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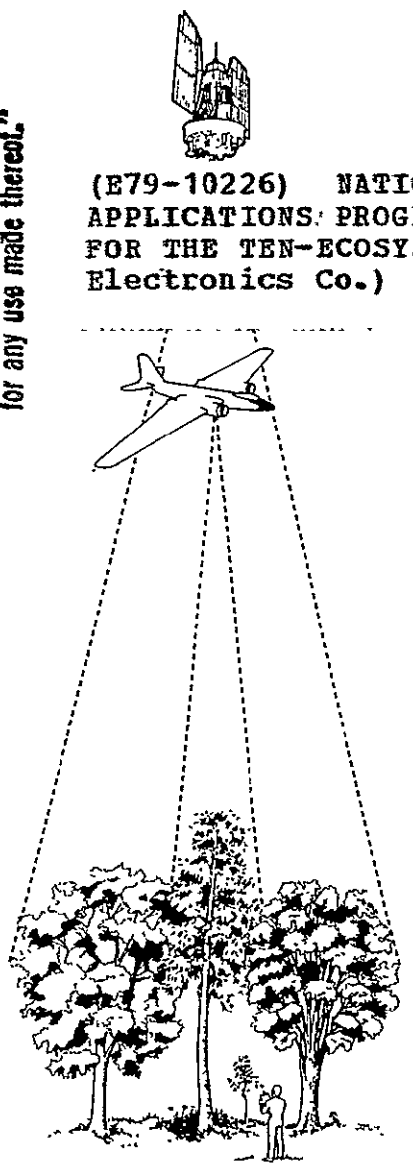

EVALUATION PROCESS FOR THE
TEN-ECOSYSTEM STUDY

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NOTE: In 1976, the Nationwide Forestry Applications Program was expanded from a Regional project by cooperative agreement between the Forest Service, U. S. Department of Agriculture, and the National Aeronautics and Space Administration (NASA). The Program is designed to sponsor research and development on the application of remote sensing analysis techniques to problems arising from the need to inventory, monitor and manage forests and rangelands, including the assessment of impacts on forest stands from insect and disease damage.

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16. Abstract

This report describes the evaluation process used throughout the Ten-Ecosystem Study and the results of the evaluation of each of the sites. Tables showing the percent of correct classification, the class proportions, and the class proportion errors are included.

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ACRONYMS

DAS	data analysis station
PCC	percent of correct classification
pixel	picture element
PSU	primary sampling unit
SSU	secondary sampling unit
TES	Ten-Ecosystem Study
ZTS	Zoom Transfer Scope

PREFACE

The Nationwide Forestry Applications Program was established in 1971 at the Lyndon B. Johnson Space Center of the National Aeronautics and Space Administration to develop and demonstrate remote sensing technology in performing forest resources inventories. Several localized feasibility studies of small areas were conducted, and the technology was developed for automatic data processing of satellite and aircraft multispectral scanner data. With the recent passage of the Forest and Rangeland Renewable Resources Planning Act, Public Law 93-378, there was a need to extend the technology to larger and more widely scattered areas. The Ten-Ecosystem Study was initiated in response to some of the research requirements of these acts.

The Ten-Ecosystem Study is an automatic data processing feasibility study, using Landsat data, supporting aircraft imagery, and ancillary information for inventorying forest, grassland, and water by administrative boundaries in 10 categorized ecosystems of the United States. Successes and failures were identified and recommendations were made regarding future large area studies in each specific ecosystem.

The primary objectives of the Ten-Ecosystem Study were as follows:

a. To investigate the feasibility of using data processing of remotely sensed data to inventory forest, grassland, and inland water areas within designated boundaries for specified ecosystems of the United States

b. To identify automatic data classification problems related to each site and recommend solutions

c. To define the requirements for an automatic data processing system to perform a nationwide forest and grassland inventory

These objectives are addressed in the Ten-Ecosystem Study final report.

In this report, the evaluation process is discussed and the results of all the sites under investigation are presented. This document was prepared by Lockheed Electronics Company, Inc., under Contract NAS 9-15800, Job Order 75-325, Action Document 63-1737-5325-53. Distribution of this report has been approved by the supervisor of the Forestry Applications Section.

1. INTRODUCTION

The Ten-Ecosystem Study (TES) is an automatic data processing feasibility study using Landsat data, supporting aircraft imagery, and ancillary information for inventorying forest, grassland, and water by administrative boundaries in 10 categorized ecosystems of the United States. The evaluation process (fig. 1-1) used for the TES is described in this report. Procedures for transferring primary sampling unit (PSU) locations from data analysis station (DAS) transparencies to aerial photographs and for comparison of classification products with aerial photographs are included in appendixes A and B, respectively. Summaries of percent of correct classification (PCC), class proportions, and class proportion errors are included in appendix C.

To evaluate a classification process, certain basic rules need to be established and followed. Two rules established for TES were: (1) aerial photography would be regarded as ground truth, and (2) the distribution and size of the sample areas which were to be used as classification areas were delineated.

Aerial photographs at a scale of 1:120 000 with color-infrared film were used to differentiate the features of softwood, hardwood, grassland, water, and "other" into a classification system. The category "other" included everything not included in the softwood, hardwood, grassland, or water groups. For reliability of the photointerpretation of the TES sites, field trips to each TES site were made where a comparison of actual vegetation on the ground with data of the photographs was completed. In this manner, the criteria for ground truth of the TES were established.

At least 10 sample areas, 50 by 50 picture elements (pixels) in size and randomly selected throughout a site, were chosen as the PSU's. Within each of these PSU's, 10 secondary sampling units

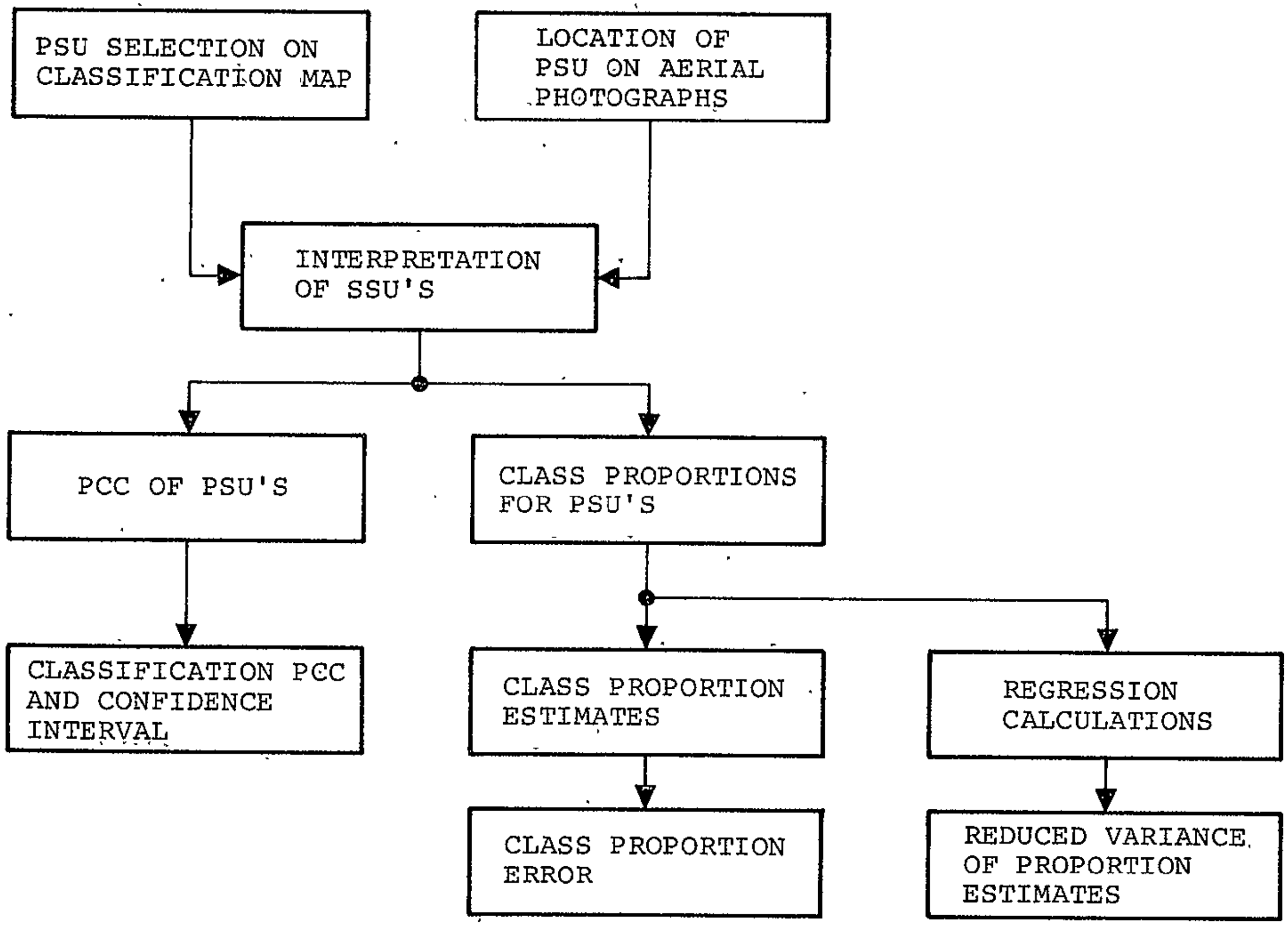

Figure 1-1.— The flow diagram of the evaluation process.

