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VEGETATION-TERRAIN FEATURE RELATIONSHIPS IN SOUTHEAST ARIZONA

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by

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The research upon which this paper is based was initiated by earlier NASA funding and constitutes a portion of our ERTS-I investigation under the auspices of the Rangeland Resources Program at Oregon State University.*

Our ERTS-I involvement incorporates ERTS-I data into vegetation inventory procedures. It involves the uses of ERTS-I imagery at the first stage of a multistage sampling technique, the purpose of which is to determine the types and amounts of vegetation representing a cross section of formations in Southern Arizona. Studies of relationships of vegetation distribution to geomorphic characteristics of the landscape and of plant phenological patterns to vegetation identification on satellite imagery are expected to contribute to ERTS data interpretation. A comparison is being made of the facility with which landform identifications can be made using low sun angle monoscopic versus high sun angle stereoscopic techniques.

Apparent spectral signatures of some vegetation types will be determined from digital multispectral scanner (MSS) data. Collaboration is planned with personnel from the Arizona Regional Ecological Test Site, Forestry Remote Sensing Laboratory, University of California, Berkeley; and the Environmental Remote Sensing Applications Laboratory, Oregon State University, Corvallis.

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*ERTS-I investigation entitled, "Inventory and Monitoring of Natural Vegetation and Related Resources in an Arid Environment." Barry J. Schrumpf, Principal Invest

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One of the chief goals of our project has been, and continues to be, the classification, analysis, and monitoring of environmental resource data. We have tended to concentrate our research on vegetation. Toward that end, we have employed high altitude (approximately 1:120,000) and space (approximately 1:700,000) photographic imagery, and to a limited extent large scale (1:35,000).

While some vegetation units can be more or less directly interpreted at those scales, associated environmental variables including terrain feature variables may be employed to facilitate, reinforce, and refine that work. In fact, they are used as a part of the interpretation process. Most studies involving terrain feature-vegetation relationships have involved looking at one or two variables. A simple and obvious example involves elevation and serves to illustrate the utility of associated evidence. There is general acceptance of the idea that forests occur at higher elevations in the southwest, while scrub-shrub (desert) vegetation grows at lower elevations. A photo interpreter who is more or less aware of that elevational stratification of vegetation principle can guess the relative elevational differences in a given area. He can utilize that information in his interpretation process.

Studies of terrain feature-vegetation relationships often involve vegetational changes with aspect. Kendall Cumming, in 1951, for example, wrote a (master's) thesis on "The Effect of Slope and Exposure on Range Vegetation in Desert Grassland and Oak Woodland Areas of Santa Cruz County." In that thesis, he pointed out certain species which preferred certain slope and aspect situations over others. David E. Bradbury wrote a thesis on the influence of parent materials on vegetation in the Swisshelm Mountains. Bradbury points out the indicator value of certain species for identifying parent materials. R. H. Whittaker has written a number of articles on gradient analysis of vegetation in the Santa Catalina Mountains. In his articles, he considers the importance of the influence of a moisture gradient on vegetation. His moisture gradient is based primarily on aspect and elevation.

My study differs from these in that rather than looking at one or two environmental variables in a fairly small area, I'm looking at eight variables over a wider area - 3,000 square miles. Figure 1 illustrates the location of the study area.

I felt that since some non-vegetational variables were easier to interpret than vegetation on small-scale photography, I would examine relationships between some of those variables and vegetation. With positive results it would lead to more accurate interpretation of vegetation on small-scale photography over a relatively short time.

A principal consideration inherent in this approach is obvious: if positive terrain feature-vegetation relationships exist, how accurately and consistently can those terrain feature variables be identified and interpreted on the photography? Although this latter consideration wasn't the prime objective of the research, it has been important and constitutes a considerable portion of the research I and our research crew at Oregon State University have undertaken.

Those variables chosen were selected on the basis of their relative interpretability or determination from photographic evidence and subsequent extrapolation. Figure 2 illustrates the classes of terrain feature variables used in this study.

Elevation is easily determined when stereo coverage is available. Accurate measurement of parallax enables the determination of relief displacement.

