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JUNGLE VISION VIII

VISUAL DETECTION OF MOVING TARGETS IN A SEMIEVERGREEN TROPIC FOREST

INTERIM REPORT

BY

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OCTOBER 1971

UNITED STATES ARMY TROPIC TEST CENTER

FORT CLAYTON, CANAL ZONE

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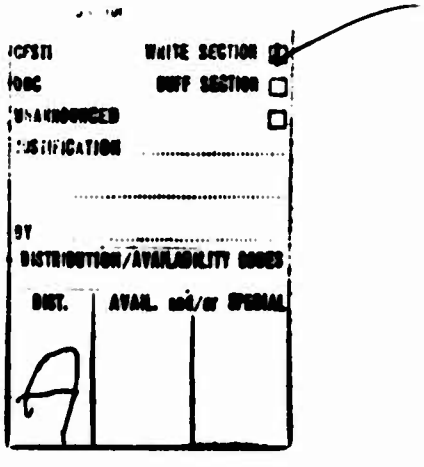

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13. ABSTRACT

The United States Army Tropic Test Center conducted a study of visual detection of human targets in a semievergreen tropic forest. Testing was conducted in the Panama Canal Zone at three jungle sites during October through December 1967 (wet season) and April 1969 (dry season). The purpose of the study was to determine typical detection distances of moving targets in the tropic forest. Among the major factors considered were effects of season and type of target dress upon detection distances.

A total of 120 enlisted men from TO&E units in the Canal Zone were used as observers (60 during the wet season and 60 during the dry season). The observers did not use visual performance aids. Targets were viewed as they appeared randomly, one at a time, moving along one of 10 separate radii laid out over a 180° field of view. Each observer received 30 trials. Targets wore either OD fatigues or black pajama-type clothing common to Vietnam.

Target detection distances did not differ significantly with either season or mode of dress. Mean target detection distances for tne wet and dry season were 52.6 and 55.8 feet, respectively. A difference in detection distance of only 1.2 feet was obtained among targets wearing OD or black clothing. Beyond 70 feet target detection dropped to only 14.6 percent.

Obscuration by eye-level vegetation appears to be the major factor in limiting detection distances of moving targets in semievergreen tropic forests. Differences in vegetation density from wet to dry season did not have meaningful effects upon detection distances.

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SUMMARY ABSTRACT

The US Army Tropic Test Center conducted a study of visual detection of human targets in a semievergreen tropic forest. Testing was conducted in the Panama Canal Zone at three jungle sites during October through December 1967 (wet season) and April 1969 (dry season).

The purpose of the study was to determine typical detection distances of moving targets in the tropic forest. Among the major factors considered were effects of season and type of target dress upon detection distances.

A total of 120 enlisted men from TO&E units in the Canal Zone were used as observers (60 during the wet season and 60 during the dry season). The observers did not use visual performance aids. Targets were viewed as they appeared randomly, one at a time, moving along one of 10 separate radii laid out over a 180° field of view. Each observer received 30 trials. Targets wore either OD fatigues or black pajama-type clothing common to Vietnam.

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Obscuration by eye-level vegetation appears to be the major factor in limiting detection distances of moving targets in semievergreen tropic forests. Differences in vegetation density from wet to dry season did not have meaningful effects upon detection distances.

FOREWORD

This is the eighth report in the US Army Tropic Test Center's series that deals with visual personnel detection in tropic forests. The research was supported by the US Army In-House Laboratory Independent Research Program (ILIR). As an ILIR work unit under DA Project 1T061101A91A, the visual detection series was terminated at the end of fiscal year 1970.

The primary purpose of these studies was to make available, for the first time, a baseline of quantitatively sound data concerning the visual capabilities of soldiers in the jungle. To date, the reports have dealt with detection of motionless targets during wet and dry seasons in different forest types, evaluations of performance aids, and the use of standard visibility objects. The present study compares the detection of moving targets during wet and dry seasons in a semievergreen tropic forest. Effects of two different types of uniform on visibility were also examined.

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BRIEF OF RESULTS

The purposes of the present study were to determine (a) detection distances of moving human targets in a semievergreen tropic forest (b) effects of season upon detection distances and (c) effects of type of target dress upon detection.

