EVALUATION OF USEFULNESS OF SKYLAB EREP S-190 AND S-192 IMAGERY IN MULTISTAGE FOREST SURVEYS

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Progress Report

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OVERALL STATUS

Since the last report progress has been made primarily in the following areas: (a) multi-spectral combining of EREP imagery, (b) testing of developed interpretation software, and (c) testing of manual photo interpretation techniques.

With these new developments, our status with respect to the submitted EREP Investigation #473 milestone plan is as follows:

Subtask 1--coordinate transform program preparation and testing, has been completed.

Subtask 2--digital interpretation program preparation and testing, has also been completed.

Subtask 3--the development of sampling techniques has been modified to the extent that we are not concentrating this effort in a given time period. Rather, we evaluate the possible gain for a set of sampling methods throughout our experimentation with various interpretation techniques to determine which sampling method is best suited to the particular interpretation technique.

Subtasks 4 and 5--first-look analyses of SL/2 and RB-57 imagery have been completed and reported on in the previous progress reports.

Subtask 6--multi-spectral combining of images is reported on in the present report.

Subtask 7--the automated interpretation of S-192 tapes with the LARS system has been deleted. We have found that our problem is of a unique nature, not very well suited to a treatment with the LARS system. We are, therefore, putting our efforts in the testing of the software system specifically developed for forest volume prediction.

Subtask 8--the coordinate transfer of sample units to RB-57 and EREP imagery has been completed.

Subtasks 9 and 10--manual and digital image interpretation have been in progress through the months of February and March and will continue through April.

Subtasks 11 and 12--will be performed shortly before the due date of the final report.

A significant result was obtained during the completion of Task 1, the coordinate transforms for the S-190A and S-192 systems, with the resectioning of an S-190A image. The 70 mm image was enlarged to a scale of 1:843,526 and transferred to a glass plate on which 34 control points were measured with a Mann TAPI comparator. The coordinates of these points, and ground control point coordinates obtained from the Coast and Geodetic survey were then used in a spatial resectioning program. This program is capable of doing a classical resection as well as an empirical polynomial adjustment. The overall RMSE of the resectioning proved to be 106 m on the ground. With an additional 2^{nd} power polynomial adjustment RMSE's of 100 and 90.2 m were obtained in the x and y directions, respectively. These results are better by a magnitude of 2 than those obtained from ERTS, due to a better defined geometry, the use of SKYBET parameters, and a better ground resolution for control point identification.

In the following sections we report on the completion of subtasks 2 and 6, digital interpretation system testing and multi-spectral combining of EREP images.

Testing of the Digital Volume Prediction System

In the previous report we described the testing of the digital timber volume prediction system on a 64-square-mile test area in Northern California's

Trinity Alps. From this systematic experiment with two ERTS MSS bands from which tone and contrast features were extracted, we initially estimated that a potential gain of 50% in sampling precision could be realized by using the digital prediction system. This optimism has been reduced somewhat for our test area although the gains still appear to be significant. Testing for the potential gain that may be realized from EREP S-192 data still needs to be determined.

The first test area contained a water body, which we thought could exaggerate the potential gain, as water is naturally associated with zero timber volume. For this reason we also tested the system on another area situated further north in the Trinity Alps which contained no waterbodies. For calibration purposes we again used timber volume estimates obtained manually from highflight U2 photographs and volume estimates provided by the Southern Pacific Land Company. We performed the same kind of systematic experiment as the one for the first test area, but omitted the contrast factor, as we had found it to be of little significance.

The results for this test area confirmed our previous findings as far as the ERTS band combinations were concerned, but the estimated potential gain was somewhat lower at 35%.

The calculated gain percentages were estimates based on test areas, and the real performance of the system can best be assessed by predicting timber volumes over a much larger area, based on the calibration data of the two test areas. Consequently, calibration coefficients were obtained by making a combined interpretation of the two test areas (128 square miles). The estimated potential gain from this combined test area run was 44%.

The statistical significance necessary for a useful predictor was more than twice the required value. Thus, we were confident that statistically significant results could be obtained outside the test areas.

