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APPLIED REMOTE SENSING PROGRAM (ARSP)

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Third and Fourth Quarter Report of LANDSAT Investigation
#23610

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For the Period

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In cooperation with

local, regional, state, and federal agencies
within the State of Arizona

23610

PROGRESS REPORT

Objectives of Investigation #23610

The objective of LANDSAT investigation #23610 is to establish through joint projects, centers of remote sensing competence and awareness in local and state agencies. To accomplish this objective, various applied remote sensing projects have been initiated with state agencies and/or rural county governments.

As reported in the second quarter report, land use studies have been initiated with four rural Arizona counties (Apache, Graham, Yavapai, and Yuma). This progress report gives the final products derived and utility of the information for the Yuma county planning department. The final report will detail the remaining county work.

Yuma County Project Background

Recent state and federal legislation has made the mapping of flood prone areas mandatory for federal flood insurance purposes. This coupled with the continued pressure for development of floodplains prompted Yuma County to seek maps of flood prone areas and current land use.

Local governmental planning agencies have traditionally regulated the design of new subdivisions by adoption of local regulations which sometimes require (among other considerations) minimum drainage design criteria. Due to passage of the mandatory floodplain regulations at the state level, local planning agencies are now faced with the task of the delineation of floodplains. Remote sensing systems offer a dynamic resource inventory system which can be used to complement traditional detailed studies or serve as an important source of information in regions where detailed studies are not available. In Yuma County remote sensing techniques have provided hydrologic information in areas where planning had been hampered by the lack of suitable hydrologic data. The County Planning Department can now, with only limited funds and manpower, guide development more wisely away from flood prone areas.

Methods and Procedures for Floodplain Delineation

An area along the lower Colorado and Gila Rivers were selected as priority areas for intensive floodplain mapping. Parameters for selecting priority areas were those areas of special interest to the county planning staff and the combination of areas of imminent or ongoing development and areas known to be subject to inundation by storm runoff.

"Priority areas" refer to entire watersheds or significant portions thereof. Very little data were available on the watershed characteristics and stream flow of the priority areas and the information available from various sources was not in agreement regarding boundaries. Existing data were therefore used only for backup and cross reference for the remote sensing-derived-watershed and flood boundaries.

The use of remote sensing for drainage pattern and watershed configuration analysis necessitates the examination of soil color, texture, image appearance, and vegetation. Field checking served as the main backup to the interpretations.

Soils

A USDA, Soil Conservation Service General Soils Map is of considerable use in floodplain delineations. Soils associated with channels and low terraces are young with little or no subsurface development. The B horizon, an area of illuvial clays and blocky structure that is typical of older, more mature soils, is not present in low terrace and channel soils. These soils have a very high reflectance on LANDSAT MSS 4, 5, and 6, and color infrared photographs. The general soils map of the four counties delineate these soils as a Torrifluvents and River Wash Colluvium Association. Field checking can therefore be held to a minimum by using a General Soils Map as a reference.

Areas of periodic inundation, the so-called 25, 50, and 100 year flood events, are also associated with young soils that lack B horizon development. However their reflectance on LANDSAT bands 4, 5, and 6, and color infrared photographs has a darker tone than the channel and low terrace soils and they can be readily identified and mapped separately.

In areas of overgrazing the loss of vegetation combined with a slope of 2 or 3 percent results in sheet flow erosion. This is caused by water coalescing into a "sheet" that may be several hundred meters wide and 10 to 20 centimeters deep. This erosion strips off the surface soil to varying depths. Sheet flow causes a very light reflectance on LANDSAT bands 5 and 7 and color infrared photographs. This tonal reflectance is different from the reflectance received from floodplains and channel soils making it possible to map boundaries of past flood events of various magnitudes using the reflectance received from all 3 soil types.

Geomorphology

The LANDSAT color infrared imagery (bands 4, 5, and 7) were used to compile a watershed map of the priority areas. The imagery was used in the form of 70 mm chips for enhancement in a color additive viewer and in all available enlargement modes. The transparencies were viewed in color enhancement and on the light table in order to construct a map of watershed configuration at a scale of 1:62,500. Drainage patterns and erosional features interpreted from LANDSAT imagery at 1:250,000 was found to be nearly equal in accuracy to the output of a similar analysis of the high-altitude color infrared transparencies.

Vegetation

Vegetation was useful in mapping flood prone areas. Dominant vegetation types for a given area are associated with soils, moisture, and climate. The vegetation analysis consisted of two parts.

1) The classification of vegetation (Table 1)
2) The determination of percent cover.

High altitude aircraft photography at a scale of 1:120,000 and LANDSAT imagery at a scale of 1:500,000 were employed in mapping the vegetation. The aerial photography was necessary for the detailed delineations of smaller channels.

