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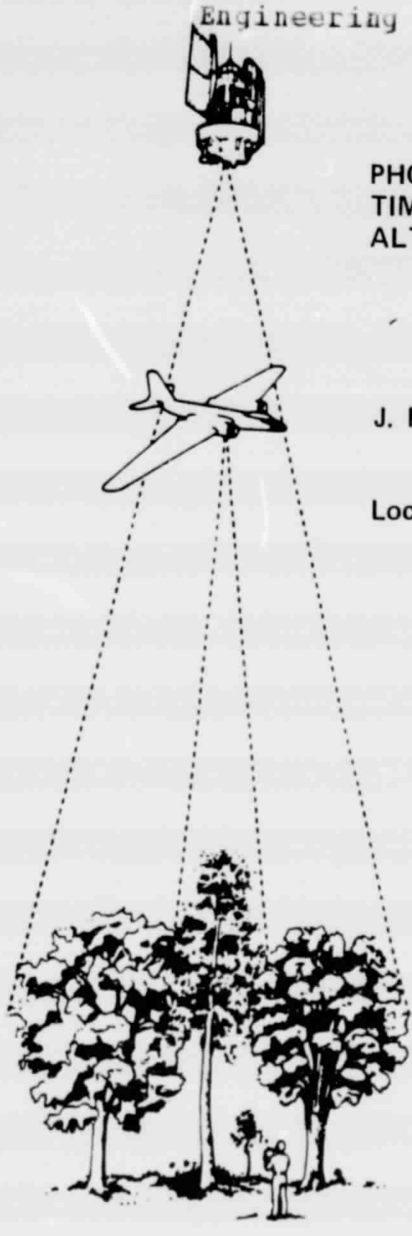

PHOTOGRAPHIC TECHNOLOGY DEVELOPMENT PROJECT: TIMBER TYPING IN THE TAHOE BASIN USING HIGH ALTITUDE PANORAMIC PHOTOGRAPHY: FINAL REPORT

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Houston, Texas

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16. Abstract

The purpose for conducting this study was to develop and test procedures for using KA-80A optical bar camera panoramic photography for timber typing forest land and classifying nonforest land. The study area was the south half of the Lake Tahoe Basin Management Unit. Final products from this study include four timber type map overlays on 1:24,000 orthophoto maps.

The following conclusions can be drawn from this study:

1. Established conventional timber typing procedures can be used on panoramic photography if the necessary equipment is available.

2. The classification and consistency results warrant further study in using panoramic photography for timber typing.

3. Timber type mapping can be done as fast or faster with panoramic photography than with resource photography while maintaining comparable accuracy.

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FINAL REPORT

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Prepared By

LOCKHEED ENGINEERING AND MANAGEMENT SERVICES COMPANY, INC.

Remote Sensing Technology Implementation Project

Under Contract 53-3182-0-29

For

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE
1050 Bay Area Boulevard
Houston, Texas 77058

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CONTENTS

Section | Page

Appendix

TABLES

Table | Page

FIGURES

Figure		Page

1. INTRODUCTION

Reliable information is needed on timber volume and its location for planning harvests, making growth and yield predictions, and managing land at all levels. A timber type map is very useful for achieving these goals, and such a map can show foresters the stand size, the overall tree size, the density, and the exact location of a specified area. In the past, these maps have usually been made with conventional 9- by 9-inch contact prints that are normally on black and white or true color film. However, 1:30,000 nadir scale, high-altitude color infrared, panoramic photography has recently been made available for resource management planning. Its primary advantages are that a larger area can be photographed in less time and on fewer frames without losing resolution. The photography has been used for stratifying and quantifying insect-killed trees in Montana (Klein et al., 1980) and South Dakota (Dillman et al., 1979), locating forest regeneration sites in Louisiana (Eav et al., 1980), and estimating the volume of standing dead timber in Idaho (Weber et al., 1977). This is, however, the first time that panoramic photography has been used for timber type mapping.

1.1 PURPOSE

The purpose for conducting this study was to develop and test procedures for using panoramic aerial photography for timber typing forest land and classifying nonforest land. The results of the project will assist in determining if panoramic aerial photography can help the United States Department of Agriculture (USDA) Forest Service personnel stratify vegetation for timber inventory and management planning.

1.2 OBJECTIVES

The study objectives were to (1) test the feasibility of using high-altitude panoramic photography for timber type mapping and classifying nonforest land and (2) compare the resulting timber type map with one done over the same area using standard (1:15,840 scale) resource photography and ground truth.

This study provided the following information and products.

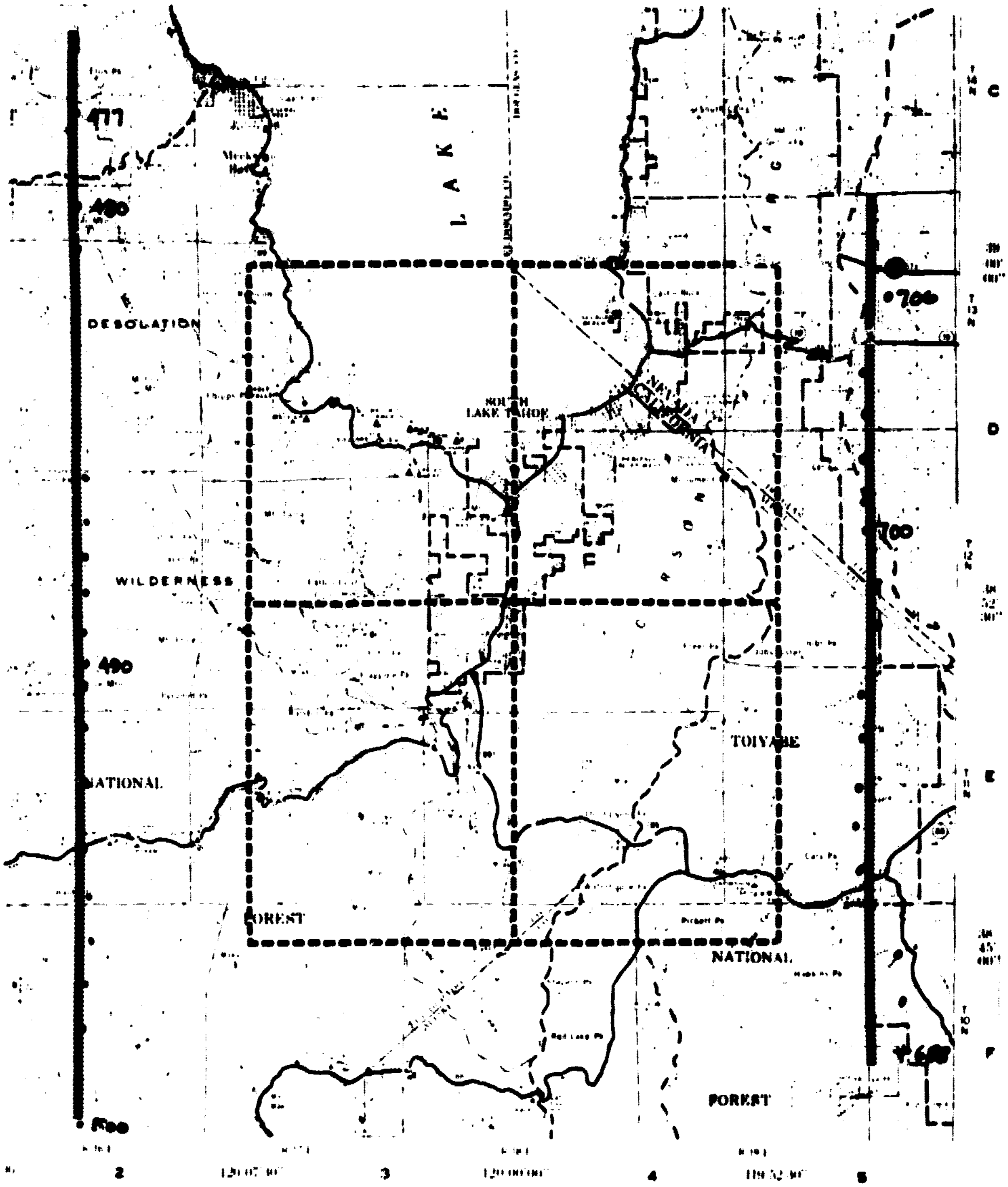
a. Four orthophoto maps were drafted at a 1:24,000 scale showing the delineation and classification of vegetative and nonvegetative ground cover down to a 10-acre minimum size.
b. A final report was written which included procedures, equipment, and manpower required to complete the project. It also contained results of accuracy assessment, discussion of problems encountered, and conclusions.

2. STUDY SITE

The study site was an area contained within four adjacent 1:24,000 United States Geological Survey (USGS) 7.5-minute quadrangle maps within the Lake Tahoe Basin Management Unit. The areas covered on the quadrangle maps were: South Lake Tahoe, California-Nevada; Emerald Bay, California; Freel Peak, California; and Echo Lake, California. The arrangement of these quadrangle maps may be seen in figure 2-1.

The Tahoe Basin is a watershed located in the central western portion of California on the Nevada border. Elevations range from 6,229 feet at Lake Tahoe to 10,881 feet at the Freel Peak summit. Most of the higher peaks range from 9,000 to 10,000 feet. There were no major rivers in the area, but there was an abundance of streams draining the mountains; some streams flowed through a large flat on the south side into the lake where all the streams eventually ended.

