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7. ECOLOGICAL INVESTIGATIONS

B. VEGETATION STUDIES

PRELIMINARY FINDINGS ~~7B01~~

MASTER

FC20-78LC10787

DISCLAIMER

CONTENTS

AKNOWLEDGEMENT

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INTRODUCTION

Vegetation studies on the Geokinetics' Kamp Kerogen Field research site on Section 2, T14S, R22E, Uintah County, Utah, have three principal components:

1. Floristics; collecting, identifying and cataloging of plant species present on the site, including any rare, restricted, endangered, and/or threatened species that may occur;

2. Phytosociology: Determining structural and compositional characteristics of the major vegetation types occuring on the site, including mapping of the distribution of those types; and

3. Productivity: Assessing the amount of biomass produced by herbaceous and shrubby vegetation in each major vegetation type.

These components, taken together, integrated with information and data derived from the wildlife studies, soil investigations, and ecoclimatological monitoring studies comprise the ecological research program. The information

obtained in each of the above categories during baseline studies will be accumulative. Reporting of data obtained from each of the components, as well as interpretive analyses obtained from correlation with other relevant studies, will be accomplished periodically as investigations progress.

OBJECTIVES

The focal concept underlying the design of the biological baseline studies on the research site is that of carrying capacity. Carrying capacity is an ecosystem component that brings together those elements which are structurally and functionally related to the system's overall operation. Understanding the interface between various ecosystem components that comprise carrying capacity provides the greatest basis for defining potential impacts, their ramifications to the functioning system, and the mitigation of those impacts.

The objective of the vegetation studies conducted on the research site is: To produce a descriptive data base that can be applied to determinations of carrying capacity of the site and surrounding area. Vegetation, the primary producer in the ecosystem, is the fundamental unit of carrying capacity. Identification of extent, internal composition, and productivity of major vegetation groupings provides information on the amount and kinds of vegetation potentially available to herbivores. Additional information obtained about parameters that influence vegetation growth and maintenance of soil nutrients, and moisture and temperature regimes help define dynamic relationships that must be understood to effect successful revegetation and habitat rehabilitation.

The descriptive vegetation baseline also provides a point of departure for design of future monitoring programs, and predictive models and strategies to be used in dealing with impact mitigation; in turn, monitoring programs and predictive modeling form the bases for making distinctions between natural trends and man-induced perturbations.

DESIGN

Vegetation sampling programs have been designed to identify and describe the characteristics of the major vegetation types occurring in the research locale.

Vegetation mapping techniques were used to define the occurrence, location, locale and extent of the major types. Vegetation sampling sites were subsequently established for phytosociological and productivity sampling. Floristic sampling is conducted throughout the immediate area.

Whenever and wherever possible, the vegetation sampling sites were located and arranged to differentiate between effects from experimental in-situ oil shale production and concomitant activity, and effects caused by natural trends and cycles. Sampling sites located in each of the major vegetation types are paired so that each vegetation type is examined in detail in remote areas as well as areas proximate to experimental development operations. Initial

calibration of these sites -- loosely termed development and control -- permits future comparisons of site changes as development of process experimentation proceeds. Data obtained from each sampling site will be analyzed using standard statistical procedures that will identify site differences and test validity of comparisons.

METHODS

Vegetation Mapping. Vegetation mapping is produced from aerial photography of the site. The preliminary vegetation map produced is ground-truthed while conducting floristic and phytosociological studies.

Floristic Studies. The herbaceous, woody, and succulent flora of the site is studied through systematic ground reconnaisance and survey of the site, collecting and subsequently identifying all species occurring. A reference collection is being formed from the systematic collections. Species classed as rare, restricted, endangered, and/or threatened are also identified and represented in this manner.

Phytosociological Studies. Eight vegetation sampling sites have been established according to the design illustrated in Figure 1; locations are given in the appended map. Designations and descriptions of the sites are given

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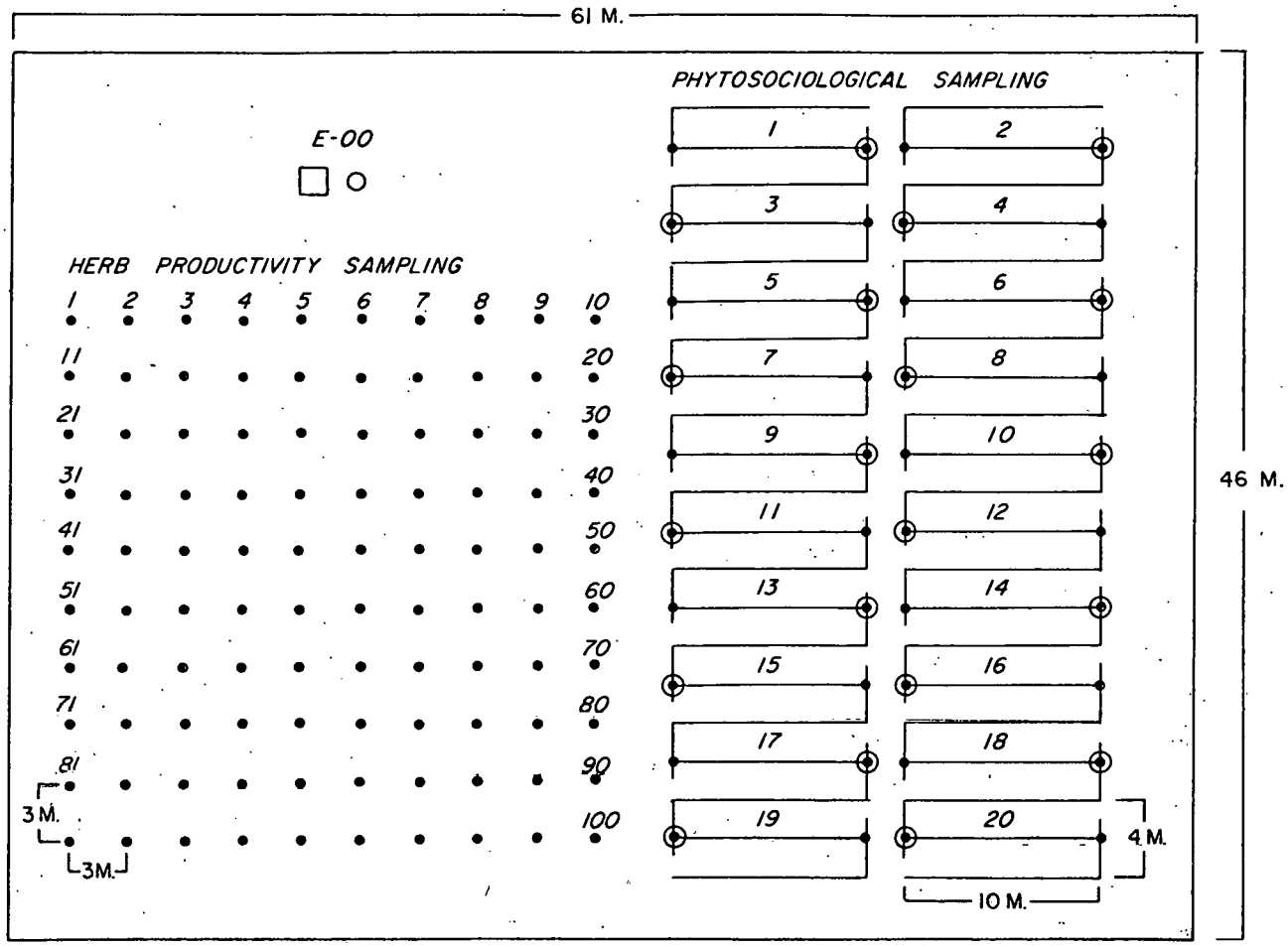
FIGURE 1

VEGETATION PLOT DESIGN



ECOCLIMATOLOGICAL DATA STATION

ONE-CENTARE HERB QUADRAT

SHRUB BELT TRANSECT

in Table 1. Structural and compositional features of each of the major vegetation types (and hence each pair of plots) are investigated using the following strategies:

Herb Layer Vegetation: Herbaceous vegetation is sampled using a quadrat method. Twenty $1m^2Ø$ quadrats, permanently located and marked in each sampling site were sampled during May, 1978. The density and frequency of each herbaceous species occurring in each plot were determined using the quadrats. Cover by soil, rock, litter, lichens, mosses, woody vegetation, and total herbaceous vegetation were also estimated visually.

