MOUNTAIN SEARCHES:

Effectiveness of Helicopters

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Illustrations by Laurence G. Cripe

NATIONAL ASSOCIATION FOR SEARCH AND RESCUE ™

This textbook is intended solely as a guide to search procedures that have been applied to stated problems in an experimental setting. It is intended to complement, not replace field training and experience by competent search leaders. It is the duty of every agency and official with search and rescue responsibilities to obtain and apply the knowledge necessary to perform effective, efficient search and rescue operations. The information presented in this publication will serve as one aspect of that body of knowledge. The authors, contributors and the National Association for Search and Rescue assume no responsibility for the use of this book or the information contained therein. Endorsement of specific equipment or manufacturers is neither granted nor implied.

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MOUNTAIN SEARCHES: EFFECTIVENESS OF HELICOPTERS

A variety of resources may be employed in searches for lost persons. These include both fixed wing and rotor wing aircraft, trackers, hasty teams, search dogs, and infrared, heat sensitive detectors. It is the responsibility of the search management team to deploy resources by the most effective means possible. To accomplish effective resource deployment the search manager will delineate areas of highest priority and estimate the cumulative effectiveness (probability of detection) of search resources in finding clues and lost persons.

The United States Coast Guard has conducted research into the effectiveness of resources in searches of the maritime environment (1). Unfortunately, little research exists that has quantitatively measured the effectiveness of search resources in finding lost persons in the inland environment. Prior to this report, two inland studies have been conducted. They are: "An Experimental Analysis of Grid Sweep Searching" (the study of ground personnel grid searching heavily forested terrain of Washington State) (2); and "Desert Searches: The Effectiveness of Helicopters" (the study of helicopter search effectiveness in the Sonoran Desert of Southern Arizona) (3).

The purpose of this research is to measure the effectiveness of United States Air Force Air Rescue crews searching for lost persons in a rugged mountain environment of Southern Arizona.

This task was accomplished by simulating actual air search operations in a mountain environment. A total of 9 separate search scenarios were conducted. The results and conditions of each scenario, as well as crew and victim debriefings are documented in this study.

As anticipated, the mountain environment provided new challenges not encountered in the previous study, "Desert Searches: Effectiveness of Helicopters". "Mountain Searches" found that the position and action of the lost subjects affected their chances of being found. Also, the location and function of crew members on the search aircraft seemed to affect their ability to locate lost subjects.

Many variables affect a helicopter search crew's ability to find lost persons. The victims' ability to signal effectively may be the most important variable. The numerical results of this research may be used as a management aid in actual search operations. These results must be used cautiously and with close attention to the conditions of this study which will be referred to as the "Green Mountain Experiment".

The information obtained in this research will broaden present knowledge of helicopter search effectiveness and it will complement the "Sonoran Desert" helicopter study by providing a means of comparison, wherein helicopter search effectiveness is contrasted in two very different search environments.

THE EXPERIMENT SIMULATED ACTUAL MOUNTAIN AIR SEARCHES

Details of Search Area

The search area is composed of Green Mountain and its eastern drainage basin, Bear Canyon. Located about 11 miles northeast of Tucson, Arizona, in the Santa Catalina Mountains, the search area extends from 6,000 feet elevation at the General Hitchcock camping area, to 7,904 feet elevation at the summit of Green Mountain. This area occupies about two square mile sections of United States Forest Service land.

The Green Mountain - Bear Canyon area is bordered by a two lane, paved roadway (Mount Lemmon Highway) on the west and south, a minor unnamed drainage on the southwest, and the Green Mountain Trail on the north and east. This area was chosen for the experiment because it is relatively safe terrain for mountain helicopter flight. It represents typical mountain terrain in which people frequently become lost; and finally, it is not time consuming for capable hikers to reach their assigned position and act as lost persons. This rugged terrain is characterized by the mound-shaped Green Mountain and deep, well defined drainages. The eastern slopes of Green Mountain drain into the Bear Canyon basin.

The search area is covered with a mixture of evergreen and deciduous vegetation. Tall ponderosa pines are plentiful on Green Mountain and in the Bear Canyon drainage. A variety of brush such as scrub oak and manzanita abound. The vegetation is thickest on the north and west exposures, especially in the canyon bottoms. In contrast, the east and south exposures are more open and composed of brush and fewer tall trees. Moreover, some segments of the search area are densely vegetated, and others include large massifs of exposed bare rock.

The reader who wishes to compare the Green Mountain area with other areas should study the topographical features shown in Figure 1 and five vegetation sub-areas shown in Figures 2 through 7. Sub-area 1 is shown in Figure 3. This is the southwest exposure of Green Mt. composed of cliffbands and alternating short forest that grades to moderately thick chaparral. Foot travel in this terrain and vegetation is difficult.

The trees of the ridge and open slope are pinyon (Pinus cembroides) and evergreen oaks (Quercus spp.) and juniper (Juniperus spp.) (4). The chaparral is characterized by the tough, springy branches of shin-to head-high manzanita (Arctostaphylos spp.), skunkbush (Rhus trilobata), silk-tassel (Garrya wrightii), shindagger (Agave schottii), and Yucca spp. There are occasional cacti, especially on ledges and crevices of the cliffs. In drainages the trees are taller with the added species of ponderosa pine (Pinus ponderosa), Douglas fir (Pseudotsuga taxifolia), Chihuahua pine (Pinus chihuahuana) and limber pine (cf. Pinus reflexa). The chaparral may be replaced by grape (Vitis arizonica), poison ivy (Rhus radicans) and other vines, or by thorny shrubs such as catclaw (Acacia greggii).

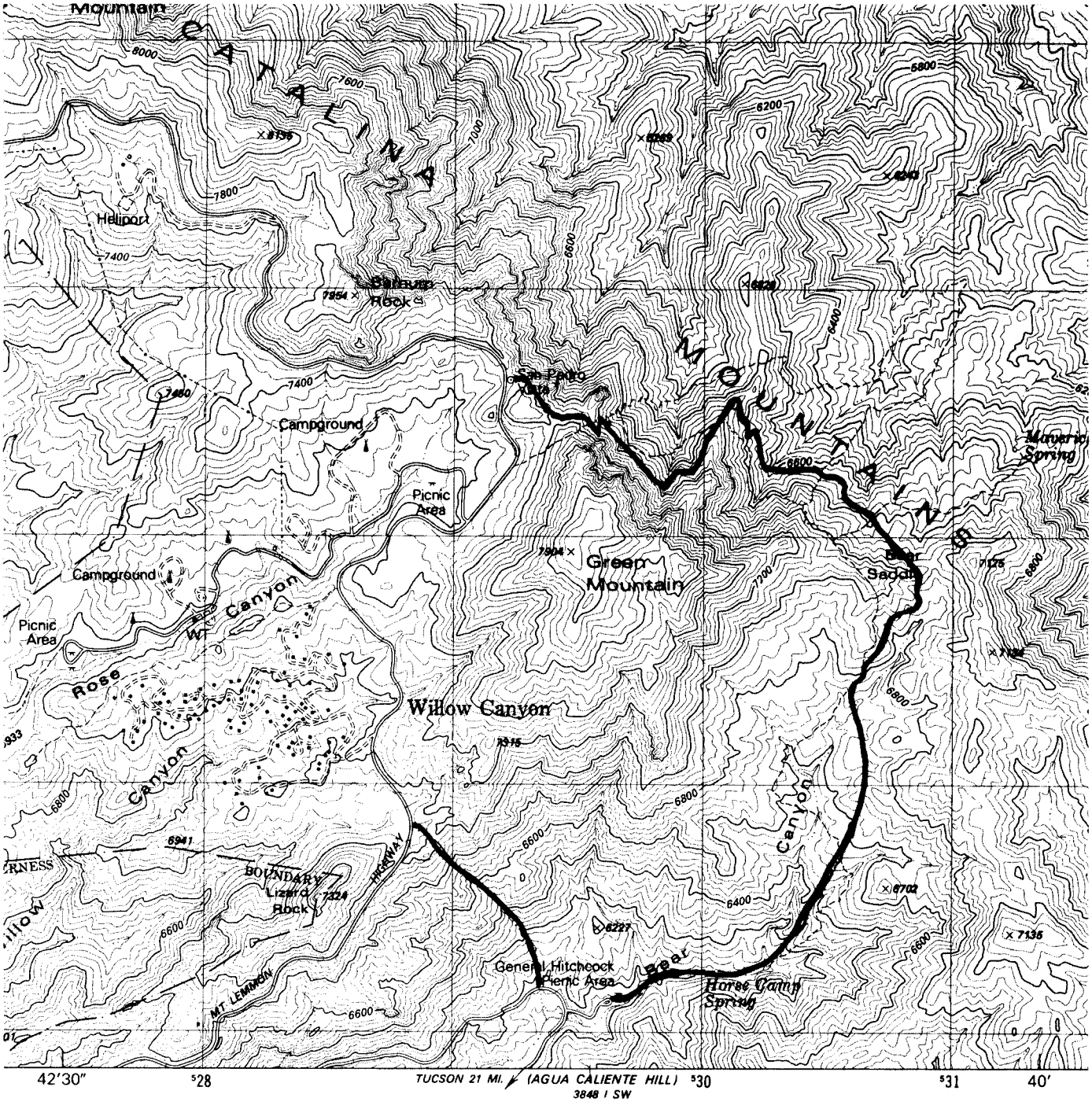

FIGURE 1: **Contour Map of Test Area**

A segment of the Mt. Bigelow, Arizona, 1981 quadrangle (7.5 minute series) illustrating the area used for this experiment. The search area is outlined in black and bordered on the west by the Mt. Lemmon Highway.

