TECHNICAL MANUAL
ON
INTERPRETATION OF AERIAL PHOTOGRAPHS

Technical Manual Series on
the Feasibility Study on the Forest Management Plan
in the Central Highland in Socialist Republic of Viet Nam
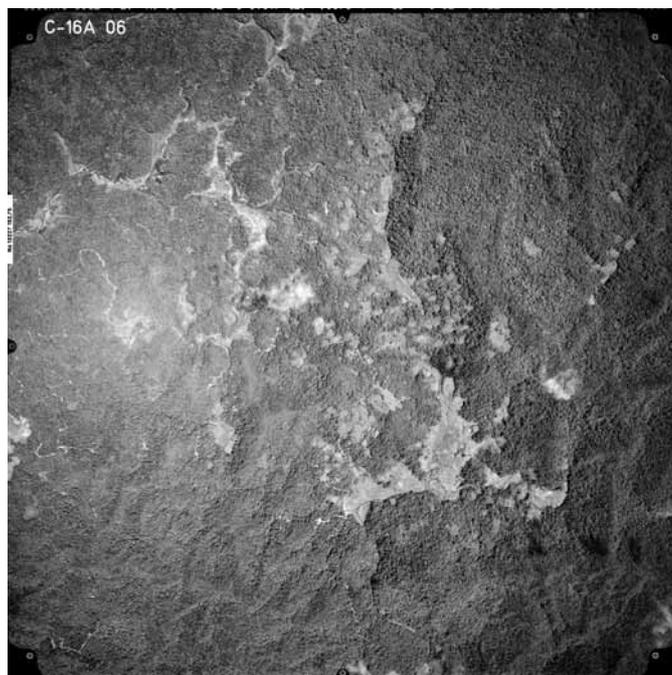
December 2002

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Introduction

This manual was prepared as a component of the "The Feasibility Study on the Forest Management Plan in the Central Highlands in the Socialist Republic of Viet Nam" (hereinafter referred to as "the Study")- a Development Study Cooperation Program between the GOVERNMENT of SOCIALIST REPUBLIC of VIET NAM and the GOVERNMENT of JAPAN. The purpose of this manual is to help facilitate accurate assessment of forest resources in Viet Nam using Aerial Photographs.

In preparing the manual, it was envisioned that principal users will be those personnel of the Ministry of Agriculture and Rural Development (MARD) and Department of Agriculture and Rural Development (DARD) who are presently at the "beginners stage" in learning how to utilise and interpret aerial photographs to conduct analysis of forests. Additionally, the manual is intended to serve as a textbook or reference to facilitate utilisation of aerial photographs by those who are interested in the interpretation of aerial photographs.

The main topics of the manual are arranged in the sequence of the activities to be carried out when conducting an analysis of field conditions: (i) stereo view of aerial photographs, (ii) pre-interpretation, (iii) field verification, (iv) natural forest classification, and (v) transferring the classification to the base map.

1. How to do stereo viewing.

1.1   Basic information about Aerial Photographs

(1)   Overlap and Sidelap

Forest surveys using aerial photographs are normally implemented in units that cover broad areas. Aerial photographs consist of a series of images taken from an airplane flying on pre-determined flight paths or lines. These lines are equidistant from, and parallel to one another. Thus, the resulting images (photographs) line up at equal intervals within the flight path. (Figs. 1 and 2)

Fig 1 A series of aerial photography conditions

Fig. 2 Sidelap and Overlap

Overlap

Sidelap

60%

30%
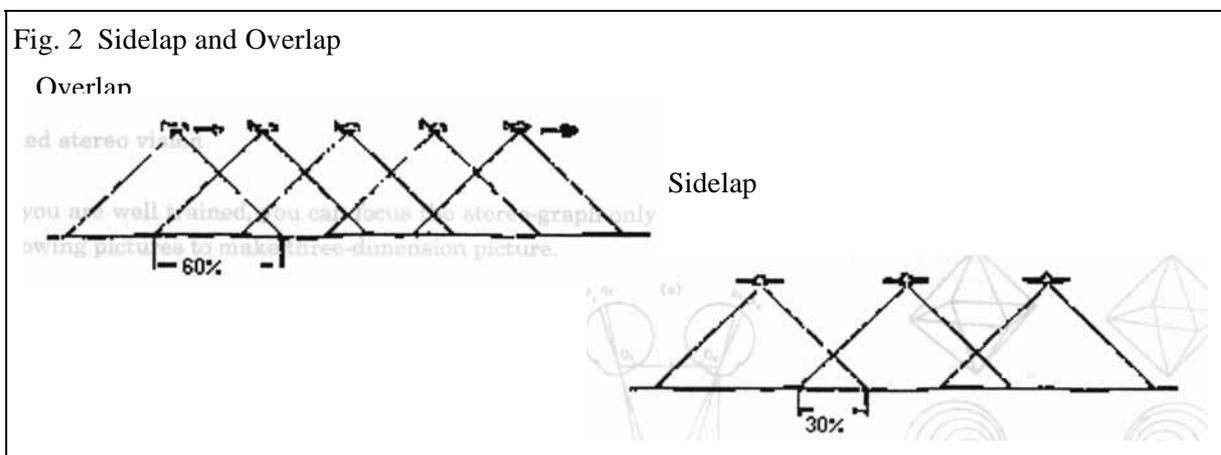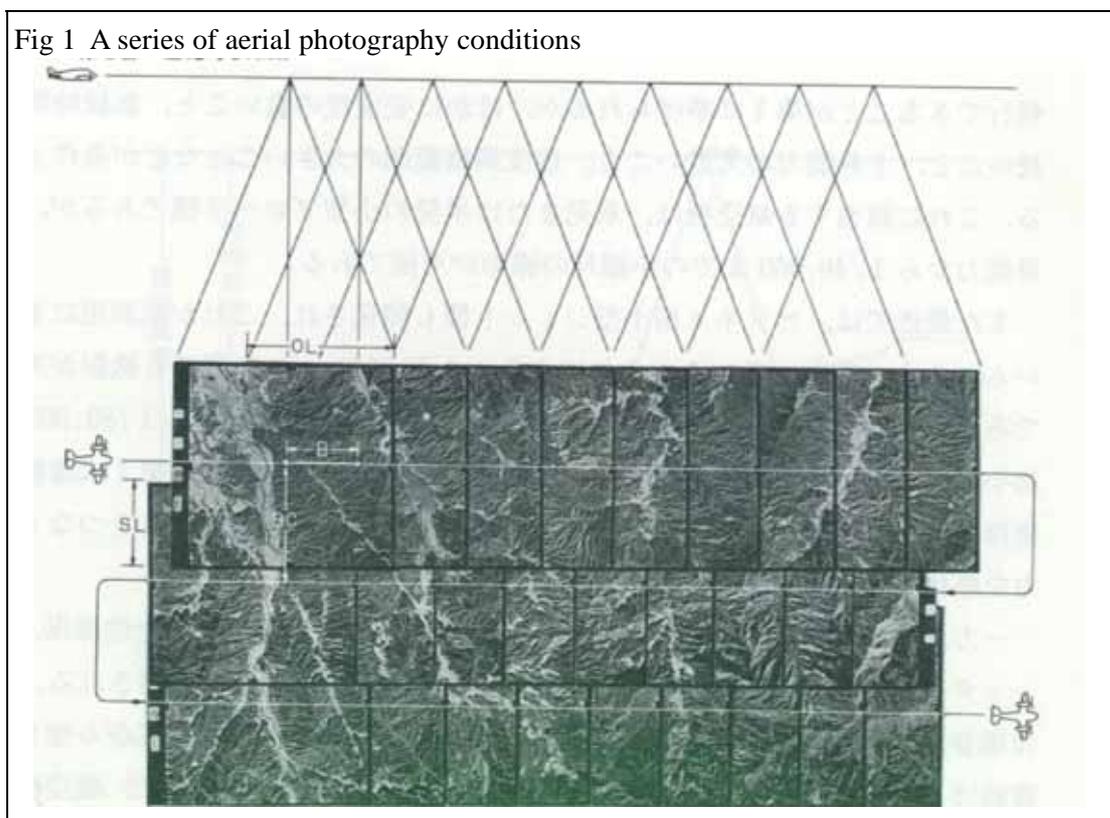
For the stereo view, the aerial photographs have to be shot with sufficient overlap and sidelap to maintain a significant connection between flight paths (i.e. a connection that is easy to recognize). Generally, aerial photographs are taken with a 60 % overlap and 30% sidelap.

 (2)   Characteristics of an Aerial Photograph

To use aerial photographs, it is important to understand the characteristics of an aerial photo image. Photographs taken from high up in the sky look down vertically at the ground. These photographs record everything on the ground through the lens of the camera.

Relationships between a negative film, a printed photograph, and the ground are shown on Fig. 3. Triangle ABO, (grand length and real flight height) and triangle a'b'o' (length on negative film and focal length of the lens) are similar triangles. Likewise, triangle ABO and triangle abo (length on printed photograph) are similar triangles. This relationship makes it possible to measure the distance between two points on an aerial photograph and use this data to calculate the actual distance on the ground between the same two points, taking into account the altitude (height) from which the aerial photograph was taken. This is the basis of aerial photography utilisation in land surveys.

Fig. 3 Relationship between figures actually existing on the ground and the image appearing on an aerial photograph
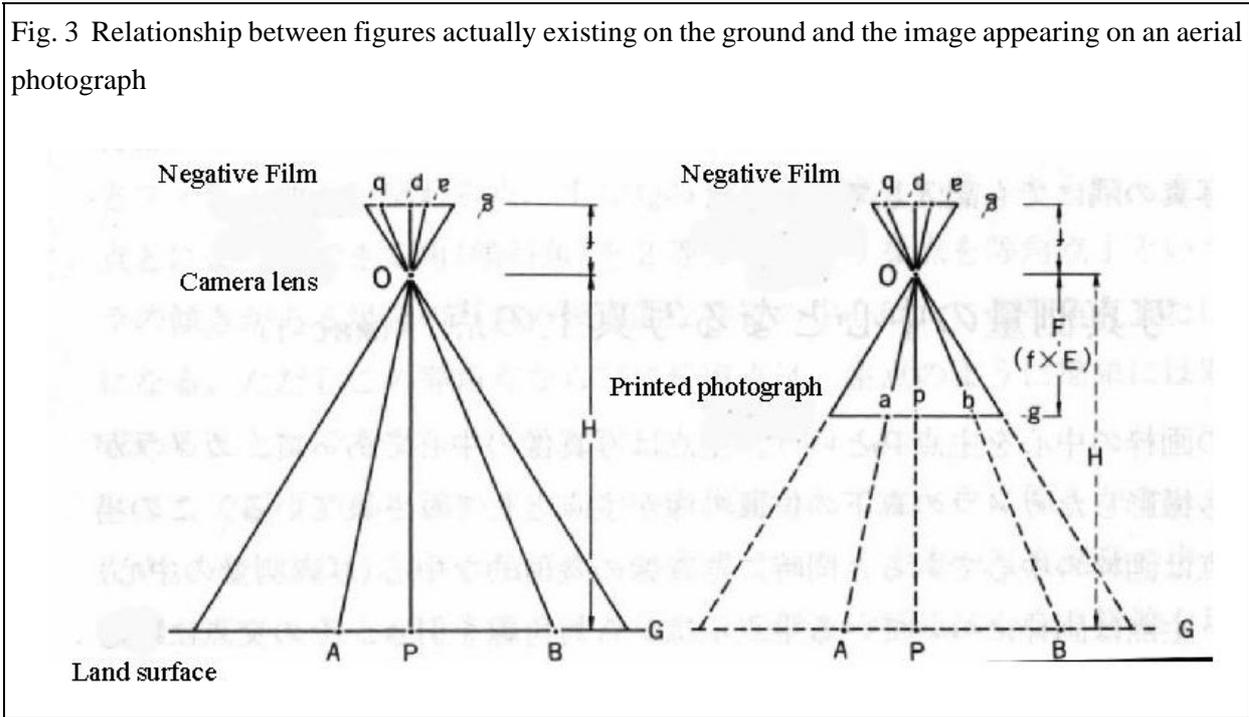
The line marked H on Figure 3 is the altitude (height) from which the aerial photograph was taken. F is the size of the magnified (i.e. enlarged) print of the aerial photograph. Size is equivalent to the product of (E) times the focal length of the camera (f).

