INVENTORIES OF IRRIGATED LANDS IN SOUTHERN IDAHO USING VARIOUS REMOTE SENSING TECHNIQUES

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Final Report

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S U M M A R Y

This is a final report describing the activities of University of Idaho research personnel conducted under a contract between Idaho Department of Water Resources and the University of Idaho. The Idaho Water Resource Research Institute and the College of Forestry, Wildlife and Range Sciences participated in research described in this report. The contract period was for the 1977 fiscal year. The Final Report has been delayed because of operational problems encountered during the Phase III B inventory and in delays in receiving the initial inventory data.

The overall objective of the research contract was for the University of Idaho to provide professional expertise to Idaho Department of Water Resource (IDWR) for the purpose of participating in the Pacific Northwest Regional Commission's (PNRC) Land Resource Inventory Demonstration Project and to assist IDWR in developing an operational remote sensing capability. The activities concerning Idaho personnel during the PNRC Demonstration Project, primarily sample data collection, are documented. Also, a comparison analysis of irrigated cropland acreages was made of the LANDSAT computer classified data with acreage determination from U-2 aerial photography. The LANDSAT and U-2 data correlated well with a correlation coefficient of .963. The LANDSAT computer classified estimates, when combined with an agricultural-nonagricultural stratification, are very similar to information derived from U-2 aerial photography and will meet IDWR's information requirements concerning irrigated cropland acreages. Secondary information resulting from the LANDSAT based inventory; crop type, irrigation method, and irrigation water source, was not determined. Crop type information is the most important type of secondary information, and additional work is required to develop inventory procedures which will allow at least general crop type distributions to be determined.

An investigation into determining the location of newly irrigated cropland using multidate (1973-1976) LANDSAT imagery was conducted. Five LANDSAT scenes of southern Idaho were interpreted. Difficulties were encountered with image compositing especially when compositing LANDSAT I and LANDSAT II images. Accuracy of identifying newly irrigated cropland ranged from 93 percent to 60 percent. Poor image registration and changing irrigation practices were the most common sources of interpretation error. Evaluation of change detection on an annual basis (1975-1976) was conducted for a single scene resulting in an accuracy of 74 percent. It is felt that this methodology is not as productive as was hoped and additional work is required in order to achieve consistent accuracy levels above 80 percent.

A methodology for improving water rights adjudication mapping procedures is proposed. The adjudication maps would be based on USGS orthophoto maps (1:24,000) and current aerial photography would be used to map recent irrigation development. A review of Idaho Department of Water Resources remote sensing capability is also presented.

INTRODUCTION

The Idaho Department of Water Resources (IDWR) is in the process of developing a remote sensing capability for the purpose of obtaining widely distributed resource information. Initial remote sensing efforts have been directed towards conducting inventories of irrigated cropland. Irrigation is the basis of the state's largest industry and is the major water consumer in Idaho. Therefore, the physical extent of irrigated agriculture, cropping practice, and irrigation procedures greatly influence water resources throughout the state.

In order to obtain professional assistance and gain experience in the application of remote sensing techniques, IDWR is a participant in the Pacific Northwest Regional Commission's (PNRC) Land Resources Inventory Demonstration Project. The project is a joint effort by the National Aeronautical and Space Administration (NASA), the United States Geological Survey (USGS), the PNRC, and individual member state agencies for the purpose of determining the applicability of information obtained from satellite and high altitude aircraft remote sensing data to the solution of regional land resource problems. In conjunction with its participation in the PNRC Land Resources Demonstration Project, IDWR has also supported remote sensing research by the University of Idaho, College of Forestry, Wildlife and Range Sciences for the purpose of assisting in the PNRC Project and developing a remote capability within IDWR. This is a report concerning the activities conducted by the University of Idaho during the past fiscal year (1977).

During the past year, investigations have been directed towards a number of objectives. Work was conducted in support of the PNRC Project which was primarily concerned with sample unit data collection and evaluation of the inventory results. LANDSAT imagery has been investigated for determining the expansion of irrigated cropland in Idaho. The application of various remote sensing data products has been evaluated for use in water rights adjudication mapping procedures. In addition to the specific objective oriented activities, the integration of remote sensing procedures with IDWR operational activities has been undertaken.

AN INVENTORY OF IRRIGATED CROPLAND (PHASE III B)

An inventory of irrigated cropland throughout the southern portion of Idaho (south of 45^{o} N) is being conducted as a PNRC Land Resource Inventory Demonstration Project. Participants in the inventory are NASA, Electromagnetic Systems Laboratories (ESL), a NASA contractor, IDWR, and the University of Idaho. The objective of the inventory is to enumerate the irrigated cropland within southern Idaho on a 5 km by 5 km cell basis for the purpose of determining water demand due to irrigated agriculture. The area to be inventoried was limited to southern Idaho since 98% of the irrigated cropland in Idaho occurs in the southern portion of the state.

Grid System

As with any data collection effort the inventory design is greatly influenced by the intended application of the inventory data. In this case the irrigated cropland information will be used as input data for hydrologic modeling being done by IDWR. IDWR operates a number of digital hydrologic models which require water related land use data. A major model currently being used is the Snake River Plain Groundwater Model. This model operates on a 5 km by 5 km nodal cell basis and requires land use information for the entire area overlying the aquifer, an area of approximately 9,000 square miles. Since the model's basic input/output data unit is a 5 km by 5 km nodal cell the irrigated cropland inventory is also being conducted on a 5 km by 5 km cell basis to insure data compatibility with the Snake River Plain Groundwater Model. Although the Snake River plain aquifer does not include all of the inventory area, the same 5 km by 5 km cell size was used for the entire inventory.

The Universal Transverse Mercator (UTM) grid system was used to define the 5 km by 5 km cells. Idaho lies within two UTM zones; that area of Idaho east of 114^{o} W is in zone 12 while the area west of 114^{o} W is in zone 11. The inventory data will be based on the appropriate UTM zone grid system. The grid cells have been located on 1:250,000 USGS/AMS maps which are the only map series depicting the entire inventory area at a common scale. The 1:250,000 series uses the Transverse Mercator Projection resulting in the UTM lines being straight and at right angles which allows the grid to be located and reproduced relatively easily.

The Snake River Plain Aquifer Model also lies in both UTM zones. But in the case of the model, in order to maintain uniform cell size, all grid cells are based on the UTM zone 12 grid. Therefore, the grid cells in the western portion of the model which actually is in zone 11 are an extension of the zone 12 grid. The overall result is that there are three distinct areas (Figure 1) of grid cells for which inventory data will be reported. The areas are: 1) UTM Zone 12, 2) UTM Zone 11, and 3) that portion of the aquifer model west of the 114^{o} W using grid cells based on UTM Zone 12.

Inventory Procedures

The overall inventory design was developed by ESL Inc., who is responsible for the computer classification of LANDSAT data, the statistical analysis, and the determinations of the final estimators. The following brief description is based on information supplied by ESL. The irrigated cropland inventory was based on two levels of data. The first level consists of a complete classification of all land within the inventory area using LANDSAT digital multispectral scanner data. Next, for each possible sample unit, 0.5 km by 5 km, digital data were analyzed to determine the percent of agriculture within the unit. This estimate of agricultural land was then used to select 64 sample units that contain acreages of agricultural cropland. The selected units were photographed at a scale of 1:9,600 with 70 mm color infrared film using low altitude aircraft. The aerial photography was interpreted and ground checked to determine the acreage by crop type, irrigation method, and irrigation source within each of the selected sample units.

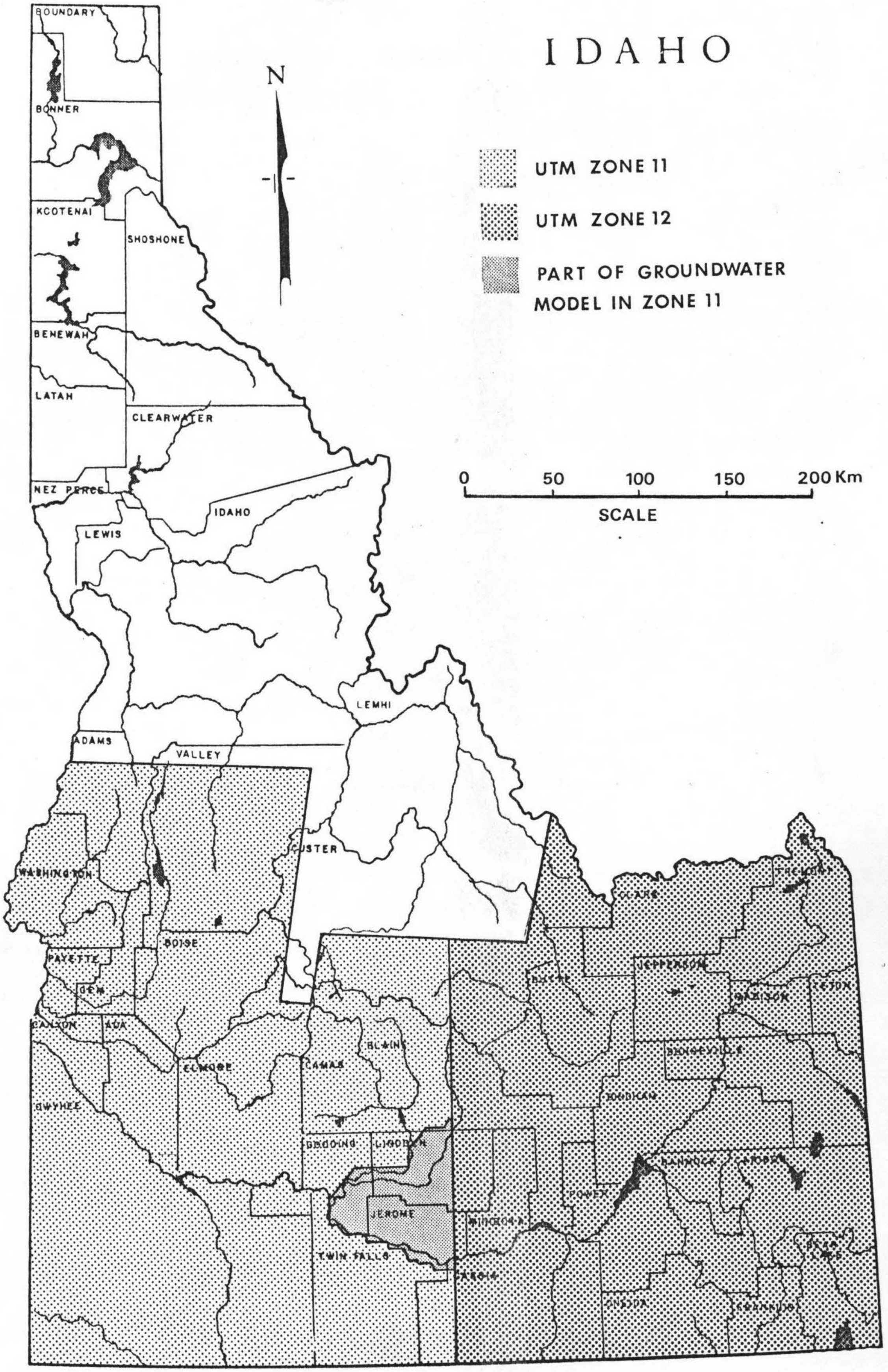

Figure 1. UTM zones 11 and 12 and the extended area where zone 12 is used for the groundwater model.

A regression relationship between the photo/ground (observed) and the LANDSAT classification results (predicted) for the sample units is being determined. This regression relationship will be used to predict the occurrence of irrigated cropland within all the 5 km by 5 km cells. Confidence intervals will be provided for all the estimates. Final data products will consist of the following:

1. Summary statistics by nodal cell listing predicted water demand, irrigated acreage, crop type where feasible, and irrigation source where feasible.
2. Data summaries for selected hydrologic units and environmental strata.
3. Color coded map products, displaying cover classes for the two LANDSAT scenes covering the largest area.

Sample Unit Data

Idaho personnel did participate in the initial training for the computer classification of LANDSAT data and were responsible for the collection, interpretation and summarization of the sample unit data. Once the individual sample units were selected, the latitude-longitude coordinates of the corners of each sample unit (0.5 km by 5 km) were determined by ESL. As previously stated, 64 sample units were used. Each sample unit was located on the best available base map. The majority of sample units, 54, were located on USGS 7½' (1:24,000) maps, 6 units on USGS 15' (1:62,500) maps, and 4 units on Idaho State Highway Department county maps (1:126,720). Figure 2 shows the relative locations of the sample units.

Once all sample units were located, 70 mm color infrared aerial photography was obtained for each 0.5 km by 5 km unit. Complete stereo coverage was obtained at the scale of 1:9,600. The scale was selected in order to obtain coverage of the complete sample unit width with a single flight line. All aerial photography was taken between August 23 and 27, 1976. No reflights were necessary. The aerial photography was flown later than was originally planned due to delays in receiving the sample unit coordinates. In southwestern Idaho and in some of the dry land farming areas, harvesting had already begun. Within irrigated areas crop types for harvested fields were determined during ground visitations. In the dry land farming areas where harvesting had occurred, it was not possible to distinguish the harvested cropland from fallow land. It is felt that no significant amount of information was lost due to the lateness of the aerial photography. In southern Idaho dry land cropping practices are such that normally a field is cropped every other year resulting in roughly half of the dry land areas being cropped each year. These fields are easily identified.