The primary tree species found in the Basin were Jeffrey pine (*Pinus jeffreyi*) (which is similar to Ponderosa pine and



— — — Quadrangle map boundaries illustrating study site

•••••••• U-2 flight line

Figure 2-1.- Tahoe Basin timber typing study site.

was typed as ponderosa pine), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus murayana*), white fir (*Abies concolor*), and red fir (*Albies magnifica*). There were lesser scattered amounts of incense cedar (*Libocedrus decurrens*), sugar pine (*Pinus lambertiana*), western white pine (*Pinus monticola*), and whitebark pine (*Pinus albicaulis*).

Also, there were some aspen (*Populus tremuloides*) stands in the mountains, with willow (*Salix spp.*) and cottonwood (*Populus fremontii*) growing along the streams. Various brush species such as greenleaf manzanita (*Arctostaphylos patula*), bush chinquapin (*Chrysolepis sempervirens*), deerbrush (*Ceanothus integerrimus*), and tobacco brush (*Ceanothus veluthinus*) were found throughout the site.

Accessibility within the study site was good. There was at least one major State highway reaching into each quadrangle map (State Highways 50, 89, 19, and 88), and smaller dirt roads provided access to some more remote areas. Even with this road network, large areas were left inaccessible.

3. PROJECT METHODOLOGY

There were six basic steps used during this project to derive the final products. They were:

1. Photograph preparation
2. Photointerpreter training
3. Polygon delineation
4. Polygon labeling
5. Polygon transfer
6. Accuracy assessment

The methodology presented in this section describes only how it was done. For discussion on the methodology, see section 6.1 of this report. The statement of work (S.O.W.) contains the guidelines and constraints on the project procedures and may be found in appendix A.

3.1 PHOTOGRAPH PREPARATION

As soon as the panoramic photography was received, it was laminated. This was an essential step for the protection of the photographs. It also provided a good surface to hold ink, making direct delineation on the photographs possible. Overlays were not used on the photography. After lamination, the photographs were indexed on a Lake Tahoe Basin Management Unit Map and grouped according to quadrangle coverage. Four stereo triplets of photography were required to cover one 7.5-minute quadrangle map. The boundaries of the quadrangle map were then laid out on the photographs, and the effective area of each stereo model was delineated in black nonsmear ink.

3.2 PHOTOINTERPRETER TRAINING

From the ground, the photointerpreter observed the different timber types of the Tahoe Basin, and then he matched these types with the panoramic aerial photography of the area. This was also helpful in learning where, in relation to topography, the various timber types were normally found.

The study at Tahoe Basin was from June 16 to June 20, 1980. Two USDA Forest Service Region 5 timber management personnel went on the trip with the Lockheed photointerpreter. Their help was very valuable in describing particular growing sites for the various timber types, showing prime examples of each site, and discussing different aspects of the projects.

While at the District office, a portion of a timber type map currently being used by the Tahoe Forest personnel was given to the photointerpreter for training purposes. It covered about 10.5 square miles in the southwest corner of the South Lake Tahoe quadrangle map and contained an example of most of the timber types to be found on the forest. The map was made from the resource photography (see section 4.1.2) and was used for training because the timber type maps made from panoramic photography were to be compared to those made from the resource photography to check for consistency of interpretation. The resource photographic type map was taken back to Houston and reviewed before interpretation of panoramic photography began. Each of the timber types was located on the panoramic aerial photography so the individual color, texture, tone, and growing site could be learned and then extended to similar sites on the same forest. This proved to be a very helpful tool in learning enough about the forest to make a consistent and relatively accurate timber type map.

The photointerpretation performance covered in this report is representative of expectations from most professional foresters.

3.3 POLYGON DELINEATION

After the photographs were laminated, indexed, and delineated for effective data, and after the interpreter felt he had a sufficient working knowledge of the area, the tedious job of delineating the polygons which represent the timber types began. A Bausch and Lomb zoom 240 stereoscope mounted on a Richards MIM 4 light table was used to complete the photointerpretation phase of the project. The first step in this procedure was to break the land cover into three major categories: nonvegetated, nonforest, and forest. The next step was to examine each polygon and determine if it could be subdivided into smaller polygons that are more homogeneous. The minimum size of a polygon was 10 acres, and this presented no problems for mapping from the photography. The S.O.W. (appendix A) contains a good illustration of how the subdivision process should work.

Three basic factors were considered while delineating polygons of forest land. The first was the species or combination of species, which could usually be defined by its color, shape, tone, location relative to topography, and water source. The next concern was the average size of the trees within a polygon. The texture and, if visible, the individual trees would portray this factor. A good textural contrast exists between small crown and large crown trees. Normally, smaller crown trees have a smoother texture than the coarser textured large crown trees. The next factor considered was the density of the stand. Again, texture is the primary means of delineation. However, in this case, texture is the contrast of forest to nonforest, and the denser the forest the smoother the texture.

One of the feasibility study guidelines given in the S.O.W. was that all polygons should match when moving from one stereo triplet to another and when going from one quadrangle map to another. This was easily done by removing the common frame between two stereo triplets and then matching details along the edge of the effective area on the frames.

3.4 POLYGON LABELING

Polygon labeling was the next step in the project. It was not started until the polygon delineation phase was completed on every frame of all four quadrangle maps. It was done this way, rather than complete all procedural phases on one quadrangle map from start to finish, to keep the variation of interpretation between maps to a minimum.

Interpretation for labeling was either direct or inferred. Direct interpretation is when a function such as color, shape, and/or location could distinguish a single timber type from all other types in question. When none of the previous functions applied, the identification was inferred or decided according to the site on which it was growing. The labeling process identified the three factors already discussed in section 3.3 of this report: species, size, and density. The acceptable codes for each of these are seen in table 3-1. Later in the project, Region 5 timber management personnel

TABLE 3-1.- ACCEPTANCE LABELING CODES FOR LAND COVER VEGETATION, SIZE, AND DENSITY

(a) Nonvegetation and nonforest

Code	Description	Further specification
	Nonvegetation	
NB	Barren	Rock, highway cuts and fills
NW	Water	Lakes, permanent snowfields
ND	Urban developed	Settlements, quarries
NX	Clearcuts, type conversions, burned areas	Bare soil with no vegetation visible
	Nonforest	
GX	Nonwoody	Grassland, meadows
SX	Woody shrubs	Brushfields, riparian shrubs along streams
CL	Cultivated	Farms and orchards

TABLE 3-1.- Continued.

(b) Forest polygons

Code	Description
Noncommercial conifers	
KP	Knobcone pine
DP	Digger pine
PJ	Pinyon-juniper
WB	White bark pine
Commercial conifers	
PP	Ponderosa or Jeffrey pine
SP	Sugar pine
WP	Western white pine
LP	Lodgepole pine
WF	White fir
RF	Red fir
DF	Douglas fir
LC	Incense cedar
MH	Mountain hemlock
Hardwoods	
HA	Aspen
HB	Black oak
HB	Tanoak
HB	Pacific madrone
HL	Live oak
HX	Miscellaneous hardwoods

TABLE 3-1.- Concluded.

(c) Size class codes

Code	Description	Size class
1	Crowns $\leq$5 ft diameter	Seedlings and saplings
2	Crowns 6-12 ft diameter	
3	Crowns 13-24 ft diameter	Small sawtimber
4	Crowns 25-40 ft diameter	Medium sawtimber
5	Crowns over 40 ft diameter	Large sawtimber
6	Two-storied	

(d) Acceptable density codes

Code	Crown closure
S	<20%
P	20-39%
N	40-69%
G	70-100%

decided to aggregate these classes into twelve new classes. The refined classes are found in table 3-2.

3.5 POLYGON TRANSFER

The last step in developing the timber type maps is transferring the polygons from the panoramic aerial photographs to overlays of the 1:24,000 orthophoto maps. This procedure was done by two methods. When there was a sufficient number of control points and it was not too far from nadir, the Bausch and Lomb stereo zoom transfer scope (ZTS) was used. The stereo ZTS enables the user to "rubber sheet" the polygons from the distorted stereo pair of panoramic photographs to the rectified orthophoto maps. The other method was to simply identify detail on both the orthophoto maps and the panoramic photos, and then draw in the polygons in relation to the detail. After all the polygons were transferred to the orthophoto maps, the edges were matched and the whole quadrangle map was edited for open polygons and missing labels. The orthophoto maps with a timber type map overlay were then given to Lockheed Technical Publications Section to be made into final production overlays.

3.6 ACCURACY ASSESSMENT

This phase of the project was conducted during a second trip to the forest during December 15-19, 1980. The panoramic photographic timber type map on the 1:24,000 orthophoto map base was compared to timber type maps at the same scale of the same area made from color contact prints. Two identical transparent grids with 396 checkpoints on each were made (figure 3-1) for the assessment. Approximately 100 acres were represented by each sample point in each quadrangle map.

One grid was placed over each timber type map, and each checkpoint was compared and recorded. Major discrepancies in species, size, or density were noted for field inspection. For an evaluation of these results, see sections 6.2 and 6.3 of this report.