The measurement of slope angle is determined by measuring the difference in elevation between two points using parallax, for example, and then measuring

Figure 1. Location of study area (shaded).

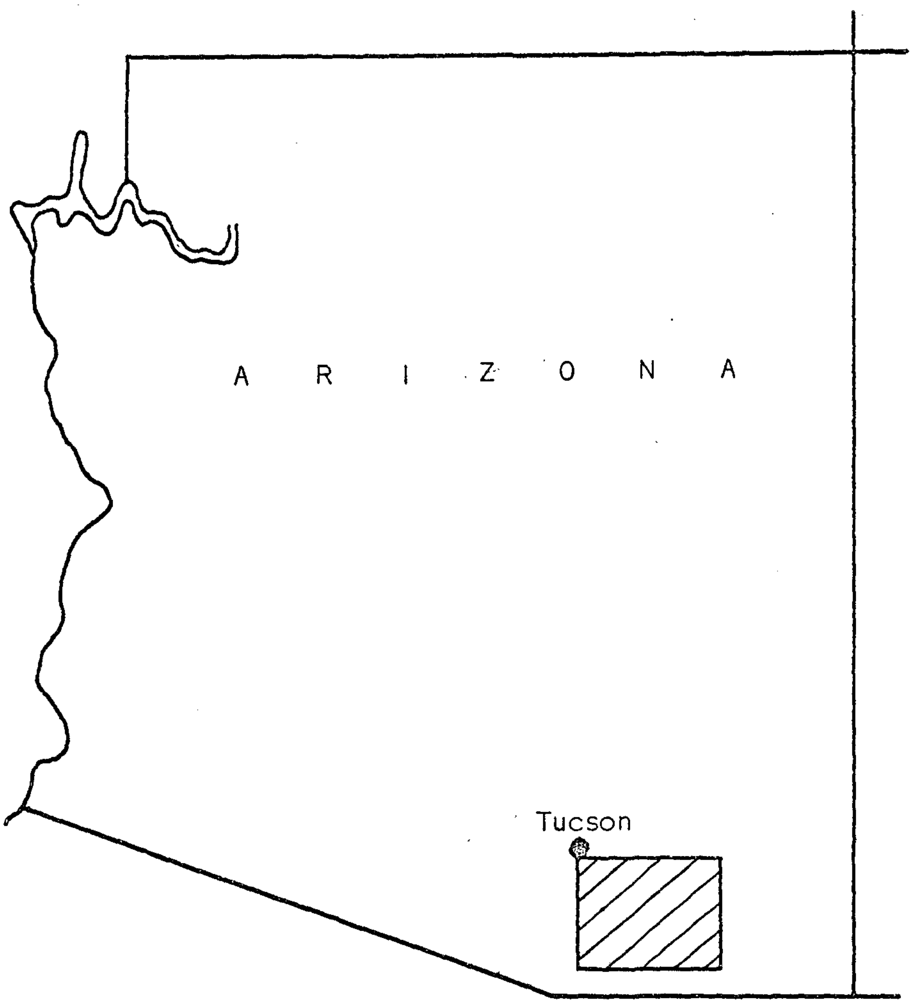

Figure 2. Terrain feature classes.

Elevation Classes

< 3000'
3000'-3500'
3500'-4000'
4000'-4500'
4500'-5000'
> 5000'

Aspect

1 - northeast
2 - north
3 - east
4 - northwest
5 - level
6 - southeast
7 - west
8 - south
9 - southwest

Solar Radiation Index

< 51 - low
51-54 - medium
> 54 - high

Landform Type

00 - landforms developed upon non-consolidated materials
01 - swale
02 - floodplain
03 - narrow floodplain
04 - alluvial terrace
05 - valley fill
06 - dissected valley fill
07 - lacustrine plain
08 - sand dunes
10 - undifferentiated bajada - non-dissected
11 - upper bajada
12 - lower bajada
13 - undifferentiated dissected bajada
14 - convex slope of dissected bajada
15 - midslope of dissected bajada
16 - interfluve
20 - landforms developed upon consolidated materials
21 - convex hillslopes
22 - upper middle hillslope
23 - middle hillslope
24 - lower middle hillslope
25 - concave hillslope
26 - interfluve
27 - drainageway
28 - pediment