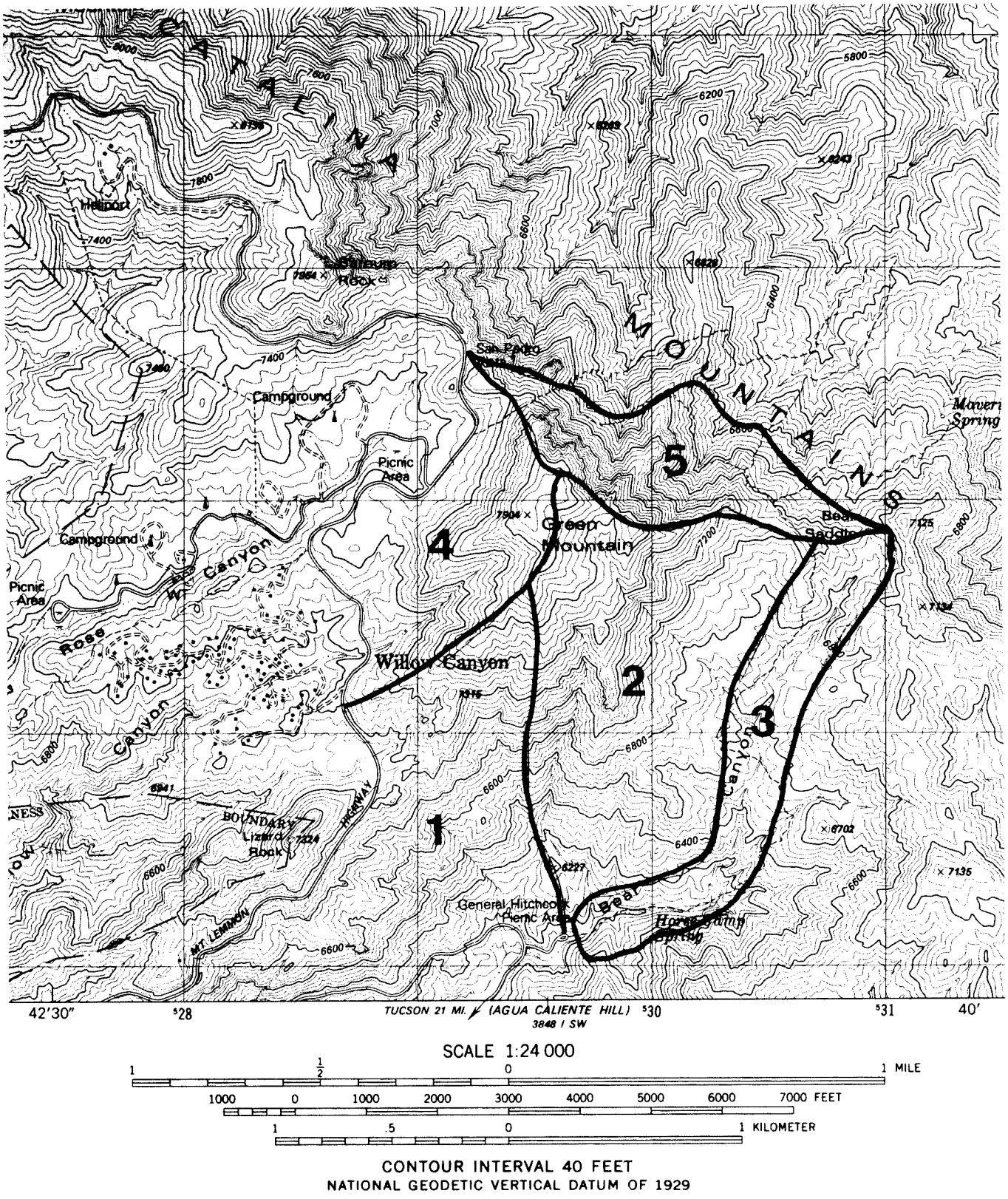

FIGURE 2: **Contour Map of Five Vegetation Sub-Areas**

The five vegetation sub-areas within the Green Mountain search area.

Figure 4 shows sub-area 2, the south side of the Green Mt. summit. The denser, taller, canyon vegetation is apparent; this is ponderosa pine and Douglas fir forest. The open slopes are pinyon pine, juniper and oak trees with understory of chaparral shrubs as described in sub-area 1. As elevation increases toward the summit, the amount of bare ground decreases. A person walking on a lower slope is exposed to the sky because there are spaces between the shrubs and because the vegetation of human height or over is sparse. Nearer the summit, the tree canopy grows taller and begins to close. The patches of open sky overhead grow smaller.

Sub-area 3 (Figure 5) illustrates the strongly contrasting north and south exposures that meet along the major drainage of Bear Canyon. Simply, on the left is chaparral, on the right, tall timber. In the bottom of the drainage there is sand and rock with a riot of trees, shrubs and vines reminiscent of colder, wetter climes. These sharp contrasts are normal in arid mountain ranges such as those in southern Arizona and California. Figure 16 shows what an observer in the canyon bottom may see looking up the drier south exposure.

The thickly wooded west side of Green Mt. summit as seen in sub-area 4, Figure 6, is best characterized by noting that it makes an ideal summer hike to escape the 100° F heat of the Tucson valley. The trees are tall, to 70 feet, spaced such that shade is discontinuous but highly significant. There is a well developed understory of young coniferous trees, shrubs, wildflowers and grass. Cliffy drainages and occurrences of oak brush impede direct-line travel. Figure 12 shows the peculiar sun and shade mixture of these ponderosa pine parklands.

Sub-area 5 is the highest, the steepest, the most rugged and least arid part of Green Mt. It is a north and northeast exposure receiving more precipitation due to the peculiarities of local storm tracks, and retains snow longer in spring, than any other part of the study area. Figure 7 shows three of its characteristic features. In the center of the picture is a very heavily timbered, extremely steep canyon. The trees are taller pine species, true fir (Abies concolor) and Douglas fir, alder (Alnus spp.) and maples (Acer spp.). Under their canopy there is continuous shade, many downed logs and boulders. To the left in the photo is part of a chaparral stand with open ground spotted through tangled thickets of manzanita and oak. To the right is a bare rock outcrop lightly vegetated by stunted trees. This type of terrain may be essentially vertical faces, or towers and columns of rock. Although rock climbers may seek it out, those wanting reasonable cross-country routes must avoid it. At the top of the photograph one again sees the pine parkland of Figure 12.

Description of Lost Persons

The Pima County Sheriff's Department's search and rescue files show that in searches of mountainous terrain (4,000 feet to 10,000 feet elevation) most of the lost persons are found either in drainages or on trails. In the cases studied from January 1, 1980 through December 1, 1983 it is noted that of all lost persons found, 13 lost persons were found in canyon bottoms, 10 on trails or roads and 2 were found in other locations (one found on a ridge, one found exiting the mountains and in rolling desert terrain).