4. DATA, EQUIPMENT, AND MANHOURS

4.1 PHOTOGRAPHIC MISSION

4.1.1 PANORAMIC AERIAL PHOTOGRAPHY

The color infrared panoramic aerial photography used for this study was obtained from a U-2 aircraft National Aeronautics and Space Administration (NASA) mission 78-140. The camera used was the KA-80A optical bar camera (OBC). The mission contained two flight lines made up of frames 688-708 and 477-500. The photographs were exposed on October 3, 1979, from an altitude of 65,000 feet on Kodak Ektachrome high-definition infrared (S0131) film.

The flight lines may be seen in figure 2-1. The KA-80A OBC produces a series of 4.5- by 50.26-inch images on a 5-inch wide film format. The cross track coverage is 60 degrees on either side of nadir. The focal length of the KA-80A is 24 inches, and when flown at 65,000 feet it produced photographs at a 1:30,000 nadir scale and an approximate 1:60,000 scale at the cross track edge of the frame. The ground coverage of the panoramic photographs is 1.8 nautical miles in track at nadir and 3.6 nautical miles in track at the frame's edge. The cross track coverage is 34.2 nautical miles.

4.1.2 RESOURCE PHOTOGRAPHY

The resource photography currently used by the El Dorado National Forest and the Lake Tahoe Basin Management Unit was flown by Murray McCormick Aerial Surveys (contract 39-5529). The photographs were made during a period from May to September 1976. They are 9- by 9-inch color contact prints using Kodak aerial color negative film 2445 in a Zeiss-RMKA 21/23 camera. The altitude of the aircraft was approximately

TABLE 3-2.- AGGREGATED LAKE TAHOE BASIN TIMBER TYPE LABELS

No.	Label	Description
1.	L3G	All labels beginning with LP size classes 2, 3, 4, and 5
2.	MIX	All labels beginning with PP, WF, SP, WP, RF and having size class 1
3.	M3P	Labels beginning with PP, WF, SP, WP and having size classes 2 and 3 and densities S and P
4.	M3G	Same as 3 but having densities N and G
5.	M4P	Same beginning labels as 3 and having size classes 4 and 5 and densities S and P
6.	M4G	Same as 5 but with densities N and G
7.	R3P	Labels beginning with RF and having size classes 2 and 3 and densities S and P
8.	R3G	Same as 7 but with densities N and G
9.	R4P	Labels beginning with RF and having size classes 4 and 5 and densities S and P
10.	R4G	Same as 9 but densities N and G
11.	H3N	Labels beginning with MH (mountain hemlock)
12.	M6G	Any size class 6 stand

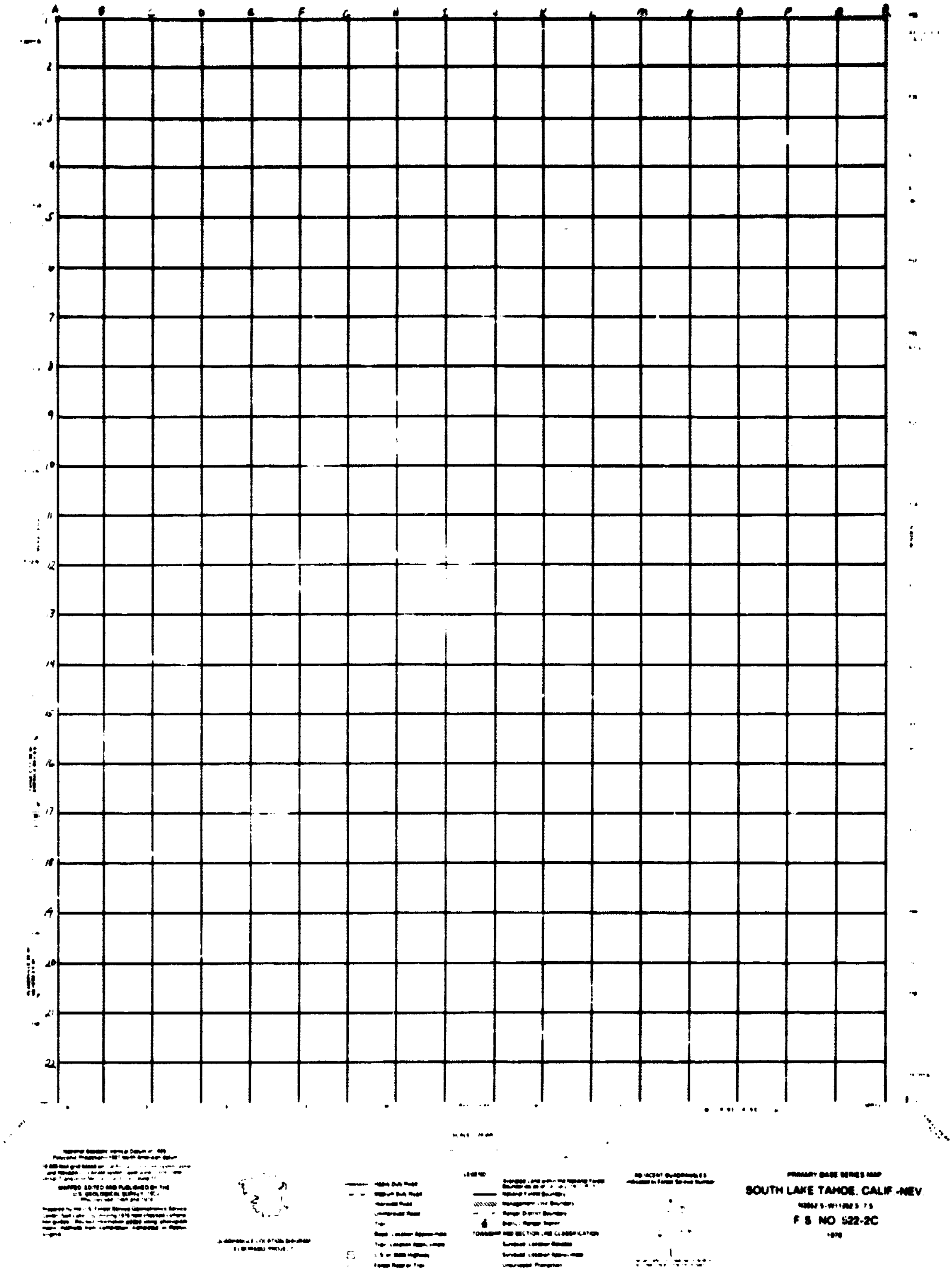


Figure 3-1.- Transparent overlay grid used for the accuracy assessment.

10,890 feet above ground level, and a scale of 1:15,840 was obtained using an 8.25-inch focal length camera.

4.2 EQUIPMENT

The equipment used for this project is listed below.

- Bausch and Lomb zoom 240 stereoscope - This was used during the polygon delineation and labeling phases of the project (fig 4-1). A mirror stereoscope and an Old Delft scanning stereoscope were tried, but neither provided the magnification or the optic quality desired to do the work. The zoom 240 stereoscope outfitted with 10X eyepiece optics and .43X optics mounted on rhomboid arms was used during the project.
- Richards MIM 4 light table - The primary reason for using this table is because it provided a mount for the zoom 240 stereoscope (fig 4-1). It was used during the same project phases.
- Bausch and Lomb ZTS model ZT-4 - This is a fairly sophisticated piece of equipment used during the polygon transfer phase (fig. 4-2). It was most useful when there were enough control points on both the panoramic photograph and the orthophoto map, and when the area to be transferred was not too far from nadir. Because of the stereographic capability of the equipment, it would have been possible to transfer to a 7.5-minute quadrangle sheet if orthophoto maps had not been available, in which case it would be essential. It was a very useful piece of equipment; however, as stated in section 3 of this report, other methods exist that will give good results when transferring to an orthophoto map.
- Richards light table, model GFL 30-40 - Because of the large surface dimensions of this table (42 by 31 inches) it was useful for laying out the orthophoto map when doing the polygon transfer phase by detail.
- General Binding Company laminator - This was essential for laminating the photographs which not only protected the film, but also provided a good ink holding surface for polygon delineation and labeling.
- Drafting Materials:

  Mylar - The clear mylar was used for overlay material on the orthophoto map sheets.

  Rapidograph pens with 0 and #2 points - The 0 point was used for polygon delineation and labeling on the photography, and the #2 point was used to meet the S.O.W. specifications for the final product.

  Higgins black ink - This is a nonsmear ink that was used during all phases of work.

4.3 MAN-HOURS

One person completed the project from start to finish except for final products, which were done by the Lockheed Technical Publications Department. Table 4-1 shows a breakdown of total hours expended for the different project phases.

TABLE 4-1.- BREAKDOWN OF TOTAL HOURS EXPENDED FOR DIFFERENT PROJECT PHASES

Project Phases	Per frame	Per quad*	Total hrs.
Photopreparation	.25	1.0	8.0
Photointerpreter training	N/A	N/A	60.0
Polygon delineation	3.0	12.0	48.0
Polygon labeling	5.0	20.0	30.0
Polygon transfer	4.0	16.0	64.0
Accuracy assessment	N/A	2.5	80.0
Reporting	N/A	N/A	120.0
Total			460.0

*Quadrangle map.