Shrub Layer Vegetation: Shrub layer vegetation in shrub-dominated areas and in forested stands was sampled during May, 1978, using a line-strip or belt transect. Twenty line-strips were permanently located in each vegetation sampling site. Shrub canopy cover, density, and frequency were estimated along each transect.

Tree Layer Vegetation: Trees in forested stands were sampled using a point-centered quarter method. Tree density, cover (basal area), and frequency for each species were measured during May, 1978, using 48 sampling points.

Herbaceous Productivity Studies. Herbaceous productivity will be estimated in each of the vegetation sampling sites during June and August/September, 1978. The method of sampling will be double-sampling technique. In each of the stands, 100 one-quarter ($o.25m^2Ø$) meter quadrats will be

located along ten transects. Ten of the quadrats will be selected for harvest; selection will be made by random number generation. The remaining 90 quadrats will be estimated using an ocular technique. The harvest samples will be processed to obtain fresh and dry weights. A total estimate of sampling site productivity will be made by regression analysis.

Shrub Productivity Studies. Shrub productivity studies will be done in association with wildlife studies on the site. These studies will be begun in the fall of 1978. Detailed design and method features will be reported subsequently.

Data Treatment and Analysis. Vegetation data obtained during the May, 1978 sampling period has been subjected to standard reduction and analysis techniques. These procedures produce summarized raw field data to represent the vegetation characteristics of the entire site. The data have been further tested to determine degree of vegetation sampling site similarity and to assess adequacy of sampling.

Determining vegetation site similarity is an initial step in site calibration. The formula used to determine the coefficient of similarity for any two given sites is:

$$\text{Coefficient of Similarity} = \frac{200\ w}{a + b}$$

where w is the amount of shared information in any two stands given, a is the information in one of the stands, and b is the information in the other of the pair of stands.

Sample adequacy has been tested by calculating the standard error of the mean and the percent standard error of the mean for the data obtained in each sampling site. Density values obtained for each of the three layers (herb, shrub, and tree) were tested using the formula:

$$\text{Standard Error of the Mean } (S\bar{X}) = \frac{SD}{n},$$

where SD is the standard deviation (N-1 weighted) and n is the sample number % Standard Error of the Mean $(\%S\bar{X}) = \frac{SX}{\bar{X}}$, where $S\bar{X}$ is the standard error of the mean and $\bar{X}$ is the mean.

RESULTS AND DISCUSSION

Vegetation Mapping. Four major vegetation types were identified and mapped on the research site: 1. South-facing pinyon-juniper woodlands; 2. North-facing pinyon juniper woodlands; 3. Sagebrush-grass uplands; and 4. Sagebrush-saltbush lowlands. Distributions of these type groupings is illustrated on the accompanying map.

Floristics. Species of herbaceous, woody, and succulent plants occurring on the research site are listed in Table 2 of the appended data. This is a preliminary list, subject to alterations and/or additions; genus and species designations are field-determined and proportionately accurate.

No rare, restricted, endangered, and/or threatened species of plants have been found on the site. Table 3 lists rare, restricted, endangered, and/or threatened species

known to occur in Uintah County, in habitats like those found on or near the research site. These species will be given special attention during future systematic flora investigations.

Phytosociological Sampling and Descriptions of Vegetation Types.

Pinyon-Juniper Woodlands are the predominant vegetation type of the Intermountain Region, in which the research site is located. These open evergreen forests are composed of two main species, pinyon pine (Pinus edulis) and Rocky Mountain juniper (Juniperus scopulorum). Topographically, the woodlands occupy positions along ridge crests and gentle slopes that lie above the lowlands dominated by big sagebrush.

Two subtypes of pinyon-juniper woodlands occur on the research site. Woodland stands on north- and south-facing slopes are differentiated because of their potential differences as wildlife habitat types. The major structural difference in the two subtypes is in the density of tree species, and in the development of shrub and herb layer understories.

South-Facing Pinyon-Juniper Woodlands. Structure and Composition: (Table 4) The mean tree density of south-facing woodland sites sampled is 279 individuals per hectare. This compares with 706 individuals per hectare on the north-facing sampled stands. Pinyon pine is the predominant tree in these stands, as in all woodland stands sampled. Cover by trees averages 29 percent of the area sampled in south-facing stands, compared with 34 percent cover in the north-facing stands. Rocky Mountain juniper makes up a somewhat greater portion of the cover values, even though its densities are less than that of pinyon pine. This factor is accounted for by the tendency of juniper to form multi-boled trunks.

The shrub layer of the south-facing woodlands is dominated by big sagebrush (Artemisia tridentata). This species accounts for 5 percent of the total shrub cover in these stands. Mean sagebrush density per hectare is 475 individuals (Tables 5 and 6). Other important shrub layer species include saltbush (Atriplex canescense) and samplings of pinyon and juniper. The half-shrub snakeweed (Gutierrezia sarothrae), also attains high density values in some stands (Table 6). The shrub understory in both woodland types is

poorly developed. South-facing woodlands have mean shrub cover values of almost 9 percent, as compared to the mean cover values of less than 1 for north-facing sites. Mean density per hectare on the south-facing sampled stands is 1738 individuals, as compared with 283 individuals per hectare for the north-facing stands (Tables 5 through 8). The south-facing stands also demonstrate a slightly higher shrub species than do the north-facing stands.

The herb layer of the south-facing stands is also better developed than that occurring in the north-facing stands. Neither type has a well-developed herbaceous layer, however. Total cover by herbs on south-facing sites averages approximately 7 percent and 40 percent, respectively (Tables 9 and 10). The predominant herb is grama grass (Bouteloua gracilis). This is a perennial grass that is well-rooted and can evade drouth extinction through its perennial habit. Western wheatgrass (Agropyron smithii) also occurs on these sites, but at low frequencies. The majority of the remaining portions of the herb layer are occupied by annual forbs, such as baby blue eyes (Collinsia parviflora) and wild

parsley (Lomatium grayii). Other scattered perennial forbs, such as pin cushion (Chaenactis douglasii), milk vetch (Astragalus spp.) and dwarf goldenweed (Happlopappus acaulis) also occur, but at low frequencies.

Two species present in the herb layer deserve special attention because of the probable dynamic roles they play in the south-facing pinyon-juniper sites: Grama grass and dwarf goldenweed represent a growth form that is important in understanding the dynamics of herbaceous species growing on these sites. Both species are perennials that form bunches or cushions. These basal cushions are composed of both living and dead plant material and of fine soil material that is trapped by the cushions as it is carried over the slopes by wind or water. The environment formed by the cushions appears considerably more stable than that of the bare soil, litter, and rock interstitial areas that dominate much of the woodland sites. The cushions not only build up fine soil material, but also can retain moisture and trap organic material.

Stability, Diversity, and Succession: In general terms, the pinyon-juniper woodlands are the most stable vegetation types in the Intermountain Region. Although no site specific data are available on tree age of either woodland species, other regional data indicate that the approximate age of these woodlands would range between 150 and 200 years (Tueller and Clark, 1975). Seedlings and saplings of both species occur in relatively low numbers, suggesting slow but orderly replacement of older trees. The shrub layer within the woodlands is similarly mature and apparently stable. The herbaceous layer is the only factor of the woodland vegetation that suggests instability. The ground surface is a channery soil that shows many evidences of seasonal instability. During frost-free months, the surface becomes quite soft. Although no measurements or direct observations have been made, the surface is apparently subjected to substantial episodes of freeze-thaw cycles and the consequent surface instability associated with this heaving. This instability is reflected in the growth form of the herbaceous vegetation that dominates these sites, as discussed above. It is important to

note, also, that the paucity of the herb layer is also a product of the dry conditions that are, in part, generated by the well-drained soils of these sites.

Environment: Detailed ecoclimatologic data and soils information are not available for inclusion at this time. These data and their significance to the south-facing pinyon-juniper sites will be reported subsequently.

