mining Complex for threatened and endangered species. The vegetation types in the study area were predominantly pinyon-juniper with inclusions of sagebrush shrubland comprising a variable mosaic.

Using maps provided by PWCC and plotted over a photographic base with Universal Transverse Mercator (UTM) waypoints marking the boundaries, ESCO personnel walked throughout these areas searching for the listed species' habitat requirements. If habitat was found, a more detailed search of the area was performed. During the course of this survey, 'lookalike' species were noted as were 'cultural' species (those of significance to the Navajo and Hopi). Occasionally these specimens were entered into a handheld Global Positioning Device (GPS) for potential seed collecting or salvage purposes. If any species of concern were encountered these would also have been mapped using the GPS and located on the maps provided by PWCC.

Quantitative Vegetation Sampling

Quantitative data were collected for cover and woody plant density in the area surveyed for threatened and endangered species (discussed above). A map with randomly generated sampling points (Map 1) overlaying a photographic base was provided by PWCC for each of the baseline areas to be sampled. This information is included on Map 1. UTM coordinates were also provided for each point that in conjunction with the use of hand-held GPS units, assisted in objective sample point location.

COVER SAMPLING

Cover data were collected along randomly oriented 50 m transects using a point-intercept method in which data were recorded as interceptions of a point with a plant species, litter, standing dead plant material, bare soil, or rock. Plant material produced during 2003 and still standing was tallied by species. Litter was considered to be any organic material that had fallen, or begun to fall to the soil surface. Standing dead was any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter. Inorganic materials greater than 1 cm in diameter were considered rock. The cover sampling points were optically projected using a Cover-Point Optical Point Projection Device developed by ESCO Associates. One hundred points were collected at each transect. The points were evenly distributed; a pair of points collected on opposite sides of every meter mark along the 50 m transect (50 X 2 = 100).

First hit interceptions were used to calculate absolute top layer foliar cover by dividing the number of interceptions for a particular species or ground cover type by the total number of points taken (100). First hit relative vegetation cover was calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover was calculated by dividing all hits (first-hits and additional-hits) for a particular species by the total number of points taken (100). In addition, all-layer relative cover was calculated using all hits for a particular species divided by the total hits accumulated during sampling of the transect.

PLANT SPECIES FREQUENCY AND DENSITY MEASUREMENTS

During the course of cover sampling, all plant species occurring within one meter of either side of the cover sample transect were noted as present within each sample. The total number of species (within each lifeform) observed in each 100 sq.m. sample provides a measure of species density, indicating the relative species richness of different areas. Frequency for each plant species observed during sampling was calculated by dividing the number of sample transects in which the species was observed by the total number of samples.

WOODY PLANT DENSITY SAMPLING

Woody plant density sampling was undertaken in all sample areas along each transect established for cover. Trees, shrubs, subshrubs, and agavoids with root crowns located

within the boundaries of the quadrats (belt transects) were tallied according to species. In pinyon-juniper areas, woody plant density sampling was collected in 4x50 meter plots, 2 meters on either side of the cover transect. In sagebrush areas, woody plants were counted inside the 2x50 meter transects established for cover. The presence of dead individuals was not included in woody plant density calculations.

LIFEFORMS USED IN DATA PRESENTATION

All data and summary tables are organized by lifeform to facilitate data interpretation and analysis. The lifeform categories that follow reflect growth habit and provenance.

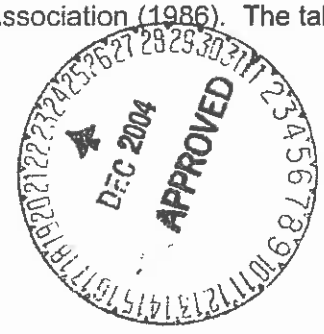
Lifeforms Present in 2003

Native Annual & Biennial Forbs	Native Subshrubs
Introduced Annual & Biennial Forbs	Native Shrubs
Introduced Annual Grasses	Introduced Shrubs
Native Perennial Forbs	Native Trees
Introduced Perennial Forbs	Succulents
Native Perennial Cool Season Grasses	Agavoids
Introduced Perennial Cool Season Grasses	Lichens
Native Perennial Warm Season Grasses	Mosses

Both grasses and graminoids (grass-like plants) are included in the Native Perennial Cool Season Grasses lifeform.

PLANT SPECIES LISTING

Scientific names used generally follow McDougall (1973) or Kearney and Peebles (1960) while the common names cited are found in Beetle (1970), Nickerson et al. (1976), or Soil Conservation Service (1979). Lichens and mosses were described in Hale (1969) and Conard (1956), respectively. Scientific names for vascular plants not found in the sources listed above were described by either Welsh et al (1993) or Great Plains Flora Association (1986). The table below lists these species with their sources:



Vascular plants not found in McDougall (1973) or Kearney and Peebles (1960)	Great Plains Flora Association (1986)	Welsh et al. (1993)
Arenaria hookeri	X	X
Bahia oppositifolia	X	
Cryptantha flavoculata		X
Elymus junceus	X	X
Erysimum **asperum**	X	X
Lygodesmia juncea	X	X
Puccinellia distans	X	X
Stephanomeria runicnata	X	X

During the course of fieldwork, a list of all encountered plant species (quantitative plus incidental observations) was compiled for each area. These lists are summarized in Appendix 2, 'Plant Species from the Study Area', which includes current nomenclature, cross-references to older nomenclature, common name, and the area in which the species was observed.

RESULTS

Tables containing the baseline sampling data are present in Appendix 1. Results of quantitative cover sampling of sagebrush shrubland are presented in Table 1, and data from pinyon-juniper woodland are found in Table 2. Woody plant density data from sagebrush shrubland are presented in Table 3. Woody plant density data from pinyon-juniper woodland are found in Table 4. Cover and woody plant density data are summarized in Table 5. Relative cover data organized by lifeform are presented in Table 6. Data on species density separated by lifeform are present in Table 7. A listing of all plant species encountered during quantitative sampling is provided in Table 8. Photographic documentation from representative quantitative sampling locations is available in Photographs 1 through 8, present in Appendix 4.

DISCUSSION

Sagebrush Shrubland

Areas mapped as sagebrush shrubland in the baseline sampling area are for the most part dominated by big sagebrush (*Artemisia tridentata*) and woody plants. This was typically in the form of varying and sometimes substantial presence of other shrubs and subshrubs, especially fourwing saltbush (*Atriplex canescens*), Douglas rabbitbrush

(*Chrysothamnus viscidiflorus*), and rubber rabbitbrush (*C. nauseosus*). Along with blue grama, the grass component of many sagebrush stands included galleta (*Hilaria jamesii*) and, more occasionally, bottlebrush squirreltail (*Sitanion jubatum* and *S. longifolium*), needle and thread (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*), and western wheatgrass (*Agropyron smithii*). However, the latter five cool season grasses were almost always less abundant than the warm season grasses blue grama and galleta. A preponderance of warm season grasses is consistent with environmental conditions that are strongly characterized by low and variable precipitation concentrated in summer "monsoon" episodes. Major exceptions to the strong presence of big sagebrush in this vegetation occur on shallow soils such as are found in J5/6 and J13/14 where woody plant cover is comprised primarily of Douglas rabbitbrush and shadscale saltbush (*Atriplex confertifolia*).

Total vegetation cover in the sagebrush shrubland type averaged 13.8 percent (Table 1). These data suggest that abundance of sagebrush is an indicator of overall soil productivity and that, within the limitations imposed by low annual precipitation, highest cover within the sagebrush type is expectable on the deeper (alluvial/colluvial) substrates.

Bare soil (Table 1) is very abundant within the sagebrush shrubland vegetation type, averaging 47 percent cover, while rock, averaged over 3 percent cover. Standing dead was probably more abundant in 2003 than usual because of the widespread death of sagebrush following the 2000-2002 drought (see below). It averaged over 15 percent cover in the 2003 sampling and was primarily dead big sagebrush.

Relative vegetation cover data (Table 6) show that shrubs are by far the most abundant lifeform in the sagebrush shrubland type at over 87 percent of total vegetation cover. Warm and cool season perennial grasses were much less, averaging only 2.8 percent of total vegetation cover.

With regard to woody plant density, the total density within sampled areas for sagebrush shrubland was 7196 stems per acre (Table 3). The bulk of the high values for this type were big sagebrush, Douglas rabbitbrush, rubber rabbitbrush, and fourwing saltbush (Atriplex canescens). Other shrubs that were encountered during sampling include the

subshrubs winterfat (*Ceratoides lanata*), snakeweed (*Gutierrezia sarothrae*), fringed sage (*Artemisia frigida*), and Greene rabbitbrush (*C. greenei*).

Among the sagebrush shrubland sites with deeper soils, invasion of pinyon pine is widespread. The pines are most often found directly beneath sagebrush where shading or other protection has apparently provided critical assistance in establishment.

That big sagebrush is among the native plants sensitive to moisture deprivation was evident throughout the Black Mesa area in 2003. The effects of serious drought conditions of the previous few years were very clear. Within the baseline areas examined in 2003, it is estimated that approximately 30% of sagebrush shrubland stands had suffered heavy die-back of sagebrush, while another 50 to 60% had experienced light to moderate die-back. About 10 to 20% of stands had little or no die-back. See the discussion of the drought sensitivity of sagebrush in the next section.

Species density (Table 7) within the sampled sagebrush shrubland stands averaged 12.4 species per 100 sq.m. This is a lower species density value for historically observed values on the Black Mesa leasehold.

Pinyon-Juniper Woodland

Although pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) are by far the most abundant plants on these sites in terms of ground cover and presumably biomass, their abundance is on the low end of the spectrum for this type in the Southwest (Moir and Carleton 1986). With tree canopy cover mostly in the range of 4 to 10 percent (and ranging down to 1 percent) for the 10 samples (Table 2), these sites do not meet the UNESCO definition of woodland (> 40 percent tree cover, UNESCO 1973). Pinyon-juniper vegetation at similar elevation (6300 ft) with the same tree dominants in Zion National Park had 38 percent cover (by ocular estimate; Harper 2003). Inasmuch as trees are by far the most abundant lifeform, it is reasonable to continue to refer to the type as woodlands.

Beyond the tree cover, shrubs are the next most abundant lifeform, being comprised of cliffrose (*Cowania mexicana*) and either fourwing saltbush or big sagebrush. Accompanying shrubs (or subshrubs) include Douglas rabbitbrush, fringed sage, snakeweed, and mountain joint-fir (*Ephedra viridis*). For the most part, herbaceous

cover in all the pinyon-juniper vegetation is very sparse. Warm season grass cover is very limited, mostly considerably less than 1 percent. Blue grama had the only measurable cover for all herbaceous species (Table 2). Cool season native grasses are more abundant in the pinyon-juniper vegetation type than in the sagebrush shrubland, but they had no measurable cover. More commonly observed species include bottlebrush squirreltail and Indian ricegrass. Native perennial forbs are more frequently encountered in the pinyon-juniper than in sagebrush shrubland, but still are very minor in the quantitative sense. Some pinyon-juniper stands give the general impression of virtually bare understory, while others have at least moderate presence of shrub cover.

Total vegetation cover (Table 2) was 16.4 percent, comparatively sparse for reported pinyon-juniper woodland. Harper (2003) for example, found an average of 62 percent live vegetation cover in his examination of pinyon-juniper woodland at Zion National Park. Rock averaged 20 percent cover over all the sampled area compared to about 3 percent in sagebrush shrubland. Standing dead of approximately 3 percent in pinyon–juniper woodland was substantially less than the sagebrush shrubland. Although some pinyon pine did perish as a result of the drought, overall the tree cover was mostly intact. Some of the mortality of pines was indirect, caused by bark beetle infestation of stressed trees.

Study of the ecophysiology of pinyon pine, Utah juniper and sagebrush has shown that the trees have assimilation (carbon-fixation) rates that are more sensitive to drought than sagebrush (DeLucia and Schlesinger 1991), but the trees have higher "water use efficiency" (assimilation rate/transpiration rate). In other words, the trees have much tighter control on transpirative loss, so even though their assimilation drops quickly with drought, they still make a little water go farther per gram of fixed carbon than sagebrush. Flanagan et al. (1992) as cited in Nowak et al. (1999) showed that pinyon pine and Utah juniper are more dependent on summer precipitation than sagebrush.

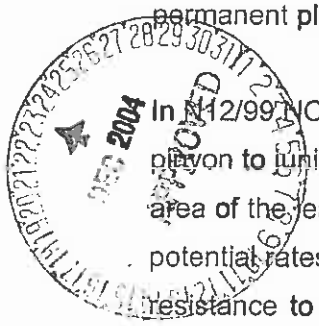
Occasional trees within the pinyon-juniper stands of the study area have been removed presumably for fuel wood. The major residual evidence is the presence of stumps and litter from limbing the bole.

In the pinyon-juniper type species density (Table 7) averaged 12.2 per 100 sq. m., essentially the same observed in sagebrush shrubland. The distribution of species is

fairly even among native perennial forbs, native perennial cool season grasses, and shrubs. Native annual forb species were distinctly less numerous in the pinyon-juniper than in the sagebrush shrubland. Compared to the range of vascular plant species density observed elsewhere in pinyon–juniper woodlands of adjacent New Mexico and Utah (Harner and Harper 1976), the study area fall somewhat below the mean of the 30 sample areas reported there which was about 22 to 23 species per 100 sq.m., and ranged from about 12 to 60 species per 100 sq.m.

Throughout the bulk of the pinyon-juniper woodland in the study area, the soil surface is trampled sufficiently frequently by livestock that "cryptobiotic" or "cryptogamic" soil crust is non-existent. In a very few sites, however, this soil crust was found intact. The cryptogams involved are predominantly blue-green algae, mosses (mostly *Polytrichum piliferum*), and lichens. Evans and Ehlehringer (1994) found that the nitrogen requirements of Utah juniper may be largely met by nitrogen fixation by the cryptobiotic crust. It may be assumed that the absence of a cryptobiotic crust in heavily trampled areas results in a diminished availability of nitrogen from atmospheric fixation.

With regard to woody plant density in the pinyon-juniper woodland type, overall woody plant densities (including subshrubs, shrubs, and trees) are far lower than in the sagebrush shrubland type, averaging about 658 stems per acre (Table 4). Tree densities were only 28 percent of the total woody plant densities, with 186 tree stems per acre. These values are comparable to the lower to middle range of densities reported for pinyon-juniper stands of the Piceance Basin by Welden et al. (1990) and well below the range reported in 1974 (599 trees per acre) and 1984 (629 trees per acre) from permanent plots in northeastern Utah by Austin (1987).



In M12/99 NORTH/SOUTH the pinyon-juniper proportions were fairly even with about 1.3 pinyon to juniper. This would appear to be related to a higher elevation and precipitation area of the lease. Pinyon pine has shown physiological evidence of having much higher potential rates of carbon fixation than junipers (Lathja and Barnes 1991), but shows less resistance to impacts of water stress on assimilation rate. Measures of the degree of soil moisture stress at which leaf turgor can no longer be maintained ("permanent wilting point") is an indication of the relative drought tolerance of a plant species. Wilkins and Klopatek (1987) determined that the "permanent wilting point" for pinyon pine was slightly higher than that for Utah juniper. Breashers et al. (1997) studied the use of soil

moisture in spaces between trees in a pinyon-juniper woodland and determined that one-seeded juniper made more effective use of shallow soil moisture between trees than pinyon pine.

In other words, pinyon pine is, in general, less accommodating of dry conditions than Utah juniper and, when competition for shallow soil moisture is intense, junipers tend to have an advantage over the pines. Lower relative abundance of pinyon pine in the southern part of the leasehold, where elevations and precipitation are lower, soils tend to be shallower (and with presumably less moisture-holding capacity), and juniper more dominant, is consistent with what is known of the ecology of these two tree species.

Occurrence of Herbaceous Species in the Study Area

Historical grazing use of these lands has been so intense and unrelenting (overstocking combined with yearlong grazing) that growth of herbaceous species in general, but especially native perennial forbs, is very restricted. Although the complete absence of native perennial forbs in a randomly sampled 100 sq.m. area was uncommon (no more than 1 of 10 such plots in the pinyon-juniper type and 1 of 5 plots in the sagebrush type were totally devoid of any native perennial forbs), the extent of native perennial forb cover is extremely limited. In the sagebrush vegetation type, percent cover by native perennial forbs averaged less than 0.1 percent and in the pinyon-juniper woodland, it also averaged less than 0.1 percent (less than 0.1 percent cover in most cases means cover is below the quantitative detection limit or the species was only present in the 100 sq. m. species density plot). In both the sagebrush shrubland and pinyon-juniper study areas, the individual cover for native perennial warm and cool season grass species was no greater than 0.2 percent. Most grasses had no measurable cover and were only present in the species density plot.

Most frequently comprising (in the 2003 sampling) the very small cover afforded by native perennial forbs were some few of the following: *Astragalus wingatanus*, *Calochortus nuttallii*, *Cryptantha flavoculata*, *Cymopterus purpureus*, *Eriogonum umbellatum*, *Aster arenosus* (*Leucelene ericoides*), *Mirabilis multiflora*, *Euphorbia fendleri*, *Pedicularis centrantherum*, *Penstemon linarioides*, *Phlox longifolia*, *Solidago petradoria* (*Petradoria pumila*), *Sphaeralcea coccinea*. Although the spring of 2003 was comparatively favorable with regard to moisture, the extent of native annual and biennial forbs was scant, averaging no more than 0.6 percent cover in the sagebrush type and

0.0 percent cover in the pinyon-juniper type. Native annual and biennial species sporadically present included: *Aster canescens*, *Chenopodium fremontii*, *Chenopodium leptophyllum*, *Descurainia pinnata*, *Gilia sinuata*, and *Lappula redowskii* ssp.

Sensitive Plant Survey Results

Survey of the inner (red) areas shown on Map 1 in spring 2003 did not reveal the presence of any of the "target" species (those deemed to have even a small chance of occurrence (see *Appendix 3, Field Guide to Potentially Occurring Rare Plants, Black Mesa Mining Complex)).*

Notes regarding the potential for the sought for rare plants to occur and the results of the intensive survey for them are summarized below:

Amsonia peeblesii – Peebles blue star

This plant is known from grasslands and desert scrub communities at elevations from 4,000 to 5,620 ft., in the arc of the Little Colorado River drainage from central Coconino County south and east into southern Navajo County, Arizona. Even the lowest reaches of the Black Mesa leasehold are nearly 1,000 ft. higher than the uppermost occurrence of this plant. The environs of the Little Colorado River to which this plant is restricted are approximately 50 miles distant. No individuals of Peebles blue star were encountered during the 2003 surveys.

Asclepias sanjuanensis – San Juan milkweed

This plant is known from sandy benches and hills in pinyon-juniper woodland vegetation near the Chaco and San Juan Rivers in San Juan County, New Mexico at 5,000 to 6,200 feet. The type locality is on the San Juan College campus in Farmington. In terms of sandy substrate and pinyon-juniper woodland vegetation, the study areas would seem to include suitable habitat. However, its nearest occurrence in areas approximately 150 mi. east and at elevations mostly below the study area elevations (approximately 6,800 ft.) made its presence unlikely; none was found during the 2003 surveys.

Astragalus cremnophylax var. *cremnophylax* – Sentry milkvetch

This milkvetch is known from Grand Canyon National Park on Kaibab limestone, a Permian-age formation. The study area do not include limestones and are far younger

(Cretaceous-age). Thus no suitable habitat was found and no sentry milkvetch was encountered.

Astragalus cutleri (*A. preusii* var. *cutleri*) – Copper Canyon milkvetch

This plant is an endemic in southern San Juan County, Utah occurring on seleniferous soils derived from the Triassic-age Shinarump Conglomerate member of the Chinle formation at 3,800 ft. The lowest Black Mesa leasehold elevations of about 6,200 ft. are substantially higher and no substrates approximating those of the known occurrences are present. No individuals of Copper Canyon milkvetch were encountered during intensive surveys.

Astragalus humillimus – Mancos milkvetch

This plant is known from San Juan County, New Mexico and adjacent Montezuma County, Colorado at elevations from about 5,000 to 6,500 ft. in cracks on "slickrock" exposures of the Cretaceous-age Point Lookout sandstone, which is also found in McKinley and Sandoval Counties, New Mexico in close association with the Satan Tongue member of Mancos Shale. In the study area, Yale Point sandstone, a facies of the Mesa Verde formation of the Black Mesa Basin, forms limited exposures of bare rock. These sandstones are older than those of the San Juan Basin, the Cretaceous sea having receded from the Black Mesa Basin before it receded from the San Juan Basin. In addition to the differences in substrates, the study area is mostly higher in elevation than the known occurrences of Mancos milkvetch. No individuals of Mancos milkvetch were found during intensive searches in 2003.

Astragalus naturitensis – Naturita milkvetch

This plant is known from sandstone mesas, ledges, crevices, and slopes from 5,000 to 7,000 ft. in McKinley Co., New Mexico, as well as in southern Utah and southwestern Colorado. Such habitats are present in the study area; those in the intensive survey areas were found not to be occupied.

Carex specuicola – Navajo sedge

This plant is known to occur in extreme northern Arizona and barely into Utah in seeps and hanging gardens below vertical cliffs of Navajo sandstone at elevations between 4,400 ft and 7,000 ft. No exposures of the lower Jurassic-age Navajo sandstone are present in the study area. The upper Cretaceous Yale Point sandstone that forms cliffs

along washes in the study area is generally without development of seepage zones. The very few seepage zones observed during the intensive surveys had extensive crusts of evaporated salt. No individuals of Navajo sedge were observed during the intensive surveys.

Clematis hirsutissima var. *arizonica* – Arizona leather flower

Although the known range of elevational occurrence (6,800 to 9,000 ft) overlaps the elevations of the study area, its preferred habitat is moist portions of mountain meadows, open woods, or thickets in ponderosa pine and mixed conifer forests on soils derived from limestone. On the Navajo Nation, it is known only from the Chuska Mountains and Defiance Plateau. None of the habitat criteria are met in the study area, and no Arizona leather flower was encountered in the intensive survey areas.

Cystopteris utahensis – Utah bladder-fern

Known from Arizona, Colorado, New Mexico, Texas, and Utah at elevations from 4,200 to 8,800 feet, this plant could reasonably occur in the study area on the very few sites where cracks in sandstones with calcareous cementation are at least slightly seeping. These locations were examined closely (in N12/N99 NORTH/SOUTH). None were found.

Echinocereus triglochidiatus var. *arizonicus* – Arizona hedgehog cactus

This rare cactus is known from central Arizona at elevations from 3,400 to 6,360 ft. on very rocky sites comprised mostly of boulders and cobbles of orthoclase-rich granite of late Cretaceous age. Other substrates on which it has been found include volcanic tuff and mid-Tertiary age dacite. Substrates of the study area are distinctly unlike these. In addition, the range of elevations within the sites is 6,200 to 7,150 feet, which is, for the most part, substantially higher than the highest known occurrences of the cactus. These facts made the occurrence of this cactus unlikely in the study area, and, in fact, no individuals of Arizona hedgehog cactus were encountered during the 2003 surveys.

Errazurizia rotundata – Round dune-broom

This plant is known from an arc of sites within a comparatively narrow elevational range (4,800 to 5,200 ft) from near Tuba City in Coconnino County, Arizona swinging south and east to near Holbrook, in general following the valley of the Little Colorado River. Substrates are of various lithologies, but are apparently coarse and loose. Although the

study area include some loose sands over sandstone, elevations are considerably higher and the sites are about 50 miles east and north from the Little Colorado drainage. No individuals of round dune-broom were encountered during 2003 intensive surveys.

Lesquerella navajoensis – Navajo bladderpod

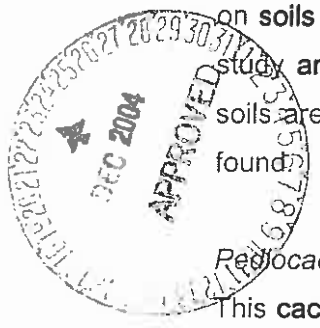
Navajo bladderpod is known to occur in McKinley County, New Mexico, Apache County, Arizona, and in Utah on windswept exposures of the Todlito limestone member of the Morrison formation at elevations between 7,200 and 7,600 ft. Upper elevations of the study area just below this range, but Morrison formation (Upper Jurassic age) materials are not present at the surface in the Black Mesa Basin. Furthermore the Upper Cretaceous sediments that are present in the study area do not include limestones. Navajo bladderpod was not considered a likely occurrence in the study area and none was found during 2003 surveys.

Pediocactus bradyi – Brady pincushion cactus

This narrow endemic is found in Coconino County, Arizona along the rim of Marble Canyon between elevations of 3,400 and 5,200 ft. Substrates are narrowly defined where intermixed Moenkopi and Kaibab formation debris form the soil parent material. Study area elevations are above 6,800 ft. Furthermore none of the Upper Cretaceous-age substrates of the area approximate the Moenkopi or Kaibab formation materials (Upper Triassic to lower Jurassic age). There was almost no chance of finding this cactus, and none were found during 2003 intensive surveys of the study area.

Pediocactus peeblesianus var. *fickeiseniae* – Fickeisen plains cactus

The known occurrences of this cactus are in Coconino and Mohave Counties, Arizona on soils derived from Kaibab limestone at elevations between 4,000 and 5,600 ft. The study area sites are all well above the known elevational limit and limestone-derived soils are not present. Nonetheless, it was sought during the intensive surveys but not found.



Pediocactus peeblesianus var. *peeblesianus* – Navajo plains cactus

This cactus is known from southern Navajo County at elevations from 5,100 to 5,650 ft. in the upper reaches of the Little Colorado River watershed on thin veneers of gravel that are not replicated in the study area. The elevations of the study area are well above

the highest known occurrence of this cactus. No individuals of Navajo plains cactus were encountered in the intensive field surveys.

Phlox cluteana – Navajo Mountain Phlox

This plant is known from the northern Chuska Mountains, Navajo Mountain, and Black Rock Mountain on the Navajo Nation, and in adjacent New Mexico and Utah at elevations from 6,000 to 10,400 ft. on sandy soils with leaf litter under ponderosa pine, Gambel oak, and pinyon – juniper woodland. Although it seems likely that the pinyon-juniper woodland habitat in which it is found represents the opposite end of the moisture spectrum from that found in the pinyon-juniper sites, it was sought in the intensive searches of spring 2003, but not found.

Platanthera zothecina – Alcove bog orchid

This plant requires the constant flow of moisture usually in hanging garden / alcove environments and is known from small populations at widely scattered locations in central and northeastern Arizona, east-central Utah, and northwestern Colorado. The northeastern Arizona locations include nearby Tsegi and Betatakin Canyons. Although nearby, these locations are in very deep canyons with overhanging cliffs of Navajo sandstone. The much younger Cretaceous-age sandstones (Yale Point member of the Mesa Verde formation) of the study area form small cliffs along some of the washes of the area, but nowhere are there deep shady well-wetted sites that would support this plant. The very few appearances of moisture on the study area cliff sites have only enough flow to periodically bring dissolved salts to the surface where rapid evaporation produces extensive salt crusting.

Puccinellia parishii – Parish's alkaligrass

This rare annual alkaligrass is found on salt-encrusted frequently wet soils at widely disjunct sites from northern and eastern Arizona, to southwestern Colorado and western New Mexico and as far away as San Bernadino County, California. Such microsites are found at a few seepage sites in study area. Although alkaligrass is present, it is saltmarsh alkaligrass (*Puccinellia fasciculata*), an introduced species now found in the northeastern U.S. and in Arizona, Colorado, and New Mexico. Careful examination of the study area alkaline/wet soils revealed only this species. Characteristics distinguishing saltmarsh alkaligrass from Parish's alkaligrass include lemmas glabrous and 2 to 2.5 mm long, panicle branches floriferous to the base, and perennial habit.

Sclerocactus mesae-verdae – Mesa Verde Cactus

This cactus is known from San Juan County, New Mexico as well as adjacent Montezuma County, Colorado at elevations from 4,900 to 5,500 ft. on very heavy soils derived from Mancos formation shales or from shaley facies of the overlying Mesa Verde formation. Exposures of Mesa Verde formation facies in the northern Black Mesa Basin, and the study area in general, are dominated by the Yale Point sandstone and extensive areas of heavy clay soils are absent. These rocks are age-equivalent to the upper Mancos and lower Mesa Verde rocks of the San Juan Basin but are not marine deposits (the Cretaceous sea having withdrawn from the Black Mesa Basin earlier). No individuals of Mesa Verde cactus were encountered during the 2003 intensive searches in the study areas.

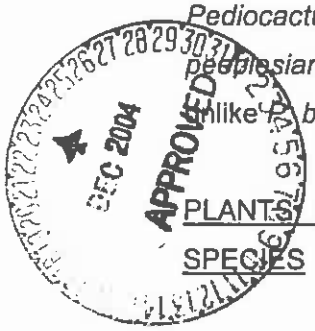
PLANTS FAIRLY COMMONLY SEEN THAT ARE SIMILAR TO TARGET SPECIES

Asclepias asperula – considerably larger than *A. sanjuanensis* in all dimensions of herbage and flowers, and with flowers with greenish corolla lobes with purplish hoods. *A. sanjuanensis* flowers have purplish corolla lobes with whitish hoods.

Phlox longifolia – This phlox has easily observed bulging intercostal membranes, unlike *P. cluteana*

Echinocereus triglochidiatus var. *mojavensis* — Differs from *E. t. arizonicus* in color, length and diameter of central and radial spines.