Ground data collection was conducted between September 7 and 30, 1976. The majority of sample units was visited. Ground data were obtained for specific fields within the sample units. The number of individual fields observed within a sample unit varied with variability of crop types and cropping practices observed. The following information was collected:

1. Crop type-land cover. Since the ultimate objective of the inventory is to obtain information concerning consumptive water demand which varies with different crops, crop types were organized according to the eleven crop classes, common to Idaho, for which the consumptive use requirements have been determined (Sutter and Correy, 1970).

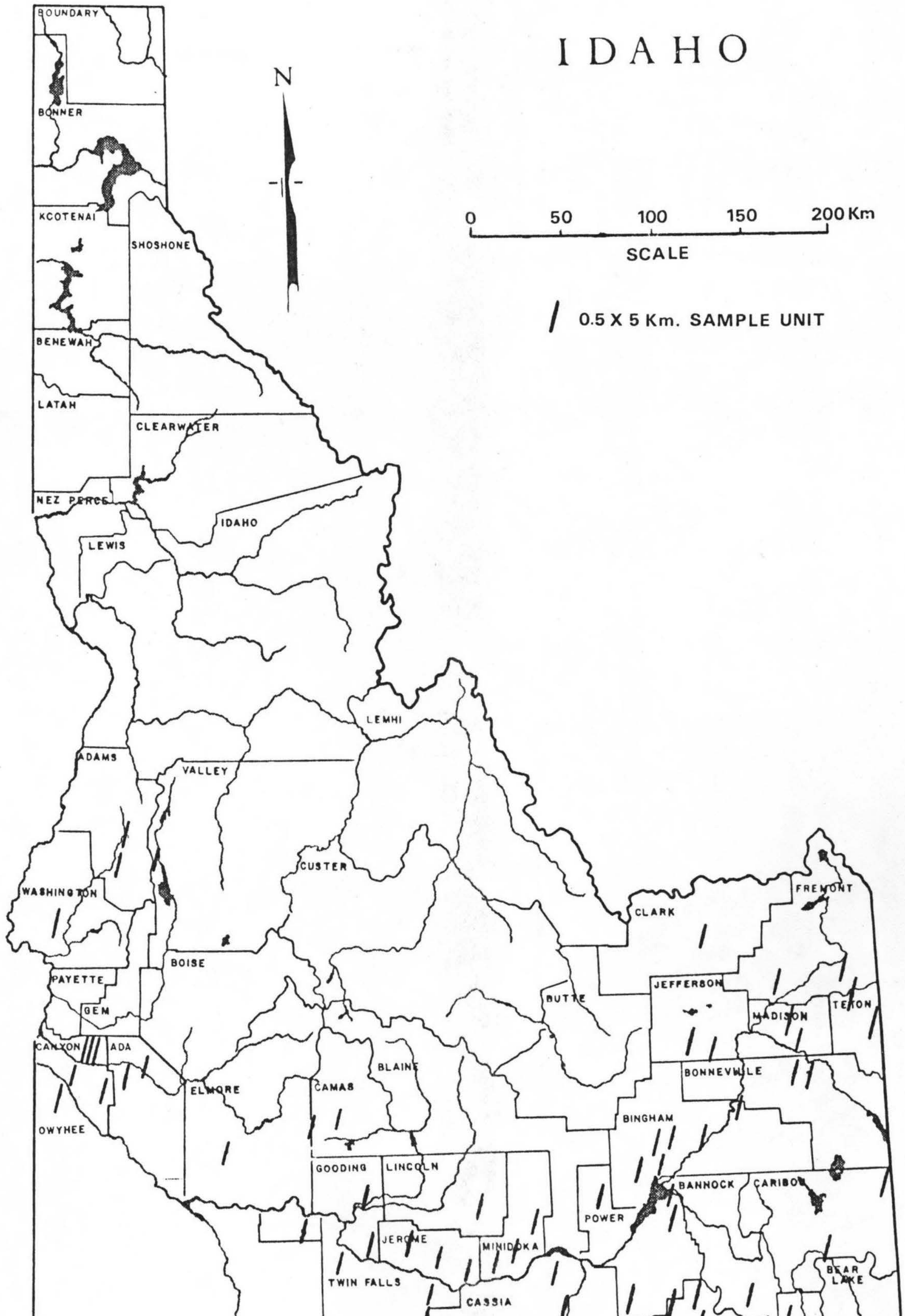

Figure 2. The relative location of the 64 sample units.

One exception was made. There is no means of readily determining if a small grain, when mature, is a winter grain or a spring grain. Therefore, all small grains were grouped into the same crop class despite a difference (average 2.5 inches throughout Idaho) of the consumptive use requirement. In the case of harvested fields, crop type was usually determined by observing plant residue remaining in the harvested fields.

In addition to identifying the crop type, major nonagriculture land cover classes such as water, rangeland, and urban areas were also identified.

2. Irrigation method. This information is of interest since the amount of water diverted for irrigation often varies with the irrigation method. In addition, the photographic appearance of a field will vary with different irrigation methods.
3. Water source. For hydrologic modeling the source of the irrigation water is necessary information for assessing the effects of irrigation upon the groundwater or surface water hydrologic system. Water source was determined based on knowledge of the area, and observation of irrigation wells.
4. Crop condition. Since ground data were not collected for all fields, the crop condition was noted in the observed fields so that photo interpretation parameters could be established.

Photo Interpretation and Data Summary

After obtaining the ground data, photo interpretation of the 70 mm aerial photography was undertaken. For each sample unit, all agricultural fields were identified and the field boundaries were transferred to the maps of the sample units. The majority of the field boundary mapping was done using high altitude (U-2) aerial photography and a Zoom Transfer Scope. The field boundaries were then checked using the 70 mm aerial photography and corrected where necessary. Using the ground data to establish the photo interpretation parameters, the crop type, irrigation method, and irrigation source were determined and recorded for each field in a sample unit. (Irrigation water source information was primarily based on ground data.)

Once the photo interpretation was completed, the acreage of each field was measured, to the nearest acre, using a graphics digital calculator. Total acreage values were not adjusted to an absolute area value. The sample units were oriented at right angles to the LANDSAT scan lines, with the northern axis bearing N 13° E. Therefore, a number of fields were disected diagonally by the sample unit. It was felt this orientation of the sample units would avoid any bias resulting from the cardinal direction axis of the township and range survey which dominates the landscape. In some cases very small portions of fields, less than one acre, fell within a sample unit. In such cases, data were recorded for these fields and the field size was listed as one acre. The listing of small fields and unavoidable measurement error contributed to the varying total recorded sample unit acreages. In these discrepancies, the rationale was that it was better to work with the data in its most direct form since the varying acreage total can be attributed to a wide variety of possible error.

As stated, the information was recorded for each field in a sample unit (0.5 km by 5 km). Within each sample unit, each field was assigned an identifying number and the crop type, irrigation method, irrigation source and acreage were recorded. Table 1 is a listing of the information categories recorded and the code numbers that were used.

Upon completion of the photo interpretation and data summary the sample unit data were given to ESL. Using this "directly observed" information, ESL will determine the regression relationship between the ground conditions and the LANDSAT digital data classification which will become the basis of the irrigated cropland inventory.

Verification of a Photo Interpretation Inventory Method

During the evaluation of the Phase III A PNRC Demonstration Project, questions were raised concerning the conclusions drawn from the University of Idaho investigation because bias was present within the data utilized to evaluate multistage variable probability sampling (Heller, et al., 1976, p. 15). As a result of a graduate remote sensing seminar project at the University of Idaho it was possible to check on the validity of using optical interpretation of LANDSAT imagery to inventory irrigated lands. Two graduate students from the College of Forestry, who had no familiarity with irrigated lands in southern Idaho but are experienced interpreters, interpreted the August 13, 1975 LANDSAT image (E 5116 - 17331). The results of their estimates of the irrigated lands on the Western Test Site are shown in Table 2 and may be compared with the Phase III A interpretation results. Note that neither of the two new interpreters had as low a coefficient of variation (% that standard deviation is of the total acreage estimated), as reported in Phase III A, but that all interpreters' estimates included the total irrigated acreage of the Western Test Site of 149,500 acres. The total irrigated acreage was determined from U-2 aerial photography. One interpreter underestimated the irrigated agriculture in one LANDSAT primary sample unit by 50 percent -- mainly because of dried bean fields in that block which appeared similar to rangeland (Interpreter 1, PSU 22,5). This underestimate from the true acreage caused his variance to escalate considerably. Both of the estimates of these photo interpreters are unbiased.

The investigators feel that this exercise fully supports the conclusions presented previously (Heller, et al., 1976) concerning the accuracy capability of the variable probability sampling scheme. In addition, the sensitivity to initial interpretation error of the variable probability sampling scheme is also demonstrated. The investigators do not support the application of multistage variable probability sampling and imagery interpretation as an ideal method for inventorying irrigated cropland throughout Idaho. But, the methodology can be very accurate and should be considered by IDWR as an operational method of obtaining total irrigated acreage values for selected regional or subregional areas, such as hydrologic units, within Idaho.

A. Crops

1. Sugar beets
2. Dry beans
3. Corn silage
4. Field corn
50. Small grains
51. Dried peas
52. Hay
53. Sweet corn seed
54. Mint
55. Other small grains
6. Potatoes
70. Vegetables
71. Onions
80. Alfalfa
81. Alfalfa seed
82. Other legume hay (including alfalfa/grass mix)
83. Hops
90. Grass pasture
91. Wild hay
92. Other grass hay
93. Clover seed
94. Other legume seed
10. Orchard
11. Fallow
12. Range
13. Urban residential
14. Bottom land (nonag.)
15. Outland
16. Stockyard
17. Water

B. Irrigation Method

1. Flood boarder
2. Flood furrow - rill
3. Flood open flow
4. Sprinkler
5. Subirrigated
6. Wild flooding
7. None

C. Water Source

1. Surface
2. Groundwater
3. Undetermined

Table 1. The data summary categories and their code numbers, information for each major heading was recorded for each field in a sample unit.

Interpreter I					Interpreter II				
PSU NO	Predicted %	Predicted Acres	Measured %	Measured Acres	PSU NO	Predicted %	Predicted Acres	Measured %	Measured Acres
5,4	40	1024	47.4	1212	8,3	20	512	26.3	672
5,7	50	1280	33.1	846	9,8	10	256	8.6	220
17,5	55	1408	67.1	1716	18,5	60	1536	57.3	1468
18,5	60	1536	54.9	1404	18,7	55	1408	50.2	1286
22,5	55	1408	91.7	2347	20,2	5	128	7.6	194
26,3	10	256	7.4	189.4	26,7	15	384	13.2	337
27,8	85	2176	80	2048	28,8	90	2304	89.1	2281
28,9	90	2304	81.1	2075	30,5	30	768	29.5	755
30,7	50	1280	39.6	1012	30,7	40	1024	39.6	1012

	Phase III A Interpreter	Interpreter I	Interpreter II
A (total acres) 1/	156,790	157,509	149,856
Var (A)	88,499,175	263,575,961	111,996,940
Std. Dev.	9,407	16,235	10,582
Sample Error	6%	10.3%	7.1%
95% C. I.	21,694	37,438	24,404
r^2	.93	.65	.98

1/ 149,500 acres measured by IDWR from U-2 photos in 1977.

Table 2. Comparison of estimates of irrigated land by three photo interpreters on Western Test Site from a LANDSAT color composite image (August 13, 1975).

A Comparison of a Limited Set of Data for Evaluation Purposes

Evaluation of the Phase III B inventory was conducted by comparing the LANDSAT based inventory results with irrigated cropland acreages determined from U-2 aerial photography on a 5 km^2 cell basis for the area of the Snake Plain Aquifer Model (total of 926 cells). Ideally one would prefer to have the comparison based on randomly distributed data throughout the Phase III B inventory area. But a random distribution of data was not possible because of the size of the inventory area and the amount of data necessary for a valid comparison. In the case of the groundwater model, it was necessary to obtain the irrigated cropland acreages in order to meet operational commitments. These data, for a limited portion of the inventory area, are in an identical format to the inventory data and well suited for comparison purposes.

Although the Snake Plain Aquifer Model makes up only a portion of the inventory area, the land uses and cover types present are representative of the majority of the inventory area. Agricultural land use, both irrigated and dry land, is widely distributed while the natural cover types are characteristic of steppe and semi-arid desert regions. It is felt that the results of the data comparison within the water model will be indicative of the Phase III B inventory, but this comparison will not allow statistical inferences to be made.

The evaluation is based on irrigated cropland acreages only. It was originally thought that information concerning crop type identification, irrigation methods, and irrigation water source would be available as inventory results, but during the conduct of the inventory it was evident that crop type and water usage information would not be available as was originally planned. Because of the inventory design and operation, information other than irrigated cropland acreages has not been determined.

Determining Irrigated Acreages from U-2 Aerial Photography

As a result of the PNRC Land Resource Inventory Demonstration Project, high altitude 1:125,000, U-2, color infrared aerial photography was available for the groundwater model area. This aerial photography is from the same growing season, 1975, as the LANDSAT data used for the inventory. The U-2 aerial photography is well suited for identifying and mapping major land use classes and cover types. Irrigated cropland was identified by photo interpretation and delineated on Idaho Department of Highway county maps (1:126,720 or ½" equals 1 mile). Because of the close scale match of the aerial photography and the county highway maps, it was possible to directly trace the irrigated cropland areas on the maps from the aerial photography. The mapping process was simplified since we were working with agricultural land use. The township and range survey grid is a major feature influencing the agricultural land use patterns in Idaho and is evident on the U-2 aerial photography. Using the section grid which is present on the county maps and is easily identifiable on the aerial photography, it is not difficult to maintain a proper registration of the map base to the aerial photography.