(3) Principal Point

The exact center of an aerial photograph is called the Principal Point. The Principle point is the point on the ground located immediately below the camera lens looking down vertically. If the airplane carrying the camera maintains a straight-and-level flight path, the appearance of objects at the principle point is identical to how they actually appear on the ground. Sometimes however, the aircraft deviates from a straight-and-level flight path due to air turbulence. In this case, the camera lens will tilt slightly and the photograph will show a slightly slanting view of the objects. This slanting effect is discussed below (see "Center Point Projection"). Nowadays ordinary cameras are able to automatically compensate for the slanting effect so that the photographs show objects exactly as they appear, without the slanting effect. The principal point is defined as the intersection point of two diagonal lines between principal point indicating marks on the outer frame of an aerial photograph.

(4)   Perspective Photo Taking and the Slanting Effect

At first glance, an aerial photograph seems to provide an accurate location of objects on the ground. In reality however, this is not always the case. Fig. 4 (below) illustrates the features of a photograph taken.

Fig. 4 Sample of the Strained Images
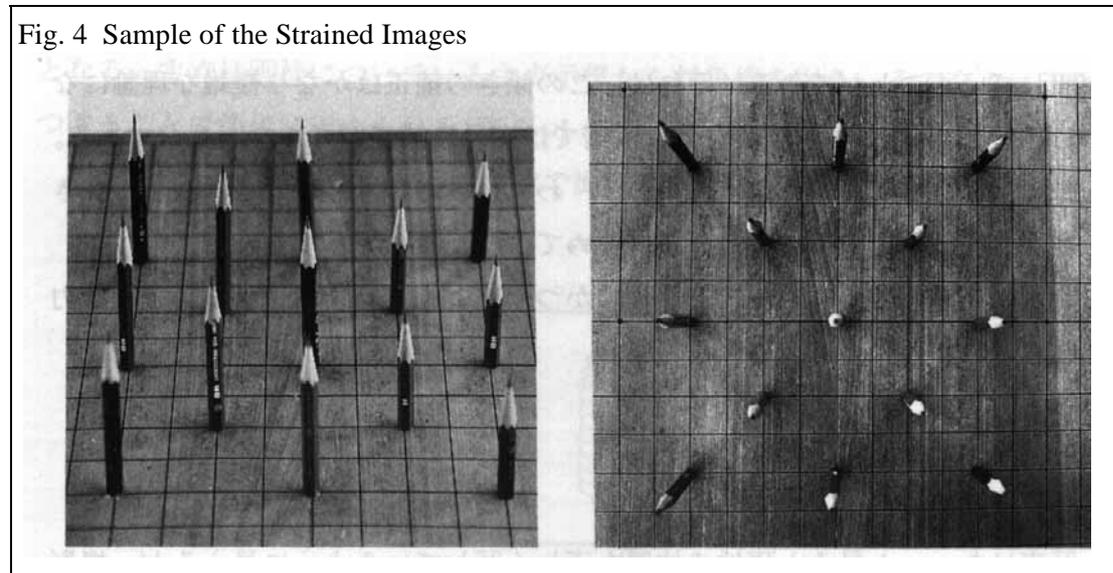
In the middle of the photo (i.e. the Principal Point), objects are correctly presented in their standing (vertical) position. Note also however that as one moves away from the Principal Point toward the edge of the photograph, objects appear in a slanting position. In other words, if you compare an aerial photograph and a map showing the same area, objects on the aerial photograph are actually slanting in a radial lay away from the center of the photograph in the direction of the frame (i.e. the border or edge). This slanting is referred to as the Strained Image. This is way an aerial photograph is taken by

perspective image.

Fig. 5 illustrates this phenomena. The lower part of Fig. 5 (triangle) shows actual locations on the ground. The upper part of Fig. 5 (rectangle) shows locations as they appear on the photograph. On the lower part of Fig. 5, note that the actual location of the base of a tree is point M and the actual location of the top of the tree is point N. Next, note that on the upper part of Fig. 5 point M on the ground appears as point m on the photo, and point N on the ground appears as point n on the photo. Note further on the upper part of Fig.5

Fig. -5 Condition of Strain and height
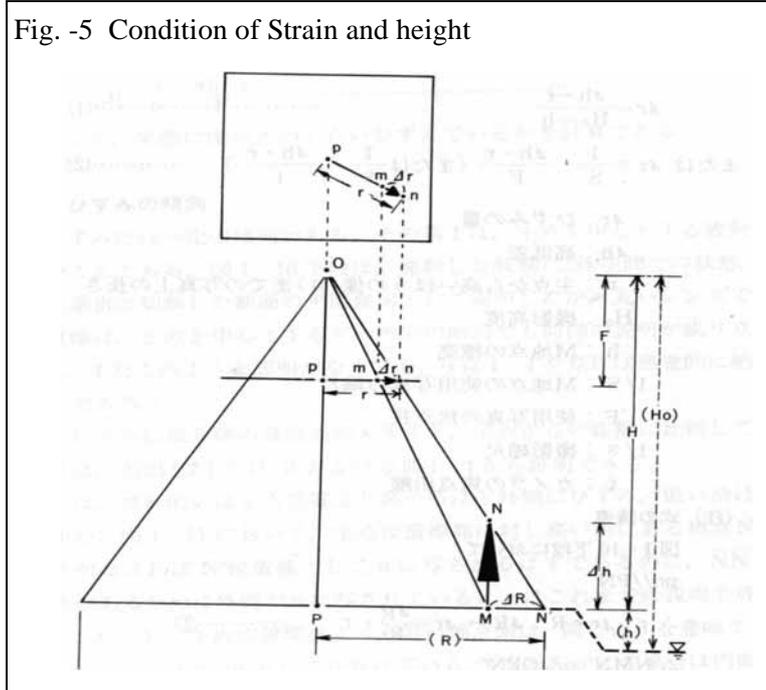
that points m and n appear to be separated when actually they are part of the same tree. This seems to be a discrepancy but it is not. This is simply the way aerial photographs present information. The tree top is printed at a slant, equivalent to the small triangle r found on the upper part of Fig.5. In other words, on the aerial photograph the tree appears to be down rather than standing up. This is one of the characteristics of aerial photos. As one moves away from the Principal Point, objects that are standing vertically (such as trees or tall building) are printed as if they were in a slightly reclining position.

(5)   Principal line

As mentioned earlier, aerial photographs are taken with a 60% overlap. Therefore, the same scene is shown on the right half of the left picture and the left half on the right picture. This pair of two pictures is called Paired Photos. Paired Photos show the same scene but from different slants (i.e.angles). This is the basis for obtaining a stereo view.

The principal points of each aerial photograph are also shown on the other aerial photographs of the same scene. Note that on Fig. 7 there is a line connecting the principal point on aerial photograph (P1) and the principal point on aerial photograph (P2). This line is called the Principal Line. It shows the flight path followed by the aircraft used to take the aerial photos. This line is important because it is the base line for both obtaining the stereo view and conducting land survey.

Fig. 6 A pair of Photographs
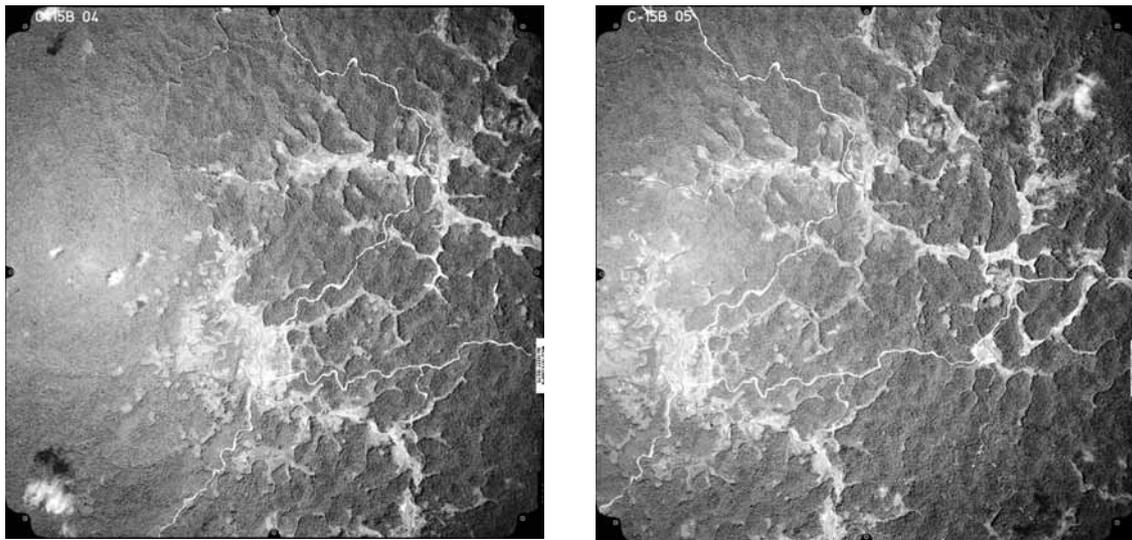
Fig. 7 Principal line
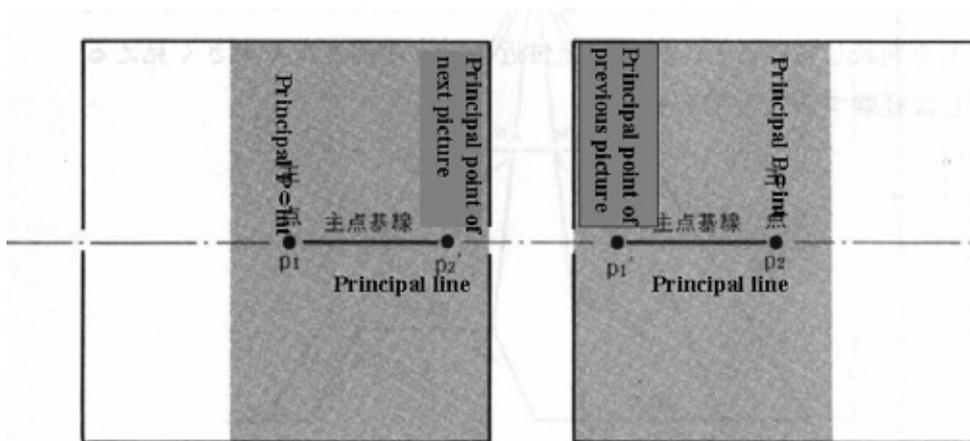
1.2 Practice in Stereo Viewing

(1)   Understanding the stereo (three-dimensional) view

For most people, the average distance between the right eye and the left eye is approximately 6 cm. As illustrated on Fig. 8, the right eye and the left eye look at objects from different angles. Points M and N are focused on m1 and n1 (respectively) on the retina of the right eye, and m2 and n2 (respectively) on

the retina of the left eye. The points m1, n1 on the right eye, and m2, n2 on the left eye are different. To compensate for this difference, the brain creates a three-dimensional picture; in other words – a stereo view. The same thing happens during stereo viewing of an aerial photograph. Looking through the stereoscope, the right eye and the left eye see different views of the same object or scene. The stereoscope compensates for differences and a stereo view appears.

