Practical Paper

Photo Interpretation of Montane Forests in the Dominican Republic

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ABSTRACT: Photo interpretation procedures were developed for mapping the montane forests of the Dominican Republic. The identification of major forest types on medium-scale black-and-white aerial photographs is illustrated with comparative examples. In addition, a classification procedure was developed for stratifying forest stands by percent crown closure into density classes. The procedures were developed in support of a national forest inventory project. Overall project objectives included (1) the development of an inventory system for the evaluation of montane forests in the Dominican Republic, (2) the provision of training to Dominican Forestry specialists in the inventory process, and (3) the provision of preliminary volume estimates of the pine resources in two inventory units. Photo interpretation and mapping procedures were designed to support a stratified random sampling, field-based forest inventory. Photo interpretation and inventory training were provided to the Dominicans in both classroom settings and in the field during the inventory of the first production unit.

A VARIETY OF tropical forest types occur throughout the Caribbean. Montane conditions occur at elevations above 2,100 m and are thus found only on the mountainous island of Hispaniola, including Haiti and the Dominican Republic. These higher elevation forests are unique to the Caribbean in that they are subjected to below freezing temperatures (Pedersen, 1953).

The montane forests of the Dominican Republic include several subtropical life zones: lower montane moist forests, lower montane wet forest, and montane wet forest (Holdridge, 1967; Tasaico, 1967). The lower montane forests occur at mid-elevations (850 to 2,100 m) of the Cordillera Central, Sierra de Nieba, and Sierra de Baoruco (Hartshorn *et al.*, 1981). True montane forests occur at elevations above 2,100 m and are found in the Cordillera Central and small portions of the Sierra de Baoruco. Vegetation of these mountainous regions consist of a mosaic of broad-leaved and pine forests. Pines occur naturally from about 150 to 3,000 m (Charden, 1941) and may, therefore, be present in broad-leaved forests at lower elevations. At higher elevations (above 800 m) open pine forests are dominant, although broad-leaved forests occur as islands within pine forest (Figure 1).

PHOTO INTERPRETATION PROCEDURES

AERIAL PHOTOGRAPHY

To perform measurements of distance, slope, and area required accurate scale determinations from the aerial photographs. Although photographs were flown at a nominal scale, variations in local elevation resulted in scale variations on any given photo. For example, the scale of the photo at Puerto Escondido (A in Figure 2), at 400 m elevation, was determined from a topographic map to be 1:50,000. Higher elevations (B in Figure 2, at approximately 1,500 m) exhibited a scale of 1:40,000. Without consideration and measurement, these scale differentials would be significant, as a one-cm photo measurement could be off by as much as 100 m on the ground.

Areas with slopes exceeding 60 percent were considered inaccessible and were excluded from the inventory. For example, the canyon at C (Figure 2) was classified as inaccessible because of its steep slope. Distances were determined from the photo or topographic map and slope determined using the formula

$$\text{Slope } \% = \frac{\text{elevational rise}}{\text{horizontal distance}} \times 100$$

The north canyon wall at C has a slope of (240 m/250 m) × 100 = 96%, or 44°.

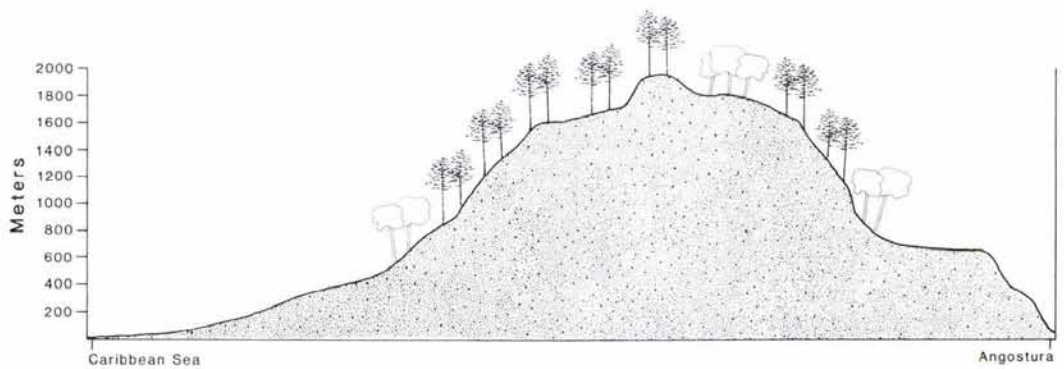

FIG. 1. Vegetation/physiographic profile across the Sierra de Baoruco.