Once the irrigated croplands were identified and delineated on the county highway maps, field work was conducted to add additional data to the maps and verify the irrigated cropland delineations. The irrigated cropland acreages, based on the county map delineations, were summarized on a 5 km^2 grid cell basis for input to the groundwater model. This is the same data summary grid that was used with the Phase III B inventory.

The 5 km^2 cells, based on the Universal Transverse Mercator (UTM) grid system, were located on the county highway maps using a scaled (1:126,720) grid overlay. The grid was plotted on clear Mylar using a digital plotter. The resulting grid was positioned on the county highway maps by transferring a number of grid intersections from the USGS 1:250,000 scale maps to the county highway maps using proportional dividers. It was realized that a precise registration of the rectangular UTM grid to the county maps on a polyconic projection was not possible. Since the area of each county map sheet was relatively limited and the grid was registered to each sheet it was decided the resulting error was minor.

Once the 5 km^2 cells were located, the irrigated cropland acreage was determined using a dot grid. Adjustments to the acreage values were made for road and housing densities. One should note that the irrigated cropland acreages determined from the U-2 aerial photography cannot be considered as absolute values. An error free measurement of irrigated cropland is impossible. The described methodology has been used for several limited areas and we feel that it yields acceptable results. But one must keep in mind that an undefined amount of error is present.

Inventory Data Comparison

The irrigated cropland acreages were compared on a cell by cell basis -- computer signature derived estimates versus U-2 photo interpretation. A total of 911 5 km^2 cells were used. The current Snake River Aquifer Model operates with 926 cells but 15 cells along the southern portion of the model were deleted. The deleted cells are bisected by the Snake River. The U-2 based data list only that irrigated cropland north of the river while the LANDSAT data list irrigated cropland for the entire cell.

During the Phase III B inventory each 5 km^2 cell was stratified as an agricultural or nonagricultural cell. This stratification was done to eliminate minor errors present in the original LANDSAT data classification and errors caused by the Y intercept values of regression estimates. The stratification values (1 or 0) were applied to the data after the predictions of irrigated acreages, based upon regression estimations, were determined. For comparison purposes both the raw or unstratified values and the stratified acreage values were used so that the effects of the stratification could be estimated.

A summary of the various irrigated acreage estimates is listed in Table 3. All the estimates compare favorably with the total difference between the U-2 acreage and the stratified LANDSAT estimate being 11.6 percent. The average difference between the U-2 acreage estimate and the stratified LANDSAT estimate, for a 5 km^2 cell, is 322 acres with a standard deviation of 529 acres. The average acreage of a 5 km^2 cell is 1605; the average difference in estimates is about 20 percent of the mean. Three outliers were observed. Two outliers were due to errors in the agricultural-nonagricultural stratification while the third outlier was caused by an error in the U-2 data. For determining the general characteristics of the difference between the data sets the three outliers were deleted. Table 4 lists the correlation coefficient between the U-2 and the LANDSAT estimates.

The figures in the Appendix are scatter plots of the compared data. The effect of the stratification can be noted by comparing Figures A1 and A2. A tighter cluster of data points is present, in Figure A2, for those cells with little or no irrigation and the correlation between the two data sets is improved. Figure A3, a plot of the stratified LANDSAT estimates

	U-2 Acreages	LANDSAT Unstratified	LANDSAT Stratified
Total Irrigated Acreages	1,462,000	1,348,000	1,292,000
Mean Irrigated Acreage Per Cell[1/]	1,605	1,480	1,418
Standard Deviation	2,093	1,802	1,834
Coefficient of Variation	130.3%	121.8%	129.4%

1/ A 5 km by 5 km cell contains 6170 acres.

Table 3. Summary values for the three irrigated acreage data sets of the Snake Plain Aquifer Model area that were compared (911 5 km by 5 km cells).

	LANDSAT Unstratified	LANDSAT Stratified	LANDSAT Stratified Without Outliers
U-2 Acreages	.955	.963	.974

Table 4. Correlation coefficients for the compared data sets.

against the U-2 estimates with the outliers deleted, is the closest to an ideal set of comparison data.

Figures A4 through A6 are scatter plots of the observed differences between the data sets plotted against the U-2 acreage estimates. Again the effect of the stratification and the data outliers can be observed. Also one can see that the LANDSAT estimates are greater for small acreages of irrigated cropland and less than the U-2 estimates for large concentrations of irrigated cropland.

Figures 7A through 9A are scatter plots of the absolute differences between the data sets. These plots indicate that there is a proportional relationship between the differences of the acreage estimates and the amount of irrigated agriculture found in a given cell.

As stated earlier it is not possible to describe the U-2 irrigated acreage value as absolute; therefore, one cannot specifically refer to the observed differences as errors on the part of the LANDSAT data. However, this comparison does allow us to view the differences between the LANDSAT derived data and data obtained by an alternative methodology. Both sets of data are very similar and would equally serve IDWR's information requirements for irrigated cropland acreages, for hydrologic modeling and for regional resource policy decision making. The comparison does demonstrate that the agricultural-nonagricultural stratification is beneficial and should be used in conjunction with the LANDSAT inventory. There may be a proportional relationship between the amount of irrigated agriculture in a cell and an expected "error", but the data we have available are not sufficient to conclusively demonstrate such a relationship.

Irrigated cropland acreages were determined on a level comparable to U-2 aerial photography using LANDSAT data and regression estimations in the Phase III B inventory. The additional water related land use parameters of crop type, irrigation method, and irrigation water source, which are objectives of the inventory were not identified. It was realized at the outset of the inventory that information concerning irrigation method and water source would probably not be available as a result of digital analysis of LANDSAT imagery.

Crop type or crop group identification should be possible with LANDSAT digital analysis but no conclusive results have been obtained by either the Phase III A pilot inventories or the Phase III B inventory. The lack of crop type information can be attributed to operational problems encountered during the Phase III B inventory and the overall inventory design which stressed the determination of irrigated cropland acreages. Additional information addressing the requirements for an operational methodology which will allow at least a limited crop group identification is required. Crop type distribution is necessary for hydrologic modeling and there is a definite potential of obtaining such information with LANDSAT which has not been adequately investigated.

IDENTIFICATION OF NEWLY IRRIGATED CROPLANDS

Irrigation development in Idaho has been ongoing at a relatively steady rate. Increases of irrigated cropland have averaged 60,000 acres annually from 1950 to 1970. Future increases of irrigated cropland are expected to average 25,000 to 35,000 acres annually through 2000. Accurate and timely information concerning the distribution and amounts of irrigated cropland development is required to effectively operate digital hydrologic models of groundwater and surface water systems. Presently, the only means of obtaining current information about irrigated cropland distribution is by total enumeration. But once an accurate level data base is established it will be desirable to be able to consistently and accurately update the information. The most desirable frequency for updating irrigated cropland data is annually. A complete enumeration of irrigated cropland is not economically practical on an annual basis using present methods.

Objectives

The objective of this investigation was to evaluate the effectiveness of multidate LANDSAT imagery interpretation for identifying newly irrigated cropland. LANDSAT imagery is well suited for such a task. The large area coverage of each scene limits the amount of data handling that is necessary. The sequential coverage of LANDSAT insures the capability of obtaining data from different growing seasons; LANDSAT is readily available; and the costs are nominal. In addition to the general characteristics of LANDSAT data, numerous investigations have demonstrated that one can readily identify agricultural croplands using LANDSAT imagery.

In selecting LANDSAT imagery as a potential means of identifying newly irrigated cropland on an annual basis, the technical capability of IDWR was a criteria. IDWR is currently capable of conducting imagery interpretation analysis on an "in house" basis. By conducting an imagery based inventory the specific expertise of IDWR personnel with Idaho agriculture may be drawn upon and the successful conduct and completion of such an activity is totally in the control and responsibility of the agency which will apply the resulting information.

Project Design

The method investigated for the purpose of identifying newly irrigated cropland is by the interpretation of a single multidate color composite scene. Initial investigations using multidate images indicated that it was possible to identify newly irrigated cropland using multidate images (Heller, et al., 1976).

Color Composite Multidate Image

A single multidate color composite image is constructed in much the same manner as a single date color composite image. In the case of a color composite multidate image, selected single band 70 mm "chips" from two dates are combined using an additive color combiner to form a single "false color" image.

The choice of the individual satellite bands and the colors with which they are projected may be varied so that phenomenon of interest, in this case newly irrigated cropland, is most evident. Once the color composite imagery is produced, interpretation is conducted. Image interpretation is primarily based on the color characteristics although other factors such as size, shape, and site (location) also enter into the interpretation process.

In addition to the multidate color composite imagery, a black and white print (1:1,000,000) of band 5 was also used to assist the interpreter in identifying the newly irrigated cropland. If the interpreter questioned his interpretation of the multidate image he could check both the black and white prints for the presence or absence of irrigated cropland at a specific location.

The objective of the interpretation was to locate newly irrigated cropland. Acreage determinations, based on LANDSAT imagery, were not undertaken for several reasons. First, the format of the imagery, 1:1,000,000, was not suitable for accurate acreage determinations. Secondly, once the location of newly irrigated cropland is determined, additional information, primarily the source of the irrigation water, must be obtained by IDWR. Acreage measurements can be more effectively determined on the ground at the same time as the additional required information is obtained.

Imagery Interpretation Evaluation

Once the multidate color composite imagery interpretation was completed, it was necessary to determine the accuracy of the interpretation results for identifying newly irrigated cropland. U-2 high altitude color infrared aerial photography (scale 1:125,000) was available for several growing seasons for a large portion of the agricultural areas of Idaho. By comparative interpretation of the different dates of U-2 photography the changes of irrigated cropland could be noted and compared against the LANDSAT interpretation results. Past experiences in Idaho, and by other investigations, have shown the U-2 aerial photography a very effective, but not economical, means of obtaining accurate land use information. Upon completion of the U-2 aerial photography interpretation the accuracy of the LANDSAT interpretation could be expressed as number, or percent, of correct identification of newly irrigated cropland, an omission error, and a commission error.

Image Combination

Color composite imagery was made for five LANDSAT scene areas of southern Idaho. Although the selected imagery does not permit full coverage of the irrigated agricultural areas of southern Idaho, approximately 80 percent coverage was achieved with the five composite LANDSAT scenes. Figure 3 depicts the coverage achieved with the five composite scenes while Table 5 lists the individual scenes that were used.

The ability to detect change over two different time periods was evaluated. The primary time period was from 1973 to 1976. The three year time span was chosen for several reasons. U-2 photography was available for large portions of southern Idaho for both 1973 and 1976 which could be used to evaluate the LANDSAT imagery interpretation results. Also, we did not know how well the multidate color composites would work and desired a time frame large enough to insure there was significant amounts of newly irrigated cropland present to insure some level of detection. Since it is desirable to be able to identify the change on an annual basis, one 1975-1976 color composite,

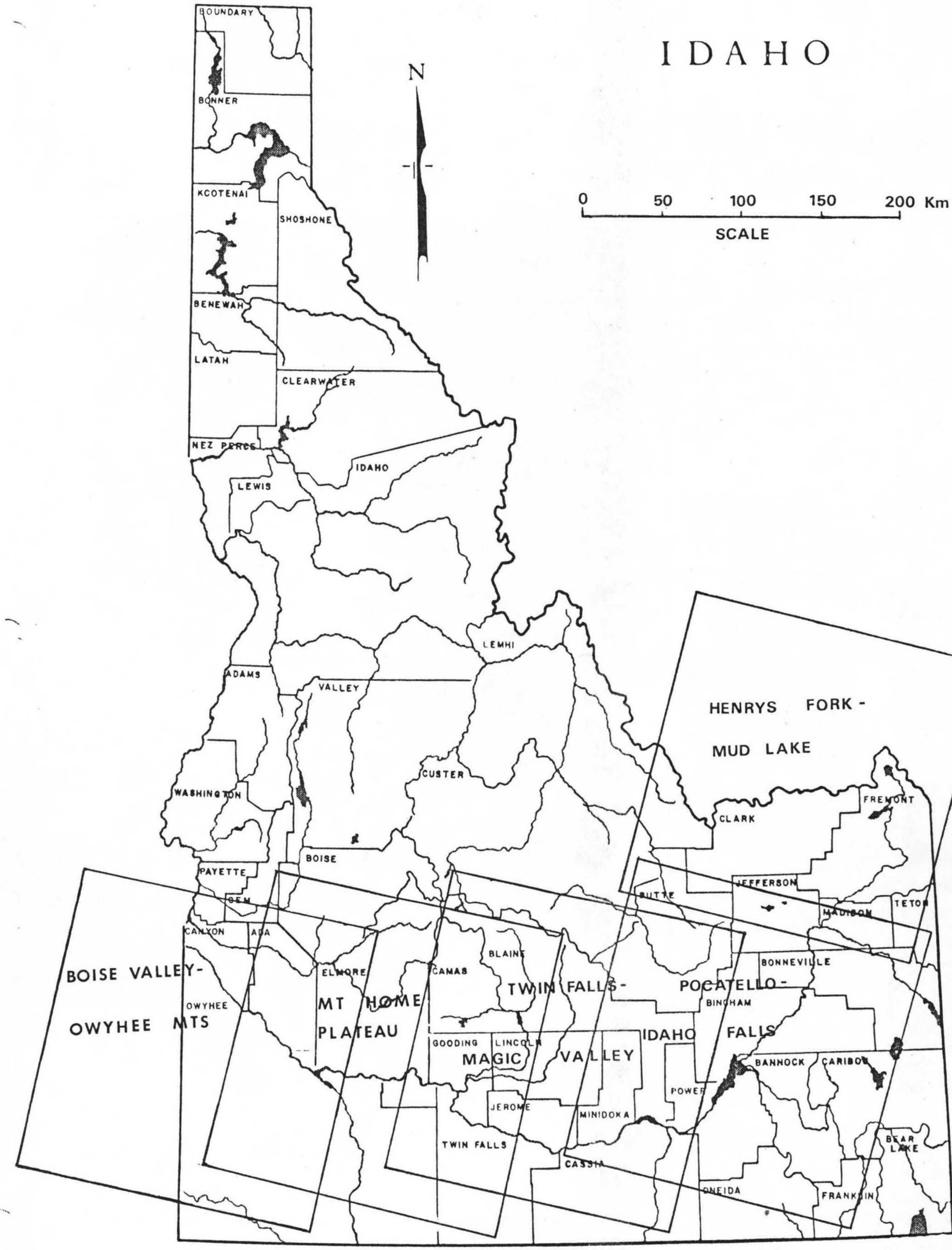

Figure 3. The LANDSAT scene coverage used for change detection.