(SSU's), 2 by 2 pixels in size, were randomly located. The SSU represents the actual areas of comparison between the classification data and the photographic ground truth (ref. 1).

2. REGISTRATION OF LANDSAT IMAGES TO AERIAL PHOTOGRAPHS

Ensuring that an accurate correlation between the aerial photographs and the DAS Landsat color composite image was an important aspect of the evaluation process. The registration of Landsat images to aerial photographs was done using a Dell Foster digitizer and a Texas Instruments' SR51 calculator. The PSU's were located on alphameric printouts of the classification data. Using the random number selector of the SR51 calculator, the first number generated indicated the line and the second number defined the column of the upper left corner of a 50-pixel by 50-pixel PSU. The Dell Foster digitizer was used to plot these points on the DAS transparency. The transparency was squared on the Dell Foster light table, the scale adjusted to fit the pixel count, and the line and column locations were made.

The aerial photograph which covered the area represented by the DAS transparency was then placed on the Dell Foster light table and aligned. The method of registering the photograph to the DAS transparency involved selecting and determining the coordinates of at least six points readily identifiable such as road intersections, confluence of rivers, or other natural or man-made features on both the DAS transparency and the aerial photograph. A least-squares program in the SR51 calculator was used to determine the linear registration coefficients. The linear registration polynomials are:

$$XP = a(SI) + b(LI) + c$$

$$YP = d(SI) + e(LI) + f$$

See table 2-1 for the registration computation worksheet and refer to appendix A for detailed procedures on registering Landsat images to aerial photographs.

TABLE 2-1.— REGISTRATION COMPUTATION WORKSHEET

Point		Landsat sample (SI)	Landsat line (LI)	Photo-X (PX)	Photo-Y (PY)	Computed X (CX)	Computed Y (CY)	Error X (ΔX = CX - PX)	Error Y (ΔY = CY - PY)	Remarks
Registration control	1									
	2									
	3									
	.									
	.									
	.									
PSU corners	1									
	2									
	3									
	4									

3. INTERPRETATION OF SSU's

When all the PSU locations had been placed on the aerial photographs, the actual evaluation of the classification data began. In the evaluation process, the Zoom Transfer Scope (ZTS) was used as the major instrument to accomplish photointerpretation of the classification data. All the aerial photographs and the alphameric printouts of the classification data were taken to the ZTS. Using the coordinates for the location of a PSU, a 50-pixel by 50-pixel area was marked on its corresponding alphameric printout. Through the use of overlays, the 2-pixel by 2-pixel SSU's of the alphameric printout were compared with the interpretation of the same area of the aerial photograph which was mounted on the ZTS viewing screen. The two readings were then recorded. Refer to appendix B for details of this procedure.

The worksheet (table 3-1), containing the readings from the photointerpretations and the classification maps, was completed for each SSU in every PSU. The photointerpretation readings were represented by P: P_1 = softwood, P_2 = hardwood, P_3 = grassland, P_4 = water, and P_5 = other. The classification map readings were recorded under $\hat{P}$: $\hat{P}_1$ = softwood, $\hat{P}_2$ = hardwood, $\hat{P}_3$ = grassland, $\hat{P}_4$ = water, and $\hat{P}_5$ = other.

When restricting a residual registration error to not more than 1 pixel between the DAS transparency and the aerial photograph, there were nine possible locations on or around each SSU on the DAS transparency that could represent the corresponding area on the photograph (fig. 3-1). These nine possible locations were examined to determine which one most nearly duplicated the photointerpretation (ref. 2).

TABLE 3-1.– WORKSHEET FOR PHOTOINTERPRETATION AND CLASSIFICATION MAP READINGS

Site ______________ PSU ______________ SSU ______________ ANALYST ______________

Photointerpretation: P_1 __________, P_2 __________, P_3 __________, P_4 __________, P_5 __________

Classification map readings:

Location	$\hat{P}_1$	$\hat{P}_2$	$\hat{P}_3$	$\hat{P}_4$	$\hat{P}_5$	A $(P_1-\hat{P}_1)^2$	B $(P_2-\hat{P}_2)^2$	C $(P_3-\hat{P}_3)^2$	D $(P_4-\hat{P}_4)^2$	E $(P_5-\hat{P}_5)^2$	F = A+B+C+D+E
a											
b											
c											
d											
e											
f											
g											
h											
i											

Site ______________ PSU ______________ SSU ______________ ANALYST ______________

Photointerpretation: P_1 __________, P_2 __________, P_3 __________, P_4 __________, P_5 __________

Classification map readings:

Location	$\hat{P}_1$	$\hat{P}_2$	$\hat{P}_3$	$\hat{P}_4$	$\hat{P}_5$	A $(P_1-\hat{P}_1)^2$	B $(P_2-\hat{P}_2)^2$	C $(P_3-\hat{P}_3)^2$	D $(P_4-\hat{P}_4)^2$	E $(P_5-\hat{P}_5)^2$	F = A+B+C+D+E
a											
b											
c											
d											
e											
f											
g											
h											
i											