Pediocactus simpsonii – Possesses normal spines rather than the corky spines of *P. peeblesianus* var. *fickeiseniae* and *P. p.* var. *peeblesianus.* Possesses central spines, unlike *P. bradyi.*



PLANTS OCCASIONALLY ENCOUNTERED THAT ARE SIMILAR TO TARGET SPECIES

Asclepias involucrata (Photograph 87) – Differs from *A. sanjuanensis* in having cream to greenish flowers.

Puccinellia fasciculata – Differs from *P. parishii* in being perennial and having lemmas glabrous and 2 to 2.5 mm long.

Habitats of the Outer Areas

The areas between the red and blue boundaries on Map 1 were examined in fall 2003 for the presence of habitats either different from those of the inner (blue) areas that were examined in detail in spring 2003 and / or the same as those in the inner areas that had the potential to support sensitive species. Habitats in the outer areas that were as potentially suitable for *Asclepias sanjuanensis*, *Astragalus humillimus*, and *Astragalus naturitensis* as those in the inner areas were found. It should be noted, of course, that those same types of potentially suitable habitats were found not to support any of these species in the adjacent inner areas in spring 2003 surveys.

No new habitats (i.e. habitats not represented in the inner areas) were found in the fall 2003 examination of the outer areas. No additional wet seepage sites were located. Drainages found in the outer areas were dry and generally heavily trampled by livestock.

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APPENDIX 1

DATA TABLES

Cover data tables: Both first and additional hit data are presented in these tables. Additional hit data are shown in parentheses.

Woody plant density data tables: Counts of dead shrubs are shown in parentheses but are not included in density totals.

Table 1. Cover Data - N12/N99 NORTH/SOUTH Sagebrush Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover* ---Sample Number--- 1	2	3	4	5
NATIVE ANNUAL & BIENNIAL FORBS										
Aster canescens	0.00	20.00	0.00	0.00	0.00	P				
Chenopodium leptophyllum	0.00	40.00	0.00	0.00	0.00			P	P	
Descurainia pinnata	0.00	20.00	0.00	0.00	0.00			P		
Gilia sinuata	0.00	20.00	0.00	0.00	0.00					P
Lappula redowskii	0.60	80.00	4.35	0.60	4.23	P	P	3		P
TOTAL NATIVE ANN. & BIEN. FORBS	0.6	100.0	4.3	0.6	4.2	P	P	3	P	P
INTRODUCED ANNUAL & BIENNIAL FORBS										
Sisymbrium altissimum	0.00	20.00	0.00	0.00	0.00			P		
TOTAL INTRO. ANN. & BIEN. FORBS	0.0	20.0	0.0	0.0	0.0	---	---	P	---	---
NATIVE PERENNIAL FORBS										
Aster arenosus	0.00	60.00	0.00	0.00	0.00	P			P	P
Bahia oppositifolia	0.00	20.00	0.00	0.00	0.00					P
Calochortus nuttallii	0.00	40.00	0.00	0.00	0.00			P		P
Phlox longifolia	0.00	40.00	0.00	0.00	0.00			P	P	
Sphaeralcea coccinea	0.00	80.00	0.00	0.00	0.00	P		P	P	P
TOTAL NATIVE PERENNIAL FORBS	0.0	80.0	0.0	0.0	0.0	P	—	P	P	P
INTRODUCED PERENNIAL FORBS										
Corydalis aurea	0.00	20.00	0.00	0.00	0.00			P		
TOTAL INTRO. PERENNIAL FORBS	0.0	20.0	0.0	0.0	0.0	—	---	P	---	---
NATIVE PERENNIAL GRASSES (cool)										
Agropyron smithii	0.20	80.00	1.45	0.40	2.82		1	(1)	P	P
Oryzopsis hymenoides	0.00	40.00	0.00	0.00	0.00			P		P
Sitanion longifolium	0.00	60.00	0.00	0.00	0.00			P	P	P
TOTAL NATIVE PERENNIAL GRASSES (c)	0.2	80.0	1.4	0.4	2.8	---	1	(1)	P	P
INTRODUCED PERENNIAL GRASSES (cool)										
Poa compressa	0.00	20.00	0.00	0.00	0.00		P			
TOTAL INTRO. PERENNIAL GRASSES (c)	0.0	20.0	0.0	0.0	0.0	---	P	—	—	---
NATIVE PERENNIAL GRASSES (warm)										
Bouteloua gracilis	0.20	40.00	1.45	0.20	1.41	P				1
Hilaria jamesii	0.00	40.00	0.00	0.20	1.41	P				(1)
Sporobolus cryptandrus	0.00	20.00	0.00	0.00	0.00		P			
TOTAL NATIVE PERENNIAL GRASSES (w)	0.2	60.0	1.4	0.4	2.8	P	P	—	—	1(1)
NATIVE SUBSHRUBS										
Artemisia frigida	0.00	20.00	0.00	0.00	0.00		P			
Chrysothamnus greenei	0.00	40.00	0.00	0.00	0.00				P	P
Eurotia lanata	0.00	20.00	0.00	0.00	0.00			P		
Gutierrezia sarothrae	0.00	20.00	0.00	0.00	0.00				P	
TOTAL NATIVE SUBSHRUBS	0.0	80.0	0.0	0.0	0.0	---	P	P	P	P
NATIVE SHRUBS										
Artemisia tridentata	9.60	100.00	69.57	9.60	67.61	6	11	7	6	18
Atriplex canescens	1.20	60.00	8.70	1.20	8.45	1		3	2	
Chrysothamnus nauseosus	1.40	20.00	10.14	1.40	9.86		7			
Chrysothamnus viscidiflorus	0.20	60.00	1.45	0.20	1.41	P		1		P
TOTAL NATIVE SHRUBS	12.4	100.0	89.9	12.4	87.3	7	18	11	8	18
INTRODUCED SHRUBS										
Tamarix pentandra	0.00	20.00	0.00	0.00	0.00		P			
TOTAL INTRODUCED SHRUBS	0.0	20.0	0.0	0.0	0.0	—	P	—	—	—
NATIVE TREES										
Pinus edulis	0.40	60.00	2.90	0.40	2.82	1	1			P
TOTAL NATIVE TREES	0.4	60.0	2.9	0.4	2.8	1	1	—	—	P

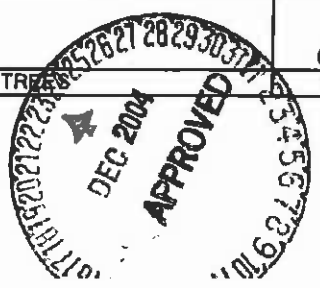


Table 1. Cover Data - N12/N99 NORTH/SOUTH Sagebrush Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover* ---Sample Number-- 1	2	3	4	5
MOSS										
Moss	0.00	20.00	0.00	0.00	0.00	P				
TOTAL MOSS	0.0	20.0	0.0	0.0	0.0	P	—	—	—	—
LICHEN										
Parmelia chlorochroa	0.00	20.00	0.00	0.00	0.00					P
TOTAL LICHEN	0.0	20.0	0.0	0.0	0.0	—	—	—	—	P
SUCCULENT										
Opuntia macrorhiza	0.00	20.00	0.00	0.00	0.00	P				
TOTAL SUCCULENT	0.0	20.0	0.0	0.0	0.0	P	—	—	—	—
Standing dead	15.20	100.00		15.20		15	23	12	19	7
Litter	21.00	100.00		21.00		2	25	34	25	19
Bare ground	46.80	100.00		46.80		70	30	37	46	51
Rock	3.20	100.00		3.20		5	2	3	2	4
TOTALS	100.0			100.4		100	100	100	100	100
TOTAL VEGETATION COVER	13.8 (s=5.8)		100.0	14.2 (s=6.0)	100.0	8	20	14(1)	8	19(1)
GROUND COVER (Litter+Rock+Veg+St.Dead	53.2			53.6		30	70	63(1)	54	49(1)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 12.4 Std.Dev.= 3.0)						12	9	15	10	16

*P=Present wilhin 1 m. of either side of the cover transect, but not quantitatively encountered.

Table 2. Cover Data - N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003 Page 1 of 4

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover* ---Sample Number---- 1	2	3	4	5
NATIVE ANNUAL & BIENNIAL FORBS										
Chenopodium fremontii	0.00	10.00	0.00	0.00	0.00					
Descurainia pinnata	0.00	20.00	0.00	0.00	0.00					
Lappula redowskii	0.00	10.00	0.00	0.00	0.00					
TOTAL NATIVE ANN. & BIEN. FORBS	0.0	30.0	0.0	0.0	0.0	---	---	---	---	---
INTRODUCED ANNUAL GRASSES										
Bromus tectorum	0.00	10.00	0.00	0.00	0.00					
TOTAL INTRO. ANN. GRASSES	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---
NATIVE PERENNIAL FORBS										
Aster arenosus	0.00	50.00	0.00	0.00	0.00	P		P	P	
Astragalus wingatanus	0.00	20.00	0.00	0.00	0.00					
Cryptantha flavoculata	0.00	10.00	0.00	0.00	0.00					
Cryptantha sp.	0.00	10.00	0.00	0.00	0.00		P			
Cymopterus purpurascens	0.00	20.00	0.00	0.00	0.00					
Eriogonum umbellatum	0.00	20.00	0.00	0.00	0.00		P			
Euphorbia fendleri	0.00	30.00	0.00	0.00	0.00		P	P		
Mirabilis multiflora	0.00	10.00	0.00	0.00	0.00					
Pedicularis centranthera	0.00	30.00	0.00	0.00	0.00					
Penstemon linarioides	0.00	30.00	0.00	0.00	0.00					
Psilostrophe sparsiflora	0.00	10.00	0.00	0.00	0.00		P			
Solidago petradoria	0.00	30.00	0.00	0.10	0.59	P				
Stanleya pinnata	0.00	20.00	0.00	0.00	0.00	P				
Streptanthus cordatus	0.00	10.00	0.00	0.00	0.00				P	
TOTAL NATIVE PERENNIAL FORBS	0.0	90.0	0.0	0.1	0.6	P	P	P	P	---
NATIVE PERENNIAL GRASSES (cool)										
Carex occidentalis	0.00	10.00	0.00	0.00	0.00			P		
Oryzopsis hymenoides	0.00	70.00	0.00	0.00	0.00	P	P	P	P	
Poa fendleriana	0.00	10.00	0.00	0.00	0.00					
Sitanion longifolium	0.00	40.00	0.00	0.00	0.00		P			
Stipa comata	0.00	10.00	0.00	0.00	0.00			P		
TOTAL NATIVE PERENNIAL GRASSES (c)	0.0	80.0	0.0	0.0	0.0	P	P	P	P	---
NATIVE PERENNIAL GRASSES (warm)										
Bouteloua gracilis	0.20	60.00	1.22	0.20	1.18	P	1	P		1
Hilaria jamesii	0.00	40.00	0.00	0.00	0.00	P		P		
TOTAL NATIVE PERENNIAL GRASSES (w)	0.2	60.0	1.2	0.2	1.2	P	1	P	---	1
NATIVE SUBSHRUBS										
Artemisia frigida	0.00	10.00	0.00	0.00	0.00					
Eriogonum aureum	0.00	10.00	0.00	0.00	0.00					
Eriogonum corymbosum	0.00	10.00	0.00	0.00	0.00		P			
Gutierrezia sarothrae	0.10	80.00	0.61	0.10	0.59	P	P	P		1
TOTAL NATIVE SUBSHRUBS	0.1	90.0	0.6	0.1	0.6	P	P	P	---	1
NATIVE SHRUBS										
Artemisia tridentata	0.40	40.00	2.44	0.40	2.35	1	P		1	2
Atriplex canescens	0.10	10.00	0.61	0.10	0.59	1				
Chrysothamnus viscidiflorus	0.00	30.00	0.00	0.00	0.00	P				
Cowania mexicana	1.20	70.00	7.32	1.30	7.65		2	2		1
Ephedra viridis	0.00	10.00	0.00	0.00	0.00					
TOTAL NATIVE SHRUBS	1.7	90.0	10.4	1.8	10.6	2	2	2	1	3
NATIVE TREES										
Juniperus osteosperma	6.10	100.00	37.20	6.30	37.06	1	6	9	9	1
Pinus edulis	7.90	100.00	48.17	8.00	47.06	8	2	4	10	5
TOTAL NATIVE TREES	14.0	100.0	85.4	14.3	84.1	9	8	13	19	6

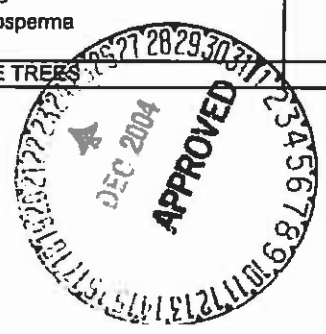
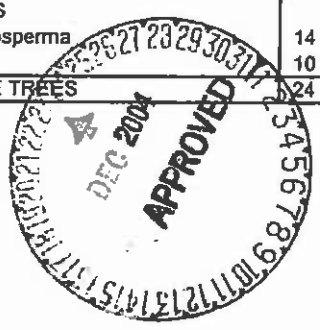


Table 2. Cover Data - N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003 Page 2 of 4

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover* —Sample Number— 1	2	3	4	5
MOSS										
Moss	0.10	40.00	0.61	0.10	0.59	P		P		1
Polytrichum piliferum	0.00	30.00	0.00	0.10	0.59					
TOTAL MOSS	0.1	70.0	0.6	0.2	1.2	P	---	P	---	1
LICHEN										
Lecidea sp.	0.10	10.00	0.61	0.10	0.59					
Parmelia chlorochroa	0.10	20.00	0.61	0.10	0.59	1				
TOTAL LICHEN	0.2	30.0	1.2	0.2	1.2	1	---	---	---	---
SUCCULENT										
Mammilaria microcarpa	0.00	10.00	0.00	0.00	0.00			P		
Opuntia macrorhiza	0.00	20.00	0.00	0.00	0.00	P		P		
Opuntia polyacantha	0.10	10.00	0.61	0.10	0.59					
Pediocactus simpsonii	0.00	10.00	0.00	0.00	0.00	P				
TOTAL SUCCULENT	0.1	30.0	0.6	0.1	0.6	P	---	P	---	---
AGAVOIDS										
Yucca angustissima	0.00	10.00	0.00	0.00	0.00		P			
TOTAL AGAVOIDS	0.0	10.0	0.0	0.0	0.0	---	P	---	---	---
Standing dead	2.90	70.00		2.90		5	1	7	5	3
Litter	20.00	100.00		20.00		16	14	22	31	9
Bare ground	40.60	100.00		40.60		29	56	36	34	34
Rock	20.10	100.00		20.10		38	18	20	10	42
TOTALS	100.0			100.6		100	100	100	100	100
TOTAL VEGETATION COVER	16.4 (s=5.4)		100.0	17.0 (s=5.5)	100.0	12	11	15	20	12
GROUND COVER (Litter+Rock+Veg+Sl.Dead	59.4			60.0		71	44	64	66	66
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 12.2 Std.Dev.= 3.6)						16	14	14	6	7

Percent Foliar Cover*

PLANT SPECIES	—Sample Number—				
	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS					
Chenopodium fremontii		P			
Descurainia pinnata	P		P		
Lappula redowskii			P		
TOTAL NATIVE ANN. & BIEN. FORBS	P	P	P	---	---
INTRODUCED ANNUAL GRASSES					
Bromus tectorum			P		
TOTAL INTRO. ANN. GRASSES	---	---	P	---	---
NATIVE PERENNIAL FORBS					
Aster arenosus		P		P	
Astragalus wingatanus	P		P		
Cryptantha flavoculata			P		
Cryptantha sp.					
Cymopterus purpurascens			P		P
Eriogonum umbellatum				P	
Euphorbia fendleri		P			
Mirabilis multiflora		P			
Pedicularis centrantherum	P		P		P
Penstemon linarioides	P		P		P
Psilostrophe sparsiflora					
Solidago petradoria				P	(1)
Stanleya pinnata		P			
Streptanthus cordatus					
TOTAL NATIVE PERENNIAL FORBS	P	P	P	P	(1)
NATIVE PERENNIAL GRASSES (cool)					
Carex occidentalis					
Oryzopsis hymenoides	P	P			P
Poa fendleriana					P
Sitanion longifolium	P	P	P		
Stipa comata					
TOTAL NATIVE PERENNIAL GRASSES (c)	P	P	P	---	P
NATIVE PERENNIAL GRASSES (warm)					
Bouteloua gracilis		P			P
Hilaria jamesii		P			P
TOTAL NATIVE PERENNIAL GRASSES (w)	---	P	---	---	P
NATIVE SUBSHRUBS					
Artemisia frigida				P	
Eriogonum aureum		P			
Eriogonum corymbosum					
Gutierrezia sarothrae	P		P	P	P
TOTAL NATIVE SUBSHRUBS	P	P	P	P	P
NATIVE SHRUBS					
Artemisia tridentata					
Atriplex canescens					
Chrysothamnus viscidiflorus		P	P		
Cowania mexicana	2	2	2(1)	1	
Ephedra viridis				P	
TOTAL NATIVE SHRUBS	2	2	2(1)	1	---
NATIVE TREES					
Juniperus osteosperma	14	2(2)	4	8	7
Pinus edulis	10	7	14(1)	11	8
TOTAL NATIVE TREES	24	9(2)	18(1)	19	15



Percent Foliar Cover*

PLANT SPECIES	----Sample Number----				
	6	7	8	9	10
MOSS					
Moss		P			
Polytrichum piliferum	P		(1)		P
TOTAL MOSS	P	P	(1)	—	P
LICHEN					
Lecidea sp.	1				
Parmelia chlorochroa				P	
TOTAL LICHEN	1	—	—	P	—
SUCCULENT					
Mammilaria microcarpa					
Opuntia macrorhiza					
Opuntia polyacantha			1		
Pediocactus simpsonii					
TOTAL SUCCULENT	—	—	1	—	—
AGAVOIDS					
Yucca angustissima					
TOTAL AGAVOIDS	—	—	—	—	—
Standing dead		3		5	
Litter	28	19	29	15	17
Bare ground	40	47	38	46	46
Rock	5	20	12	14	22
TOTALS	100	100	100	100	100
TOTAL VEGETATION COVER	27	11(2)	21(3)	20	15(1)
GROUND COVER (Litter+Rock+Veg+St.Dead	60	53(2)	62(3)	54	54(1)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 12.2 Std.Dev.= 3.6)	12	15	16	10	12

*P=Present within 1 m. of either side of the cover transect, but not quantitatively encountered.

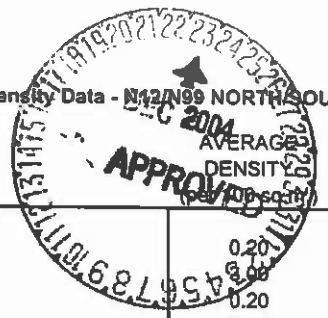


Table 3. Woody Plant Density Data - N12/N99 NORTH/SOUTH Sagebrush Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003

PLANT SPECIES	AVERAGE DENSITY (per 100 sq.m.)	DENSITY (per acre)	FREQUENCY (%)	Shrubs per 100 sq.m. —Sample Number— 1	2	3	4	5
NATIVE SUBSHRUBS								
Artemisia frigida	0.20	8.1	20.00		1			
Chrysothamnus greenei	3.00	121.4	20.00				15	
Eurotia lanata	0.20	8.1	20.00			1		
Gutierrezia sarothrae	0.20	8.1	20.00				1	
TOTAL NATIVE SUBSHRUBS	3.6	145.7	60.0	—	1	1	16	—
NATIVE SHRUBS								
Artemisia tridentata	101.40	4,103.7	100.00	53	99	69	105	181
Atriplex canescens	20.80	841.8	60.00	13		53	38	
Chrysothamnus nauseosus	10.60	429.0	20.00		53			
Chrysothamnus viscidiflorus	39.80	1,610.7	60.00	123		71		5
TOTAL NATIVE SHRUBS	172.6	6,985.1	100.0	189	152	193	143	186
INTRODUCED SHRUBS								
Tamarix pentandra	0.20	8.1	20.00		1			
TOTAL INTRODUCED SHRUBS	0.2	8.1	20.0	—	1	—	—	—
NATIVE TREES								
Pinus edulis	1.40	56.7	60.00	1	1			5
TOTAL NATIVE TREES	1.4	56.7	60.0	1	1	—	—	5
TOTAL DENSITY	177.8	7,195.6		190	155	194	159	191
Standard Deviation	19.1	773.0						
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 4.0 Std.Dev.= 0.7)				4	5	4	4	3

Table 4. Woody Plant Density Data - N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003

PLANT SPECIES	AVERAGE DENSITY (per 200 sq.m.)	DENSITY (per acre)	FREQUENCY (%)	Shrubs per 200 sq.m. —Sample Number— 1	2	3	4	5	6	7	8	9	10
NATIVE SUBSHRUBS													
Chrysothamnus depressus	0.40	8.09	10.00					4					
Eriogonum aureum	0.10	2.02	10.00							1			
Eriogonum corymbosum	0.60	12.14	30.00		1			2					3
Gutierrezia sarothrae	9.60	194.26	30.00						2		77		17
TOTAL NATIVE SUBSHRUBS	10.7	216.5	60.0	—	1	—	—	6	2	1	77	—	20
NATIVE SHRUBS													
Artemisia tridentata	0.80	16.19	40.00	5	1		1			1			
Atriplex canescens	0.90	18.21	10.00	9									
Chrysothamnus viscidiflorus	2.20	44.52	40.00	2	1			2		17			
Cowania mexicana	8.50	172.00	70.00	1	13	15		9	28		15	4	
Ephedra viridis	0.10	2.02	10.00									1	
TOTAL NATIVE SHRUBS	12.5	252.9	90.0	17	15	15	1	11	28	18	15	5	—
NATIVE TREES													
Juniperus osteosperma	4.00	80.94	100.00	4	1	3	5	2	7	4	1	9	4
Pinus edulis	5.20	105.22	90.00		6	7	6	3	8	10	6	3	3
TOTAL NATIVE TREES	9.2	186.2	100.0	4	7	10	11	5	15	14	7	12	7
AGAVOIDS													
Yucca angustissima	0.10	2.02	10.00		1								
TOTAL AGAVOIDS	0.1	2.0	10.0	—	1	—	—	—	—	—	—	—	—
TOTAL DENSITY	32.5	657.6		21	24	25	12	22	45	33	99	17	27
Standard Deviation	25.0	505.9											
SPECIES DENSITY (# of species/200 sq.m.) (AVERAGE= 4.5 Std.Dev.= 1.3)				5	7	3	3	6	4	5	4	4	4

Table 5. Cover and Woody Plant Density Data Summary, N12/N99 North/South Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003

AREA	TOTAL FOLIAR COVER	STANDING DEAD	LITTER	ROCK	SOIL	WOODY PLANT DENSITY
	(%)	(%)	(%)	(%)	(%)	(shrubs/acre)
N12/N99 SAGEBRUSH NORTH/SOUTH	13.8	15.2	21	3.2	46.8	7,195.6
N12/N99 PINYON-JUNIPER NORTH/SOUTH	16.4	2.9	20	20.1	40.6	657.6

Table 6. Relative Vegetation Cover by Lifeform Data Summary, N12/N99 North/South Baseline, Black Mesa Mining Complex, PWCC, AZ - 2003

RELATIVE VEGETATION COVER - ALL HITS (%)

			——INTRODUCED——						——NATIVE——								
		TOTAL	—FORBS—		—GRASSES—			TOTAL	—FORBS—			—GRASSES—		SUB-SHRUBS			
AREA	TOTAL*	INTRO. SP.	ANNUAL+	PERENN.	ANNUAL	PERENN. (C)	SUB-SHRUBS	NATIVE SP.	ANNUAL+	PERENN.	ANNUAL+	PERENN. (C)	PERENN. (W)		SHRUBS	TREES	OTHER**
N12/N99 NORTH/SOUTH SAGEBRUSH	99.9	0.0	0.0	0.0	0.0	0.0	0.0	99.9	4.2	0.0	0.0	2.8	2.8	0.0	87.3	2.8	0.0
N12/N99 NORTH/SOUTH PINYON-JUNIPER	100.1	0.0	0.0	0.0	0.0	0.0	0.0	100.1	0.0	0.6	0.0	0.0	1.2	0.6	10.6	84.1	3.0

*May sum to 100.0 plus or minus 0.2 due to rounding errors.
** Lower plants (mosses, lichens, parasites), succulents, and agavoids.
+ANNUAL category includes biennials.

Table 7. Species Density Data Summary, N12/N99 North/South Baseline, Black Mesa Mining Complex, PWCC, AZ - 2002

SPECIES DENSITY (number of species / 100 sq.m.)

AREA	TOTAL*	TOTAL INTRO. SP.	INTRODUCED —FORBS— ANNUAL+	INTRODUCED —FORBS— PERENN.	INTRODUCED —GRASSES— ANNUAL	INTRODUCED —GRASSES— PERENN. (C)	INTRODUCED SHRUBS	TOTAL NATIVE SP.	NATIVE —FORBS— ANNUAL+	NATIVE —FORBS— PERENN.	NATIVE —GRASSES— ANNUAL+	NATIVE —GRASSES— PERENN. (C)	NATIVE —GRASSES— PERENN. (W)	SUB SHRUBS	SHRUBS	TREES	OTHER**
N12/N99 NORTH/SOUTH SAGEBRUSH	12.4	0.8	0.2	0.2	0.0	0.2	0.2	11.6	1.8	2.4	0.0	1.8	1.0	1.0	2.4	0.6	0.6
N12/N99 NORTH/SOUTH PINYON-JUNIPER	12.2	0.1	0.0	0.0	0.1	0.0	0.0	12.1	0.4	3.0	0.0	1.4	1.0	1.1	1.8	2.0	1.6

* Due to rounding errors, table values may not exactly match this value.
** Lower plants (mosses, lichens, parasites), succulents, and agavoids.
+ANNUAL category includes biennials.