North-Facing Pinyon-Juniper Woodlands. Structure and Composition (Table 4): The mean tree density of the north-facing pinyon-juniper woodlands is 706 individuals per hectare. The average tree cover is approximately 34 percent of the sampled area. The greater portion of the total density is accounted for by pinyon pine. The predominance of pinyon in all woodland sites is attributed to the favorability of the environment for this species. Pinyon characteristically predominates in open woodland sites in areas of adequate winter precipitation.

The shrub layer of the north-facing pinyon-juniper woodlands is sparse (Table 5). Mean cover for shrubs in the sampled stands is less than one percent. Mean shrub density per hectare is 283 individuals. The predominant shrub in

these stands is big sagebrush, although sapling of pinyon and juniper account for much of the cover in the shrub layer. The half-shrub snakeweed is also common on these sites.

As in the south-facing stands, grama grass is a common herb. The importance of grama grass in the north-facing stands is overshadowed, however, by a species of sedge (Carex sp.). The herb layer is little-developed in the north-facing stands, even in comparison with south-facing sites. Mean herbaceous cover on the north-facing stands is 1 percent. Rock, litter, and soil account for approximately 21 percent, 67 percent, and 18 percent, respectively, of the surface cover of these areas (Tables 11 and 12). Other perennial herbs occurring on these sites include Indian ricegrass (Oryzopsis hymenoides) and fleabane daisy (Erigeron argentatus). Annual forbs are moderately frequent on these sites.

Stability, Diversity, and Succession: As discussed, above, pinyon-juniper woodlands are well-established vegetation types in the Intermountain Region. In terms of tree and shrub layer vegetation, the north-facing woodlands

are similar to south-facing woodlands in age and successional attributes. The major point of departure is in the stability of the surface. The surface areas of the north-facing woodlands are apparently not instable like those of the south-facing sites. The sparseness of the herb layer in the north-facing sites is the product of shallow, highly channery soils, and low available moisture; and generally has few of the growth characteristics demonstrated in the south-facing woodland herb layer.

Environment: Ecoclimatological and soils data will be made available in future reports.

Big Sagebrush Shrublands. General Location and Description: Vegetation stands dominated by big sagebrush (Artemisia tridentata) occupy areas of the site formed from alluvium and mixtures of alluvial and colluvial materials. The two big sagebrush vegetation types, sagebrush-grass uplands and sagebrush-saltbush lowlands, are gradual intergrades that follow the drainages on the site from their intermediate upland position on the western portion of the site to the deeper valleys on the northeastern side of the

site. Although both types are dominated by sagebrush, the density and stature of the types are markedly different. Upland sagebrush stands are low in stature; the density of the sagebrush is less than one quarter of that occurring in the bottomland sites. The open canopy of the upland sites provides space for considerable herbaceous growth, as opposed to the bottomland sites where the herb understory is sparse and composed almost entirely of annuals.

Sagebrush-Saltbush Bottomlands. Structure and Composition: Big sagebrush is the dominant shrub in these stands. This species accounts for more than 50 percent of the cover and 80 percent of the shrub density in the stands sampled (Tables 13 and 14). Total shrub cover in these stands averages approximately 67 percent. The mean density per hectare is 12,563 individuals.

Although no tree layer is present in the bottomland sagebrush stands, there is a secondary layering effect produced by the shrub species. The tall shrub layer is formed by big sagebrush, rubber rabbitbrush (Chrysothamnus nauseousus), and saltbush (Atriplex canescens). The low shrub layer is composed of winter fat (Ceratoides lanata),

pasture sage (A. frigida), and snake weed (Gutierrezia sarothrae).

The herb layer in these stands is composed chiefly of annual forbs, ragweed (Abrosia artemisifolia), baby blue eyes (Collinsia parviflora), tansy mustard (Descurainia pinnata), and wild carrot (Lomatium dissectum) (Tables 15 and 16). Total herb cover in the bottomland stands is 24 percent. Cover by rock, litter, and soil are 3 percent, 55 percent, and 28 percent, respectively.

Stability, Diversity, and Succession: The sagebrush-saltbush bottomland communities are a widespread type in the Intermountain Region. This together with the general homogeneity of sites and maturity of the individual stands suggests that it is a dynamically stable type. Structurally, all size classes (age classes) are present, including seedling and sampling of all representative shrub species, and dead and decaying individuals. This suggests an orderly replacement of individuals within stands.

The herb layer is apparently not as stable as the shrub layers. This is suggested by the predominance of annual

species present. However, it is probable that the annual forb population is perpetuated by the configuration and composition of the shrub layers: The dense shrub canopy severely limits the amount of light that reaches the surface available for germination of any but the most aggressive species; in addition, the litter fall from sagebrush increases the toxigen concentration of the soil and further limits the growth of herbaceous species.

Environment: Ecoclimatological and soils data are not available for inclusion at this point. According to other studies in the region (Olgeirson, 1977) the influence of the canopy and toxigens (both soil and plant derived) is primary to the formation and maintenance of the herb layer. Future, site-specific data will be applied to the verification of these interrelationships.

Sagebrush-Grass Uplands. Structure and Composition: As in the bottomland sites, the major shrub species in the sagebrush-grass uplands is big sagebrush. Density of this species is less than that of big sagebrush in the bottomland sites. Sagebrush accounts for approximately 21 percent of

the density in upland sites, compared with 50 percent in the bottomland sites (Tables 17, 18, 13, and 14). Covered by sagebrush in the upland sites is comparatively less, also: Approximately 11 percent of the total shrub cover.

Although the stature of the upland sagebrush sites is less than that of the bottomland sites--a mean height of 0.5 meters compared with 2 meters--two shrub layers are formed in the upland sites, as well. The tall shrub layer is dominated by big sagebrush and saltbush (Atriplex canescens). The low shrub layer is composed of those same species found in the bottomlands, with the exception of rabbitbrush: Silvery wormwood (Artemisia cana), pasture sage (A. frigida), and snakeweed (Gutierrezia sarothrae). Snakeweed is more prevalent in the upland sites. Prickly pear cactus (Opuntia polyacantha) is also found more frequently in the upland sites.

The herb layer of the upland sites is significantly better developed than that of the bottomland sites. The major portion of the herb layer is formed by the perennial grasses, grama grass (Bouteloua gracilis) and western wheatgrass (Agropyron smithii). These two species account

for more than 50 percent of the herb density of the sampled sites (Tables 19 and 20). Other common perennial species include copper mallow (Sphaeralcea coccinea), Indian ricegrass (Oryzopsis hymenoides), longleafed phlox (Phlox longifolia), and blue grass (Poa arida). Annual forbs are also frequent in these sites, although less predominant than in the bottomland sites. Among the more common annual forbs are cheat grass (Bromus tectorum), baby blue eyes (Collinsia parviflora), and tansy mustard (Descurainia pinnata). Half-shrub seedlings and saplings are other important species occurring in the herb layer. Chief in importance among the half-shrubs is pasture sage (Artemisia frigida). Mean herb cover in the upland sites is 13 percent. Although this total is less than that of the bottomland sites, it is represented by perennial, perpetuating species, rather than by ephemeral annuals. Covered by rock, litter, and soil average 1 percent, 16 percent, and 62 percent, respectively.

Stability, Diversity, and Succession: The upland sagebrush sites are the most diverse occurring on the site. The species that occupy the shrub layer are ubiquitous on the

site, occurring in all the types sampled. However, their total distributions are more regular in the upland sagebrush sites. Herb species diversity is significantly greater than in other stands, as is seen in the listing of plant species and their vegetation type affinities (Table 21).

The structure of the herb layer, along with the number of seedlings of all important shrubs suggest that these layers are stable and mature. The herb layer is also apparently stable, with some conditions. The essential functional organization of the upland sites is that of shrub islands alternating with open interstitial spaces. The shrub islands are co-occupied by the shrubs that form them and herbaceous species that root in the zone of litter and soil accumulation at the bases of the shrubs. These are the most favorable and most stable environments within the type. The interstitial spaces are occupied by a sparse cover of perennial grass and half-shrubs. As the result of soil compaction caused by diurnal temperature changes and large herbivore compaction, coupled with wind and water erosion, these sites are subjected to perpetual disturbance. The

vegetation of the open interstitial spaces may be in an essential balance with these effects, since there are no positive signs of overgrazing present.