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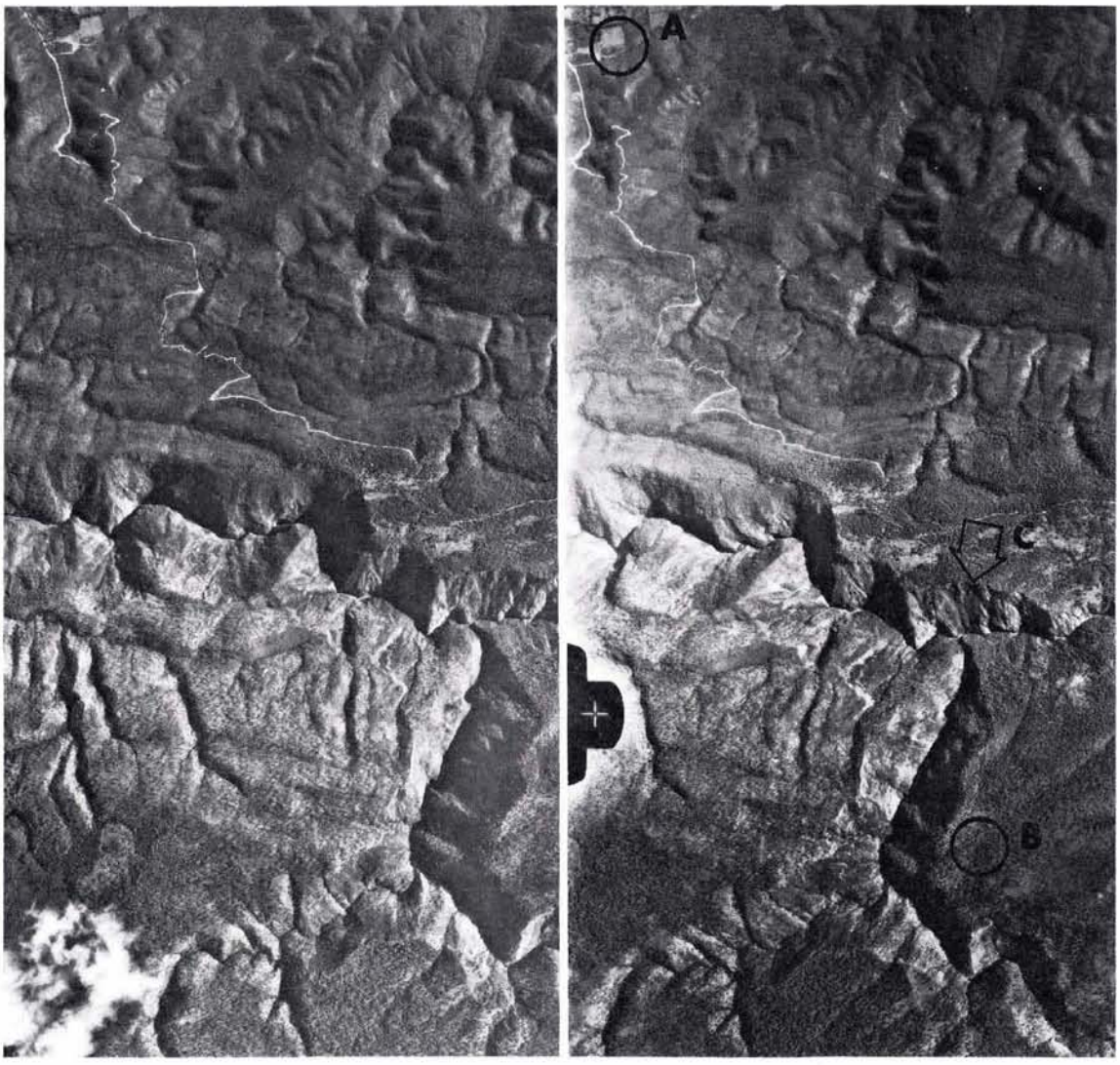

FIG. 2. Stereogram illustrating the change in photo scale due to variations in local elevation.

FIG. 3. West Indian Pines; note the open, narrowly rounded crowns.

FOREST COVER IDENTIFICATION

The pine species of the Dominican Republic, West Indian pine (*Pinus occidentalis* SW.), are medium to large trees with straight, undivided trunks. The photo identification of these pines was aided by their uniquely shaped crowns. Branching is normally confined to the upper portion of the tree and consists of stout, horizontal, and spreading branches (Figure 3). Crowns are narrowly rounded (crown apices are often obtuse to acute), somewhat open, and typically asymmetrical. Occasionally, trees will form flat, spreading crowns composed of a few large, nearly horizontal branches.