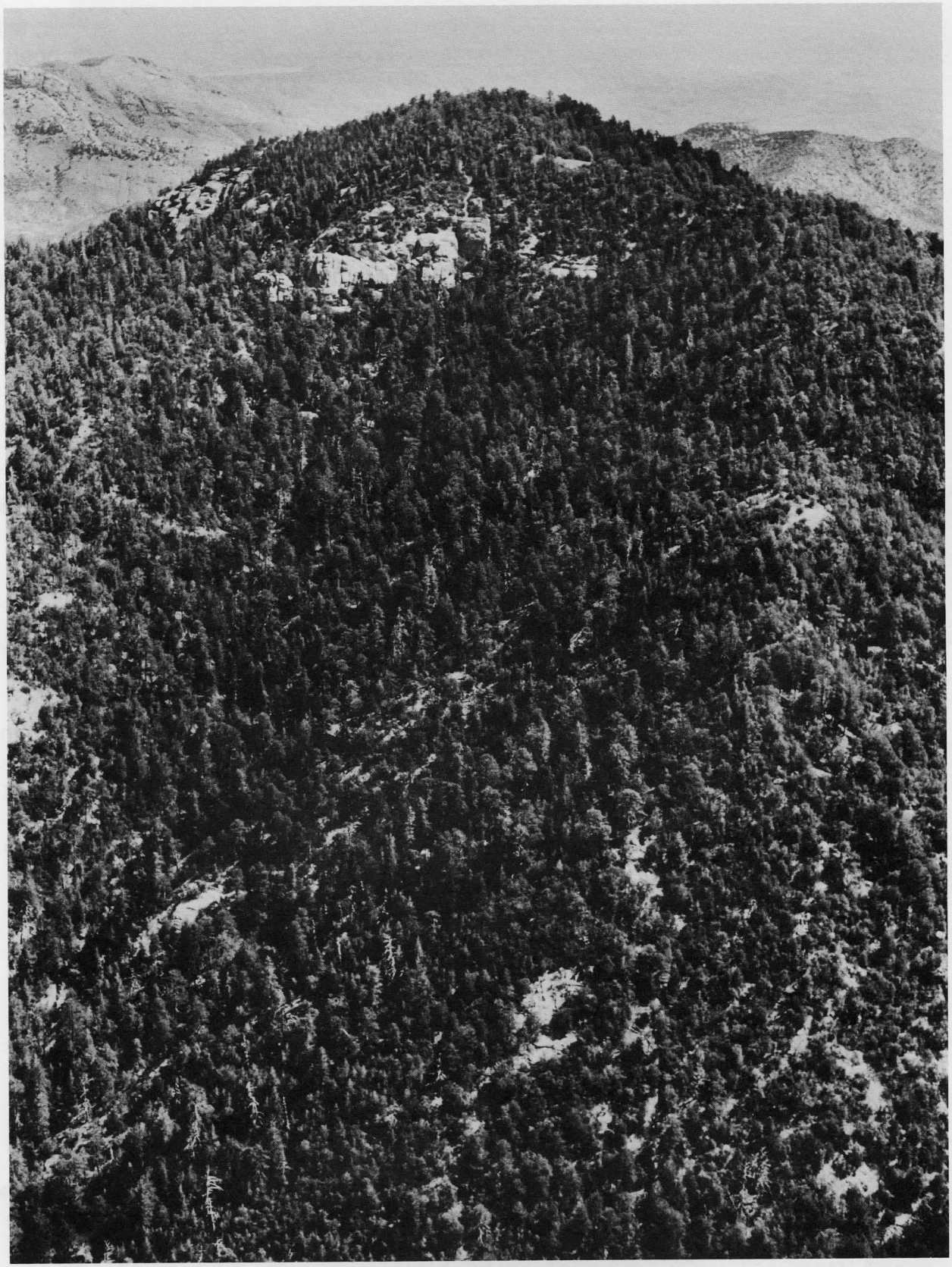

FIGURE 3: **Photograph of Sub-Area One**

Sub-area one, the southwest exposure of Green Mountain. Composed of cliffbands and alternating short forest that grades to moderately thick chaparral.

FIGURE 4: **Photograph of Sub-Area Two**

Sub-area two, the southern exposure of Green Mountain. Dense, tall ponderosa pine and Douglas fir are apparent in the canyons.

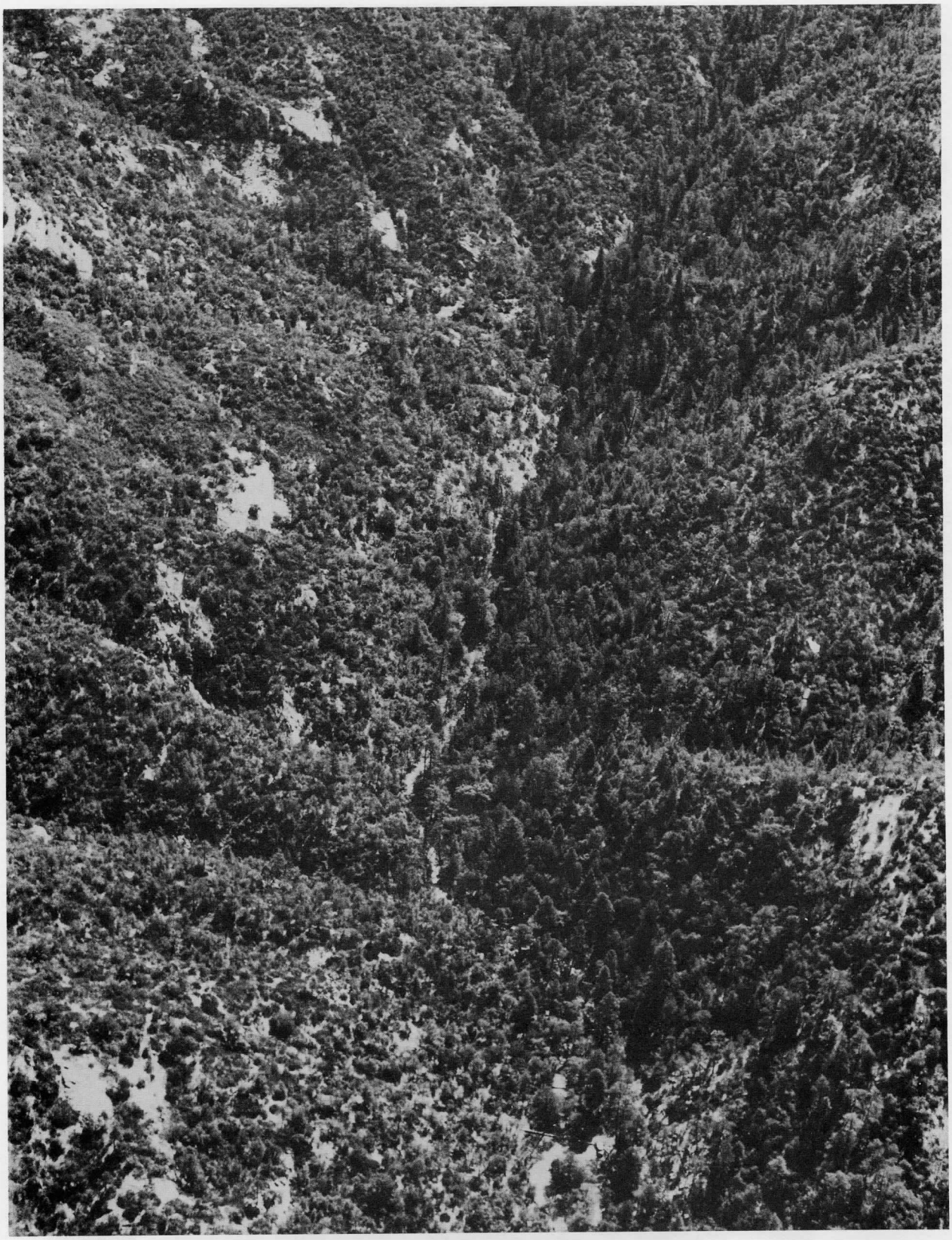

FIGURE 5: **Photograph of Sub-Area Three**

Sub-area three illustrates strongly contrasting north and south exposures that meet along the major drainage of Bear Canyon. On the left is chaparral; on the right, tall timber.

FIGURE 6: **Photograph of Sub-Area Four**

Sub-area four, thick forest on the west side of Green Mountain summit. Conifers reach 70 feet tall and there is an understory of shorter trees, shrubs, wildflowers and grass.

FIGURE 7: **Photograph of Sub-Area Five**

Sub-area five, the highest, steepest, most rugged and least arid segment of Green Mountain. North and northeast exposures.

It is important to note that these persons considered themselves to be lost or disoriented. These cases do not represent persons who were merely overdue from a mountain wilderness outing and happened to be the object of a search effort.

