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ERTS-1 IMAGE ENHANCEMENT BY OPTICALLY COMBINING DENSITY SLICES

Gerald O. Tapper and Robert W. Pease, *Department of Geography, University of California, Riverside, California 92502*

ABSTRACT

The technique of density slicing using a photographic film and its application to enhancement of ERTS-1 imagery has proved to be useful for mapping varigated areal phenomena and provides a useful supplement to the I^{2}S Mini-Addcol viewing system. The initial experiments conducted with this film were encouraging, and indicated that this technique of density slicing using readily accessible darkroom facilities and simple darkroom procedures allows rapid, accurate, and facile interpretation of certain areal phenomena to be made from the imagery. The distribution of the Tree Yucca, Yucca brevifolia Jaegeriana. In the Eastern Mojave Desert of Southern California and Southern Nevada was used as an example to test the accuracy of the technique for mapping purposes. The distribution was mapped at a relatively high level of accuracy.

1. INTRODUCTION

The technique of density slicing using a photographic film and its application for pre-enhancing ERTS-1 imagery in preliminary testing appears to be an effective tool for mapping varigated areal phenomena and provides a useful supplement to the I^{2}S Mini-Addcol viewing system. The test involved enhancement of selected ERTS-1 imagery (November 1972), out of the Las Vegas, Nevada region and eastern Mojave desert. Early difficulties in obtaining high resolution enhanced imagery from ERTS-1 MSS imagery by use of Diazochrome composites and initial interpretation from the 70 mm MSS chips in the viewer (Figure 1) led to experimentation with an equidensity film, Agfacontour Professional, to pre-enhance selected ERTS-1 MSS bands.

2. EQUIDENSITY FILM

Briefly, Agfacontour equidensity film is a black and white copy film, which at a specific exposure and development becomes transparent, creating a band or line of isodensity.[1] Caution is required during

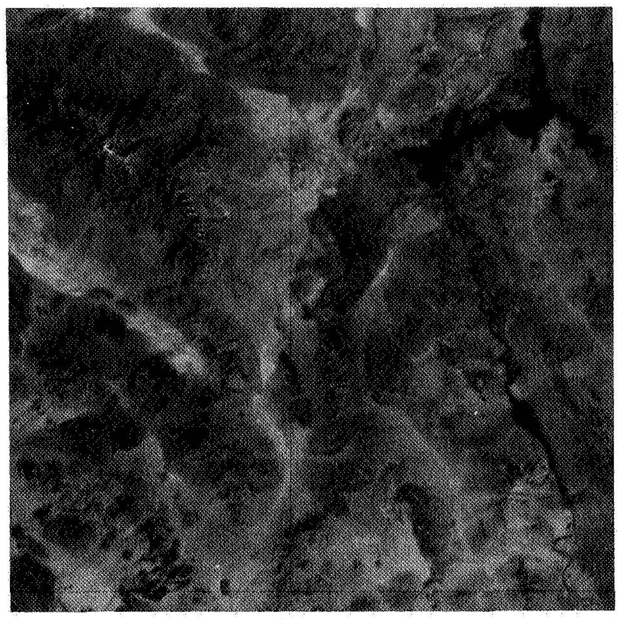


FIGURE 1: ERTS-1 Frame 1106-17495, Band 7, Eastern Mojave Desert of Southern Nevada and Southern California.

FIGURE 2: Density slice enhancement of ERTS-1 Frame 1106-17495.

exposure and development, and adequate control of both exposure and development is critical to obtain proper densities on the positive density slices. The underexposed and overexposed areas of the film adjacent to the transparent sector essentially remain black or opaque. The transparent portions of the image relate to a specific band of density on the negative and an areal representation of that density manifests itself on the positive equidensity film. The emulsion is blue sensitive, and the width of this band or thickness of the density slice can be varied by increasing or decreasing the amount of yellow filtration used during the exposure process. Only first generation equidensity of the ERTS-1 imagery were used in this study, and subsequent enhancements of the imagery should include second generation density slices. The above implies a procedure where by the first generation density slice is contacted onto a litho film and a subsequent density slice is taken from that negative. Perhaps even third generation density slices might be required to further enhance the image. Initial results indicate this technique of density slicing, using accessible darkroom facilities and procedures, allows rapid, accurate, and facile interpretation of certain areal phenomena. The distribution of the Joshua Tree or Tree Yucca, Yucca brevifolia (Jaeger variation)[2] in the Eastern Mojave Desert of Southern California, and Southern Nevada was used as an example to test the technique in terms of accurately mapping a minor element of the desert's environment.