Environment: Ecoclimatological and soils data are not available for inclusion at this time. These data will provide important insights into the relative stability of the interstitial zones in the upland sagebrush sites. This is especially true of the potential for increased herb production under more controlled grazing conditions, if it can be determined that overgrazing is an effect on growth in the open interstices.

Sample Adequacy. Adequacy of the sampling performed in the eight paired vegetation sites was tested using determination of the percent standard error of the mean. This is one method of assessing whether the size of a sample is large enough to account for the variation that is inherent in large units of vegetation. It is commonly taken that a sample that has a percent standard error of the mean of less than 20 is adequate in describing vegetation variation. Table 22 lists the percent standard error of the mean for each of the sampled stands.

Site Similarity. As an initial step in site calibration, similarity values have been calculated for each of the sites (Tables 23, 24, and 25). These values are an indication of how alike the stands are in terms of vegetation. Since vegetation is only one component of the sites, the similarity calculations must be used in conjunction with other tests on physical parameters to be most meaningful. However, when used in conjunction with the sample adequacy tests, the similarity values can be used to further determine sample adequacy.

CONCLUSIONS AND RECOMMENDATIONS

Certain of the vegetation characteristics discussed in this report have important implications for revegetation and habitat reclamation. Chief among these are the growth patterns and configuration of herbaceous vegetation in all of the sites. These features and their probable controls must be further understood before they can be combined in a productive revegetation program. Such elucidation will be derived from the data generated in soils and ecoclimatologic studies, and their subsequent co-analysis with the vegetation data.

The sample adequacy and similarity values calculated from the vegetation sampling program indicate that some additional sampling may be necessary to compare the control and development sites in terms of differentiating future maninduced changes versus natural trends. The vegetation types that would benefit from a low level additional sampling

effort are the woodland sites (V-11 and V-21; herb layer only), and one bottomland site (V-31; herb layer only). The percent standard error of the mean values in Table 22 that are slightly greater than 20 are not of major significance. Additional sampling in the control and development sites for the purpose of decreasing the percent standard error of the mean in these samples would be undertaken during the 1978 sampling. As a result of seasonal changes, additional sampling during this season is not expected to decrease the variability of the sample. Sampling to increase similarity between control and treatment stands can be undertaken at any time since the main concern in this effort is the similarity of the shrub layer.

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APPENDIX A. DATA

TABLE 1

Designations and Descriptions of
Vegetation Sampling Sites

Stand or Site Number	Station	Description
V10	1	South-Facing pinyon-juniper group, control
V11	5	South-Facing pinyon-juniper group, experimental
V20	2	North-Facing, pinyon-juniper group, control
V21	6	North-Facing, pinyon-juniper group, experimental
V30	3	Bottomland sage group, control
V31	7	Bottomland sage group, experimental
V40	4	Upland sage group, control
V41	8	Upland sage group, experimental

TABLE 2

LISTING OF SPECIES OF PLANTS
OCCURRING ON THE GEOKINETICS SITE

SCIENTIFIC NAME	COMMON NAME
Grasses and Forbs	
Agropyron smithii	western sheatgrass
Allium geyeri	wild onion
Ambrosia artemisifolia	ragweed
Antennaria parvifolia	pussytoes
Arabis divaricarpa	rock-cress
Astaragalus ceramicus	milkvetch
A. kentrophyta	skeleton milkvetch
Bouteloua gracilis	grama grass
Bromus tectorum	cheatgrass
Carex sp.	sedge
Castilleja chromosa	Indian paintbrush
Chaenactis douglasii	pincushion; false yarrow
Chenopodium album	goosefoot
Collinsia parviflora	baby blue-eyes; blue-eyed Mary
Crepis accuminata	hawks beard
Crypatantha nana	crypatantha
Delphinium nelsonii	larkspur
Descurainia pinnata	tansy mustard
Draba brachycarpa	whitlow wort
Erigeron argentatus	fleabane daisy
Erigeron utahensis	fleabane daisy
Eriogonum caespitosum	eriogonum
Erysimum capitatum	wallflower
Euphorbia robusta	spurge
Haplopappus acaulis	dwarf goldenweed
Hymenoxys acaulis	actinea
Iva xanthifolia	marsh elder
Linum lewisii	false-flax
Lithospermum ruderale	pucoon

Lomatium dissectum	wild carrot
L. grayii	wild parsley
Oenothera caespitosa	evening primrose
Oryzopsis hymenoides	Indian ricegrass
Penstemon sp.	penstemon
Phlox longifolia	long-leafed phlox
Physaria floribunda	bladder-pod
Poa arida	bluegrass
Senecio multilobatus	golden ragwort
Salsola iberica	Russian thistle
Sisymbrium altissimum	thumble mustard
Sphaeralcea coccinea	copper mallow
Stipa comata	needle-and-thread grass
Taraxacum officinale	dandelion
Townsendia scapigera	easter daisy
Verbascum thapsus	mullien

SCIENTIFIC NAME	COMMON NAME
<u>Trees, Shrubs, Half-Shrubs, and Succulents</u>	
Artemisia cana	silvery wormwood
Artemisia frigida	pasture sage
Artemisia tridentata	big sagebrush
Atriplex canescens	four-singed saltbush
Ceratoides lanata	winter fat
Cercocarpus montanus	mountain mahogany
Coryphantha vivipara	mountain ball cactus
Chysothamnus nauseousus	rubber rabbitbrush
Chrysothamnus viscidiflorus	little rabbitbrush
Ephedra viridis	Mormon tea
Gutierrezia sarothrae	snakeweed
Juniperus scopulorum	Rocky Mountain juniper
Leptodactylon pungens	prickly gilia
Opuntia polyacantha	prickly pear cactus
Pinus edulis	pinyon pine
Purshia tridentata	antelope bitterbrush
Symphoricarpos oreophilus	snowberry
Yucca sp.	yucca

TABLE 3

RARE, ENDANGERED, THREATENED, RESTRICTED, AND ENDEMIC PLANT SPECIES
known to occur* in Uintah County, Utah in habitats like those on or near the Geokinetics site.

Enceliopsis nutans (COMPOSITAE) -- rare and restricted

Cryptantha barnebyi (BORAGINACEAE) -- rare, endemic, threatened

C. rollinsii -- endemic

Glaucocarpum suffrutescens (CRUCIFERAE) -- endemic, rare, endangered

Astragalus detrialis (LEGUMINOSAE) -- endemic

A. hamiltonii -- endemic, rare, threatened

A. lutosus -- endemic, restricted, endangered

Hermidium alipes (NYCTAGINACEAE) -- endemic, rare, endangered

Gilia mcvickerae (POLEMONIACEAE) -- Endemic, rare, endangered

G. stenothyrsa -- endemic

Phlox grahamii (POLEMONIACEAE) -- endemic, rare, threatened

Erigonium ephedroides (POLYGONACEAE) -- endemic, rare, restricted, endangered

E. saurinum -- restricted, threatened

Penstemon grahammii (SCHROPHULARIACEAE) -- endemic, rare, restricted threatened

*Source: Welsh, S.L. et al. 1975

TABLE 4

TREE LAYER DATA, ALL STANDS

SPECIES	% COVER $\bar{X}$	% FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
4a STAND V-10, 1978				
Pinus edulis	13	35	141	129
Juniperus scopulorum	14	56	192	171
4b STAND V-11, 1978				
Pinus edulis	15	48	135	159
Juniperus scopulorum	16	48	89	141
4c STAND V-20, 1978				
Pinus edulis	14	50	421	144
Juniperus scopulorum	23	48	346	156
4d STAND V-21, 1978				
Pinus edulis	11	69	499	184
Juniperus scopulorum	19	29	146	116

TABLE 7

SHRUB LAYER DATA, STAND V-20
1978

SPECIES	%COVER $\bar{X}$	%FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia tridentata	0.0	30	88	39
Gutierrezia sarothrae	0.0	10	25	12
Juniperus scopulorum	0.0	25	63	30
Opuntia polyacantha	0.0	65	13	38
Pinus edulis	0.0	50	188	75
Symphoricarpos oreophilus	0.0	5	13	6

TABLE 8

SHRUB LAYER DATA, STAND V-21
1978

SPECIES	%COVER $\bar{X}$	% FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia tridentata	0.0	10	25	31
Juniperus scopulorum	0.3	20	63	169
Pinus edulis	0.0	30	88	100