Consequently, in order to imitate a realistic scenario, these experiments were restricted to placing victims in only these locations. The Green Mountain Search Area contains 20,600 feet of trails and 24,800 feet of major drainages. The actual location of a victim and whether he/she was on a trail or in a drainage was determined randomly (with a random number generator). If in the same experiment the generator placed two victims within 100 yards of each other, the second victim's position was rejected and replaced by the next assignment.

To aid the victims in locating their assigned positions, all trails were accurately marked at 1/10th mile intervals with inconspicuous markers, placed there with the aid of a measuring wheel. No markers were placed in drainages. However, these areas were reserved for the more experienced victims who were capable of judging their position accurately.

In a realistic situation, an actual victim might be in the open or under cover. Furthermore, the victim might be passive (if unconscious or dead) or active (conscious and trying to attract attention). Of these four possible combinations, it seemed that a victim attracting attention in the open would be easier to detect than one who was unconscious and under cover. With no previous data to go on, it was decided to run a set of experiments on the following situation: in the open and actively trying to attract attention. Additionally, one experiment (which was ignored in our statistical summaries) was conducted where the victims were simulating both unconsciousness and under cover - no one was found.

In order to account for an active person, the victims were advised to find their assigned position and then find the most open area within one minute's movement of the spot (called the "60 second rule"), and move to it and wait for the start of the experiment. This was done in order to simulate an actual victim who, upon hearing a helicopter, would attempt to get to the most open area in the immediate vicinity. In some instances the best area still had a tree canopy or only a small "window" open to the sky.

Once in the "open" area, two different means of signalling the air crew were tested; attraction by movement (waving objects, arms, jackets, and moving sideways) and attraction by contrast (lying down but making the body conspicuous against the background, assuming a "spread eagle" position, thereby forming the letter "X" with the arms and legs).

In all experiments victims were asked to wear "everyday" clothing (which ranged from white T-shirts and blue jeans to brown and green checked shirts and khaki trousers) and were not permitted to wear clothing with large areas of orange or bright yellow (thought to be highly visible). The use of any signalling device (e.g. mirror) was prohibited.

Description of Searchers and Search Pattern

Air search crews employ a variety of search patterns depending upon type of aircraft, terrain, unique features of the search area, and the known plans of the lost person.

The aircraft flown in this exercise were Bell Helicopters, Type HH-1H Iroquois ("Hueys"), of Detachment 1 37th Aerospace Rescue and Recovery Squadron. The air search crews consisted of a pilot, copilot, and two to three scanners positioned in the cargo compartment of the aircraft. It is important to note that this crew configuration may differ from smaller, less powerful aircraft which may be unable to carry two to three scanners on the aircraft due to power or space limitations.

The air search crews employed a contour search pattern to search the entire area. An additional route search was used to search the main trail and a major canyon bottom.

The Aerospace Rescue and Recovery Service helicopter operations manual describes a contour search as follows:

(1) The contour search is used to search mountainous or hilly terrain. The search legs may be flown around a peak or back and forth along the side of the mountain, depending upon the size and accessibility of the area to be searched (Figure 8).

(2) Start searching above the highest peak or ridge and search from top to bottom. Descend at the end of each leg. Use extreme care during the search. Do not fly this type of search when terrain conditions, high winds, turbulence, visibility, or other weather conditions create a hazard to safe flight. Monitor and evaluate these conditions constantly throughout the search. The pilot flying the aircraft must devote full attention to evaluating terrain for clearance and hazards to flight. All other crew members should aid in clearing power lines, cables, etc. Exercise extreme caution when searching in canyons and valleys. Assure adequate clearance before entering the area. Always maintain an "out". Plan ahead and know which way to turn in the event of an emergency (5:17-9).

The same operations manual describes a route search as follows:

(1) Route search consists of one search leg along a given track (Figure 9).

(2) Start the search leg at the point nearest the search aircraft's departure base and search along the proposed route of the mission objective between the last known position (LKP) and the intended destination. If the LKP is the last position report received from the mission objective, search between the LKP and the point where the next report was due (5:17-4).

Note: The last paragraph of the route search description was written with missing aircraft in mind. However, the same principles apply to searches for lost persons.

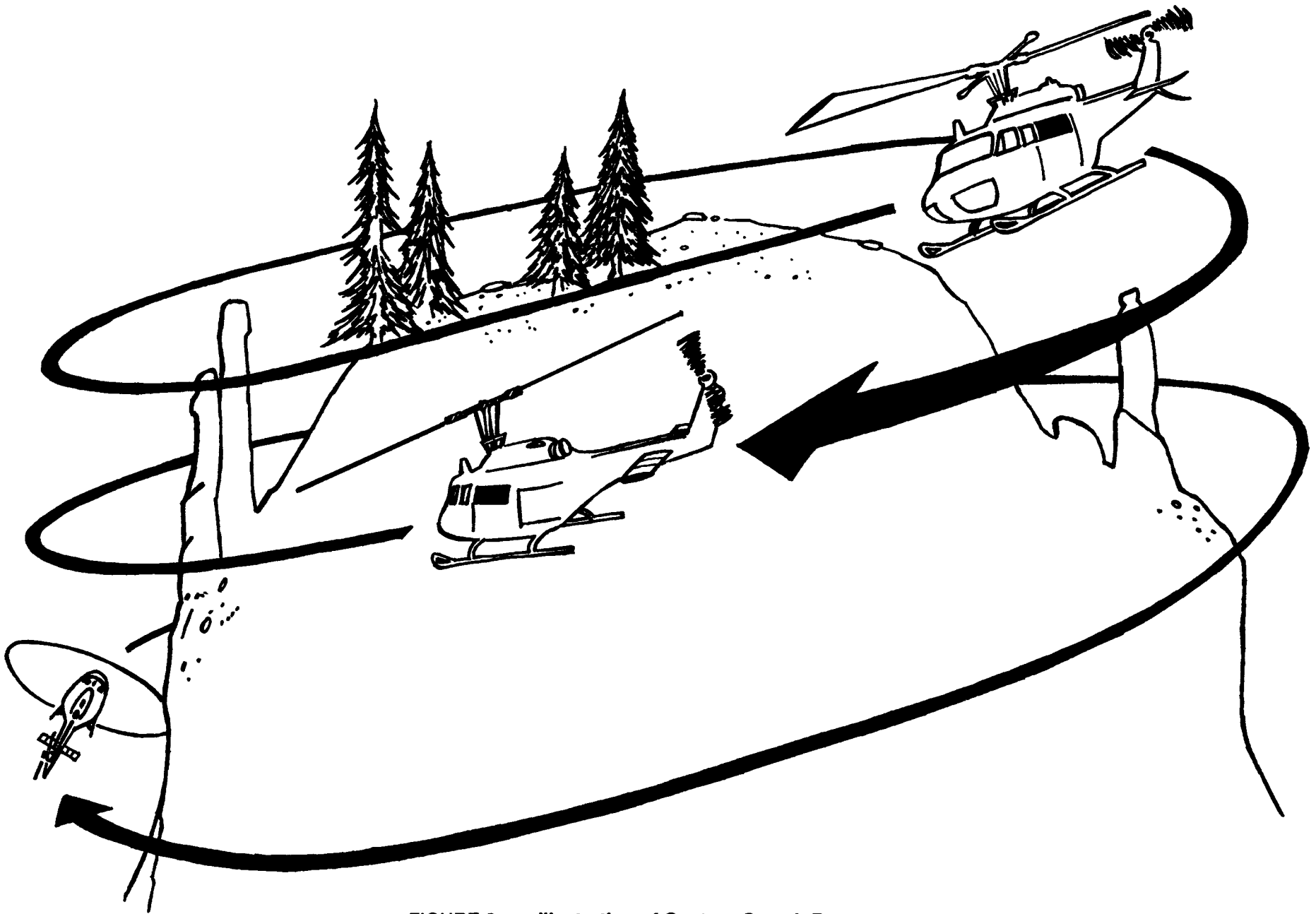

FIGURE 8: **Illustration of Contour Search Pattern**

The upper segments of Green Mountain were searched with a contour search pattern. (Not to scale.)

Description of a Find

If a victim was found the scanners in the helicopter would shine a highly visible light on the victim. When the victim was absolutely certain he/she had been found that victim would don a bright orange vest, which until then, had been kept concealed. The crew would then disregard anyone in an orange vest and continue searching.