Parent Materials

1 - alluvium
2 - sedimentary not incl. limestone
3.- limestone
4 - intrusive volcanics
5 - volcanics

Slope Angle

1 - < 1 1/2%
2 - 1 1/2 to 3%
3 - 3 1/2 to 10%
4 - 11 to 25%
5 - 26 to 50%
6 - > 50%

Drainage Density

< 5.0 - low
5.0-7.2 - medium
> 7.2 - high

based upon length of streams in miles in plots averaging 3.14 $miles^2$

Macrorelief

1.0 - Flat lands (regional slope < 10%)
  1.1 - nondissected
  1.2 - dissected (local relief < 10%)
2.0 - Rolling (slopes 10-25%) and moderately dissected lands
  2.1 - rolling (regional slope not apparent)
  2.2 - dissected (local relief 10' to 100', regional slope apparent)
3.0 - Hilly lands (local relief > 100', slopes > 25%)
4.0 - Mountainous lands (local relief > 1000', slopes > 25%)

on the photograph the horizontal distance between the two points. Stereoscopic observation enables the viewer to determine the spatial distribution of the slope segment.

Aspect is easily measured although problems arise in small-scale photography on account of the possible proximity of opposing slopes and their tendency to merge on the photograph.

A solar radiation value, used in this study, was extrapolated from slope angle and aspect since solar radiation is a function of those two variables. Five broad classes of parent materials were used in the study. More than half the study area was underlain by alluvium while the rest was divided more or less equally between non-alluvial groups: undifferentiated volcanics, igneous, metamorphic (nearly all metamorphics in the area are metamorphosed igneous), limestone, and other sedimentary not including limestone. These five parent material classes were chosen as representing a fairly wide cross-section of geologic environments. Most of the parent material classes are fairly readily interpretable on high altitude and space photography. Bedding, jointing, drainage patterns, associated landforms, tone, and texture are all used in the interpretation process. Interpretation keys and tests are being developed at our lab to determine the relative interpretability of those parent materials.

Landform types, likewise, are fairly easily interpreted. Classes of landform types were selected on the basis of environmental significance, facility for interpretation and acceptance by other geomorphologists. The landform type classes describe either the morphologic character of a particular surface, a morphogenetic character of a surface, or a relative position of that surface with respect to other similar surfaces. Closely related to these landform type classes are macrorelief classes. The concept of macrorelief entails the general gross relief of a local area. Units or classes of macrorelief with which to map areas having similar relief have been devised by our crew. Six classes were developed on the basis of slope angle, relative dissection, and local relief. Macrorelief is quite readily interpreted - we have determined this through experimentation on its degree of interpretability. Results are favorable with most interpreters having little difficulty separating major classes. It was also found that stereoscopic interpretation provides more favorable results than monoscopic interpretation of macrorelief on space photography.

Drainage density is the ratio of the total length of streams over the area of the sampled site. A combination of macrorelief and drainage density offers a fairly accurate picture of topographic texture and possibly relates to the degree of soil drainage and hence moisture availability. The (resultant) ratio appears to be more easily obtained and is more reliable if performed on highflight imagery than if performed on topographic maps. Studies performed in our lab have led us to that conclusion.

The area chosen for study was ground sampled in the following manner: the area was accurately stratified with respect to elevation categories of < 3000', 3000'-3500', 3500'-4000', 4000'-4500', 4500'-5000', and > 5000'. It was also stratified with respect to parent materials - the data being drawn from available geologic maps. The numbers of samples taken were chosen such that they were approximately proportional to their respective parent material-elevation area. If an elevation-parent material area were of such small size that proportional-to-area samples were less than three, the number of samples was raised to at least that figure. Locations of samples were chosen by the me author with consideration of access as a guide.

Environmental data on terrain feature variables as well as prominence and cover values of species were taken. In addition, soil samples were collected and soil color recorded.