Vegetation cover is important in determining direct runoff, as the greater the vegetation cover, the less the runoff. "Cover density" (vegetation cover) is defined as the percent of ground surface covered by the crown canopy of plants and plant litter. The Arizona Highway Department procedure used in the study calls for three broad ranges of cover:

1)	poor	0 - 20% cover
2)	fair	20 - 40% cover
3)	good	more than 40% cover

The parameters for the analysis procedure were: soils, geomorphology, vegetation, and hydrologic calculations. Past experience has shown that the combination of these methods provides an effective and reliable means of delineating areas subject to periodic inundation.

Analysis of hydrologic characteristics, watershed configurations, drainage patterns, and vegetation were conducted using data in a step-down procedure from LANDSAT and high altitude aircraft flights. LANDSAT imagery was used at scales of 1:1,000,000, 1:500,000, and 1:250,000. High altitude aircraft color infrared imagery was used at scales of 1:120,000 and 1:60,000.

Table 1. General Vegetation Classification of the Study Area

Desert Brush - includes mesquite, creosote bush, catclaw, ocotillo, and numerous species of cactus. Cottonwood, willow, and tamarisk trees occur along the larger stream channels. Desert brush is typical of lower elevations and low annual rainfall.

Herbaceous - typical grasses include: grama grasses, three-awn, sacaton, lovegrass, and muhly. Common shrub species found include: whitethorn, snakeweed, burro weed, agave, mesquite, and assorted cacti.

Mountain Brush - includes mixtures of oak, aspen, mountain mahogany, manzanita, bitter brush, maple, etc. This group is typical of intermediate elevations and generally higher annual rainfall than herbaceous areas.

Juniper/Grass - includes mixtures of juniper, oak, and walnut, with various grasses that are generally denser than desert grasses due to higher annual precipitation. The Juniper/grass association with a less dense canopy relative to Mountain Brush is typical of higher elevations.

Ponderosa Pine - Ponderosa pine forests are typical of higher elevations and higher annual precipitation. They are generally found above 6500 feet.

Vegetation cover was estimated by imagery analysis and field checking. The ground-checked interpretation confirmed a close agreement between areas designated as flood hazard zones on the basis of vegetation analysis and those generated by hydrologic calculation.

While photointerpretive techniques based on vegetation analysis are highly useful for floodplain mapping in semiarid situations, ground observation or low altitude oblique views are important for refinement of the mapping. Assessment of tree condition in and near channels has a potential as a data source. Examination of riparian growth by infrared photographic methods in a low-altitude oblique mode offers the possibility of partial elimination of ground-checks and the capability of coverage of large areas in a shorter time.

An additional vegetation-related factor which is worthy of inclusion in the analytical process is flood-deposited debris. This means of establishing high-water limits is obviously limited to ground-check observation, unless the debris is of considerable magnitude. This part of the vegetation-based method overlaps to some extent the historic data method.

Hydrologic Calculation

The procedures used in making the hydrologic calculations were basically those of the U. S. Department of Agriculture Soil Conservation Service (SCS), National Engineering Handbook, Section 4 Hydrology. A detailed, step-by-step process is presented in the SCS publication.

Hydrologic calculations were done based on valley cross-sections surveyed at two-to-three-mile intervals, and on the parameters include in the SCS discharge equation:

$$Q_p = \frac{484\ A\ Q}{\frac{D}{2} + .6T_c}$$

Where:

Q_p	=	peak discharge in cfs
A	=	drainage area in mi^2
Q	=	storm runoff in inches
D	=	storm duration in hours
T_c	=	time of concentration in hours

484 is a constant for units used

Values for variables in the previous equation were determined using curves in the SCS handbook. Data used in the curves were determined by analysis of remotely sensed imagery with ground-check coordination. One of the variables of obvious significance is drainage area; as stated previously, this data was not available for most of the counties. The watershed map, which was one of the early products of this study, provided figures for drainage area. Time of concentration, which is the time required for water falling on the most hydrologically remote portion of a watershed to reach the point of concentration or discharge, was also obtained during the delineation of drainage patterns. Two additional factors which are necessary in order to obtain values for the component variables in the SCS equation are "curve number" and "soil hydrologic group." These values are the product of a complex set of relationships between four basic factors: (1) climate, mainly rainfall and temperature; (2) soil, its resistance to erosion and rate of water intake; (3) topography, length and incline of slope; and (4) vegetation canopy. Soil hydrologic groups, as defined by the Soil Conservation Service, are based upon the capacity of a soil to transmit water when the soil is in a saturated condition. A high rate of water transmission is associated with low runoff potential.