At the conclusion of each experiment, the crew was usually advised by radio of the location of the victims they had missed and were directed towards them. The victims would then attempt to signal the aircraft by waving an orange vest. Even so, under these apparently advantageous conditions, the crew members were occasionally unable to see them. Sometimes a direct mirror flash was required for detection.

The lost subjects and crews were debriefed after each experiment.

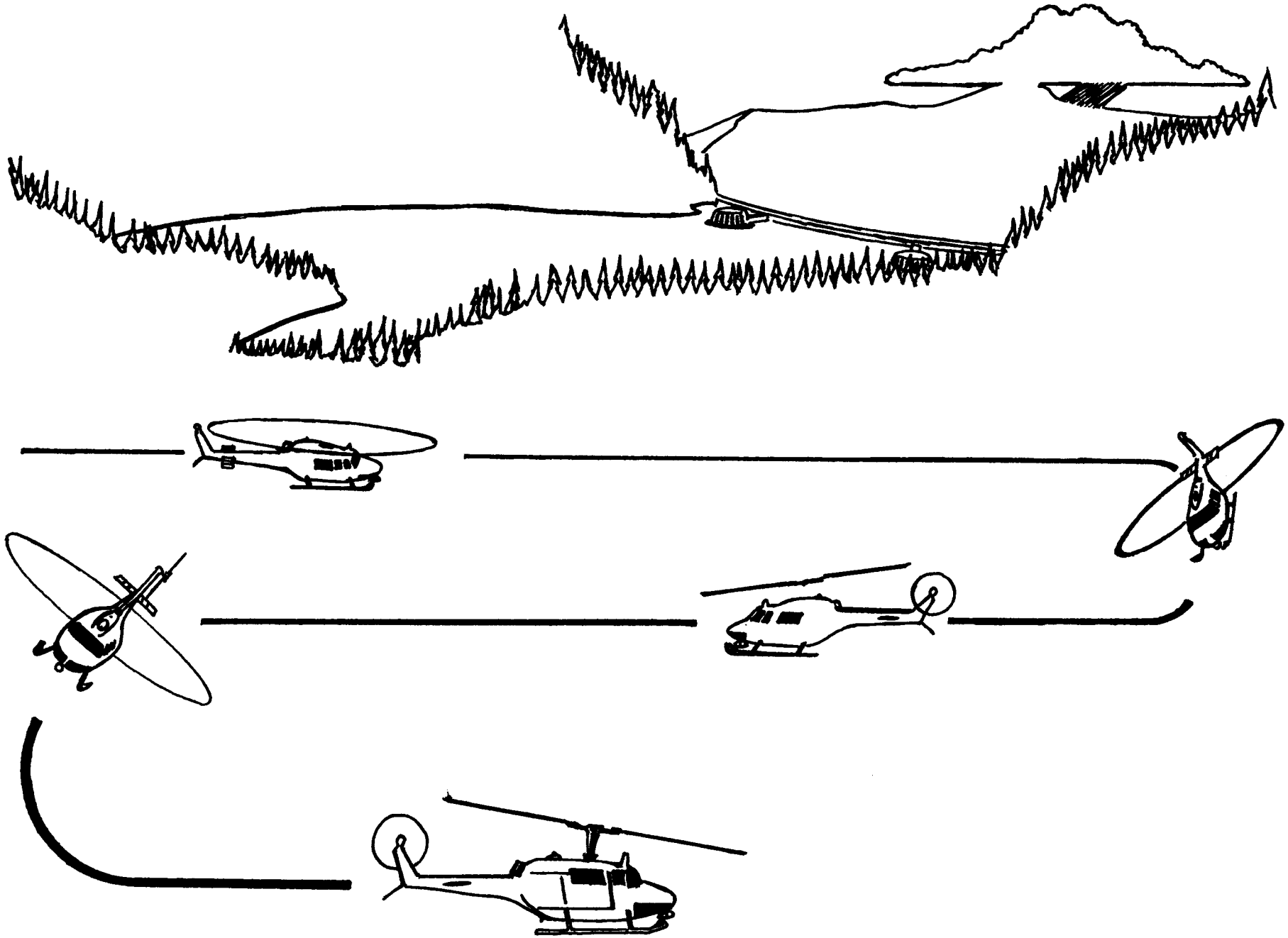

FIGURE 9: **Illustration of Route Search**

The Green Mountain trail and the Bear Canyon drainage were searched with a route search pattern.

FIGURE 10: **Photograph of Helicopter Search Crew**

An air rescue crew of Detachment 1 37th Aerospace Rescue and Recovery Squadron searching the mountain area west of Green Mountain. Note the scanners' superior visibility through the open cargo door.

MORE LOST PERSONS IN SPREAD EAGLE POSITION WERE FOUND

Over the period of November 2, 1982 to June 3, 1983 a total of nine search mission experiments were flown. For reasons of safety and availability of the aircraft and crew, the time of day for the start of each flight over the Green Mountain search area was early to mid-morning or early afternoon. However, the ninth experiment on June 3, 1983 was conducted under different conditions than the first eight. The data from this last flight were not considered in the computation of the experimental POD and the results of that mission are reported separately below.

Lost Persons, Motionless Under Cover (0% Found)

The ninth search mission was conducted under conditions that were drastically changed from search missions 1 through 8. The lost subjects were placed on or near the usual trails and drainages and were instructed to simulate an unconscious person who was under cover of natural vegetation, but not hidden. These conditions were the same, (except for the drastic difference in terrain) as those tested in "Desert Searches: Effectiveness of Helicopters". The results of search mission 9 were not included in the POD calculations reported below in "Combined Results" but are included here for their dramatic comparative function in Table 1.

Table 1

Results of Search Mission 9, Lost Persons
Under Cover and Simulating Unconsciousness

Number of Lost Persons	7
Number of Lost Persons Found	0

It is important to note here that the results of search mission 9 are consistent with previous statements of the air search crews. They indicated that an unconscious person, under cover (with no further clues) would be very difficult to find by air search. The authors believe that if many missions were flown under the conditions of search mission 9, the experimental POD would be quite low. This does not imply that helicopters shouldn't be used in an effort to find the victim that is unconscious and under brush.