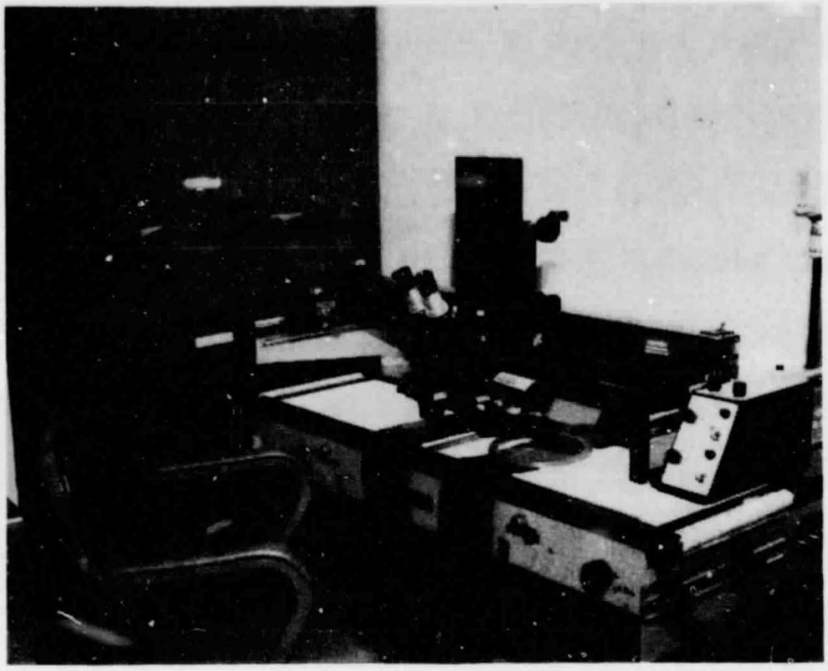


Figure 4-1.- Bausch and Lomb zoom 240 stereoscope mounted on a Richards MIM 4 light table.

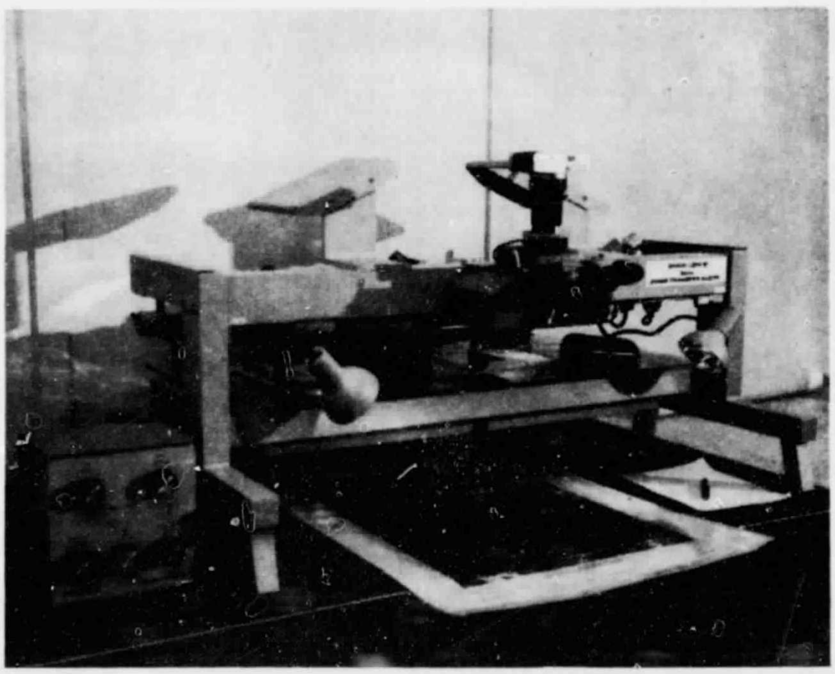


Figure 4-2.- Bausch and Lomb stereo zoom transfer scope model ZT-4.

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The reported man-hours per quadrangle map could easily be reduced when:

1. Procedures become more clearly defined.
2. Interpreters become more familiar with the photography and study area.
3. The new aggregation of codes come into use, reducing the number of codes from which to choose.
4. A larger study area is interpreted, making use of the large area coverage of panoramic photography.

5. RESULTS

The results from the accuracy assessment phase of the project are presented in this section. The percentage of agreement for all four quadrangle maps are shown on table 5-1. The agreement is expressed in six categories. The first three are land cover, vegetated land cover, and timber type, while the last three are subdivisions of the timber type class, species, size, and density. An objective analysis of the results from the South Lake Tahoe quadrangle map is seen in table 5-2. It is a confusion table which compares the aggregated classes from the panoramic photography timber type map with the same classes interpreted from resource photography.

It must be emphasized at this point that the comparisons were not made with actual observed ground truth, but with the existing resource photographic type map currently being used by the forest. Errors were found with this map when examining major discrepancies between the two maps; however, it was the best existing source for comparison. It could not be considered a final answer for classification, but it did provide a good source for checking consistency.

An example of a portion of a panoramic photograph stereopair may be seen in figure 5-1. It contains labeled polygons of interpreted land cover. Figure 5-2 is a timber type map made from the resource photography and may be compared with figure 5-3, a timber type map interpreted from panoramic aerial photography. The timber type map made from the panoramic aerial photography is also shown overlaying an orthophoto map in figure 5-4 and a standard 7.5-minute quadrangle map in figure 5-5. All the above figures were made from the South Lake Tahoe quadrangle map. They should be examined while reading section 6 of this report. The label codes are explained in table 3-1.

6. DISCUSSION

The following section will discuss procedural problems and their possible solutions and improvements. The advantages of color infrared panoramic photography will also be covered. An analysis of the objective results of the accuracy assessment will be made along with a subjective opinion of the project.

6.1 PROCEDURAL PROBLEMS

6.1.1 TRAINING PHASE

The first problem encountered was during the photointerpreter's training phase. While at South Lake Tahoe on the first field trip, some resource photographs were borrowed by the Lockheed photointerpreter for training purposes. These photographs were needed by the USDA Forest Service before the photointerpreter had finished studying them. Since the accuracy of classification is dependent on the background of the interpreter, he should be given every opportunity to learn as much as possible about the timber types.

6.1.2 GEOMETRIC DISTORTION

Another problem area was the geometric distortion of the photography. This problem primarily affected the labeling and transfer phases of the project. The study area ranged from approximately 11 to 38 degrees from

TABLE 5-1.- RESULTS OF COMPARING THE TIMBER TYPE MAPS FROM OBC PANORAMIC PHOTOGRAPHY WITH THOSE MADE FROM RESOURCE PHOTOGRAPHY FOR ALL FOUR QUADRANGLE MAPSEETS

	South Lake Tahoe quad	Freel Peak quad	Emerald Bay quad	Echo Lake quad	Overall site
Land cover/total samples	71.2	51.6	74.0	62.8	809/1208 = 66.9 ± 1.4% (1S.E.)
Cover type/veg. classes	62.4	46.1	56.1	57.1	429/772 = 55.6 ± 1.8% (1S.E.)
Timber type/forest classes	53.5	42.7	45.5	46.0	302/638 = 47.3 ± 2.0% (1S.E.)
• Species/forest classes	78.3	54.4	73.8	67.0	438/638 = 68.7 ± 1.8% (1S.E.)
• Density/forest classes	80.8	73.7	80.0	79.8	501/638 = 78.5 ± 1.6% (1S.E.)
• Size/forest classes	72.2	60.2	68.3	75.8	439/638 = 68.6 ± 1.8% (1S.E.)

Note: The following equation was used to determine the standard error.

$$S.E. = \sqrt{\frac{pq}{n-1}}$$

where: $p = \frac{\text{number of sample points in agreement}}{\text{number of sample points per class}}$

$q = 1 - p$

$ч$ = number of sample points per class

Figure 5-1.- A stereogram of a timber type map made from panoramic photography of a portion of the South Lake Tahoe Quad Sheet. (See Table 3-1 for legend.)

Figure 5-2.- Timber type map made from resource photography.