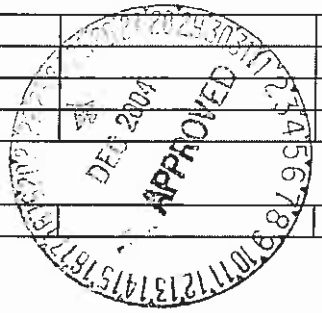
APPENDIX 2

SPECIES PRESENCE FOR THE
N12/N99 NORTH/SOUTH STUDY AREA

Table 8. Species Presence for the N12/N99 Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

SPECIES	COMMON NAME	SYNONYM	N12/N99 NORTH/SOUTH PJUN	N12/N99 NORTH/SOUTH SAGE
NATIVE ANNUAL & BIENNIAL FORBS				
Aster **canescens**	hoary tansyaster	Machaeranthera canescens		X
Chenopodium **fremontii**	Fremont goosefoot		X	
Chenopodium leptophyllum	narrowleaf goosefoot			X
Descurainia pinnata	pinnate tansy-mustard		X	X
Gilia sinuata	floccose gilia	G. inconspicua		X
Lappula **redowskii**	bluebur **stickseed**		X	X
INTRODUCED ANNUAL & BIENNIAL FORBS				
Sisymbrium **altissimum**	tumble **mustard**			X
INTRODUCED ANNUAL GRASSES				
Bromus tectorum	cheatgrass		X	
NATIVE PERENNIAL FORBS				
Aster arenosus	**white aster**	**Leucelene ericoides**	X	X
Astragalus wingatanus	**Fort Wingate milkvetch**		X	
Bahia oppositifolia	**Plains bahia**	**Picradeniopsis oppositifolia**		X
Calochortus nuttallii	**sego lily**			X
Cryptantha flavoculata	**cryptantha**		X	
Cryptantha sp.	**cryptantha**		X	
Cymopterus purpurascens	**spring parsley**		X	
Eriogonum umbellatum	**sulfur wild buckwheat**		X	
Euphorbia fendleri	**Fendler spurge**		X	
Mirabilis multiflora	**colorado four o'clock**		X	
Pedicularis centrantherum	**wood betony**		X	
Penstemon linarioides	**mat penstemon**		X	
Phlox longifolia	**longleaf phlox**			X
Psilostrophe sparsiflora	**greenstem paperflower**		X	
Solidago petradoria	**rock goldenrod**	**Petradoria pumila**	X	
Sphaeralcea coccinea	**scarlet globemallow**			X
Stanleya pinnata	**desert plume**		X	
Streptanthus cordatus	**twistflower**		X	
INTRODUCED PERENNIAL FORBS				
Corydalis **aurea**	scrambled eggs			X
NATIVE PERENNIAL GRASSES (cool)				
Agropyron smithii	**Western wheatgrass**			X
Carex occidentalis	**Western sedge**		X	
Oryzopsis hymenoides	**Indian ricegrass**		X	X
Poa fendleriana	**mutton grass**		X	
Sitanion longifolium	**bottlebrush squirreltail**	**Sitanion hystrix**	X	X
Stipa comata	**needle-and-thread grass**		X	

SPECIES	COMMON NAME	SYNONYM	N12/N99 NORTH/SOUTH PJUN	N12/N99 NORTH/SOUTH SAGE
INTRODUCED PERENNIAL GRASSES (cool)				
Poa compressa	Canada blu**egrass**			X
Puccinellia distans	European **alkaligrass**		X	
NATIVE PERENNIAL GRASSES (warm)				
Bouteloua gracilis	blue grama		X	X
Hilaria jamesii	galleta		X	X
Sporobolus cryptandrus	sand drops**eed**			X
NATIVE SUBSHRUBS				
Artemisia frigida	fringed sage**wort**		X	X
Chrysothamnus greenei	Greene **rabbitbrush**			X
Eriogonum **aureum**	slenderbush **wild buckwheat**	E. **microthecum**	X	
Eriogonum corymbosum	buckwheat		X	
Eurotia lanata	winterfat	Ceratoides **lanata**		X
Gutierrezia sarothrae	broom **snakeweed**		X	X
NATIVE SHRUBS				
Artemisia tridentata	big sagebr**ush**		X	X
Atriplex **canescens**	four-wing **saltbush**		X	X
Chrysothamnus **nauseosus**	rubber rabbitbrush			X
Chrysothamnus **viscidiflorus**	sticky-leaved **rabbitbrush**		X	X
Cowania mexicana	cliff rose	Purshia **stansburiana**	X	
Ephedra **viridis**	mountain jo**int-fir**		X	
Forestiera neomexicana	desert **olive**		X	
INTRODUCED SHRUBS				
Tamarix pentandra	saltcedar			X
NATIVE TREES				
Juniperus osteosperma	Utah juniper		X	
Pinus edulis	Colorado pin**yon**		X	X
MOSSES				
Moss	moss		X	X
Polytrichum piliferum	moss		X	
LICHENS				
Lecidea sp.	lichen		X	
Parmelia chlorochroa	lichen	**Xanthoparmelia chlorochroa**	X	X
SUCCULENTS				
Mammilaria microcarpa	pincushion **cactus**		X	
Opuntia **macrorhiza**	thickroot pricklypear		X	X
Opuntia polyacantha	plains pricklypear		X	
Pediocactus simpsonii	ball **cactus**		X	
AGAVOIDS				
Yucca angustissima	Spanish bay**onet**		X	



APPENDIX 3

Black Mesa Mining Complex

Field Guide

To

Potentially Occurring Rare Plants

2003

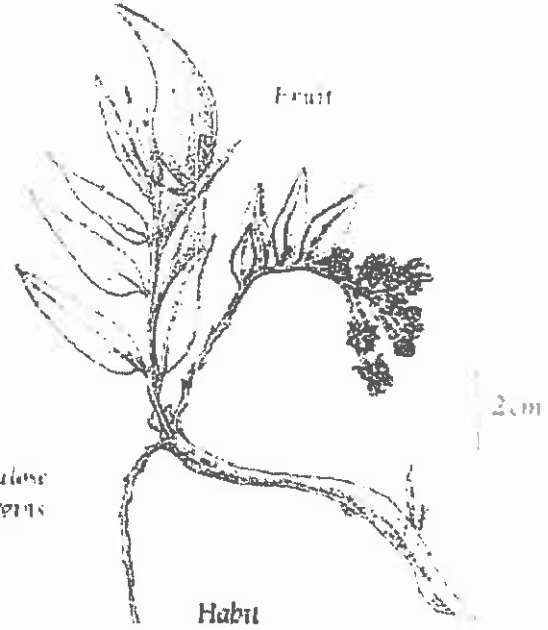
Black Mesa Mining Complex Field Guide to Potentially Occurring Rare Plants 2003

peeblesii, D. Roub/NNHP

Table of Contents

PINYON-JUNIPER WOODLAND SPECIES

***Asclepias sanjuanensis* – San Juan Milkweed**
Family: Asclepiadaceae
Synonyms: *A. **unicialis** var. ruthiae* (debated)
Status: Federal, 3B; NN, G4



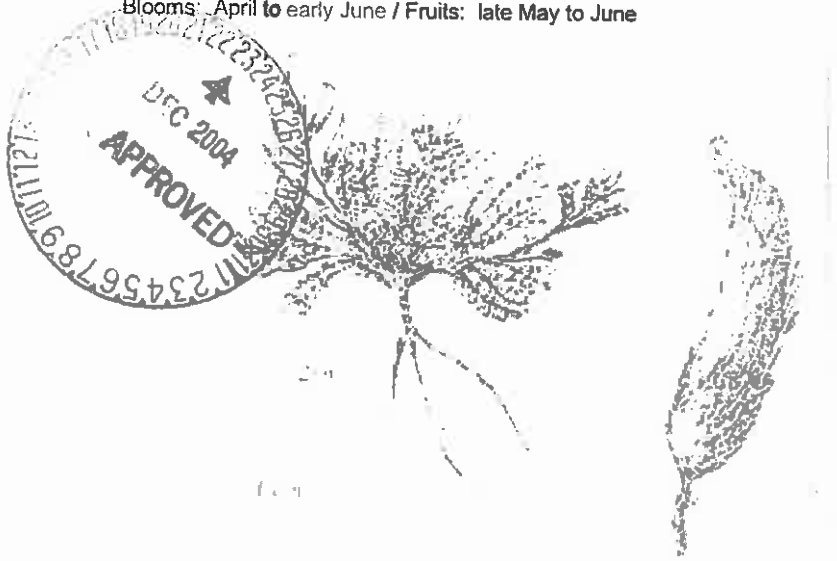
Distinguishing characteristics
Milky white latex in stems and leaves; 2-7 branches, the auricles of the hood are erect, herbage pubescence is sparse, leaf shape lanceolate to broadly lanceolate.
Stems: woody taproot, 4-8 cm tall, prostrate to ascending
Leaves: 2-4 cm long, oblong-lanceolate, white tomentulose on leaf margins
Flower: inflorescence terminal; corolla reddish-violet; follicle 1/8-1/4 inch long
Blooms: Late April-early May
Lookalikes: *A. ruthiae* usu. has one branch, auricles of the hood not erect, herbage pubescence is dense, leaf shape broadly ovate to broadly lanceolate. *A. macrosperma* has tomentose herbage, pedicels, and calyx; leaves ovate-lanceolate to nearly orbicular; stems 5-15 cm long.
Habitat: grows on sandy benches and hills near the Chaco River, NM in pinyon-juniper woodland and Great Basin grassland communities

***Astragalus humillimus* – Mancos milkvetch**
Family: Fabaceae
Synonyms: *Tragacantha humillima, Phaca humillima*
Status: Federal, LE; NN, G2

Distinguishing Characteristics:
Tufted perennial forming clumps up to 30 cm across
Stems: **only Astragalus in the area with persistent spiny leaf petioles**, up to 1 cm long.
Pod: spreading, egg shaped, ellipsoid, 4.5 mm long, 2 mm wide
Leaves: crowded, up to 4 cm long, 7-11 oval leaflets, 0.7-2 mm long
Flower: branches short, 1-3 flowers, petals lavender to purplish, conspicuous lighter colored spot in the throat of the corolla tube; banner 7-10 mm long; keel and banner petal 6-8 mm long; calyx, 3mm long
Phenology: flowers late april to early may, fruits june to early july.
Lookalikes: *A. deterior* and *A. calycosus* var. *scaposus* have flaccid leaf petioles and longer, oblong, or narrowly ellipsoid pods. *A. micromerius* doesn't have persistent spiny leaf stalks.
Habitat: ledges and mesa tops in slickrock communities / pinyon-juniper woodlands of the Mesa Verde Group, often in cracks in the sandstone substrate or in shallow pockets of sandy soil. 5,000-5,850 ft in elevation.

Astragalus naturitensis – Naturita milkvetch
Family: Fabaceae
Synonyms: *A. arientinus* var. *stipularis*
Status: Federal, 3C (more abundant than prev. thought); NN, G4

Distinguishing Characteristics:
Low growing, miniature spreading perennial about 10 cm tall
Stems: ascending, 2-6 cm long
Calyx: 4-8 mm, cylindrical, mixed white and black pubescent, lobes 1-1.5 mm
Pod: leathery, less than 2 cm long, more than twice as long as wide, widely spreading, covered with short, stiff, flat-lying hairs, straight except for beak, usually red mottled.
Leaves: basal, pinnate with 9-15 leaflets, leaves 2-7 mm, clustered, obovate to elliptic, mostly folded, often glabrate above, stipules free
Peduncles: scapose, 2-7 cm, with 4-9 subcapitate or briefly racemose ascending flowers
Flowers: 10-15 mm long, bi-color banner white with lilac, keel purple spotted, and wings reddish purple or purple tipped
Blooms: April to early June / Fruits: late May to June



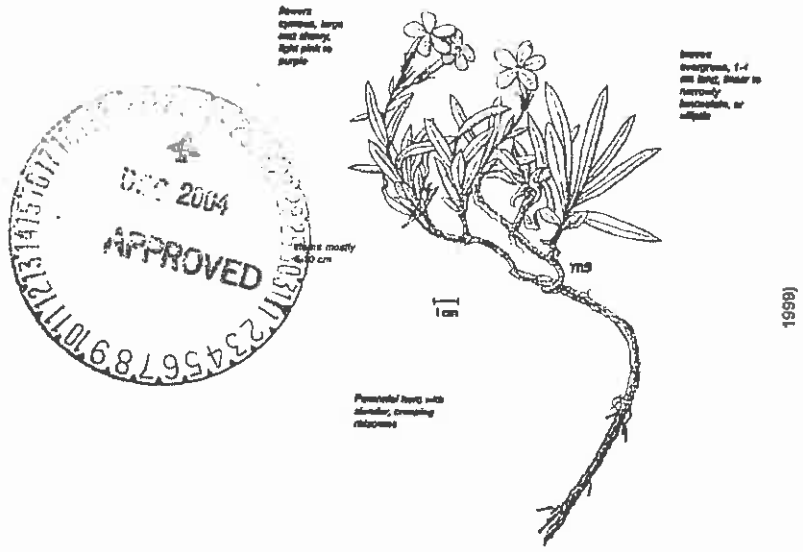
Lookalikes: *A. deterior* has yellow-white flowers, *A. desperatus* has smaller flowers and loosely hirsute pods of broader and shorter outline. *A. monumentalis* var. *cottamii* has firm-walled, dorsiventrally compressed, unilocular pods, *A. humillimus* has persistent, spiny rachises.
Habitat: Sandstone mesas, ledges, crevices and slopes in pinyon-juniper **woodlands**. 5,000-7,000 ft in elevation.

Clematis hirsutissima var. ***arizonica*** – Arizona leather flower
Family: Ranunculaceae
Synonym: *C. arizonica, C. h.* var. *hirsutissima*
Status: Federal, none, NN, G4

Distinguishing characteristics
Herbaceous perennial, 20-70 cm high
Fruit: head of achenes, each bearing a 4-6 cm plumose style
Flowers: nodding, solitary at the end of ea. Stem, 2-4 cm long
No petals, but w/ 4, thick purplish sepals, numerous stamens and pistils
Stems: erect from a somewhat woody base, ~5 cm to 1st branch
Leaves: pubescent to nearly glabrous, pinnately compound w/ 7-13 leaflets, these divisions narrowly linear, usually 1-2 mm, but rarely up to 12 mm
Blooms: Late April to June, Fruits July to August

Lookalikes: other *Clematis* are vine forming. *C. hirsutissima* (no variety) has more spreading petioles, narrower almost filiform leaflets (1-2mm wide), and mostly smaller flowers (sepals less than or equal to 2.5 cm long).
Habitat: moist mtn meadows, prairies, and open woods and thickets usually in limestone soils of ponderosa pine and mixed conifer forests, 6,800 to 9,000 ft

***Phlox cluteana* – Navajo Mountain Phlox**
Family: Polemoniaceae (Phlox family)
Status:



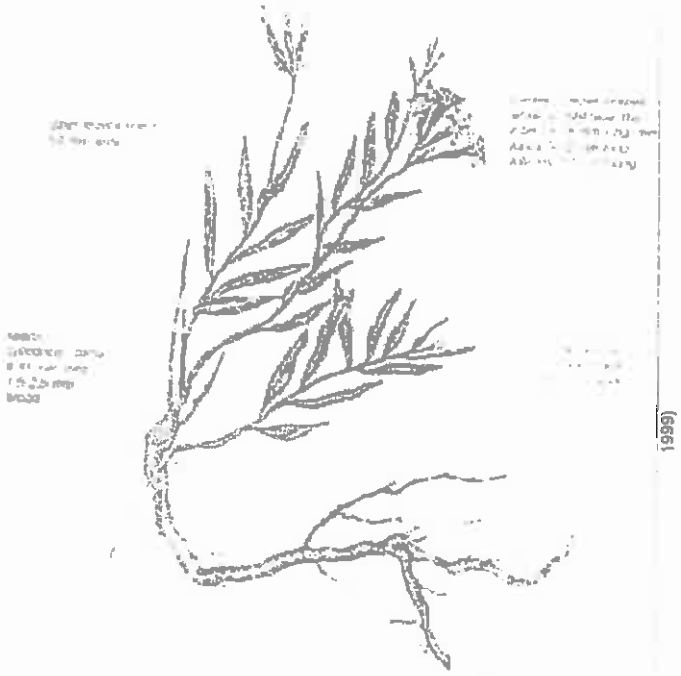
Polemoniaceae (Phlox Family)

Distinguishing characteristics
Plants with stems single or more/less clumped from subterranean, many-headed, subrhizomatous caudices. 4-12 cm tall
Stems: 8-10 cmm tall, sparsely to densely glandular pubescent
Leaves: 1-4 cm long, linear to narrowly lanceolate or elliptic, glabrous or ciliate or pubescent (like the stem) 2-5 mm wide
Flowers: cymose, large and showy, on pedicels 3-15 mm long, alone or 2 to several in terminal cymes; calyx: 7-9 mm long, intercostally flat; corolla tube: 14-18 mm long; lobes 7-10 mm long and nearly as wide, pink to lavender or white; stamens included or slightly exserted; style 9-14 mm long
Rhizomes: long, slender, terminating in clusters of evergreen leaves
Lookalikes: *P. longifolia* and *P. amabilis* have taproots and deciduous leaves
Habitat: Light to heavy shade under ponderosa pine, gambel oak, or pinyon-juniper in sandy soils with leaf litter; 6,400-10,400 ft

SHRUBLAND SPECIES

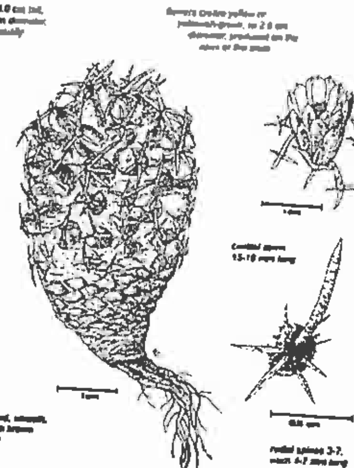
***Amsonia peeblesii* – Peebles blue star**
Family: Apocynaceae (Dogbane)
Status: Federal, none; NN, G4

Distinguishing Characteristics
Robust, herbaceous perennial, glabrous, 40-90 cm tall
Seeds: cylindrical, corky, 8-11mm long, 1.5-2.5 mm broad
Leaves: upper leaves linear, 1-2 mm wide
lower leaves oblong-linear, 4-9 mm wide
Flower: corolla trumpet shaped, white or light blue
tube 13-19 mm long
lobes 5-10 mm long
follicle 2-10 cm long
Blooms: May to June, leaves turn golden color in fall
Lookalikes: Glabrous form of *A. tomentosa* var. *stenophylla* has smaller flowers (7-12 mm long) and the follicles are moderately constricted between the seeds (*A. peeblesii* has smoothly cylindrical follicles)
Habitat: Little Colorado watershed; grows in grasslands and Great Basin desertscrub communities. Subtrate types range from strongly alkaline sedimentary conglomerates to volcanic cinders; 4,000-5,620 ft



Apocynaceae (Dogbane Family)

***Pediocactus peeblesianus* var. *fickeiseniae* – Fickeisen plains cactus, Fickeisen pincushion cactus**



1999)

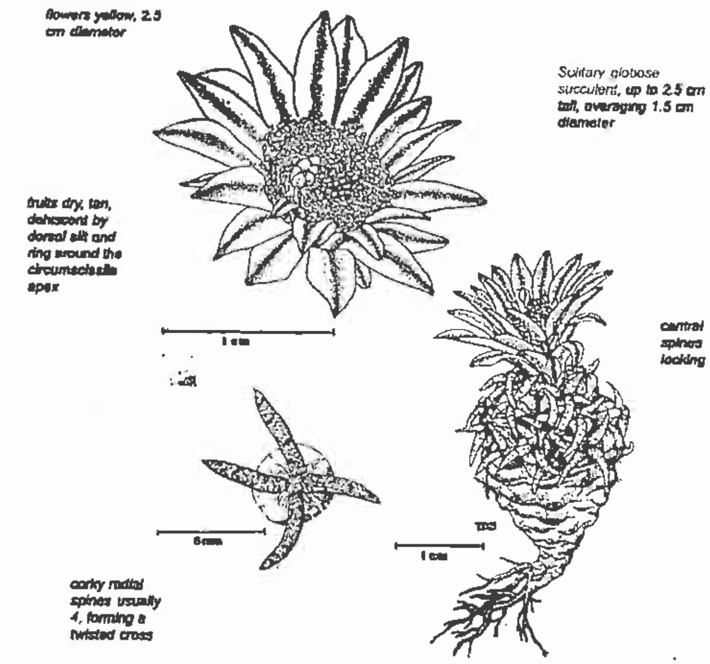
Cactaceae (Cactus Family)

Family: **Cactaceae**
Synonyms: *Navajoa fickeisenii*, ***Toumeya fickeisenii***
Status: **Federal**, Candidate; NN, **G3**

<u>Distinguishing characteristics</u>
The **genus** *Pediocactus* have **no ribs, cylindric to globose stems, flowers <25mm in diameter, petals white or with pink or yellow at least on the midribs; fruit, dry, green, to tan/yellow, naked or scaly.** ***P. p.* var. *fickeiseniae* is a solitary or clustered cactus, globose 2.5-6 cm tall and 2-5.5 cm in diameter**
Flowers: cream-yellow or yellowish-green, to 2.5 cm diameter, produced on the apex of the stem, petaloid perianth parts cream, yellow, or yellowish-green; outer perianth parts **with pink or green midstripe; stamens yellow; stigma yellow.**
Tubercles: 3-7 mm long, 4-6 mm broad
Aureoles: circular
Stems: 2.5-6 cm tall, 2-5.5 cm in diameter, spherical, **usu. solitary**
Central spine: 15-18 mm long, spongy, white to pale gray, **ascending, mostly 1 mm wide at base**
Radial spines: 3-7, each 4-7 mm long, spongy, not obscuring the stem, long, white to pale gray, recurving
Fruit: top-shaped, smooth, turning **reddish brown upon maturity**
Blooms: April, **retracts into the** soil **in drought**
Lookalikes/Varieties: ***P.p.* var. *peeblesianus* has no central spine and 4-5 radial spines. *P. simpsonii* has a smooth spine spreading at right angles to tubercles, tubercles have strait central spines, not ribbed**
Habitat: gravelly limestone/gravelly loam in desertscrub; 4,300-5,450 ft.

***Pediocactus peeblesianus* var. *peeblesianus* – Navajo plains cactus**
Family: Cactaceae
Status: Federal, LE; NN, none

<u>Distinguishing characteristics</u>
Solitary globose succulent, **up to 2.5 cm tall, averaging 1.5 cm diameter**
Flowers: yellow, **2.5 cm in diameter**
Central spines: **lacking**
Radial spines: corky, **usu. 4, forming a twisted cross**
Fruits: dry, tan, dehiscent **by dorsal slit and ring around the circumscissile apex**
Blooms: April, fruits **May to June, retract during drought / dry**
Lookalikes/varieties: ***P. p.* var. *fickeiseniae* has a prominent central spine, more radial spines and grows** larger. **See above** description **of *P. simpsonii*.**
Habitat: low hills in desertscrub and **grassland; 5,100-5,650 ft.**

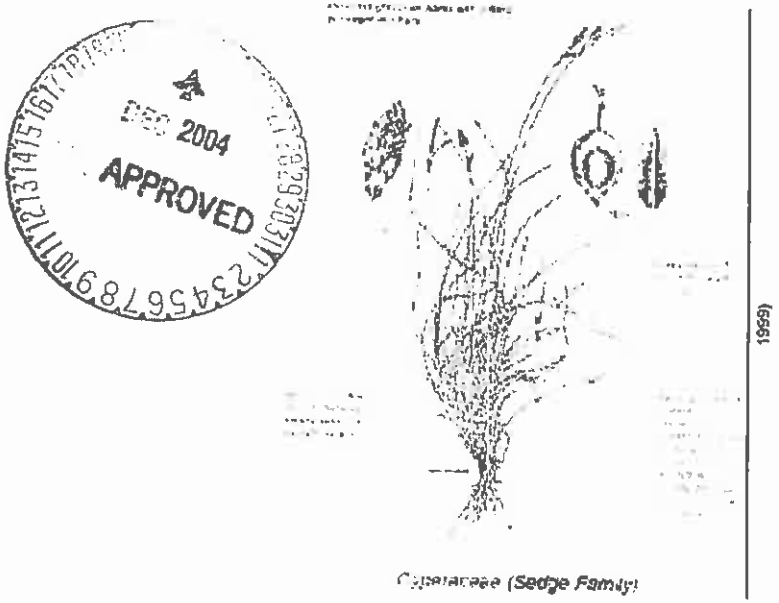


Cactaceae (Cactus Family)

SEEPS / STREAMS / HANGING GARDENS

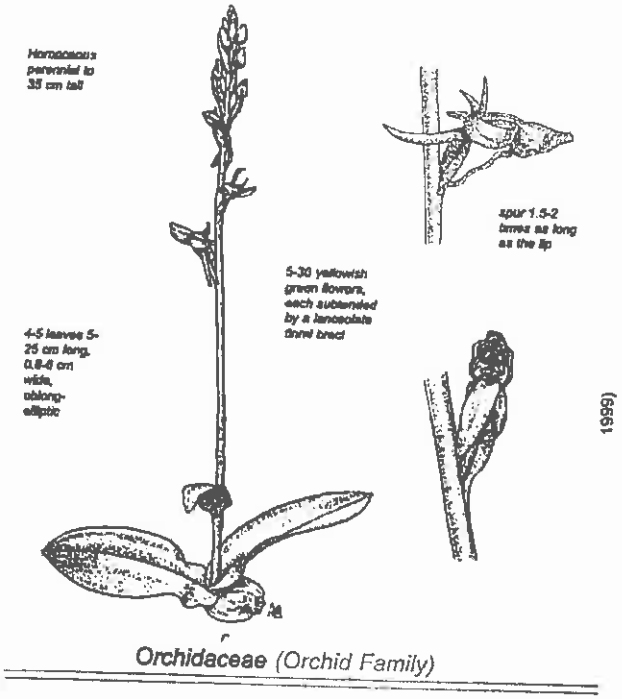
Carex specuicola **– Navajo Sedge**
Family: Cyperaceae
Status: Federal, LT; NN, G3

Distinguishing characteristic
Perennial grass-like plant with a dried, reddish, persistent leaf base
Styles: 2-branched with lenticular achenes and 3-branched with trigonous achenes, 2-branched style is more common
Terminal spike: usu. gynaecandrous, short peduncled or sessile
Perigynea: nerveless or finely few-nerved, strongly flattened, papillose, broadly elliptic or obovate, stigmas 2 or 3
Leaves: narrow, 1-3 mm wide, 12-20 cm long
Flowers: grouped into 2-4 short, pedunculate spikelets with male and female flowers, 8-10 mm long, clustered at the end of a long thin stalk, 2-3 times the length of the leaves. Female flowers located above male flowers
Phenology: flowering and fruit set occur from spring to summer, most reproduction appears to be vegetative
Lookalikes: *C. aurea* does not have a strongly flattened perigynia or female flowers located above male flowers. *C. occidentalis* has slender, longer stems (20-70 cm); *C. geophila* has fertile stems shorter than most leaves, leaf blades 5-15 cm long (shorter)
Habitat: N. AZ, seeps and hanging gardens, on vertical Navajo sandstone cliffs and alcoves; 4,400-7,000 ft.



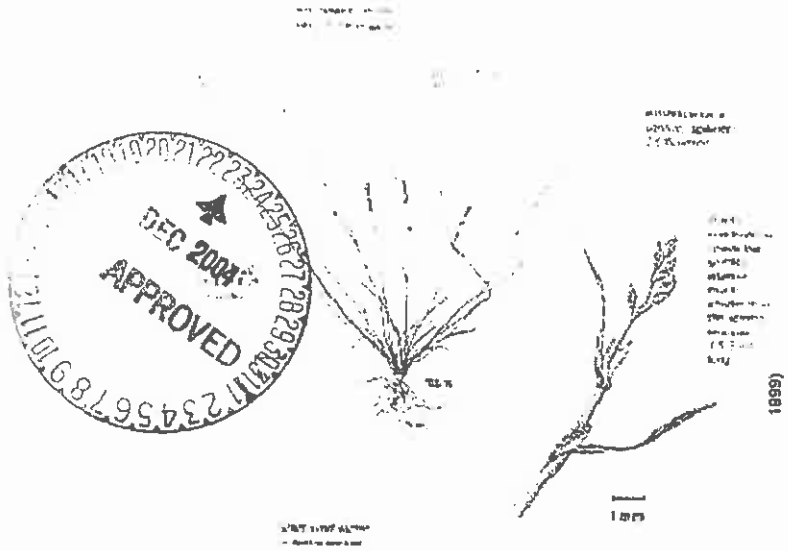
Platanthera zothecina **– alcove bog orchid**
Family: Orchidaceae
Synonym: *Limnorchis zothecina, Habenana zothecina*
Status: Federal, SC (species of concern); NN, G3

Distinguishing characteristics
Herbaceous perennial to 35 cm tall
Spur: 1.5-2 times as long as the lip
Inflorescence: 5-30 yellowish green flowers, each subtended by a lanceolate floral bract
Leaves: 4-5 leaves, 5-25 cm long, 0.8-6 cm wide, oblong-elliptic, appear late April to early May
Spike: develops in early June
Flowers: corolla tube, yellowish-green
Blooms: mid June-July
Capsules: mature in about one month
Lookalikes: *P. sparsiflora* has spur equal or slightly exceeding lip, less rounded basal leaves, and a less elliptic lip
Habitat: seeps, streams, hanging gardens and wet canyon alcoves, 5,000-9,000 ft. requires constant moisture, full to partial sun



Orchidaceae *(Orchid Family)*

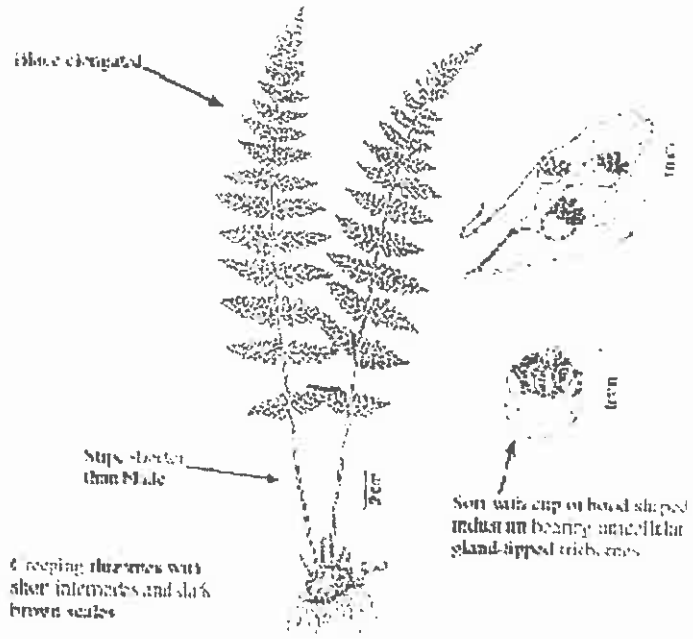
***Puccinellia parishii* – Parish's alkali grass**
Family: Poaceae
Status: Federal, SC; NN, G2



Poaceae (Grass Family)

Distinguishing characteristics
winter or spring annual dwarf grass, 5-28 cm tall
Leaves: blades 1-6 cm long, 1-2 mm wide; flat to slightly involute
Ligules: 1-3 mm long
Inflorescence: narrow panicle; spikelets 2-6 flowered, 3-5 mm long
Florets: disarticulating above the glumes
Glumes: much shorter than the lemma, unequal, broad, strongly nerved, scarious margined
Lemma: 1.5-2 mm long, pubescent on nerves only, firm, obtuse
Culms: 5-28 cm tall; 1-25 in number
Flowers: April to May and June to September
Lookalikes: *P. fasciculata* and *P. airoides*. Both perennial; if hairy, hairs not confined to nerves of lemma; *P. fasciculata* is 20-50 cm tall (on average, taller); *P. airoides* is 15-80 cm tall (also taller, on average); *Poa annua* has boat shaped leaves
Habitat: Marshy ground along seeps and streams, saline or alkaline soil forming a white crust on the ground; associated with pinyon-juniper woodlands to desert communities, 2,950-6,070 ft.