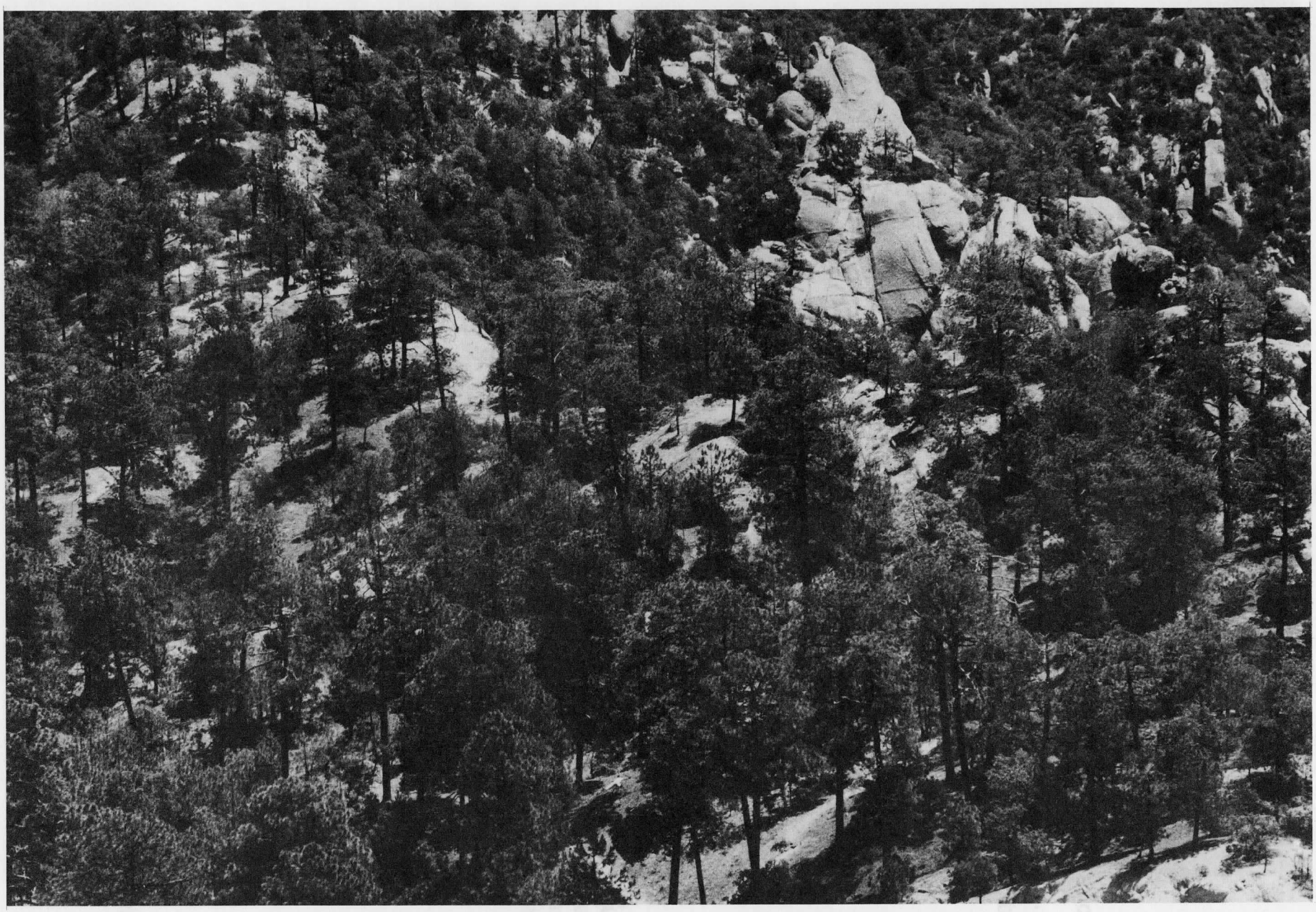

FIGURE 11: **Aerial Photograph of Lost Persons "Spread Eagle"**

Two lost persons lying spread eagle south of the Green Mountain summit. This photo was taken from a normal search altitude.

Lost Persons in a Waving, Upright Position (60% Found)

There were five search missions flown with lost subjects in a waving upright position.

As discussed in "Description of Lost Persons" all subjects were located on or near a trail or drainage by experimental design. The results are summarized in Table 2.

Table 2

Individual Experimental Results for Waving, Upright Lost Persons

Mission Number	1	2	3	4	5
Number of Lost Persons	11	6	8	9	6
Number of Lost Persons Found	7	2	5	6	4
Experimental POD	0.64	0.33	0.63	0.67	0.67

Note that search mission 2 seems anomalous. Since this mission was flown in a manner with no basic differences than other missions, there is no reason to exclude it. In fact, with the exception of search mission 9, (lost persons unconscious under brush) no data are excluded from the combined results.

The overall experimental results for waving, upright lost persons are summarized in Table 3.

Table 3

Overall Experimental Results for Waving, Upright Lost Persons

Number of Lost Persons	40
Number of Lost Persons Found	24
Overall Experimental POD (Waving, Upright)	0.60

Hence, the Green Mountain POD experiment resulted in an experimental POD of 0.60 for lost persons who are upright and waving.

Lost Persons in a Spread Eagle Position (81% Found)

There were three search missions (6 through 8) flown with the lost subjects instructed to lie in a prone spread eagle position (X). Note: The spread eagle position is taught as a means of signalling search helicopters in "Hug a Tree and Survive", a survival program for children (6).

As before, all lost persons were placed on or near a trail or drainage. The results are summarized in Table 4.

Table 4

Individual Experimental Results for
Lost Persons in Spread Eagle Position

Mission Number	6	7	8
Number of Lost Persons	7	8	6
Number of Lost Persons Found	6	7	4
Experimental POD	0.86	0.88	0.67

The overall experimental results for lost persons in the spread eagle position are summarized in Table 5.

Table 5

Overall Experimental Results for
Lost Persons in Spread Eagle Position

Number of Lost Persons	21
Number of Lost Persons Found	17
Overall Experimental POD (Spread Eagle Position)	0.81

Hence, the Green Mountain Experiment, using lost persons in the spread eagle position resulted in an experimental POD of 0.81.

Again, because of the inadvisability of using methods whose sophistication may exceed that of the data being used, no attempt was made to describe a "significant difference" between lost persons who are standing and waving as opposed to lost persons who are lying in a spread eagle position. This matter is discussed further in "Attraction and Contrast Created Effective Signals".

Combined Results of Search Missions 1 through 8

Table 6 represents a collective summary of search missions 1 through 8.

Table 6

Overall Experimental POD of Search Missions 1 - 8

Total Number of Lost Persons	61
Total Number of Lost Persons Found	41
Experimental POD	0.67

The Green Mountain Experiment suggests that if a lost person is on or near a trail or drainage and is standing and waving or lying in the spread eagle position, and has placed him/herself in what appears to be the "best spot around", then the POD may reasonably be considered to be 0.67. (Or, two out of three lost persons in this experiment were found.)

MANY VARIABLES AFFECT HELICOPTER SEARCH CREWS' ABILITY TO FIND LOST PERSONS

The following points represent a summary of numerous analytical discussions concerning this experiment. These discussions are the result of the observations of air search crew members, the lost subjects, and the authors. These points do not lend themselves to further statistical analysis, and they are included here for the benefit of prospective search managers who may profit from such discussions.

The Pilot and Copilot Made the Majority of Finds

W.H. Teichner (7) suggests that the pilot and copilot in Bell Type HH-1H helicopters are occupied most of the time with flying the aircraft in flights of low altitude over rough terrain. The result, according to Teicher is that the pilot and copilot have little time to devote to other tasks. Does this mean that the pilot and copilot will be ineffective searchers? Will the scanners in the cargo compartment of the aircraft make the majority of finds?

The experiment was not particularly designed to answer these questions. However, the data in Table 7 was obtained from search missions 2,3,6,7 and 8 where the actual number of "finds" by the pilot and copilot are known.

Table 7

Percentage of Finds Due to Pilot/Copilot
in Search Missions 2, 3, 6, 7, 8

Total Number of Lost Persons	35
Total Number of Lost Persons Found	24
Total Number of Lost Persons Found by Pilot/CoPilot	16
Percent Found by Pilot/Copilot	66%

Upon debriefing the various crews, it came to light that in most of the Green Mountain area, the pilot and copilot did not feel overburdened in flying the aircraft. This was especially true of the copilot. Consequently, due to the superior visibility afforded the pilot and copilot in the cockpit of the Huey helicopter, their search efforts turned out to be quite profitable. Also, the crew said that on cool days (most of the missions were flown in the cooler months, at an altitude of 6,000-8,000 feet), it is difficult to maintain an optimum level of comfort for the scanners searching from an open cargo area. Cold winds cause tearing of the eyes, and uncomfortable conditions for the scanners, resulting in decreased effectiveness. It is important to remind the reader that these conditions are routinely encountered in mountain searches in Southern Arizona. In colder areas, this point may take on added significance.

Missions Were Flown in Sunny Weather

All missions in this experiment were flown during sunny weather with some variety in wind conditions and temperature. Although several searches were scheduled during low-ceiling conditions, they were aborted for safety reasons. If an air crew searches mountainous terrain during overcast weather, it is not known (from this experiment) what to assume for the appropriate POD. Logically, an overcast weather POD in the mountains should be higher for lost persons in shady areas. "Desert Searches" found that a crew's POD is significantly higher on a cloudy day than it is on a bright day when searching for a subject who is in the shade. Unfortunately, weather conditions did not allow for a study of overcast search conditions.

Mountainous Regions Considered More Difficult to Fly/Search

The air search crews commented that the north side of Green Mountain and Bear Canyon are more difficult to search than other segments of the search area.

The "Crew Debriefing Summary" indicates that 5 of 8 air crews considered the north slope more difficult. This segment of the search area is unique because much of it is shielded from direct sunlight. The air search crews commonly had to look into bright sunlight (on the southern horizon) while searching this area. In addition, the northern slopes are comparatively steeper with thick vegetation in the narrow, well defined canyons. These radical terrain features did not allow close "contour flight" as in other segments of the search area.

Bear Canyon is a large, well defined drainage basin. It was described as a difficult area to search because of tall stands of ponderosa pines (that shaded lost persons) in the stream bed and the perceived danger of flying over a confined area such as this. In the event of an engine failure there is no obvious escape route to acquire a safe landing. To maintain adequate safety the air crew searched at higher altitudes and air speed.

Consequently, it seems advisable to assume a lower POD for areas such as these in a real search. These assumptions must be supported by a thorough debriefing of the air search crew.