Fig. 8 How the three-dimensional view is recognised

Fig -9 How to recognise stereo view of the aerial photographs

(2) Practice in Stereo Viewing

Before interpreting aerial photographs, analysers have to be familiar with the three-dimensional view using Paired Photos. The images of three-dimensional pictures are obtained by focusing on two

overlapping pictures through the right and left eyes. Aerial photos consist of two artificial pictures that are the same as natural pictures seen in normal view by the left and right eyes.

A person with extensive experience in analysis of aerial photographs can often obtain a stereo-view using only his naked eyes. Pictures on Fig. 10 are prepared to help beginners practice stereo-viewing with the naked eye. Try to examine pictures on the right using only the right eye, and pictures on the left using only the left eye. If this if difficult, try separating the pictures by placing a card standing upright like a wall between the right and left pictures.

Practice naked-eye viewing as follows:

a. Place a card standing upright between pictures on the right side and pictures on the left side. This will block the right eye from seeing the left side picture and the left eye from seeing the right side picture.

b. Bring your face close to the practice pictures sheet (Fig.10) and focus each on its respective picture (i.e. right eye on right picture and left eye on left picture).

c. Focus intensively. You will note that the pictures move close to one another and finally overlap, producing a three-dimensional image.

d. Repeat these process, to become familiar with the phenomena of two pictures blending into one image.

e. Try the same practice without a card between the right and left side pictures.

Familiarity with stereo-viewing by the naked eyes is very helpful when using aerial photographs in the field while carrying out surveying activities.

Fig -10 Practice pictures on stereo-viewing with the naked eyes
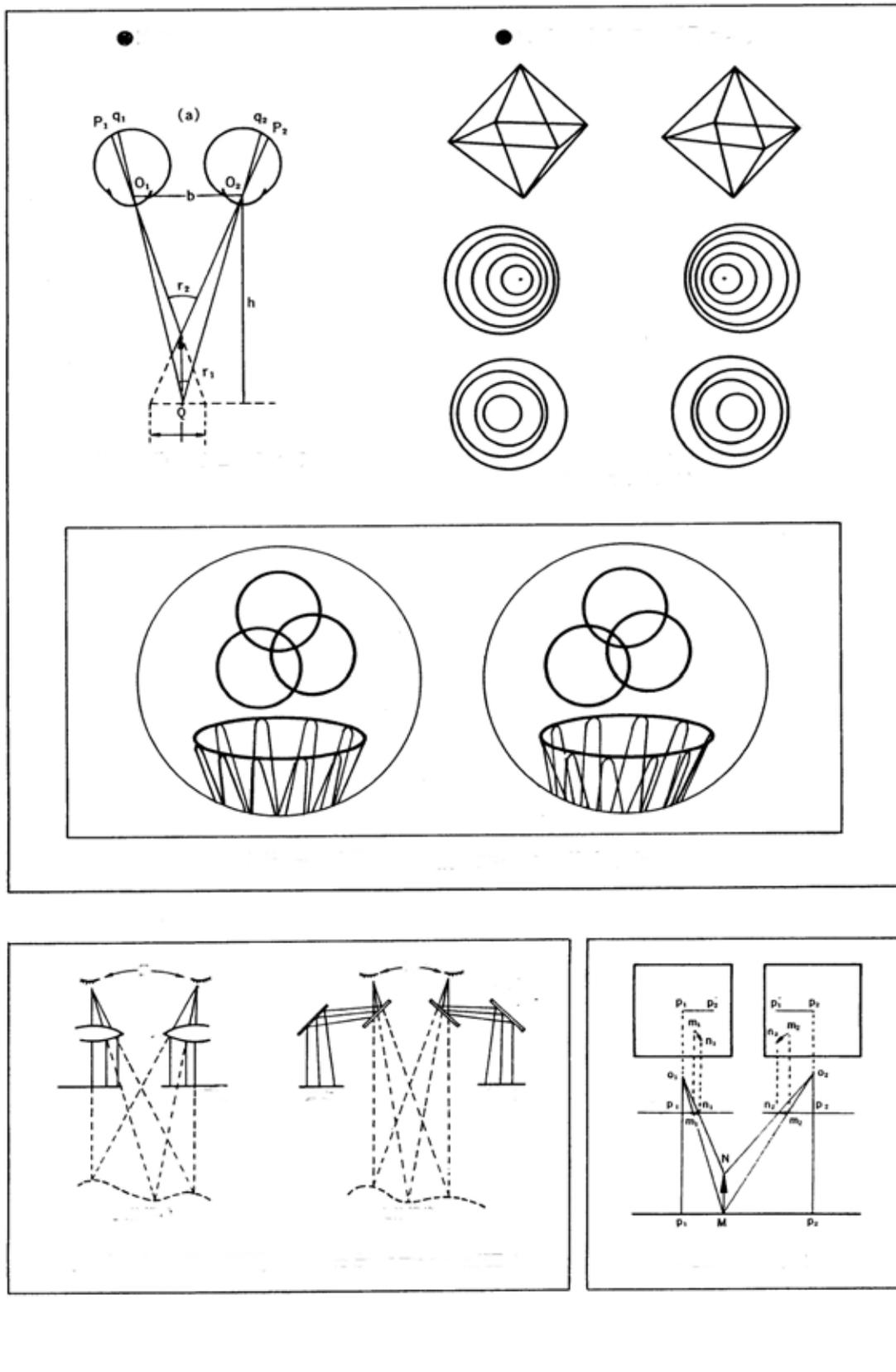
(3)   Preparation of materials

For the interpretation of aerial photographs, the following materials are required.

Fig. 11 Instruments and materials for interpretation of aerial photographs
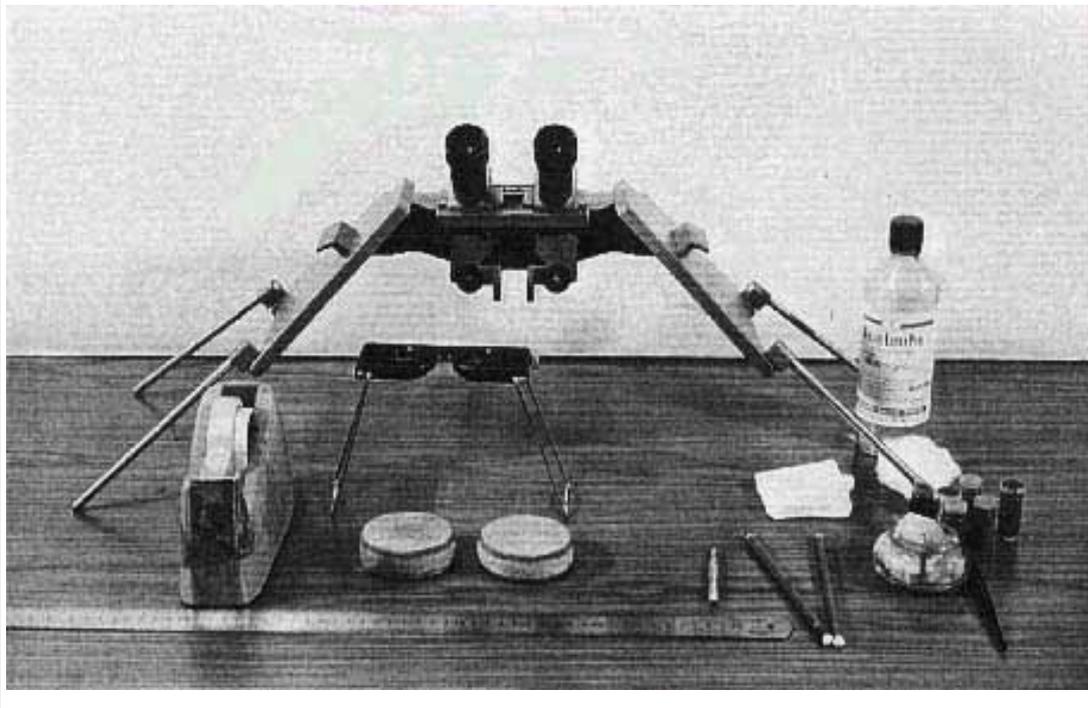
1)   Mirror Stereoscope

The Mirror Stereoscope shown on Fig. 12 uses mirrors and prisms to help analyzers observe aerial photographs easily by looking at left and right photos through the left and right eyes respectively. Without the Mirror stereoscope, it difficult to view and examine aerial photographs that have been enlarged several times.

Fig. 12 Mirror Stereoscope
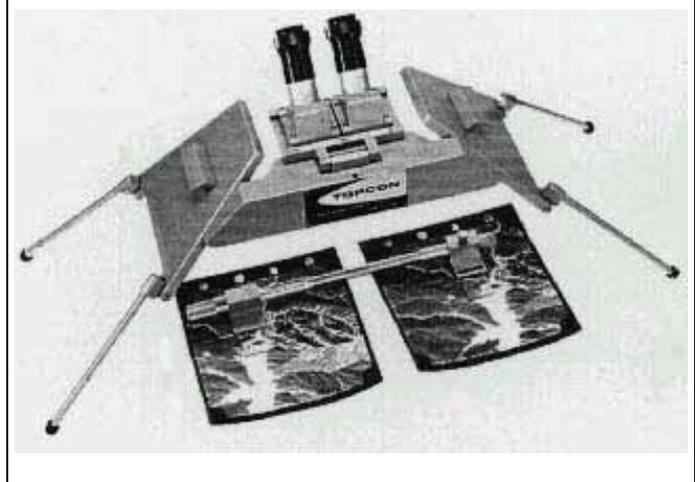
2)   Handy type stereo scope

Fig. 13 shows the handy-type stereo scope for field use. This
piece of equipment consists of two convex lenses with 3-power
magnification capability. The lenses are adjustable to match the
distance between left and right eyes. The handy-type scope
stands eight (8) cm high. It is intended for viewing contact prints
of aerial photographs in the field.

Fig. 13 Pocket stereo scope

ポケット 実体鏡 II 型

3)   Ruler - This piece of equipment is made of celluloid or
steel and is calibrated at one millimeter (1mm) intervals. The ruler is used for locating principal points
and setting the principal lines.

4)   Color pencil (for all types of surfaces)

5)   Gravity or Scotch tape

(4)   Aerial photograph data

In the Study, specifications of the aerial photographs taken are as follows:

    Scale …………………………………. 1:20,000.
    Effective Screen Size……………………. 230mm× 230mm.
    Established flight plan
    Altitude   : 152mm× 20,000   = 3,000m
    Spacing   : 230mm× 20,000× 0.3   = 1,380m (30% sidelap)
    Exposure interval   :230mm× 20,000× 0.6   = 2,760m (60% overlap)

Data recorded on the aerial photographs are shown on Figure -14.