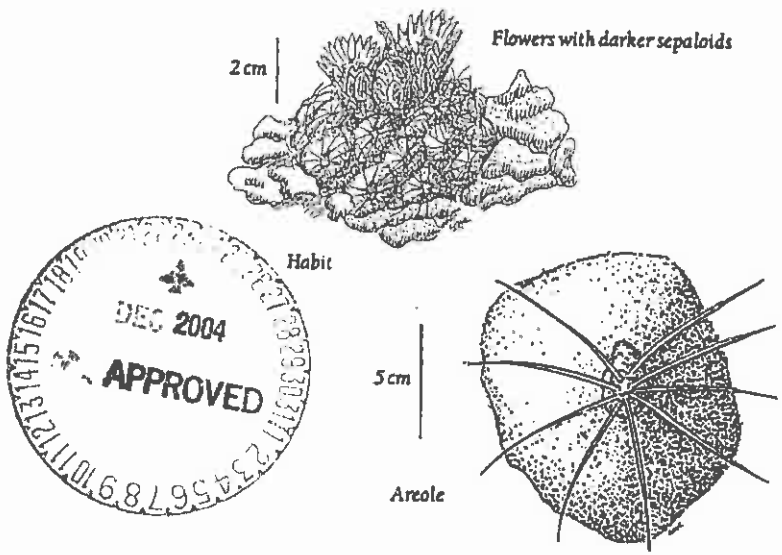
***Cystopteris utahensis* – Utah bladder-fern**
Family: Polypodiaceae
Status: Federal, none; NN, G4



Distinguishing characteristics
Stems: creeping, not cordlike, internodes short, heavily beset with old petiole bases, hairs absent; scales lanceolate
Fronds: monomorphic, clustered at stem apex, to 45 cm, nearly all bearing sori.
Petiole: green to straw colored; blade deltate, 2 pinnate-pinnatifid, usually widest at or near the base, apex short-attenuate, rachis and costae with unicellular, gland-tipped hairs
Phenology: sporulating summer to fall
Lookalikes: *C. fragilis* does not have small glands and scaly bulblets near the tip of the frond, as wells as dark scales on the underground stem made up of cells with very thick walls
Habitat: seepages, crack, and ledges on cliffs; on calcareous substrates including sandstone, limestone, and dacite. On the NN, known from sandstone cracks above the streambed, 4,200-8,800 ft

BOTH SHRUB AND PINYON-JUNIPER

Sclerocactus mesae-verdae **– Mesa Verde cactus**
Family: Cactaceae
Synonyms: *Coloradoa mesae-verdae, Echinocactus mesae-verdae, Pediocactus mesae-verdae*
Status: Federal, LT; NN, G3



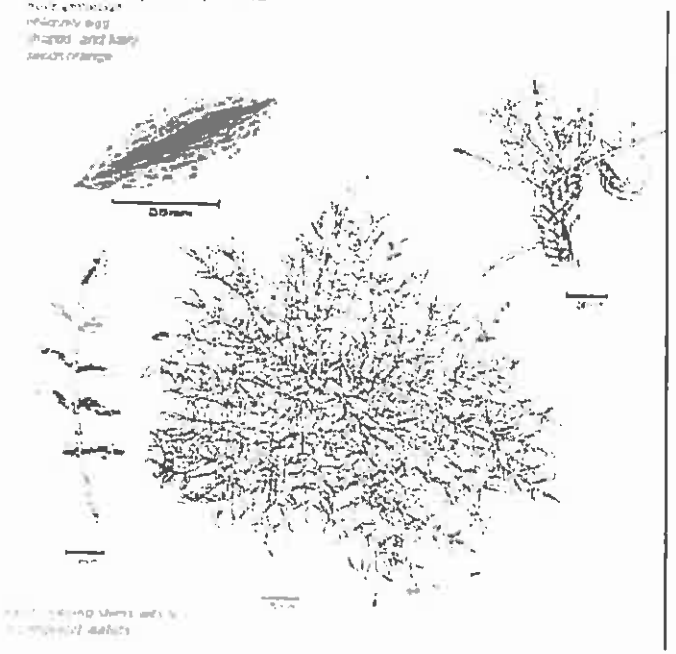
SCLEROCACTUS MESAE-VERDAE
(Boissevain ex Hill & Salisbury) L. Benson
Cact. and Succ. Jour. 38: 54. 1966.

Distinguishing characteristics
The genus *Sclerocactus* are subglobose, depressed-hemispheric, ovoid, obovoid, or cylindroid; ribs 8-17; one or more of lower central spines usu strongly hooked. *S. mesae-verdae* is~ 2 cm tall, above ground
Areole: 0.5 cm diameter
Stems: mostly solitary, sometimes in clusters, 3-11 cm tall, oval to depressed-globose
Central spines: none or rarely 1
Radial spines: 8-10
Flowers: cream to pink, born below but adjacent to apex of the stem
Fruit: green turning tan; oblong
Blooms: late April to early May
Lookalikes: *S. parviflorus* usu. has 4 central spines, green cylindroidal to elongate cylindroidal stems. *S. whipplei* is taller (stems 10-25 cm tall), has 1-3 or more central spines, 3-5 cm long, 1-3 or more radial spines usu obscure the stem, 5000-6000 ft.
Habitat: barren clay hills of Fruitland and Mancos shale formation

VERY UNLIKELY TO BE SEEN

Astragalus cremnophylax **var.** ***cremnophylax*** **Barneby – Sentry milkvetch**
Family: Fabaceae
Status: Federal, none; NN, G4

Distinguishing characteristics
Dwarf, evergreen, perennial, mat forming herb, 2-25 cm in diameter
Flowers: tiny, pale pinkish-lilac, white tipped keep incurved 100-120 degrees, purple veined banner; borne on a raceme of 1-3 flowers, held slightly above the mat, less than 10mm long, immersed in leaves
Leaves: all diminutive, leaf stalk 2-5 mm, softly tipped; leaflets 3-7, leaves 3-10mm, crowded pinnate or subpalmate
Fruit: ascending, unilocular, deciduous ovoid/obliquely egg-shaped, and hairy. Seeds orange. Ovules 4-6, fruits May to June
Blooms: late April to May, rarely a 2nd flowering in fall
Lookalikes: *A. c.* var. *myriorrphaphis* has spinescent leaf bases; *A.c.* var. *hevronii* has larger flowers; and *A. calycosus* has larger leaflets and does not have unilocular fruits
Habitat: Grand Canyon NP in crevices and depressions w/shallow soils on Kaibab limestone on rim-rock benches at the canyon edge in pinyon-juniper woodland at 7,050-7,960 ft.



VERY UNLIKELY TO BE SEEN

***Astragalus cutleri* – Cutler's milkvetch**
Family: Fabaceae
Synonyms: *Astragalus preussii* var. *cutleri*
Status: Federal, LE: NN, G3

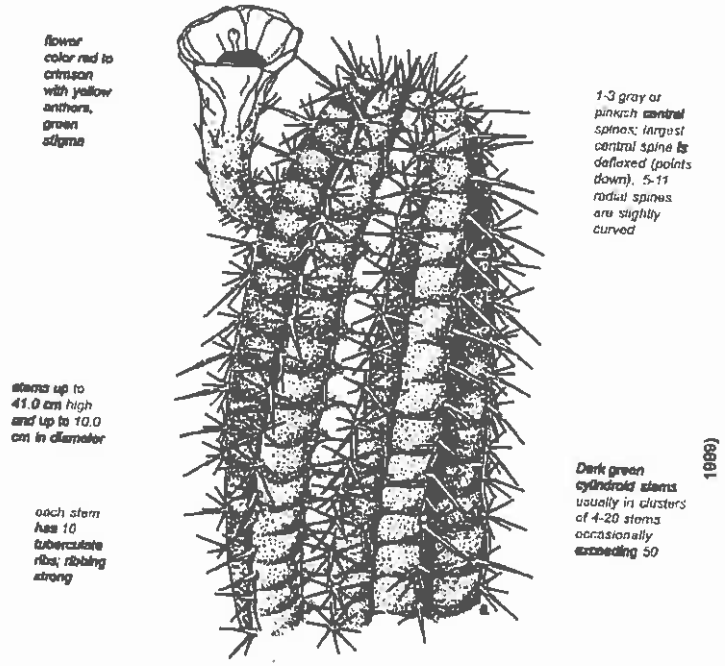
Distinguishing characteristics
Moderate, caulescent, short lived perennial, 10-35 mm long, from a woody caudex, pubescence affixed by its base
Flowers: 15-16 mm long; white or faintly blue tinged; ascending peduncles, 2-15 cm long; racemes, 3 to 22 flowered, axis 1-20 cm long in fruit; bracts,1.5-4 mm long; pedicels,1-5.5 mm long; bracteoles, 2; calyx, 6.4-12.3mm long; tube, 5.1-9.7 mm long, cylindric, thinly strigose, purple; teeth, 1.3-2.6 mm long, subulate
Fruit: pods thin textured, often drying straw colored, erect to ascending, stipitate, or subsessile; stipe, 2-7 mm long, oblong-ellipsoid, inflated, 12-34 mm long, 6-13 mm thick, glabrous or puberulent , stiffly papery to leathery,unilocular; ovules 20-44
Leaves: 3.5-13 cm long
Leaflets: few, 5-13, 7-12 mm wide, obovate to obchordate to oblong, narrowly elliptic, lanceolate, or linear, emarginate to rounded, obtuse, or acute, glabrous
Stipule: 2-7 mm long, all distinct
Stems: few to several, erect or ascending, forming clumps
Blooms:
Lookalikes: *A. p.* var. *laxiflorus* and *A. p.* var. *preussii* have vivid purple flowers and more, narrower leaflets, and the pods dry brownish
Habitat: warm desert shrub communities on sandy, seleniferous soils with level to moderate slopes, on the Shinarump and Chinle Formations. Known from 3,800 ft elevation.

VERY UNLIKELY TO BE SEEN

***Echinocereus triglochidiatus* var. *arizonicus* – Arizona hedgehog cactus**
Family: Cactaceae
Synonyms: *E. arizonicus var. arizonicus, E. coccineus var. arizonicus, Cereus polycanthus, Echinocereus polycanthus*
Status: Federal, LE; NN, none

Distinguishing characteristics
Plant caespitose, few branches or stems grow in clumps. As with all *Echinocereus* flowers burst through sides of stem, leaving scar on stem right above spine.
Stems: 22.5-40 cm long, 7.5-10 cm in diameter; dark green and cylindroid, usu. in clusters of 4-20 stems, occasionally exceeding 50.
Central Spines: 1-3, 2.5-40 cm long, grey or pinkish, the largest deflexed
Radial spines: 5-11, appresed, 0.5-1 cm long, light yellow or pinkish tab, often slightly curved.
Stem ribs: +/- 7 cm long. 10 tuberculate ribs, ribbing strong
Areoles: (of mature parts of stems) white felt or cobwebby hairs; nearly circular
Flowers: stay open for 2-3 days, even at night; +/- 5 cm in diameter and +/- 7 cm long; red to crimson (as with all *E. t.*) with yellow anthers, green stigma; style 2mm in diameter
Fruit: Red, fleshy at maturity
Blooms / fruits: April to May/ May to June; germinates mid-summer
Other varieties: As opposed to other varieties, *E.t.* var. *arizonicus* has flowers on upper third of stem ribs. Spines are shorter and more robust than other *Echinocereus*. *E.t.* var. *melanacanthus* has much smaller stems (in height and width), each cluster has many (up to 500) stems. *E.t.* var. *neomexicanus* has weaker ribbing, thinner central spines (0.5-1mm); central spines are not deflexed, smooth and are 4.5-7 cm long.
Habitat: open slopes of rugged steep-walled canyons, granite boulder-pile ridges and slopes in AZ desert grassland; shrubby vegetation, understory of shrubs, does not do well without extensive rock cover; 3,400-6,360 ft
Substrate: Normally found on Orthoclase-rich granite of late Cretaceous age; other parent materials in the area include volcanic tuff, mid-Tertiary age dacite and perhaps rhyolite.
Plant community: interior Chaparral and Madrean Evergreen Woodland; also into desert grassland. Often with the following associated species: *Quercus turbinella, Q. emoryi, Arcostaphylos pungens, Cercocarpus montanus, Nolina microcarpa, Dasylirion wheeleri, Agave chrysantha, Muhlenbergia emersleyi, Pinus monophylla, Juniperus erythrocarpa,* and *Rhus trilobata.*

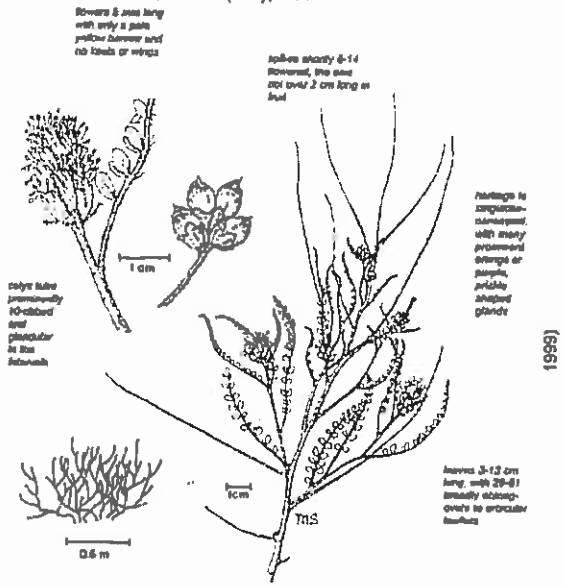
See next page for illustration



Cactaceae *(Cactus Family)*

VERY UNLIKELY TO BE SEEN

Errazurizia rotundata – Round dune-broom
Family: Fabaceae
Synonym: *Paryella rotundata*
Status: Federal, none; NN, G4; State (AZ), SR



Fabaceae (Pea Family)

Distinguishing characteristics
Low, clonal, woody shrub, up to 30 cm tall
Flowers: 5 mm long with only a pale yellow banner and no keels or wings
Spikes: shortly 6-14 flowered, the axis not over 2 cm long in fruit
Herbage: strigulose-canescent, many prominent orange or purple, prickle shaped glands
Leaves: 3-13 cm long, with 29-61 broadly oblong-ovate to orbicular leaflets
Calyx: 5-6 mm long, turbinate campanulate, tube prominently 10-ribbed and glandular in the intervals
Blooms: late April to early May
Habitat: Little Colorado River drainage, exposed sites in several types of outcrops ranging from sandy soils in sandstone, gravelly soils in calcareous outcrops to deep, alluvial cinders in sandstone breaks; **desertscrub**, 4,800-5,200 ft.

VERY UNLIKELY TO BE SEEN

Lesquerella navajoensis O' Kane – Navajo Bladderpod
Family: **Brassicaceae**
Synonyms: **none**
Status: **Federal, none, NN, G4**

Distinguishing characteristics
Perennial, cushion forming from a thick taproot
Flowers / Fruits: May to June

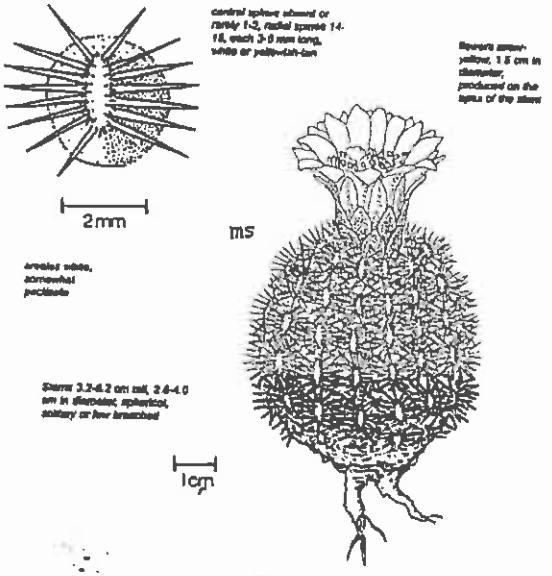
Lookalikes: *L. fendleri* has a deep orange "eye", the veins of the petals near the eye are also orange, the petals much larger and the stellate trichomes are webbed for at least half the length of the rays, *L. navajoensis* has a faint orange eye and no orange veins, the flowers are much smaller and the trichomes are not webbed.

Habitat: limited to windward, windswept mesa rims and nearby habitat with little vegetative cover (pinyon-juniper) and high insolation. Typically only found on the nearly white Todilto limestone member of the Morrison foundation which forms local mesa rims capping the Entrada Sandstone formation. Elevations range from 7200-7600 ft

VERY UNLIKELY TO BE SEEN

***Pedicactus bradyi* – Brady pincushion cactus**
Family: **Cactaceae**
Synonym: *Toumeya bradyi*
Status: **Federal, LE; NN, G2**

Distinguishing characteristics
The **genus** *Pediocactus* have **no ribs, cylindric to globose stems, flowers <25mm in diameter, petals white or with pink or** yellow **at least on the midribs; fruit, dry, green,** to tan/yellow, **naked or scaly.** ***P. bradyi*** **is defined by unique capsule dehiscence, it is an** endemic **to Marble Canyon**
Small, semi-globose, ranging from 2.5 to 5 cm in diameter
Central spines: absent or rarely **1-2**
Radial spines: 14-15, each 3-5 mm long, white, yellowish-tan
Areoles: white, somewhat pectinate; vertical elongate
Stems: 3.2-6.2 cm tall, 2.6-4 cm in diameter, spherical, **solitary or few-branched**
Flowers: straw yellow, **1.5 cm in diameter,** produced **on the apex of the stem**
Blooms: March to april, **retracts into the soil in response to drought**
Lookalikes: similar to juveniles of *Corypantha vivpara* but radial spines shorter
Habitat: Kaibab limestone **chips** overlaying **soils derived from** Moenkopi **formation, 3,340-5,200 ft (very specific** soil **requirements). Only grows in Marble Canyon**



Cactaceae (Cactus Family)

APPENDIX 4

Vegetation Sampling Area Photos
N12/N99 North/South Study Area
Black Mesa Mining Complex
2003

Photograph 1. N12/N99 NORTH/SOUTH Sagebrush Baseline, Sample 1, Spring 2003

Photograph 2. N12/N99 NORTH/SOUTH Sagebrush Baseline, Sample 2, Spring 2003

Photograph 3. N12/N99 NORTH/SOUTH Sagebrush Baseline, Sample 3, Spring 2003

Photograph 4. N12/N99 NORTH/SOUTH Sagebrush Baseline, Sample 4, Spring 2003

Photograph 5. N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Sample 1, Spring 2003

Photograph 6. N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Sample 2, Spring 2003

Photograph 7. N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Sample 3, Spring 2003

Photograph 8. N12/N99 NORTH/SOUTH Pinyon-Juniper Baseline, Sample 4, Spring 2003

Map 1

N12/N99 North/South Baseline Vegetation Sampling Map,
Black Mesa Mining Complex

Attachment 5

2003 Baseline Vegetation Sampling Report
N9 Study Area

Black Mesa Mining Complex

N9 Coal Resource Area
VEGETATION BASELINE SAMPLING REPORT
(Spring 2003 Sampling Project)

Black Mesa Mining Complex

December 2004

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And

Peabody Western Coal Company
P.O Box 650
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Appendix 3 – Black Mesa Mining Complex Field Guide to Potentially Occurring Rare Plants

Appendix 4 – Vegetation Baseline Photos, N9 Study and Adjacent Areas, Black Mesa Mining Complex, - PWCC, AZ - 2003

LIST OF MAPS

INTRODUCTION

In late May and early June 2003, ESCO Associates conducted a baseline vegetation study of the N9 area within Peabody Western Coal Company's (PWCC) Black Mesa Mining Complex leasehold. The purpose of this sampling was to describe species composition, woody plant density, and diversity in the study area prior to disturbance by mining. Both quantitative and qualitative data were collected in the study area; methods, sample areas, and sample sizes were those specified by PWCC.

The vegetation resources in the project areas were similar to those described in previous baseline studies (Peabody Coal Company 1985), consisting of a mosaic of sagebrush and pinyon-juniper vegetation communities. Vegetation resources in the N9 area were classified as pinyon-juniper woodland, sagebrush shrubland, or saltbush shrubland using aerial photos and previous baseline vegetation maps.

METHODS

Sensitive Plant Surveys

A list of sensitive plant species was compiled from the following sources under the following definitions:

USFWS THREATENED AND ENDANGERED SPECIES (50CFR 17.11 AND 17.12, DEC. 1999)

Endangered species: any species which is in danger of extinction throughout all or a significant portion of its range (other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under the provisions of The Endangered Species Act of 1973 would present an overwhelming and overriding risk to man).

Threatened species: any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, as determined by the Secretary.

NAVAJO ENDANGERED SPECIES LIST (NESL)

The following definitions are taken from the Navajo Endangered Species List (NESL) issued by the Navajo Nation Department of Fish and Wildlife-NNDFWL (2001)

Group 1: Those species or subspecies that no longer occur on the Navajo Nation

Group 2 (**G2**) & Group 3 (**G3**): "Endangered" – Any species or subspecies whose prospects of survival or recruitment within the Navajo Nation are in jeopardy or are likely within the foreseeable future to become so.

G2: A species or subspecies whose prospects of survival or recruitment are in jeopardy.

G3: A species or subspecies whose prospects of survival or recruitment are likely to be in jeopardy in the foreseeable future.

Group 4: Any species or subspecies for which the Navajo Nation Department of Fish & Wildlife (NNDFWL) does not currently have sufficient information to support their listing as G2 or G3 but has reason to consider them. The NNDFWL will actively seek information on these species to determine if they warrant inclusion in a different group or removal from the list.

The final sensitive plant species list (Appendix 3 – *Field Guide to Potentially Occurring Rare Plants, Black Mesa Mining Complex*) was organized by species growth habit and habitat preferences, and included detailed descriptions and drawings of morphological traits, mention of look-alikes and distinguishing characteristics, habitat requirements, and phenology. A literature review was conducted on the appropriate species listed in the above sources to compile this information (see Kearny and Peebles 1960, McDougall 1973, Arizona Rare Plant Committee 2000, Ecosphere 1995, Great Plains Flora Association 1986, Utah TES Plant Interagency Committee 1991, Spahr 1991, Spackman et al. 1997, Welsh et al. 1993).

The inner boundary (blue) areas shown on Map 1 were traversed on foot to ascertain the presence of the target species. This pedestrian survey took place between May 20 and June 1, 2003. As of September 2003, the areas to be included in baseline study increased [see outer (red) boundaries]. Inasmuch as the target species were all most reliably to be identified in the early season, the additional areas could not be inventoried for species presence. Rather, they were visited in September and early October 2003 to determine the comparability of habitats of the outer areas to those of the inner areas that were surveyed in detail in the blooming season. This knowledge of the habitats of the outer areas was used to assess the likelihood of the occurrence there of each target species.

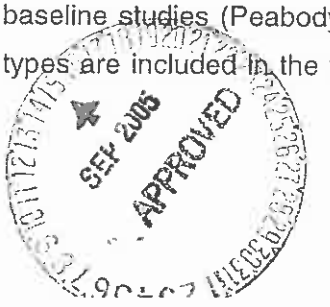
Qualitative Data Collection

The N9 study area was surveyed in May and June 2003 for threatened and endangered species. The vegetation types in the study area were predominantly pinyon-juniper woodland, with inclusions of sagebrush shrubland and saltbush shrubland comprising a variable mosaic (Map 1).

Using maps provided by PWCC and plotted over a photographic base with Universal Transverse Mercator (UTM) waypoints marking the boundaries, ESCO personnel walked throughout these areas searching for the listed species' habitat requirements. If habitat was found, a more detailed search of the area was performed. During the course of this survey, 'look-alike' species were noted, as were 'cultural' species (those of significance to the Navajo and Hopi). Occasionally these specimens were entered into a handheld Global Positioning Device (GPS) for potential seed collecting or salvage purposes. If any species of concern were encountered these would also have been mapped using the GPS and located on the maps provided by PWCC.

Quantitative Vegetation Sampling

Quantitative data were collected for cover and woody plant density in the pinyon-juniper woodland only. In discussions with OSMRE it was agreed that the sagebrush shrubland and saltbush shrubland represented only a small portion of the total N9 area and would not require quantitative sampling. These types are representative of the sagebrush and saltbush shrublands present on the lease area and are more fully described in previous baseline studies (Peabody Coal Company 1985). Descriptive summaries of these two types are included in the following sections. A map with randomly generated sampling



points (Map 1) overlaying a photographic base was provided by PWCC for each of the baseline areas to be sampled. This information is included on Map 1. UTM coordinates were also provided for each point that in conjunction with the use of hand-held GPS units, assisted in objective sample point location.

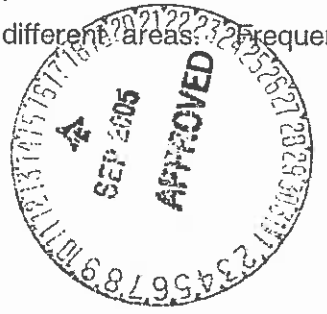
COVER SAMPLING

Cover data were collected along randomly oriented 50 m transects using a point-intercept method in which data were recorded as interceptions of a point with a plant species, litter, standing dead plant material, bare soil, or rock. Plant material produced during 2003 and still standing was tallied by species. Litter was considered to be any organic material that had fallen, or begun to fall to the soil surface. Standing dead was any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter. Inorganic materials greater than 1 cm in diameter were considered rock. The cover sampling points were optically projected using a Cover-Point Optical Point Projection Device developed by ESCO Associates. One hundred points were collected at each transect. The points were evenly distributed; a pair of points were collected on opposite sides of every meter mark along the 50 m transect (50 X 2 = 100).

First hit interceptions were used to calculate absolute top layer foliar cover by dividing the number of interceptions for a particular species or ground cover type by the total number of points taken (100). First hit relative vegetation cover was calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover was calculated by dividing all hits (first-hits and additional-hits) for a particular species by the total number of points taken (100). In addition, all-layer relative cover was calculated using all hits for a particular species divided by the total hits accumulated during sampling of the transect.

PLANT SPECIES FREQUENCY AND DENSITY MEASUREMENTS

During the course of cover sampling, all plant species occurring within one meter of either side of the cover sample transect were noted as present within each sample. The total number of species (within each lifeform) observed in each 100 sq.m. sample provides a measure of species density, indicating the relative species richness of different areas. Frequency for each plant species observed during sampling was



calculated by dividing the number of sample transects in which the species was observed by the total number of samples.

WOODY PLANT DENSITY SAMPLING

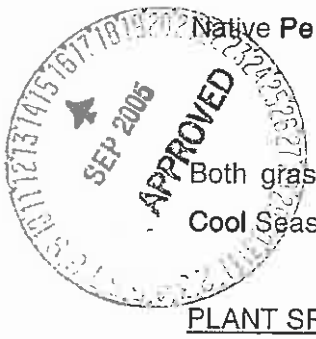
Woody plant density sampling was undertaken in all sample areas along each transect established for cover. Trees, shrubs, subshrubs, and agavoids with root crowns located within the boundaries of the quadrats (belt transects) were tallied according to species. In pinyon-juniper areas, woody plant density sampling was collected in 4x50 meter plots, 2 meters on either side of the cover transect. In sagebrush areas, woody plants were counted inside the 2x50 meter transects established for cover. The presence of dead individuals was not included in woody plant density calculations.

LIFEFORMS USED IN DATA PRESENTATION

All data and summary tables are organized by lifeform to facilitate data interpretation and analysis. The lifeform categories that follow reflect growth habit and provenance.

Lifeforms Present in 2003

Native Annual & Biennial Forbs	Native Subshrubs
Introduced Annual & Biennial Forbs	Native Shrubs
Introduced Annual Grasses	Introduced Shrubs
Native Perennial Forbs	Native Trees
Introduced Perennial Forbs	Succulents
Native Perennial Cool Season Grasses	Agavoids
Introduced Perennial Cool Season Grasses	Lichens
Native Perennial Warm Season Grasses	Mosses



Both grasses and graminoids (grass-like plants) are included in the Native Perennial Cool Season Grasses lifeform.

PLANT SPECIES LISTING

Scientific names used generally follow McDougall (1973) or Kearney and Peebles (1960) while the common names cited are found in Beetle (1970), Nickerson et al. (1976), or Soil Conservation Service (1979). Lichens and mosses were described in Hale (1969) and Conard (1956), respectively. Scientific names for vascular plants not found in the

sources listed above were described by either Welsh et al (1993) or Great Plains Flora Association (1986). The table below lists these species with their sources:

Vascular plants not found in McDougall (1973) or Kearney and Peebles (1960)	Great Plains Flora Association (1986)	Welsh et al. (1993)
Arenaria hookeri	X	X
Bahia oppositifolia	X	
Cryptantha flavoiculata		X
Elymus junceus	X	X
Erysimum ***asperum***	X	X
Lygodesmia juncea	X	X
Puccinellia distans	X	X
Stephanomeria runicnata	X	X

During the course of fieldwork, a list of all encountered plant species (quantitative plus incidental observations) was compiled for each area. These lists are summarized in Appendix 2, 'Plant Species from the Study Area', which includes current nomenclature, cross-references to older nomenclature, common name, and the area in which the species was observed.

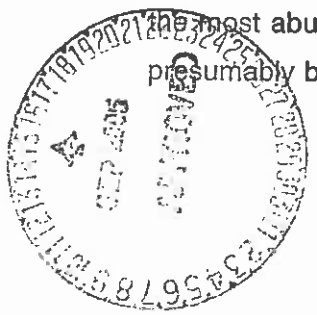
RESULTS

Tables containing the baseline sampling data are presented in Appendix 1. Results of quantitative cover sampling of pinyon-juniper woodland are found in Table 1. Woody plant density data from pinyon-juniper woodland are found in Table 2. Cover and woody plant density data are summarized in Table 3. Relative cover data organized by lifeform are presented in Table 4. Data on species density separated by lifeform are presented in Table 5. A listing of all plant species encountered during quantitative sampling is provided in Table 6. Photographic documentation from representative quantitative sampling locations is available in Appendix 4, Vegetation Sampling Area Photos.