Crown diameter to tree height ratios range from 0.25 to 0.50. When viewed from above, the crowns have an irregular shape and frequently appear asymmetrical (Figure 4). Crown margins are often deeply serrate but occasionally appear lobed due to large horizontally protruding branches. Tone, as determined from a calibrated gray scale, is light gray to gray. On any single photograph, however, it is normally one-to two-steps lighter than broad-leaved trees (Figure 5). These features greatly facilitated their identification on aerial photos.

Stand structure is highly variable but typically presents a somewhat open pattern across the landscape. Due to the open

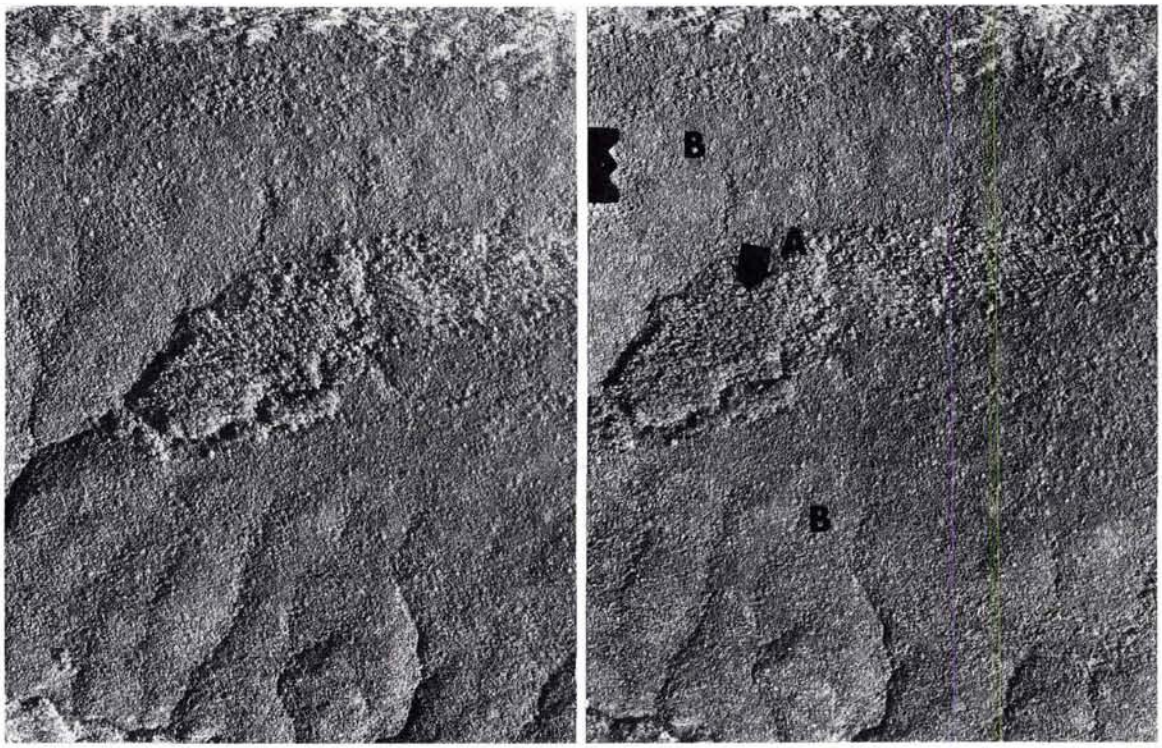

FIG. 4. Stereogram (1:20,000) showing contrast between pine (A) and broad-leaved (B) forest types.