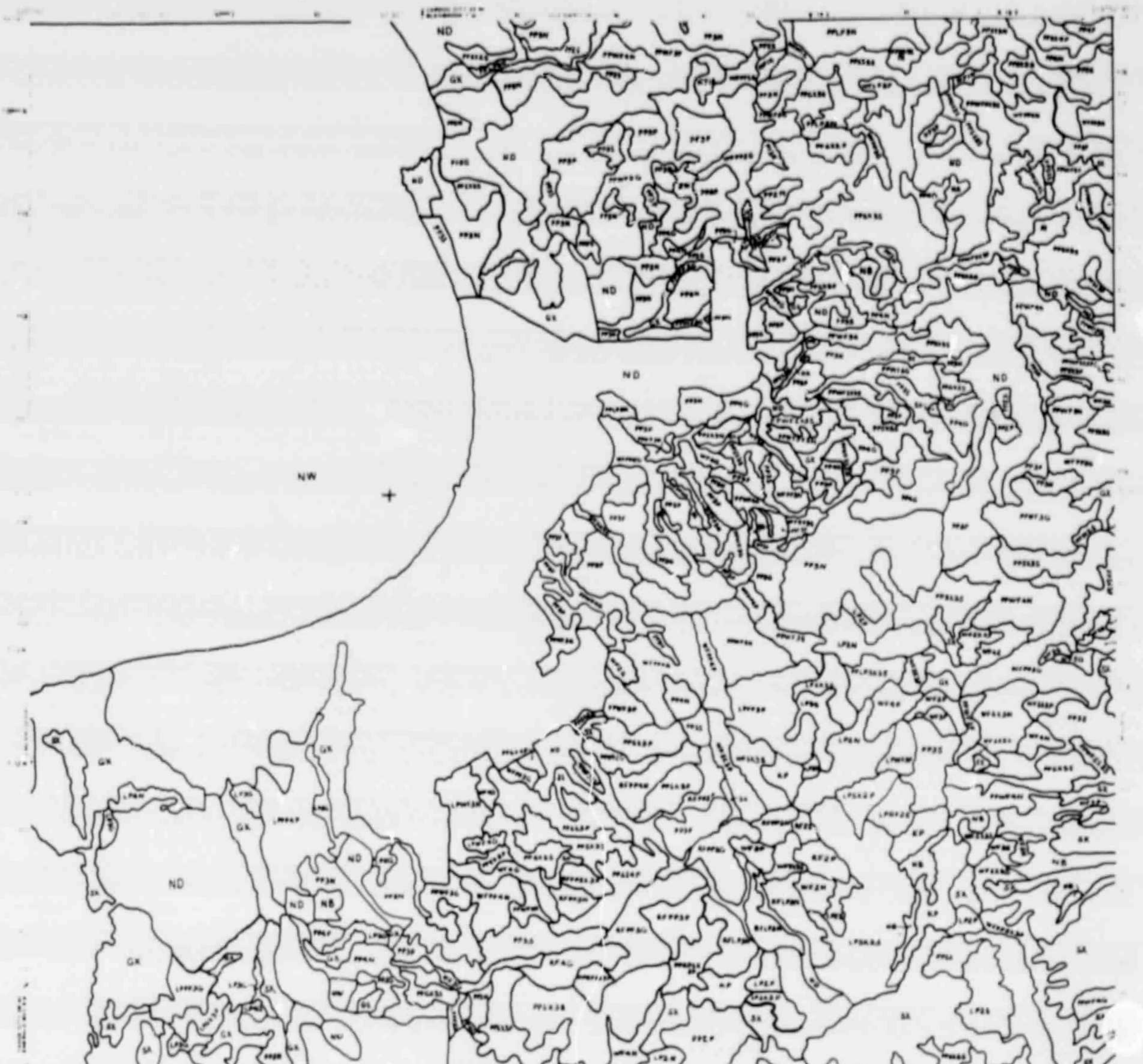

Figure 5-3.- Timber type map interpreted from panoramic aerial photography.

Figure 5-4.- Aerial panoramic timber type map on orthophoto quadrangle map.

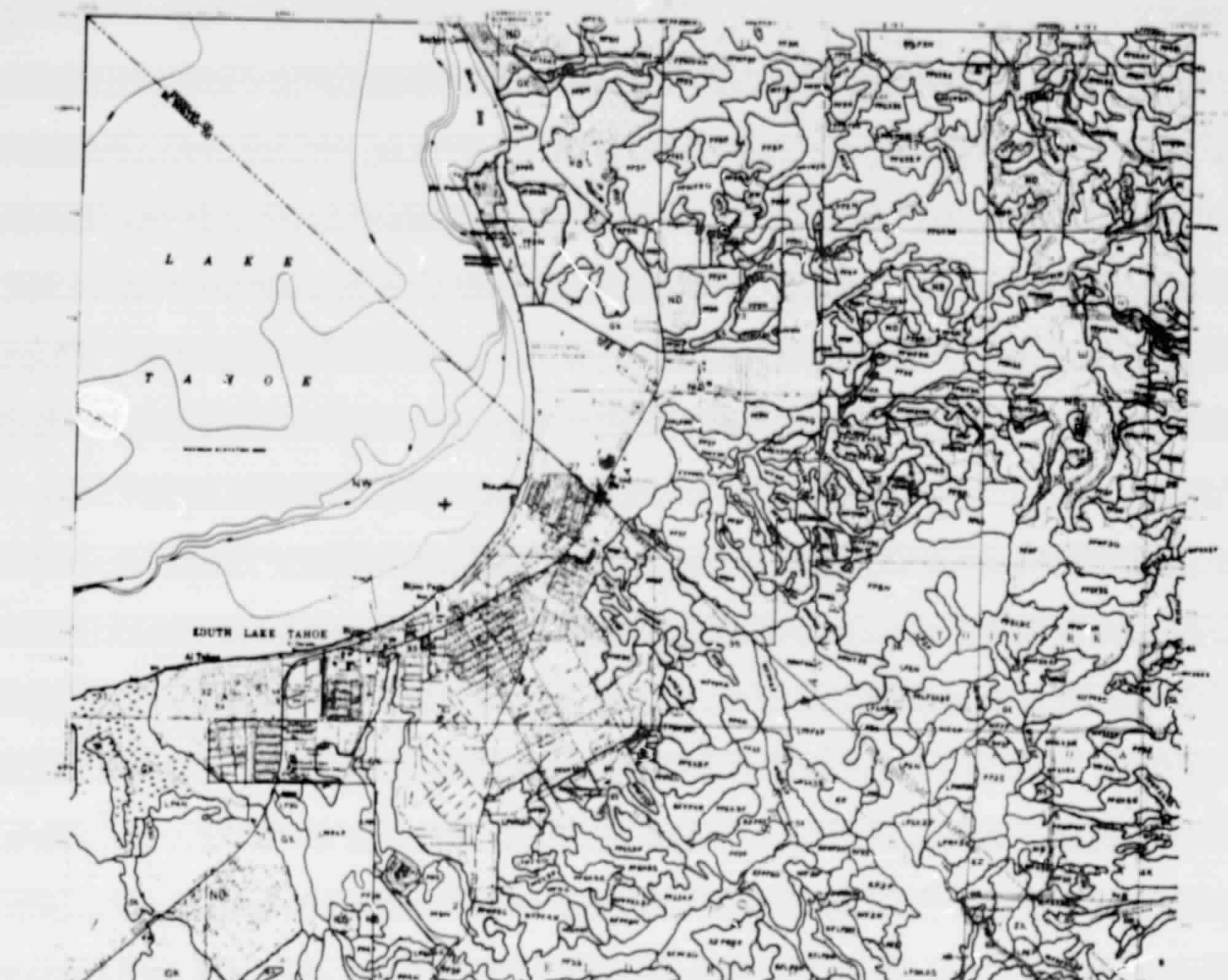

Figure 5-5.- Panoramic aerial timber type map on 7.5-minute quadrangle map.

nadir when viewing photographs from the east flight line, and 20 to 44 degrees when using west flight line photographs. On panoramic photography, the degree of distortion and obliquity is a function of how far the study site is from nadir. It also has a constantly shrinking scale moving away from nadir. The scale of the study site on the panoramic photographs ranged from approximately 1:30,600 to 1:41,700.

It is obvious that a change in scale such as this would cause a problem. The photointerpreter had to constantly make mental adjustments for the scale change, especially when dealing with size and density. The obliquity of the photograph made classifying density difficult because a side view of the trees was obtained rather than a vertical view of the tree crowns. It also made the classification of a mixed stand more difficult when determining the proportion of composition. For example, the resource photography might have contained an LPPP3C (lodgepole pine/ponderosa pine mix, small sawtimber, 70- to 100-percent crown closure) classification, while the panoramic photography classified the same site PPLP3C (ponderosa pine/lodgepole pine mix, small sawtimber 70- to 100-percent crown closure). This resulted in an incorrect classification. Another problem dealt with during this phase of the project was a slight attenuation in color increasing out from nadir. This is caused by the increased path lengths and visibility differential absorption and reflected light coming from objects further from the camera lens. This attenuation caused minor problems with interpretation of species when color and tone were critical for separation, such as between white fir and ponderosa pine.

During the polygon transfer phase, difficulty was encountered because the photographic distortion altered the shape and relative position of the polygon. When transferring the portion of the site farthest from nadir, the distortion was beyond the capability of the ZTS to correct it.

Polygon boundaries on this portion of the site were transferred by drawing in the boundaries in relation to detail available on the panoramic photographs and the orthophoto maps.

The two orthophoto maps on the west side of the site were of poor quality. At some points on the orthophoto map, double and triple exposures were observed causing considerable question as to where to draw the polygon boundary.

6.1.3 EXPENSE AND AVAILABILITY OF EQUIPMENT

During the beginning phase of the project, it was found that pocket stereoscopes, the Old Delft scanning stereoscope, and the Zeiss mirror stereoscope did not provide the desired magnification or optical quality necessary to do the interpretation. A problem lies in the expense and general availability of the stereoscope that works best, the Bausch and Lomb zoom 240 stereoscope. The Bausch and Lomb stereo ZTS is another expensive piece of equipment, but it is extremely useful if transferring polygons to a regular 7.5-minute quadrangle map. When transferring to an orthophoto map, it is helpful, but not necessary.

6.1.4 SUMMARY OF PROCEDURAL PROBLEMS

In summary, most of these procedural problems can be solved by a careful placement of flight lines so the area of interest is as near as possible to nadir. Of course, this ideal solution is not possible in all cases, but when it is possible, advantage should be made of it. A goal to aim for is to place the farthest edge of the study site within 35 degrees of nadir. North-south flight lines are regarded as essential to facilitate the map transfer process.