Fig. -14 Sample of data on a aerial photographs

Course Number and Photo Number

Principal point indicator

C-12A 34

Unique counter number on
negative film and focal length
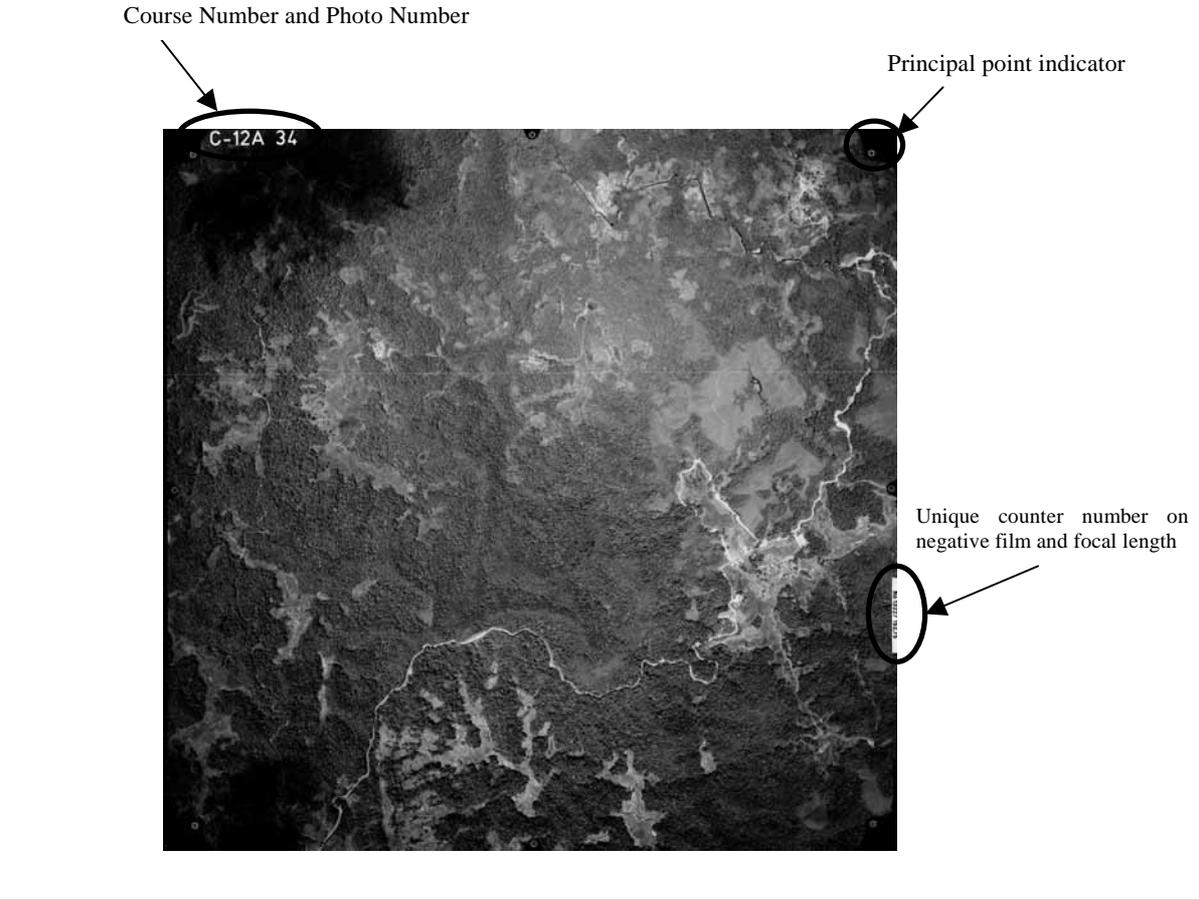
2.　Preparatory steps for pre-interpretation

The following preparatory steps are necessary for pre-interpretation of aerial photographs:

marking principal points (step 1)

adjusting a pair of aerial photographs for the mirror stereoscope (step 2) and

transfer of a principal point to the next photo (step 3).

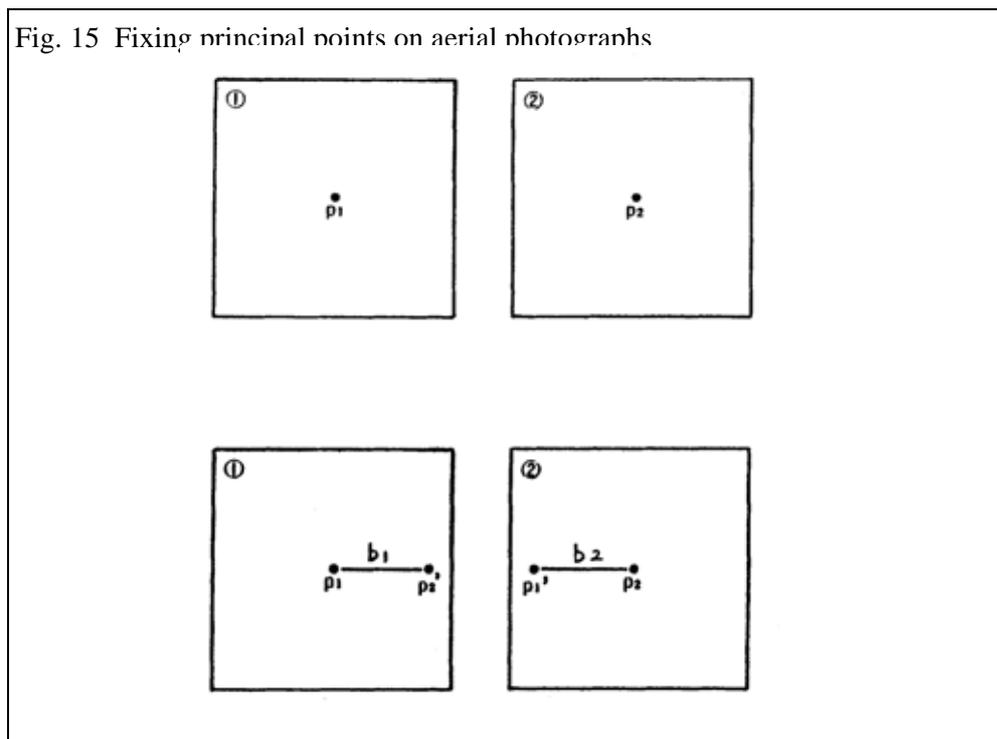The reader may now practice these steps as illustrated in Fig. 15 and discussed below.

Fig. 15　Fixing principal points on aerial photographs

(1)　　Principal Point Marking (step 1)

　1)　Fixing a principal point

　　a.　Set a ruler in a diagonal position on the principal point indicator marks found on the frame portion of the aerial photograph. (Figure 16-a)

　　b.　Draw a line approximately 2 cm long on the center part. (Figure 16-b)

　　c.　Repeat the same process as in "a" above on the other diagonal principal point indicators. (Figure 16-c)

　　d.　Repeat "b" above for the principal point indicators covered in "c" above. In other words, draw another line approximately 2 cm. long. (Figure 16-d)

　　f.　The principal point is defined as the intersection point of the two lines

Fig. -16 How to fix a principal point

a..

b.

c.

d.
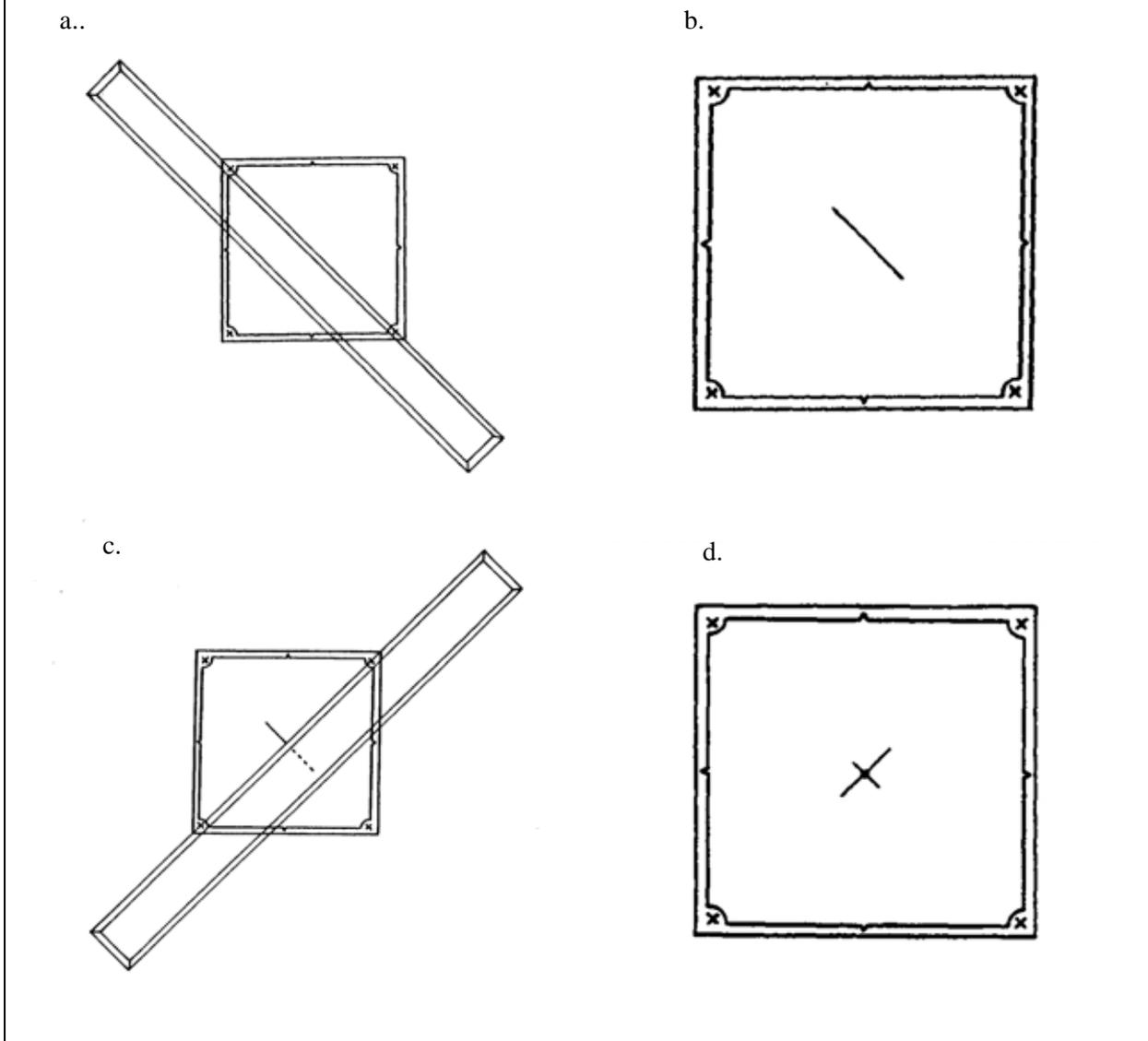
2)   Process

Fixing of principals points is essential in order to obtain a stereo view.

Procedures for fixing principal points and for drawing principal lines on the Paired photos are illustrated on Fig. 15.

a. fix a principal point on picture 1 (p1)

b. fix a principal point on picture 2 (p2)

c.   transfer p1 to picture 2 and transfer p2 to picture 1

d.   connect p1 to transferred p2 as principal line b1 on the first photo.

e.   connect transferred p1 to p2 as principal line b1 on the second photo.