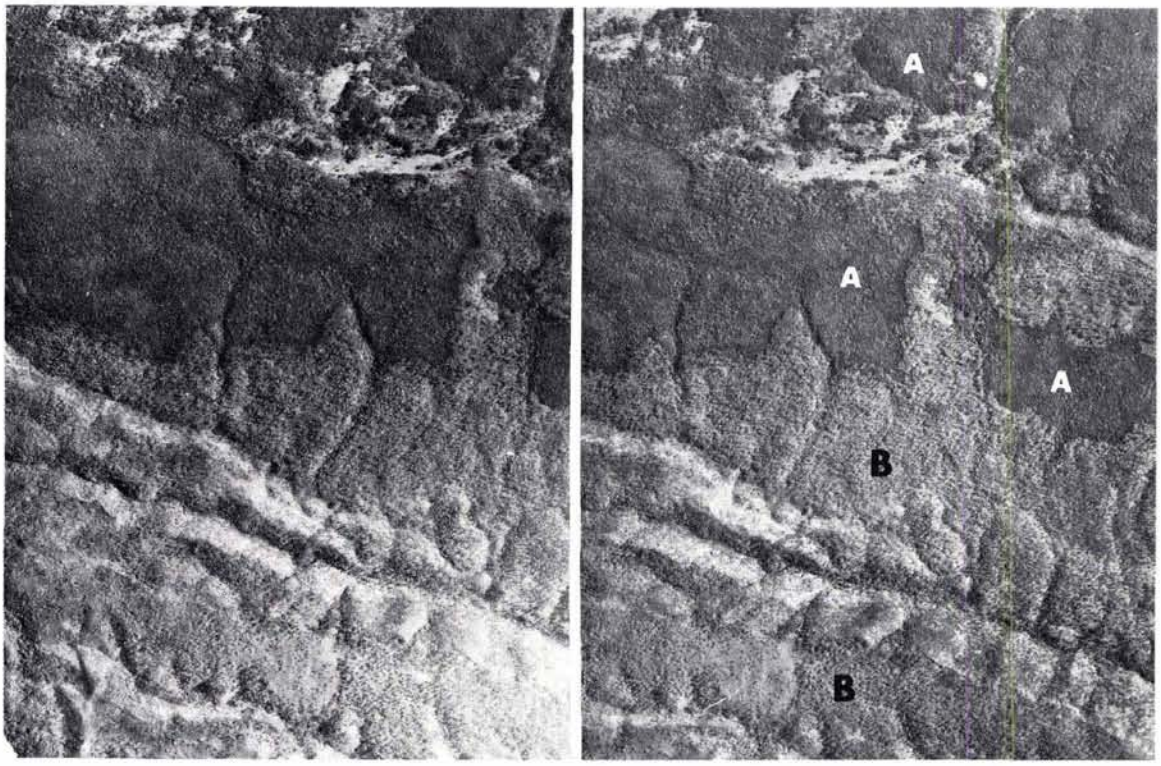

FIG. 5. Stereogram (1:40,000). Note the dark gray tone and smooth structure of broad-leaved stands (A) compared to the light gray tone and rough stand structure of pines (B).

nature of the stands and the irregular outline of pine crowns, the pine type will display a much rougher texture and less uniform pattern than broad-leaved stands (Figure 5). A summary of the distinguishing characteristics of the forest types is presented in Table 1.

Broad-leaved cover types are dominant at low to mid-elevations

TABLE 1. SUMMARY OF DISTINGUISHING AIRPHOTO CHARACTERISTICS FOR INTERPRETATION OF FOREST STANDS IN MONTANE AREAS OF HISPANIOLA

P.I.	Detailed Characteristics	
Feature	Pines	Broad-leaved
Crown shape	narrowly rounded, open, asymmetrical	flat to broadly rounded, solid, may be wide-spreading
Crown margin	deeply serrate, occasionally lobed	smooth to slightly sinnuate
Crown diameter/ tree height ratio	0.25 – 0.50	0.70 – 1.0
Tone	light gray	dark gray
Stand structure	open, uneven	closed, uniform
Texture	rough, broken	smooth (occasionally, a bulbous crown)
Site	800 – 3,000 m	below 1,000 m, above 1,000 m as "islands"

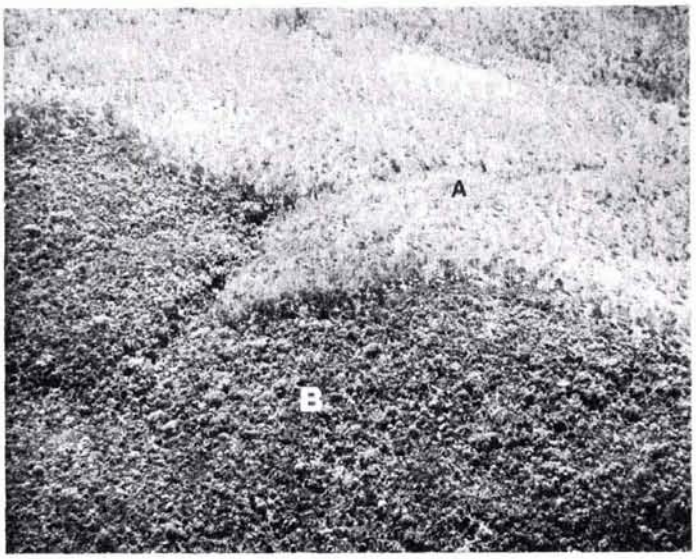

FIG. 7. Oblique view comparing stand structure of pines (A) and broad-leaved forest (B).