One hundred and twenty enlisted men from infantry and artillery units in the Canal Zone observed moving human targets wearing either OD fatigues or a black pajama-type of clothing common to Vietnam. Sixty of the observers (Os) were used as subjects for a wet season study phase and 60 during a dry season study phase. Each O was given 30 different trials to detect the target as it moved at a slow walking pace (an average of 2.8 feet per second) along one of 10 radii. All Os wore ear protectors to prevent their obtaining localization cues created by noise made by targets moving through the vegetation. The search area was laid out over a 180° radius, and the targets appeared one at a time, in a random-type sequence, along one of the 10 radii. The following major results were obtained:

a. Mean target detection distance was 52.6 feet for the wet season and 55.8 feet for the dry season. The difference of only 3.2 feet for wet and dry season detection distances was not statistically significant. Differences in vegetation density from wet to dry season did not have meaningful effects upon detection distances of moving targets.

b. Visibility gradients[1] for wet and dry seasons were very similar, both having a reverse "S" slope. Beyond 60 feet target detection dropped substantially, beyond 69 feet less than 15 percent of the targets were detected. One hundred percent of the targets were detected at a distance of 30 to 60 feet from the O position.

c. Within a given season, detection distances differed significantly among the three test sites used (with one exception out of six comparisons). Overall mean detection distances varied from a low of 44.6 feet to a high of 68.0 feet. The most difficult site, in terms of detection distance, remained so from one season to the next. By the same token the least difficult site remained so from one season to the next, thus order of site difficulty did not change.

d. Type of clothing worn by the targets did not affect target detection distances. Mean detection distance of targets wearing OD fatigues was 54.7 feet and 53.5 feet for targets wearing the black clothing. The difference of 1.2 feet in detection distances was not statistically significant.

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[1] For purpose of this study, cumulative frequency distributions are expressed in terms of percent targets detected at given distances.

e. No one radius within the Os field of search appeared to consistently yield the maximum detection distance. Significant differences in detection distance among radii were obtained, but the sequence of differences (from most difficult to least difficult) was not consistent from one test site to the next, nor from one season to the next. Thus, no evidence could be found that one area in the Os field of search - left, center or right - was better than another in terms of target detection distance.

f. Practice effects were not evident when the 30 trials were broken out into blocks of the first, second and third 10 trials. The largest difference in detection distances from one trial block to another was 2.1 feet.

g. All Os indicated that detection of movement first directed them to the target location. When asked what portion of the target was seen first, the results were that the trunk, legs and head accounted for over 62 percent of the responses.

INTRODUCTION

Prior to the initiation of a series of studies by the United States Army Tropic Test Center (USATTC) little quantitative data were available on visibility in tropic forests. Subsequent studies conducted by USATTC were primarily designed to provide a baseline of data against which resultant gains from detection devices and optical aids undergoing testing in the tropics could be determined.

The wet season phase of Jungle Vision VIII was conducted during the tropical wet season of 1967 (October through December) and the dry season phase during the tropical dry season of 1969 (April). Seasonal differences between the detection of moving targets wearing two types of functional mode of dress was the chief consideration of the study.

The present study represents the eighth and final investigation of the Jungle Vision Series. A brief final report that summarizes major findings of the eight studies will be distributed at a future date.

BACKGROUND

Five previous studies conducted by USATTC (Literature Cited, 1, 2, 3, 4 and 5) were investigations of the effects of distance, seasonal variations and types of tropic forest upon detectability of human "targets" wearing standard olive drab (OD) fatigue uniforms. One study (4) also compared detection of human targets with standard visibility objects.

In all cases the targets were immobile, and observers did not use visual performance aids. No significant differences in 50 percent detection thresholds[1] were found between wet and dry seasons in a broadleaf evergreen-type tropic forest, although illumination levels during the dry season were much higher and noticeable changes in vegetation existed (3). In a semievergreen tropic forest significant differences between detection thresholds for wet and dry seasons were obtained, targets being detected at greater distances during the dry season (5). In contrast to the broadleaf evergreen-type forest the seasonal semievergreen forest has a larger amount of dense, eye-level undergrowth that loses a substantial amount of leaves in the dry season (January through April). This one fact alone contributed heavily to differences in visibility between the two seasons in the semievergreen forest. Another major finding resulting from these studies was that 50 percent detection thresholds averaged (depending upon season) from 14 to 28 feet more in distance in the broadleaf evergreen type forest, although that distance at which target visibility was zero was only slightly higher than for the semievergreen forest. Typically, targets were completely obscured by 100 to 115 feet in distance regardless of forest type (5).

The studies referenced above have accomplished the intended objective of determining basic visibility thresholds, quantitatively derived, for two major types of tropic forests during wet and dry seasons. Within an operational environment many factors may serve to influence the degree to which soldiers can detect human targets. Such things as rain, uneven terrain and effective camouflage would obviously reduce chances of detecting human targets. Other factors such as target motions or noise can most likely increase overall visual detection distance. The present study was the first in the series to investigate the effects of movement upon detection distance. Human targets wore two modes of functional dress typical of many Vietnamese and, combined with movement, represented several operational detection parameters that could be experienced in a jungle environment.