Pocatello-Idaho Falls, was also constructed and interpreted.

The image combination was done using the College of Forestry Remote Sensing Lab's additive color combiner at the University of Idaho with which the 70 mm black and white single band images, from the two different dates, were combined. A number of multispectral scanner bands and filtration combinations were tried. The best rendition, which was the same as used previously (Heller, et al., 1976), was from the combination of bands 5 and 7 of the 1976 (new) imagery and band 7 of the 1973 (old) imagery (Figure 4). For each composite scene a color internegative was produced from which one color transparency and two color prints were made for interpretation.

Some problems were encountered during the image combination procedures. The most significant problem was that of registration of the individual bands from scenes of two different dates throughout the composite scene area. Satellite altitude, yaw and roll, and the nadir point location affect the geometric characteristics of individual scenes limiting the capability of achieving precise registration between the two sets of imagery used for a composite. The composite images were set up so that the registration was best within those areas, agricultural lands, of interest. It was noted that scene registration was more of a problem when the composite image was composed of scenes from LANDSAT I and LANDSAT II rather than scenes from the same satellite. Unfortunately initial scene selection was based on the date, image quality, and cloud cover; individual satellite obtaining the multispectral data was not considered as criteria for selecting the LANDSAT imagery.

Scene Location	Identification Number	Date
Boise Valley and Owyhee Mts.	E-13791-8041	August 6, 1973
	E-54591-1716	July 21, 1976
Mt. Home Plateau	E-13421-7585	June 30, 1973
	E-25181-7404	June 23, 1976
Twin Falls Magic Valley	E-13591-7530	July 17, 1973
	E-25351-7343	July 10, 1976
Pocatello-Idaho Falls	E-13581-7471	July 16, 1973
	E-21921-7352	August 2, 1975
	E-25341-7285	July 9, 1976
Henry's Fork-Mud Lake	E-13581-7465	July 19, 1973
	E-25341-7282	July 9, 1976

Table 5. The LANDSAT scenes used to make the multidate color composite imagery for identifying newly irrigated cropland.

Imagery Interpretation

The primary factor used for the identification of newly irrigated cropland by interpretation of the multidate composite imagery was color or hue. The new (1976) bands 5 (green filter) and 7 (blue filter) were used to locate the presence of irrigated cropland in 1976 while the old band 7 (1973) (red filter) was used to identify areas of nonagricultural land use during the 1973

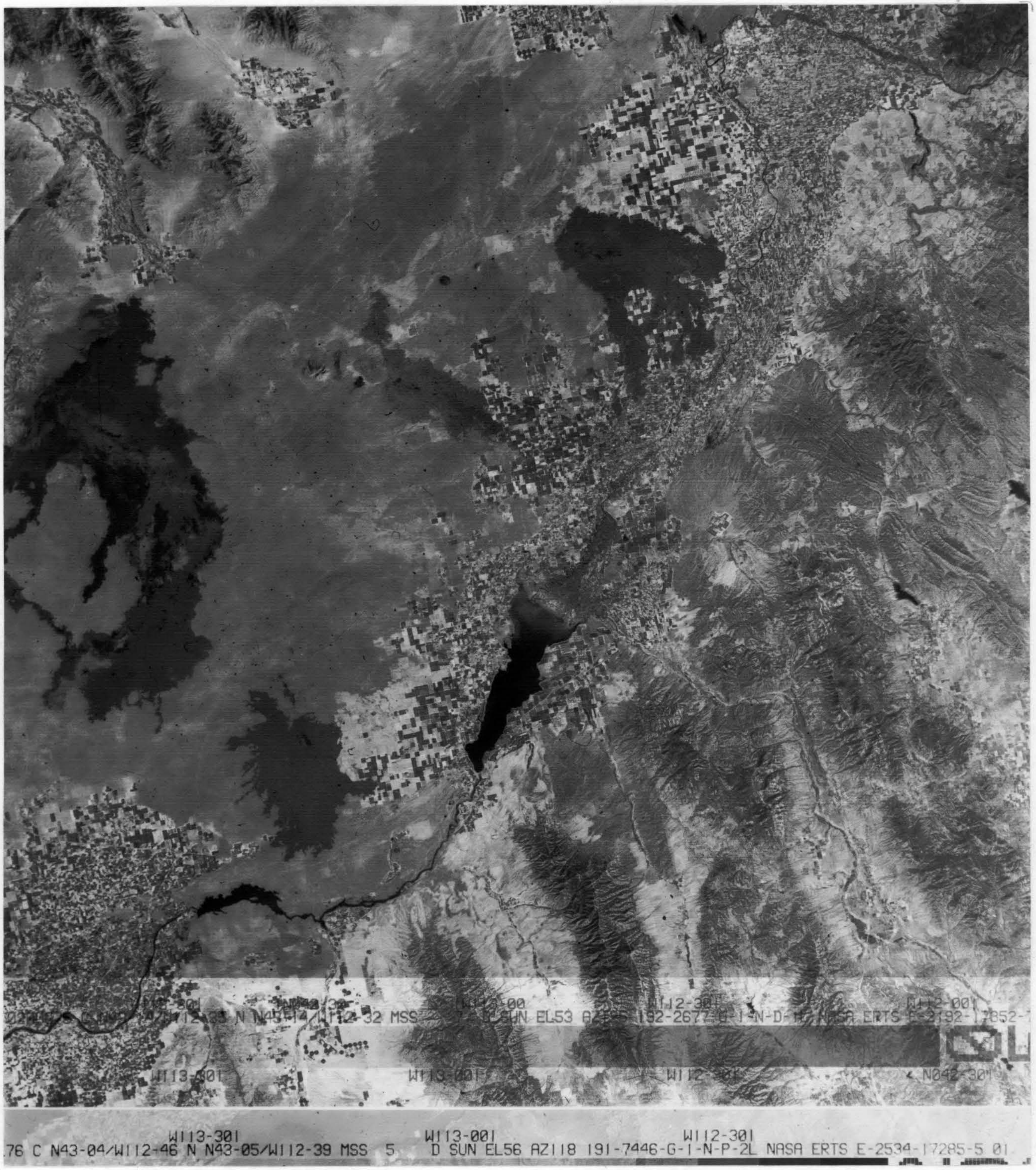

Figure 4. An example of the multidate imagery used to identify newly irrigated cropland. This scene is composite of scene E 21921-7352, Aug. 2, 1975 and scene E 253-41-7285, July 9, 1976 of the Pocatello-Idaho Falls area.

growing season. In those cases where irrigated cropland existed in 1973 and 1976 the color hues will vary from magenta to white, while newly irrigated croplands can be identified by various hues of cyan to violet, where red light is lacking.

The interpretation methodology used the three forms of LANDSAT imagery; multidate transparencies, multidate prints, and single date black and white prints. The majority of the interpretation was done using a zoom microscope to examine the multidate transparencies. A zoom transfer scope was also used, primarily to locate those areas identified as newly irrigated on 1:250,000 scale maps. The color composite products were examined and areas identified as newly irrigated cropland were marked. If the interpreter was not confident in his identifications he could examine the single data prints which in some cases greatly aided in the interpretation process.

Aerial Photography Interpretation

Based on the location of areas containing newly irrigated cropland depicted on the 1:250,000 maps, U-2 aerial photography (1:120,000) from flights in 1972-73 and 1975-76 (Table 6) was selected. The multidate aerial photography was interpreted in combination and the newly irrigated croplands were identified. It was felt that the information obtained from the U-2 aerial photography would be of sufficient accuracy for evaluating the multidate color composite interpretation results.

Flight Number	Date
72-186	October 25, 1972
73-075	May 5, 1973
73-172	October 5, 1973
75-131	August 6, 1975
76-133	August 20, 1976

Table 6. The U-2 aerial photography that was used for evaluation of the multidate composite imagery interpretation for identification of newly irrigated croplands.

Evaluation of the Interpretation Results

The interpretation results were evaluated based on two criteria. The first criterion is that of correctly identifying newly irrigated agricultural units. For this application an agricultural unit is defined as an agricultural management area of similar cover type. That is, those areas that are identifiable as individual entities when interpreting the LANDSAT imagery. Size is highly variable with the agricultural units ranging from 20 acres to over 2,000 acres. The occurrence of newly irrigated cropland was initially recorded by agricultural units. As previously stated, it was felt that the small scale LANDSAT data would not be suitable for reasonable acreage estimation.

In addition to evaluating the interpretation results based on correct identification of newly irrigated areas, it was felt that the evaluation should in some manner take into account the area of the identified newly irrigated cropland. Using the delineations on the 1:250,000 maps the agricultural units were subdivided into 160 acre "fields". A 160 acre, quarter section, is an eighth inch square at 1:250,000. Each unit smaller than 160 acres was counted as an individual field while those units larger than 160 acres were subdivided to the appropriate number of 160 acre fields. The 160 acre, quarter section, works well for this purpose since irrigation development often occurs by units of the township and range survey. The summary evaluation results are listed in Table 7 by agricultural units and in Table 8 by 160 acre fields. The percentage values are based on the total amount of newly irrigated cropland as identified by the interpretation of the U-2 aerial photography.

The evaluation results indicated a nonacceptable level of accuracy. By comparison of Tables 7 and 8 one can see that errors of omission do seem to occur more often in the case of small agricultural fields, while the errors of commission often do involve large agricultural fields. A number of factors contribute to overall low accuracy of the interpretations. The authors feel a major contribution to the inaccuracy was the inability to obtain good scene registration; especially for those composite images utilizing data from both LANDSAT I and LANDSAT II. Only the Boise Valley-Owyhee Mountains scene was made with all the images from the same satellite, LANDSAT I. Note that both kinds of errors were lower when data from the same satellite were available.

There were a number of cases where the LANDSAT multidate composite format was not suitable for identifying newly irrigated cropland. The composite color format was designed so that newly irrigated cropland was identifiable by various combinations of green and blue light, or the lack of red light. There were a number of cases where moderate to high reflectance was recorded by the old (1973) band 7 that was not associated with the presence of irrigated cropland. The two most common problems were high infrared reflectance in areas of alkaline soils and in dryland farming areas which are being converted to irrigated cropland. The identification of newly irrigated cropland was most difficult in the (1973) dryland farming regions.

Commission errors were greatly influenced by changing irrigation practices between the periods of observation. Within two groundwater irrigation areas, in the Twin Falls-Magic Valley and the Pocatello-Idaho Falls scenes, substantial changes from flood irrigation to center pivot irrigation have taken place. The multidate imagery indicated change had taken place, but the change was one of irrigation methods not new irrigation. The occurrence of this change greatly influenced the commission errors for the two scenes in which it was observed (Table 9).

Scene	Number of Units: Correct	Number of Units: Omission	Number of Units: Commission	Percentage: Correct	Percentage: Omission	Percentage: Commission
Boise Valley - Owyhee Mts.	20	3	2	87	13	9
Mt. Home Plateau	51	15	19	77	23	29
Twin Falls - Magic Valley	46	18	34	72	28	53
Pocatello - Idaho Falls	69	39	35	64	36	32
Henry's Fork - Mud Lake	18	17	6	51	49	17
Total	204	92	96	69	31	32

Table 7. Summary by agricultural units of the evaluation of the LANDSAT multidate color composite imagery interpretation for the 1973-1976 scenes.

Scene	Number of Fields: Correct	Number of Fields: Omission	Number of Fields: Commission	Percentage: Correct	Percentage: Omission	Percentage: Commission
Boise Valley - Owyhee Mts.	53	4	4	93	7	9
Mt. Home Plateau	185	26	48	88	12	23
Twin Falls - Magic Valley	131	40	120	77	23	70
Pocatello - Idaho Falls	181	82	107	69	31	41
Henry's Fork - Mud Lake	90	25	15	78	22	13
Total	640	177	294	78	22	36

Table 8. Summary by 160 acre fields of the evaluation of the LANDSAT multidate color composite imagery interpretation for the 1973-1976 scenes.

Scene	Units: Total Commission Error	Units: Due to Change #	Units: Due to Change %	Fields: Total Commission Error	Fields: Due to Change #	Fields: Due to Change %
Twin Falls - Magic Valley	34	18	53	120	90	75
Pocatello - Idaho Falls	35	12	34	107	51	48

Table 9. The total commission error in two scenes and that portion of the error which may be attributed to recent development of central pivot irrigation system, listed by agricultural units and 160 acre fields.