FIG. 6. Oblique view of broad-leaved species with large, broadly rounded crowns.

FIG. 8. Oblique view showing mixed forests (A) and pure broad-leaved forest (B).

within the montane forests. A fairly sharp transition occurs at mid-elevation (varying from 800 to 1,100 m) to forests dominated by pine. Braod-leaved forests also occur as "islands" within these higher elevation pine forests.

The broad-leaved species of these montane forests are typically small to medium size trees. Branching is either from a single dominant stem or from multi-stemmed trunks. Crowns are characteristically flat to broadly rounded, solid, and smooth (Figure 6). Crowns were often wide spreading with crown diameter to tree height ratios of 0.70 to greater than 1.00. When viewed from above, the crowns will appear small (compared to the tree's height) and broadly rounded (Figure 4). Crown margins are typically smooth to slightly sinnuate. Tone is dark gray to gray and normally one to two-steps darker than pines (Figure 5).

The stand structure is fairly systematic, consisting of closed stands composed of trees of similar sizes (Figure 7). This results in an even, relatively smooth texture of the stand, broken only by an occasional bulbous tree crown.

Areas of mixed forest may also be encountered, especially near the transition from broad-leaved to pine forests. Mixed forests are recognized by the lighter toned, irregular shape of the emergent pines over the smooth textured darker toned broad-leaved forest (Figure 8 and 9).

PHOTO STRATIFICATION

Sample strata for each inventory unit were defined on the basis of stocking estimates. Stand stocking classifications were

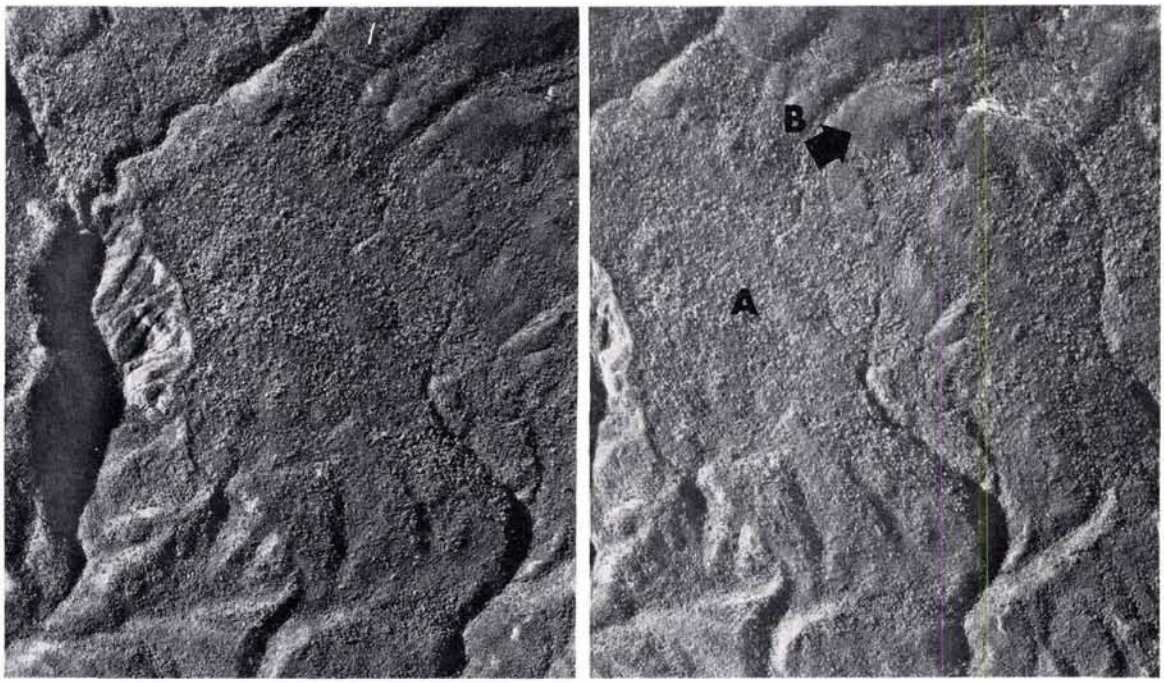

FIG. 9. Stereogram (1:40,000), same area as shown in Figure 8, showing mixed forests (A) and pure broad-leaved forests (B).