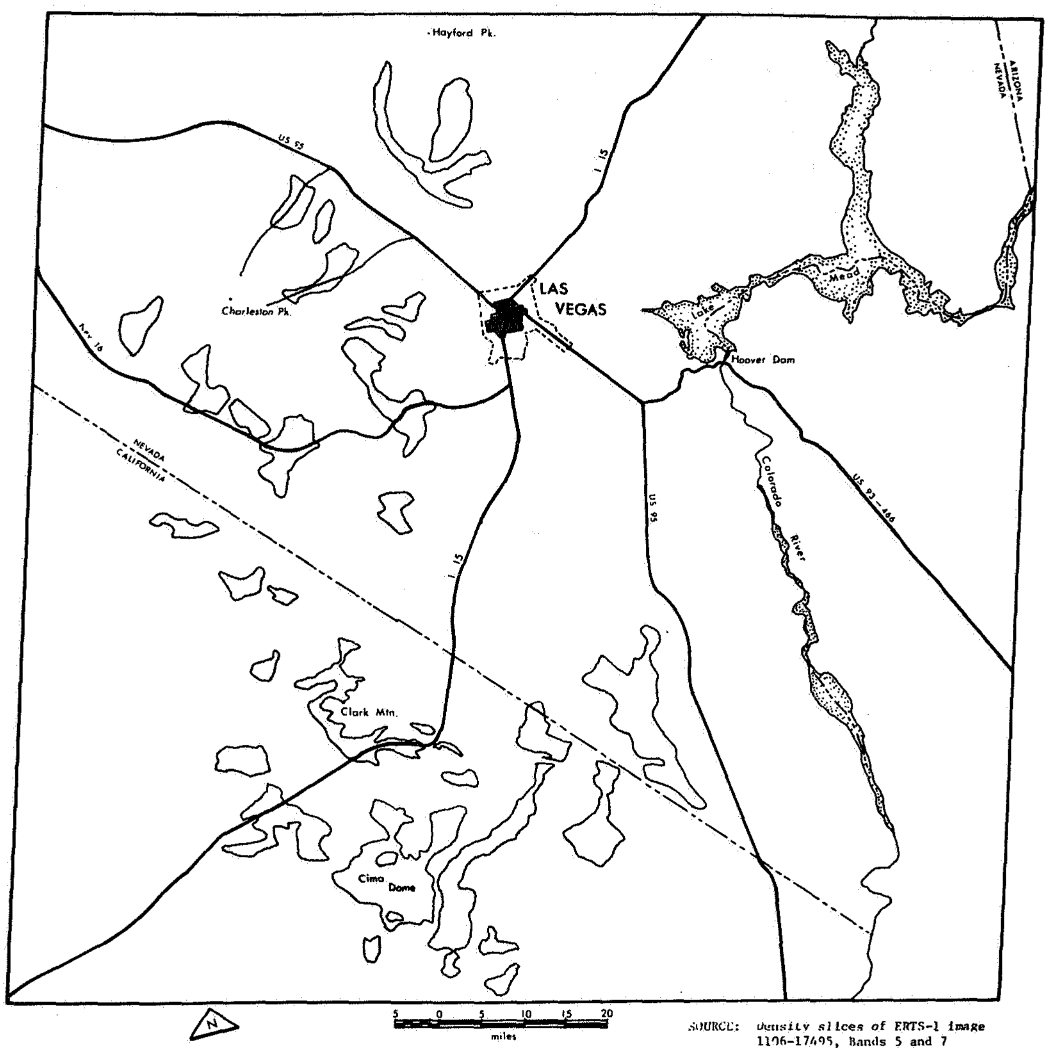
3. MAPPING OF YUCCA BREVIFOLIA JAEGERIANA[3]

The negatives of MSS Bands 5 (0.6-0.7 micrometers) and 7, (0.8-1.1 micrometers) of the Las Vegas region were used to produce various density slices on the equidensity film. The first step in this process was to determine the negative density of a predetermined concentration of Y. brevifolia Jaegeriana. Teutonia Peak or Cima Dome, a well known geomorphic feature in the Eastern Mojave, covered by a dense stand of Tree Yucca Y. brevifolia Jaegeriana, was used.[4] Once this density had been determined using a densitometer with a suitably small sensing spot, the equidensity film was exposed to isolate this preselected density. A series of different density slices were also extracted from the same negatives bracketing the above key density. The resultant density slices were than viewed in the combiner using various filter combinations. The result is an enhanced and mappable bispectral signature for an environment containing the Y. brevifolia (Figure 2). The enhanced density slice specifically depicting this environment was viewed through a green filter, the other three density slices used for the combination were projected through red, blue, and white (no filter) filters. It is felt that the green signature was most easily accommodated by the human eye for proper interpretive purposes. The areal expression of the environment containing Tree Yucca was then mapped from the combined enhanced imagery (Figure 3).

