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DYNAMICS OF PLAYA LAKES IN THE TEXAS HIGH PLAINS

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ABSTRACT

This study shows that satellite imagery can be used for a census of the thousands of lake basins which commonly exist in semi-arid areas, and which sporadically contain water at various times of the year. Storm paths and runoff collected by such lake basins can also be closely monitored, the accuracy dependent on periodicity of the orbits and the size of the basins. Study of the relationships between spectral differences (obtained from ERTS-1 imagery) and the water balance ecosystem of the lake basins is in a preliminary stage. However, examination of ERTS-1 MSS frames show that Band 4 has the poorest tonal contrast in semi-arid West Texas, Band 5 is best for definition of vegetation, Band 6 is best for defining large water areas, and Band 7 is best for counting small lake basins with water.

Ground-truth studies reveal significant differences between the test sites, the relative importance of which will be reflected by the hydrologic balance of each lake basin.

1. INTRODUCTION

The study area covers approximately 30,000 square miles of the southern High Plains of West Texas and eastern New Mexico (Fig. 1), extending from the Canadian River Valley on the north to the Edwards Plateau on the south. East and west boundaries are marked by high caliche escarpments. In this area three small playa lake basins, considered typical of the tens-of-thousands of lake basins which pockmark the area, were originally selected as ERTS-1 study sites, a fourth larger basin complex typical of the large lake basins of the area being added after receipt of the first imagery. Objectives were: 1) to study the water budget of the lake basins, 2) to relate spectral differences obtained by ERTS satellite photography to the water balance ecosystem and geology of the basins, 3) to extrapolate these integrated

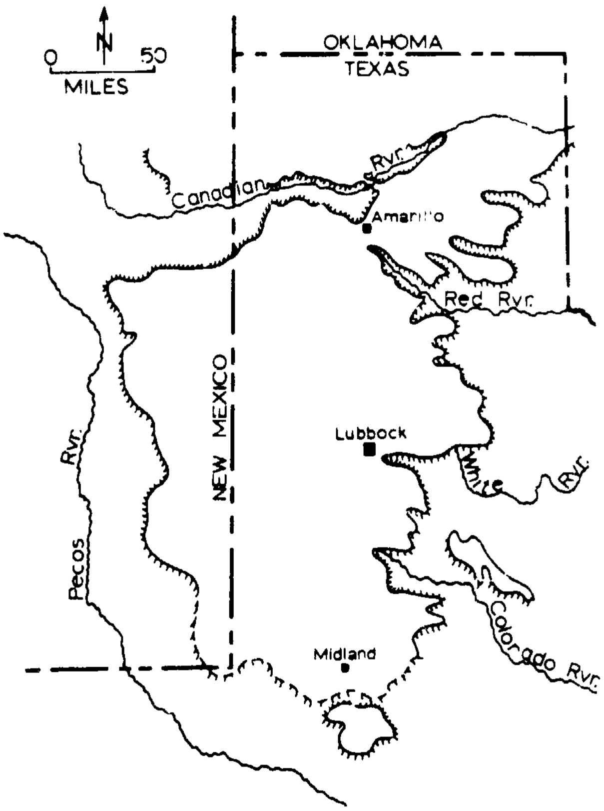

Figure 1 - Index of the southern High Plains.

data to other such lake basins on the Plains and, 4) to correlate space-acquired signatures to soils, soil moisture, geology and plants.

The original PI, Dr. W.D. Miller, was killed in a tragic accident June 22, thus, in addition to the ground truth studies and photo interpretation, I assumed responsibility of keeping up with the "intermittent" paper work. The project has also been plagued by weather. Out of 11 passes through January 1973, only 5 have been usable: we have received only 4 of those. However, the detrimental climatic events have been yielding an unusual wealth of hydrologic data.

2. APPROACH

Ground truth of the three small playa basins was secured during the summer of 1972, and ground truth studies are still underway at the large study site. This data consists of: 1) soil surveys, 2) vegetation surveys, 3) geologic surveys, and 4) water balance studies.

The three basins, each covering approximately 10,000 square meters, and the three playas each covering approximately 1000 square meters, were staked on 100 m grids. Soil scientists, using a power probe and soil auger, took cores or samples to -6 feet at each intersection. Intersections, starting in the present playas, were drilled by power flight-auger until the strand lines and thickness of the lacustrine sediments were defined. Each basin was cored in the deepest spot. Vegetation studies (contributed to the program by an outside investigator) are being conducted by 10 x 10 m grid sampling over an 800 m grid square. The large basin, (Fig. 2), consisting of a dual playa complex 5 miles long in a 9 square mile basin, is not being studied in such detail, although a geologic map, soil survey, and subsurface maps are being constructed. The water balance in one of the small basins and in the large playa complex is monitored by checking rainfall, runoff, infiltration (by tensiometers) and evaporation. Figure 3 illustrates the weather monitoring set up at small T-Bar playa, ERTS-1 test site No. 3.