DISCUSSION

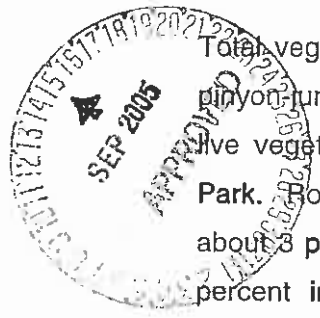
Pinyon-Juniper Woodland

Although pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) are by far the most abundant plants in the pinyon-juniper woodland in terms of ground cover and presumably biomass, their abundance is on the low end of the spectrum for this type in



the Southwest (Moir and Carleton 1986). With N9 tree canopy cover in the range of 8 to 29 percent for the 10 samples (Table 1), these sites do not meet the UNESCO definition of woodland (> 40 percent tree cover, UNESCO 1973). Pinyon-juniper vegetation at similar elevation (6300 ft) with the same tree dominants in Zion National Park had 38 percent cover (by ocular estimate; Harper 2003). Inasmuch as trees are by far the most abundant lifeform, it is reasonable to continue to refer to the type as woodland. See photos 1 through 4 illustrating the N9 pinyon-juniper type.

Beyond the tree cover, shrubs are the next most abundant lifeform, being comprised of cliffrose (*Cowania mexicana*) and either big sagebrush (*Artemisia tridentata*), fourwing saltbush (*Atriplex canescens*), or rubber rabbitbrush (*Chrysothamnus nauseosus*). Accompanying shrubs (or subshrubs) include Douglas rabbitbrush (*C. viscidiflorus*), fringed sage (*Artemisia frigida*), snakeweed (*Gutierrezia sarothrae*), antelope bitterbrush (*Purshia tridentata*), roundleaf buffaloberry (*Shepherdia rotundifolia*), and mountain joint-fir (*Ephedra viridis*). For the most part, herbaceous cover in all the pinyon-juniper vegetation is very sparse. Warm season grass cover is very limited, having no measurable cover in the 10 samples (Table 1). Cool season native grasses are more abundant in the N9 pinyon-juniper vegetation type than in the N99 sagebrush shrubland (4 versus 2 species, respectively). However, only one grass species, Indian ricegrass (*Oryzopsis* hymenoides), had measurable cover in N9. More commonly observed species include bottlebrush squirreltail (*Bottlebrush squirreltail*) and Indian ricegrass. Native perennial forbs are more frequently encountered in the pinyon-juniper than in sagebrush shrubland, but still are very minor in the quantitative sense. Some pinyon-juniper stands give the general impression of a virtually bare understory, while others have at least moderate presence of shrub cover.



Total vegetation cover (Table 1) was 22.0 percent, comparatively sparse for reported pinyon-juniper woodland. Harper (2003) for example, found an average of 62 percent live vegetation cover in his examination of pinyon-juniper woodland at Zion National Park. Rock averaged nearly 14 percent cover over all the sampled area compared to about 3 percent in the N99 sagebrush shrubland. Standing dead of approximately 4.3 percent in the N9 pinyon–juniper woodland was substantially less than the N99 sagebrush shrubland. Although some pinyon pine did perish as a result of the drought, overall the tree cover was mostly intact. Some of the mortality of pines was indirect, caused by bark beetle infestation of stressed trees.

Study of the ecophysiology of pinyon pine, Utah juniper and big sagebrush has shown that the trees have assimilation (carbon-fixation) rates that are more sensitive to drought than sagebrush (DeLucia and Schlesinger 1991), but the trees have higher "water use efficiency" (assimilation rate/transpiration rate). In other words, the trees have much tighter control on transpirative loss, so even though their assimilation drops quickly with drought, they still make a little water go farther per gram of fixed carbon than sagebrush. Flanagan et al. (1992) as cited in Nowak et al. (1999) showed that pinyon pine and Utah juniper are more dependent on summer precipitation than sagebrush.

In the pinyon-juniper type species density (Table 5) averaged 18.9 per 100 sq. m., higher than that observed in N99 sagebrush shrubland or N7/8 sagebrush reference area. The distribution of species is fairly even among native annual forbs, native perennial cool season grasses, shrubs, and trees. Compared to the range of vascular plant species density observed elsewhere in pinyon–juniper woodlands of adjacent New Mexico and Utah (Harner and Harper 1976), the study area falls somewhat below the mean of the 30 sample areas reported there which was about 22 to 23 species per 100 sq.m., and ranged from about 12 to 60 species per 100 sq.m.

Throughout the bulk of the pinyon-juniper woodland in the study area, the soil surface is trampled sufficiently frequently by livestock that "cryptobiotic" or "cryptogamic" soil crust is non-existent. In a very few sites, however, this soil crust was found intact. The cryptogams involved are predominantly blue-green algae, mosses (mostly *Polytrichum piliferum*), and lichens. Evans and Ehlehringer (1994) found that the nitrogen requirements of Utah juniper may be largely met by nitrogen fixation by the cryptobiotic crust. It may be assumed that the absence of a cryptobiotic crust in heavily trampled areas results in a diminished availability of nitrogen from atmospheric fixation.

With regard to woody plant density in the N9 pinyon-juniper woodland type, overall woody plant densities (including subshrubs, shrubs, and trees) are far lower than in the a sagebrush shrubland, averaging about 1173 stems per acre (Table 2). Tree densities were only 23 percent of the total woody plant density, with 275 tree stems per acre. These values are comparable to the lower to middle range of densities reported for pinyon-juniper stands of the Piceance Basin by Welden et al. (1990) and well below the

range reported in 1974 (599 trees per acre) and 1984 (629 trees per acre) from permanent plots in northeastern Utah by Austin (1987).

In N9 the pinyon-juniper proportions are about 2.5 pinyon to juniper. This greater proportion of pinyon pine to juniper is related to higher elevation and precipitation in the N9 area of the lease. Pinyon pine has shown physiological evidence of having much higher potential rates of carbon fixation than junipers (Lathja and Barnes 1991), but shows less resistance to impacts of water stress on assimilation rate. Measures of the degree of soil moisture stress at which leaf turgor can no longer be maintained ("permanent wilting point") is an indication of the relative drought tolerance of a plant species. Wilkins and Klopatek (1987) determined that the "permanent wilting point" for pinyon pine was slightly higher than that for Utah juniper. Breashers et al. (1997) studied the use of soil moisture in spaces between trees in a pinyon-juniper woodland and determined that one-seeded juniper made more effective use of shallow soil moisture between trees than pinyon pine.

In other words, pinyon pine is, in general, less accommodating of dry conditions than Utah juniper and, when competition for shallow soil moisture is intense, junipers tend to have an advantage over the pines. Lower relative abundance of pinyon pine in the southern part of the leasehold, where elevations and precipitation are lower, soils tend to be shallower (and with presumably less moisture-holding capacity), and juniper more dominant, is consistent with what is known of the ecology of these two tree species.

Sagebrush Shrubland

Areas mapped as sagebrush shrubland in the baseline sampling area are for the most part dominated by big sagebrush and a variety of other woody plants. This was typically in the form of varying and sometimes substantial presence of other shrubs and subshrubs, especially fourwing saltbush, Douglas rabbitbrush, and rubber rabbitbrush. Along with blue grama (*Bouteloua gracilis*), the grass component of many sagebrush stands included galleta (*Hilaria jamesii*) and, more occasionally, bottlebrush squirreltail (*Sitanion jubatum* and *S. longifolium*), needle and thread (*Stipa comata*), Indian ricegrass, and western wheatgrass (*Agropyron smithii*). However, the latter five cool season grasses were almost always less abundant than the warm season grasses blue grama and galleta. A preponderance of warm season grasses is consistent with environmental conditions that are strongly characterized by low and variable

precipitation concentrated in summer "monsoon" episodes. The N99 baseline area and the N7/8 sagebrush reference area are located to the southeast and southwest of the N9 area respectively, and have similar characteristics to the sagebrush shrubland in the N9 area. A brief description of sagebrush shrubland characteristics based on spring 2003 sampling in these two areas is provided below. See photos 5 through 8 for representative images of the sagebrush shrubland type.

Total vegetation cover in the sagebrush shrubland type in N99 averaged 13.8 percent (AZ-0001D 2004) while the N7/8 sagebrush reference area had 12.2 percent cover (PWCC 2004). Big sagebrush was the dominant in both areas with 70 percent relative cover in the N99 area and 54 percent relative cover in the N7/8 sagebrush reference area. These data suggest that abundance of big sagebrush is an indicator of overall soil productivity and that, within the limitations imposed by low annual precipitation, highest cover within the sagebrush type is expectable on the deeper (alluvial/colluvial) substrates as represented in the comparable N99 area. Observations in the N9 area indicate this same relationship and variation in sagebrush shrubland characteristics.

Bare soil is very abundant within the sagebrush shrubland vegetation type, averaging 47 percent cover in the N99 area to over 51 percent in the N7/8 sagebrush reference area. Rock averaged over 3 percent cover in the N99 area and increased to over 14 percent in the N7/8 reference area. Standing dead was probably more abundant in 2003 than usual because of the widespread death of sagebrush following the 2000-2002 drought (see below). This averaged over 15 percent cover in the 2003 N99 sampling area and nearly 10 percent in the N7/8 reference area, being primarily due to dead big sagebrush.

Relative vegetation cover data show that shrubs are by far the most abundant lifeform in the sagebrush shrubland type at nearly 90 percent of total vegetation cover in N99 but dropping to 59 percent in the N78 sagebrush reference area. Warm and cool season perennial grasses were much less, averaging only 2.8 percent of total vegetation cover in N99 but rising to nearly 10 percent in the N7/8 sagebrush reference area where sagebrush is less dominant. The N7/8 sagebrush reference area has been excluded from grazing for more than 20 years possibly benefiting grass presence.

With regard to woody plant density in the N99 area, the total density for sagebrush shrubland was 7196 stems per acre. The bulk of the high values for this type were big

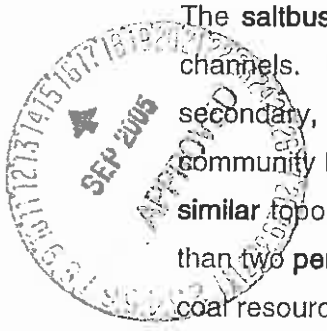
sagebrush, Douglas rabbitbrush, rubber rabbitbrush, and fourwing saltbush. Other shrubs that were encountered during sampling include the subshrubs winterfat (*Ceratoides lanata*), snakeweed, fringed sage, and Greene rabbitbrush (*C. greenei*).

Among sagebrush shrubland sites, invasion of pinyon pine is widespread. The pines are most often found directly beneath sagebrush where shading or other protection has apparently provided critical assistance in establishment.

That big sagebrush is among the native plants sensitive to moisture deprivation was evident throughout the Black Mesa area in 2003. The effects of serious drought conditions of the previous few years were very clear. Within the baseline areas examined in 2003, it is estimated that approximately 30% of sagebrush shrubland stands had suffered heavy die-back of sagebrush, while another 50 to 60% had experienced light to moderate die-back (photos 5, 6, and 8). About 10 to 20% of stands had little or no die-back (photo 7). See the discussion of the drought sensitivity of sagebrush in the next section.

Species density within the N99 sampled sagebrush shrubland stands averaged 12.4 species per 100 sq.m. This is a lower species density value for historically observed values on the Black Mesa leasehold. The N7/8 reference area was higher at 14.1 species per 100 sq. m.

Saltbush Shrubland



The saltbush shrubland type is located in alluvial bottoms, adjacent to or in drainage channels. It may be situated along the margins of terraces associated with primary, secondary, and occasionally tertiary drainages. Fourwing saltbush dominates this community but can integrate quickly with big sagebrush dominated shrubland that is on similar topographic or edaphic site conditions. The saltbush shrubland represents less than two percent of the entire Black Mesa lease area and less than six percent of the N9 coal resource area.

Previous baseline studies on the Black Mesa lease area found that total vegetation cover for the saltbush shrubland type averaged over 27 percent (Peabody Coal Company 1985). The dominant species, fourwing saltbush, accounted for greater than 55 percent of the vegetation cover. Big sagebrush is a codominant with varying cover

but this is always less than the cover contributed by fourwing saltbush. Typically, herbaceous understory is represented by western wheatgrass, blue grama, and a number of annual, biennial, and perennial forbs. Annuals including cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola iberica*) may have a high level of cover in this type. Woody density can average greater than 15,000 stems per acre. Both the annual composition and high woody density, at the expense of more desirable perennial herbaceous species, corresponds to heavy, long-term grazing pressure that has caused a deteriated range condition in this and other native plant communities on Black Mesa.

Occurrence of Herbaceous Species in the Study Area

Historical grazing use on Black Mesa has been long-term, heavy and continuous (overstocking combined with yearlong grazing). Growth of herbaceous species in general, but especially native perennial forbs, is limited. Although there was no absence of native perennial forbs in the 10 randomly sampled 100 sq.m. areas in the pinyon-juniper woodland, only three species had measurable cover (totaling 0.3 percent) and 4 out of 10 samples had 3 or fewer perennial forbs present (Table 1). The low native perennial forb cover in N9 is representative of the pinyon-juniper woodland on Black Mesa. In the N99 sagebrush shrubland sample area, 1 of 5 plots had no forbs present and no measurable cover was recorded for any perennial forb species. In the N9 pinyon-juniper study area, there was measurable cover for only one native perennial warm or cool season grass species (Indian ricegrass). In the N99 sagebrush shrubland there was measurable cover for only 2 out of 7 perennial grasses present and it never exceeded 0.2 percent for any species. In the N9 area most grasses had no measurable cover and were only present in the species density plot. The N7/8 sagebrush reference area was better with 5 of 7 perennial grass species having measurable cover, combining for 1.1 percent cover for the growth form.

Note that the N7/8 sagebrush reference area has been protected from grazing for more that 20 years but had received the same heavy continuous grazing pressure as other areas at Black Mesa prior to exclosure. While perennial grass cover and presence was better in the reference area as noted above, spring 2003 sampling showed that forb cover was only 0.4 percent, one plot had no perennial forbs (n=11), and 6 of 11 samples had 3 or fewer forbs present. This would indicate that even with complete absence of grazing over a long period, range recovery is slow given the environmental conditions and history of grazing on Black Mesa.

Although the spring of 2003 was comparatively favorable with regard to moisture, the extent of native annual and biennial forbs was scant, averaging no more than 0.6 percent cover in the N99 sagebrush shrubland type, 0.1 percent in the N7/8 sagebrush reference area, and 0.0 percent cover in the N9 pinyon-juniper woodland.

Sensitive Plant Survey Results

Survey of the inner (red) areas shown on Map 1 in spring 2003 did not reveal the presence of any of the "target" species (those deemed to have even a small chance of occurrence (see *Appendix 3, Field Guide to Potentially Occurring Rare Plants, Black Mesa Mining Complex)).*

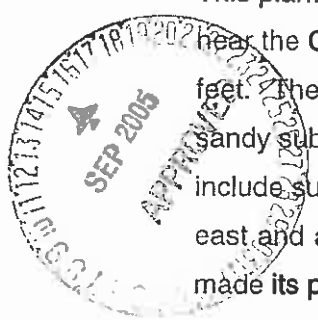
Notes regarding the potential for the sought for rare plants to occur and the results of the intensive survey for them are summarized below:

Amsonia peeblesii – Peebles blue star

This plant is known from grasslands and desert scrub communities at elevations from 4,000 to 5,620 ft., in the arc of the Little Colorado River drainage from central Coconino County south and east into southern Navajo County, Arizona. Even the lowest reaches of the Black Mesa leasehold are nearly 1,000 ft. higher than the uppermost occurrence of this plant. The environs of the Little Colorado River to which this plant is restricted are approximately 50 miles distant. No individuals of Peebles blue star were encountered during the 2003 surveys.

Asclepias sanjuanensis – San Juan milkweed

This plant is known from sandy benches and hills in pinyon-juniper woodland vegetation near the Chaco and San Juan Rivers in San Juan County, New Mexico at 5,000 to 6,200 feet. The type locality is on the San Juan College campus in Farmington. In terms of sandy substrate and pinyon-juniper woodland vegetation, the study areas would seem to include suitable habitat. However, its nearest occurrence in areas approximately 150 mi. east and at elevations mostly below the study area elevations (approximately 6,800 ft.) made its presence unlikely; none was found during the 2003 surveys.



Astragalus cremnophylax var. *cremnophylax* – Sentry milkvetch

This milkvetch is known from Grand Canyon National Park on Kaibab limestone, a Permian-age formation. The study area do not include limestone and are far younger (Cretaceous-age). Thus no suitable habitat was found and no sentry milkvetch was encountered.

Astragalus cutleri (*A. preusii* var. *cutleri*) – Copper Canyon milkvetch

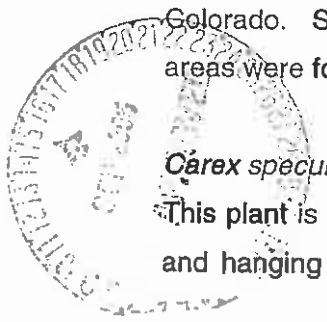
This plant is an endemic in southern San Juan County, Utah occurring on seleniferous soils derived from the Triassic-age Shinarump Conglomerate member of the Chinle formation at 3,800 ft. The lowest Black Mesa leasehold elevations of about 6,200 ft. are substantially higher and no substrates approximating those of the known occurrences are present. No individuals of Copper Canyon milkvetch were encountered during intensive surveys.

Astragalus humillimus – Mancos milkvetch

This plant is known from San Juan County, New Mexico and adjacent Montezuma County, Colorado at elevations from about 5,000 to 6,500 ft. in cracks on "slickrock" exposures of the Cretaceous-age Point Lookout sandstone, which is also found in McKinley and Sandoval Counties, New Mexico in close association with the Satan Tongue member of Mancos Shale. In the study area, Yale Point sandstone, a facies of the Mesa Verde formation of the Black Mesa Basin, forms limited exposures of bare rock. These sandstones are older than those of the San Juan Basin, the Cretaceous sea having receded from the Black Mesa Basin before it receded from the San Juan Basin. In addition to the differences in substrates, the study area is mostly higher in elevation than the known occurrences of Mancos milkvetch. No individuals of Mancos milkvetch were found during intensive searches in 2003.

Astragalus naturitensis – Naturita milkvetch

This plant is known from sandstone mesas, ledges, crevices, and slopes from 5,000 to 7,000 ft. in McKinley Co., New Mexico, as well as in southern Utah and southwestern Colorado. Such habitats are present in the study area; those in the intensive survey areas were found not to be occupied.



Carex specuicola – Navajo sedge

This plant is known to occur in extreme northern Arizona and barely into Utah in seeps and hanging gardens below vertical cliffs of Navajo sandstone at elevations between

4,400 ft and 7,000 ft. No exposures of the lower Jurassic-age Navajo sandstone are present in the study area. The upper Cretaceous Yale Point sandstone that forms cliffs along washes in the study area is generally without development of seepage zones. The very few seepage zones observed during the intensive surveys had extensive crusts of evaporated salt. No individuals of Navajo sedge were observed during the intensive surveys.

Clematis hirsutissima var. *arizonica* – Arizona leather flower

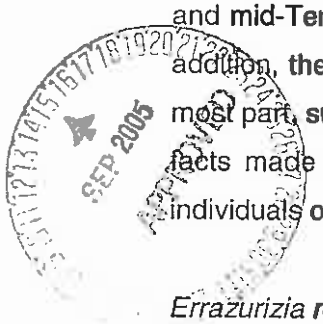
Although the known range of elevational occurrence (6,800 to 9,000 ft) overlaps the elevations of the study area, its preferred habitat is moist portions of mountain meadows, open woods, or thickets in ponderosa pine and mixed conifer forests on soils derived from limestone. On the Navajo Nation, it is known only from the Chuska Mountains and Defiance Plateau. None of the habitat criteria are met in the study area, and no Arizona leather flower was encountered in the intensive survey areas.

Cystopteris utahensis – Utah bladder-fern

Known from Arizona, Colorado, New Mexico, Texas, and Utah at elevations from 4,200 to 8,800 feet, this plant could reasonably occur in the study area on the very few sites where cracks in sandstones with calcareous cementation are at least slightly seeping. These locations were examined closely (in N12/N99 NORTH/SOUTH). None were found.

Echinocereus triglochidiatus var. *arizonicus* – Arizona hedgehog cactus

This rare cactus is known from central Arizona at elevations from 3,400 to 6,360 ft. on very rocky sites comprised mostly of boulders and cobbles of orthoclase-rich granite of late Cretaceous age. Other substrates on which it has been found include volcanic tuff and mid-Tertiary age dacite. Substrates of the study area are distinctly unlike these. In addition, the range of elevations within the sites is 6,200 to 7,150 feet, which is, for the most part, substantially higher than the highest known occurrences of the cactus. These facts made the occurrence of this cactus unlikely in the study area, and, in fact, no individuals of Arizona hedgehog cactus were encountered during the 2003 surveys.



Errazurizia rotundata – Round dune-broom

This plant is known from an arc of sites within a comparatively narrow elevational range (4,800 to 5,200 ft) from near Tuba City in Coconnino County, Arizona swinging south

and east to near Holbrook, in general following the valley of the Little Colorado River. Substrates are of various lithologies, but are apparently coarse and loose. Although the study area includes some loose sands over sandstone, elevations are considerably higher and the sites are about 50 miles east and north from the Little Colorado drainage. No individuals of round dune-broom were encountered during 2003 intensive surveys.

Lesquerella navajoensis – Navajo bladderpod

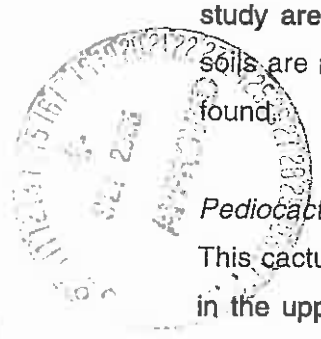
Navajo bladderpod is known to occur in McKinley County, New Mexico, Apache County, Arizona, and in Utah on windswept exposures of the Todlito limestone member of the Morrison formation at elevations between 7,200 and 7,600 ft. Upper elevations of the study area just below this range, but Morrison formation (Upper Jurassic age) materials are not present at the surface in the Black Mesa Basin. Furthermore the Upper Cretaceous sediments that are present in the study area do not include limestone. Navajo bladderpod was not considered a likely occurrence in the study area and none was found during 2003 surveys.

Pediocactus bradyi – Brady pincushion cactus

This narrow endemic is found in Coconino County, Arizona along the rim of Marble Canyon between elevations of 3,400 and 5,200 ft. Substrates are narrowly defined where intermixed Moenkopi and Kaibab formation debris form the soil parent material. Study area elevations are above 6,800 ft. Furthermore none of the Upper Cretaceous-age substrates of the area approximate the Moenkopi or Kaibab formation materials (Upper Triassic to lower Jurassic age). There was almost no chance of finding this cactus, and none were found during 2003 intensive surveys of the study area.

Pediocactus peeblesianus var. *fickeiseniae* – Fickeisen plains cactus

The known occurrences of this cactus are in Coconino and Mohave Counties, Arizona on soils derived from Kaibab limestone at elevations between 4,000 and 5,600 ft. The study area sites are all well above the known elevational limit and limestone-derived soils are **not** present. Nonetheless, it was sought during the intensive surveys but not found.



Pediocactus peeblesianus var. *peeblesianus* – Navajo plains cactus

This cactus is known from southern Navajo County at elevations from 5,100 to 5,650 ft. in the upper reaches of the Little Colorado River watershed on thin veneers of gravel

that are not replicated in the study area. The elevations of the study area are well above the highest known occurrence of this cactus. No individuals of Navajo plains cactus were encountered in the intensive field surveys.

Phlox cluteana – Navajo Mountain Phlox

This plant is known from the northern Chuska Mountains, Navajo Mountain, and Black Rock Mountain on the Navajo Nation, and in adjacent New Mexico and Utah at elevations from 6,000 to 10,400 ft. on sandy soils with leaf litter under ponderosa pine, Gambel oak, and pinyon – juniper woodland. Although it seems likely that the pinyon-juniper woodland habitat in which it is found represents the opposite end of the moisture spectrum from that found in the pinyon-juniper sites, it was sought in the intensive searches of spring 2003, but not found.

Platanthera zothecina – Alcove bog orchid

This plant requires the constant flow of moisture usually in hanging garden / alcove environments and is known from small populations at widely scattered locations in central and northeastern Arizona, east-central Utah, and northwestern Colorado. The northeastern Arizona locations include nearby Tsegi and Betatakin Canyons. Although nearby, these locations are in very deep canyons with overhanging cliffs of Navajo sandstone. The much younger Cretaceous-age sandstones (Yale Point member of the Mesa Verde formation) of the study area form small cliffs along some of the washes of the area, but nowhere are there deep shady well-wetted sites that would support this plant. The very few appearances of moisture on the study area cliff sites have only enough flow to periodically bring dissolved salts to the surface where rapid evaporation produces extensive salt crusting.

Puccinellia parishii – Parish's alkaligrass

This rare annual alkaligrass is found on salt-encrusted frequently wet soils at widely disjunct sites from northern and eastern Arizona, to southwestern Colorado and western New Mexico and as far away as San Bernadino County, California. Such microsites are found at a few seepage sites in study area. Although alkaligrass is present, it is saltmarsh alkaligrass (*Puccinellia fasciculata*), an introduced species now found in the northeastern U.S. and in Arizona, Colorado, and New Mexico. Careful examination of the study area alkaline/wet soils revealed only this species. Characteristics

distinguishing saltmarsh alkaligrass from Parish's alkaligrass include lemmas glabrous and 2 to 2.5 mm long, panicle branches floriferous to the base, and perennial habit.

Sclerocactus mesae-verdae – Mesa Verde Cactus

This cactus is known from San Juan County, New Mexico as well as adjacent Montezuma County, Colorado at elevations from 4,900 to 5,500 ft. on very heavy soils derived from Mancos formation shales or from shaley facies of the overlying Mesa Verde formation. Exposures of Mesa Verde formation facies in the northern Black Mesa Basin, and the study area in general, are dominated by the Yale Point sandstone and extensive areas of heavy clay soils are absent. These rocks are age-equivalent to the upper Mancos and lower Mesa Verde rocks of the San Juan Basin but are not marine deposits (the Cretaceous sea having withdrawn from the Black Mesa Basin earlier). No individuals of Mesa Verde cactus were encountered during the 2003 intensive searches in the study areas.

Plants fairly commonly seen that are similar to target species

Asclepias asperula – considerably larger than *A. sanjuanensis* in all dimensions of herbage and flowers, and with flowers with greenish corolla lobes with purplish hoods. *A. sanjuanensis* flowers have purplish corolla lobes with whitish hoods.

Phlox longifolia – This phlox has easily observed bulging intercostal membranes, unlike *P. cluteana*

Echinocereus triglochidiatus var. *mojavensis* — Differs from *E. t. arizonicus* in color, length and diameter of central and radial spines.

Pediocactus simpsonii – Possesses normal spines rather than the corky spines of *P. peeblesianus* var. *fickeiseniae* and *P. p.* var. *peeblesianus.* Possesses central spines, unlike *P. bradyi.*

Plants occasionally encountered that are similar to target species

Asclepias involucrata (Photograph 87) – Differs from *A. sanjuanensis* in having cream to greenish flowers.

Puccinellia fasciculata – Differs from P. parishii in being perennial and having lemmas glabrous and 2 to 2.5 mm long.

Habitats of the Outer Areas

The areas between the red and blue boundaries on Map 1 were examined in fall 2003 for the presence of habitats either different from those of the inner (blue) areas that were examined in detail in spring 2003 and / or the same as those in the inner areas that had the potential to support sensitive species. Habitats in the outer areas that were as potentially suitable for *Asclepias sanjuanensis*, *Astragalus humillimus*, and *Astragalus naturitensis* as those in the inner areas were found. It should be noted, of course, that those same types of potentially suitable habitats were found not to support any of these species in the adjacent inner areas in spring 2003 surveys.

No new habitats (i.e. habitats not represented in the inner areas) were found in the fall 2003 examination of the outer areas. No additional wet seepage sites were located. Drainages found in the outer areas were dry and generally heavily trampled by livestock.

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APPENDIX 1

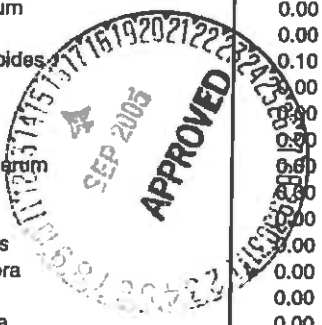
DATA TABLES

Cover data tables: Both first and additional hit data are presented in these tables. Additional hit data are shown in parentheses.

Woody plant density data tables: Counts of dead shrubs are shown in parentheses but are not included in density totals.