Another approach to solving some of the mentioned problems is improving the camera system and film for resolution. Advanced panoramic cameras such as the IRIS II and IRIS III camera systems should provide such an improvement. Reconnaissance cameras of the type used in this study do not have color calibrated lenses, but procedures can be used in acquisition and processing to minimize film response variations.

6.2 ADVANTAGES OF THE COLOR INFRARED PANORAMIC PHOTOGRAPHY

So far, only problems have been discussed, but it should be noted there are several advantages to using color infrared panoramic photography.

6.2.1 FORMAT OF PHOTOGRAPHY

Because a single panoramic photograph covers such a wide area, the width of as many as three quadrangle maps may be covered on one frame. This can be a tremendous time saver when timber typing because only four frames of photography (four stereo triplets) would be required to complete three full quadrangle maps. The width of coverage will reduce the number of frames needed per map and the time spent on edge matching.

Another advantage to the format is that it permits rapid coverage of large areas of land with fewer frames of photography. For example, during the 1980 Mountain Pine Bark Beetle Damage Assessment Survey, 12 million acres in Colorado were photographed in about 4 hours (Dillman et al., 1981).

6.2.2 MULTIUSE OF PHOTOGRAPHY

Panoramic photography provides a continuous coverage of forested land and should be made available to other disciplines or uses, such as range analysis, change detection, damage assessment, road location, watershed management, soils mapping, and general land use planning. It may be possible to work out an inter- or intra-agency cost sharing plan for the photograph acquisition.

6.2.3 RESOLUTION OF PHOTOGRAPHY

Although the photography was flown at 65,000 feet and produced photographs at a nadir scale of 1:30,000, it provided a resolution of 2 to 3 feet. This resolution was equivalent to that of the resource photographs, provided a stereoscope with sufficient magnification was used. It is believed by the photointerpreter of this project that the superior resolution of the photography compensated for the smaller scale. In most instances, tree shape was distinguishable for species identification.

6.2.4 FILM TYPE

The color infrared film used is not unique for the panoramic photography. Any aerial camera can be loaded with infrared film, but it has some advantages that should be discussed.

a. Haze penetration - When the color infrared film is used with a Wratton 12 yellow filter, it has an excellent capability of penetrating atmospheric haze and giving a very clear photograph. This feature is particularly important for photography acquisition obtained from high-altitude platforms such as provided by the U-2 aircraft.
b. Species identification - Many tree species have a unique distinguishing color and/or shape which is enhanced by the greater color contrast of color infrared film. On this particular roll of photography, lodgepole pine appeared a dark violet or purple while white fir was a very bright red. Ponderosa pine and red fir did not have as unique a signature. Sugar pine, with its long spindly branches, had a pale red color. Lush areas of plant growth appeared bright red, making color infrared film good for riparian mapping and planning.
c. Multiuse application - Although this project was only concerned with

timber typing, the same photography mission could, as previously mentioned, be used for many other applications. Because of its greater contrast, color infrared film is probably the most versatile and discriminating film type that could be used. For example, it has proved to be the best film for detecting stress in vegetation and is therefore used for insect damage assessment surveys. It was also compared with color and black-and-white film and found to be the best film type for land use mapping in south Texas (Ward, 1974). The aerial photography used to support this timber typing feasibility study was obtained from a series of missions which photographed approximately 42 million acres of forest land in northern California. It was principally used to identify dead and dying timber affected by prolonged drought and support salvage logging operations in 14 National Forests.

6.3 ANALYSIS OF RESULTS

Results of this project are presented in tables 5-1 and 5-2. Table 5-1 presents the results in six general categories of the entire study site. Table 5-2 is more specific. It displays the comparison of each sample point on the South Lake Tahoe quadrangle map and allows the reader to see where the errors of confusion occurred. It also shows the omission and commission errors. As stated previously in section 3.6 of this report, the basis of comparison was the existing timber type maps, and not actual ground truth. Although the initial labeling was done according to table 3-1, the accuracy assessment was done using the more current aggregated classes as seen on table 3-2.

6.3.1 ANALYSIS OF TABLE 5-1

The results of table 5-1 were broken into six categories, from general to specific, so the reader can see where the difficult and the simple classifications are. The first category, land cover, includes every sample point on the map within the management basin boundary. South Lake Tahoe and Emerald Bay quadrangle maps contained many water and urban sample points, and because these are easily identified, the results of 71.1 percent and 74.0 percent are significantly higher than the other two maps. The second category is vegetated cover type. To obtain the results on table 5-1, only the vegetated classes were examined, which means water, urban, and barren samples were removed. As expected, a drastic drop in agreement occurred for the two previously mentioned quadrangle maps with the large number of nonforest, water, and urban samples; but there was only a small decrease on the two, with barren being the only nonforest class. The vegetated cover type category includes grass, shrub, hardwood, and noncommercial conifer, in addition to the forested sites.

The timber type category 3 is probably the most informative of this project. Only forested samples were compared, and in order to be considered agreeable, the species, size, and density had to agree. If one of these factors were off by one increment, the whole classification was called a miss. For example, if a sample on the panoramic photography timber type map was labeled RF3G, but was labeled RF4G on the resource photography timber type map, it would be wrong. At first, the low percentage of agreement in this category might seem to indicate panoramic photography is not useful for timber typing; however, three points must be considered.

a. Table 5-1 does not display the consistency achieved. It only shows agreement of the classifications.
b. Comparisons were made with another map and not actual ground truth.
c. The photointerpreter did not have an in-depth knowledge of the area.

Categories 4, 5, and 6 are subclasses of the forested sample points. They represent the species, size, and density, respectively. All the forested points were examined for species only, and the results are presented in category 4. The Freel Peak quadrangle map was the lowest because of a major discrepancy in distinguishing lodgepole pine and white fir. The resource photography timber type map called many of the samples lodgepole pine, while the panoramic timber type map said it was white fir. Unfortunately, the area was inaccessible during the accuracy assessment field trip, but one of the Region 5 foresters had visited the site the previous summer and felt certain the samples were white fir rather than lodgepole pine.

The tree size, category 5, was the second most accurate classification. One reason for this is that even though four size classes were possible, most of the timber types fell into one of only two size classes. To tabulate the results of this class, just the size function of the timber type maps for all the forested points was considered.

The last category was density. This was by far the most accurate and consistent of the three label functions. After aggregating the timber type classes, there were only two density classes, "P" (0-50 percent) and "G" (51-100 percent).

On all four quadrangle maps, the accuracy or agreement became worse with increasing distance from nadir because of the distortion of the polygon, the loss in resolution, and the obliquity problems in the photography. It became critical at approximately 35 degrees from nadir.

6.3.2 ANALYSIS OF TABLE 5-2

Table 5-2 is a confusion matrix that shows the results of each sample point on the South Lake Tahoe quadrangle map timber type map. The results are a comparison of the timber type map made from panoramic photography with one made from resource photography. The columns are classes from the panoramic photography, and the rows are resource photography classes. All the class labels come from the aggregated labels as seen in table 3-2. The confusion matrix will allow the reader to examine each forest and nonforest class to see where the problems existed. It shows the percentage of omission and commission error along with the percentage of each type of error. Subtracting this from 100 will give the percentage of correct classification.

At this time, a brief general discussion comparing the map derived from panoramic photography to the resource map will be presented. The three labeling factors will be examined. First is the confusion of species. The most confused species class was lodgepole pine. The resource photography map indicated 57 sample points of lodgepole, and the panoramic photography map showed only 38 samples. Lodgepole was most often confused with mixed stands. If resource said it was LPPP3G (aggregated label L3G), and panoramic said it was PPLP3G (aggregated label M3G), it would be called wrong. Lodgepole was confused five times with red fir, once with shrub, and once with white bark pine.

Another problem with species was confusion between red fir and mixed conifer. A similar problem of stand composition could exist here also. White fir/red fir mix was a fairly common class, and to be correct the percentage stand composition had to be accurately estimated.

The last major area of species disagreement was found with white bark pine, a high-altitude noncommercial species. The resource map called it seven times, and the panoramic map called it only three times. The confusion was between white bark pine and small sparse lodgepole pine because both can inhabit the same site, and both appear relatively dark on the infrared photography.

The next problem would be in confusion of size class, as seen in the aggregated classes M3P, M3G, and M4G. The class M3P agreed 26 times, but was placed in the next higher size class, M4P, 17 times. M3G agreed 32 times and was confused with M4G 14 times.

A lesser problem within the same group is density. M3P was called M3G six times, and M4P was confused with M4G four times.

The nonforested classes naturally had a higher percentage of agreement because land cover was the only function involved. Water (NW) was in agreement 100 percent. Developed (ND) changed slightly because of the difference in dates of photography acquisition or difference in polygon boundaries when near a developed area. Grassland (GS) was in agreement 16 times and confused only twice. Shrubs (SX) had two missed when the panoramic map called for it 15 times. Hardwood (HX) had only three sample points on the entire quadrangle map, but it was in agreement all three times.