The next step was to test the performance of the system on a set of primary units spread over a 1600-square-mile area. The selected primary units were previous sample units in a timber inventory performed by Earth Satellite Corporation for the Southern Pacific Land Company. We, therefore, have accurate and recent timber volume estimates for each unit based on ground samples and low-altitude aerial photography. Each primary sample unit may consist of up to 8 one-square-mile land sections. The following results were obtained for the interpretations made for the complete set of PSU's.

Table I shows the reduction in the variance of the estimate of total timber volume and volume per acre that is attributable to digital interpretation of ERTS data or manual interpretation of highflight color infrared aerial photography, scale 1/120,000 for three types of sampling plans. In all cases the figures show the gain achieved when the NASA-furnished data are used in conjunction with EarthSat's estimates derived from ground data and low-altitude aerial photography.

It is significant to note that the gains are generally higher when estimating total volume than when estimating volume per acre. The magnitude of these differences indicates that the size of the area covered by a particular vegetation class, as interpreted from the space or highflight imagery, is at least as important as the absolute values obtained from the signature analyses per se.

Table I

REDUCTION IN VARIANCE DUE TO DIGITAL ERTS OR HIGHFLIGHT DATA
(In Percent)

		All Primary Units N = 41		Four Outlyers Removed N = 37	
	Data Source:	Digital	Highflight	Digital	Highflight
Total Volume	Variable Probability Sampling	44	8	57	12
	Stratified Sampling	21	17	12	9
	Regression Sampling	49	34	55	31
Volume per Acre	Variable Probability Sampling	17	1	17	-43
	Stratified Sampling	6	27	9	64
	Regression Sampling	11	9	18	7

The next step in the digital processing phase will be to repeat the test sequence using data from the EREP S-192 multi-spectral scanner.

Multi-Spectral Combining of EREP Images

We have examined photographic and scanner type images from Skylab S-190A and S-192 passes #34 and #37 over our northern California test area. Instruments used during the image analysis were the I^2S Addcol (International Image Systems) and the VP-8 Image Analyzer (Image Systems International). In this section we describe the techniques used with each machine, the image materials used, and the results we have obtained to date.

I^2S Addcol

The basic technique used with this machine is the use of projected light through colored optical glass filters for each of four image samples.

The samples are selected bands of the multi-spectral coverages of the S-190A imaging system.

The four image samples (70mm positive transparencies) are viewed first without filters in concert and registered on a diffuse glass viewing screen as one composite image. A colored optical filter is then placed between each of the projection lights and the image samples. The result is a color composite image on the viewing screen. For enhancement purposes the light intensity, light position and filter color can be varied for each image sample. When the desired image is produced on the viewing screen the image is copied from the screen using a Hasselblad camera and Ektacolor film. Our experience with the S-190A imagery resulted in the following combinations of light intensity settings and filter for each image sample:

Sample Skylab Image	Bandwidth μ	I^2S Addcol Light Intensity	Filter
Roll 1	6900 - 8000	9.1	Red
Roll 2	7700 - 1000	8.7	Red
Roll 5	5800 - 8000	8.5	Green
Roll 6	4700 - 5800	10.0	Blue

The resulting image provides the greatest contrast and enhancement which could be obtained with the sample images when judged visually. In this case our objective was to register the existing forest stands in contrast to non-timbered and barren lands over our test area. This method would provide us with a level of data input for initial timber volume predictions over the test site.

The same procedure was used with S-192 images from pass #37. In this case we had only three image samples which represented the spectral bands and bandwidths of concern to us in this investigation. Light intensity

settings and filter combinations used for each image sample were as follows:

S-192 Skylab Image	Bandwidth μ	I^2S Addcol Light Intensity	Filter
Band 7	.78 - .88	8.7	Green
Band 11	1.55 - 1.75	8.5	Red
Band 2	.46 - .51	7.8	Blue

Our observations of the composite images produced for the S-190A and S-192 image sample have led us to the following conclusions: (1) In the case of the S-190 composite image we find that there is a loss of image quality from combining the images and projecting them onto a ground diffuse glass viewing screen. Second- or third-generation color infrared transparencies already delivered as a Skylab product are several orders of magnitude better for interpreting photographic detail; (2) we find that color enhancement of the several bands via the I^2S machine does not produce equally as good or better color contrasts for forest vegetation over our test area as does the color infrared film transparencies already delivered to the investigator. In the case of the S-192 images, the photographic quality is fair to poor. However, we can make a few comments regarding our observations of the utility of S-192 as an imaging system.