Soil hydrologic groups and curve numbers were evaluated using LANDSAT 70 mm chips in color infrared enhancement and high-altitude color infrared photographs in stereovision at 3x magnification. The bases for these interpretations were general slope class, soil reflectance as an erosion indicator and apparent density and condition of vegetation cover. Estimates of hydrologic groups were found to be in agreement with soil type-hydrologic group placements determined by SCS in most (approximately 85 percent) of the areas observed.

Floodplain lines generated by hydrologic techniques were assumed to be correct and delineations made based upon the various photointerpretive methods were measured against these lines. The confidence level with which one could interpret flood ways on the remotely sensed imagery far surpassed previously used hydrologic methods in delineating areas known to be subject to flooding.

Remote Sensing Products

Yuma County, in the extremely arid southwestern corner of the state, shares in the problems of other rural jurisdictions: rapidly changing patterns of land use--some of it in areas environmentally unsuited for development, and very little data upon which to base planning decisions or long-range planning objectives. The development of land use overlays (Figure 1) as documented above was necessary in order to provide the county planning staff with basic, up-to-date locational data. A continuing problem in southern Yuma County is the subdivision of prime agricultural property along the Gila River. The net effects of this situation are the removal of land from production and the placement of development in the easily developable, but flood prone valley of the Gila. By identifying flood hazard areas (Figure 2) much of this land can be zoned for agricultural and related uses, thus being maintained in production without the threat of land speculation.