6.4 CONSISTENCY OF RESULTS

A special emphasis must be brought to this section because consistency was the primary goal of the photointerpreter rather than an absolute correct classification. If consistency can be achieved and proven from the panoramic photographs, then all that is necessary to get a high degree of classification accuracy is to adjust labels according to ground truth.

Data on consistency cannot be put into tabular form, but trends can be noted and comparisons can be made with resource photography. Density had a tendency throughout the site to be labeled more dense than less dense if not correct. For example, if a timber stand had a ground truth density label of 'N' (40-69 percent) and a mistake occurred, chances were greater it would be a 'G' (70-100 percent) rather than a 'P' (20-39 percent). This type of mistake would probably increase as obliquity increased when moving away from nadir. The density interpretations from panoramic photography tended to be more dense than those made from resource photography.

When mistakes occurred on tree size, the trend was for the panoramic photography interpretations to call it a smaller crown than the resource photography. A frequently occuring disagreement between the two timber type maps was found on the Freel Peak quadrangle map. The interpretation of species from the panoramic photography was a 'WF' (white fir), while the resource map called the same points 'LP' (lodgepole pine). Both were consistent in the interpretation, and with ground truth, one of the two could easily be changed to reflect the correct classification. This would have been done during the December field trip if the area of interest had been accessible. Other similar comparisons of specific problem areas were made, and, in most cases, consistency was found.

After comparing and examining the sample points, it was generally believed by both the Lockheed interpreter and the two Region 5 timber management foresters that the timber type maps interpreted from panoramic photography were indeed consistent and have the potential for a high degree of accurate land classification.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The objectives of this study were to (1) test the feasibility of using high-altitude panoramic photography for timber type mapping and classifying nonforest land and (2) compare the OBC timber type map with one done over the same area with resource photography and ground truth. The following conclusions can be made in light of the project objectives:

- Established conventional timber typing procedures can be used on panoramic photography if the necessary equipment is available.

- No accuracy standards were set by the S.O.W. (appendix A), but it is believed by the Lockheed and Region 5 timber personnel that the classification and consistency results warrant further study in using panoramic photography for timber typing.
- Timber type mapping can be done as fast or faster with panoramic photography than with resource photography while maintaining a comparable accuracy. This cost effectiveness is obtained by the large area coverage of panoramic photography.

7.2 RECOMMENDATIONS

There are two recommendations to be made as a result of this feasibility study.

- A comparison of the timber type map from panoramic photography should be made with actual ground truth to determine real classification accuracy.
- A timber typing project over a large administrative unit such as a National Forest District is needed. It is recommended that this be combined with timber inventory update objectives in a pilot test format.

8. REFERENCES

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APPENDIX A

SPECIFICATIONS FOR OPTICAL BAR CAMERA IMAGERY
DELINEATION, DETAIL TRANSFER, AND MAP PREPARATION
1980

SPECIFICATIONS FOR OPTICAL BAR CAMERA IMAGERY DELINEATION, DETAIL TRANSFER AND MAP PREPARATION 1980

DIVISION 100 - GENERAL SPECIFICATIONS

110 - Scope of Contract. The contractor shall furnish all transportation, supervision, labor, equipment, and supplies (other than that which is listed in 140 - Government-Furnished Property) necessary to delineate and classify vegetation and non-vegetated areas on optical bar imagery, transfer that delineation and classification to furnished orthophotos, and submit a final report concerning the process and procedures used.

120 - Project Location and Description.- The area contained within four (4) adjacent 1:24,000 USGS 7½' Quadrangle maps within the Lake Tahoe Basin Management Unit has been chosen as the project area. This area was type-mapped on 1:24,000 color contact prints in 1979 and transferred to USGS 7½' Quads. The product obtained under this contract will be compared with the product obtained in 1979 to visually ascertain the accuracy and utility of delineation and classification of areas on optical bar camera (OBC) imagery.

130 - Contractor Responsibility. - The Contractor shall furnish the necessary plant facilities, personnel, materials, supervision, labor, equipment, and transportation to perform the work specified. The end product of this contract shall be finished inked orthophotos at 1:24,000 scale delineating and classifying vegetative and non-vegetative areas within the project area to a 10 acre minimum size. All land within the project area will be so delineated and classified.

140 - Government-Furnished Property. The government will deliver to the Contractor the following listed materials, supplies, property, or service (hereinafter referred to as "Government-Furnished Property") listed below. Contractor shall be liable for all loss or damage of such delivered Government-furnished property until completion and final acceptance of work required under this contract. If the Government fails to make timely delivery of such Government-furnished property suitable for its intended use, and upon written request from the Contractor, the Contracting Officer shall make an equitable adjustment of contract delivery or performance dates or contract price, or both, pursuant to the "Changes" clause of the General Provisions of this contract.

141 - The Contracting Officer will make the following items available to the Contractor, at Contractor's request:

a) One set of color infrared OBC imagery covering the project area on which to do delineation and classification. This imagery is laminated with clear plastic for protection and to facilitate marking upon it.

b) Four (4) orthophotos covering project area upon which the delineations and classifying labels will be transferred.

c) Location map outlining project area and showing location of flight strip(s) for OBC imagery.

DIVISION 200 - TECHNICAL SPECIFICATIONS

210 - Intent: Vegetative and Non-Vegetative Delineation and Timber Stand Classification

This system provides the means for National Forest personnel to stratify the Forest vegetation or lack of it, for inventory sampling, growth predictions, and harvest allocation. Photo interpretation is to be based only on what can be seen on the aerial photographs and verified by sufficient ground examination to assure accuracy of delineation and classification. It is not intended that the classifier make inferences concerning growth, decadence, or management decisions.

220 - Preparation of Effective Photo Area

221 - The effective photo area shall be delineated by a solid line in black, blue, green or red nonsmear ink to insure complete photogrammetric coverage of the project area and matching of delineation from photogrammetric model to photogrammetric model.

222 - Lines delineating the effective photo area shall not be wider than one millimeter.

230 - Delineation of Polygon Boundaries

231 - Polygons will be as small as possible but in no case smaller than 10 (ten) acres.

232 - Lines delineating polygon boundaries shall not be wider than 0.5 (one-half) millimeter.

233 - Polygon boundaries will close.

234 - Polygon boundaries on each mapping photograph will match those on adjacent mapping photos.

235 - Black or blue non-smear ink will be used to delineate polygon boundaries.

236 - Three broad types of polygons are recognized:

Non-Vegetated areas are less than 10 (ten) percent vegetated by area. They include rocky areas, lakes, permanent snowfields, settlements, quarries, clearcuts, type conversions, and recently burned areas that haven't been revegetated.

Non-Forest areas are more than 10 (ten) percent vegetated but trees make up less than 10 (ten) percent of the vegetative cover by area. They include meadows, grasslands, brushfields, riparian shrubs, and cultivated lands. Orchards are assigned to the Non-forest type even though the trees make up more than 10 (ten) percent of the vegetative cover.

Forest areas are more than 10 (ten) percent vegetated and trees make up more than 10 (ten) percent of the vegetative cover by area. (Orchards are the exception as noted above in the Non-Forest description.) Forest areas include a variety of mixtures of non-commercial conifers, commercial conifers, hardwoods, grasses, and shrubs.

237 - Example of Procedure for Delineating Polygons

The first step is to delineate the three broad types of polygons: Non-Vegetated, Non-Forest, and Forest.

The second step is to examine the polygons to determine whether or not they can be subdivided into smaller polygons that are more homogeneous.

a. Example of subdividing a Non-Vegetated polygon
The polygon contains 25 (twenty-five) acres of rock, a lake of 10 (ten) acres and another lake of 5 (five) acres. This polygon can be subdivided into two: a homogeneous polygon of rock, and a homogeneous polygon of water (the 10 acre lake). The lake of 5 acres is smaller than the minimum size for delineation and is included in the rock polygon.

b. Example of subdividing a Non-Forest polygon
The polygon contains a meadow of 50 (fifty) acres and 10 (ten) acres of shrubs growing along a stream. This polygon can be subdivided into two: a homogeneous polygon of grass and a homogeneous polygon of shrubs.

c. Example of Subdividing a Forest Polygon
The polygon is 60 acres total (See Figure 1). It contains a 10 (ten) acre group of tanoak, and a 50 (fifty) acre group of commercial conifers. The polygon can be initially subdivided intc two: 10 (ten) acres of tanoak, and 50 (fifty) acres of commercial conifers. Upon further examination of the 50 acres of commercial conifers, two homogeneous groups of commercial confiers can be identified based on density. One area is 20 acres and is 30 (thirty) percent covered with commercial

conifer tree crowns, the other area is 30 acres and is 80 (eighty) percent covered with commercial conifer tree crowns. Thus two more polygons can be delineated. Upon further examination four more homogeneous groups can be identified based on size of trees. In the 20 acre area with 30 percent crown cover, 10 acres is small sawtimber and 10 acres is large sawtimber, making two more polygons. In the 30 acre area with 80 percent crown cover there is a group of 20 acres of large saw-timber, and a group of 10 acres of poles. A final check of species composition is done at this point for any polygon that could be subdivided into at least two 10 acre polygons. In this example, the only candidate is the 20 acre group of large sawtimber with 80 percent crown cover. A mixture of sugar pine and white fir occurs in a group of 10 acres, and a group of almost pure Douglas-fir (greater than 90%) of commercial conifer crown cover is Douglas-fir occurs in another 10 acre group. Thus the 20 acre polygon can be sub-divided into two. At this point no further subdivisions can be made.