As stated in the objectives, it is desirable to be able to identify newly irrigated cropland on an annual basis. In order to determine if there is a difference in the capability of multidate color composite imagery on a three year time span as compared to a one year time span, a 1975-1976 multidate color composite image of the Pocatello-Idaho Falls scene was made and interpreted. This scene was selected because color infrared U-2 aerial photography of the area was available for both 1975 and 1976. The U-2 photography used to evaluate the 1975-1976 composite was:

Flight 75-113 - July 10, 1975
Flight 76-133 - August 20, 1976

For evaluation purposes, acreages were determined from the 1976 aerial photography using a dot grid. Table 10 is summary of the evaluation results for the 1975-1976 composite imagery.

Scene	Acres: Correct	Acres: Omission	Acres: Commission	Percentage: Correct	Percentage: Omission	Percentage: Commission
Pocatello - Idaho Falls	9470	3250	1570	74	26	12

Table 10. Summary of evaluation of the 1975-1976 color composite image interpretation.

The accuracy level of the 1975-1976 composite is very similar to that of the average of the 1973-1976 scenes. Therefore, we feel the ability to identify newly irrigated cropland on an annual basis is the same as that for a three year, or longer, period of time. In the case of the 1975-1976 composite image all scenes were from the same satellite, LANDSAT II, and the overall scene registration was good. The interpretation accuracy of the 1975-1976 Pocatello-Idaho Falls composite is somewhat better than the accuracy of the 1973-1976 composite. The commission error was much lower because most of the change to center pivot irrigation mentioned earlier had taken place by 1975. It is felt the somewhat lower omission error is due to better scene registration. But, the omission error is still substantial because most of the irrigation development in this region is occurring in previously dryland farming areas. Obviously more refined techniques need to be developed.

Costs

Although the authors are not pleased with the accuracy levels obtained by interpretation of the multidate color composite imagery, it is for the data user or resource manager, in this case IDWR, to determine the effectiveness of such procedure for operational implementation. In addition to accuracy another major factor is cost. Of course, very accurate determinations of the distribution and amounts of newly irrigated cropland can be made by interpretation of sequential aerial photography as was done in this investigation, for evaluation purposes, with the U-2 photography. But, such a procedure on an operational basis is inordinately expensive. The costs of the multidate color composite imagery method have been determined from the experiences of this investigation and modified slightly so that they may be reported and evaluated based on an operational basis. The direct operational costs are listed in Table 11. Several assumptions were made. The assumptions are:

1. The area to be investigated would be the same 5 scene areas used in the investigation.
2. In the operational mode, only the current year LANDSAT scenes would be purchased since the previous year scenes would already be on hand.
3. Image color compositing costs are based on U of I, College of Forestry Remote Sensing Lab's costs of $36 for a single date color composite. Since scene registration is difficult with multidate imagery, more time is necessary for each composite. An additional $10 was added to the cost of a normal composite scene for this reason making the total multidate composite cost $46. The image compositing costs include the cost of the photographic products used in this investigation.
4. Personnel costs were calculated at $7.00 per hour. This cost is not representative of a specific position but represents average cost for a junior full time professional employee of IDWR. Indirect costs for employees and benefit costs are not included.
5. Travel costs are estimated based on the amount of newly irrigated cropland observed during the evaluation of the 1975-1976 imagery.
6. These cost figures do not include overhead and capital equipment costs. It is assumed IDWR will have the necessary equipment, such as a light table, low power microscope, and a zoom transfer scope in order to conduct the interpretation and data recording.

Conclusions and Recommendations

Multidate color composite LANDSAT imagery does not allow one to accurately identify all the newly irrigated cropland. The multidate composite methodology is encouraging, although such factors as high alkaline soils and the presence of dryland farming prior to irrigation development reduce interpretation accuracy. During this investigation evaluation of color composite satellite band filtration combinations were based on the operator's opinion when viewing selected areas of known new irrigation development. It may be beneficial to evaluate various compositing combinations in a controlled interpretation test of a limited region.

Purchase of 70 mm LANDSAT chips 3 chips/scene - 5 scenes	$12/chip	$ 180.00
Composite image costs and photographic products (5)	$46/composite	230.00
Composite image interpretation 8 hrs/composite	40 hours	280.00
Data recording 3 hrs/composite	15 hours	105.00
Field checking 4 weeks	160 hours	1,120.00
Travel costs		
Mileage 1500 miles @ .15/mi		225.00
Per diem $25/day - 20 days		500.00
Data summary - 2 weeks	80 hours	560.00
Total		$3,200.00

Table 11. Direct cost of conducting an operational investigation for identifying newly irrigated cropland on annual basis using multidate color composite imagery.

Additional information concerning irrigation methods and cropping practices which may influence imagery interpretation is required. In this investigation, changes other than irrigation development, most often changes in irrigation methods, influenced the results. Such additional types of changes must be identified.

It is the opinion of the investigators that the multidate color composite imagery does contain significant amounts of information concerning irrigation development. Such information may be best applied at the initial stage of a multistage investigation design. The interpretation of the U-2 aerial photography indicated that those areas of southern Idaho that have experienced irrigation development were correctly identified despite errors in identifying specific locations of newly irrigated cropland. The ability of the LANDSAT color composite imagery to point the investigation in the right direction is valuable and should not be minimized.

LANDSAT is the best available data source for change detection on the large scale basis that is necessary for obtaining information throughout southern Idaho. Considering both the low level remote sensing data handling capability in Idaho and the associated high computer costs, the interpretation of LANDSAT photographic products is the most effective means to detect changes. But, the best method of determining the extent of irrigation development has not been determined. More serious consideration should be given to comparative interpretation of two single date LANDSAT color composite images.

IDWR has indicated that timely information concerning irrigation development is highly desirable and in the future such information may become a necessity. Considering these information needs, the accuracies achieved to date and the knowledge gained by this investigation should be continued to develop a suitable methodology for identifying newly irrigated cropland from LANDSAT data annually.

A D J U D I C A T I O N   M A P P I N G

It was our intent at the outset of this project to conduct a small water rights adjudications mapping project for the purpose of developing a more efficient method of adjudications mapping. The plan was to produce adjudication maps for a small adjudication project while at the same time current mapping procedures used by IDWR were also employed on the same area. This method would allow a direct comparison of the different mapping methods. Unfortunately, anticipated requests for water rights adjudications did not materialize and we were unable to conduct the planned investigation.

A water rights adjudication requires the production of a detailed map of the area being adjudicated. In part, Section 42-1408 of the Idaho Code reads as follows:

> "The Director of the Department of Water Resources shall prepare a map or maps showing the water system, the canals and ditches and the lands thereunder, listing thereon the names of the users of water and the location of their uses."

In the past, adjudications mapping has been accomplished with ASCS rectified aerial photography at a scale of 1:15,840. Using the rectified prints cadastral surveys, irrigated areas and water delivery systems are mapped. Then, based on county tax records, land ownership is determined and the process of soliciting, receiving and verifying water rights claims are begun. Each land owner declaring a water right and their declared rights is listed in the legend of the map. These maps form part of the official court decree at the completion of the adjudication process.

With the current procedures a substantial amount of time is required to produce the maps. A major problem is that the aerial photography is often out of date, up to ten years old, and a large amount of field work is necessary. The maps must be accurate and reflect the current land-water use system of the area at the time of the adjudication. Based on the requirements of current, large scale, maps the following methodology is proposed:

It is proposed that adjudications mapping be based on USGS orthophoto maps. Currently orthophoto maps are available, or being prepared for most of Idaho. Orthophoto maps are aerial photographic products in which distortion, parallax due to terrain relief, and aircraft altitude have been removed most commonly by a process referred to as differential rectification. Rectification of an aerial photograph is accomplished by dividing the photograph into numerous small sections which are individually rectified. The result is a photo map product with all images placed on a single datum plane possessing the geometric accuracy of a map and the information content of an aerial photograph.

Using the accurate base of the orthophoto map cadastral survey points, water works, and irrigated areas can be accurately located and measured. In addition to the accuracy levels allowable by using the orthophoto quads, relatively up to date information would be available if the USGS maintains its proposed mapping schedule. The current water related land uses, primarily irrigated agriculture, would be easily discernible and measurable. The township and range survey "corners" can be accurately located and time saved in dealing with "irregular sized" sections.

We contacted the USGS western regional office in Menlo Park, California and reviewed the available orthophoto products and developed the following combination of products that can be organized into an adjudications mapping system:

Cronopaque continuous tone prints - these are photographic reproductions of the orthophoto negatives on stable base material. Since the orthophoto is photographically reproduced, this product has the highest image quality and is well suited for interpretation purpose. The stable base material allows for accurate area measurement and is suited for overlay purposes. The cronopaque print would be the base map for the mapping system.

Positive frosted Mylar land net overlay - again this product is on stable base material. The land net, the township and range survey, is accurately reproduced photographically in a left reading, or emulsion down mode. The overlay is registered to fit precisely on the orthophoto base map. The drafting of canals, ownership boundaries and other features necessary would be done on this overlay. The township and range corners will be accurately located reducing locational and measurement error. Since the emulsion side of the overlay is down, correction to the drafted portion of the map may be done without destroying the township and range information. The combination of the orthophoto print and the land net overlay with drafted details would make up the adjudications map.

Halftone blue line orthophoto prints - these maps are halftone screened rendition of the orthophotography which are reproduced by the Ozaloid process.

Although image quality of these prints is less than those that are photographically reproduced, the cost is substantially lower. The halftone prints would be used as working prints and for field mapping purposes.

By using the orthophoto products the advantages of aerial photography, a record of the current land use, and the metric accuracy of a map are combined. The information on the orthophotos should be relatively current although field checking will be necessary. For field work purposes, the orthophoto maps will be valuable since they contain valuable information such as field boundaries, canal locations, and vegetative cover that will allow one to more easily locate a specific ground area and determine its extent. The use of the orthophoto maps will not eliminate all problems associated with obtaining current land use information as is required for adjudications mapping. The use of the orthophotos should reduce the map compilation time and reduce time spent in the field.

Additional activities for the purpose of speeding up the adjudications mapping time may be considered by IDWR. The greatest time saving procedure would be for IDWR to contract for aerial photography of an area to be adjudicated. Having current (same year) information would greatly reduce the amount of field time necessary to conduct an adjudication since problems caused by land use change would be minimized. The savings in man hours would probably justify the cost of the aerial photography.

DEVELOPING A REMOTE SENSING CAPABILITY AT IDWR

During the past year, efforts have been underway to develop an ongoing remote sensing capability at IDWR. This effort has involved the acquisition of remote sensing materials and the necessary equipment for utilizing remote sensing data. In conjunction with developing the necessary physical equipment, efforts have been made to integrate remote sensing with the operational activities of IDWR.

Materials and Equipment

The majority of remote sensing data on hand at IDWR is a result of the agency's participation in the PNRC project. LANDSAT imagery from 1975 and 1976 of southern Idaho is available. This imagery is in a number of formats ranging from 70 mm single band chips to 1:250,000 color composite prints. The largest group of imagery is 70 mm black and white chips of sequential LANDSAT coverage. These are available at a 30 day interval of the five scene areas of southern Idaho and were used for determining newly irrigated cropland from May through October 1976. It has been proposed that color composite scenes be made of this imagery for the purpose of determining and documenting optimum periods for various LANDSAT imagery interpretation tasks.

IDWR does have a large collection of U-2 aerial photography. This is 9 x 9 color infrared (with the exception of one flight which is normally color) 1:120,000 scale aerial photography in transparency form. Currently photography from seven U-2 flights over southern and central Idaho in 1975 and 1976 is on hand and has been indexed (Table 12). It is anticipated that additional aerial photography of Idaho will be obtained during the summer season of 1977. The U-2 photography on hand has been flown by NASA in support of the PNRC Land Resource Inventory Demonstration Projects. In addition to the U-2 aerial photography, limited amounts of color and black and white aerial photography of various dates and at a variety of scales is available.

All equipment available is for photographic interpretation purposes. Two large light tables and three portable light tables are available. Currently the two large light tables and one of the portable light tables are used on a regular basis.

The optical interpretation equipment includes one Bausch and Lomb Zoom Microscope. This monocular instrument is well suited for interpretation of the 1:1,000,000 LANDSAT images and has been used for this purpose. A Nikon mirror stereoscope is equipped with a parallax bar for determining elevation differences. The primary use of the mirror stereoscope is for interpretation of the U-2 aerial photography. In addition to the major photographic interpretation equipment, other necessary equipment such as planimeters, proportional dividers, scales and drafting equipment is also on hand. In order to facilitate the interpretation and data recording activities a map collection containing the USGS 1:250,000 series, 15 min. series, 7½ series, and state county highway maps is maintained. IDWR is planning to acquire a Bausch and Lomb Zoom Transfer Scope in the near future. This instrument is designed for transferring data from aerial photography and imagery to a map base. It is anticipated that the zoom transfer scope will greatly increase our land use mapping capability by allowing the base maps used for data recording to be selected based on the information need rather than the aerial photography scale.

Applications of Remotely Sensed Data

The overall objective of the developing remote sensing capability at IDWR is to supply timely and accurate water related resource information. The initial efforts have been directed towards developing a data base dealing with the distribution of irrigated cropland. Both LANDSAT data and aerial photography have been used for this purpose. The primary application of the irrigated agriculture data has been as input data for IDWR hydrologic models. The data have also been used for determining the extent of possible impact upon the state as a whole and for selected regions of the state due to the drought.

Additional uses of aerial photography within the past year include the following activities:

1. Determining land use and cropping practices in specific areas of interest such as when a water right or well application is contested.
2. Mapping canal systems in areas where accurate system plans or maps are available.
3. Determine reservoir surface area for the purpose of developing area - capacity curves.
4. Determining the before and after conditions resulting from stream channel modifications.
5. Land classification of areas where new irrigation developments (Carey Act applications) are proposed.