TABLE 5

SHRUB LAYER DATA, STAND V-10
1978

SPECIES	%COVER $\bar{X}$	% FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia tridentata	8.9	55	625	87
Atriplex canescens	0.5	5	13	5
Cercocarpus montanus	0.2	10	25	5
Juniperus scopulorum	2.7	50	213	38
Leptodactylon pungens	0.0	30	150	12
Opuntia polyacantha	0.02	20	175	10
Pinus edulis	2.1	50	163	33
Purshia tridentata	0.0	10	25	4

TABLE 6

SHRUB LAYER DATA, STAND V-11
1978

SPECIES	%COVER $\bar{X}$	% FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia tridentata	0.1	55	325	43
Atriplex canescens	0.0	15	38	8
Gutierrezia sarothrae	0.0	70	1250	90
Juniperus scopulorum	1.2	25	75	59
Opuntia polyacantha	0.2	20	236	27
Pinus edulis	1.2	50	163	74

TABLE 9

HERB LAYER DATA, STAND V-10
1978

SPECIES	%FREQUENCY	DENSITY	#/HECTARE	%COVER ($\bar{X}$)
Agropyron smithii	5	1	500	
Artemisia frigida	5	1	500	
Bouteloua gracilis	60	77	38,500	
Chaenactis douglasii	5	1	500	
Collinsia parviflora	30	19	9,500	
Draba brachycarpa	10	20	10,000	
Gutierrezia sarothrae	60	39	19,500	
Lomatium grayii	20	4	2,000	
Oryzopsis hymenoides	20	12	6,000	
Senecio multilobatus	5	1	500	
Townsendia scapigera	15	3	500	
Artemisia tidentata				
seedlings	5	1	500	
saplings	5	1	500	
Total herb cover				6
Rock				42
Litter				36
Soil				45
Lichens (crustose)				3
Mosses				-1*
Woody cover				0

(*data values less-than-one)

TABLE 10

HERB LAYER DATA, STAND V-11
1978

SPECIES	% FREQUENCY	DENSITY	#/HECTARE	%COVER ($\bar{X}$)
Artemisia frigida	5	3	1,500	
Bouteloua gracilis	45	98	49,000	
Chaenactis doublasii	15	3	1,500	
Collinsia parviflora	25	16	8,000	
Cryptantha nana	10	3	1,500	
Draba brachycarpa	10	7	3,500	
Euphorbia robusta	10	3	1,500	
Gutierrezia sarothrae	10	4	2,000	
Haplopappus acaulis	10	5	2,500	
Hymenoxys acaulis	5	3	1,500	
Lomatium grayii	5	1	500	
Townsendia scapigera	10	2	1,000	
Artemisia tridentata seedlings	5	1	500	
Total herb cover				7
Rock				25
Litter				53
Soil				34
Lichens (crustose)				1
Mosses				-1
Woody cover				0

TABLE 11

HERB LAYER DATA, STAND V-20
1978

SPECIES	%FREQUENCY	DENSITY	#/HECTARE	%COVER ($\bar{X}$)
Arabis divaricarpa	15	19	9,500	
Bouteloua gracilis	5	1	500	
Carex sp.	50	22	11,000	
Chaenactis douglasii	5	2	1,000	
Descurainia pinnata	10	3	1,500	
Erigeron argentatus	5	1	500	
Haplopappus acaulis	5	1	500	
Oryzopsis hymenoides	5	3	1,500	
Townsendia scapigera	5	1	500	
Unknown Composite	5	8	4,000	
Total herb cover				1
Rock				18
Litter				64
Soil				22
Lichens (crustose)				2
Mosses				4
Woody cover				1

TABLE 12

HERB LAYER DATA, STAND V-21
1978

SPECIES	% FREQUENCY	DENSITY	#/HECTARE	%COVER($\bar{X}$)
Bouteloua gracilis	5	6	3,000	
Carex sp.	10	8	4,000	
Collinsia parviflora	5	1	500	
Erigeron argentatus	5	1	500	
Haplopappus acaulis	5	1	500	
Pinus edulis seedlings	5	2	1,000	
Total herb cover				-1
Rock				24
Litter				69
Soil				13
Lichens (crustose)				4
Mosses				-1
Woody cover				3

TABLE 13

SHRUB LAYER DATA, STAND V-30
1978

SPECIES	%COVER $\bar{X}$	%FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia tridentata	51.7	100	8175	198
Atriplex cannescens	0.4	2	450	6
Chrysothamnus nauseosus	16.3	85	3175	96

TABLE 14

SHRUB LAYER DATA, STAND V-30
1978

SPECIES	%COVER $\bar{X}$	%FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia frigida	0.0	40	238	16
Artemisia tridentata	61.1	100	12163	222
Atriplex canescens	0.1	40	250	17
Ceratoides lanata	1.6	10	25	6
Chrysothamnus nauseosus	1.8	55	538	27
Gutierrezia sarothrae	0.0	10	25	4
Opuntia polyacantha	0.1	20	75	8

TABLE 15

HERB LAYER DATA, STAND V-30
1978

SPECIES	%FREQUENCY	DENSITY	#/HECTARE	%COVER ($\bar{X}$)
Ambrosia artemisifolia	65	1307	653,500	
Artemisia frigida	30	81	40,500	
Bromus tectorum	5	1	500	
Collinsia parviflora	20	6	3,000	
Descurainia pinnata	70	109	54,500	
Draba brachycarpa	5	5	2,500	
Iva xanthifolia	5	3	1,500	
Lomatium disscetum	35	254	121,500	
Salsola iberica	10	59	29,500	
Unknown Composite	85	188	94,000	
Artemisia tridentata				
seedlings	65	167	83,500	
saplings	75	43	3,500	
Chrysothamnus nauseosus				
seedlings	25	106	53,000	
saplings	75	43	21,500	
Total herb cover				41
Rock				5
Litter				48
Soil				25
Lichens (crustose/foliose)				1
Mosses				1
Woody cover				9

TABLE 16

HERB LAYER DATA, STAND V-31
1978

SPECIES	%FREQUENCY	DENSITY	#/HECTARE	%COVER($\bar{X}$)
Ambrosia artemisifolia	10	69	34,500	
Artemisia frigida	25	21	10,500	
Bromus tectorum	10	9	4,500	
Chaenactis douglassi	5	1	500	
Chenopodium album	15	24	12,000	
Collinspi parviflora	25	21	10,500	
Descurainia pinnata	55	60	30,000	
Draba brachycarpa	10	7	3,500	
Erigeron utahensis	5	3	1,500	
Lithospermum	5	1	500	
Lomatium dissectum	30	87	43,500	
Poa arida	20	9	4,500	
Salsola iberica	15	85	42,500	
Stpia comata	5	4	2,000	
Artemisia tridentata				
seedlings	25	16	8,000	
saplings	10	2	1,000	
Chrysothamnus nauseosus				
seedlings	5	3	1,500	
saplings	5	3	1,500	
Total herb cover				7
Rock				1
Litter				61
Soil				30
Lichens (crustose/folliose)				1
Mosses				6
Woody cover				12

TABLE 17

SHRUB LAYER DATA, STAND V-40
1978

SPECIES	%COVER $\bar{X}$	%FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia frigida	0.5	100	13538	75
Artemisia tridentata	5.8	85	3638	67
Atriplex canescens	7.5	100	3588	81
Ceratoides lanata	2.8	100	5400	59
Gutierrezia sarothrae	0.02	50	950	15
Opuntia polyacantha	0.0	15	50	4

TABLE 18

SHRUB LAYER DATA, STAND V-41
1978

SPECIES	%COVER $\bar{X}$	% FREQUENCY	$\bar{X}$ DENSITY PER HECTARE	IMPORTANCE VALUE
Artemisia frigida	1.8	100	13650	77
Artemisia tridentata	15.4	100	8725	127
Atriplex canescens	1.8	95	1750	36
Ceratoides lanata	1.5	100	4438	44
Gutierreizia sarothrae	0.0	55	925	15
Opuntia polyacantha	0.0	5	13	1