(2)   Adjusting a pair of aerial photographs for viewing in the mirror stereoscope (step 2)

Set a pair of aerial photographs under the mirror stereoscope as shown on Figures 17 and 18.

Fig. 17 Stereo Viewing of an image using the Mirror Stereoscope

Theory of the stereo viewer by lenze

Theory of refrectional mirror stereo viewer

Photo image on right and left photos
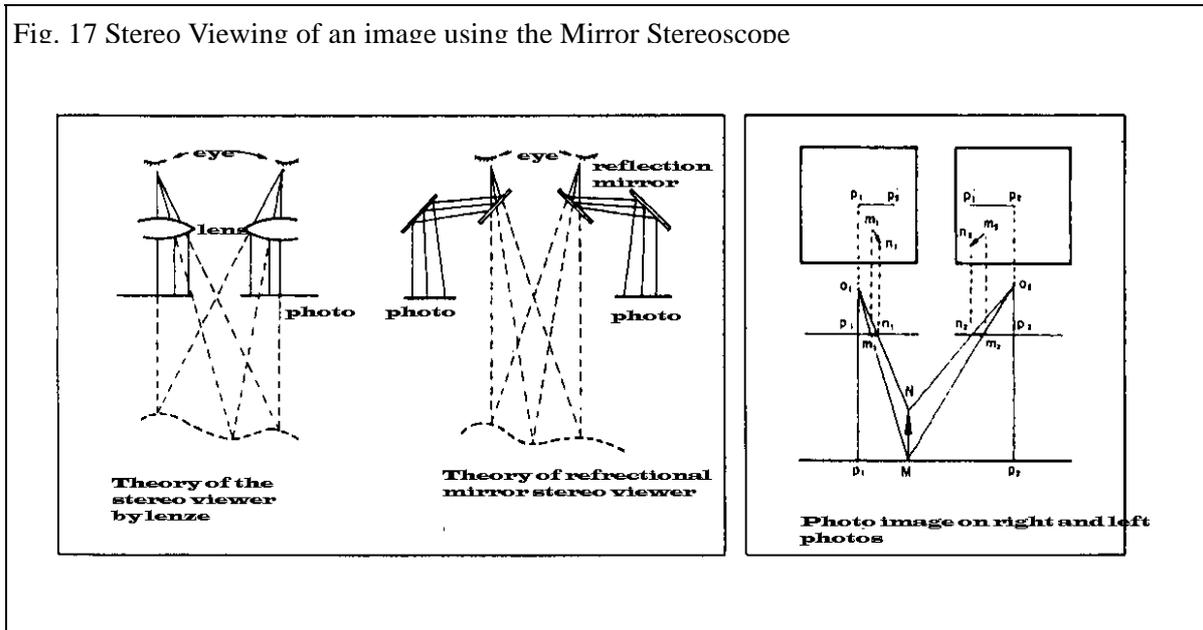
Fig. 18 How to set Mirror Stereoscope and aerial photographs

Contact print case

Center point P₁

Center point P₁ transplanted

1 ··· eye pece lens
2 ··· prism
3 ··· refrection mirror
4 ···Centerpoints
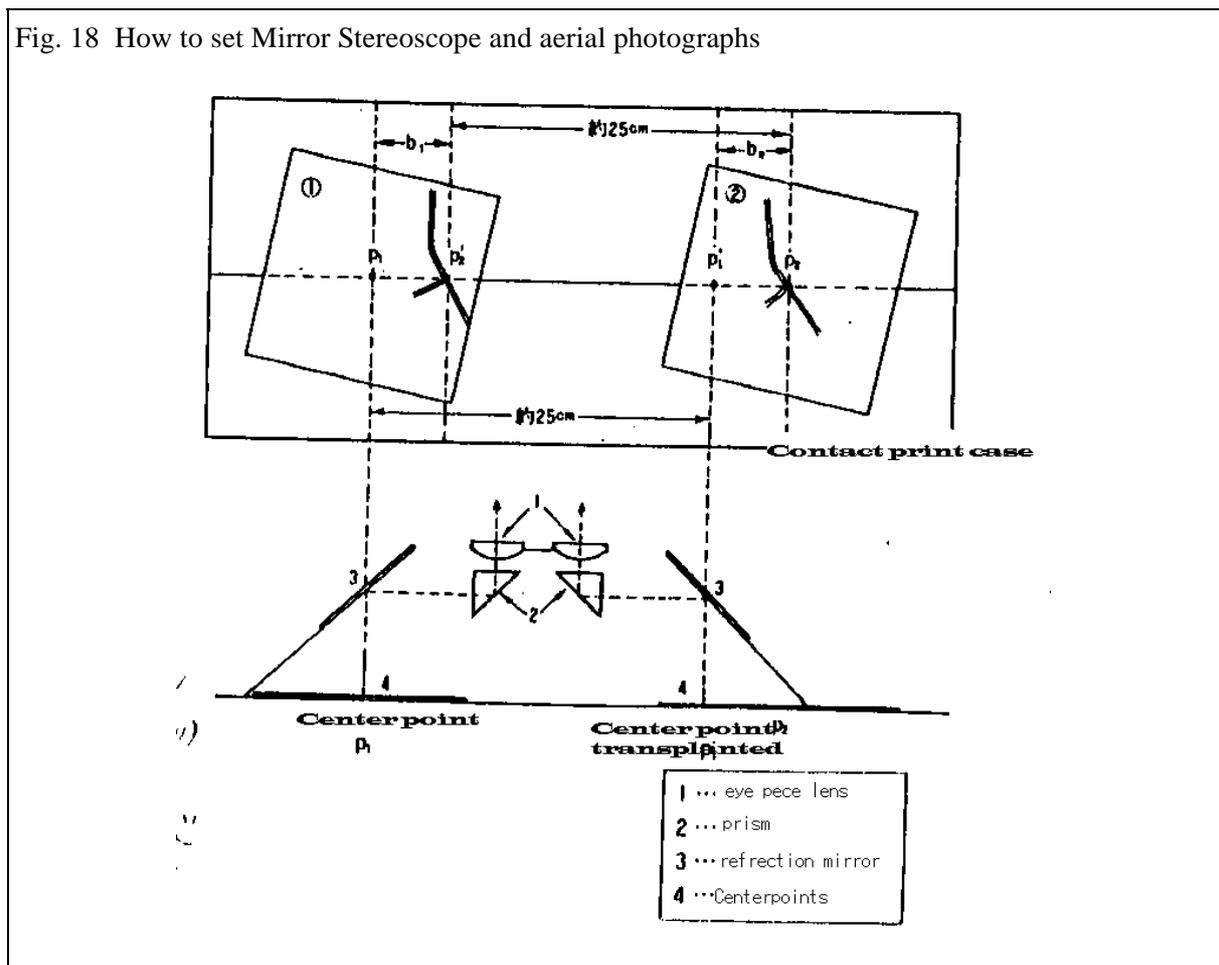
a.   Set the pair of aerial photographs proper distance between the principal point and its

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conjugate principal point on the next photograph.

b. Put these together at the center of each eyes view.

c. Adjust the two pictures to focus the stereo view. In this process, placing fingers on both of the principal points will help facilitate the adjustment needed to obtain the stereo view.

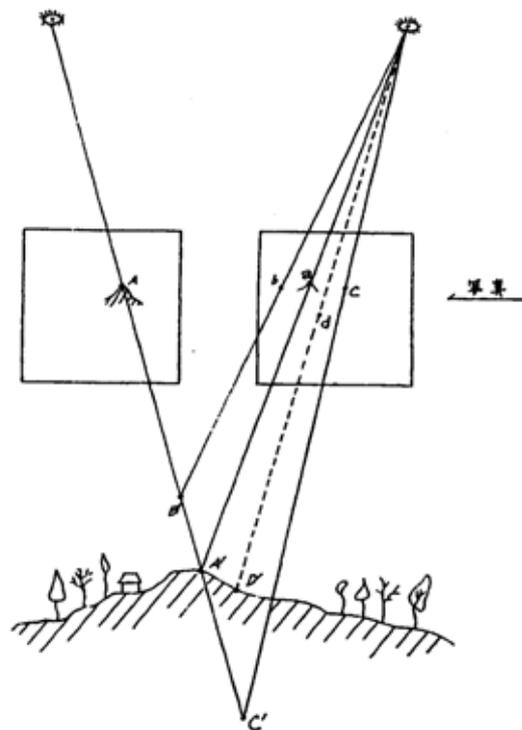(3) Transfer a principal point to the next photo (step 3)

Procedures for transferring a principal point to the other photograph are as follows: (See Fig. 19)

a. Fix a principal point on the left side picture following the processes described above.

b. Arrange a pair of aerial photographs under the mirror scope.

c. Looking at the image in stereo view, mark the principal point on the right side aerial photograph using the color pen.

d. Check the principal point view just on the ground level.

When marking the principal point on the right side of an aerial photograph, the following matters should be taken into account:

Fig -19 How to adjust the principal point to another aerial photograph

a. Transfer the principal point to the position which shows objects as they actually appear on the ground. For example, trees at the principal point will appear in a vertical or standing position.

b. If the transferred point is too far towards the inner side, the point will appear to be floating above the ground level. To correct this problem, adjust the point a little more towards the right side.

c. If the transferred point is too far towards the outer side, the point will appear to be buried below the ground level. To correct this problem, adjust the point a little more towards the left side.

d. If the transferred point appears at the upper or lower side, this means the points have not converged (two points are observed). Re-adjustment is necessary.

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3. Pre-interpretation

3.1 Basic knowledge on Interpretation

The process of interpreting aerial photographs consists of a series of activities implemented to classify the areas covered by the photographs. Classification is based on the conditions prevailing in different areas as derived from observation of the information recorded on the aerial photographs. The process of the interpretation is divided into three steps (See Figure 20). The first step is observation. By conducting thorough and careful observation using the Mirror Stereoscope, the analyser will be able to find typical patterns and/or groups of similar patterns. The second step is to analyse typical aerial photograph images, paying close attention to shape, the mix of colors and other factors, and then to determine the meaning of each of these various groups. The third step is to judge the groups.