Flight No.	Date	Film	Scale	Area Coverage
75-113	July 10, 1975	CIR	1:120,000	S.E. Idaho Twin Falls to Rexburg
75-133	Aug. 6, 1975	CIR	1:120,000	S.W. Idaho Weiser to Twin Falls
75-151	Aug. 26, 1975	CIR	1:120,000	S.E. Idaho Bear Lake to Rexburg
75-169	Sept 30, 1975	CIR	1:120,000	Central Idaho Hells Canyon to Sawtooth Mt.
76-133	Aug. 20, 1976	CIR	1:120,000	S.E. Idaho Idaho-Wyoming Border to Lake Walcott
76-141 A	Aug. 31, 1976	CIR	1:120,000	S.E. Idaho Idaho-Wyoming Border to Lake Walcott
76-141 B	Aug. 31, 1976	Normal Color	1:120,000	S.E. Idaho Idaho-Wyoming Border to Lake Walcott

Table 12. U-2 aerial photography on hand at IDWR.

By developing its own remote sensing data collection capability IDWR is able to insure data compatibility and reliability. Flexibility of data collection is another advantage. Initial acreage estimates throughout Idaho of the extent of the drought's impact were determined in two days using data supplied by hydrologic models to identify impact areas and the combination of existing land use data and the remote sensing data on hand. IDWR is also developing a series of water related land use maps based on the 1975 agricultural season. These data will be used as base level information for hydrologic mdoels and for determining the change occurring in agricultural development. The initial data were developed for a sixteen county area in south central Idaho during a one year period. Currently additional information is being obtained and maps of the sixteen counties will be published for use by other agencies and the public.

The facilities, personnel, and equipment at the University of Idaho Remote Sensing Research Unit are also available for consultation and cooperative studies should the need arise.

LITERATURE CITED

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Heller, R. C., J. J. Ulliman and K. Johnson. 1976. A contract to inventory irrigated lands on selected areas in southern Idaho. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, Idaho. 32 p.

A P P E N D I X

Data Labels[1/]

IRRACRES - Irrigated cropland acreages by 5 km^2 cell determined by U-2 aerial photography interpretation.

LPIRRACR - Irrigated cropland acreages by 5 km^2 cell determined by LANDSAT data anlysis, nonstratified.

STRIRAC - Irrigated cropland acreages by 5 km^2 cell determined by LANDSAT data analysis combined with a cell by cell agricultural-nonagricultural stratification.

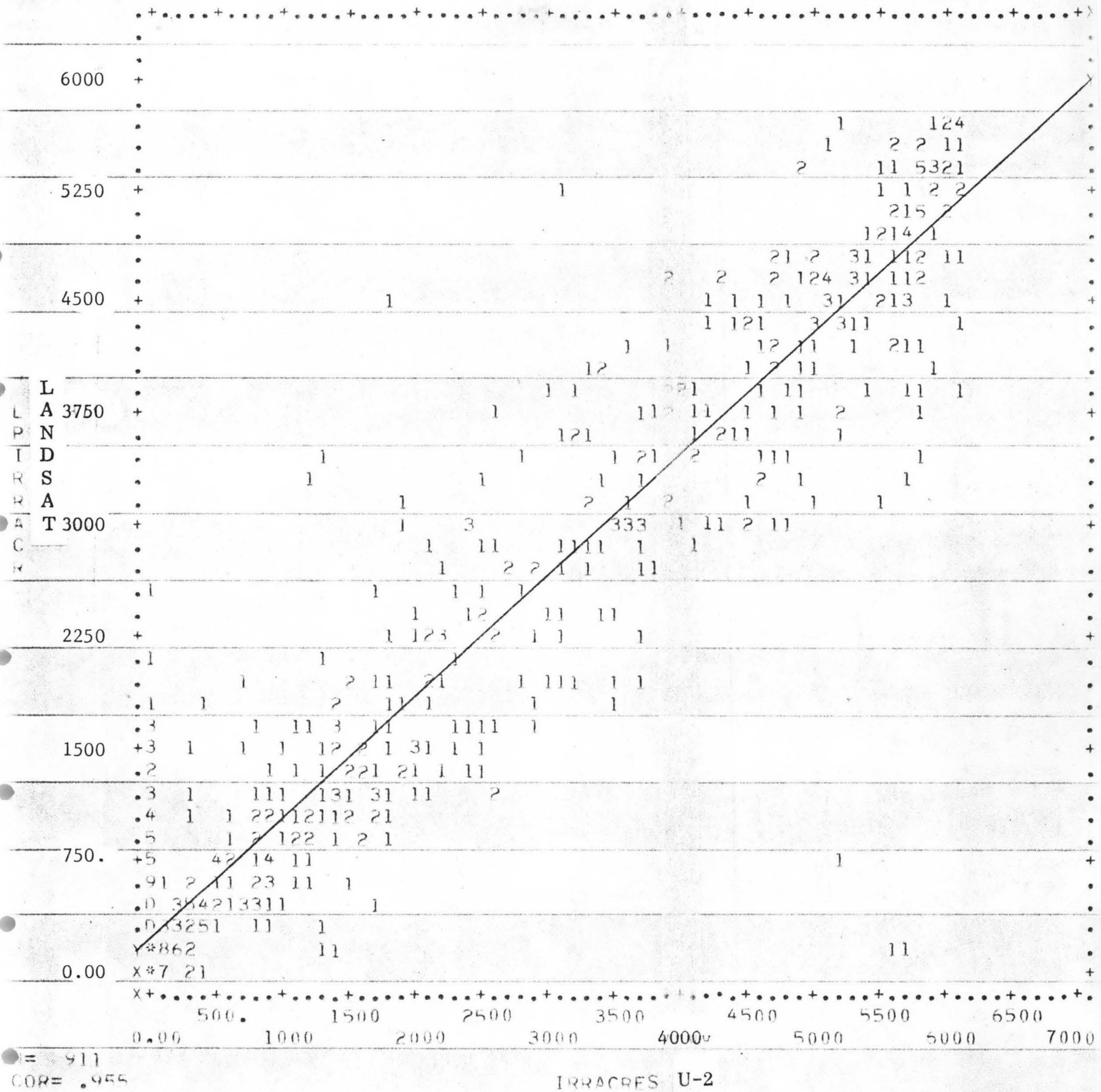
DIFF 1 - The signed differences between the LANDSAT nonstratified acreages and the U-2 acreages, i.e. DIFF 1 = LPIRRACR - IRRACRES.

DIFF 3 - The signed differences between the LANDSAT stratified acreages and the U-2 acreages, i.e. DIFF 3 = STRIRAC - IRRACRES.

ABSDIFF - The absolute value of differences between the LANDSAT stratified acreages and the U-2 acreages, i.e. ABSDIFF = STRIRAC - IRRACRES.

ABSDIFF 2 - The absolute value of the differences between the LANDSAT nonstratified acreages and the U-2 acreages, i.e. ABSDIFF 2 = LPIRRACR - IRRACRES.

1/ These data labels are identifiers for the x and y coordinates shown in the following figures A1 through A9.



N= 911
COR= .955

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
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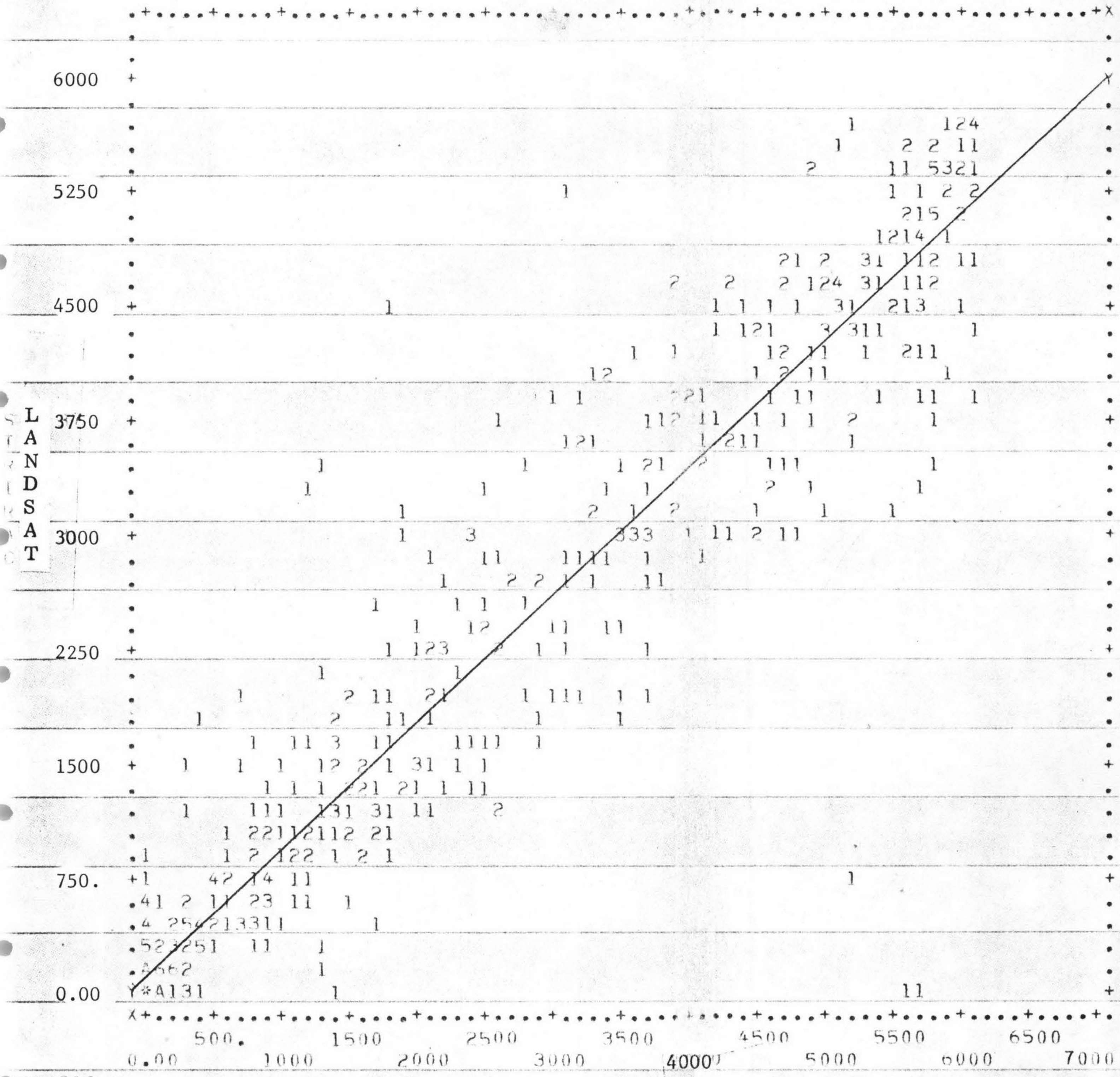
Y	1479.9	1801.7	Y= .82243*X+ 159.76	284099

Figure A1. Scatter plot of the U-2 acreage vlaues and the unstratified LANDSAT estimates.

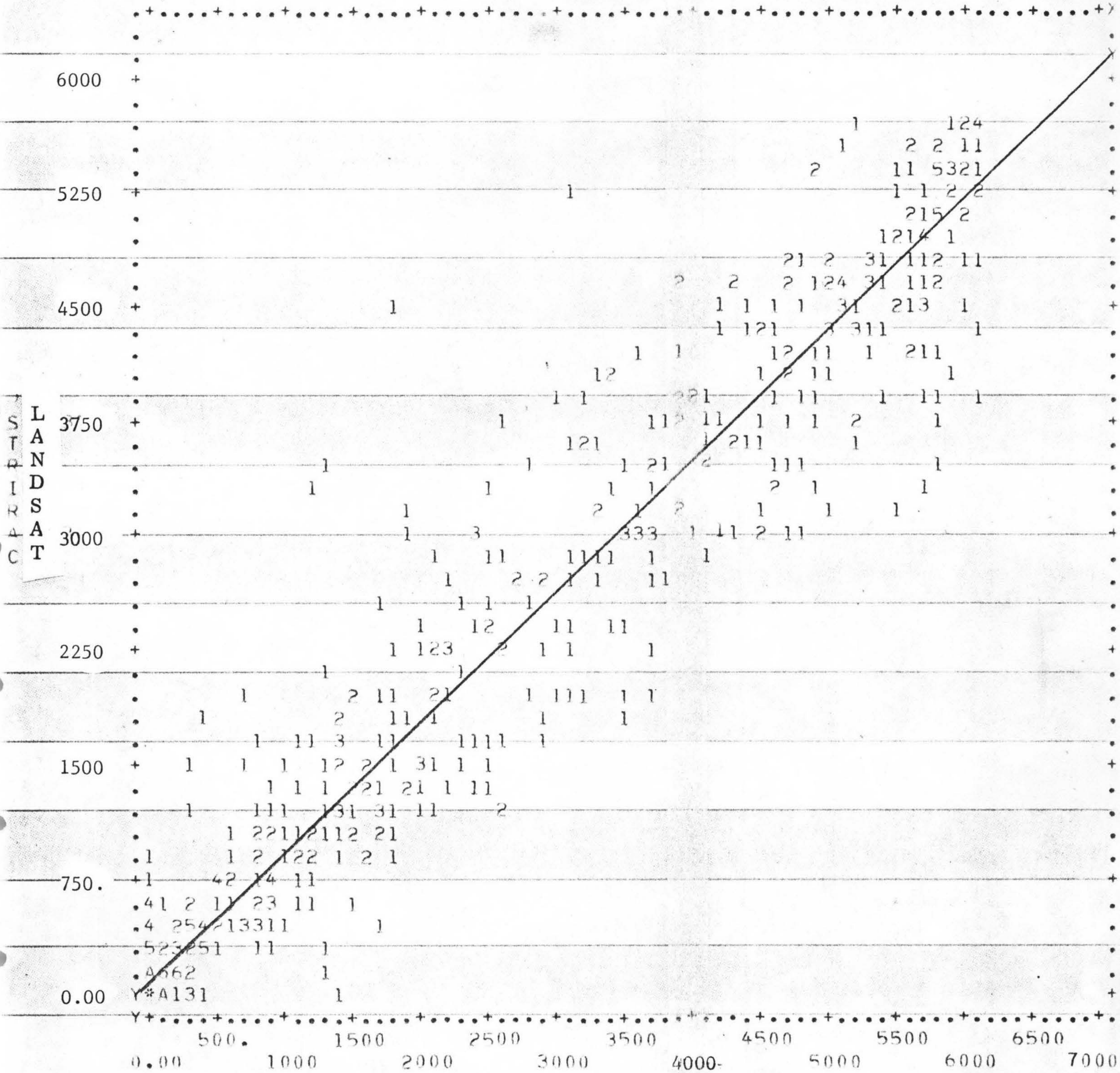


= 911
COR= .963

IRRACRES - U-2

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1605.1	2092.8	X= 1.0987*Y+ 46.821	315838
Y	1418.3	1834.9	Y= .84460*X+ 62.618	242787