Total correct SSU's ___
Total SSU's __________
PCC __________

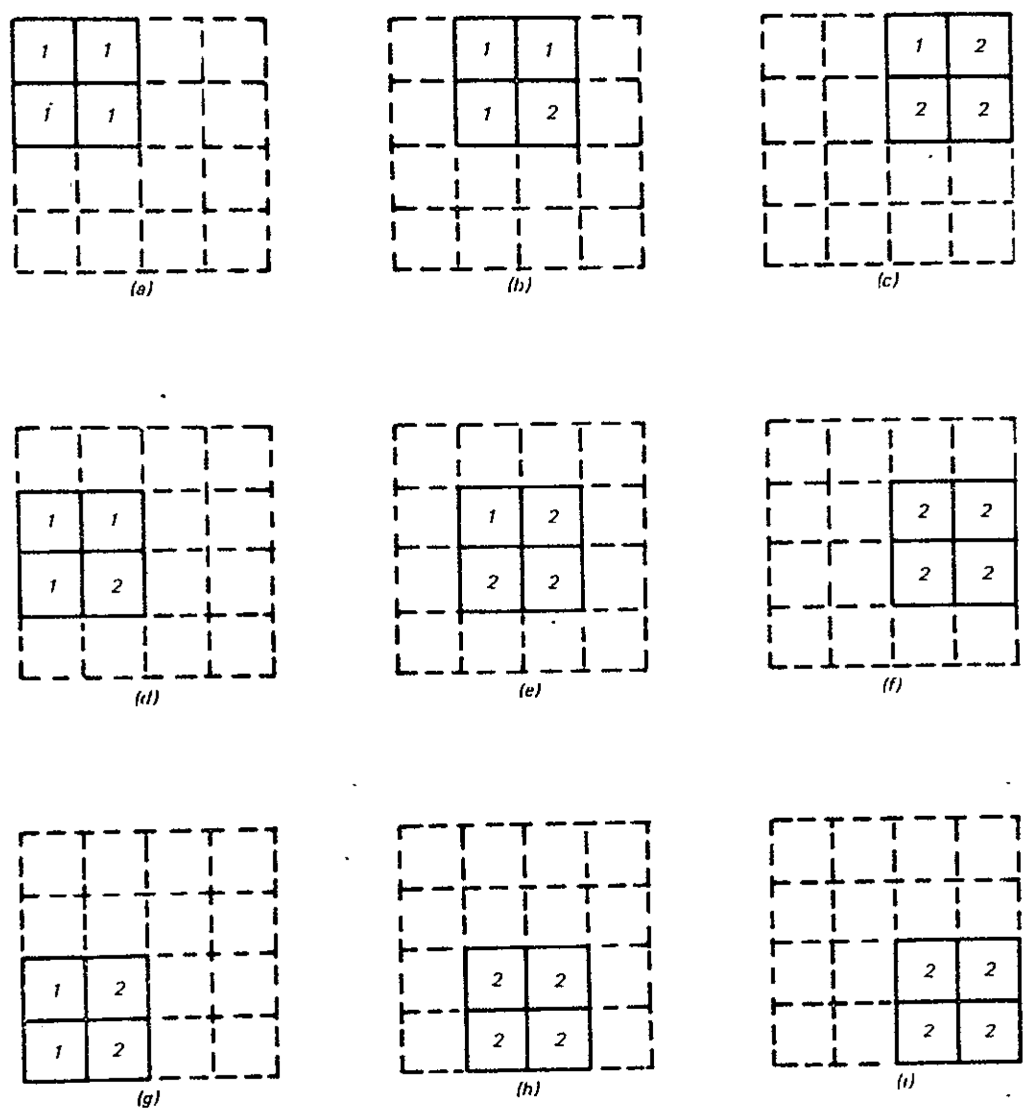

Figure 3-1.— The nine possible locations on or around the SSU with a classification assignment to class 1 or 2.

The formula for determining the difference between the photointerpretation and the DAS transparency readings is:

$$E = (P_1 - \hat{P}_1)^2 + (P_2 - \hat{P}_2)^2 + (P_3 - \hat{P}_3)^2 + (P_4 - \hat{P}_4)^2 + (P_5 - \hat{P}_5)^2$$

When applying this formula, if the difference between photointerpretation and the DAS transparency were 0.15 or less, the classification was accepted as correct (ref. 1). After all 10 SSU's were checked to determine which were correctly classified, the PCC was determined by dividing the total number of SSU's into the total correctly classified SSU's.

4. MEAN AND STANDARD DEVIATION

After all 10 PSU's were interpreted and the difference between the aerial photograph and the DAS transparency calculated, the average PCC for the TES site was computed using the SR51A hand-held calculator. The formulas used for the mean and the standard deviation of the mean are presented in table 4-1, Summary of PCC Calculations. When calculating these statistical parameters, each datum was treated separately or as ungrouped data.

The formula for deriving the standard deviation of the mean is:

$$S^2_{PCC} = (1-f)\,\frac{1}{m(m-1)}\sum_{i=1}^{m}(PCC_i - PCC)^2$$

The f varies with the number of PSU's and is the function of:

$$\sqrt{1 - f/m}$$

where m = number of PSU's and

$$f = m \times (50^2/(970)^2$$

(Note: 50 = pixel size of PSU and 970 = number of pixels in a frame)

The next phase calculated was the half-confidence interval or Δ. This number was the result of multiplying the standard deviation of the mean by the number taken from the statistical tables; i.e., the critical t-value from the cumulative t-distribution list. This constant varied with the number of PSU's being evaluated and the level of confidence desired.

The confidence interval of PCC was obtained by merely subtracting Δ from PCC for the lower range and adding Δ to PCC for the upper range.

TABLE 4-1.— SUMMARY OF PCC CALCULATIONS

(a) PCC calculations worksheet

PSU number	PCC_i

(b) Calculation formulas

Calculation of mean:

$$\overline{PCC} = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

where m = total number of data points

Calculation of standard deviation of the mean:

$$S_{PCC}^2 = (1-f) \frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - \overline{PCC})^2$$

$$f = \frac{m-1}{M-1}$$

Calculation of the PCC half-confidence interval at the 90-percent level:

$$\Lambda = t_{0.95(m-1)} S_{PCC}$$

Confidence interval of PCC:

$$(\overline{PCC} - \Lambda,\ \overline{PCC} + \Lambda)$$

Symbol definition:

m	— PSU sample size.
M	— PSU population size.
$\overline{PCC}$	— Average of PSU sample.
PCC_i	— PCC for the *ith* PSU.
S^2_{PCC}	— Variance of PCC.
S_{PCC}	— Standard deviation of PCC.
Λ	— Allowable error (half-confidence interval).
$t_{0.95(m-1)}$	— Cumulative t-statistic for 0.95 level and (m-1) degrees of freedom.

In TES, the number of PSU's chosen was determined so that the upper limit of the half-confidence interval or Δ was less than or equal to 0.05 PCC at a confidence level of 0.90. This number is a popular criterion for qualifying a good, tight statistical estimate and was used for that reason. If (with the use of 10 PSU's) the Δ were larger than 0.05 PCC, more PSU's were selected and evaluated. The maximum number of PSU's for the TES was set at 25. Some sites with a Δ larger than 0.05 PCC required 25 PSU's to be evaluated.

W

5. CLASS PROPORTIONS

The photointerpretation and classification map readings presented in table 3-1 of section 3 are used in the evaluation process to obtain a summary of class proportions (table 5-1). The mathematical procedure for this is described below.

From table 3-1, obtain the total of SSU proportions by class (softwood, hardwood, etc.) for photointerpretation (P) and divide this number by the total number of SSU's in each PSU which is always 10 for TES. Enter the results in table 5-1 under the appropriate heading. For the classification map proportions, obtain the total of the most nearly correct proportion set and divide by the number of SSU's in each PSU (10 for TES). Enter the result in table 5-1.

All the data calculated for table 5-1 were used for the summary of class proportion errors (table 5-2). By adding each classification column $\hat{P}_i$ of table 5-1, the total of the readings from the classification map are derived for softwood, hardwood, grassland, water, and other. For each classification, divide the total of column $\hat{P}_i$ by the number of PSU's evaluated for the estimated class proportion. This number for each class should result in a total of 1; otherwise, mathematical errors are suspected.

The SR51A calculator was used to determine the error bias (column B, table 5-2). The sum of the differences between the photointerpretation and the classification map totals for softwood in table 5-1 were averaged to obtain the average error (B) for softwood.

TABLE 5-1.— SUMMARY OF CLASS PROPORTIONS WORKSHEET

PSU number	Softwood		Hardwood		Grassland		Water		"Other"	
	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$
1										
2										
3										
•										
•										
•										

Total number of PSU's = ________

TABLE 5-2.— SUMMARY OF CLASS PROPORTION ERRORS[a] WORKSHEET

Classes	Proportion error					Relative proportion error	
	Estimate of of class proportion, $\hat{P}$	Average error, B	Standard deviation of average error, S_B	$\Delta_{0.9}$	Confidence interval	Photointerpreted class proportion, P	Relative error, RB
Softwood							
Hardwood							
Grassland							
Water							
Other							

[a]The algorithms used in the computation of the class proportion errors are:

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m} \hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (P_i - \hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

The standard deviation of the average error (S_B) was also obtained and the formula used is:

$$S_B = \left[(1-f) \frac{1}{m(m-1)} \sum_{i=1}^{m} (B_i - B)^2\right]^{1/2}$$

The standard deviation S_B times the same cumulative t-distribution constant, previously used, gave the Δ for a 0.9 confidence level. The average error (B) minus and plus the Δ determined the confidence interval of this average error.

The relative error (column RB, table 5-2) was determined by dividing the average error (B) by the estimated class porportion (P) of the photointerpretation and multiplying the result by 100 to obtain a percentage reading.

This summary of class proportion errors completes the major part of the evaluation process.

6. REFERENCES

1. Kan, E. P.: An Ad-Hoc Map Evaluation Procedure. Lockheed Electronics Company, Inc. (Houston, Tex.), LEC-8278 (JSC-11154), April 1976.

2. Kan, Edwin P. (ed): Technical Analysis Procedures for the Ten-Ecosystem Study. Lockheed Electronics Company, Inc. (Houston, Tex.), LEC-9379, Dec. 1976.