Accurate judgement is largely a function of the analyser's experience and knowledge. If the analyser has experience regarding the patterns appearing on aerial photographs that

Fig. 20 Aerial Photograph Interpretation Process

indicate paddy fields, man-made forest, dry Dipterocarpus forest, fallow and so on, he can easily classify these areas without field verification. However, a beginner should verify the aerial photograph pattern and the above groups in the field to be sure that the conclusion he draws from the photographs is correct. After repeating observation and field verification many times, the beginner will eventually become an expert.
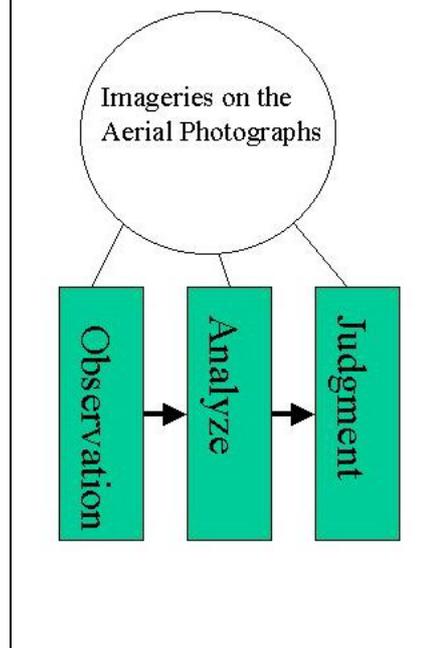
(1) Basic conditions for aerial photograph interpretation

Before starting the work, the analyser should attend to the following matters:

a. Be sure about the date and time that the aerial photographs were taken.
Date and time of the aerial photographs may also affect conditions that need to be considered such as shadows, and the seasonal differences in the color of deciduous forests. Similarly, the analyser should try to determine the number of years that have passed between the occurrence of forest harvesting, burning, fallow or other events and the time that the aerial photographs were taken. The analyser should collect all available relevant information in addition to the data that can be derived from interpretation of the aerial photographs.

b. Scale of the aerial photographs

Aerial photograph imageries are presented in different colors, textures, shapes and scales. It is very important to know the scale of the photos being interpreted.

c. Observe the three-dimensional view

To classify aerial photograph imagery patterns, the observer should use mirror stereoscope. Information derived from the image of a single picture is significantly different from the information derived through stereo viewing.

d. Gathering technical data and other relevant information

For example, if the observer/analyst intends to classify a natural forest area, he should first collect basic information about natural forests, such as location of natural forests in the area, distribution of each kind of natural forest classified such as ever-green forest, semi-deciduous forest, dry Dipterocarpus forest, and general species composition of natural forests in the area and so on. These data/information will help the observer/analyst make accurate decisions on categorization and classification of the area into meaningful groups.

e. General field observation

General field observation should be carried out keeping technical data and other relevant information mentioned above in mind and brain. The observation should ideally cover all area of the aerial photographs to be interpreted. However, the observation should be actually done in the area where accessibility is easy.

(2) Basic Factors for interpretation

Interpretation of aerial photographs involves the identification of significant differences appearing on the photos, and then determining what these differences mean or tell us about the status or condition of the area being studied. The following factors are important to consider when examining the photos:

a. Shape and size

Shape is usually the most easily-recognized factor that can be used to identify objects. For example, roads usually appear as straight lines, houses may have square shapes, and ponds are usually rectangular or sometimes circular. Many trees also have identifiable shapes. Depending on the crown characteristics of different species, these shapes may be in the form of a circular cone, a temple bell, an umbrella or spherical. Through careful examination of the photos, preceded by field observation of crown characteristics, the analyst can often identify unique features appearing on the photo images. This information is valuable in identification and classification of natural forests. For obvious reasons, size is also another important factor.

b. Color tone

On a monochrome photo, different objects usually have different colors ranging from white to black. An object that reflects sun light efficiently will appear white on an aerial photograph. By contrast, forests absorb sunlight and therefore have a rather dark appearance. Each object has it's own refraction ratio. This ratio affects the color of the object on the photo. Additionally, color is also affected by conditions prevailing at the time the photograph was taken. Color tones are used to make comparisons between objects on an aerial photograph.

c. Shadow

Depending on the time of day and/or the terrain, shadows produce copies of the shape of objects on the ground. These shadows reflect the length of the objects. The relative length of objects may be compared by examining the relative lengths of the shadows they produce.

d. Pattern

The patterns of objects being observed is another factor that can assist in identification of groups. Patterns may appear in the form of lines. They may also be recognized by their density, length, height, etc. For example, the crowns of man-made forests usually appear in straight lines.

e. Texture

By carefully examining the surface of the photos, the analyst may acquire certain perceptions such as hard, soft, rough, tender, warm, cold.

Aerial photographs show all of the five (5) factors just discussed: (i) shape and size (ii) color tone, (iii) shadow, (iv) pattern, and (v) texture. The interpretation process consists of assessing and evaluating the combination of these factors and the refraction of distinct and separate objects. The interpreter has the responsibility to judge field conditions based on observation of these factors on aerial photographs and observations conducted in the field. This knowledge and skill can be acquired through careful observation and field verification, combined with diligence in the study of relevant information regarding forest types, characteristics and other data pertinent to the area being studied.

3.2 Pre-interpretation

As mentioned earlier, the task of the analyst begins with accumulation of general knowledge and specific data. In this study, general knowledge tree species and forests was acquired from the results of previous research and studies. These results provide information on many relevant topics such as the ecological or vegetative features of forests in Viet Nam.

Pre-interpretation is carried out through following four steps:

Step 1   Identification of each land use category

Step 2   Delineation of block and compartment boundary lines and tentative lines of the land use categories on the aerial photographs

Step 3   Examining for classification of forest vegetation and cover types

Step 4   Marking of places which are unclear and questionable to be checked at the time of field verification.

(1)   Identification of land use categories (Step 1)

The objective of this first step is to arrive at a preliminary (tentative) delineation of land use categories by separating forest areas from other types of land use such as agriculture lands and grasslands. The degree of accuracy required in sub-classification or categorization of areas other than forests will depend on study objectives.

It is important to point out that in pre-interpretation work, categorization should be based on well-known and generally-accepted criteria. A good rule-of-thumb is to conform with the standard categories used in other land use studies. Designation of new categories should be avoided, as this may lead to confusion. Remember that the objective of pre-interpretation is not to establish final dividing lines, but rather to understand overall conditions in the study areas.

(2)   Delineation of block and compartment boundary and tentative lines of the land use categories on the aerial photographs (Step 2)

Forests in Kon Plong District have divided several units for management conveniences. These management units are usually called compartment system. In a direction for setting such groups of stands in Vietnam, units should be called Block and compartment according to size. The area of a Block is approximately 1000 ha. The Block is usually divided into approximately 100 ha of units called compartment, basically followed topographic feature (stream line or summit line). In the Study the team followed existed compartment system for the convenience to follow the relation for past forest operations and new proposed operations.

Therefore, delineation of block and compartment boundary should be made on the aerial photographs based on the existing block and compartment system maps as much as possible. However, when the delineation will be made based on the aerial photographs newly taken, boundary lines of the block and compartment should be adjusted to topographic feature such as ridgeline and streamline and constructed feature such as road.

Regarding tentative lines of the land use categories, the objective of this step is to make tentative lines dividing forest and the non-forest areas. Using the mirror stereoscope, the analyst/interpreter should implement the following:

- Locate the boundary line between forest areas and other land use areas on the aerial photographs.
- Check aerial photographs imagery of agriculture land such as paddy fields, grasslands, bush land, water body and residential area other than forest area.

Please see Fig. 21 for delineation of block and compartment boundary (red lines) and tentative lines between forest areas and other land use areas (green lines) on the aerial photographs.

Fig. 21 Delineation of block and compartment boundary and tentative lines between forest areas and other land use areas
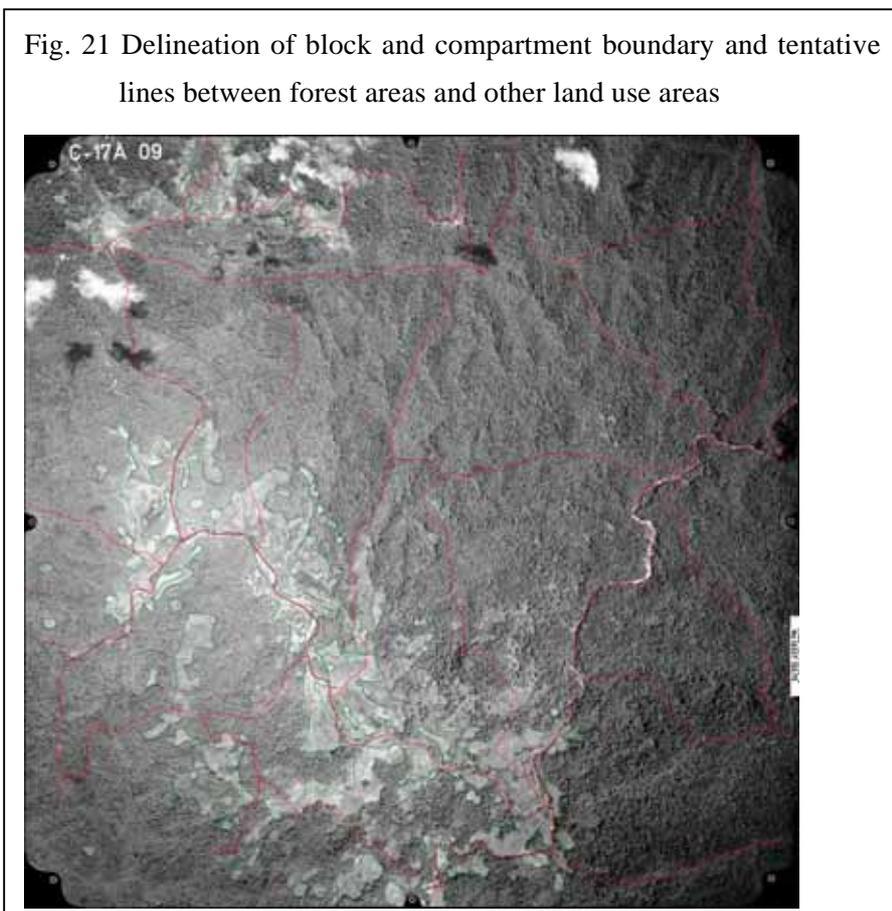
(3) Examining for classification of forest vegetation and cover types (Step 3)

The basic factors of photo imagery such as shape and size, color tone and shadow (see the Section 3.1 (2)) should be identified considering the classification of forest vegetation and cover types. Then, it should be examined how forest vegetation and cover types can be classified based on the difference of photo imagery by each basic factor which analysts/interpreters can distinguish, the technical data and other relevant information gathered in advance (see the Section 3.1 (1) d), and results of general field

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observation (see the Section 3.1 (1) e)

Typical aerial photograph images reflecting some vegetation and cover types should be marked on the aerial photographs.

For the natural forest vegetation types in the Study area, classification of the types such as ever-green forest (mixing of broad-leaved forest and coniferous forest and/or un-mixing of them), semi-deciduous forest, dry Dipterocarpus forest and man-made forest can be considered. For the forest cover types, classification of the types by crown density and crown size can be considered.

(4) Marking of places which are unclear and questionable to be checked at the time of field verification (Step 4)

Places which are unclear and questionable photo imagery should be marked on the aerial photographs while analysts/interpreters examine the classification of forest vegetation and cover types. These places should be checked at the time of field verification.

4 Field Verification

Pre-interpretation of photos is done in an office using a stereo mirror. Since analysts may not always be familiar with conditions in the field, they may not be sure about their conclusions regarding the status of some portions of the areas. While the intention is to divide into categories, it is sometimes necessary to merge categories. Decisions on whether to divide or merge depend on the size (no. of ha.) being covered and the final objectives of the study.

Through the careful examination of the photos in the pre-interpretation stage, the analyst/interpreter should use a color pencil to mark those parts where is not sure of the category as mentioned above. Then, field verification should be done to determine the categories of these parts. Field verification activities are very important not only to ensure accurate categorization, but also to obtain information about the entire area and to broaden general knowledge. This experience is essential in developing the skills required to become a qualified interpreter.

The field verification process includes careful checking of the unsure parts marked on the photos in the office, and appropriate adjustment to conform to actual field conditions. In this process, the analyst/interpreter must concurrently pay attention to the factors cited earlier (i.e. shape, size, color tone, etc.) as these will be the basis for final interpretation. Field verification procedures are as follows:

a. Keep in mind the scale of the aerial photographs

Surveying skills are need to accurately locate on the ground those unsure parts marked on the photos. Thus it is imperative to know the scale of the photos. Without this knowledge, survey work to locate the unsure parts will be difficult or impossible.

b. Trace the way, and put marks on the aerial photographs.