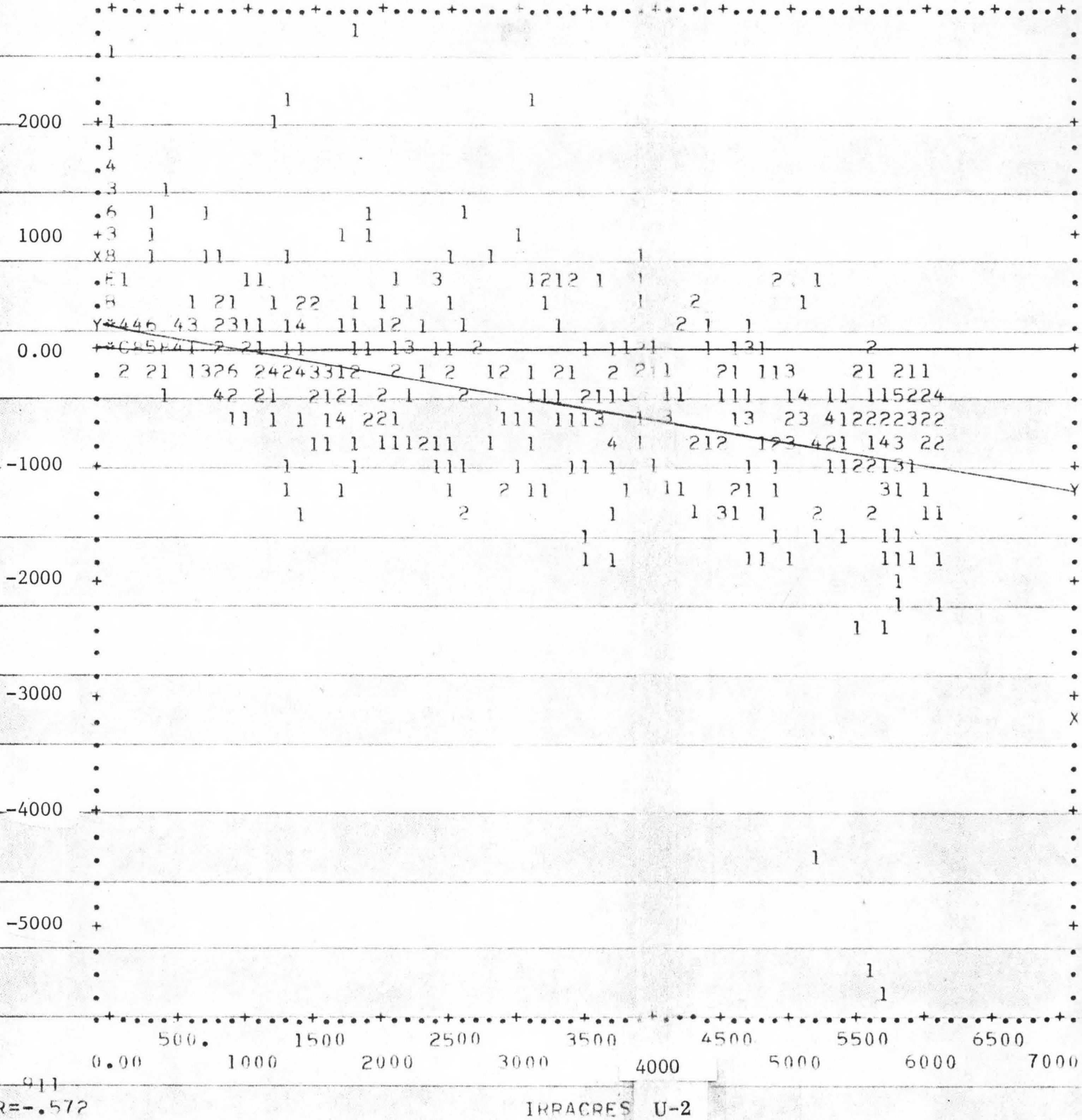
Figure A2. Scatter plot of the U-2 acreage values and the stratified LANDSAT estimates.



N= 908
COR= .974 IRRACRES U-2

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1592.3	2084.2	X= 1.1048*Y+ 21.094	226913
Y	1422.1	1836.6	Y= .85790*X+ 56.108	176199

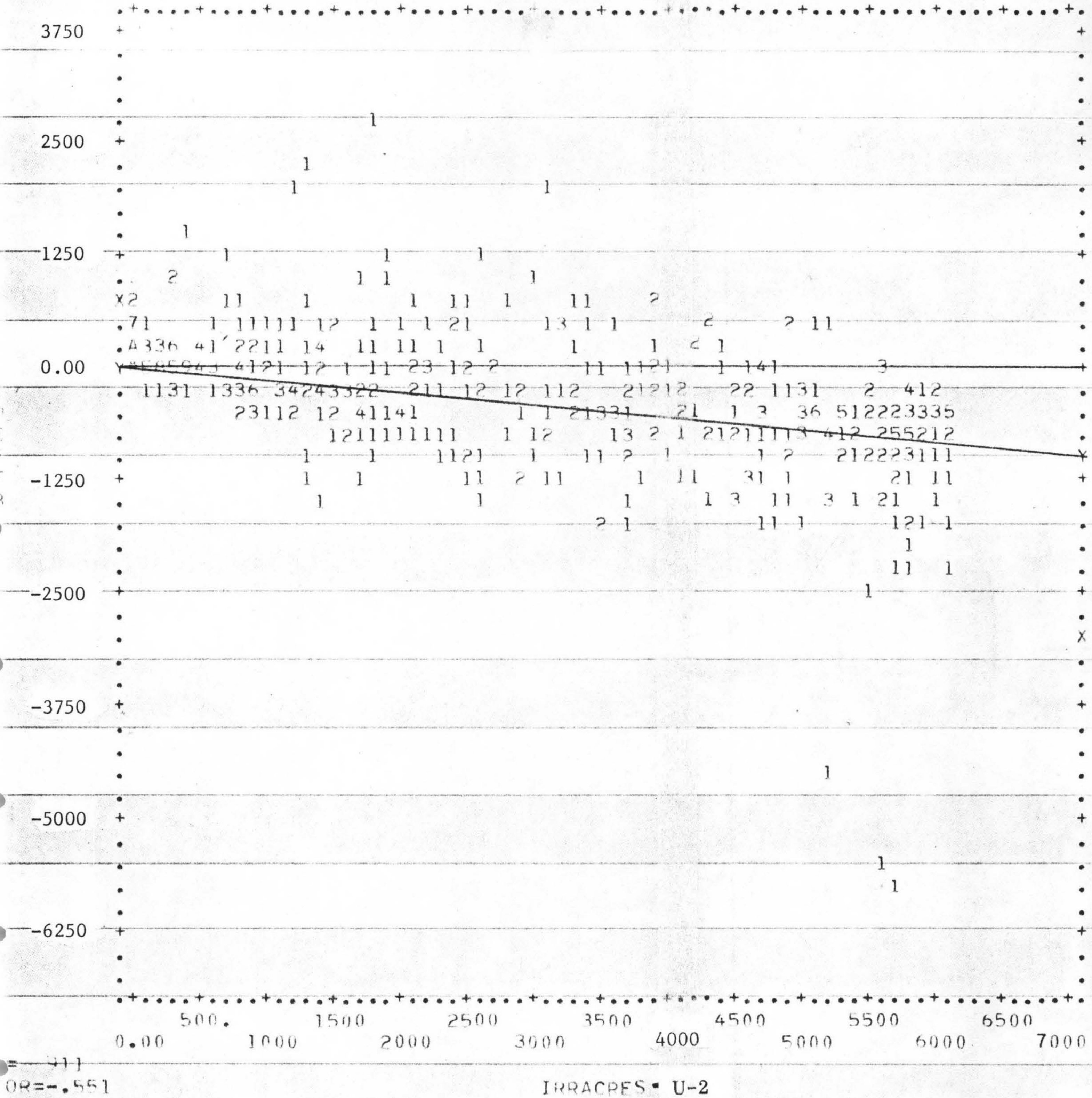
Figure A3. Scatter plot of the U-2 acreage values and the stratified LANDSAT estimates with three outliers deleted.



N= 911
COR=-.572

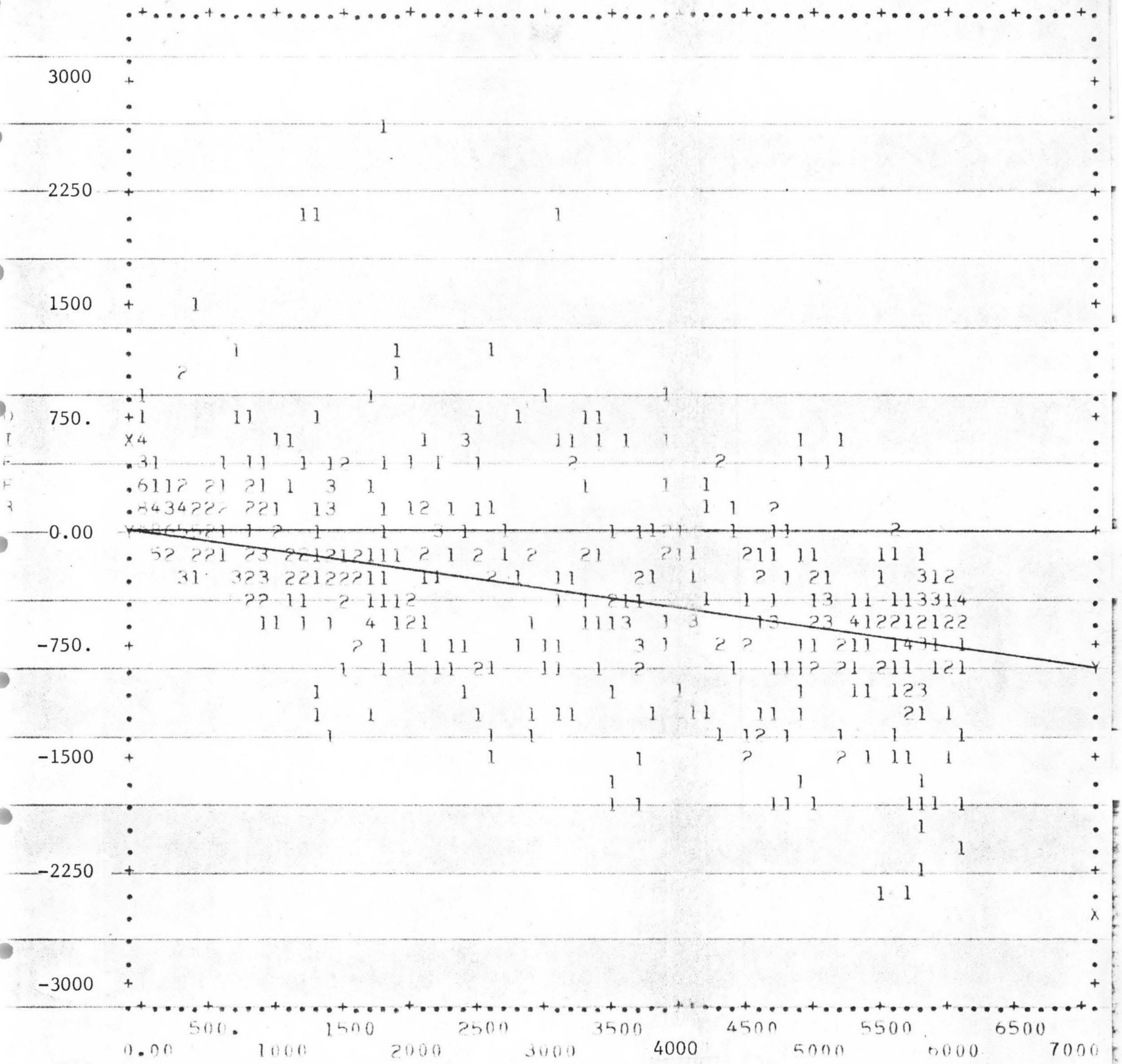
	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1605.1	2092.8	X=-1.8434*Y+ 1374.2	2950E3
Y	-125.25	649.51	Y=-.17755*X+ 159.74	284104

Figure A4. Scatter plot of the differences between the U-2 acreage values and the unstratified LANDSAT estimates plotted against the U-2 acreage values.