APPENDIX A

A PROCEDURE FOR TRANSFERRING PSU LOCATIONS FROM DAS TRANSPARENCY TO AN AERIAL PHOTOGRAPH

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A PROCEDURE FOR TRANSFERRING PSU LOCATIONS FROM DAS TRANSPARENCY TO AN AERIAL PHOTOGRAPH

The Dell Foster digitizer and the Texas Instruments SR51 calculator were used to transfer PSU locations from the DAS transparencies to aerial photographs. The DAS transparency and the aerial photograph (color infrared, scale 1:120 000) covering the same area were mounted on the Dell Foster light table. They were carefully squared using the sliding action of the eyepiece and then firmly secured in place. At this point, the photograph and DAS image were studied to find at least six correlative points, such as confluence of drainage, road intersections, or any other finite point that could be identified on both images. Corresponding points were given a number with a Rapidograph pen.

Working first with the Landsat DAS imagery, each site was divided into four quadrants. Each quadrant was approximately 485 by 485 pixels in size, but there was a slight variation with each site which required a different scale for each quadrant of every site. A scale of 685 for X and 671 for Y gave a close approximation and offered a number from which adjustments could be made. When the proper scale was found, the coordinates of each of the six selected points were located and entered on the worksheet.

After changing the scale to X = 1000 and Y = 1000, the same procedure was followed to read the location of the six selected points from the aerial photograph. These coordinates were entered on the worksheet. With the addition of the four corner coordinates from the PSU, all the necessary data were in place and the calculations could be made using the SR51 calculator.

The following steps outline the method for generating the coordinates for the location of the PSU on the aerial photograph.

a. Two plastic program cards numbered 12-1 and 12-2, containing the least-squares program, are removed from the carrying case.

b. Turn on the SR51 calculator; insert card 12-1, side A; hit "2nd" then "Read"; insert side B; hit "2nd" then "Read." Punch E' to initialize.

c. The calculator was now programmed to receive the coordinate numbers. Punch in the Landsat sample number, enter in A; then Landsat line number, enter in B; then punch in the coordinate from the photograph, photo-X, and enter it in C. All six sample, line, and photo-X numbers were entered in a like manner.

d. Do not clear the machine; insert the second card 12-2, side A; hit "2nd" then "Read"; insert side B, hit "2nd" then "Read." At this point, (by punching A) the coefficient for c is calculated; punch B and receive the coefficient for a; punch C and receive the coefficient for b.

e. The last step in this phase was to insert the Landsat sample number and punch D; insert the Landsat line number and punch E and get the computed X for each of the six registration control points. The computed X numbers were then compared to the photo-X control point numbers to prove their validity. If the computed X number was within 2 digits of the photo-X number, it was considered good enough to be acceptable. If the difference were larger than 2 digits, other points must be picked and checked in the same manner as described above.

f. When all six registration control points have been calculated and proved acceptable, the first PSU corner point for the Landsat sample was entered and D was punched; then the Landsat line number was entered and E was punched. This generated the computed X-coordinate for one corner of the PSU. The remaining three corner numbers were entered in like manner, and all four computed X-coordinates of the PSU were thusly located.

To determine the computed Y-coordinates, the exact procedure used to find the computed X-coordinates was used, with exception of using the photo-X number. Instead, the photo-Y number was employed in conjunction with the Landsat sample and Landsat line numbers.

APPENDIX B

PROCEDURE FOR COMPARISON OF CLASSIFICATION PRODUCT WITH AERIAL PHOTOGRAPH

APPENDIX B

PROCEDURE FOR COMPARISON OF CLASSIFICATION PRODUCT WITH AERIAL PHOTOGRAPHS

In order to compare the results of the classification product with the ground truth of the aerial photographs, some special equipment was necessary; therefore, 10 stabilene overlays were constructed to fit the area covered by the 50-pixel by 50-pixel PSU's of the alphameric printouts. Each overlay had ten 2-pixel by 2-pixel SSU's outlined. These SSU's were randomly placed, using the random number selector on the hand-held calculator. Ten different sets were generated to further ensure a truly random selection.

An aerial photograph with the outline of the PSU was mounted on the viewing screen Zoom Transfer Scope (ZTS). A PSU overlay with 10 SSU locations was then situated beneath the ZTS; and, using the enlarging, stretching, and image rotation selectors, the image on the photograph was made to fit exactly the overlay underneath. It was then possible for the photointerpreter to identify and classify the areas under each of the 10 SSU's on the overlay. These interpretations were recorded and represented the ground-truth data used in the evaluation. The overlay was then removed and situated over the corresponding PSU on the alphameric printout, thus making it possible to compare directly the same areas from the photograph with the alphameric classifications. Both the photointerpretation and the alphameric readings were recorded on a worksheet for further study.

APPENDIX C

SUMMARY EVALUATION TABLES FOR TES SITES

EXTRACTED FROM OTHER TES DOCUMENTS

TABLE 4-1.- SUMMARY TABLE OF PCC CALCULATIONS

GRAND COUNTY, COLORADO (INVENTORY)

PSU#	PCC_i
2	0.90
3	.70
5	.80
6	.80
7	.70
8	.70
9	.90
10	1.00
11	.90
12	.40
13	.80
15	.70
16	.70
18	.60
19	.50
20	.70
21	.70
23	.60
24	1.00
25	.80

Total #PSU = m = 20

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= 0.75$$

$$S^2_{PCC} = (1-f) \frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = 0.033$$

$$\Delta = t_{0.95(m-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= 0.058$$

Confidence interval of PCC

$$= (PCC - \Delta, PCC + \Delta)$$

$$= (0.69, 0.81)$$

TABLE 5-1._ SUMMARY TABLE OF CLASS PROPORTIONS
GRAND COUNTY COLORADO, (INVENTORY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
2	.41	.425	0	0	0	0	0	0	.59	.575
3	.95	.80	0	0	.05	.05	0	0	0	.15
5	0	0	0	0	.16	.025	0	0	.84	.975
6	.57	.575	0	0	.15	0	0	0	.28	.425
7	.29	.1	0	0	0	.075	0	0	.71	.825
8	.57	.575	0	0	.01	0	0	0	.42	.425
12	.74	.3	0	0	.02	.05	0	0	.24	.65
13	.85	.725	0	0	0	.05	0	0	.15	.225
16	.78	.515	0	0	0	.05	0	0	.22	.375
18	.8	.775	0	0	.17	.075	0	0	.03	.15
19	.8	.525	0	0	.06	.15	0	0	.14	.325
20	.29	.175	0	0	0	.025	.13	.10	.58	.7
21	.37	.2	0	0	.1	.1	0	0	.53	.7
23	.67	.475	0	0	.13	.15	0	0	.20	.375
24	.84	.75	0	0	.07	.175	0	0	.09	.075
9	.06	.025	0	0	.03	0	0	0	.91	.975
10	.60	.70	0	0	0	0	0	0	.40	.30
11	.08	.075	0	0	.04	0	0	0	.88	.925
15	.71	.65	0	0	0	0	0	0	.29	.35
25	.24	.125	0	0	.13	.125	0	0	.63	.75

Total #PSU = m = 20

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS

GRAND COUNTY, COLORADO (INVENTORY AND SEPARABILITY)

Classes	True class proportion,	Separability: Estimated class proportion, $\hat{p}$	Separability: Error, B	Confidence interval, 0.9 level	True class proportion, p	Simulated inventory: Estimated class proportion, $\hat{p}$	Simulated inventory: Error, B	Confidence interval, 0.9 level
Hardwood	0.001	0.02	-0.019	-0.026, -0.012	(b)	(b)	(b)	(b)
Softwood	.517	.555	.038	-.085, .009	0.531	0.4275	0.1035	0.0596, 0.1474
Grassland	.0055	.045	.0105	-.016, .037	.056	.055	.001	-.0227, .0247
Water	.0065	.0075	-.001	-.003, .001	.0065	.005	.0015	-.0009, .0039
Other	.42	.3725	.0475	.004, .091	.4063	.5125	-.106	-.143, -.069

[a]True class proportion (p) comes from photointerpretation, and estimated class proportion ($\hat{p}$) comes from pixel-counting of ADP classifications. The true class proportions are slightly different between the two classification methods. This results from the use of one set of SSU locations, for each PSU, in the inventory study and the use of a different set of random SSU's for each PSU in the separability study. The later procedure will be used in all subsequent evaluation in TES.