TABLE 19

HERB LAYER DATA, STAND V-40
1978

SPECIES	%FREQUENCY	DENSITY	#/HECTARE	%COVER ($\bar{X}$)
Agropyron smithii	90	755	377,500	
Artemisia frigida	10	3	1,500	
Bouteloua gracilis	95	264	132,000	
Bromus tectorum	50	288	144,000	
Collinsia parviflora	55	35	17,500	
Delphinium nelsonii	5	1	500	
Descurainia pinnata	5	1	500	
Gutierrezia sarothrae	5	2	1,000	
Haplopappus acaulis	10	6	3,000	
Hymenoxys acaulis	10	7	3,500	
Oryzopsis hymenoides	5	1	500	
Phlox longifolia	45	46	23,000	
Physaria floribunda	5	2	1,000	
Poa arida	45	57	28,500	
Sphaeralcea coccinea	75	154	77,000	
Unknown annual forb	30	18	9,000	
Opuntia polyacantha	5	1	500	
Artemisia cana seedlings	20	12	6,000	
Artemisia tridentata seedlings	20	5	2,500	
Total herb cover				14
Rock				1
Litter				16
Soil				61
Lichens (crustose/folliose)				<1
Mosses				<1
Woody cover				17

TABLE 20

HERB LAYER DATA, STAND V-41
1978

SPECIES	%FREQUENCY	DENSITY	#/HECTARE	%COVER($\bar{X}$)
Agropyron smithii	100	741	370,500	
Artemisia frigida	70	60	30,000	
Bouteloua gracilis	50	112	56,000	
Bromus tectorum	45	96	48,000	
Collinsia parviflora	40	20	10,000	
Descurainia pinnata	5	1	500	
Erigeron argentatus	25	13	6,500	
Gutierrezia sarothrae	5	3	1,500	
Haplopappus acaulis	5	1	500	
Hymenoxys acaulis	10	5	2,500	
Oryzopsis hymenoides	25	12	6,000	
Phlox longifolia	60	90	45,000	
Physaria floribunda	5	3	1,500	
Poa arida	45	41	20,500	
Salsola iberica	35	20	10,000	
Sphaeralcea coccinea	65	71	35,500	
Unknown annual forb	15	6	3,000	
Artemisia cana				
saplings	5	2	1,000	
Artemisia tridentata				
seedlings	15	19	9,500	
saplings	40	16	8,000	
Total herb cover				12
Rock				1
Litter				15
Soil				63
Lichens				0
Mosses				1
Woody cover				18

TABLE 21

PLANT SPECIES AND VEGETATION TYPE ASSOCIATIONS
GEOKINETICS SITE

SPECIES	V-10	V-11	V-20	V-21	V-30	V-31	V-40	V-41	DISTURBED SITES
Grasses and Forbs									
Agropyron smithii	x			x			x	x	
Allium geyeri	x	x					x		
Ambrosia artemisifolia						x	x		
Antennaria parvifolia			x						
Arabis divaricarpa			x		x				
Astragalus ceramicus	x	x	x	x			x	x	
A. kentrophyta	x	x	x	x					
Bouteloua gracilis	x	x	x	x			x	x	
Bromus tectorum									
Carex sp.	x	x	x	x					
Castilleia chromosa							x	x	
Chaenactis douglasii	x	x	x			x			
Chenopodium album			x			x	x		
Collinsia parviflora	x	x		x	x	x	x	x	
Crepis accuminata	x								
Cryptantha nana	x	x	x				x	x	
Delphinium nelsonii							x	x	
Descurainia pinnata	x		x		x	x	x	x	x
Draba brachycarpa	x	x	x						
Erigeron argentatus			x	x			x	x	
E. utahensis			x	x		x	x	x	
Eriogonum caespitosum	x								
Erysimum capitata			x						
Euphorbia robusta		x	x						
Haplopappus acaulis	x	x	x	x			x	x	
Hymenoxys acaulis	x	x						x	
Iva xanthifolia					x				

TABLE 21 (CONTINUED)

SPECIES	V-10	V-11	V-20	V-21	V-30	V-31	V-40	V-41	DISTURBED SITES
Grasses and Forbs (Continued)									
Linum lewisii									x
Lithospermum ruderale	x	x				x	x	x	
Lomatium dissectum					x	x			
L. grayii	x	x					x	x	
Oenothera caespitosa	x	x							x
Oryzopsis hymenoides	x	x	x				x	x	
Penstemon sp.			x	x					
Phlox longifolia	x	x					x	x	
Physaria floribunda	x	x	x				x	x	
Poa arida			x	x		x	x	x	
Senecio multilobatus	x		x	x	x				
Salsola iberica						x			
Sisymbrium altissimum		x					x	x	
Sphaeralcea coccinea	x	x					x	x	
Stipa comata	x	x			x	x			
Taraxacum officinale						x			
Townsendia scapigera	x	x	x	x			x	x	
Verbascum thapsus									x
Trees, Shrubs, Half-Shrubs and Succulents									
Artemisia cana			x	x		x	x		
A. frigida	x	x			x	x	x		
A. tridentata	x	x	x	x	x	x	x	x	
Atriplex canescens	x	x			x	x	x	x	
Ceratoides lanata					x	x	x	x	
Cercocarpus montanus	x								
Coryphantha vivipara	x	x					x	x	
Chrysothamnus nauseosus			x		x	x			
C. viscidiflorus					x	x			
Ephedra viridis	x	x					x	x	
Gutierrezia sarothrae	x	x	x	x			x	x	
Juniperus scopulorum	x	x	x	x					

TABLE 21 (CONTINUED)

SPECIES	V-10	V-11	V-20	V-21	V-30	V-31	V-40	V-41	DISTURBED SITES
Trees, Shrubs, Half-Shrubs and Succlents (Continued)									
Leptodactylon pungens	x	x							
Opuntia polyacantha			x	x		x	x	x	
Pinus edulis	x	x	x	x					
Purshia tridentata	x	x							
Symphoricarpos oreophilus			x						
Yucca sp.	x	x							

TABLE 22

PERCENT STANDARD ERROR OF MEAN VALUES
FOR EIGHT VEGETATION SAMPLING SITES

VEGETATION SAMPLING SITE	HERB LAYER	SHRUB LAYER	TREE LAYER
V-10	15.8	20.6	7.1
V-11	37.2	21.5	5.9
V-20	36.1	21.6	4.6
V-21	45.4	22.4	9.5
V-30	20.4	3.6	
V-31	30.4	7.1	
V-40	22.4	7.3	
V-41	9.9	5.6	

Based on the formula: $\%S\bar{X} = \frac{S\bar{X}}{\bar{X}}$, values derived from density data

TABLE 23

MATRIX OF SIMILARITY VALUES
BASED ON HERB LAYER DENSITY*

	V-10	V-11	V-20	V-21	V-30	V-31	V-40	V-41
V-10	--							
V-11	59							
V-20	11	18						
V-21	7	15	47					
V-30	10	10	5	2				
V-31	19	20	8	3	55			
V-40	28	27	7	5	10	18		
V-41	28	21	7	3	12	21	74	--

*Similarity Values (Coefficient of Similarity) are calculated from 1978 density values according to the following formula:

$$\text{Coefficient of Similarity} = \frac{2w}{a + b} \times 100,$$

where, w= the amount of information (i.e., density) shared by species occurring in any given pair of sampled stands,
a= the information in stand a (one of any pair),
b= the information in stand b

TABLE 24

MATRIX OF SIMILARITY VALUES
BASED ON SHRUB LAYER DENSITY

	V-10	V-11	V-20	V-21	V-30	V-31	V-40	V-41
V-10	--							
V-11	74							
V-20	41	60						
V-21	34	54	45					
V-30	31	16	13	10				
V-31	35	21	17	10	77			
V-40	30	23	18	10	6	38		
V-41	36	22	17	10	49	57	80	--

TABLE 25

MATRIX OF SIMILARITY VALUES
BASED ON TREE LAYER DENSITY

	V-10	V-11	V-20	V-21
V-10	--			
V-11	90			
V-20	95	95		
V-21	82	92	87	--

APPENDIX B. PLATES

Plate 1. North-facing pinyon-juniper woodlands and sagebrush-saltbrush bottoms.

Plate 2. South-facing pinyon-juniper woodlands and sagebrush-saltbrush bottoms.

Plate 3. Grama grass herb layer in the sagebrush-grass upland to south-facing pinyon-juniper transition zone.