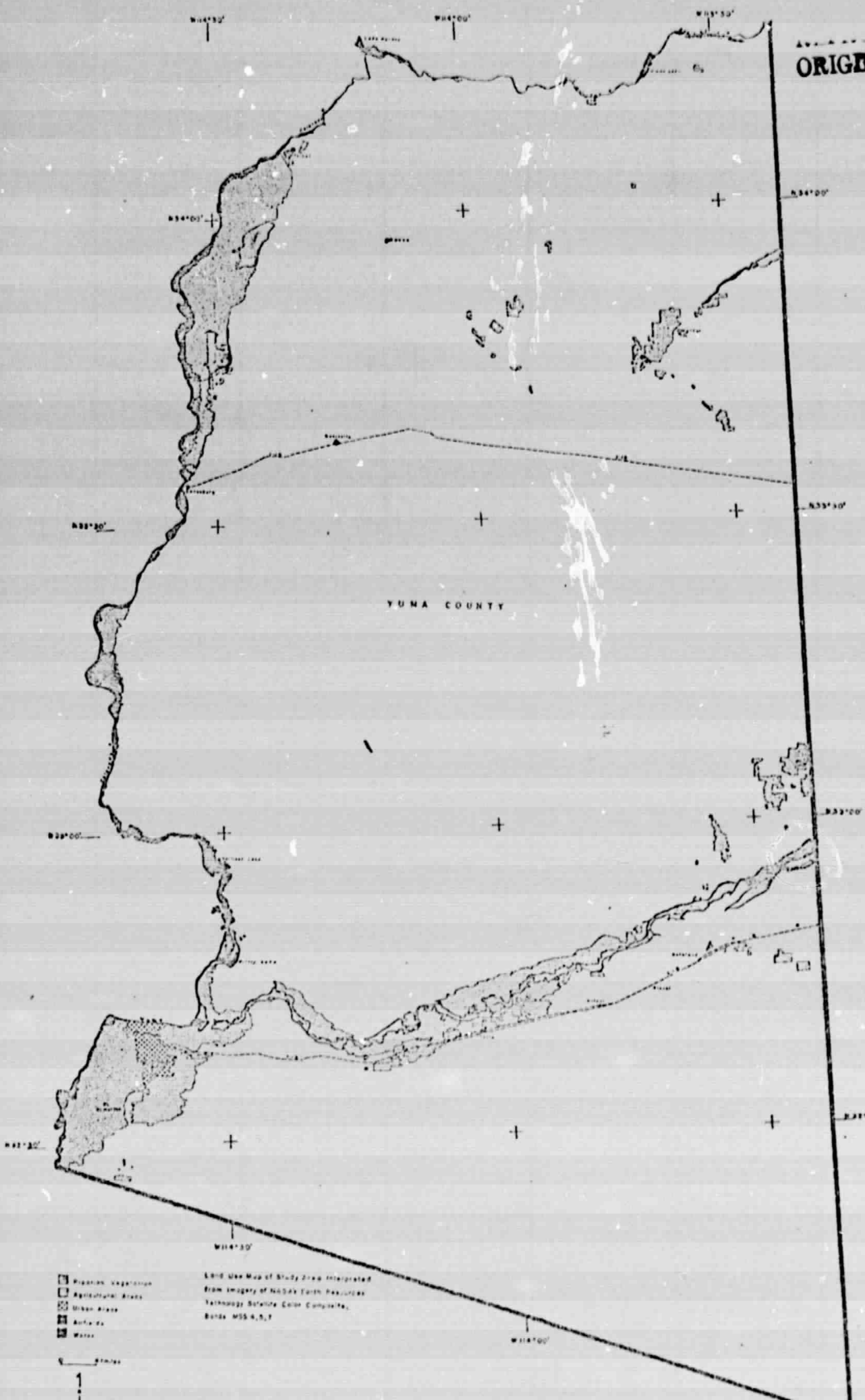

Figure 1. Yuma County Land Use Map

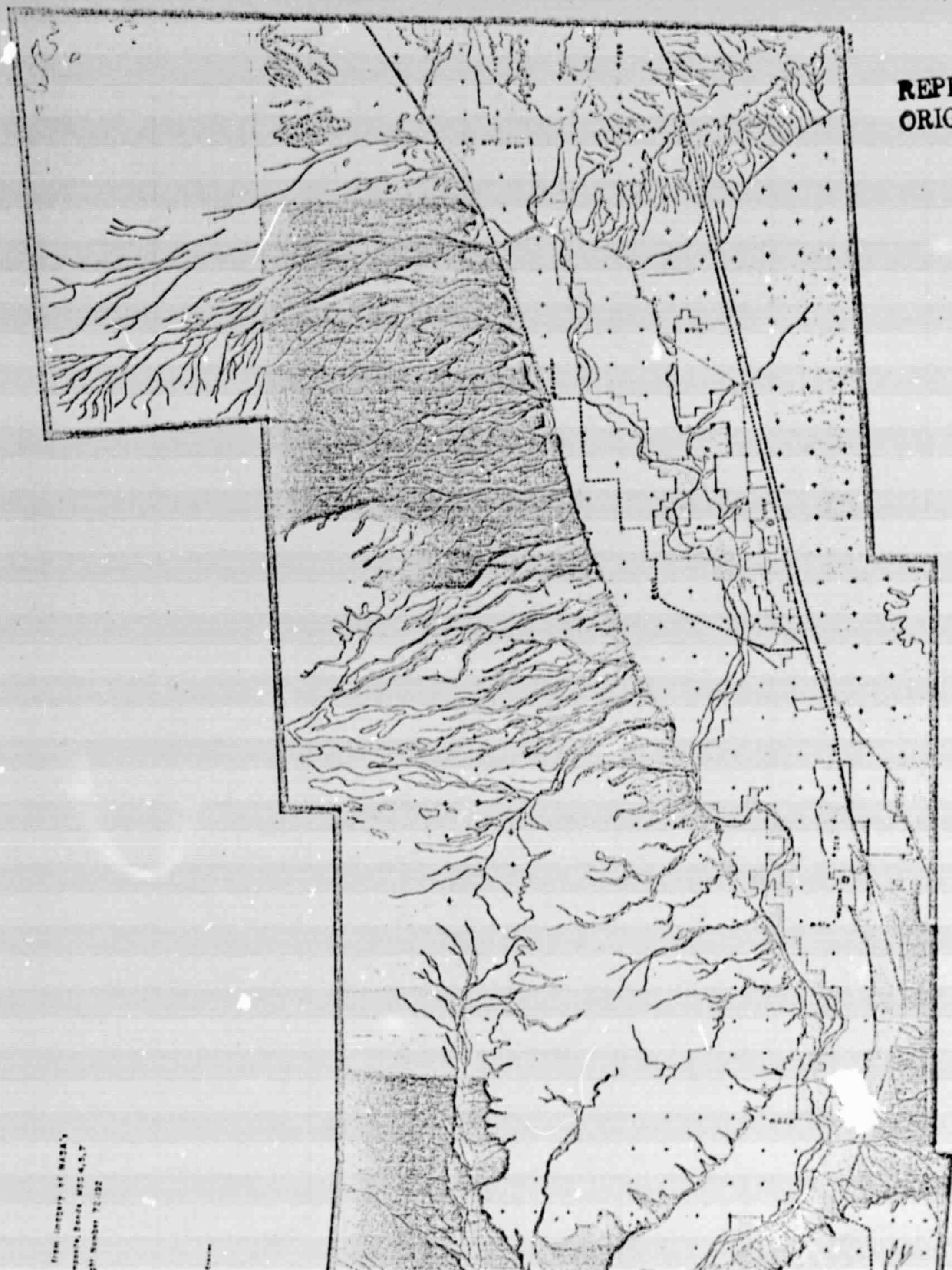

Figure 2. Yuma County Flood Hazard Map