[b]Extensive hardwood sites did not occur in the area from which signatures were extracted and thus this class was not considered for this portion of the evaluation.

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m}\hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m}B_i = \frac{1}{m}\sum_{i=1}(P_i-\hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i-B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P}\times 100$$

where RB is expressed as a percentage.

TABLE 4-1.—SUMMARY TABLE OF PCC CALCULATIONS
GRAND COUNTY, COLORADO (SEPARABILITY)

PSU#	PCC_i
2	.50
3	.80
5	.80
6	.70
7	.60
8	.50
9	.80
10	.70
11	.90
12	.80
13	.80
15	.80
16	1.00
18	.80
19	.70
20	.70
21	.50
23	.70
24	.80
25	.60

Total #PSU = m = 20

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .73$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .0289$$

$$\Delta = t_{.95(n-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= .050$$

Confidence interval of PCC

$$= (PCC-\Delta,\ PCC+\Delta)$$

$$= (.68\ ,\ .78\ )$$

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS
GRAND COUNTY, COLORADO (SEPARABILITY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
2	.41	.575	0	0	0	0	0	0	.59	.425
3	.85	.925	0	0	.15	.05	0	0	0	.025
5	0	0	0	.025	.16	.025	0	0	.84	.95
6	.57	.825	0	0	.15	0	0	0	.28	.175
7	.29	.25	0	.025	0	.1	0	0	.71	.625
8	.57	.725	.02	.05	.01	.05	0	.025	.40	.15
9	.06	0	0	0	.03	0	0	0	.91	1.00
10	.76	.875	0	.025	0	0	0	0	.24	.1
11	.08	0	0	.025	.04	.05	0	0	.88	.925
12	.82	.90	0	0	.09	.075	0	0	.09	.025
13	.78	.725	0	.05	.02	.1	0	0	.20	.125
15	.71	.725	0	0	0	.025	0	0	.29	.250
16	.71	.70	0	0	.01	0	0	0	.28	.30
18	.85	.95	0	0	.03	.025	0	0	.12	.025
19	.55	.85	0	.025	.19	.025	0	0	.26	.1
20	.29	.325	0	.05	0	.075	.13	.125	.58	.425
21	.37	.275	0	.025	.10	.15	0	0	.53	.55
23	.69	.85	0	.05	0	.025	0	0	.31	.075
24	.74	.575	0	.05	0	0	0	0	.26	.375
25	.24	.05	0	0	.13	.125	0	0	.63	.825

Total #PSU = m = 20

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS
WARREN COUNTY, PENNSYLVANIA (INVENTORY)

PSU#	PCC_i
2	.70
4	.80
5	.60
8	.80
10	.90
12	.90
15	1.00
17	1.00
18	1.00
20	.80
21	1.00
23	.90
3	1.00
11	.70
16	.70
24	1.00

Total #PSU = m = 16

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .86$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .033$$

$$\Delta = t_{.95(n-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= .058$$

Confidence interval of PCC —

$$= (PCC-\Delta,\ PCC+\Delta)$$

$$= (.80\ ,\ .92\ )$$

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS

WARREN COUNTY, PENNSYLVANIA (INVENTORY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$
2	0	0	.73	.575	0	0	0	0	.27	.425
4	0	0	.41	.525	0	.025	0	0	.59	.450
5	.02	0	.69	.625	0	0	0	0	.29	.375
8	.05	0	.85	.950	0	0	0	0	.10	.05
10	0	0	.96	.900	0	0	0	0	.04	.10
12	.03	0	.71	.650	0	0	0	0	.26	.35
15	0	0	.98	.975	0	0	0	0	.02	.025
17	0	0	.90	.875	0	0	0	0	.10	.125
18	0	0	1.00	1.00	0	0	0	0	0	0
20	0	0	.69	.725	0	.05	0	0	.31	.225
21	0	0	.97	.950	0	0	0	0	.03	.05
23	0	0	.96	.925	0	0	0	0	.04	.075
3	0	0	.67	.70	0	0	0	0	.33	.30
11	.13	0	.72	.725	0	.025	0	0	.15	.25
16	0	0	.23	.25	.18	.125	0	0	.59	.625
24	0	.025	.10	.975	0	0	0	0	0	0

Total #PSU = m =16

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS

WARREN COUNTY, PENNSYLVANIA (INVENTORY AND SEPARABILITY)

Class	May separability study				May inventory study			
	Estimated class proportion, $\hat{p}$	Error, B	Confidence interval, $\Delta 0.9$	Significance of error	Estimated class proportion, $\hat{p}$	Error, B	Confidence interval, $\Delta 0.9$	Significance of error
Hardwood	0.773	0.005	-0.018, 0.029	None	0.770	0.009	-0.003, 0.029	None
Softwood	.005	.010	-.006, .026	None	.002	.013	-.002, .028	None
Rangeland	.016	-.004	-.011, .003	None	.014	-.003	-.012, .006	None
Water								
Other	.206	-.011	-.034, .012	None	.214	-.019	-.050, .013	None

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m}\hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1}(P_i-\hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i-B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\, S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS

WARREN COUNTY, PENNSYLVANIA (SEPARABILITY)

PSU#	PCC_i
2	.70
4	1.00
5	.70
8	.80
10	.90
12	1.00
15	.90
17	.90
20	.80
21	.90
18	1.00
23	.90
3	1.00
11	.70
16	.70
24	.80

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .856$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .028$$

$$\Delta = t_{.95}(n-1)S_{PCC}$$

= half width of 90% confidence interval

$$= .049$$

Confidence interval of PCC

$$= (PCC-\Delta,\ PCC+\Delta)$$

$$= (.807\ ,\ .905\ )$$

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS
WARREN COUNTY, PENNSYLVANIA (SEPARABILITY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
2	0	0	.73	.775	0	.025	0	0	.27	.2
4	0	0	.41	.375	0	.025	0	0	.59	.6
5	.02	0	.69	.725	0	0	0	0	.29	.275
8	.05	0	.85	.950	0	0	0	0	.10	.05
10	0	0	.96	.925	0	0	0	0	.04	.075
12	.03	0	.71	.750	0	0	0	0	.26	.250
15	0	0	.98	.95	0	0	0	0	.02	.05
17	0	0	.90	.925	0	0	0	0	.10	.075
20	0	.025	.69	.725	0	0	0	0	.31	.250
21	0	0	.97	.875	0	0	0	0	.03	.125
18	0	0	1.0	1.0	0	0	0	0	0	0
23	0	.025	.96	.925	0	0	0	0	.04	.05
3	0	0	.67	.65	0	.025	0	0	.33	.325
11	.13	0	.72	.725	0	.025	0	0	.15	.25
16	0	0	.23	.20	.18	.15	0	0	.59	.65
24	0	.025	1.00	.90	0	0	0	0	0	.075

Total #PSU = m = 16

TABLE 4-1.— SUMMARY OF PCC CALCULATIONS

ST. LOUIS COUNTY, MINNESOTA (INVENTORY)

[Calculations, ref. 4]

Quad-rant	PSU no.	PCC_i
1	1	0.70
	23	.90
	29	.70
	35	.80
2	2	0.60
	4	.80
	5	.90
	21	.70
	22	.90
	36	.70
3	1	0.70
	26	.50
	28	.70
	30	.70
	34	.50
4	2	0.80
	4	.90
	5	1.00
	24	.90
	32	.80

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= 0.76$$

$$S_{PCC}^2 = (1 - f)\frac{1}{m(m - 1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$= 0.029$$

$$\Delta = tS_{PCC} \quad (t = 1.729)$$

$$= 1.729S_{PCC} \text{ at 0.9 confidence level}$$

$$= 0.051$$

Confidence interval of PCC

$$= (PCC - \Delta, PCC + \Delta)$$

$$= (0.71, 0.81)$$

NOTE: Total number of PSU's = m = 20. The PSU numbers listed here are those used in the calculations and do not include those PSU's randomly selected but not used because of cloud cover, hazy photographic rendition, etc. Thirty-five PSU's were randomly selected originally, but 15 were eliminated from use.