In this example a Forest polygon was subdivided into six homogeneous polygons, based on density, size, and species xomposition. The polygons are now ready for labeling.

240 - RULES FOR LABELLING POLYGONS

241 - Labels will be legible.

242 - Labels will be made with black or blue nonsmear ink.

243 - Maximum width of lines is 0.5 (one-half) millimeter.

244 - Each polygon will have a single label.

245 - Polygon labels on each mapping photography will match those on adjacent photos.

246 - Labels too large to be contained within the polygon shall be placed outside the polygons and referenced to the polygon with an arrow, the tip of which will be inside the polygon referenced.

247 - Non-Vegetated polygons will be labeled with the single most appropriate code indicating the surface condition based on plurality of area in a specific condition. Acceptable codes are shown in Section 251.

248 - Non-Forest polygons will be labeled with the single most appropriate code based on plurality of the vegetational cover within the polygon. Acceptable codes are shown in Section 252.

249 - Labels for Forest polygons will be made up of three label elements, which are: species, size, and density; they will always be listed in that order. An exception is when hardwoods or non-commercial conifers predomiante and commerciai conifers constitute less than 10 (ten) percent of the tree crown area, or when hardwoods or non-commercial conifers occur by themselves in the polygon, there will be no size or density label elements in the label.

Acceptable codes and combinations of codes for the species label element are shown in Sections 253 and 254. No more than two species can be shown in the species label element. The Non-Forest codes GX and SX are acceptable under certain conditions in combination with Forest codes in the species label element as shown in Section 254.

The two predominant tree species (in terms of area occupied by crowns) will be shown in their order of abundance in terms of crown area; and the most abundant species will be shown in the first position of the species label element. The following are exceptions to the above rule:

a. If a particular tree species does not make up at least 10 (ten) percent of the tree crown area it cannot be coded as a second species.

b. If the area is 50 (fifty) to 90 (ninety) percent grass or shrubs, show the predominant tree species first, followed by the grass (GX) or shrub (SX) code.

c. if the area is less than 60 (fifty) percent grass or shrubs ignore the non-forest vegetation and code only the tree species.

d. If hardwoods or non-commercial conifers predominate in a mixture with commercial conifers, and the commercial conifers constitute at least 10 (ten) percent of the tree crown area, the most abundant commercial conifer (in terms of area occupied by corwns) will be shown in the second position of the species label element regardless of the amount of crown area represented by other hardwood on non-commercial conifer species also present. Example: a polygon has 50% black oak, 30% tan oak, 20% ponderosa pine. The correct species element of the label is HBPP.

250 - ACCEPTABLE VEGETATED AND NON-VEGETATED CODES

251 - Non-Vegetated

Code	Description	Further Specification
NF	Barren	Rock, highway cuts and fills.
NW	Water	Lakes, permanent snowfields.
ND	Urban-Developed	Settlements, quarries.
NS	Clearcuts, Type Conversions, Burned Areas	Bare soil with no vegetation visible.

252 - Non-Forest

GX	Non-woody	Grassland, meadows.
SX	Woody shrubs	Brushfields, riparian shrubs along streams.
CL	Cultivated	Farms and orchards.

253 - Forest polygons

a. Non-commercial Conifers

KP	Knobcone Pine
DP	Digger Pine
PJ	Pinyon-Juniper

b. Commercial Conifers

PP	Ponderosa or Jeffrey Pine
SP	Sugar Pine
WP	Western White Pine
LP	Lodgepole Pine
WF	White Fir
RF	Red Fir
DF	Douglas-Fir
LC	Incense-Cedar
MH	Mountain Hemlock

c. Hardwoods

HA	Aspen
HB	Black Oak
HB	Tanoak
HB	Pacific Mandrone
HL	Live Oak
HX	Miscellaneous Hardwoods

254 - Acceptable Species Combinations

Use only the labels listed below for species combinations. Where two or more species are present in a delineated polygon and no label for the combination is shown below, use the label for the single most predominant species or species group (species labels can stand alone).

PPSP	WFPP	RFPP	DFPP	LCPP	HBPP
PPWF	WFSP	RFSP	DFSP	LCHB	HBSP
PPRF	WFRF	RFWF	DFWF	LCHL	HBWF
PPDF	WFDF		DFLC	LCGX	HBDF
PPLC	WFHB	LPPP	DFHB	LCSX	HBLC
PPHB	WFGX	LPWF	DFGX		HBGX
PPHL	WFSX	LPKP	DFSX		HBSX
PPGX	WFLP				
PPSX					
PPLP					

260 - SIZE CLASS LABELING

261 - Size class codes are based only on crown diameter of commercial conifers present in the polygon.

262 - Two-storied polygons (code 6) are defined as polygons of commercial conifers with an overstory of size class 4 or 5 and an understory at least two size classes smaller. Overstory density must be between 10 and 20 percent and the total density of the understory must be greater than or equal to 70 percent.

263 - In polygons that do not meet the two-storied definition, size class is based on the predominant crown area of saw-timber-sized commercial conifers with the following exceptions: if less than 10% of the overstory is saw-timber-sized trees the size class is based on the predominant crown area of commercial conifer poles or saplings.

264 - Acceptable Size Class Codes are:

Code	Description	Size Class
1	Crowns 5 feet diameter	Seedlings and saplings
2	Crowns 6-12 feet diameter	Poles
3	Crowns 13-24 feet diameter	Small Sawtimber
4	Crowns 25-40 feet diameter	Medium Sawtimber
5	Crowns over 40 feet diameter	Large Sawtimber
6	Two-storied	

270 - DENSITY CLASS LABELING WILL BE DONE AS FOLLOWS:

271 - Density class applies only to the commercial conifer component in any polygon. Heavily stocked polygons could conceivably be classifed as "S" or "P" if the stocking were mainly in hardwoods and/or non-commercial conifers.

272 - Polygons that qualify as Two-storied (see 262) will be assigned a density code of G. In all other cases density is estimated as the ratio of sawtimber-sized commercial conifer tree crown areas to total area within a polygon, except when less than 10% of the overstory is sawtimber-sized trees the density class applies only to the predominant commercial conifers in size class 1 or 2.

273 - Acceptable density codes are:

Code	Crown Closure
S	<20%
P	20-39%
N	40-69%
G	≥70%

280 - EXAMPLES OF POLYGON LABELS

Label	Species Composition	Size Class	Density
PP4N	Predominately ponderosa pine; no other tree species comprising 10% of crown area	Most crowns 25-40 ft. dia.	40-69% of polygon area in sawtimber-sized commercial conifer crowns
PPWF6G	Predominately ponderosa pine; white fir at least 10% of the tree crown area	Two-storied (understory at least 2 size classes smaller. Overstory must be a 4 or 5 in size)	Overstory 10-20% crown area; total density of understory greater than or equal to 70%
PPHB3P	Predominately ponderosa pine. Black oak at least 10% of tree crown area	Most 13-24 crown diameter	Sawtimber-sized commercial conifer crowns 20-39% of polygon area

Label	Species Composition	Size Class	Density
SX	Over 50% woody shrubs. Less than 10% crown cover of acceptable tree species code.	N/A	N/A
WFSX2S	Over 50% shrubs. Over 10% white fir of tree crown area	Most 6-12 foot crown diameter	Commercial conifer crowns of size class 2 are 10-20% polygon area

290 - Transfer to Orthophotos. Transfer the delineated boundaries with their labels to the furnished orthophotos. Transfer may be done by projection, or optically, or by whatever means seems most accurate and expedient. Boundaries and labels will be ink-drafted on the orthophoto using a good quality waterproof ink of a color that is highly visible. Free hand letter is acceptable if it is neatly done and uniform throughout.

DIVISION 300 - FINAL REPORT

A typed final report shall be submitted to the Contracting Officer at the completion of the project. Tell us in the report of the procedures, steps, equipment, and man-power used. Give us your evaluation of the practicability of doing this kind of work on OBC imagery. List suggestions concerning ways to improve the procedure. Tell what major problems were encountered. State what you would have liked to have done, but was outside of contract specifications. The Final Report will be used to determine whether it is in the best interest of the Government to further pursue stand mapping on OBC imagery.

DIVISION 400 - INSPECTION AND ACCEPTANCE

410 - The inked orthophotos will be compared against maps prepared in 1979 from delineation and classification done on U.S. Forest Service color contact prints. It is expected that delineation will compare closely. We are unable to set accuracy standards, for we don't know what can be done on OBC imagery by a competent photo interpreter as concerns this kind of project. We are unaware of another project of this nature. We expect a professional job, done in a workmanlike manner. The Final Report must thoroughly evaluate the procedure used, and the problems encountered. Final acceptance will occur when the total project area delineated, labeled, transferred, and ink-drafted according to specifications herein and the Final Report is accepted as complete.

DIVISION 500 - PAYMENT

510 - Bid price should be based on the total jobs as outlined herein.

520 - Progress payments may be made in accordance with Clause 14 of the Forest Service General Provisions (6300-38) if desired. Otherwise, total payment will be made when final acceptance is made as outlined in Division 400, above.