Start from a good reference point. From this point, proceed to the exact place where the unsure part (object) is located. Check the route followed in comparison with the photo using reference points which can be easily-distinguished on the aerial photographs such as a structure or a large tree. Mark the photo to show the route (bearing and distance). If it becomes unknown on which part of the photograph the surveyor is standing, return to a place where the surveyor identifies the position and repeat the foregoing process.

c. Verify the objects

Upon arrival at the target location (i.e. the unsure part/object), check back again to confirm that you are in the right place. Then examine the object/part to verify its status/identity and also the surrounding/adjacent areas. While implementing field verification, the analyst/interpreter should examine the stereo photo using the handy stereo viewer or the naked eye. Careful examination and observation are necessary to adjust categories on the aerial photographs with the real conditions in the field.

In case that the analyst/interpreter have to grasp stand volume through the interpretation of aerial photographs, the analyst/interpreter should implement the sample plot survey in the field at the stage of the field verification. Regarding methods of the sample plot survey, please refer to "Technical Manual on Estimation Methods for Yield Prediction and Increment in Natural Forest and Man-made Forest" within the technical manual series on the Study.

5 Standardization for Interpretation

After field verification, standard for interpretation of aerial photographs including land use categories and classification of forest vegetation and cover types should be decided, and prepare aerial photo interpretation cards.

5.1 Determining Standard for the Interpretation

The standards for the land use categories and classification of forest vegetation and cover types should be determined. The procedures for standardization for the interpretation of aerial photographs are as follows:

a. Results from pre-interpretation of aerial photographs must be re-examined and amended based on results and information obtained from field verification including sample plot surveys.

b. Using the mirror stereoscope, compare the aerial photograph imagery with the detailed data obtained from field surveys. After making these comparisons, determine the factors such as shape, size and color tone needed for preparing the standards. For the determination, It is important to select the factors which interpreter can distinguish.

c. The standards should be determined based on the entire information collected through the process of the aerial photograph interpretation just before the standardization such as pre-interpretation and field verification.

In the preparing the forest management plan in model area in the Study, the land use categories other than forests were divided into six (6) categories as follows:

- Rice paddy fields
- Upland farms
- Bush lands
- Grassland
- Water body
- Residential areas.

In the preparing the forest management plan in model area in the Study, the forest cover types were categorised by forest crown density and forest crown size as indicated below.

Crown size	Crown density			
	scarce	low	medium	dense
	0-10%	10-40%	40-70%	70-100%
Small	E	E	D1	C1
Medium	E	D2	C2	B1
Large	D3	C3	B2	A

Note : The 'Forest type A' belongs to the single category and 'Forest type E' has no sub-classification.

Since only ever-green forests and man-made forests were observed in the model area, special classification for forest vegetation types was not made except for these two forests categorised. However, ever-green forest is supplementary and further categorized with a factor of degree of combination with coniferous tree species particularly Podocarpus species. Therefore, some forests

would be indicated with the below coniferous species density as well as the above general forest cover type.

	Coniferous species density
P1	70 - 100%
P2	30 - 70%

The descriptions of each forest type are as follows:

1) Forest type A

This category is extremely closed to primary forest with dense crown density and large crown size. Accordingly, the forest is classified as the richest forest with high bio-diversity. As the stoking volume is quite high, this forest type in the production forests would be included in the harvest plan.

2) Forest type B1

This forest is also closed to primary conditions with dense crown density but medium crown size. The forests generally exist combining with the forest type A. The stoking volume is high enough and the forest in the production forest would also be included in the harvest plan.

3) Forest type B2

This category is also closed to primary forest with medium crown density and large crown size. The forests generally exist combining with the forest type A mainly in slope areas of the mountain ridges. The forest in the production forest would also be included in the harvest plan.

4) Forest type C1

This forest is also closed to primary conditions with dense crown density but small crown diameter. The forests almost distribute in the whole area particularly on the ridges and around mountain summits. The forests are equivalent to 'Young Forest' which is a category applied in Vietnam and there seems to be a few trees for harvest. Coniferous (Podocarpus species) forests on the ridge are classified into this category.

5) Forest type C2

This forest is categorized into primary forest and secondary forest after harvesting and slash-and-burn cultivation. The Forest's crown density is medium and crown diameter is medium as well. The forests exist around villages and/or agricultural lands and are generally used by local people. The forests are remained for the future harvest plan but not earlier rotation. Majority of the forest stands is under regulated size because of poor soil condition and long-time use by villagers.

6) Forest type C3

This forest is classified into secondary forest after harvesting and slash-and-burn cultivation and is still used by local people. The medium-large size trees are already logged and the crown density is scarce. This classified forest is not included in the harvest plan because it seems natural generation takes a long time.

7) Forest type D1

This type of forests covers rather poor vegetation with small-sized trees, presumably recovered from logging and slash-and-burn cultivation. The forest also includes patches of stands that are remained from agricultural use along valleys and steep ridges. As the forests are severely degraded, the natural regeneration, therefore, will take a long time until harvest can be applied.

8) Forest type D2

The forest is the one that some medium-sized trees are still remained in abandoned agricultural lands because of unsuitable geographical land and is being used by local people. The forest also mainly distributes around villages and cultivation. Natural regeneration in the forests seems to take a long time until forest cover will be enough for the harvest.

9) Forest type D3

The forests are scattered around villages and agricultural lands and categorized into areas that are being over-used by local people as the same Forest Type D2 and/or agricultural fallow. Accordingly, this category of forests is considered to be difficult for natural regeneration.

10) Forest type E

The forests are closed to bush with small-sized trees and had been utilized as cultivation until recently by local farmers. As the soil condition is also poor, natural regeneration will be very hard and take a very long time.

11) Forest type P1

This type of forests typically distributes along ridges and around the top of mountains consisting of high ratio of coniferous trees (70% or more with Podocarpus species). The forests would be considered as the target area of the harvest plan.

12) Forest type P2

This forest presents mixed forests with coniferous and broad-leaved species (30-70% of Podocarpus species) and exists around the Forest Type P1 in mid-slope area. This forest is included in the harvest plan.

The following aerial photograph imageries provide several samples of typical land use categories and forest types that were used for interpretation in the Study.
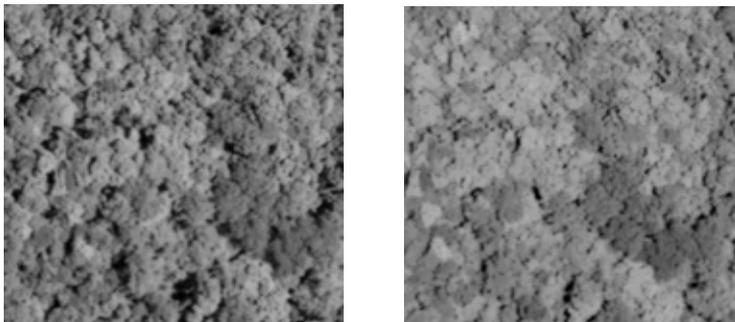
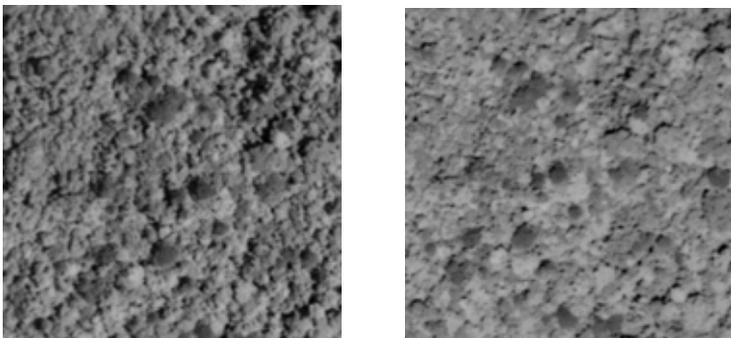Fig. 21 (a) Forest Type A
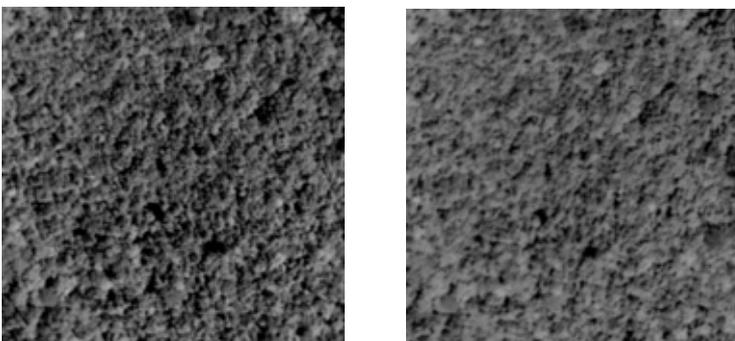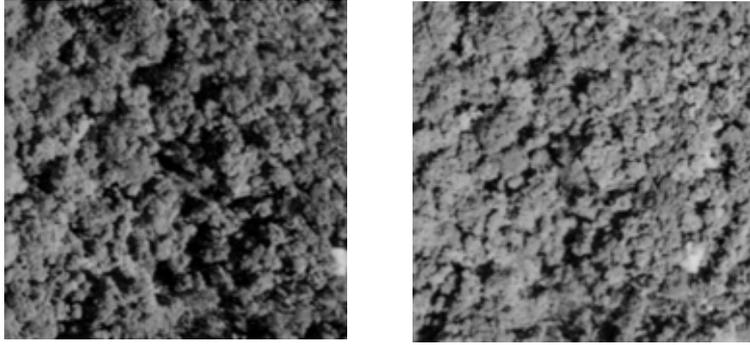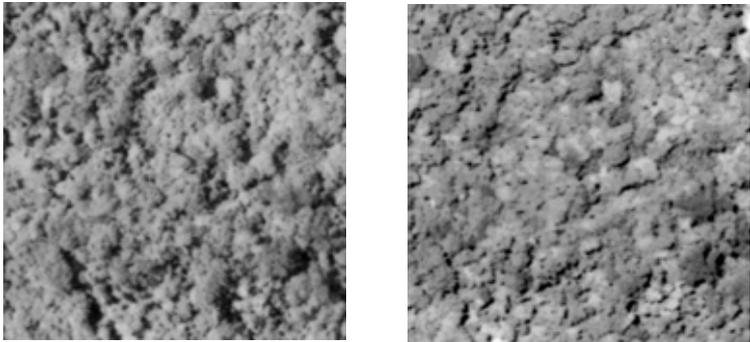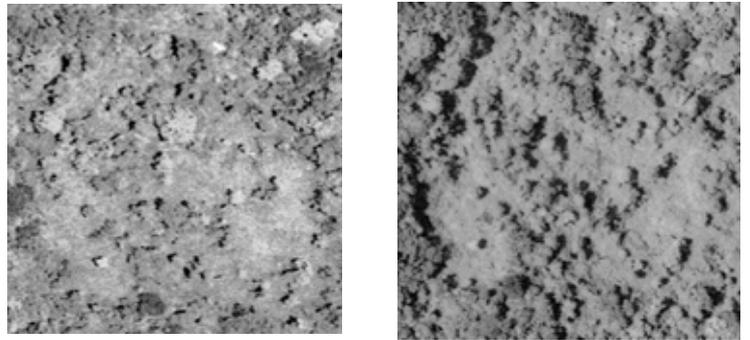