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS

ST. LOUIS COUNTY, MINNESOTA (INVENTORY)

[Computed by evaluating PSU's on the photographs, p_i, and on the alphanumeric map, $\hat{p}_i$]

Landsat quadrant	PSU No.	Softwood		Hardwood		Grassland		Water		Other	
		p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
1	1	0.05	0.025	0.72	0.6	0.07	0.225	0.03	0	0.13	0.15
	23	.41	0.4	.08	.05	.02	.075	.03	.025	.46	.45
	29	.22	0.15	.31	.225	.03	.1	0	0	.44	.525
	25	.2	0.225	.58	.4	.09	.125	0	0	.13	.25
2	2	0.44	0.475	0.11	0.075	0	0	0	0	0.45	0.45
	4	.15	0.225	.64	.525	.04	0.025	.10	.10	.07	.125
	5	.65	.575	.11	.05	.04	0.075	.20	.20	0	.1
	21	.51	.425	.42	.375	.07	0	0	0	0	.2
	22	.73	.75	.02	0	0	0	.25	.2	0	.05
	36	.55	.475	.21	.125	.04	0	.15	.15	.05	.25
3	1	0.04	0.075	0.65	0.475	0.22	0.125	0	0	0.09	0.325
	26	.02	.125	.6	.4	.07	.125	.3	.175	.01	.175
	28	.16	.2	.58	.45	.1	0	.15	.175	.01	.175
	30	0	0	.7	.65	.29	.175	0	0	.01	.175
	34	.19	.1	.59	.55	0	0	.22	.125	0	0.225
4	2	0.28	0.125	0.52	0.55	0.03	0.05	0.12	0.1	0.05	0.175
	4	.12	.075	.23	.225	.04	.025	.51	.5	.1	.175
	5	0	0	.05	.05	0	0	.9	.9	.05	.05
	24	.3	.225	.7	.7	0	0	0	0	0	.075
	32	.62	.6	.3	.15	.08	.025	0	0	0	.225

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS ST. LOUIS COUNTY, MINNESOTA (INVENTORY)

Class	Simulated inventory estimate, $\hat{p}$	Photointerpretation estimate, p	Average error, B $(p-\hat{p})$	Standard deviation error, S_B	One-half confidence interval, $\Delta.9$, for error (a)	Confidence interval $(B \pm \Delta)$	Does interval contain zero?	Relative error, % (100B/p)	ADP agreed, over/under estimate
Softwood	0.263	0.282	0.020	0.014	0.024	(-0.004, 0.044)	Yes	7.07	Agreed
Hardwood	.331	.406	.075	.015	.025	(.050, .100)	No	19.47	Over
Grassland	.058	.062	.004	.014	.024	(-.02, .028)	Yes	6.47	Agreed
Water	.132	.148	.016	.008	.013	(-.003, .029)	Yes	10.81	Agreed

[a]$\Delta.9 = 1.729 S_B$.

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m} \hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (P_i - \hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS
SANDOVAL COUNTY, NEW MEXICO (INVENTORY)

PSU#	PCC_i
3	.70
6	.80
17	1.00
21	1.00
8	1.00
15	1.00
5	1.00
18	1.00
1	1.00
23	1.00
9	1.00
4	.70
9-3	1.00
9-4	1.00
9-5	1.00
9-6	.90
6-7	.80
6-8	1.00
6-9	1.00
6-10	.80

Total #PSU = m = 20

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .935$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .024$$

$$\Delta = t_{.95(n-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= .039$$

Confidence interval of PCC

$$= (PCC-\Delta,\ PCC+\Delta)$$

$$= (.896\ ,\ .974\ )$$

Inventory	PCC	90-percent confidence interval	Δ
20 PSU's	93.5	89.6 to 97.4	±3.9

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS
SANDOVAL COUNTY, NEW MEXICO (INVENTORY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$	P_i	$\hat{P}_i$
3	.98	.775	.01	0	0	0	0	0	.01	.225
6	.54	.45	0	0	0	0	0	0	.46	.55
17	.07	.025	0	0	0	0	0	0	.93	.975
21	0	0	0	0	.03	.025	0	0	.97	.975
8	0	0	0	0	.04	.025	0	0	.96	.975
15	0	0	0	0	0	0	0	0	1.0	1.0
5	0	0	0	0	.08	.05	0	0	.92	.95
18	0	0	0	0	.35	.30	0	0	.65	.70
1	0	0	0	0	.32	.325	0	0	.68	.675
23	0	0	0	0	.24	.275	0	0	.76	.725
9	.21	.20	.11	.125	0	0	0	0	.68	.675
4	.59	.425	0	0	0	0	0	0	.41	.575
9-3	.18	.20	.10	.075	0	0	0	0	.72	.725
9-4	.09	.05	.09	.075	0	0	0	0	.82	.875
9-5	.12	.125	0	0	0	0	0	0	.88	.875
9-6	.12	.075	.05	.05	0	0	0	0	.83	.875
6-7	.33	.35	0	0	0	0	0	0	.67	.65
6-8	.50	.50	0	0	0	0	0	0	.50	.50
6-9	.55	.50	0	0	0	0	0	0	.45	.50
6-10	.40	.525	0	0	0	0	0	0	.60	.475

Total #PSU = m = 20

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS

SANDOVAL COUNTY, NEW MEXICO (INVENTORY)

Class	Inventory 11 PSU's				Inventory 20 PSU's			
	True class proportion, p	Estimated class proportion, $\hat{p}$	Average error, B	Confidence interval, $2\Delta 0.9$	True class proportion, p	Estimated class proportion, $\hat{p}$	Average error, B	Confidence interval, $2\Delta 0.9$
Softwood	0.164	0.132	0.032	(0.001, 0.063)	0.234	0.21	0.024	(-0.001, 0.049)
Hardwood	.011	.011	-.0004	(-.031, .031)	.018	.016	.002	(-.001, .005)
Rangeland	.096	.091	.005	(-.005, .015)	.053	.05	.003	(-.003, .009)
Water	No Water				No water			
Other	.729	.766	-.037	(-.07, -.004)	.695	.724	-.029	(-.054, -.004)

[a]True class proportion (p) comes from photointerpretation; estimated class proportion ($\hat{p}$) comes from SSU evaluation.

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m} \hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (P_i - \hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m} (B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS
KERSHAW COUNTY, SOUTH CAROLINA (INVENTORY)

PSU#	PCC_i
1	.90
2	.60
4	.70
5	.40
7	.50
9	.80
10	.80
11	1.00
12	.90
13	.80
14	.80
15	.80
16	.40
18	.50
20	.70
23	.60
25	.90
1-A	.70
2-A	.90
3-A	.70
4-A	.80
5-A	.50
6-A	.50
7-A	.70

Total #PSU = m = 24

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .704$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .034$$

$$\Delta = t_{.95(n-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= .058$$

Confidence interval of PCC

$= (PCC-\Delta,\ PCC+\Delta)$

$= (.65\ ,\ .76\ )$

Inventory[a]	Number of PSU's	PCC	90-percent confidence interval	$\Delta.9$
Original PSU locations	18	60.0	(0.54, 0.66)	0.058
Best fit (local registration)	24	70.0	(.64, .76)	.057

[a]ANOVA: Calculated $F_{1,40}$ = 4.0336.
Tabulated F(0.05 significance) = 4.08.