Plate 1. 7B01.57

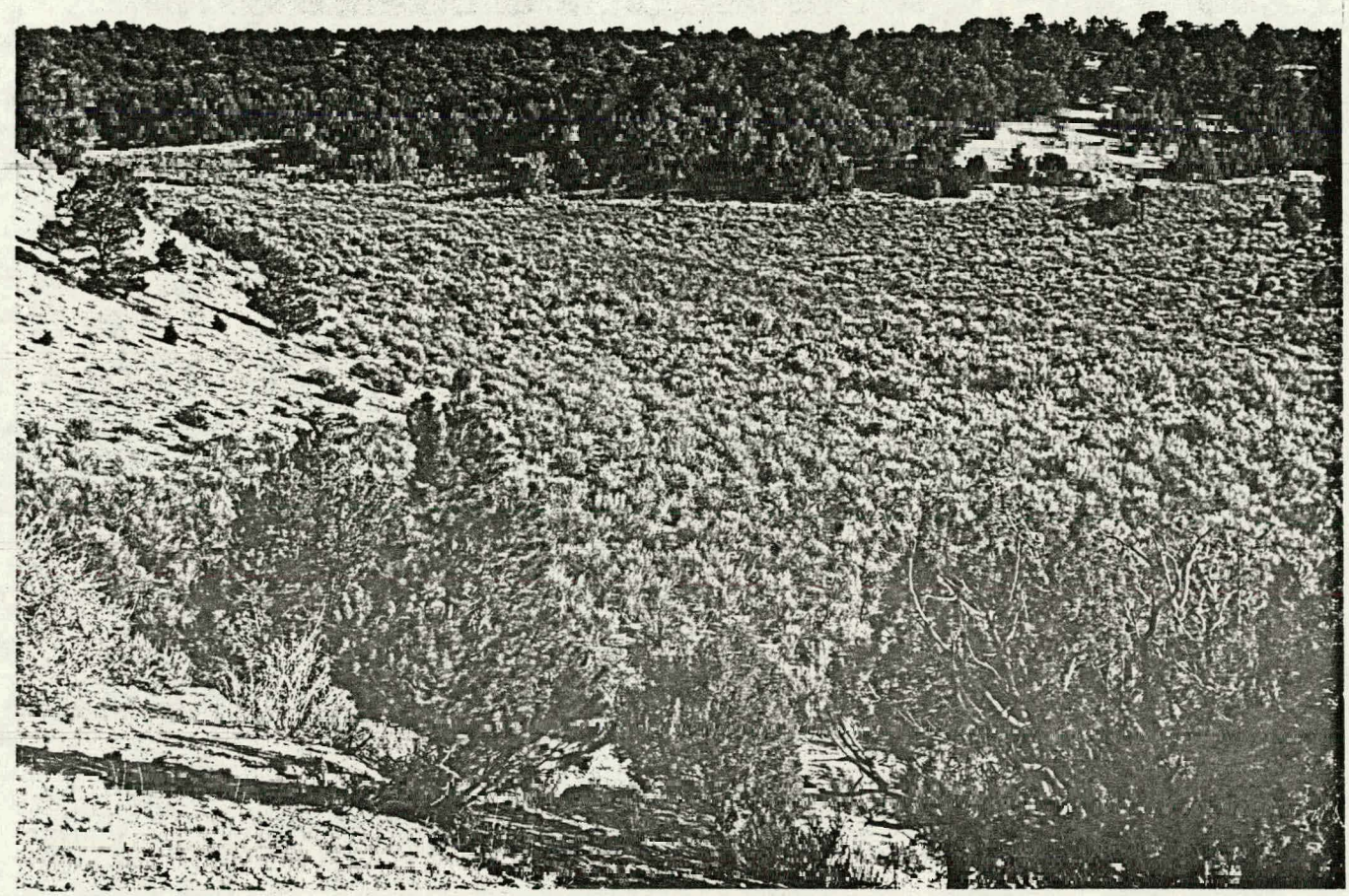


Plate 2.