Attraction and Contrast Created Effective Signals

Probability of detection is dependent upon two primary factors. Firstly, it is dependent upon the effectiveness of the searcher. Searchers' effectiveness can be influenced by many variables such as fatigue, motivation, experience, and search conditions. Secondly, a primary factor affecting POD is the lost person's ability to signal effectively. Or, how easy will the lost person make it for the searcher to find him?

The SAR section of the Pima County Sheriff's Department has noted that most lost persons attempt to signal search aircraft by waving arms and clothing, or yelling for help. Very few utilize known effective tools such as signal mirrors, brightly colored-contrasting clothing and equipment, smokey signal fires, or similar techniques.

In search missions 1 through 5 the air search crews indicated that motion was perhaps the greatest contributing factor to persons being found. It was noted that a person standing motionless in drab non-contrasting clothing tends to blend in with the surrounding area. This person is standing, in a vertical plane, just as the surrounding pine trees exist in a vertical plane. When the person moves, the added element of motion helps to "catch the eye" of the searcher. It has also been noted on past searches for lost persons, that air search crews are able to see animals running and birds flying close to the ground. Yet the animals and birds seem to disappear when they stop and allow their natural camouflage to take effect.

The search crews commented that in search mission 1 the white "T" shirt worn by a lost person attracted the searcher rather than the large tan colored parka being waved overhead of the lost person. It was also noted that this lost person's background was composed of an open slab of granite rock of a color similar to that of the parka. In search mission 4 the air crew said that one lost person was spotted because of a white hat rather than the motion created by a dark colored jacket waved overhead.

In search missions 6,7 and 8, lost persons assumed a prone "spread eagle" position, with no motion, in a location consistent with the "60 second rule". To the surprise of the authors, 17 of 21 (81%) were found. Upon debriefing the crew members, they consistently stated that the "spread eagle" position created a "very conspicuous outline" and an "unnatural shape in the wild". Conversely, it is believed that if a person were to curl up or lie in a normal anatomical position they would be much more difficult to spot. This was noted in search mission 9 where 0 of 7 were found.

In light of these observations it appears that not only motion, but also contrasting colors and shapes will aid the lost person in being found.

Air searchers observed that dark-colored clothing against a light-colored background or light against dark will make the lost person more visible in the search environment. Similarly, it seems that "spread eagle" by itself, will not in all cases be an effective signal. THE LOST PERSON MUST USE THIS TECHNIQUE (or any other) INTELLIGENTLY. For example: White clothing was recognized as a contributing factor in finding two lost persons on Green Mt. Obviously, white clothing will act as camouflage in a snowy

environment, unless the sun angle aids in creating a shadow of a contrasting outline. Dark clothing will act as camouflage against a dark background. Bright colors such as yellow, orange, or red are usually considered to be effective in attracting attention. However, will these colors be effective during the fall when the leaves of deciduous trees turn into an array of bright colors?

Throughout the Green Mt. SAR experiments air search crews noted that shaded areas were very difficult to search. In compliance with the "60 second rule", some lost persons were not able to find an open, sunny area. Several found themselves in thick brush and in a shaded area. Search crews consistently noted that lost persons in brushy, heavily vegetated areas, or in the shade were very difficult to find and many were not found.

The location and position of the lost person "spread eagle", in relation to the field of view of the search crew will affect the searchers ability to see the lost person. It is assumed that ideally the plane of the "spread eagle" will be at right angles to the line of sight of the searcher. If the plane of the "spread eagle" is the same as the line of sight of the searcher the lost person will be very difficult to spot. Note: These observations are consistent with the aerial photos in Figures 12 through 15 that simulate these conditions.

FIGURE 12: **Aerial Photograph of Lost Person "Waving"**

A lost person signals a search helicopter by waving a jacket overhead. Motion was observed to be a contributing factor in effective signals.

FIGURE 13: **Aerial Photograph of Contrasting Colors**

The spread eagle position creates a conspicuous "cookie cutter" shape. Contrasting colors seem to aid searchers success. Note the white clothing on a dark background and the dark clothing on a light background.

FIGURE 14: **Aerial Photograph of Camouflage Effect**

Clothing colors similar to surroundings contribute to a camouflage effect.

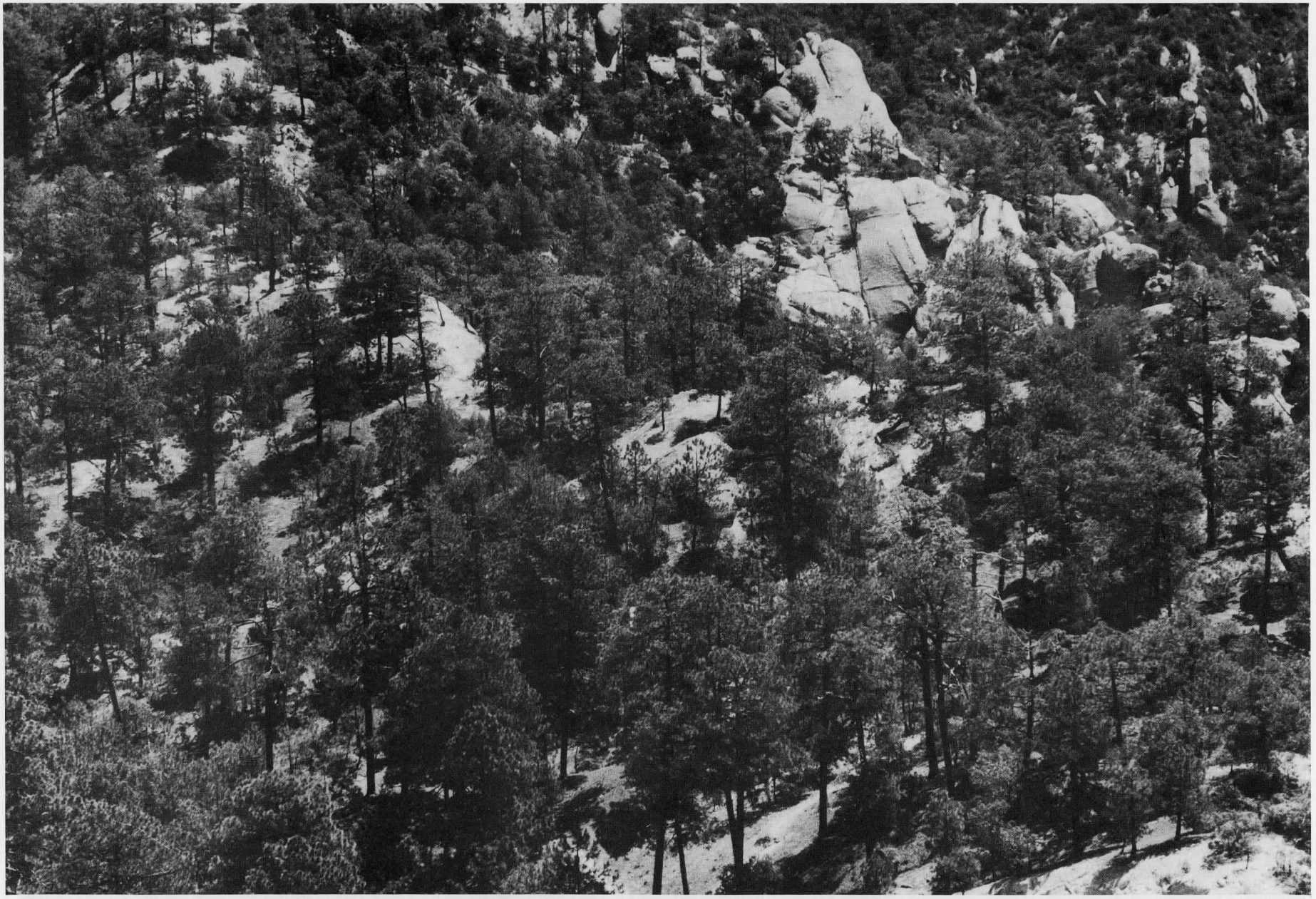

FIGURE 15: **Aerial Photograph of Shade Effect**

Shade was observed to aid effective camouflage. This effect was especially pronounced with dark clothing. The color white was much more visible in the shade but difficult to identify in this photo due to the "curled up" position.

THE RESULTS MUST BE USED CAUTIOUSLY

This experiment is too simplistic to satisfy the dictates of rigorous statistical analysis. The user of this report must reconcile these results with the realities of the search at hand. This experiment does not attempt to identify all of the variables which play a role in establishing probability of detection for a helicopter crew in a mountain search. With this firmly in mind, the preceding experimental values for PODs represent an estimate which will be helpful to a reasonable person.