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS
KERSHAW COUNTY, SOUTH CAROLINA (INVENTORY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
1	.66	.7	.14	.05	0	0	.1	.1	.1	.15
2	.38	.4	.46	.275	0	0	0	0	.16	.325
4	.20	.15	.20	.1	0	0	0	0	.6	.75
5	.49	.075	.08	.05	0	.075	.02	0	.41	.8
7	.36	.225	.44	.25	0	0	0	0	.2	.525
9	.5	.4	.24	.175	.1	.1	0	0	.16	.325
10	.65	.575	.35	.375	0	0	0	0	0	.05
11	.4	.425	0	0	0	0	0	0	.6	.575
12	.34	.35	.45	.475	.18	.075	0	0	.03	.1
13	0	0	.22	.275	.1	.05	.1	0	.58	.675
14	.41	.375	.25	.175	0	.025	0	0	.34	.425
15	.05	.075	.2	.125	.1	.225	0	0	.65	.575
16	.47	.325	.29	.1	0	.05	0	0	.24	.525
18	.1	.2	.64	.325	0	.025	0	0	.26	.45
20	.41	.425	.37	.275	0	0	.2	.2	.02	.1
23	.21	.05	.19	.025	0	.1	0	0	.6	.825
25	.5	.4	.3	.4	0	0	0	0	.2	.2
1-A	.47	.525	.28	.15	0	.025	0	0	.25	.3
2-A	.2	.25	.65	.575	0	0	0	0	.15	.175
3-A	.69	.575	.1	.225	.2	.05	0	0	.01	.150
4-A	.54	.4	.07	.075	0	0	0	.05	.39	.475
5-A	.26	.20	.27	.20	.12	0	0	0	.35	.6
6-A	.12	.05	.5	.275	.11	.20	0	0	.27	.475
7-A	.5	.4	.37	.375	.03	0	0	0	.1	.225

Total #PSU = m = 24

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS

KERSHAW COUNTY, SOUTH CAROLINA (INVENTORY)

Feature	Proportion error			
	Photographic class proportion, p	ADP class proportion, $\hat{p}$	Average error, B	90-percent confidence interval
Softwood	0.371	0.314	0.057	(0.021, 0.093)
Hardwood	.291	.222	.069	(.036, .108)
Grassland	.039	.042	−.003	(−.025, .019)
Water	.018	.015	.003	(−.005, .011)
Other	.278	.407	−.129	(−.167, .091)

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m} \hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (P_i - \hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS

FORT YUKON, ALASKA (INVENTORY)

PSU#		PCC_i
I	3	.30
	5	.40
	6	.80
	11	.90
	14	.80
	17	.90
	18	.70
II	13	.80
	16	.90
	21	.60
	22	.50
	23	.60
III	2	.60
	4	.80
	7	.70
	8	.70
	9	.40
	15	.90
	20	.80
	25	.80
IV	1	.70
	10	1.00
	12	.50
	19	.80
	24	.90

Total #PSU = m = 25

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .712$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .035$$

$$\Delta = t_{.95}(n-1)\, S_{PCC}$$

= half width of 90% confidence interval

$$= .060$$

Confidence interval of PCC

$$= (PCC-\Delta,\ PCC+\Delta)$$

$$= (.65\ ,\ .77\ )$$

Inventory sample size	PCC	Half-confidence interval, $\Delta_{.9}$	$PCC \pm \Delta_{.9}$
25 PSU's	72.4%	5.9%	66.5% to 78.3%

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS

FORT YUKON, ALASKA (INVENTORY)

PSU#	Softwood		Hardwood		Grassland		Water		"Other"	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
I 3	.21	.3	.02	0	.2	.05	.04	.025	.53	.625
5	.21	.15	0	.05	.66	.5	0	0	.13	.3
6	.32	.4	0	0	.63	.475	0	0	.05	.125
11	.92	.875	.08	.025	0	.025	0	0	0	.075
14	0	.025	.4	.4	.39	.425	0	0	.21	.15
17	.07	.075	.3	.25	.6	.6	0	0	.03	.075
18	.05	.05	.1	.075	.42	.5	0	0	.43	.375
II 13	.71	.825	.04	0	.14	.05	0	0	.11	.125
16	.79	.8	.13	.075	0	.05	0	0	.08	.075
21	.20	.325	.15	.025	.36	.275	0	0	.29	.375
22	.51	.725	.06	0	.24	.175	0	0	.19	.1
23	.68	.775	.05	.025	.17	.05	0	0	.1	.15
III 2	.76	.75	.18	.025	0	.1	0	0	.06	.125
4	.87	.775	0	0	0	0	.07	.05	.06	.175
7	.40	.425	0	0	.24	.2	0	0	.36	.375
8	.49	.45	.08	0	.14	.15	0	0	.29	.4
9	.1	0	.04	0	.14	.45	.21	0	.51	.55
15	.02	0	0	0	.11	.125	.04	0	.83	.875
20	.1	0	.38	.375	.41	.45	0	0	.11	.175
25	.26	.425	.21	.075	.29	.275	0	0	.24	.225
IV 1	.27	.075	.41	.5	.22	.225	0	0	.1	.2
10	.16	.175	0	0	.67	.65	.04	0	.13	.175
12	.03	.1	.1	0	.26	.275	.12	.025	.49	.6
19	.23	.425	.43	.25	.06	.1	0	0	.28	.225
24	.04	0	.38	.4	.46	.525	.1	.05	.02	.025

Total #PSU = m = 25

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS

FORT YUKON, ALASKA (INVENTORY)

Class	Inventory 25 PSU's[a]			
	Photointerpretation proportion, p	ADP class proportion, $\hat{p}$	Average error, B	Confidence interval, $B \pm \Delta_{.9}$
Softwood	0.338	0.358	-0.020	(-0.052, 0.012)
Hardwood	0.142	0.102	0.040	(0.019, 0.061)
Tundra	0.276	0.268	0.008	(-0.021, 0.037)
Water	0.008	0.005	0.003	(-0.002, 0.008)
Other	0.236	0.267	-0.031	(-0.055, -0.007)

[a]These 25 PSU's were randomly located in the site.

$$\hat{p} = \frac{1}{m}\sum_{i=1}^{m} \hat{p}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (p_i - \hat{p}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{p} \times 100$$

where RB is expressed as a percentage.

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TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS
WELD COUNTY, COLORADO (INVENTORY)

PSU#	PCC_i
1	.60
2	.80
3	.90
4	.70
5	.70
6	.70
7	.80
8	.70
9	.70
10	.70

Total #PSU = m = 10

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .73$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .026$$

$$\Delta = t_{.95(n-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= .047$$

Confidence interval of PCC

$$= (PCC-\Delta,\ PCC+\Delta)$$

$$= (.683\ ,\ .777\ )$$

Inventory sample size	PCC	Half-confidence interval, $\Delta_{.9}$	PCC ± $\Delta_{.9}$
10 PSU's	73%	4.7%	68.3% to 77.7%

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS
WELD COUNTY, COLORADO (INVENTORY)

PSU number	Cultivated		Weeds		Grassland		Water		Other	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
1	0.000	0.000	0.000	0.000	1.000	0.750	0.000	0.000	0.000	0.250
2	0.000	0.000	0.000	0.000	0.600	0.750	0.000	0.000	0.400	0.250
3	0.000	0.000	0.000	0.000	0.480	0.525	0.000	0.000	0.520	0.475
4	0.210	0.025	0.000	0.000	0.150	0.200	0.000	0.000	0.640	0.775
5	0.000	0.025	0.000	0.000	0.470	0.675	0.000	0.000	0.530	0.300
6	0.000	0.000	0.000	0.000	0.300	0.525	0.000	0.000	0.700	0.475
7	0.000	0.050	0.000	0.000	0.200	0.225	0.000	0.000	0.800	0.725
8	0.300	0.125	0.000	0.000	0.000	0.025	0.000	0.000	0.700	0.850
9	0.000	0.000	0.180	0.000	0.570	0.875	0.000	0.000	0.250	0.125
10	0.000	0.000	0.090	0.000	0.630	0.875	0.000	0.000	0.280	0.125

Definitions:

p_i = photograph sample for *ith* PSU

$\hat{p}_i$ = ADP sample for *ith* PSU

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS

WELD COUNTY, COLORADO (INVENTORY)

Class	Inventory class proportion, $\hat{p}$	Photograph class proportion, p	Average error, B	Standard deviation of error, S_B	Half-confidence interval, $\Delta_{.9}$	Confidence interval, B ± Δ	Percent relative error, RB
Cultivated	0.022	0.050	0.028	0.025	0.047	(-0.019, 0.075)	56
Weeds	0	.027	.027	.019	.035	(-.008, .062)	100
Grassland	.543	.441	-.102	.050	.091	(-.193, -.011)	23.13
Water[a]							
Other	.435	.482	.047	.052	.096	(-.049, .143)	9.75

[a]There were no significant water bodies in this site.

$$\hat{p} = \frac{1}{m}\sum_{i=1}^{m} \hat{p}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (p_i - \hat{p}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m}(B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS

GRAYS HARBOR COUNTY, WASHINGTON
(Inventory)