3. PRELIMINARY RESULTS

No results are yet available from the vegetation or water budget studies. Soil and geologic studies are complete at the three original sites and still underway at the large Double Lakes site. Work to date, using bulk positive 9 x 9 transparencies with optical magnification and density slicing, shows that Band 4 has the poorest tonal contrast, but is best for defining cities and highways. Band 5 is best for definition of vegetation, Band 6 is best for defining large water areas and Band 7 is best for counting the small lake basins with water.

Ground-truth studies show that the three small playa basins, although similar appearing, actually have many differences, and these differences are going to affect the water balance. For example, the present playa and fringing soils at Site #1 (Heard) are underlain by up to 25 feet of

Figure 2 - Aerial view of North Double Lake,
Lynn County, T(~as. South Double
Lake in backgrc nd. Star indi-
cates location uf instrumentation.

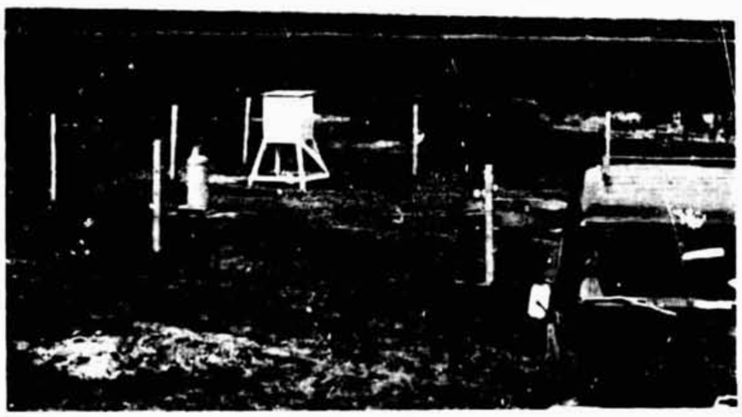

Figure 3 - T-Bar study site with weather
monitoring instrumentation.

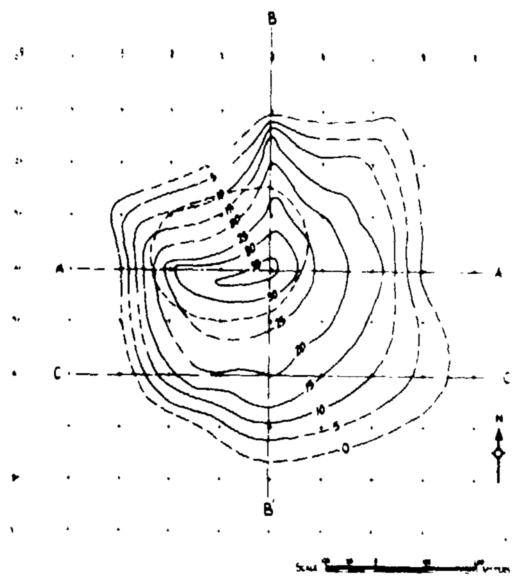

Figure 4 - Isopachous map lacustrine sediments at ERTS study site No. 1 (Heard playa). Dotted line marks present playa shape.

lacustrine clay which accumulated in a playa 4 times the size of the present playa (Fig. 4), but at Site #3 (T-Bar) the present playa marks the maximum extent of the lacustrine fill.

All of the small basins are underlain by the Pliocene caliche, the caliche exhibiting "excavations" in which the lacustrine fill collected (Fig. 5). This indicates that the basins resulted from undulations in the Pliocene surface on which the caliche formed, or that significant solution of the upper part of the caliche has occurred beneath the basins, location having nothing to do with the caliche. The former possibility appears more likely in light of other field studies of similar basins.

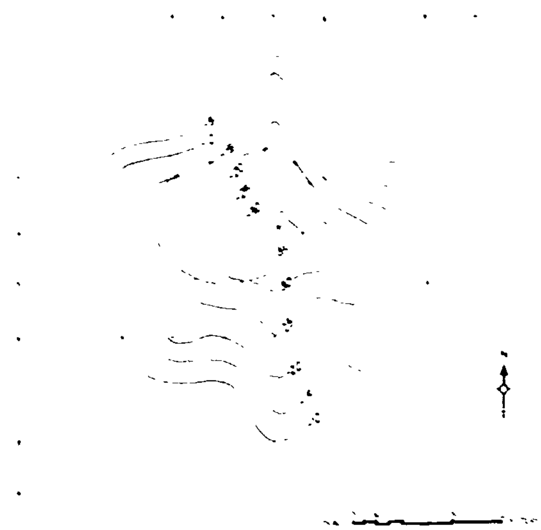

Figure 5 - Structure map on top of Pliocene caliche at ERTS-1 study site No. 1 (Heard playa).