Fig. 21 (b) Forest Type B1

Fig. 21 (c) Forest Type C1

Fig. 21 (d) Forest Type C2

Fig. 21 (e) Forest Type D1

Fig. 21 (f) Forest Type E
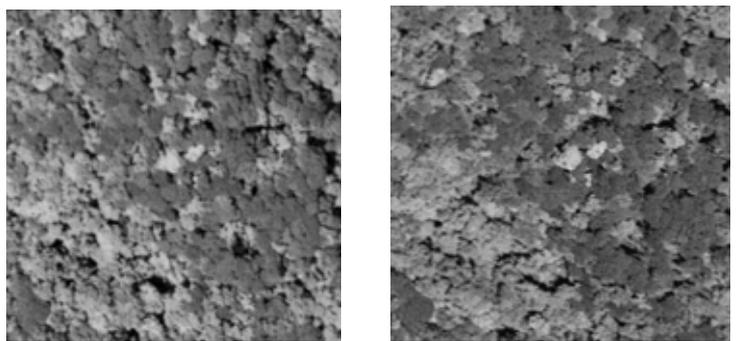

Fig. 21 (g) Podocarpus spp.
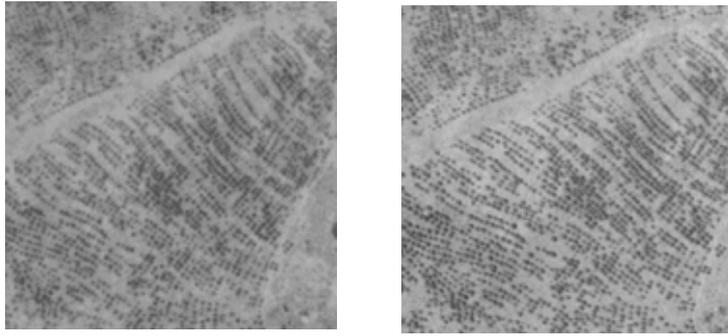
Fig. 21 (h) Man-made forest
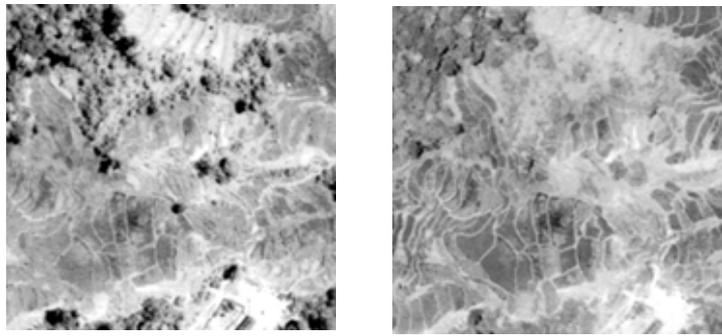

Fig. 21 (i) Agricultural Land/Paddy Field
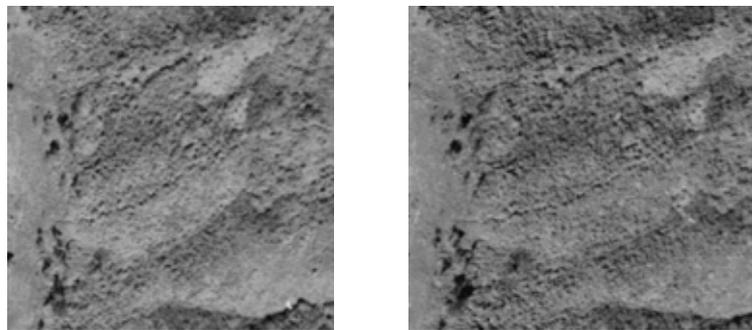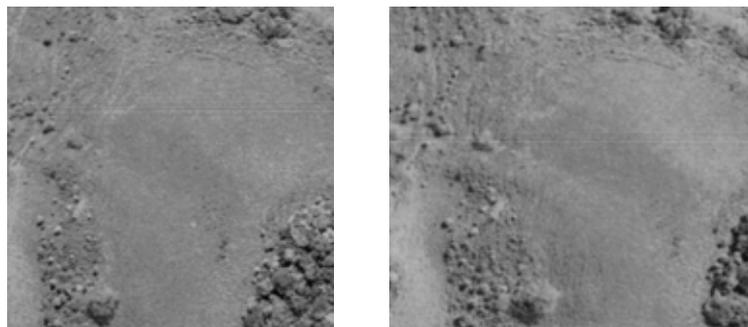

Fig. 21 (j) Bush Land

Fig. 21 (k) Grass Land

5.2 Preparing Interpretation Cards

Interpretation Cards should be prepared by each forest type and land use category and consists of aerial stereo-photographs, photographs on the ground, location map and forest condition data (tree species structure, upper story tree heights, crown density etc.). The cards maintain a certain level of technique for interpretation by several persons in accordance with the classification standards for interpreting land use and forest type . The procedures for preparing the interpretation cards were as follows:

1) Use aerial photographs newly taken.
2) Select randomly the sample survey points for the plot survey or stands representing study area.
3) Draw transect lines (2 x 2 cm) with a dermatograph on aerial photos (scale: 1 to 20,000) in order for the stereovision of sample stands.
4) Enlarge photos of sample stands two to four times (scale: 1 to 10,000 - 1 to 5,000).
5) Mount two to four times enlarged photos on cardboards in order for their stereo vision, photographs on the ground and location map, and indicate necessary items of forest condition data.

6.   Main interpretation

After standardization for the interpretation of aerial photographs, the main interpretation for categorization of land use and forest vegetation and cover types should be implemented, based on the standards of the classification prepared.

Regarding land use categories, since delineation of tentative lines of the land use categories on the aerial photographs is carried out at the stage of the pre-interpretation, the tentative lines should become definite and analysts/interpreters should decide to which land use category each surrounded area other than forest comfort.

Regarding classification of forest types, analysts/interpreters should draw lines on the aerial photographs dividing the forest area into forest types categorized.

When analysts/interpreters carry out the work, the following should be taken into account:

a   The size of each forest area to be surrounded by the delineation is different, depending on the extent and distribution of the categories according to the standard of land use and forest vegetation and cover types decided. However, smallest unit should be approx. 1 X 1 cm on a

scale of 1:10,000 because we cannot verify surrounded area with smaller size than area of 1 x 1 cm on the aerial photo and map on the same scale.

b The color tone of aerial photographs can change depending on aerial photography conditions, photograph development processes or other processes applied to the photos. To deal with this problem, analysts/interpreters have to analyse not only the aerial photographs but also related data and information. In this connection, the importance of actual observation in the field, and field verification including surveys cannot be over-emphasized. These measures will make enable the analyst/interpreter to overcome problems arising from color change and other technical imperfections in the aerial photos while also providing the basic knowledge required for efficient interpretation.

Please see Fig. 22 for the example of delineation of block and compartment boundary, land use categories, and classification of forest types.

## 7. Transferring each line on the aerial photographs to the topographic map

Then the interpretation work approaches the final stage. After completing the delineation on the aerial photographs, the all of the lines on the aerial photographs have to be transferred to the topographic map. This map should be on the same scale as the aerial photographs. To make the transfer it will be necessary to prepare an transparency topographic map.

Place the aerial photographs under the topographic map. Trace the lines previously entered on the aerial photographs onto the topographic map. As previously explained, slanting has an effect on the information presented by the aerial photographs. Slanting is minimal at the center of the photograph and increases as one moves to the frame (edge) of the image. Therefore, tracing is confined to the central part of the photograph in order to avoid tracing those portions of the photograph near the frame (edge) that are subject to the slanting effect. Those portions subject to the slanting effect are covered by making use of the overlap features of aerial photographs. When placing the photos under the transparency map, place them in an over-lapped position so that all the portions that are traced correspond with the central parts of the picture not affected by slanting.

The figure 22 shows example of the transfer of the lines, such as block and compartment boundary (red lines) and land use categories and classification of the forest types (green lines), to a topographic map.

The transferred lines on the topographic map should be applied into GIS. For the methods for storing the data in GIS, please refer to the "Operation Manual on GIS Arc View for Forest Management Planning" within the technical manual series on the Study.

Fig. 22　Delineation of classification on the aerial photograph and transfer of the lines to a topographic map
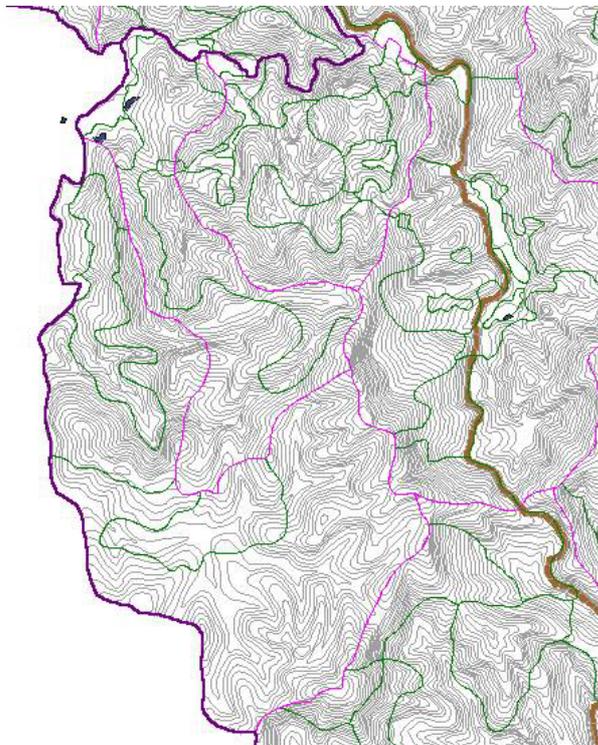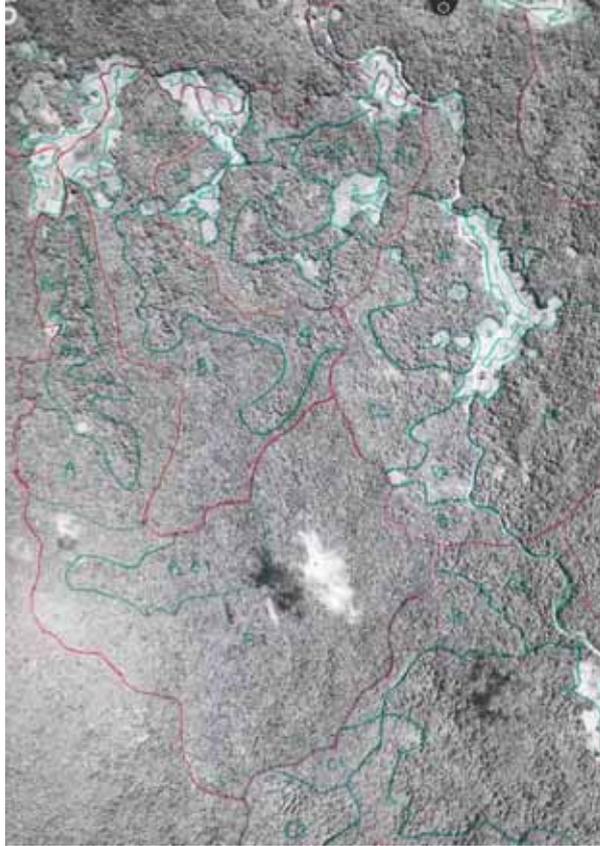
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