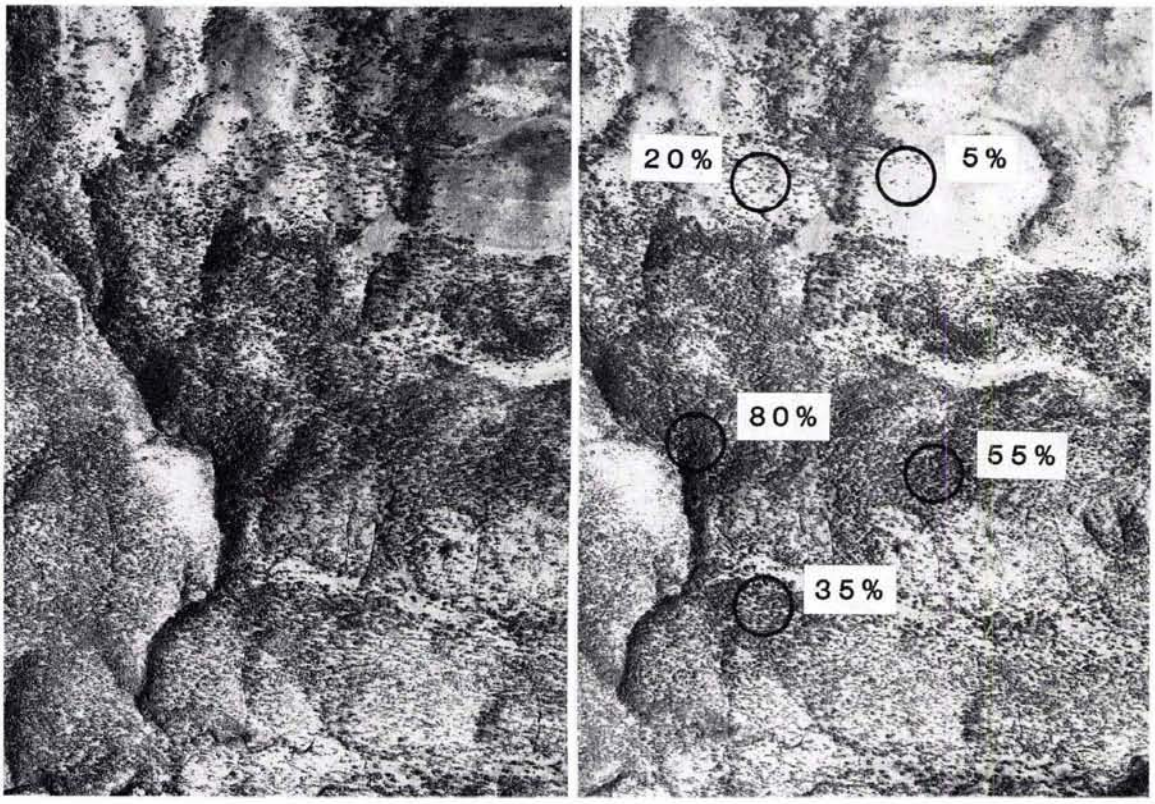

FIG. 10. Stereogram (1:20,000) showing estimates of tree crown closure.

TABLE 2. STAND STOCKING CLASSIFICATION FOR PINE FORESTS

Stocking Class	Percent Crown Closure
Non-stocked	<10
Low	10 – 39
Medium	40 – 69
Hight	70 +

determined from measurements of percent crown coverage. Percent crown closure, or crown density, is the percentage of area under consideration which is covered by tree crowns. Crown closure estimates were subjectively made by comparing the stand on the photo with a printed density scale (Avery, 1978).

Comparisons were made while viewing the photos in stereo. This was accomplished by placing the stand in question between a series of calibrated density squares and moving the scale until the densities appeared to match. The evaluation of crown closure was somewhat subjective; inexperienced interpreters tended to over estimate crown density by including crown shadows or ignoring small openings in the stand.

A stand stocking classification for the pine forest type is presented in Table 2. A stereogram illustrating various stand densities was used for comparative measurements (Figure 10.)

SUMMARY

The procedures presented in this paper should be of use to U.S. and other scientists and resource managers working on Hispaniola and possibly other montane tropical forests. The materials and procedures have been used to conduct several training sessions for technicians in the Dominican Republic and in Haiti. The procedures and this paper may be useful in training people in photo interpretation of forest types in other countries.

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