These data were collected under less controlled conditions than the data collected in "Desert Searches". This group decided that the statistical methods used to establish "confidence intervals" for "Desert Searches" (experimental POD calculations) are not appropriate here and could lead to improper interpretation. For this reason, this report:

- has displayed the basic results of conducting the experiment.
- has described in subjective terms the collective results of extensive crew and victim debriefings.
- has offered the comments of search crew members, lost persons, and the authors on points which seem salient.
- has not offered estimates of "confidence" to accompany the experimental results.

The search manager assumes the responsibility of using these results. This responsibility involves an interpretation of the conditions under which these data were collected (namely "under Green Mountain Conditions").

Any POD information taken from this experiment should be used with careful attention to the following points:

- The search area must be comparable to the terrain and vegetation encountered in the Green Mountain Experiment.
- The Green Mountain Experiment resulted in approximate, experimental PODs, assuming one helicopter search of the area. It is assumed that one search of this terrain is dictated by the procedures described in the "ARRS Helicopter Operations" manual. If an air search crew conducts several "Green Mountain Equivalent" searches of an area then the POD should be thought of as cumulative. If it is believed that the searches are equivalent and independent, then the cumulative POD is computed as in "Search is an Emergency" (8).

- The Green Mountain POD Experiment was conducted solely with the Bell HH-1H Iroquois Helicopter, and flight personnel of Detachment 1 37th A.R.R.S. Different types of aircraft will provide varied levels of suitability for searching the mountain environment. The air search crew may also vary in number, training, and experience. Consequently, POD may vary considerably.

- All search missions were flown on sunny days. Winds varied from calm to turbulent.

- These POD results will appropriately be used in scenarios which duplicate the lost person behavior of the Green Mountain Experiment.

APPENDIX
Crew Debriefing Summary (Search Missions 1 - 9)

Exp.#	1	2	3	4	5	6	7	8	9
Date	11-02-82	12-14-82	01-11-83	03-16-83	04-26-83	05-03-83	05-09-83	05-23-83	06-03-83
Time	0915	0952	1317	1327	1335	1046	1315	1445	0834
Result # Found	7/11	2/6	5/8	6/9	4/6	6/7	7/8	4/6	0-1/8**
Crew Size	5	4	4	4	4	5	4	4	5
% Time to Search: Pilot	10	20	0	20	5	70	0	5	10
Copilot	50	80	75	80	50	90	90	90	90
Scanners	100	100	100	100	100	95	95	100	100
# of V. Found by: Pilot	?	1	0	?	?	5*	4*	0	0
Copilot	?	1	3	?	?	5*	4*	2	0
Scanners	?	0	2	?	?	1	3	2	1**
Search Contour/ Pattern Route	---	---	---	---	---	---	---	---	---
Above Ground Level	?	?	100'	500'	300'	200'-300'	150'	300'	150'
Air Speed	50-60K.	20-50K.	40K.	50K.	50-60K.	50K.	50K.	50K.	50-60K.
Slant Range	600-900'	600-900'	450'	600'	660'	200-300'	200-400'	400'	200-300'
General Flying Condition	Good	Very Good	Poor Up-Down Drafts	Good	Good	Good	Turbulent	Bumpy Fast-High	Good
Weather	Sunny Cold	Sunny Cold	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Search Time	32min.	54min.	63min.	53min.	52min.	44min.	44min.	70min.	53min.
Most Difficult Area to Search	N. & N.W.	N.	N. & N.E.	N.E.	N. & E.S.E.	Bear Canyon	E.	E.	N. & N.W.
Easiest	Bear Canyon	Bear Canyon	Bear Canyon	Bear Canyon	Bear Canyon	Green Mtn.	S.E.	Upper Bear Canyon	Bear Canyon
What Caused V. to be Found	Wt. T Shirt, Open Rock	Motion	Motion, Flat Terrain	Wt. Hat	?	Spread Eagle	Sunlight, Sp. Eagle Human Figure	Sp. Eagle, Lt. Clothing	Motion (1 Found)
Not Found	Shade & Sun Angle	Sun Ang. & Steep Terrain	Slope,Dull Clothing, Brush, Shadow	Rocky Terrain, Shadows	Vegetation, Shadows, Terrain	V. at Base of Tree in Shade	Dark Clothes, Trees/Shade	Shadow, Trees	Shade, No Motion, No Attraction, Vegetation

*Victims found simultaneously by pilot and copilot.
**Victim departed from scenario plan and waved at aircraft.

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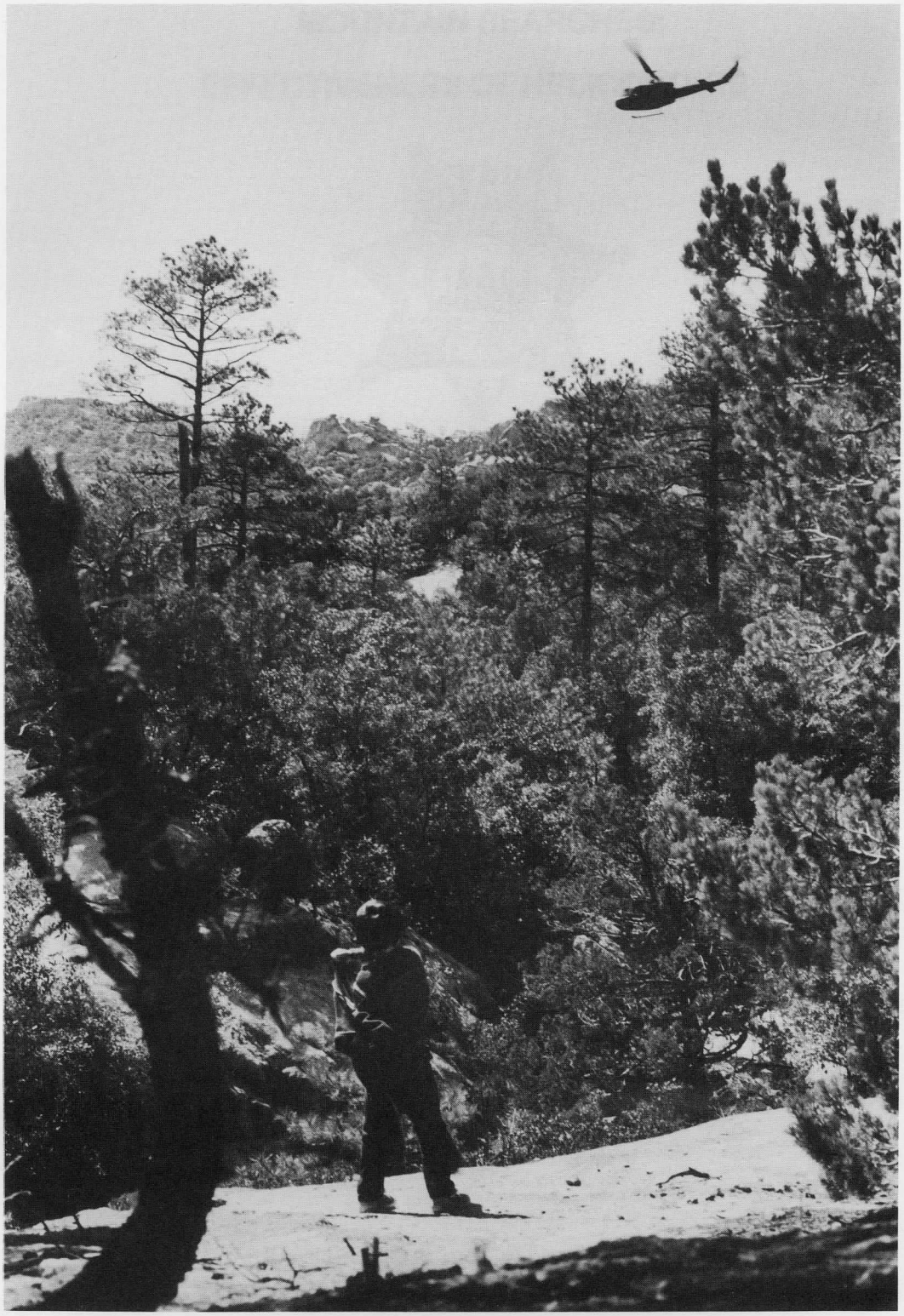

FIGURE 16: **Photograph of Lost Person Signalling Helicopter**

Five year old Patrick McHugh successfully attracts the attention of a search helicopter.