On the other hand, preliminary ground-truth at the large Double Lakes site shows that the present playa is formed on and adjacent to a Cretaceous topographic high and that older lacustrine clays overlie permeable Ogallala sands which constitute the regional aquifer. Thus, the poor quality water area in the aquifer downdip from the Double Lakes site (and this is always the case downdip from other similar large basins in the area) is probably due to infiltration of runoff through saliferous lacustrine sediments or infiltration of saline water from the present playa. We will, hopefully, be able to pinpoint this trouble when we correlate water fluctuations measured from ERTS imagery with water balance data.

The workable resolution of the imagery has presented problems. An optical resolution of about 10 m was determined for high contrast linear objects on bands 6 and 7.

Figure 6 - Double Lakes and T-Bar ERTS-1 study sites, Lynn County, Texas. Notice resolution difficulties of measuring water extent at T-Bar site (arrow) but how water extent is imaged at North Double Lake. From SRI TV monitor.

However, vegetation surrounding the three small playas, which range from 200 to 400 m in diameter, reduces contrast between the water and vegetation in the playas. Thus, although the playas are resolvable, the measurement of changes in water area, even when magnified, have not been possible with any confidence. However, water fluctuations in both playas of the Double Lake site are easily measureable. For example, on the 29 July pass South Double Lake had a water area of 1.54 km^2 and North Double Lake a water area of 1.62 km^2. Figure 6 illustrates the water area of the Double Lake site from the 9 October pass. Notice in the north playa how the water shallows to the north, the wet mud and dry parts of the playa having signatures distinct from the flooded part.

Various soil signatures in the three small lake basins are not apparent on the imagery, although the difference in basin soils which have a higher reflectivity from surrounding eolian sands is noticeable. However, in the large

Double Lake site several soils are exhibiting spectral signatures. For example, the Drake and Porter soils have a high reflectance, the Randall is opaque to white, and the surrounding Brownfield and Amarillo range in between. Enhancement by density slicing vividly emphasizes these differences in reflectivity.

In areas of dense vegetation, such as the sorghum fields in the northern half of 1007-16575, water filled lake basins cannot be distinguished on the transparencies on Band 5 because of lack of contrast between the vegetation and water signatures. However, on Bands 6 or 7, vegetation no longer appears opaque and the water-filled lake basins stand out.

4. BENEFITS

Regional scanning of the ERTS transparencies shows that the number of lake basins containing water on the southern High Plains, at any image time, can be counted. Offhand, this does not seem to be much of an advantage, but when you realize that we are talking about ±20,000 lake basins, it has here-to-fore been impossible from monetary, manpower, and time considerations, to take a regional "wet" census. For example, in an area of approximately 40 sq km on scene 1006-16522, 353 small playa lake basins contain water, and the count could be as high as 447. A total of 6631 playas contain water in the entire scene. Such a census is of great significance in any semi-arid area to determine how much water is available for artificial ground-water recharge, or for irrigation, at various times of the year.

Individual storm tracks can also be identified and the number of lake basins filled by such isolated storms can be counted. ERTS-1 scene 1006-16522 of 29 July, 1972, images a northwest-southeast trending storm path which skirted the southwest part of Lubbock. This isolated storm cell, with tops to 25,000 feet and a diameter of 2.4 km when spotted by radar at 1940 GMT 62 miles northwest of Lubbock, was moving to the southeast. The wetted path measures from 2 to nearly 5 km wide and extends for 38 km across the image. At least 347 small playa basins within this storm path contain water (on the image), but unfortunately antecedent conditions were not imaged. However, many dry playa basin immediately to either side of the storm path suggest that the basins containing water in the storm path were filled by the storm.

Subsidiary benefits not connected with this study are, to date, the conformation of previously observed regional lineaments, the local alignment of the playa lake basins, and the discovery of new lineaments. Crop signatures are distinctive and, I suspect, identifiable (see Marion Baumgardner's report, LARS, Purdue University). Grassland signatures are separable from cultivated land signatures.

Quantitative measurements of density profiles across the test sites and correlation of water depths with CCT data will be investigated in the next few months. During the coming summer, with a year's hydrologic data on hand, the relationships between the ERTS-1 spectral signatures, vegetation, lake level fluctuations and water balance of the test sites will be determined.