FIGURE 3

DISTRIBUTION OF

Yucca brevifolia Jaegeriana



SOURCE: Density slices of ERTS-1 image 1196-17495, Bands 5 and 7

4. FIELD CHECK OF MAPPED YUCCA BREVIFOLIA JAEGERIANA

Over a three day period the mapped distribution of Y. brevifolia Jaegeriana was field checked by the author.[5] This field check of the mapped data revealed a high correlation with the actual Yucca distribution. The field check also involved keying the vegetative community associated with it. This was done to determine more accurately the basis for the signature. With the exception of two sites, the mapped signature from the enhanced imagery was a location for the Y. brevifolia. Two exceptions were in areas where extremely high concentrations of another Yucca, Mojave Yucca or Yucca shidigera, was found in combination with an almost pure stand of Creosote Bush, Larrea divaricata. The morphology of mature Y. shidigera (which is quite similar to the Y. brevifolia in its juvenile form), when found in a vegetative community having a high density of the Creosote Bush as a similar signature on the imagery. The mapped locations were all indicative of Y. brevifolia Jaegeriana and its related community (Figure 4) but an inaccuracy was noted for the boundaries of each location. In all instances interpreter error on the boundary may result from the interaction of several related elements. Foremost of these is a change in topography from a low local relief fan surface to one of more rugged topography and high local relief. The key area for example, Cima Dome, where the initial sample density was determined, is a feature of low surface relief on the Mojave landscape. The density of the Y. brevifolia community as isolated on Cima Dome should apply only to other low relief features where the plant is present, i.e., upper portions of alluvial fans, old pediment surfaces, and some high elevation alluvial-filled valleys. These types of surfaces where the Tree Yucca community is present should provide similar physical characteristics of albedo, texture, slope, and exposure to the sensor, and thus would present a similar density on the density slice. Another group of factors influencing the determination of the boundary of the Y. brevifolia community is a change in the signature between the environment of one plant community and another.

Examination of the table (Figure 4) reveals that the signature mapped belongs to a vegetative community dominated by Y. brevifolia, Blackbush, Coleogyne ramosissima, and Burrograss, Scleropogon brevifolius. Note also that a group of minor species are nearly always found in association with the above dominants. These are Mormon Tea, Ephedra spp., certain varieties of Cactii, Opuntia spp. and Echinocerus spp., and Cheesebush, Hymenoclea salsola. Also, in certain sites, at lower elevations of ±1000 meters Y. shidigera becomes a codominant and is on other sites a minor species. Further tests need to be made to determine the degree to which plant associates other than the Tree Yucca contribute to the imagery signature.