Table 1. Cover Data - N9 Pinyon-Juniper Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover* ----Sample Number---- 1	2	3	4	5
NATIVE ANNUAL & BIENNIAL FORBS										
Chenopodium fremontii	0.00	30.00	0.00	0.00	0.00	P	P			
Cryptantha crassisepala	0.00	20.00	0.00	0.00	0.00				P	
Descurainia pinnata	0.00	40.00	0.00	0.00	0.00			P		P
Descurainia richardsonii	0.00	10.00	0.00	0.00	0.00				P	
Draba cuneifolia	0.00	10.00	0.00	0.00	0.00					P
Draba reptans	0.00	30.00	0.00	0.00	0.00				P	
Gilia aggregata	0.00	50.00	0.00	0.00	0.00			P	P	
Gilia sp.	0.00	10.00	0.00	0.00	0.00					P
Lappula redowskii	0.00	30.00	0.00	0.00	0.00			P		P
Phacelia crenulata	0.00	10.00	0.00	0.00	0.00		P			
TOTAL NATIVE ANN. & BIEN. FORBS	0.0	90.0	0.0	0.0	0.0	P	P	P	P	P
INTRODUCED ANNUAL & BIENNIAL FORBS										
Chenopodium album	0.00	10.00	0.00	0.00	0.00					P
Chenopodium sp.	0.00	10.00	0.00	0.00	0.00					
TOTAL INTRO. ANN. & BIEN. FORBS	0.0	20.0	0.0	0.0	0.0	---	---	---	---	P
INTRODUCED ANNUAL GRASSES										
Bromus tectorum	0.00	20.00	0.00	0.00	0.00					P
TOTAL INTRO. ANN. GRASSES	0.0	20.0	0.0	0.0	0.0	---	---	---	---	P
NATIVE PERENNIAL FORBS										
Arabis lignifera	0.00	30.00	0.00	0.00	0.00			P	P	
Asclepias asperula	0.00	10.00	0.00	0.00	0.00		P			
Aster arenosus	0.00	60.00	0.00	0.00	0.00	P	P		P	
Astragalus wingatanus	0.10	60.00	0.45	0.10	0.44	P		P		
Cryptantha sp.	0.00	10.00	0.00	0.00	0.00					
Cymopterus purpurascens	0.10	20.00	0.45	0.10	0.44	P				
Eriogonum alatum	0.00	20.00	0.00	0.00	0.00	P	P			
Eriogonum sp.	0.00	30.00	0.00	0.00	0.00	P				
Eriogonum umbellatum	0.00	20.00	0.00	0.00	0.00		P			
Euphorbia fendleri	0.00	10.00	0.00	0.00	0.00	P				
Haplopappus amerioides	0.10	10.00	0.45	0.10	0.44				1	
Haplopappus nuttallii	0.00	20.00	0.00	0.00	0.00					
Lygodesmia juncea	0.00	10.00	0.00	0.00	0.00					P
Mirabilis multiflora	0.00	10.00	0.00	0.00	0.00		P			
Pedicularis centranthera	0.00	50.00	0.00	0.00	0.00	P			P	P
Penstemon barbatus	0.00	20.00	0.00	0.00	0.00				P	
Penstemon eatoni	0.00	20.00	0.00	0.00	0.00	P				
Penstemon linarioides	0.00	70.00	0.00	0.00	0.00	P		P	P	
Psilostrophe sparsiflora	0.00	10.00	0.00	0.00	0.00					
Solidago petradoria	0.00	10.00	0.00	0.00	0.00					
Sphaeralcea coccinea	0.00	10.00	0.00	0.00	0.00		P			
Stanleya pinnata	0.00	30.00	0.00	0.00	0.00					
Streptanthus cordatus	0.00	30.00	0.00	0.00	0.00				P	P
Townsendia sp.	0.00	10.00	0.00	0.00	0.00					
TOTAL NATIVE PERENNIAL FORBS	0.3	100.0	1.4	0.3	1.3	P	P	P	1	P
NATIVE PERENNIAL GRASSES (cool)										
Carex occidentalis	0.00	10.00	0.00	0.00	0.00					
Oryzopsis hymenoides	0.10	90.00	0.45	0.10	0.44	1	P	P	P	P
Poa fendleriana	0.00	40.00	0.00	0.00	0.00			P		
Sitanion longifolium	0.00	90.00	0.00	0.00	0.00		P	P	P	P
TOTAL NATIVE PERENNIAL GRASSES (c)	0.1	100.0	0.5	0.1	0.4	1	P	P	P	P
NATIVE PERENNIAL GRASSES (warm)										
Bouteloua gracilis	0.00	40.00	0.00	0.00	0.00	P		P		
Hilaria jamesii	0.00	70.00	0.00	0.00	0.00	P	P	P	P	
TOTAL NATIVE PERENNIAL GRASSES (w)	0.0	70.0	0.0	0.0	0.0	P	P	P	P	---



PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover* ----Sample Number---- 1	2	3	4	5
NATIVE SUBSHRUBS										
Eriogonum aureum	0.00	10.00	0.00	0.00	0.00					
Gutierrezia sarothrae	0.00	90.00	0.00	0.00	0.00	P	P	P	P	P
TOTAL NATIVE SUBSHRUBS	0.0	90.0	0.0	0.0	0.0	P	P	P	P	P
NATIVE SHRUBS										
Artemisia tridentata	1.00	60.00	4.55	1.30	5.78		P	4(3)		
Atriplex canescens	0.10	10.00	0.45	0.10	0.44		1			
Chrysothamnus nauseosus	0.10	10.00	0.45	0.10	0.44					
Chrysothamnus viscidiflorus	0.00	20.00	0.00	0.00	0.00		P			P
Cowania mexicana	1.30	70.00	5.91	1.40	6.22	P			1(1)	5
Ephedra viridis	0.00	50.00	0.00	0.00	0.00			P	P	
Purshia tridentata	0.00	10.00	0.00	0.00	0.00					
Shepherdia rotundifolia	0.00	10.00	0.00	0.00	0.00					
TOTAL NATIVE SHRUBS	2.5	100.0	11.4	2.9	12.9	P	1	4(3)	1(1)	5
NATIVE TREES										
Juniperus osteosperma	8.00	100.00	36.36	8.00	35.56	4	12	12	2	12
Pinus edulis	10.80	100.00	49.09	10.90	48.44	14	9	6	23	6
Quercus gambelii	0.00	10.00	0.00	0.00	0.00				P	
TOTAL NATIVE TREES	18.8	100.0	85.5	18.9	84.0	18	21	18	25	18
MOSS										
Moss	0.30	40.00	1.36	0.30	1.33			1	P	
TOTAL MOSS	0.3	40.0	1.4	0.3	1.3	---	---	1	P	---
LICHEN										
Lichen	0.00	20.00	0.00	0.00	0.00				P	
TOTAL LICHEN	0.0	20.0	0.0	0.0	0.0	---	---	---	P	---
SUCCULENT										
Mammillaria sp.	0.00	10.00	0.00	0.00	0.00					
Opuntia macrorhiza	0.00	10.00	0.00	0.00	0.00					P
Opuntia polyacantha	0.00	50.00	0.00	0.00	0.00	P				P
TOTAL SUCCULENT	0.0	60.0	0.0	0.0	0.0	P	---	---	---	P
PARASITE										
Arceuthobium campylopodum	0.00	10.00	0.00	0.00	0.00					
TOTAL PARASITE	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---
Standing dead	4.30	100.00		4.30		6	2	9	4	3
Litter	12.60	100.00		12.60		5	8	19	13	6
Bare ground	47.40	100.00		47.40		53	41	48	38	54
Rock	13.70	100.00		13.70		17	27	1	18	14
TOTALS	100.0			100.5		100	100	100	100	100
TOTAL VEGETATION COVER	22.0 (s=5.8)		100.0	22.5 (s=5.9)	100.0	19	22	23(3)	27(1)	23
GROUND COVER (Litter+Rock+Veg+St.Dead	52.6			53.1		47	59	52(3)	62(1)	46
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 18.9 Std.Dev.= 5.3)						18	17	17	22	18

PLANT SPECIES	Percent Foliar Cover* ----Sample Number---- 6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS					
Chenopodium fremontii			P		
Cryptantha crassisepala		P			
Descurainia pinnata		P	P		
Descurainia richardsonii					
Draba cuneifolia					
Draba reptans		P		P	
Gilia aggregata	P	P		P	
Gilia sp.					
Lappula redowskii	P				
Phacelia crenulata					
TOTAL NATIVE ANN. & BIEN. FORBS	P	P	P	P	—
INTRODUCED ANNUAL & BIENNIAL FORBS					
Chenopodium album					
Chenopodium sp.		P			
TOTAL INTRO. ANN. & BIEN. FORBS	—	P	—	—	—
INTRODUCED ANNUAL GRASSES					
Bromus tectorum	P				
TOTAL INTRO. ANN. GRASSES	P	—	—	—	—
NATIVE PERENNIAL FORBS					
Arabis lignifera		P			
Asclepias asperula					
Aster arenosus	P			P	P
Astragalus wingatanus	1	P	P	P	
Cryptantha sp.		P			
Cymopterus purpurascens	1				
Eriogonum alatum					
Eriogonum sp.		P		P	
Eriogonum umbellatum			P		
Euphorbia fendleri					
Haplopappus armerioides					
Haplopappus nuttallii	P			P	
Lygodesmia juncea					
Mirabilis multiflora					
Pedicularis centranthera		P		P	
Penstemon barbatus				P	
Penstemon eatoni		P			
Penstemon linarioides	P	P	P	P	
Psilostrophe sparsiflora				P	
Solidago petradoria				P	
Sphaeralcea coccinea					
Stanleya pinnata	P	P			P
Streptanthus cordatus		P			
Townsendia sp.				P	
TOTAL NATIVE PERENNIAL FORBS	2	P	P	P	P
NATIVE PERENNIAL GRASSES (cool)					
Carex occidentalis		P			
Oryzopsis hymenoides	P	P	P	P	
Poa fendleriana	P	P		P	
Sitanion longifolium	P	P	P	P	P
TOTAL NATIVE PERENNIAL GRASSES (c)	P	P	P	P	P
NATIVE PERENNIAL GRASSES (warm)					
Bouteloua gracilis	P			P	
Hilaria jamesii	P		P	P	
TOTAL NATIVE PERENNIAL GRASSES (w)	P	—	P	P	—

PLANT SPECIES	Percent Foliar Cover* ---Sample Number--- 6	7	8	9	10
NATIVE SUBSHRUBS					
Eriogonum aureum				P	
Gutierrezia sarothrae	P	P	P	P	
TOTAL NATIVE SUBSHRUBS	P	P	P	P	---
NATIVE SHRUBS					
Artemisia tridentata	3	P	1	2	
Atriplex canescens					
Chrysothamnus nauseosus			1		
Chrysothamnus viscidiflorus					
Cowania mexicana	2	1	1		3
Ephedra viridis	P	P			P
Purshia tridentata					P
Shepherdia rotundifolia		P			
TOTAL NATIVE SHRUBS	5	1	3	2	3
NATIVE TREES					
Juniperus osteosperma	7	14	6	5	6
Pinus edulis	1	15	10(1)	5	19
Quercus gambelii					
TOTAL NATIVE TREES	8	29	16(1)	10	25
MOSS					
Moss	1	1			
TOTAL MOSS	1	1	---	---	---
LICHEN					
Lichen		P			
TOTAL LICHEN	---	P	---	---	---
SUCCULENT					
Mammillaria sp.				P	
Opuntia macrorhiza					
Opuntia polyacantha	P	P			P
TOTAL SUCCULENT	P	P	---	P	P
PARASITE					
Arceuthobium campylopodum	P				
TOTAL PARASITE	P	---	---	---	---
Standing dead	5	6	1	6	1
Litter	12	19	9	17	18
Bare ground	65	24	52	63	36
Rock	2	20	19	2	17
TOTALS	100	100	100	100	100
TOTAL VEGETATION COVER	16	31	19(1)	12	28
GROUND COVER (Litter+Rock+Veg+St.Dead	35	76	48(1)	37	64
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 18.9, Std.Dev.= 5.3)	23	28	14	23	9

*P=Present within 1 m. of either side of the cover transect, but not quantitatively encountered.

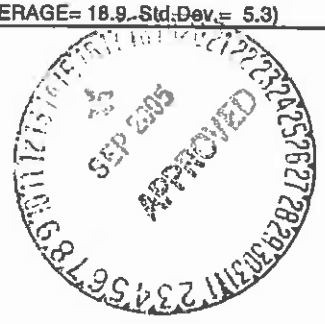


Table 2. Woody Plant Density Data - N9 Pinyon-Juniper Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

PLANT SPECIES	AVERAGE DENSITY (per 200 sq.m.)	DENSITY (per acre)	FREQUENCY (%)	Shrubs per 200 sq.m. ----Sample Number---- 1	2	3	4	5	6	7	8	9	10
NATIVE SUBSHRUBS													
Chrysothamnus depressus	0.90	18.21	10.00										
Gutierrezia sarothrae	16.30	329.83	100.00	7	1	16	23	1	92	5	1	9 16	1
TOTAL NATIVE SUBSHRUBS	17.2	348.0	100.0	7	1	16	23	1	92	5	1	25	1
NATIVE SHRUBS													
Artemisia tridentata	11.90	240.80	70.00	19	5	34			37	1	5	18	
Atriplex canescens	0.30	6.07	10.00		3								
Chrysothamnus viscidiflorus	11.20	226.63	20.00		77			35					
Cowania mexicana	3.00	60.71	40.00		1		6	3					20
Ephedra viridis	0.50	10.12	20.00			4				1			
Purshia tridentata	0.20	4.05	20.00				1						1
Shepherdia rotundifolia	0.10	2.02	10.00							1			
TOTAL NATIVE SHRUBS	27.2	550.4	100.0	19	86	38	7	38	37	3	5	18	21
NATIVE TREES													
Juniperus osteosperma	3.80	76.89	100.00	4	5	4	1	2	4	6	3	7	2
Pinus edulis	9.60	194.26	100.00	7	2	8	11	5	7	17	14	17	8
Quercus gambelii	0.20	4.05	10.00							2			
TOTAL NATIVE TREES	13.6	275.2	100.0	11	7	12	12	7	11	25	17	24	10
TOTAL DENSITY	58.0	1,173.6		37	94	66	42	46	140	33	23	67	32
Standard Deviation	36	724.4											
SPECIES DENSITY (# of species/200 sq.m.) (AVERAGE= 5.1 Std.Dev.= 1.1)				4	7	5	5	5	4	7	4	5	5

Table 3. Cover and Woody Plant Density Data Summary, N9 Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

AREA	TOTAL FOLIAR COVER (%)	STANDING DEAD (%)	LITTER (%)	ROCK (%)	SOIL (%)	WOODY PLANT DENSITY (shrubs/acre)
N12/N99 SAGEBRUSH NORTH/SOUTH*	13.8	15.2	21	3.2	46.8	7,195.6
N9 PINYON-JUNIPER	22.0	4.3	12.6	13.7	47.4	1,173.6
N7/8 SAGEBRUSH REFERENCE AREA**	12.2	9.6	12.4	14.6	51.3	N/C

* Summary data from N99 North/South baseline study (spring 2003)
** Summary data from spring 2003 annual vegetation monitoring, Black Mesa Complex
N/C = No data collected

Table 4. Relative Vegetation Cover by Lifeform Data Summary, N9 Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

RELATIVE VEGETATION COVER - ALL HITS (%)

		INTRODUCED						NATIVE									
AREA	TOTAL*	TOTAL INTRO. SP.	FORBS ANNUAL+	FORBS PERENN.	GRASSES ANNUAL	GRASSES PERENN. (C)	SUB-SHRUB	TOTAL NATIVE SP.	FORBS ANNUAL+	FORBS PERENN.	GRASSES ANNUAL+	GRASSES PERENN. (C)	GRASSES PERENN. (W)	SUB-SHRUB	SHRUBS	TREES	OTHER**
N9 PINYON-JUNIPER	99.9	0.0	0.0	0.0	0.0	0.0	0.0	99.9	0.0	1.3	0.0	0.4	0.0	0.0	12.9	84.0	1.3

*May sum to 100.0 plus or minus 0.2 due to rounding errors.
** Other includes Lower plants (mosses, lichens, parasites), succulents, and agavoids.
+ANNUAL category includes biennials.

Table 5. Species Density Data Summary, N9 Baseline Study Area, Black Mesa Mining Complex, PWCC. AZ - 2003

		---------INTRODUCED---------						----------NATIVE----------									
AREA	TOTAL*	TOTAL INTRO. SP.	---FORBS--- ANNUAL+	PERENN.	---GRASSES--- ANNUAL	PERENN.	(C) SHRUBS	TOTAL NATIVE SP.	---FORBS--- ANNUAL+	PERENN.	------GRASSES------ ANNUAL+	PERENN. (C)	PERENN. (W) SHRUBS	SUB SHRUBS	TREES	OTHER**
N9 PINYON-JUNIPER	18.9	0.4	0.2	0.0	0.2	0.0	0.0	18.5	2.4	5.8	0.0	2.3	1.1	1.0	2.4	2.1	1.4

Species density is in average # of species per $100m^2$

* Due to rounding errors, table values may not exactly match this value.
** Lower plants (mosses, lichens, parasites), succulents, and agavoids.
+ANNUAL category includes biennials.

APPENDIX 2

Species Presence for the N9 Baseline Study Area and Adjacent Areas

Table 6. Species Presence for the N9 Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

SPECIES	COMMON NAME	SYNONYM	N12/N99 NORTH/SOUTH SAGE*	N9 PJUN	N7/8 Sage Ref. Area**
NATIVE ANNUAL & BIENNIAL FORBS					
Arenaria hookeri	Hooker sandwort				
Aster canescens	hoary tansyaster	Machaeranthera canescens	X		X
Chenopodium fremontii	Fremont goosefoot			X	X
Chenopodium leptophyllum	narrowleaf goosefoot		X		
Cryptantha crassisepala	cryptantha			X	
Descurainia pinnata	pinnate tansy-mustard		X	X	X
Descurainia richardsonii	Richardson tansy-mustard			X	
Draba cuneifolia	whitlowgrass			X	
Draba reptans	whitlowwort			X	
Gilia aggregata	skyrocket gilia			X	
Gilia pumila	gilia	Ipomopsis pumila			X
Gilia sinuata	floccose gilia	G. inconspicua	X		X
Gilia sp.	gilia			X	
Lappula redowskii	bluebur stickseed		X	X	X
Phacelia crenulata	phacelia			X	X
INTRODUCED ANNUAL & BIENNIAL FORBS					
Chenopodium album	common lambsquarter			X	
Chenopodium sp.	goosefoot			X	
Euphorbia sp.	spurge				X
Sisymbrium altissimum	tumble mustard		X		X
NATIVE ANNUAL GRASSES					
Festuca octoflora	six-weeks fescue				X
INTRODUCED ANNUAL GRASSES					
Bromus tectorum	cheatgrass			X	X
NATIVE PERENNIAL FORBS					
Allium textile	prairie onion				X
Arabis lignifera	woody rockcress			X	
Asclepias asperula	creeping milkweed			X	X
Aster arenosus	white aster	Leucelene ericoides	X	X	X
Astragalus sp.	milkvetch				X
Astragalus wingatanus	Fort Wingate milkvetch			X	X
Bahia oppositifolia	Plains bahia	Picradenlopsis oppositifolia	X		
Calochortus nuttallii	sego lily		X		X
Cryptantha sp.	cryptantha			X	
Cymopterus purpurascens	spring parsley			X	X
Cymopterus purpureus	purple wafer-parsnip				X
Delphinium scaposum	barestem larkspur				X
Eriogonum alatum	winged eriogonum			X	
Eriogonum sp.	wild buckwheat			X	

Table 6. Species Presence for the N9 Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

SPECIES	COMMON NAME	SYNONYM	N12/N99 NORTH/SOUTH SAGE*	N9 PJUN	N7/8 Sage Ref. Area**
NATIVE PERENNIAL FORBS (cont)					
Eriogonum umbellatum	sulfur wild buckwheat			X	X
Euphorbia fendleri	Fendler spurge			X	X
Haplopappus armerioides	thrifty goldenweed			X	
Haplopappus nuttallii	Nuttall goldenweed			X	
Lesquerella intermedia	bladderpod				X
Leucelene ericoides	White aster				X
Lygodesmia juncea	skeletonweed			X	
Mirabilis multiflora	colorado four o'clock			X	
Pedicularis centrantherum	wood betony			X	
Penstemon barbatus	beardlip penstemon			X	
Penstemon eatoni	Eaton penstemon			X	
Penstemon linarioides	mat penstemon			X	
Phlox longifolia	longleaf phlox		X		X
Physaria acutifolia	twinpod				X
Psilostrophe sparsiflora	greenstem paperflower			X	
Solidago petradoria	rock goldenrod	Petradoria pumila		X	X
Sphaeralcea coccinea	scarlet globemallow		X	X	X
Stanleya pinnata	desert plume			X	
Streptanthus cordatus	twistflower			X	
Townsendia sp.	townsendia			X	
INTRODUCED PERENNIAL FORBS					
Corydalis aurea	scrambled eggs		X		
NATIVE PERENNIAL GRASSES (cool)					
Agropyron smithii	Western wheatgrass		X		X
Carex occidentalis	Western sedge			X	
Oryzopsis hymenoides	Indian ricegrass		X	X	X
Poa fendleriana	mutton grass			X	X
Sitanion jubatum	big squirreltail				X
Sitanion longifolium	bottlebrush squirreltail	Sitanion hystrix	X	X	X
Stipa comata	needle-and-thread grass				X
INTRODUCED PERENNIAL GRASSES (cool)					
Poa compressa	Canada bluegrass		X		
NATIVE PERENNIAL GRASSES (warm)					
Bouteloua gracilis	blue grama		X	X	X
Hilaria jamesii	galleta		X	X	X
Sporobolus airoides	alkali sacaton				
Sporobolus cryptandrus	sand dropseed		X		

Table 6. Species Presence for the N9 Baseline Study Area, Black Mesa Mining Complex, PWCC, AZ - 2003

SPECIES	COMMON NAME	SYNONYM	N12/N99 NORTH/SOUTH SAGE*	N9 PJUN	N7/8 Sage Ref. Area**
NATIVE SUBSHRUBS					
Artemisia frigida	fringed sagewort		X		
Ceratoides lanata	winterfat	Eurotia lanata	X		X
Chrysothamnus greenei	Greene rabbitbrush		X		X
Eriogonum aureum	golden wild buckwheat	E. microthecum		X	
Eurotia lanata	winterfat	Ceratoides lanata	X		
Gutierrezia sarothrae	broom snakeweed		X	X	X
NATIVE SHRUBS					
Artemisia tridentata	big sagebrush		X	X	X
Atriplex canescens	four-wing saltbush		X	X	X
Atriplex confertifolia	shadscale saltbush				
Chrysothamnus nauseosus	rubber rabbitbrush		X	X	
Chrysothamnus viscidiflorus	sticky-leaved rabbitbrush		X	X	X
Cowania mexicana	cliff rose	Purshia stansburiana		X	
Ephedra viridis	mountain joint-fir			X	X
Lycium pallidum	rabbitthorn				X
Purshia tridentata	antelope bitterbrush			X	
Shepherdia rotundifolia	roundleaf buffaloberry			X	
INTRODUCED SHRUBS					
Tamarix pentandra	saltcedar		X		
NATIVE TREES					
Juniperus osteosperma	Utah juniper			X	X
Pinus edulis	Colorado pinyon		X	X	X
Quercus gambelii	Gambel oak			X	
MOSSES					
Moss	moss		X	X	X
LICHENS					
Lichen	lichen			X	
Parmelia chlorochroa	lichen	Xanthoparmelia chlorochroa	X		
SUCCULENTS					
Mammillaria sp.	pincushion cactus			X	
Opuntia macrorhiza	thickroot pricklypear		X	X	
Opuntia polyacantha	plains pricklypear			X	X
Opuntia whipplei	whipple cholla				X
Sclerocactus parviflorus	barrel cactus				X
PARASITES					
Arceuthobium campylopodum	dwarf mistletoe			X	

APPENDIX 3

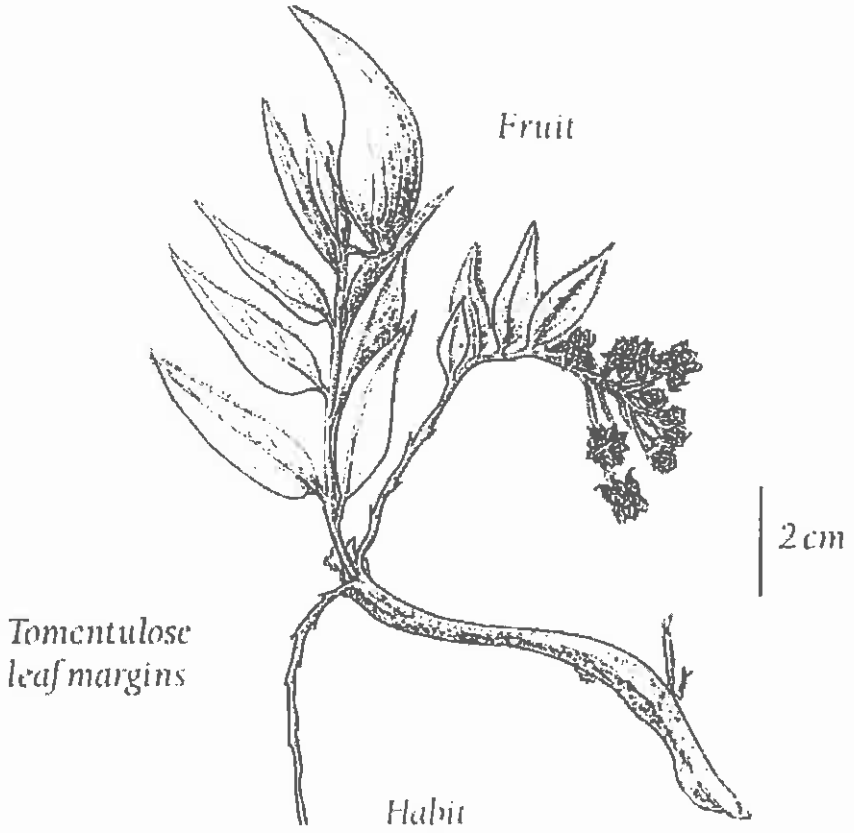
Black Mesa Mining Complex
Field Guide
To
Potentially Occurring Rare Plants
2003

Black Mesa Mining Complex
Rare Plant Field Guide
2003

Table of Contents

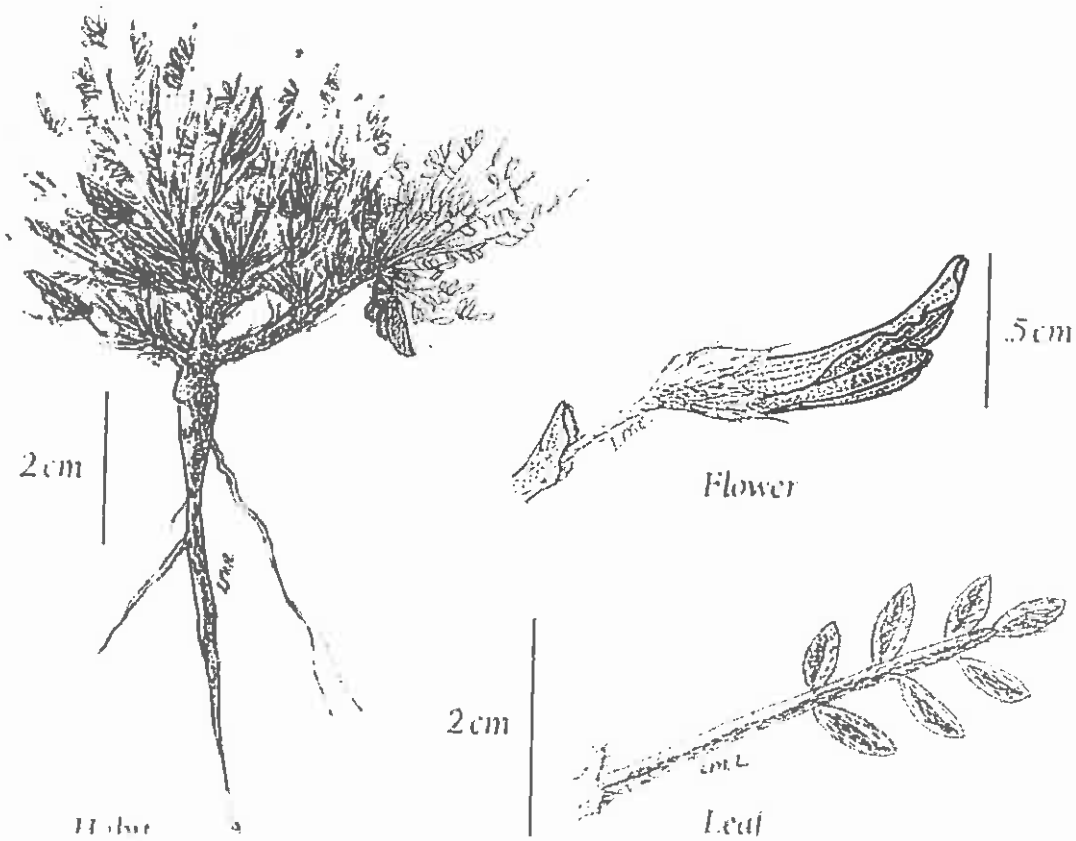
PINYON-JUNIPER WOODLAND SPECIES

***Asclepias sanjuanensis* – San Juan Milkweed**
Family: Asclepiadaceae
Synonyms: *A. unicialis* **var.** *ruthiae* **(debated)**
Status: Federal, 3B; NN, G4