Computer programs employing stepwise discriminant analysis (BMD07M) were extensively employed in that data analysis. This method has been successfully employed by ecologists wishing to establish measures of group similarity and distance of species. I used the programs in determining both individual species-terrain feature variable relationships and vegetation units-terrain feature variables relationships. As previously mentioned, species information and terrain feature variable information was collected by the author. Vegetation units or groups were determined by our research team utilizing data collected in the field over the past several years.

Stepwise discriminant analysis is a method whereby variables are analyzed in a stepwise manner to discriminate among groups of observations. Variables are either individual species or terrain features. Groups were either the vegetation units or individual terrain feature characteristics - occasionally two or more terrain feature characteristics would be combined to form groups. Stepwise discriminant analysis (in the cases where variables = species, groups = terrain features) tests the differentiating value of the character and differential species which characterize or identify groups. It explains the significance of each species and each group of individual species in the determination of pairwise differences among groups.

Runs comparing species to parent materials and species to elevation were performed initially utilizing all species. From these analyses, those certain species which were found to be the better discriminants were used in subsequent runs. Those runs included species-slope angle/aspect, species-landform type, and species-macrorelief/drainage density. Terrain feature variable-vegetation group runs were also performed.

Results obtained from those and related experiments indicate that there exists a set of species in southeast Arizona that is closely related to certain non-biotic environmental variables. Only a few species will be included in the following discussion of results. Figure 3 indicates the degree of species-terrain feature relationships for selected species discussed. Figures 4 through 7 illustrate the types of species-terrain feature relationships which were found to exist for selected species.

Some species were found which occurred only at certain elevation groups. Cercocarpus breviflorus (Figure 8 lists the common names of the species mentioned in this paper), Rhus choriophylla, Quercus hypoleucoides, Pinus cembroides, and Muhlenbergia montana are generally restricted to high elevations - above 5000'. Cereus giganteus, Cercidium microphyllum, Encelia farinosa, Franseria deltoidea, and Opuntia fulgida are generally restricted to low elevations - less than 3500'. Bouteloua rothrockii, Opuntia spinosior, and Prosopis juliflora are examples of species distributed more or less evenly throughout the elevational range of the study area.

Many species are associated with a specific parent material, some species with non-alluvial or alluvial parent materials, while others are not associated with parent materials. Agave palmeri, A. parryi, A. schottii, Cercocarpus breviflorus, Cowania mexicana, Eysenhardtia polystachya, Garrya wrightii, Heteropogon contortus, and Mortonia scabrella are examples of species generally restricted to non-alluvial parent materials. Cercocarpus breviflorus, Cowania mexicana, and Mortonia scabrella occur mainly on limestone. Arctostaphylos pungens occurs primarily on igneous parent materials. Atriplex canescens, Haplopappus tenuisectus, Larrea tridentata, Trichachne californica, and Yucca elata are generally restricted to alluvium. Bouteloua curtipendula, Opuntia

Figure 3. Degree of species-terrain feature relationships. Numerical entries 1 through 5 correspond respectively to values of poor, fair, moderate, good, and excellent relationships.

Species	Elevation	Parent Material	Aspect	Slope Angle	Solar Radiation	Landform	Macrorelief	Drainage Density
Acacia constricta	2	2	3	3	1	3	1	1
Agave pàlmeri and/or parryi	4	4	1	5	1	4	5	2
Agave schottii	5	4	3	5	2	5	5	1
Aloysia wrightii	3	4	1	5	1	4	5	3
Arctostaphylos pungens	4	4	2	4	1	3	4	2
Brickellia spp.	4	4	3	4	3	4	4	3
Calliandra eriophylla	3	1	3	3	3	2	3	2
Cercocarpus breviflorus	5	5	4	5	4	5	5	4
Cercidium microphyllum	5	2	5	2	4	3	1	5
Ferocactus wislizenii	3	2	5	3	3	2	2	2
Mimosa dysocarpa	4	1	4	5	3	4	4	4
Mortonia scabrella	4	5	3	5	4	5	5	4
Parthenium incanum	4	2	3	3	3	2	4	1
Prosopis juliflora	2	1	1	3	1	2	1	1
Quercus emoryi	4	4	4	4	3	3	4	4
Rhus choriophylla	4	4	4	4	4	4	5	4
Yucca elata	3	5	1	4	4	3	4	1
Bouteloua curtipendula	3	4	3	3	1	3	3	3
Bouteloua rothrockii	2	3	2	3	1	1	2	1
Hilaria mutica	3	4	3	4	4	4	4	4

Figure 4. Type of species-terrain feature relationships: elevation and parent material.