PSU#	PCC_i
1	.50
2	1.00
3	.60
4	.40
5	.70
6	.70
7	.90
8	.60
9	.50
10	.70
11	.60
12	.80
13	.70
14	.60
15	.90
16	.40
17	1.00
18	.90
19	.90
20	.80
21	.80
22	1.00
23	1.00
24	.40
25	.50

Total #PSU = m = 25

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= .716$$

$$S^2_{PCC} = (1-f)\frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = .039$$

$$\Delta = t_{.95(n-1)} S_{PCC}$$

= half width of 90% confidence interval

$$= .067$$

Confidence interval of PCC

= (PCC−Δ, PCC+Δ)

= (.649 , .783)

Inventory	PCC	Half-confidence interval, $\Delta_{.9}$	PCC ± $\Delta_{.9}$
25 PSU's	71.6%	±6.7%	64.9 to 78.3%

TABLE 5-1.— SUMMARY TABLE OF CLASS PROPORTIONS

GRAYS HARBOR COUNTY, WASHINGTON (INVENTORY)

PSU#	Softwood		Hardwood		Clearcut		Water		"Other"	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
1	.49	.525	0	.025	.21	.05	0	0	.3	.4
2	1.0	.975	0	.025	0	0	0	0	0	0
3	.69	.725	.05	0	.21	0	0	.025	.05	.25
4	.20	.20	.2	.15	.38	.1	.0	0	.22	.55
5	.73	.45	0	.025	.27	.075	0	.025	0	.425
6	.1	0	.25	.2	0	0	0	0	.65	.8
7	.83	.80	.05	.05	.12	.075	0	0	0	.075
8	.52	.65	.23	.05	0	0	0	0	.25	.3
9	.72	.5	0	.175	0	0	0	0	.28	.325
10	.96	.725	0	.075	0	.05	0	0	.04	.15
11	.4	.5	.28	.15	0	0	.1	0	.22	.35
12	.5	.6	.46	.325	0	0	0	0	.04	.075
13	.31	.325	.15	0	0	0	0	0	.54	.675
14	.8	.725	.04	0	.16	.05	0	.05	0	.175
15	.41	.425	0	0	.1	.025	0	0	.49	.55
16	.83	.375	0	0	.1	.275	0	0	.07	.35
17	.67	.675	0	0	.1	.1	0	0	.23	.225
18	.5	.6	0	0	0	0	0	0	.5	.4
19	.76	.825	.04	0	0	0	0	0	.2	.175
20	.5	.45	.15	.15	0	0	0	0	.35	.4
21	.44	.525	.11	.15	0	0	0	0	.45	.325
22	.98	.9	0	0	0	0	0	0	.02	.1
23	.74	.75	.12	.1	0	0	0	0	.14	.15
24	.51	.7	.44	.1	0	0	0	0	.05	.2
25	.75	.675	0	.1	.11	0	0	0	.14	.225

Total #PSU = m = 25

TABLE 5-2.— SUMMARY TABLE OF CLASS PROPORTION ERRORS
GRAYS HARBOR COUNTY, WASHINGTON (INVENTORY)

Feature	Inventory, 25 PSU's[a]			
	Photograph class proportion, p	ADP class proportion, $\hat{p}$	Average error, B	Confidence interval, $B \pm \Delta_{.9}$
Softwood	0.614	0.584	0.030	(-0.018, 0.078)
Hardwood	.103	.074	.029	(-.004, .062)
Clear-cut	.070	.032	.038	(.007, .069)
Water	.004	.004		(-.008, .008)
Other	.209	.306	-0.097	(-.137, -.057)

[a]These 25 PSU's were randomly located within the site.

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m} \hat{P}_i \qquad \text{(from table 5-1)}$$

$$B = \frac{1}{m}\sum_{i=1}^{m} B_i = \frac{1}{m}\sum_{i=1} (P_i - \hat{P}_i) \qquad \text{(from table 5-1)}$$

$$S_B = \left[(1-f)\frac{1}{m(m-1)}\sum_{i=1}^{m} (B_i - B)^2\right]^{1/2}$$

$$\Delta_{0.9} = 1.64\ S_B$$

$$RB = \frac{B}{P} \times 100$$

where RB is expressed as a percentage.

TABLE 4-1.— SUMMARY TABLE OF PCC CALCULATIONS

WASHINGTON COUNTY, MISSOURI (INVENTORY)

PSU number	PCC_i expressed as proportion
1	0.80
2	.90
3	.80
4	.90
5	.70
6	.90
7	1.00
8	.80
9	1.00
10	.70

$$PCC = \frac{1}{m} \sum_{i=1}^{m} PCC_i$$

$$= 0.85$$

$$S_{PCC}^2 = (1 - f) \frac{1}{m(m-1)} \sum_{i=1}^{m} (PCC_i - PCC)^2$$

$$S_{PCC} = 0.034$$

$$\Delta = tS_{PCC}$$

$$= 1.833 S_{PCC} \text{ at 0.9 confidence interval}$$

$$= 0.062$$

Confidence interval of PCC = (PCC − Δ, PCC + Δ)

= (0.788, 0.912)

Inventory PSU's	PCC	Half confidence interval at 0.9	PCC ± $\Delta_{0.9}$
10	85%	±6.2%	(78.8% - 91.2%)

Notation

m = number of PSU's in sample scheme.

PCC_i = percent correct classification (i = PSU index)

f = finite population constant = $(m - 1)/(N - 1)$, where m = number of PSU's in sample scheme and N = total number of PSU's in entire population

S_{PCC}^2 = variance of mean

S_{PCC} = standard deviation

t = constant obtained from statistical tables

TABLE 5-1.— SUMMARY OF CLASS PROPORTIONS WASHINGTON COUNTY, MISSOURI (INVENTORY)

PSU number	Softwood		Hardwood		Grassland		Water[a]		Other	
	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$	p_i	$\hat{p}_i$
1	0.00	0.000	0.85	0.750	0.14	0.125			0.01	0.125
2	.00	.025	1.00	.825	.00	.000			.00	.150
3	.00	.000	.77	.875	.13	.000			.10	.125
4	.00	.050	.96	.850	.02	.000			.02	.100
5	.09	.100	.81	.625	.08	.000			.02	.275
6	.07	.050	.82	.775	.10	.100			.01	.075
7	.08	.025	.86	.875	.00	.000			.06	.100
8	.00	.000	.95	.950	.00	.025			.05	.025
9	.00	.000	.88	.775	.10	.200			.02	.025
10	.05	.000	.85	.725	.04	.075			.06	.200
Total	0.29	0.250	8.75	8.025	0.61	0.525			0.35	1.200

Average proportion	Softwood		Hardwood		Grassland		Water		Other	
	p	$\hat{p}$	p	$\hat{p}$	p	$\hat{p}$	p	$\hat{p}$	p	$\hat{p}$
	0.029	0.0250	0.875	0.8025	0.061	0.0525			0.035	0.120

[a]None in test area.

<u>Notation</u>

p_i = photograph sample proportion for *ith* PSU

$\hat{p}_i$ = inventory sample proportion for *ith* PSU

p = average photograph sample proportion

$\hat{p}$ = average inventory sample proportion

TABLE 5-2.— SUMMARY OF CLASS PROPORTION ERRORS
WASHINGTON COUNTY, MISSOURI (INVENTORY)

Class	Inventory class proportion, $\hat{p}$	Photograph class proportion, p	Average error, B	Standard deviation of error, S_B	Half confidence interval, $\Delta_{0.9}$	Confidence interval, B ± Δ	Percent relative error, RB
Softwood	0.0250	0.029	0.004	0.0099	0.018	(-0.114, 0.022)	13.79
Hardwood	.8025	.875	.073	.028	.052	(.021, .125)	8.34
Grassland	.0525	.061	.009	.019	.036	(-.027, .045)	14.75
Water[a]							
Other	.120	.035	-.085	.026	.047	(-.132, .038)	-242.86

[a]None in test area.

<u>Notation</u>

$B_i = p_i - \hat{p}_i$ = individual error

$B = \frac{1}{m} \sum_{i=1}^{m} B_i$ = average error

$S_B^2 = \frac{(1 - f)}{m(m - 1)} \sum_{i=1}^{m} (B_i - B)^2$ = variance

$\Delta_{0.9} = 1.833 S_B$ = half confidence interval

$RB = \frac{B}{p} \times 100$ = relative error