	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1605.1	2092.8	X=-1.9540*Y+ 1240.1	3053E3
Y	-186.82	590.16	Y=-.15539*X+ 62.597	242807

Figure A5. Scatter plot of the difference between the U-2 acreage values and the stratified LANDSAT estimates plotted against the U-2 acreage values.

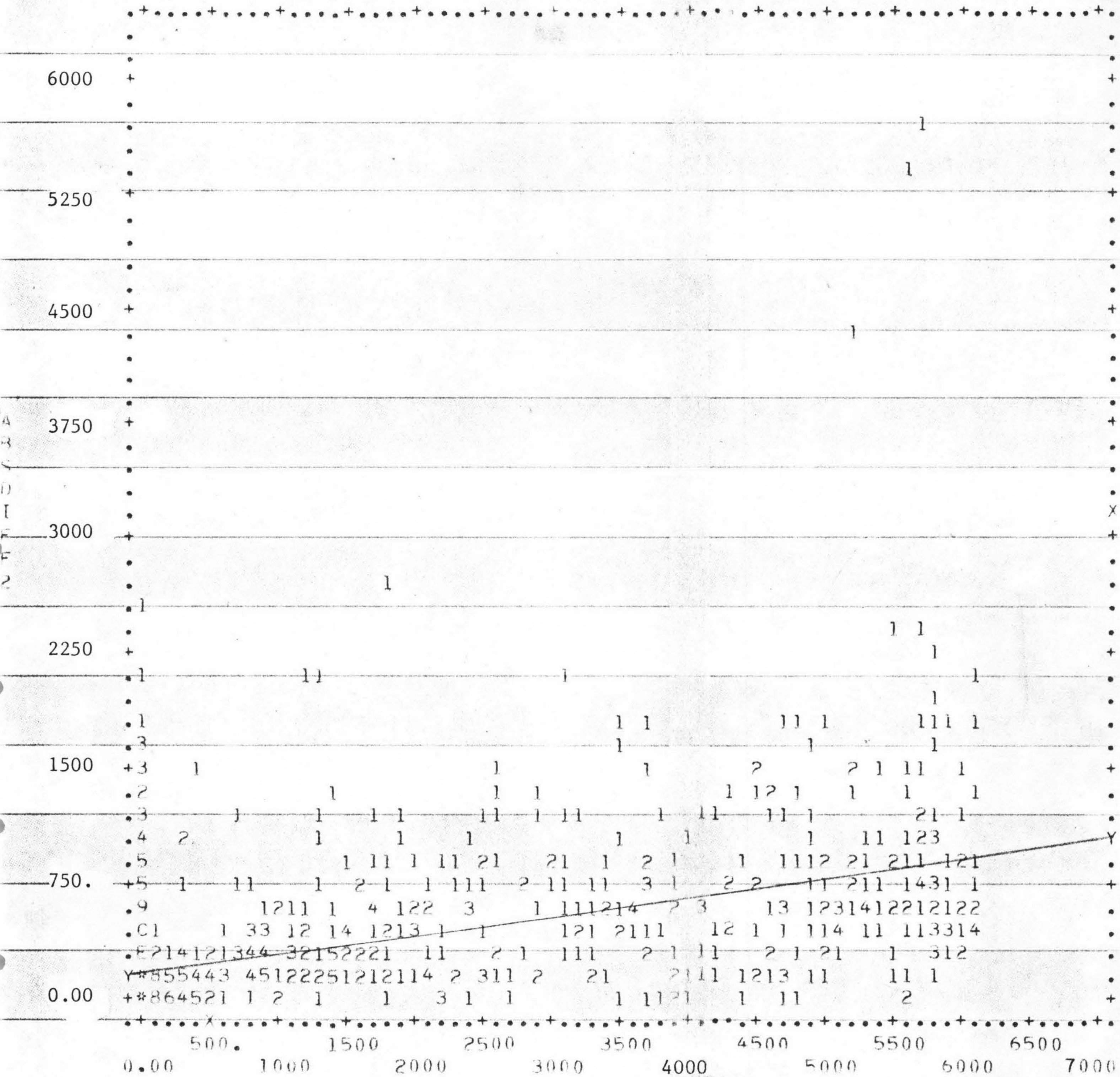


R = .908
COR=-.577

IRRACRES U-2

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1592.3	2084.2	X=-2.3404*Y+ 1194.1	2903E3
Y	-170.14	513.52	Y=-.14208*X+ 56.085	176211

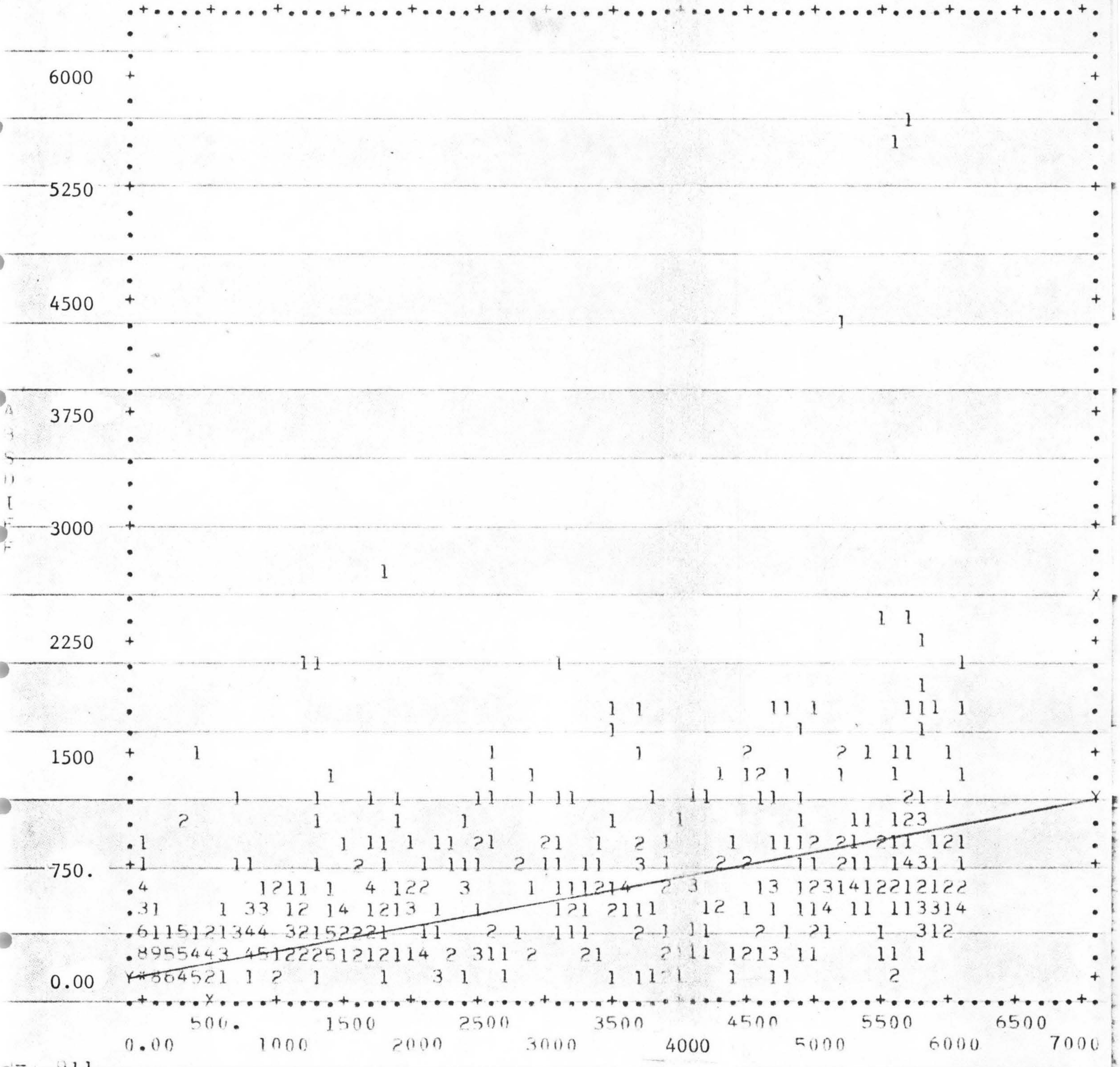
Figure A6. Scatter plot of the difference between the U-2 acreage values and the stratified LANDSAT estimates with three outliers deleted plotted against the U-2 acreage values.



N= 911
COR= .519

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1605.1	2092.8	X= 2.0090*Y+ 840.30	3203E3
Y	380.71	540.80	Y= .13415*X+ 165.38	213981

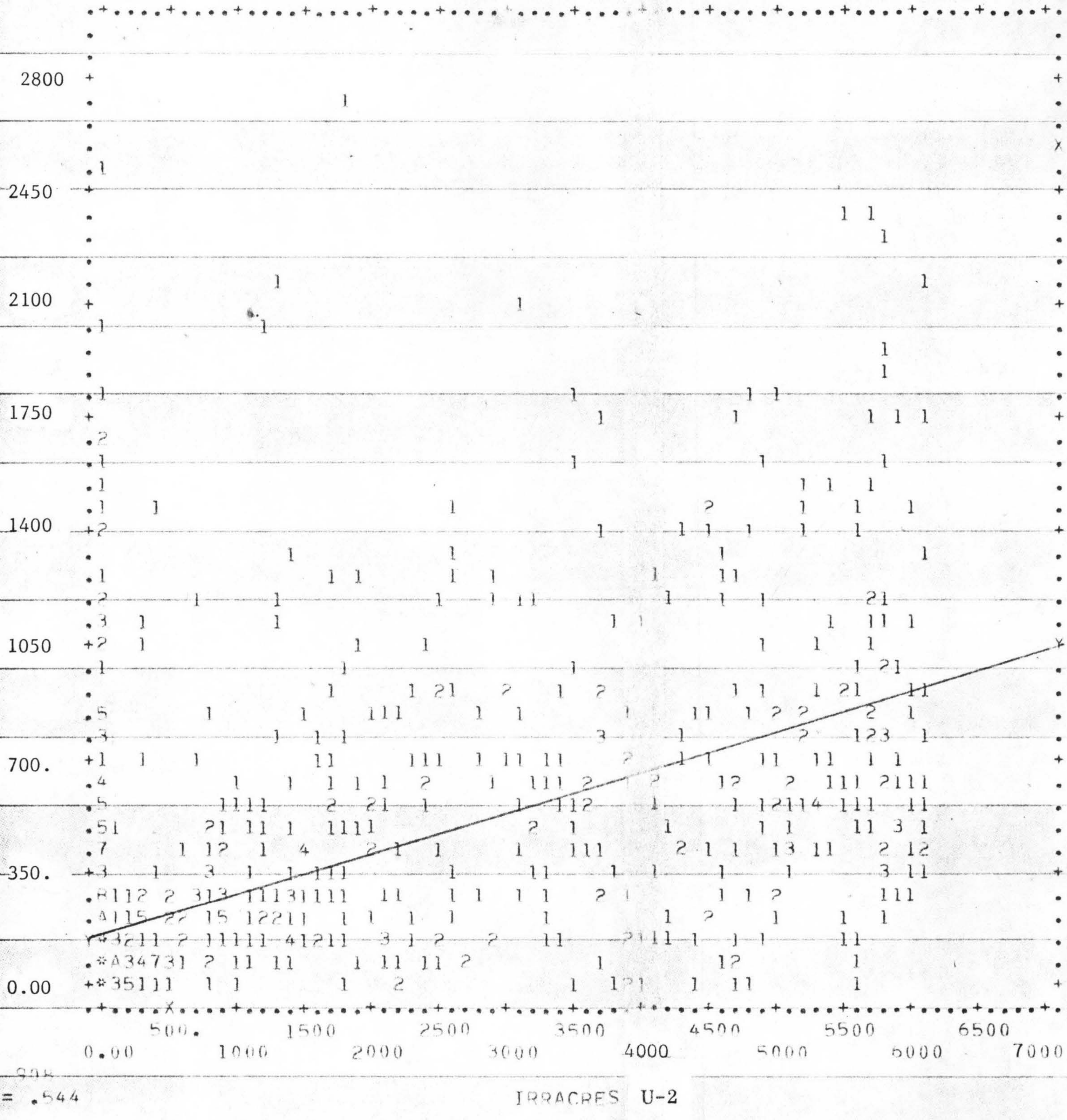
Figure A7. Scatter plot of the absolute differences between the U-2 acreage values and the unstratified LANDSAT estimates plotted against the U-2 estimates.



N= 911
COR= .618 IRRACRES U-2

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1605.1	2092.8	X= 2.4448*Y+ 813.89	2711E3
Y	321.59	528.84	Y= .15611*X+ 71.015	173120

Figure A8. Scatter plot of the absolute differences between the U-2 acreage values and the stratified LANDSAT estimates plotted against the U-2 estimates.



N= 908
COR= .544

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	1592.3	2084.2	X= 2.4373*Y+ 702.91	3062E[illegible]
Y	364.89	465.09	Y= .12137*X+ 171.63	152490

Figure A9. Scatter plot of the absolute differences between the U-2 acreage values and the stratified LANDSAT estimates with three outliers deleted plotted against the U-2 acreage values.