Species	Elevation[1]	Parent Material
Acacia constricta	tendency toward lower	not on volcanics
Agave palmeri and/or parryi	middle and upper	sedimentary & igneous
Agave schottii	upper middle	limestone & igneous
Aloysia wrightii	tendency toward middle & upper	tendency for limestone
Arctostaphylos pungens	middle & upper	tendency for igneous
Brickellia spp.	middle & upper	limestone & igneous
Calliandra eriophylla	lower & middle	no relationship
Cercocarpus breviflorus	upper	sedimentary, esp. limestone
Cercidium microphyllum	lower	alluvium
Ferocactus wislizenii	throughout, tendency to lower	alluvium
Mimosa dysocarpa	upper middle	no relationship
Mortonia scabrella	middle	sedimentary, esp. limestone
Parthenium incanum	middle & lower middle	alluvium
Prosopis juliflora	throughout, tendency to lower	no relationship
Quercus emoryi	middle & upper	igneous & volcanic
Rhus choriophylla	upper middle & upper	sedimentary, esp. limestone
Yucca elata	middle	alluvium
Bouteloua curtipendula	middle & upper	strong tendency toward hardrock
Bouteloua rothrockii	tendency toward middle	tendency toward alluvium
Hilaria mutica	lower & middle	alluvium

[1]/ Relative terms for elevation correspond to absolute values as follows: lower = < 4,000 ft., middle = 4,000-5,000 ft., and upper = > 5,000 ft.

Figure 5. Type of species-terrain feature relationships: aspect, slope angle, and solar radiation.

Species	Aspect	Slope Angle[1/]	Solar Radiation
Acacia constricta	tendency toward south	higher	no relationship
Agave palmeri and/or parryi	no relationship	higher	no relationship
Agave schottii	tendency toward south	higher	tendency toward higher
Aloysia wrightii	no relationship	higher	no relationship
Arctostaphylos pungens	tendency toward north	tendency toward higher	no relationship
Brickellia spp.	tendency toward north	tendency toward higher	tendency toward lower
Calliandra eriophylla	tendency toward south	tendency toward higher	tendency toward higher
Cercocarpus breviflorus	north	higher	lower
Cercidium microphyllum	south	tendency toward higher	higher
Ferocactus wislizenii	south	lower	tendency toward higher
Mimosa dysocarpa	south	higher	tendency toward higher
Mortonia scabrella	tendency toward north	higher	lower
Parthenium incanum	tendency toward south	tendency toward higher	tendency toward higher
Prosopis juliflora	no relationship	tendency toward lower	no relationship
Quercus emoryi	tendency toward north	higher	tendency toward lower
Rhus choriophylla	north	higher	lower
Yucca elata	no relationship	lower	middle
Bouteloua curtipendula	tendency toward north	tendency toward higher	no relationship
Bouteloua rothrockii	tendency toward north	tendency toward lower	no relationship
Hilaria mutica	tendency toward south	lower	middle to higher

1/ Slope angles of > 10% are considered "higher," while those < 10% are considered "lower."

Figure 6. Type of species-terrain feature relationship: landform.

Species	Landform Type [1]
Acacia constricta	tendency toward midslopes
Agave Palmeri and/or parryi	nonalluvial middle & upper-middle slopes
Agave schottii	nonalluvial middle & upper-middle slopes
Aloysia wrightii	nonalluvial middle slopes
Arctostaphylos pungens	tendency toward nonalluvial middle slopes
Brickellia spp.	nonalluvial middle slopes
Calliandra eriophylla	tendency toward slopes
Cercocarpus breviflorus	nonalluvial middle slopes
Cercidium microphyllum	tendency toward slopes
Ferocactus wislizenii	tendency toward slopes
Mimosa dysocarpa	nonalluvial middle slopes
Mortonia scabrella	nonalluvial middle slopes
Parthenium incanum	tendency toward slopes
Prosopis juliflora	tendency toward flat lands
Quercus emoryi	tendency toward slopes
Rhus choriophylla	nonalluvial slopes
Yucca elata	tendency toward flat lands
Bouteloua curtipendula	tendency toward slopes
Bouteloua rothrockii	no relationship
Hilaria mutica	flat lands

[1] See Figure 2 for discussion of landform types. "Slope" as used in this category refers to nonalluvial hills.