Band 2 (.46 - .51 μ) has wavelengths too short to be useful in vegetation analysis. Detail is obscured and feature contrast is almost nil.

Band 7 (.78 - .88 μ) would be the best of the three for vegetation analysis. Detail is clearer and contrasting vegetation features are interpretable with study of this iamge.

Band 11 (1.5 - 17.5 μ) seems to produce an image similar to a radar image of terrain. Geographic features show some contrast, waterbodies and water courses show sharp contrast and detail. Detail in these features is readily interpretable, but for vegetation analysis this portion of the spectrum is not appropriate over our test site in California.

VP-8 Image Analyzer

During this reporting period we have unfortunately experienced many electrical and other engineering problems with this particular machine. Consequently we have not been able to finish the experiments anticipated during this reporting period. In place of reporting results at this time we can describe the techniques we are using with the VP-8 to obtain data from the several bands of S-190A imagery.

The VP-8 system utilizes a video camera and two television receivers. Between the camera and receiver are the electronics which measure the film density responses of the several bands. The video receivers display the scene collected by the camera lens. It is possible to make point density measurements within the images area on the video screen by means of an electronics cursor which scans a coordinate system built into the video screen. Any point on the screen can be measured for density and these measurements repeated via coordinate repetition so long as the image sample is not moved.

Our measurement technique will be to select a series of nine locations within each GLO section found on the video screen image of an S-190A frame. At each of the nine locations within each section we will measure

the film density of that point. This process will be repeated for bands (Roll #5) 1, 2, 5, and 6 of the S-190A images covering the test area.

These measurements will be tallied for each section per band so that four variables will be obtained for each band per section. These four variables can then be used in a regression model. This regression model will assist in the analysis of the contribution these data make in the prediction of timber volumes from Skylab images.

EXPECTED ACCOMPLISHMENTS FOR THE NEXT PERIOD

Our expected accomplishments for the next period fall into the following categories:

1. Completion of the program to ready S-192 digital tapes.
2. Begin the analysis of the S-192 digital timber volume prediction experiment using a preliminary 5-second burst from Skylab II.
3. Manual interpretation and analysis of RB-57 photography.
4. Manual interpretation of S-190A imagery.
5. Machine-assisted interpretation of S-190A imagery (VP-8 image analyzer).

SIGNIFICANT RESULTS FOR THIS PERIOD

The digital timber volume prediction system was tested with another test area in the Trinity Alps. The estimated gain in precision was somewhat lower than the estimate for the first test area (35%). A combined interpretation of the two areas was made, yielding an estimated gain of 44%, with a high statistical significance. This interpretation was used to calibrate the system for an interpretation of 43 primary sample units distributed over 1600 square miles. Preliminary results indicate that a gain of 35% can be realized over this large area in Northern California.

The resectioning procedure for our test areas in Trinity County has been completed for the RB-57 support imagery and the SL-190A imagery. This step is important to the final analysis of our forest survey experiments using SL-190 and SL-192 Skylab coverage.

SUMMARY OUTLOOK FOR THE REMAINING EFFORT TO BE PERFORMED

We are still behind in our overall effort with respect to the milestone plan due to personnel scheduling problems and delays in delivery of the required data products. We expect to be able to extend our effort until September 30 with NASA approval.

The overall outlook for the use of space imagery in timber volume predictions is encouraging, and we expect our current ERTS results to be confirmed by experimentation with the EREP imagery. The results obtained so far are statistically significant, and their eventual implementation is, therefore, a matter of opportunity and economical considerations.

TRAVEL PLANS

None.