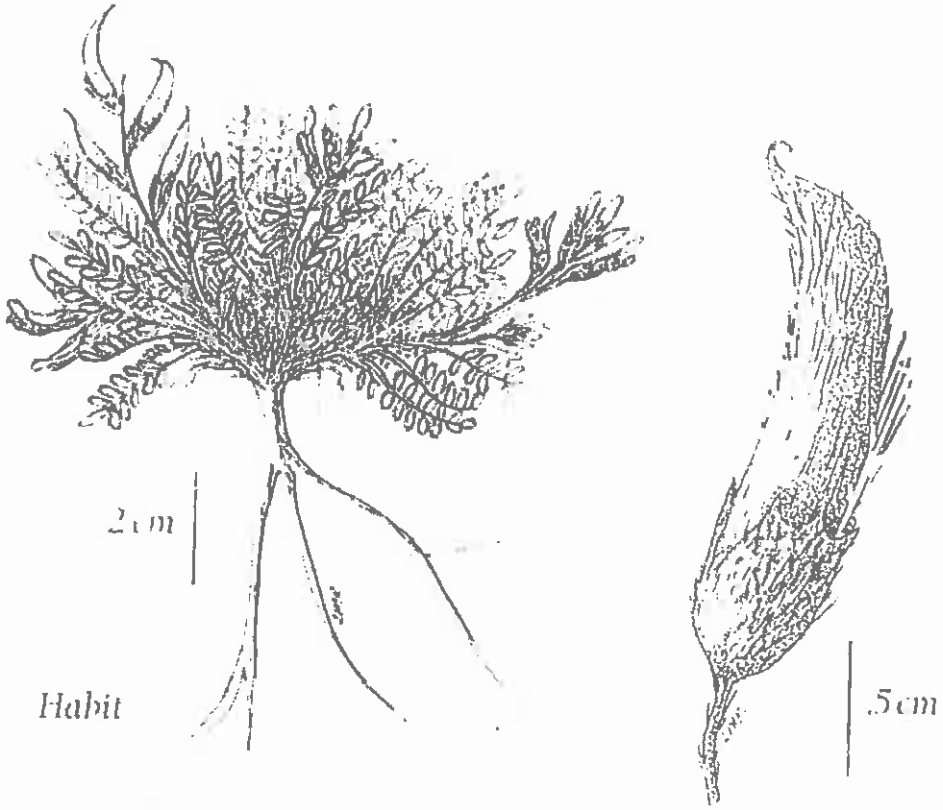
Distinguishing characteristics
Milky white latex in stems and leaves; 2-7 branches, the auricles of the hood are erect, herbage pubescence is sparse, leaf shape lanceolate to broadly lanceolate.
Stems: woody taproot, 4-8 cm tall, prostrate to ascending
Leaves: 2-4 cm long, oblong-lanceolate, white tomentulose on leaf margins
Flower: inflorescence terminal; corolla reddish-violet; follicle 1/8-1/4 inch **long**
Blooms: Late April-early May
Lookalikes: *A. ruthiae* usu. has **one branch, auricles of the hood not erect, herbage pubescence is dense, leaf shape** broadly **ovate to broadly lanceolate.**
Habitat: grows on sandy benches **and hills near the Chaco River, NM in pinyon-juniper woodland and Great Basin grassland communities**

Astragalus humillimus **– Mancos milkvetch**
Family: Fabaceae
Synonyms: *Tragacantha humillima, Phaca humillima*
Status: Federal, LE; NN, G2



Distinguishing Characteristics:
Tufted perennial **forming** clumps up to 30 cm across
Stems: only Astragalus in the area with persistent spiny leaf petioles, up to 1 cm long.
Pod: spreading, egg shaped, ellipsoid, 4.5 mm long, 2 mm wide
Leaves: crowded, up to 4 cm long, 7-11 oval leaflets, 0.7-2 mm long
Flower: branches short, 1-3 flowers, petals lavender to purplish, conspicuous lighter colored spot in the throat of the corolla tube; banner 7-10 mm long; keel and banner petal 6-8 mm long; calyx, 3mm long
Phenology: flowers late april to early may, fruits june to early july.
Lookalikes: *A. deterior* and *A. calycosus* var. *scaposus* have flaccid leaf petioles and longer, oblong, or narrowly ellipsoid pods. *A. micromerius* doesn't have persistent spiny leaf stalks.
Habitat: ledges and mesa tops in slickrock communities / pinyon-juniper woodlands of the Mesa Verde Group, often in cracks in the sandstone substrate or in shallow pockets of sandy soil. 5,000-5,850 ft in elevation.

Astragalus naturitensis – Naturita milkvetch
Family: Fabaceae
Synonyms: *A. arientinus* var. *stipularis*
Status: Federal, 3C (more abundant than prev. thought); NN, G4

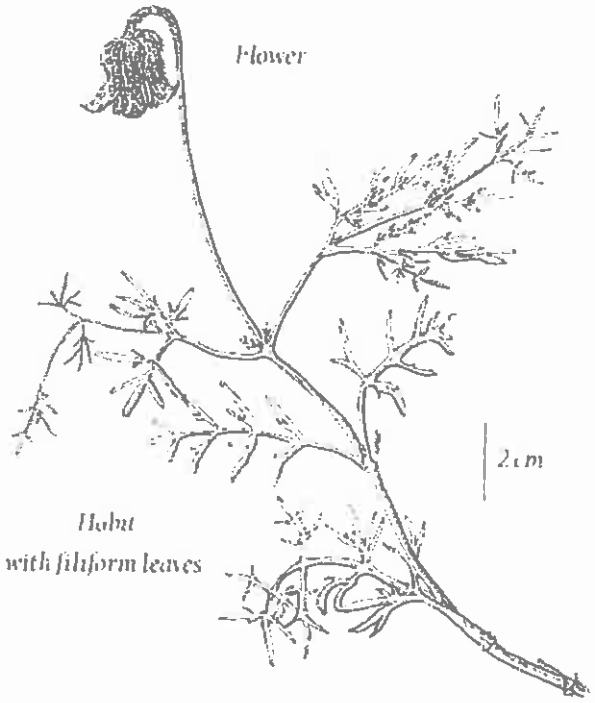


Distinguishing Characteristics:
Low growing, miniature spreading perennial about 10 cm tall
Stems: ascending, 2-6 cm long
Calyx: 4-8 mm, cylindrical, mixed white and black pubescent, lobes 1-1.5 mm
Pod: leathery, less than 2 cm long, more than twice as long as wide, widely spreading, covered with short, stiff, flat-lying hairs, straight except for beak, usually red mottled.
Leaves: basal, pinnate with 9-15 leaflets, leaves 2-7 mm, clustered, obovate to elliptic, mostly folded, often glabrate above, stipules free
Peduncles: scapose, 2-7 cm, with 4-9 subcapitate or briefly racemose ascending flowers
Flowers: 10-15 mm long, banner white, keel purple spotted, and wings reddish purple or purple tipped
Blooms: April to early June / Fruits: late May to June

Lookalikes: *A. deterior* has yellow-white flowers, *A. desperatus* has smaller flowers and loosely hirsute pods of broader and shorter outline, *A. monumentalis* var. *cottamii* has firm-walled, dorsiventrally shorter outline, *A. humillimus* has persistent, spiny racheses.
Habitat: Sandstone mesas, ledges, crevices and slopes in pinyon-juniper woodlands. 5,000-7,000 ft in elevation.

***Clematis hirsutissima* var. *arizonica* – Arizona leather flower**
Family: Ranunculaceae
Synonym: *Clematis hirsutissima* var. *hirsutissima*
Status: Federal, none, NN, G4

Distinguishing characteristics
Herbaceous perennial, 20-70 cm high
Fruit: head of achenes, each bearing a 4-6 cm plumose style
Flowers: nodding, solitary at the end of ea. Stem, 2-4 cm long
No petals, but w/ 4, thick purplish sepals, numerous stamens and pistils
Stems: erect from a somewhat woody base, ~5 cm to 1st branch
Leaves: pubescent to nearly glabrous, pinnately compound w/ 7-13 leaflets, these divisions narrowly linear, usually 1-2 mm, but rarely up to 12 mm

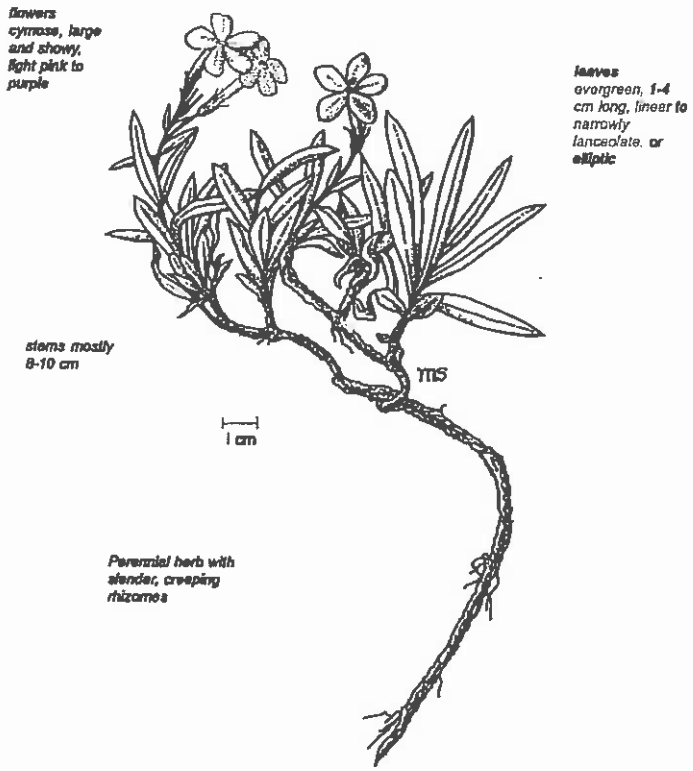


CLEMATIS HIRSUTISSIMA Pursh
var. ARIZONICA (Heller) Erickson
Ann. Missouri Bot. Gard. 30: 48. 1943.

Blooms: Late April to June, Fruits July to August

Lookalikes: other *Clematis* are vine forming
Habitat: moist mountain meadows, prairies, and open woods and thickets usually in limestone soils of ponderosa pine and mixed conifer forests, 6,800 to 9,000 ft

Phlox cluteana – Navajo Mountain Phlox
Family: Polemoniaceae (Phlox family)
Status: NN Natural Heritage Program Element Tracking List



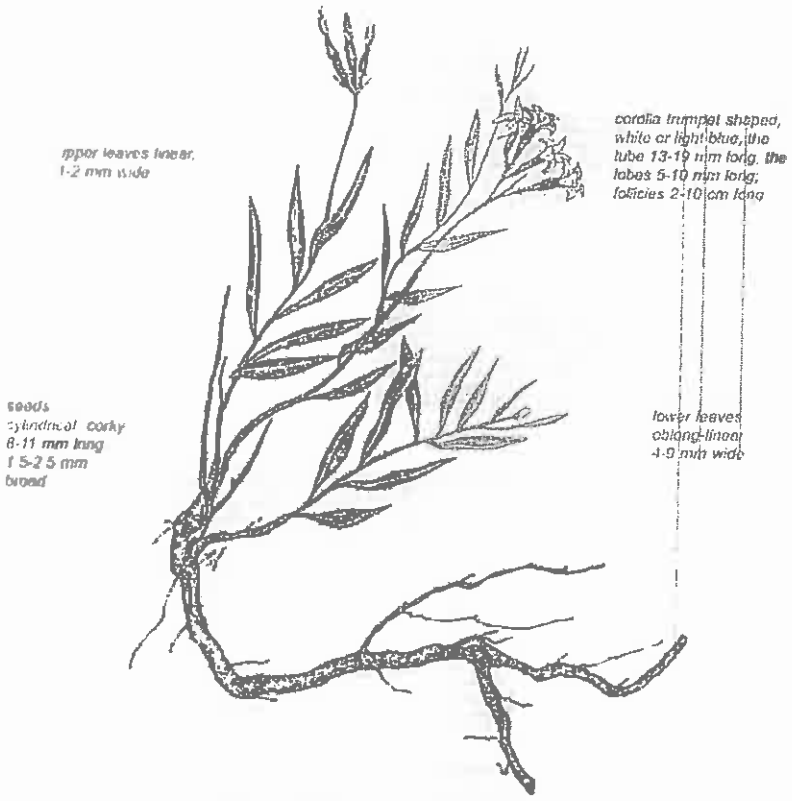
Polemoniaceae (Phlox Family)

Distinguishing characteristics
Plants with stems single or more/less clumped from subterranean, many-headed, subrhizomatous caudices. 4-12 cm tall
Stems: 8-10 cmm tall, sparsely to densely glandular pubescent
Leaves: 1-4 cm long, elliptic to linear, lanceolate, or oblanceolate, glabrous or ciliate or pubescent (like the stem) 2-5 mm wide
Flowers: cymose, large and showy, on pedicels 3-15 mm long, alone or 2 to several in terminal cymes; calyx: 7-9 mm long, intercostally flat; corolla tube: 14-18 mm long; lobes 7-10 mm long and nearly as wide, pink to lavender or white; stamens included or slightly exserted; style 9-14 mm long
Rhizomes: long, slender, terminating in clusters of evergreen leaves

Lookalikes: *P. longifolia* and *P. amabilis* has taproots and deciduous leaves
Habitat: Light to heavy shade under ponderosa pine, gambel oak, or pinyon and juniper in sandy soils with leaf litter; 6,400-10,400 ft

SHRUBLAND SPECIES

Amsonia peeblesii **– Peebles blue star**
Family: Apocynaceae (Dogbane)
Status: Federal, none; NN, G4

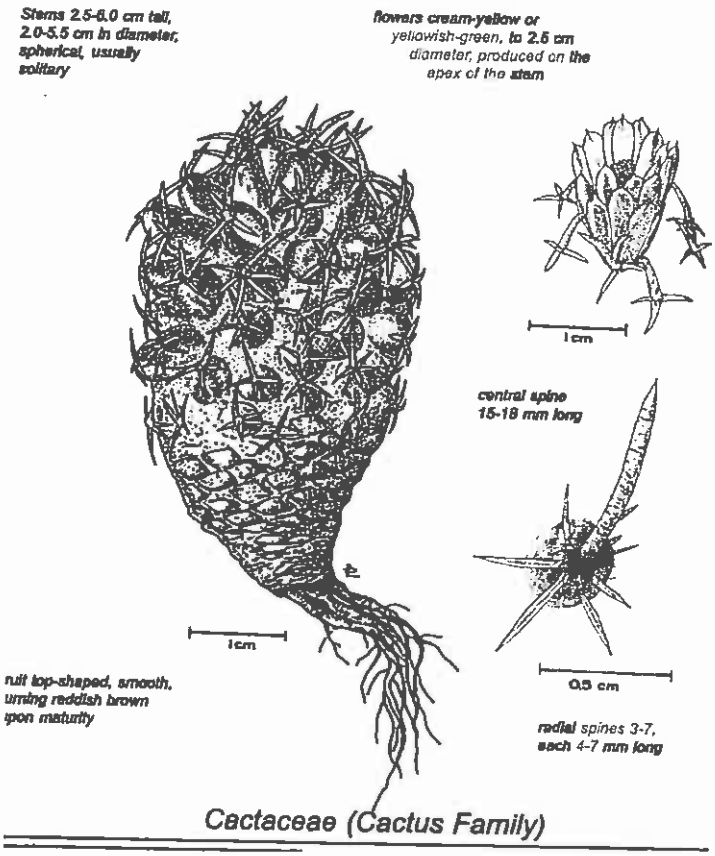


Apocynaceae (Dogbane Family)

Distinguishing Characteristics
Robust, herbaceous perennial, glabrous, 40-90 cm tall
Seeds: cylindrical, corky, **8-11**mm ling, 1.5-2.5 mm broad
Leaves: upper leaves linear, 1-2 mm wide
Lower leaves oblong-linear, 4-9 mm wide
Flower: corolla trumpet shaped, white or light blue
Tube 13-19 mm long
Lobes 5-10 mm long
Follicle 2-10 cm long
Blooms: May to June, leaves turn golden color in fall

Lookalikes: Glabrous form of *A. tomentosa* var. *stenophylla* has smaller flowers (7-12 mm long) and the follicles are moderately constricted between the seeds (*A. peeblesii* has smoothly cylindrical follicles)
Habitat: Little Colorado watershed; grows in grasslands and Great Basin desertscrub communities. Subtrate types range from strongly alkaline sedimentary conglomerates to volcanic cinders; 4,000-5,620 ft.

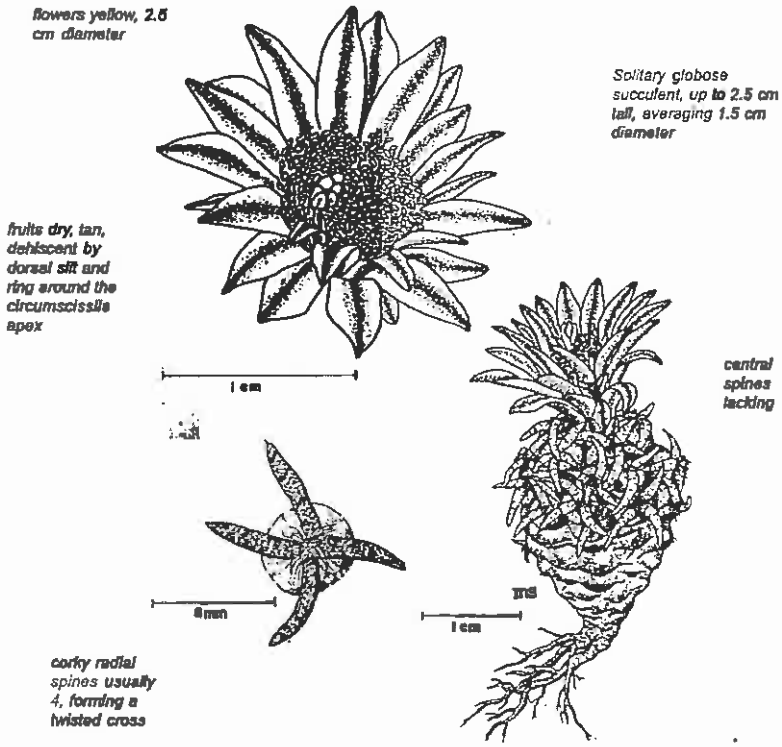
***Pediocactus peeblesianus* var. *fickeiseniae* – Fickeisen plains cactus**
Family: Cactaceae
Synonyms: *Navajoa fickeisenii, Toumeya fickeisenii*
Status: Federal, Candidate; NN, G3



Distinguishing characteristics
Pediocactus have no ribs, cylindric to globose stems, flowers <25mm in diameter, petals white or with pink or yellow at least on the midribs; fruit, dry, green, to tan/yellow, naked or scaly. *P. p. fickeiseniae* is a solitary or clustered cactus, globose to 6 cm tall and 5.5 cm in diameter
Flowers: cream-yellow or yellowish-green, to 2.5 cm diameter, produced on the apex of the stem, petaloid perianth parts cream, yellow, or yellowish-green; outer perianth parts with pink or green midstripe; stamens yellow; stigma yellow.
Tubercles: 3-7 mm long, 4-6 mm broad
Aureoles: circular
Stems: 2.5-6 cm tall, 2-5.5 cm in diameter, spherical, usu. solitary
Central spine: 15-18 mm long, spongy, white to pale gray, ascending, mostly 1 mm wide at base
Radial spines: 3-7, each 4-7 mm long, spongy, not obscuring the stem, long, white to pale gray, recurving
Fruit: top-shaped, smooth, turning reddish brown upon maturity
Blooms: April, retracts into the soil in drought

Lookalikes/Varieties: *P.p. peeblesianus* has no central spine and 4-5 radial spines. *P. simpsonii* has a smooth spine spreading at right angles to tubercles, tubercles have strait central spines, not ribbed
Habitat: gravelly limestone/gravelly loam in desertscrub; 4,300-5,450 ft.

***Pediocactus peebleslanus* var. *peebleslanus* – Navajo plains cactus**
Family: Cactaceae
Status: Federal, LE; NN, none



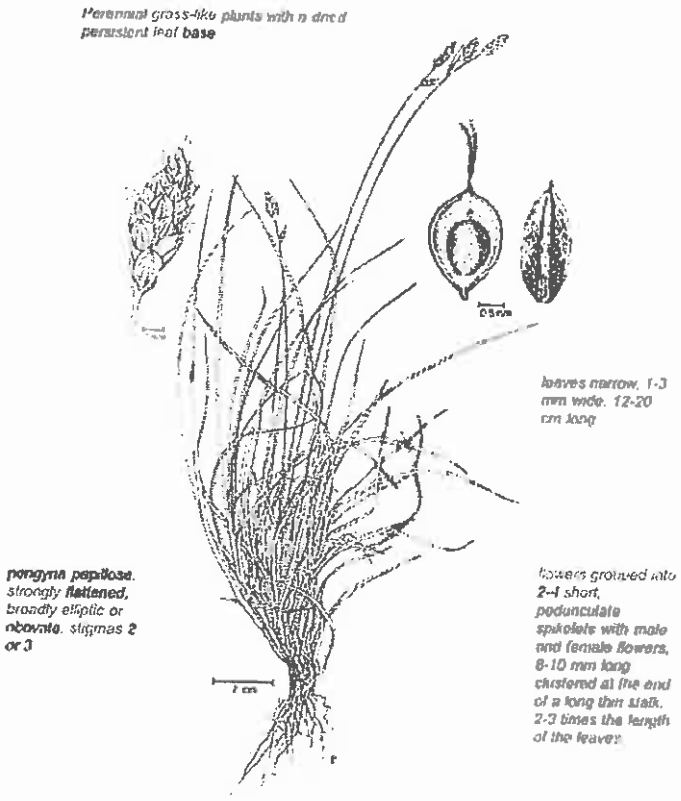
Cactaceae (Cactus Family)

Distinguishing characteristics
Solitary **globose** succulent, up to 2.5 cm tall, averaging 1.5 cm diameter
Flowers: yellow, 2.5 cm in diameter
Central spines: **lacking**
Radial spines: corky, **usu. 4, forming a twisted cross**
Fruits: dry, **tan,** dehiscent by dorsal slit and ring around the circumscissile apex
Blooms: April, **fruits May to June, retract during drought / dry**

Lookalikes/varieties: *P. p. fickeiseniae* has a prominent central spine, more radial spiines and grows larger. See above description of *P. simpsonii.*
Habitat: low hills in desertscrub and grassland; 5,100-5,650 ft.

SEEPS, STREAMS, and HANGING GARDEN SPECIES

Carex specuicola **– Navajo Sedge**
Family: Cyperaceae
Status: Federal, LT; NN, G3

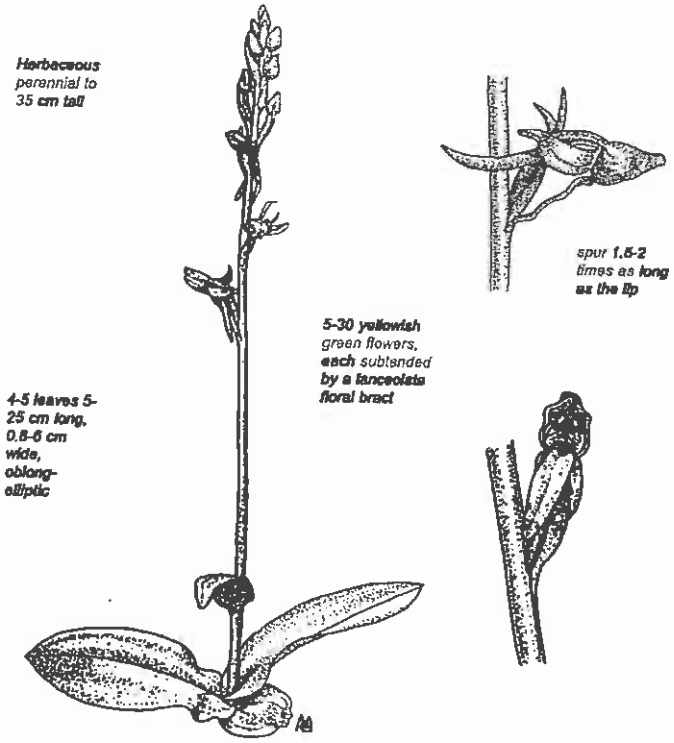


Cyperaceae (Sedge Family)

Distinguishing characteristic
Perennial grass-like plant with a dried, reddish, persistent leaf base
Styles: 2-branched with lenticular achenes and 3-branched with trigonous achenes, 2-branched style is more common
Terminal spike: usu. gynaceandrous, short peduncled or sessile
Perigynea: nerveless or finely few-nerved, strongly flattened, papillose, broadly elliptic or obovate, stigmas 2 or 3
Leaves: narrow, 1-3 mm wide, 12-20 cm long
Flowers: grouped into 2-4 short, pedunculate spikelets with male and female flowers, 8-10 mm long, clustered at the end of a long thin stalk, 2-3 times the length of the leaves. Female flowers located above male flowers
Phenology: flowering and fruit set occur from Spring to summer, most repro appears to be vegetative

Lookalikes: *C. aurea* does not have a strongly flattened perigynia or female flowers located above male flowers. *C. occidentalis* has slender, longer stems (20-70 cm); *C. geophila* has fertile stems shorter than most leaves, leaf blades 5-15 cm long (shorter)
Habitat: N. AZ, seeps and hanging gardens, on vertical Navajo sandstone cliffs and alcoves; 4,400-7,000 ft.