Figure 7. Type of species-terrain feature relationship: macrorelief and drainage density.

Species	Macrorelief Class[1/]	Drainage Density[2/]
Acacia constricta	no relationship	no relationship
Agave palmeri and/or parryi	3	tendency toward high
Agave schottii	3	no relationship
Aloysia wrightii	3	tendency toward high
Arctostaphylos pungens	tendency toward 3 & 4	tendency toward high
Brickellia spp.	3	tendency toward high
Calliandra eriophylla	tendency toward 3	tendency toward high
Cercocarpus breviflorus	3 & 4	mid to high
Cercidium microphyllum	no relationship	low
Ferocactus wislizenii	tendency toward flatter classes	tendency toward low
Mimosa dysocarpa	3	mid & high
Mortonia scabrella	3	low to mid
Parthenium incanum	2.2 & 3	no relationship
Prosopis juliflora	no relationship	no relationship
Quercus emoryi	tendency toward 3 & 4	mid to high
Rhus choriophylla	3	mid to high
Yucca elata	tendency toward 1.1	no relationship
Bouteloua curtipendula	tendency toward 2.2 & 3	tendency toward high
Bouteloua rothrockii	tendency toward flatter classes	no relationship
Hilaria mutica	tendency toward flatter classes	low to mid

1/ See Figure 2 for macrorelief definitions.

2/ See Figure 2 for drainage density determinations.

phaeacantha, and Prosopis juliflora occur over a wide variety of parent materials. Bouteloua curtipendula is almost ubiquitous on non-alluvial parent materials.

Some species were encountered which exhibited an affinity for certain landform types. Species which occur almost exclusively on hillslopes include Agaves, Arctostaphylos pungens, Brickellia species, Cercocarpus breviflorus, Mortonia scabrella, Rhus choriophylla. Hilaria mutica and Yucca elata are associated with undissected bajadas and alluvial plains. Other species, such as Acacia constricta and Prosopis juliflora do not appear to be restricted to a particular landform type or types, although Prosopis juliflora is nearly ubiquitous on floodplains and alluvial plains.

Species tended to exhibit a more positive relationship toward aspect when aspects are grouped into northerly or southerly components. Northerly aspects ranged from northwest through east, while southerly aspects ranged from west through southeast. Cercidium microphyllum, Ferocactus wislizenii, and Mimosa dysocarpa had a strong affinity for southerly slopes, while Cercocarpus breviflorus, Quercus emoryi, and Rhus choriophylla had a strong affinity for northerly slopes. Other species had a tendency, rather than a strong affinity, for one set of aspects over another.

Slope angle appears to play a more significant role in the distribution of species than does aspect. Agaves, Cercocarpus breviflorus, Mimosa dysocarpa, and Mortonia scabrella exhibit a strong positive relationship for steeper slopes (those slopes greater in declivity than 10% - although most of the above species occur above 25%). A few species including Hilaria mutica and Yucca elata exhibit a strong positive relationship for gentler slopes.

As previously mentioned, solar radiation is derived from aspect and slope angle measurements. None of the species studied exhibited an excellent relationship with solar radiation, although several species did exhibit good positive relationships toward it. *Cercocarpus breviflorus*, *Mortonia scabrella*, and *Rhus choriophylla* are associated with low solar radiation values, while *Calliandra eriophylla*, *Cercidium microphyllum*, and *Parthenium incanum* have a tendency to be associated with higher solar radiation values. *Yucca elata* is associated with moderate solar radiation values.