7B01.58

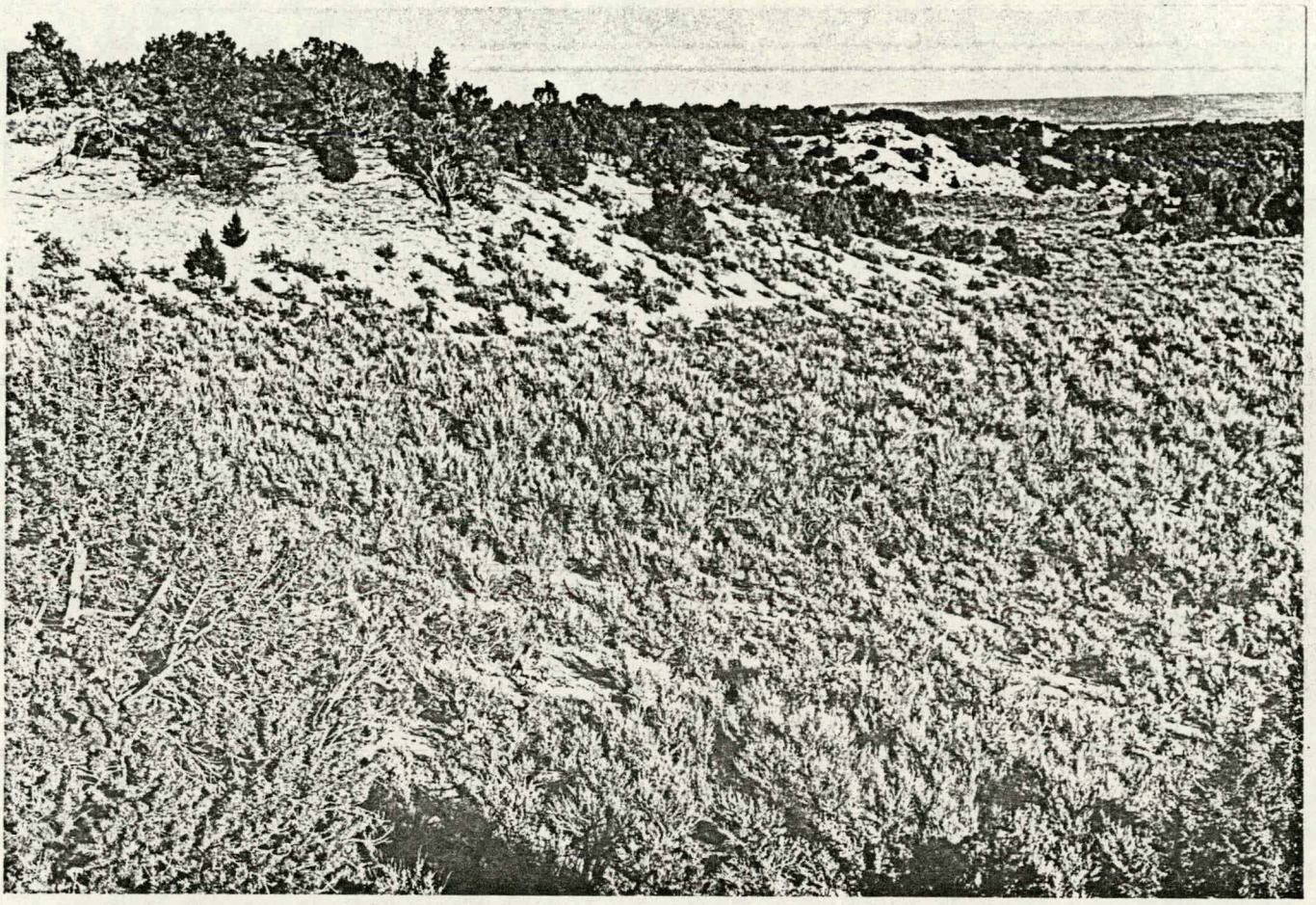
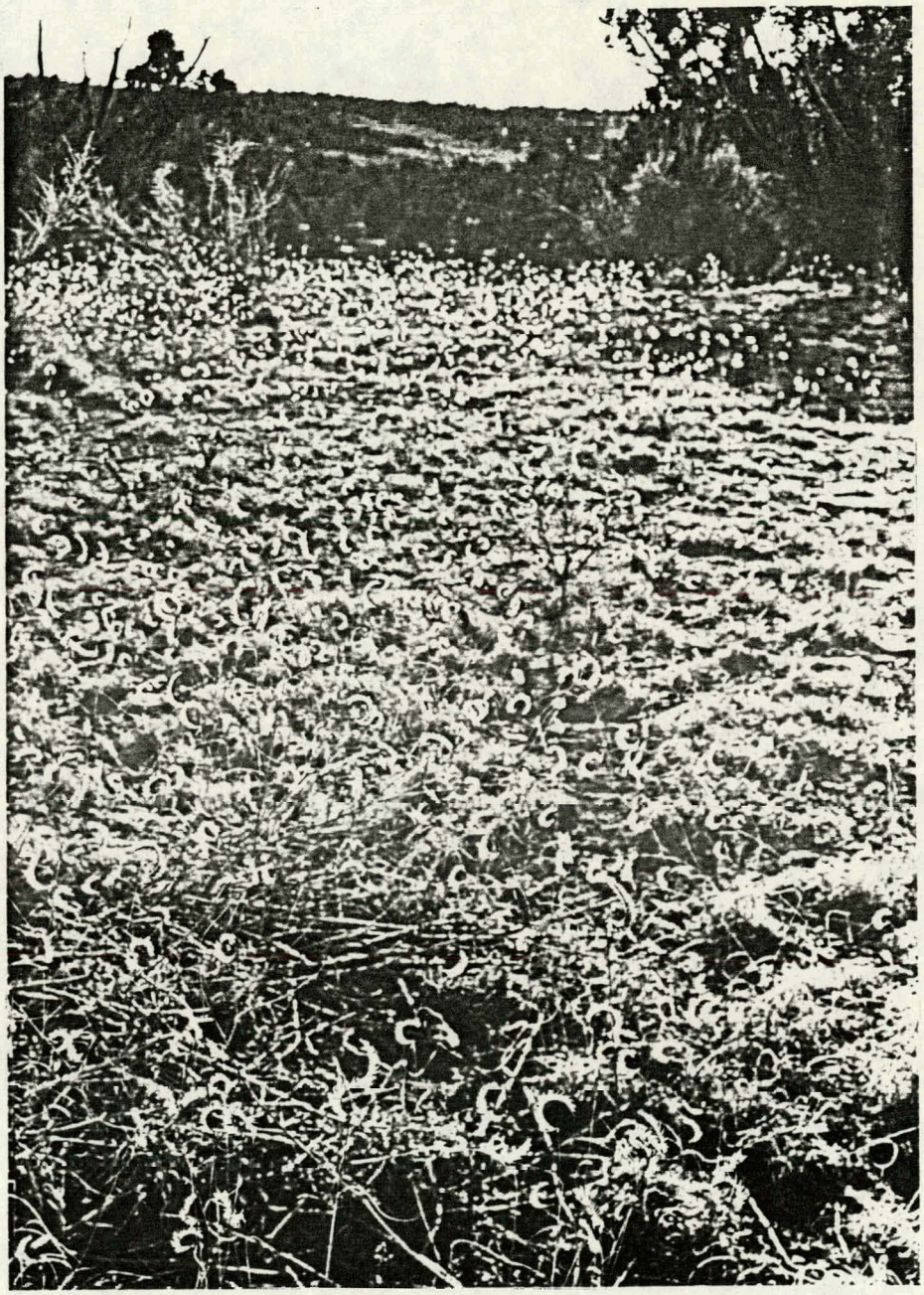
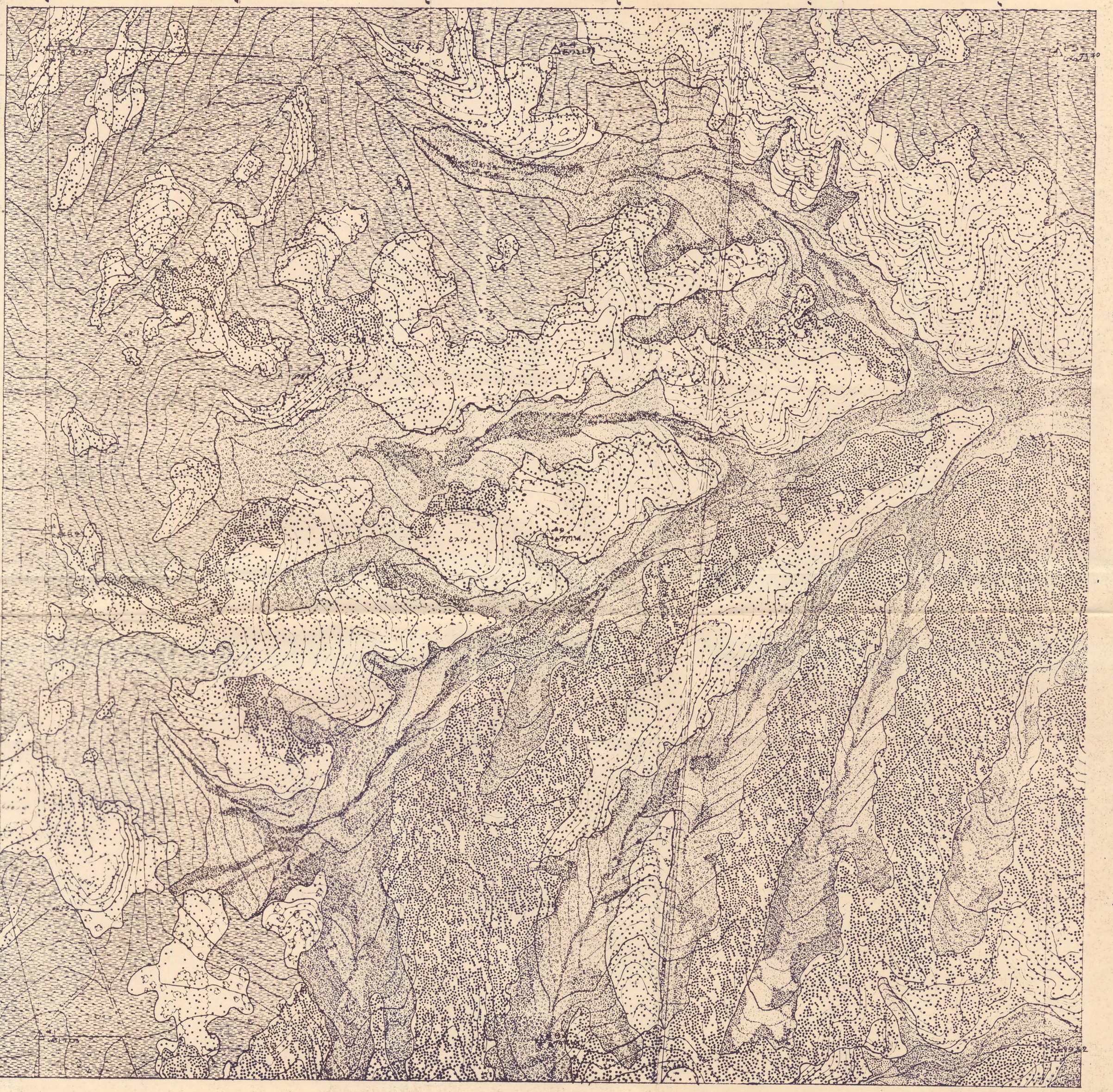


Plate 3.

7B01.59





Legend:

- pinyon-juniper woodland (N-facing) (Pinus edulis-Juniperus osteosperma)
- pinyon-juniper woodland (S-facing) (Pinus edulis-Juniperus osteosperma)
- sagebrush-saltbush lowland (Artemisia tridentata-Atriplex corescens)
- sagebrush-grass upland (Artemisia tridentata-Bouteloua gracilis)

DATE: FEBRUARY, 1978

SCALE: 1"=200'

CONTOUR INTERVAL: 5'

TOPOGRAPHIC BASE: BELL MAPPING CO., NOVEMBER, 1976

VEGETATION MAP,

GEOKINETICS' KAMP KEROGEN SITE

SECTION 2, R22E,T14S UINTAH COUNTY, UTAH

GEOKINETICS OIL SHALE PROJECT

by ERIK R. OLGEIRSON, PhD ECOLOGIST CONIFER, COLORADO