Platanthera zothecina **– alcove bog orchid**
Family: Orchidaceae
Synonym: *Limnorchis zothecina, Habenaria zothecina*
Status: Federal, SC (species of concern); NN, G3

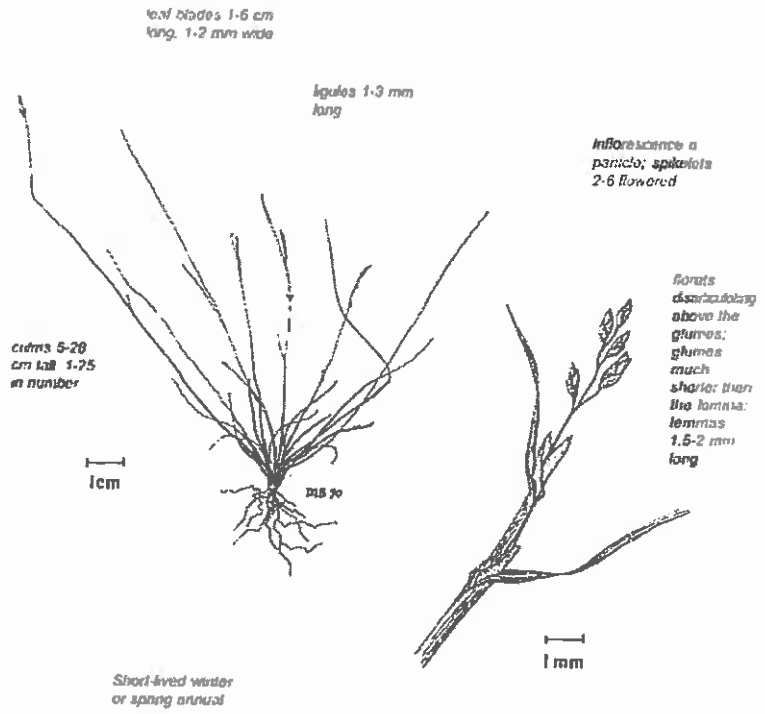


Orchidaceae (Orchid Family)

Distinguishing characteristics
Herbaceous perennial **to 35 cm tall**
Spur: **1.5-2** times **as long as the lip**
Inflorescence: **5-30** yellowish **green flowers, each subtended** by **a lanceolate floral bract**
Leaves: 4-5 leaves, 5-25 **cm long, 0.8-6 cm wide,** oblong-elliptic, **appear late April to early May**
Spike: **develops in early June**
Flowers: **corolla tube, yellowish-green**
Blooms: mid June-July
Capsules: mature in about **one month**

Lookalikes: *P. sparsiflora* has spur equal or slightly exceeding lip, less rounded basal leaves, and a less elliptic lip
Habitat: **seeps, streams, hanging gardens and wet canyon alcoves,** 5,000-9,000 ft. **requires constant moisture, full to partial sun**

Puccinellia parishii **– Parish's alkali grass**
Family: Poaceae
Status: Federal, SC; NN, G2

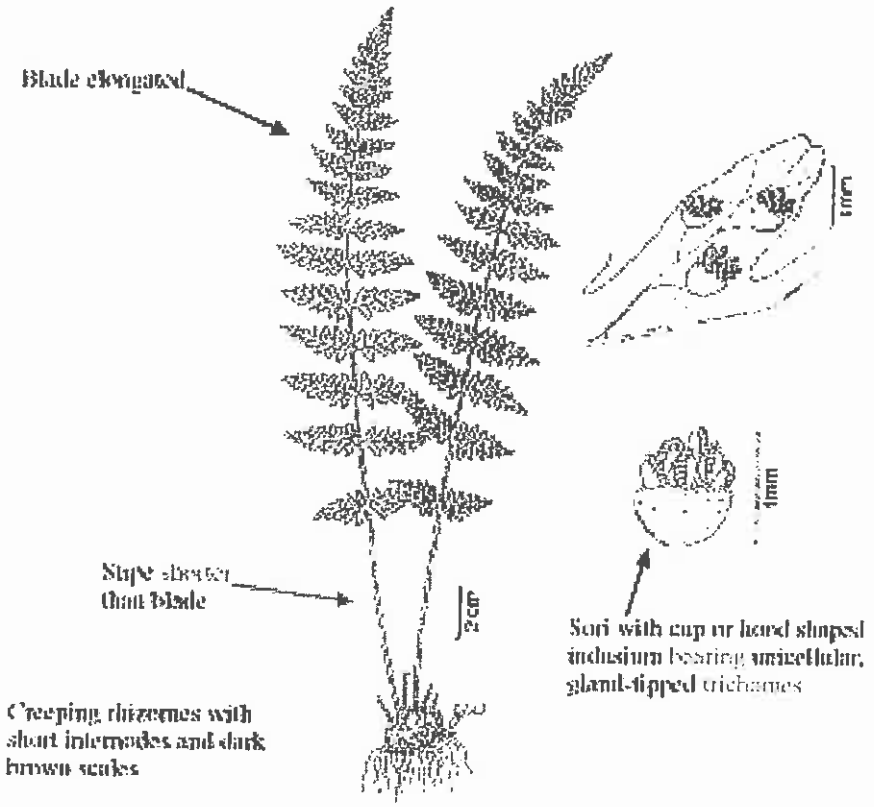


Poaceae (Grass Family)

Distinguishing characteristics
winter or spring annual dwarf **grass, 5-28 cm tall**
Leaves: blades **1-6 cm** long, **1-2 mm wide; flat to slightly involute**
Ligules: 1-3 mm long
Inflorescence: narrow panicle; **spikelets 2-6 flowered, 3-5 mm long**
Florets: disarticulating **above the glumes**
Glumes: much shorter than the lemma, unequal, broad, strongly nerved, scarious margined
Lemma: 1.5-2 mm long, pubescent on nerves only, firm, obtuse
Culms: 5-28 cm tall; 1-25 in number
Flowers: April to May and June to September

Lookalikes: ***P. fasciculata*** **and** ***P. airoides*****. Both perennial; if** hairy, **hairs not confined to nerves of lemma;** ***P. fasiculata*** **is 20-50 cm tall (on** average, **taller);** *P. airoides* **is 15-80 cm tall (also taller, on average);** ***Poa annua*** **has boat** shaped leaves
Habitat: Marhsy ground along **seeps and** streams, **saline or alkaline soil forming a white crust on the ground; assoc with** pinyon-juniper **woodlands to desert communities, 2,950-6,070 ft.**

Cystopteris utahensis **– Utah bladder-fern**
Family: Polypodiaceae
Status: Federal, none; NN, G4



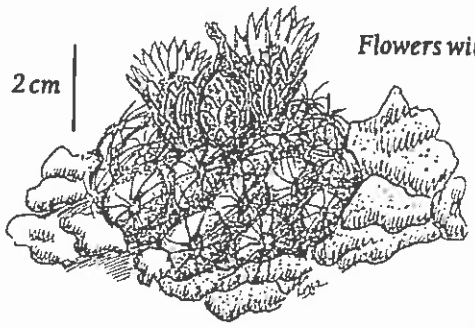
Ill. by Janet Wingate

Distinguishing characteristics
Stems: creeping, not cordlike, internodes short, heavily beset with old petiole bases, hairs absent; scales lanceolate
Fronds: monomorphic, clustered at stem apex, to 45 cm, nearly all bearing sori.
Petiole: green to straw colored; blade deltate, 2 pinnate-pinnatifid, usually widest at or near the base, apex short-attenuate, rachis and costae with unicellular, gland-tipped hairs
Phenology: sporulating summer to fall

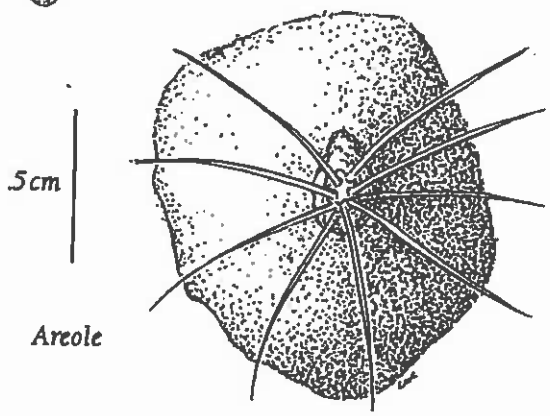
Lookalikes: *C. fragilis* does not have small glands and scaly bulblets near the tip of the frond, as wells as dark scales on the underground stem made up of cells with very thick walls
Habitat: seepages, crack, and ledges on cliffs; on calcareous substrates including sandstone, limestone, and dacite. On the NN, know from sandstone cracks above the streambed. 4,200-8,800 ft.

BOTH SHRUBLAND AND PINYON-JUNIPER WOODLAND

Sclerocactus mesae-verdae **– Mesa Vede cactus**
Family: Cactaceae
Synonyms: *Coloradoa mesae-verdae, Echinocactus mesae-verdae, Pediocactus mesae-verdae*
Status: Federal, LT; NN, G3



Habit



SCLEROCACTUS MESAE-VERDAE
(Boissevain *ex* Hill & Salisbury) L. Benson
Cact. and Succ. Jour. 38: 54. 1966.

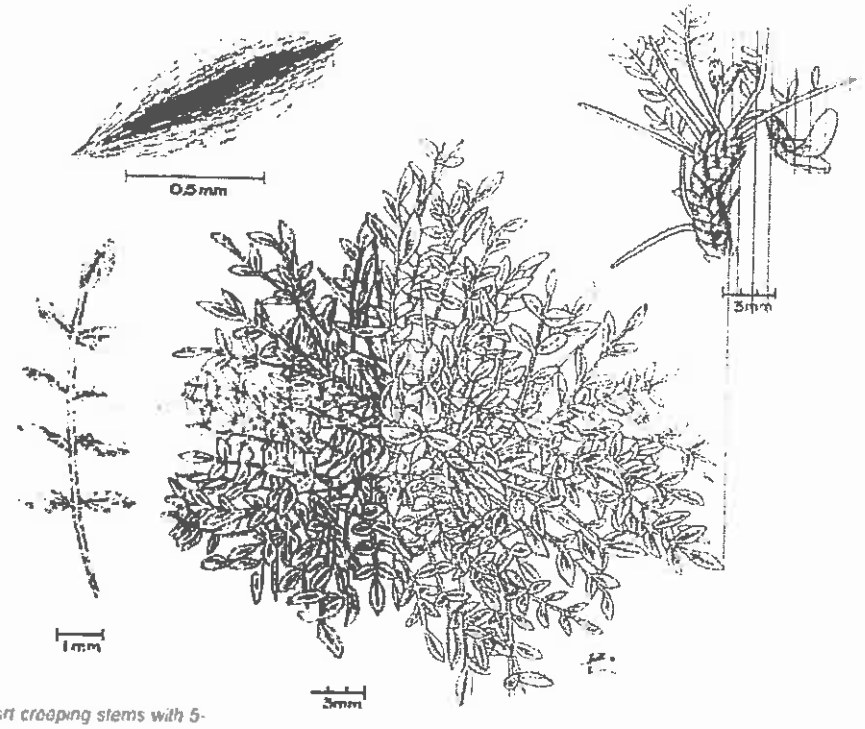
Distinguishing characteristics
Sclerocactus is subglobose, depressed-**hemispheric, ovoid, obovoid, or** cylindroid; **ribs 8-17; one or more of lower central spines usu** strongly **hooked.** ***S. mesae-verdae*** **is-** 2 cm tall, **above ground**
Areole: 0.5 cm diamter
Stems: mostly solitary, sometimes in clusters, 3-11 cm tall, oval to depressed-globose
Central spines: none or rarely 1
Radial spines: 8-10
Flowers: cream to pink, born below but adjacent to apex of the stem
Fruit: green turning tan; oblong
Blooms: late April to early May

Lookalikes: *S. parviflorus* **usu. has 4 central** spines, **green cylindroidal to elongate cylindroidal stems.** *S. whipplei* **is taller (stems 10-25 cm** tall), **has 1-3 or more central spines, 3-5 cm long, 1-3 or more** radial **spines usu obscure the stem,** 5000-6000 **ft.**
Habitat: **barren clay hills of Fruitland and Mancos shale formation**

SPECIES VERY UNLIKELY TO BE SEEN

***Astragalus cremnophylax* var. *cremnophylax* Barneby – Sentry milkvetch**
Family: Fabaceae
Status: Federal, none; NN, G4

fruits unilocular obliquely egg-shaped, and hairy seeds orange

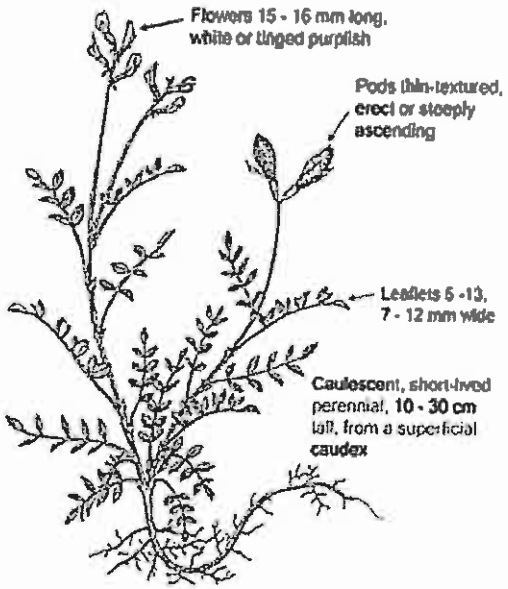


short creeping stems with 5-9 compound leaflets

Distinguishing characteristics
Dwarf, evergreen, perennial, mat forming herb, 2-25 cm in diameter
Flowers: tiny, pale pinkish-lilac, white tipped keep incurved 100-120 degrees, purple veined banner; borne on a raceme of 1-3 flowers, held slightly above the mat, less than 10mm long, immersed in leaves
Leaves: all diminutive, leaf stalk 2-5 mm, softly tipped; leaflets 3-7, leaves 3-10mm, crowded pinnate or subpalmate
Fruit: ascending, unilocular, deciduous ovoid/obliquely egg-shaped, and hairy. Seeds orange. Ovules 4-6, fruits May to June
Blooms: late April to May, rarely a 2nd flowering in fall

Lookalikes: var. *myriorrphaphis* has spinescent leaf bases; var. *hevronii* has larger flowers; and *A. calycosus* has larger leaflets and does not have unilocular fruits
Habitat: Grand Canyon NP in crevices and depressions w/shallow soils on Kaibab limestone on rim-rock benches at the canyon edge in pinyon-juniper woodland at 7,050-7,960 ft.

Astragalus cutleri **– Cutler's milkvetch**
Family: Fabaceae
Synonyms: ***Astragalus*** *preussii* var. *cutleri*
Status: Federal, LE; NN, **G3**

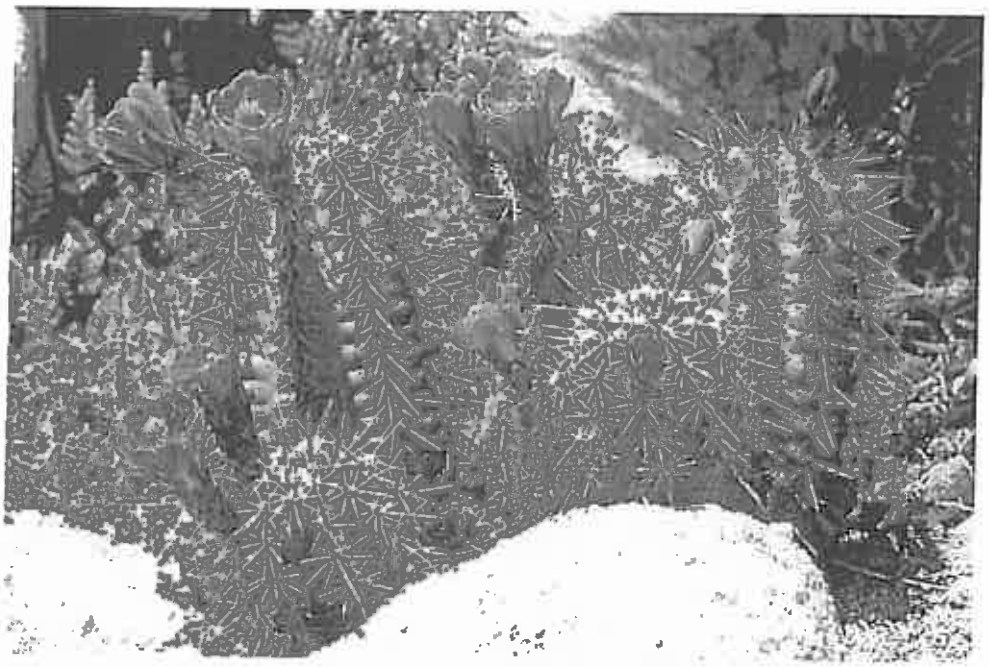


ASTRAGALUS CUTLERI

Distinguishing characteristics
Moderate, caulescent, short lived perennial, 10-35 mm long, from a woody caudex, pubescence affixed by its base
Flowers: 14-24 mm long; while or tinged or drying purplish; ascending peduncles, 2-15 cm long; racemes, 3 to 22 flowered, axis 1-20 cm long in fruit; bracts,1.5-4 mm long; pedicels,1-5.5 mm long; bracteoles, 2; calyx, 6.4-12.3mm long; tube, 5.1-9.7 mm long, cylindric, thinly strigose, purple; teeth, 1.3-2.6 mm long, subulate
Fruit: pods thin textured, often drying straw colored, erect to ascending, stipitate, or subsessile; stipe, 2-7 mm long, oblong-ellipsoid, inflated, 12-34 mm long, 6-13 mm thick, glabrous or puberulent , stiffly papery to leathery,uniloculular; ovules 20-44
Leaves: 3.5-13 cm long
Leaflets: 5-13, 7-12 mm wide, obovate to obchordate to oblong, narrrowly elliptic, lanceolate, or linear, emarginate to rounded, obtuse, or acute, glabrous
Stipule: 2-7 mm long, all distinct
Stems: few to several, erect or ascending, forming clumps
Blooms: Early spring (late April to early May?)

Lookalikes: *A. p.* var. *laxiflorus* and *A. p.* var. *preussii* have vivid purple flowers and more, narrower leaflets, and the pods dry brownish
Habitat: warm desert shrub communities on sandy, seleniferous soils with level to moderate slopes, on the Shinarump and Chinle Formations. 3,800 ft elev

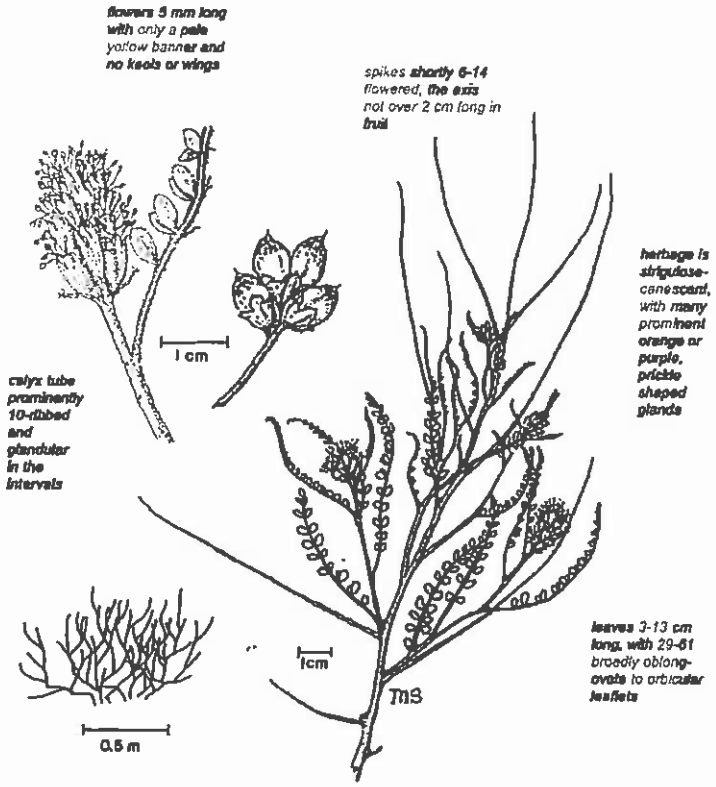
***Echinocereus triglochidiatus* var. *arizonicus* – Arizona hedgehog cactus**
Family: Cactaceae
Synonyms: *E. arizonicus var. arizonicus, E. coccineus var. arizonicus, Cereus polycanthus, Echinocereus polycanthus*
Status: Federal, LE; NN, none



Distinguishing characteristics
Plant caespitose, few branches or stems grow in clumps. As with all *Echinocereus* flowers burst through sides of stem, leaving scar on stem right above spine.
Stems: 22.5-40 cm long, 7.5-10 cm in diameter; dark green and cylindroid, usu. in clusters of 4-20 stems, occasionally exceeding 50.
Central Spines: 2-4, 2.5-40 cm long, grey or pinkish, deflexed
Radial spines: 8-10, appresed, 0.5-1 cm long, light yellow or pinkish tab, often slightly curved.
Stem ribs: +/- 7 cm long, 10 tuberculate ribs, ribbing strong
Areoles: (of mature parts of stems) white felt or cobwebby hairs; nearly circular
Flowers: stay open for 2-3 days, even at night; +/- 5 cm in diameter and +/- 7 cm long; red to crimson (as with all *E. t.*) with yellow anthers, green stigma; style 2mm in diameter
Fruit: Red, fleshy at maturity
Blooms / fruits: April to May/ May to June; germinates mid-summer

Other varieties: As opposed to other varieties, *E.t. arizonicus* has flowers on upper third of stem ribs. Spines are shorter and more robust than other *Echinocereus'*. Var. *melanacanthus* has much smaller stems (in height and width), each cluster has many (up to 500) stems. Var. *neomexicanus* has weaker ribbing, thinner central spines (0.5-1mm); central spines are not deflexed, smooth and are 4.5-7 cm long.
Habitat: open slopes of rugged steep-walled canyons, granite boulder-pile ridges and slopes in AZ desert grassland; shrubby vegetation, understory of shrubs, does not do well without extensive rock cover; 3,400-6,360 ft
Substrate: Normally found on Orthoclase-rich granite of late Cretaceous age; other parent materials in the are include volcanic tuff, mid-Tertiary age dacite and perhaps rhyolite. Schultze(?) granite, light in color.
Plant community: Interior Chaparral and Madrean Evergreen Woodland; also into desert grassland. Often with the following associated species: *Quercus turbinella, Quercus emoryi, Arcostaphylos pungens, Cercocarpus montanus, Nolina microcarpa, Dasylirion wheeleri, Agave chrysantha, Muhlenbergia emersleyi, Pinus monophylla, Juniperus erythrocarpa,* and *Rhus trilobata.*

Errazurizia rotundata **– Round dune-broom**
Family: Fabaceae
Synonym: *Paryella rotundata*
Status: Federal, none; NN, G4; State (AZ), SR

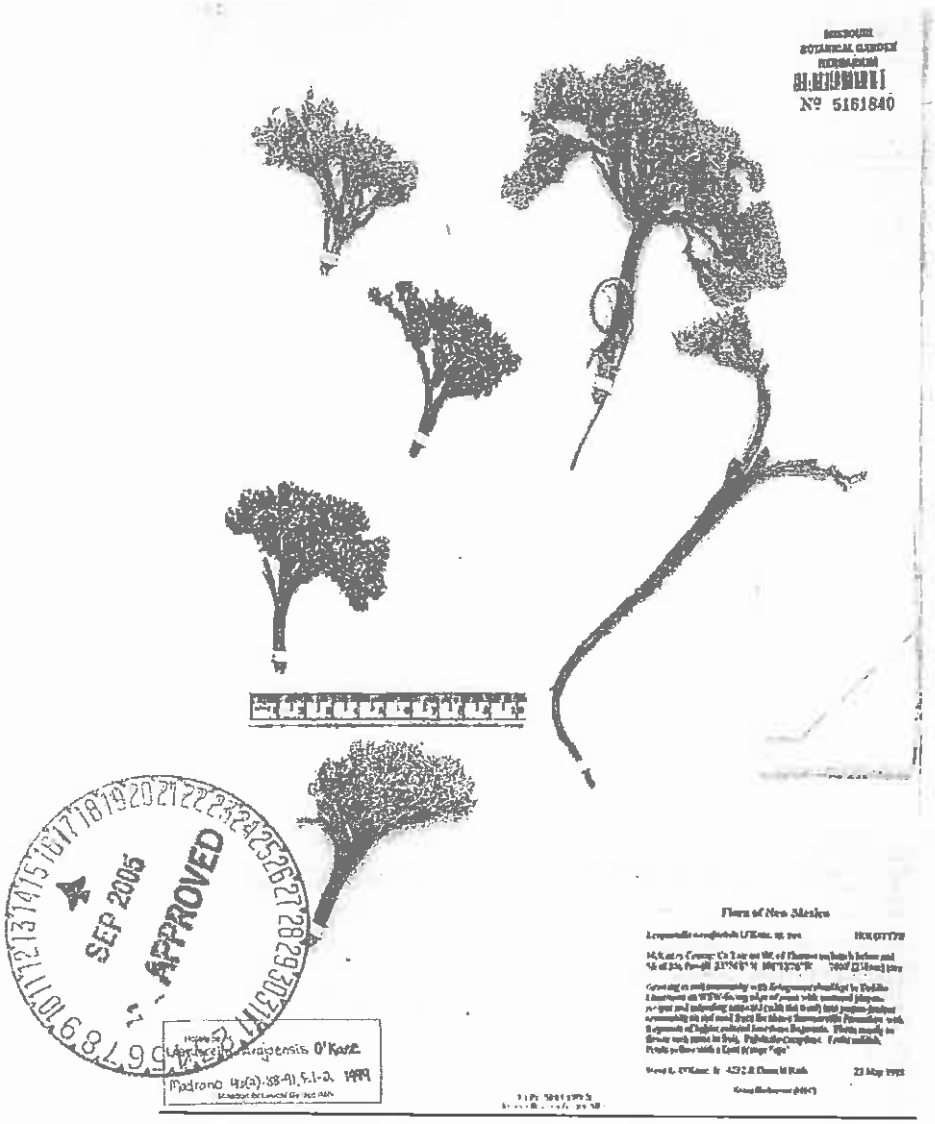


Fabaceae (Pea Family)

Distinguishing characteristics
Low, clonal, woody shrub, up **to 30 cm tall**
Flowers: 5 mm long with only **a pale yellow banner and no keels or wings**
Spikes: shortly 6-14 flowered, **the** axis **not over 2 cm long in fruit**
Herbage: strigulose-canescent, many prominent orange or purple, prickle shaped glands
Leaves: 3-13 cm long, **with 29-61 broadly** oblong-ovate **to orbicular leaflets**
Calyx: tube prominently **10-ribbed and glandular** in **the intervals**
Blooms: late April to early May

Habitat: **Little Colorado River** drainage, **exposed sites in several types of outcrops ranging from sandy soils in sandstone,** gravelly **soils in calcareous outcrops, to deep, alluvial cinders in sandstone breaks; desertscrub,** 4,800-5,200 ft.

Lesquerella navajoensis O' Kane – Navajo Bladderpod
Family: Brassicaceae
Synonyms: none
Status: Federal, none, NN, G4

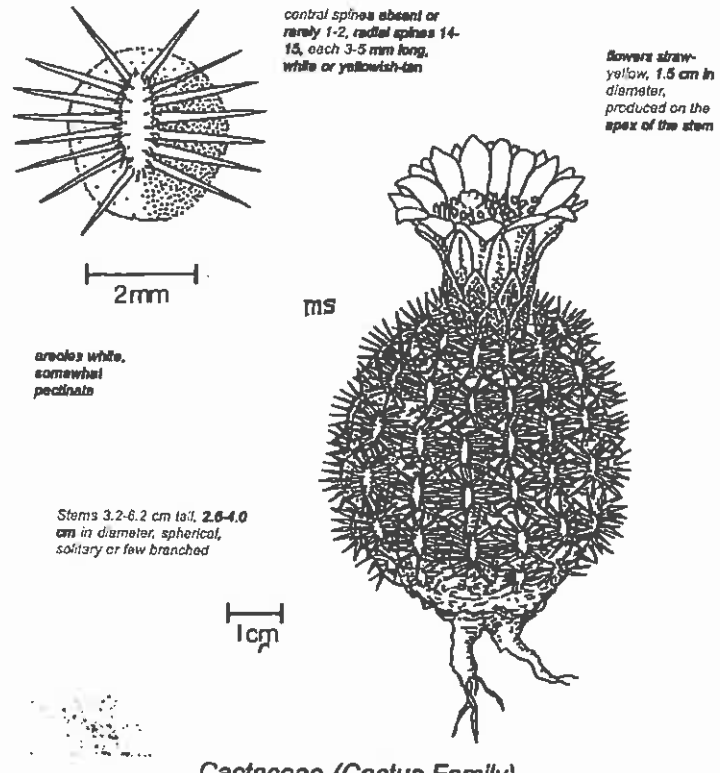


Distinguishing characteristics
Perennial, **cushion** forming from a thick taproot
Flowers / Fruits: May to June

Lookalikes: *L. fendleri* has a deep orange "eye", the veins of the petals near the eye are also orange, the petals much larger and the stellate trichomes are webbed for at least half the length of the rays, *L. navajoensis* has a faint orange eye and no orange veins, the flowers are much smaller and the trichomes are not webbed.

Habitat: limited to windward, windswept mesa rims and nearby habitat with little vegetative cover (pinyon-juniper) and high insolation. Typically only found on the nearly white Todlito limestone member of the Morrison foundation which forms local mesa rims capping the Entrada Sandstone formation. Elevations range from 7200-7600 ft

Pedicactus bradyi **– Brady pincushion cactus**
Family: Cactaceae
Synonym: *Toumeya* ***bradyi***
Status: Federal, LE; NN, G2



Cactaceae (Cactus Family)

Distinguishing characteristics
Pediocactus have no ribs, cylindric to globose stems, flowers <25mm in diameter, petals white or with pink or yellow at least on the midribs; fruit, dry, green, to tan/yellow, naked or scaly. *P. bradyi* is defined by unique capsule dehiscence, it is a restricted endemic to Marble Canyon
Small, semi-globose cacti, ranging from 2.5 to 5 cm in diameter
Central spines: absent or rarely 1-2
Radial spines: 14-15, each 3-5 mm long, white, yellowish-tan
Areoles: white, somewhat pectinate; vertical elongate
Stems: 3.2-6.2 cm tall, 2.6-4 cm in diameter, spherical, solitary or few-branched
Flowers: straw yellow, 1.5 cm in diameter, produced on the apex of the stem
Blooms: March to April, retracts into the soil in response to drought

Look-alikes: similar to juveniles of *Corypantha vivpara* but radial spines shorter
Habitat: Kaibab limestone chips overlaying soils derived from Moenkopi formation, 3,340-5,200 ft (very specific soil requirements). Only grows in Marble Canyon

APPENDIX 4

Vegetation Sampling Area Photos
N9 Baseline Study Area And Adjacent Areas
Black Mesa Mining Complex
2003

Photo 1. Pinyon-juniper woodland sample transect 1, N9 study area, spring 2003. Shading in understory reflects the approximate 18 percent canopy cover average for the pinyon-juniper woodland in the N9 study area.

Photo 2. Pinyon-juniper woodland sample transect 2, N9 study area, spring 2003. Note the sparse understory even in areas of open canopy.

Photo 3. Pinyon-juniper woodland sample transect 3, N9 study area, spring 2003. The pinyon-juniper woodland is dissected by many small, intermediate, and large drainages. This sample site had 18 percent canopy cover.

Photo 4. Pinyon-juniper woodland sample transect 4, N9 study area, spring 2003. The pinyon-juniper woodland is typically found in areas with high coarse fragment or rocky soils. This sample site had 25 percent canopy cover, approaching the high value of 29 percent canopy cover for N9 sample sites.

Photo 5. Sagebrush shrubland, N7/8 sagebrush reference area, spring 2003 sampling. The N7/8 sagebrush reference area is representative of the sagebrush shrubland in the north part of the Black Mesa leasehold where N9 is located. Note sagebrush die-back and invading pinyon pine.

Photo 6. Sagebrush shrubland, N7/8 sagebrush reference area, spring 2003 sampling. The N9 sagebrush shrubland is similar to the N7/8 sagebrush reference area and can be found on scoria soils with a high coarse fragment content. Note sagebrush die-back.

Photo 7. Sagebrush shrubland sample transect 3, N12/N99 study area, spring 2003. The N12/N99 sagebrush shrubland, located in the northern portion of the Black Mesa lease area is very similar to the N9 study area sagebrush shrubland.

Photo 8. Sagebrush shrubland sample transect 4, N12/N99 study area, spring 2003. The N9 sagebrush shrubland, as characterized by the N12/N99 study area, had similar extensive areas of sagebrush die-back as a result of ongoing drought conditions.

Map 1

N9 Baseline Vegetation Sampling Map,