Species which exhibited the strongest relationship toward macrorelief (Figures 3 & 7) occurred on hills (i.e., macrorelief = 3). Examples include *Aloysia wrightii*, *Cercocarpus breviflorus*, *Mortonia scabrella*, and *Rhus choriophylla*. *Yucca elata* and *Hilaria mutica* are strongly associated with flat lands (low macrorelief values). A few species exhibited practically no positive relationship toward macrorelief. They included *Acacia constricta*, *Cercidium microphyllum*, and *Prosopis juliflora*.

Cercidium microphyllum showed a surprisingly strong positive relationship toward drainage density, occurring on sites having a low drainage density value. *Quercus emoryi* and *Rhus choriophylla* had a good positive relationship with drainage density, occurring on sites having a high drainage density value. Few other individual species had a good positive relationship with drainage density.

Vegetation groups-terrain feature variable relationships were studied using samples drawn from six vegetation types. Those types studied included a *Sporobolus wrightii* grass bottomland type, a *Hilaria mutica* grass bottomland type, a *Fouquieria splendens* shrub type, a Chihuahuan desert evergreen shrub (includes *Mortonia scabrella*) type, a juniper woodland type, and an emory oak woodland type. Results of stepwise discriminant analysis performed on these groups with terrain features as variables showed a highly significant separation of three pairs of groups, and a less significant separation of each of the pairs. The program results considered the *Sporobolus wrightii* grass bottomland type and *Hilaria mutica* grass bottomland type to be similar, the *Fouquieria splendens* shrub type and the Chihuahuan desert evergreen shrub type to be similar, and the juniper and emory oak woodland types to be similar. Macrorelief, drainage density, and elevation were determined to be the best discriminants separating the six vegetation groups.

SUMMARY

It has been determined that there exists positive relationships between certain plant species and certain terrain features. Not all species were found to exhibit positive relationships with all terrain feature variables, but enough positive relationships seem to exist to indicate that terrain feature variable-vegetation relationship studies have a definite place in plant ecological investigations. Even more significantly, the vegetation groups examined appeared to be successfully discriminated by the terrain feature variables. This would seem to indicate that spatial interpretations of vegetation groups may be possible.

While vegetational distributions aren't determined by terrain feature differences, terrain features do mirror factors which directly influence vegetational response and hence distribution. As a result, those environmental features which can be readily and rapidly ascertained on relatively small-scale imagery may prove to be valuable indicators of vegetation distribution.

Figure 8. Scientific and common names of plant species discussed in report.

Scientific Name	Common Name
Acacia constricta	whitethorn
Agave palmeri	agave
Agave parryi	agave
Agave schottii	amole
Aloysia wrightii	wright's lippia
Arctostaphylos pungens	manzanita
Atriplex canescens	four-wing saltbush
Bouteloua curtipendula	sideoats grama
Bouteloua rothrockii	rothrock grama
Calliandra eriophylla	fairy duster, guajilla
Cercidium microphyllum	foothill palo verde
Cercocarpus breviflorus	mountain mahogany
Cereus giganteus	saguaro
Cowania mexicana	cliffrose, quinine bush
Encelia farinosa	brittle bush
Eysenhardtia polystachya	kidneywood
Ferocactus wislizenii	barrel cactus, bisnaga
Fouquieria splendens	ocotillo
Franseria deltoidea	triangle bursage
Garrya wrightii	silk tassel
Haplopappus tenuisectus	burro-weed
Heteropogon contortus	tanglehead
Hilaria mutica	tobosa
Larrea tridentata	creosote bush
Mimosa dysocarpa	velvet-pod mimosa
Mortonia scabrella	sandpaper bush
Muhlenbergia montana	mountain muhly
Opuntia fulgida	jumping cholla
Opuntia phaeacantha	prickly pear
Opuntia spinosior	cane cholla
Parthenium incanum	mariola
Pinus cembroides	Mexican pinyon
Prosopis juliflora	mesquite
Quercus emoryi	emory oak, bellota
Quercus hypoleucoides	silverleaf oak
Rhus choriophylla	sumac
Sporobolus wrightii	sacaton
Trichachne californica	cottontop
Yucca elata	palmilla

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