Yucca brevifolia Jaegeriana and its Associated Vegetation

Site	Elevation	Dominant Species								Minor Species								
		Joshua Tree <u>Yucca brevifolia Jaegeriana</u>	Mojave Yucca <u>Yucca shidigera</u>	Fleshy-fruited Yucca <u>Yucca baccata</u>	Creosote bush <u>Larrea divaricata</u>	Blackbush <u>Coleogyne ramosissima</u>	Western Juniper <u>Juniperus occidentalus</u>	Piñon Pine <u>Pinus monophylla</u>	Grasses including Burrograss <u>Scleropogon brevifolius</u>	Joshua Tree <u>Yucca brevifolia Jaegeriana</u>	Mojave Yucca <u>Yucca shidigera</u>	Fleshy-fruited Yucca <u>Yucca baccata</u>	Creosote bush <u>Larrea divaricata</u>	Blackbush <u>Coleogyne ramosissima</u>	Cactii <u>Opuntia</u> spp. <u>Echinocereus</u> spp.	Mormon Tea <u>Ephedra funera</u> <u>Ephedra nevadensis</u>	Cheesebush <u>Hymenoclea salsola</u>	Unknown species (shrubs)
Ivanpah Mountains - 1	3340'	x	x		x				x			x			x	x	x	
Ivanpah Mountains - 2	3930'	x	x						x			x	x		x	x		
Ivanpah Mountains - 3	4640'	x									x	x	x		x	x	x	
Teutonia Peak - Cima Dome	5200-4100'	x						x	x		x	x	x		x	x		
Piute Valley - 1	<3000'		x		x				x					x				
Piute Valley - 2	3000-4500'	x				x			x		x				x	x	x	
Lanfair Valley	4200'	x							x		x		x	x	x	x	x	
Halloran Summit - 1	4000'	x		x		x			x		x		x		x	x	x	x
Halloran Summit - 2	3700'	x	x		x	x			x			x			x	x	x	
New York Mountains	3200-4200'	x		x	x						x				x	x		x
Nipton	3200'	x	x		x				x			x			x	x	x	
Ivanpah - 1	<3000'		x		x				x	x				x	x			•
Ivanpah - 2	>3000'	x			x				x		x	x			x	x	x	
Clark Mountains - 1	>4000'	x							x		x			x	x	x	x	x
Clark Mountains - 2	4500-3200'	x	x	x	x		x	x	x					x	x	x	x	
Cottonwood Valley - 1	<3000'		x		x				x						x		x	
Cottonwood Valley - 2	3000-4100'	x				x			x		x		x		x	x	x	
Cottonwood Valley - 3	>4100'		x	x		x			x						x		x	
Lovell Wash - 1	>4500'	x					x	x	x		x		x	x	x		x	x
Lovell Wash - 2	3200-4500'	x							x		x	x	x	x	x	x	x	
Lovell Wash - 3	<3200'		x		x	x			x						x	x	x	x
Wheeler Fan - 1	3100'	x	x	x	x	x			x						x	x	x	x
Wheeler Fan - 2	3760'	x							x				x		x	x	x	
Wheeler Fan - 3	6200'	x					x	x	x						x	x	x	
Kyle Canyon Fan - 1	<3000'	x	x		x				x					x	x	x	x	
Kyle Canyon Fan - 2	3000-6000'	x				x			x		x					x		
Kyle Canyon Fan - 3	<6000'	x					x	x	x		x					x		x
Yucca Forest	4500-6500'	x				x			x		x		x		x	x	x	
Las Vegas Mountains	3500-4800'	x				x			x		x		x		x	x	x	
Pine Springs - 1	3200-3400'	x	x		x				x						x	x	x	
Pine Springs - 2	3500-4100'	x			x				x						x	x	x	x
Red Rock Valley	3000-3600'	x	x	x					x				x		x	x	x	
Goodspring Valley	3200-4400'	x	x		x				x					x	x	x	x	x

FIGURE 4

5. CONCLUSIONS

To reiterate, the technique of pre-enhancing ERTS-1 MSS 70 mm chips with an equidensity film has greatly enhanced the utility and application of the imagery. The density slicing technique also provides a useful supplement to the I^2S Mini-Addcol Viewing System, especially for mapping discrete varigated phenomena. It would be almost impossible to map this specific environment from the standard ERTS-1 chips alone, although a fairly good approximation could be made by a Biogeographer familiar with the region.

The technique should not be viewed as final however, since its full potential has not yet been realized. A further test of the technique might include mapping all the various vegetation environments in the Mojave, something which, when considering the facility with which *Y. brevifolia* was mapped, could be done with small inputs of interpretation time.

Density slicing of ERTS-1 imagery as realized from this technique has the potential for increasing the interpretability and use of the imagery and can provide the user with environmental data not easily obtained with other technology. The technique can contribute to studying various physical and cultural environments, and can be used to map their areal signatures at a high level of confidence.

6. FOOTNOTES

[1] Ranz, E. and E. Schneider (1970), "Der Äquidensitenfilm als Hilfsmittel bei der Photointerpretation," *Bildmessung und Luftbildwesen*, 2: 123-134.

[2] Jaeger, Edmund C. (1968), *Desert Wild Flowers*. Stanford: Stanford University Press.

[3] *Yucca brevifolia Jaegeriana* is a smaller, shorter leafed variety of the Joshua Tree, *Yucca brevifolia*, Jaeger, 1968, p. 15.

[4] Huning, J. R. and R. M. Petersen (1973), "Use of *Yucca brevifolia* as a Surrogate for Detection of Near-Surface Moisture Retention," *NASA Technical Report N-71-1*, Department of Geography, University of California, Riverside.

[5] The author would like to acknowledge the able assistance of Jack B. Bale in conducting the field check and in keying the various species of vegetation at each site.