OBJECTIVES

a. To determine the effects of target movement upon target detection in a semievergreen tropic forest.

b. To determine effects of target mode of dress upon detectability.

c. To determine the effects of wet and dry seasonal variations in vegetation upon moving target detection.

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[1] Distance in feet where target is detected on 50 percent of the trials.

METHOD

Observers. A total of 120 observers (Os) were tested - 60 during the wet season and 60 during the dry season. Wet season Os were enlisted men (EM) from the 4th Missile Battalion, 517 Artillery, Fort Clayton, Canal Zone. Dry season Os were EM from the 4th Battalion (Mechanized) 20th Infantry, Fort Clayton. Men selected as Os were tested to assure that all had normal near and far vision, freedom from color blindness and lack of restrictions in peripheral vision. Their age ranged from 17 to 37 years, with a mean of 21.0 years. Modal grade was E-4. As shown in table 1, below, very little variance in age occurred among Os tested on different sites or during different seasons. Modal grade was the same.

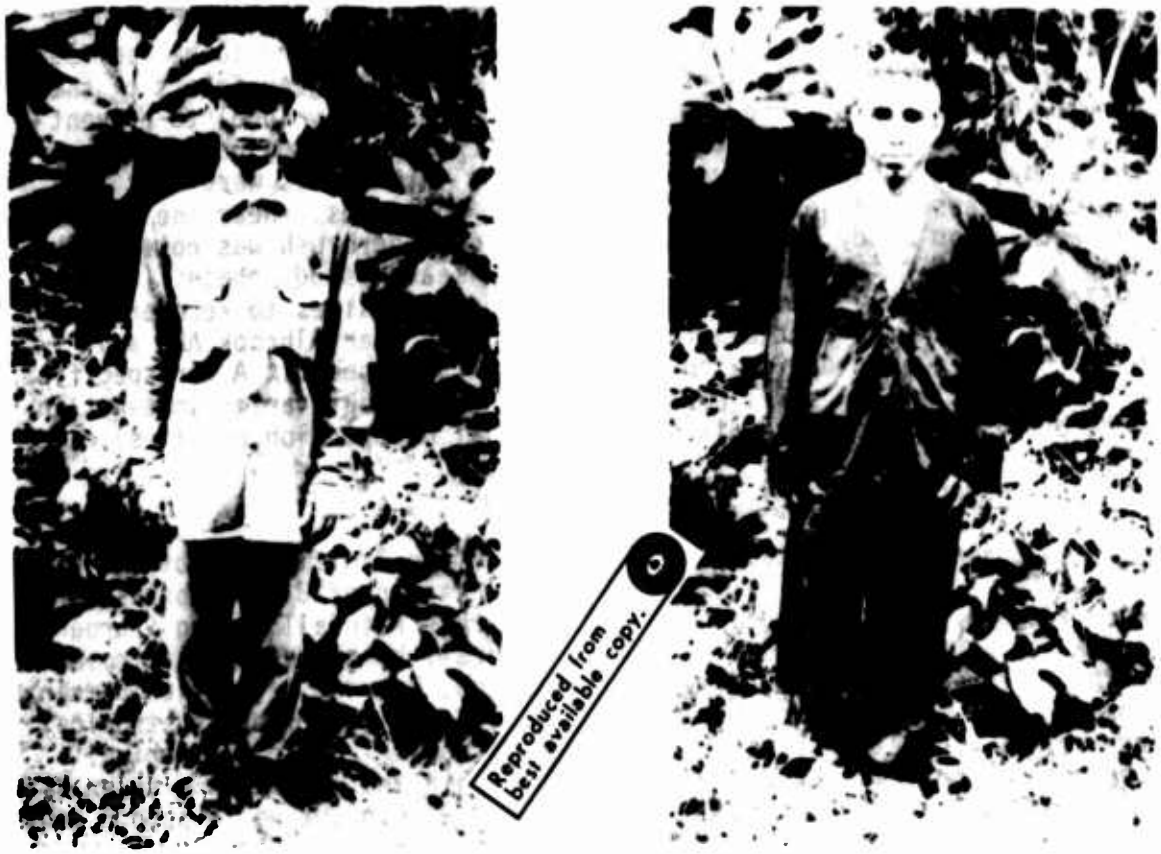
TABLE 1. AGE AND GRADE OF OBSERVERS BY TEST SITE AND SEASON

	Wet Season		Dry Season		Combined Seasons	
Site	Mean Age	Modal Grade	Mean Age	Modal Grade	Mean Age	Modal Grade
A	20.3	E-4	20.8	E-4	20.5	E-4
B	22.0	E-4	20.9	E-4	21.4	E-4
C	20.2	E-4	20.2	E-4	20.2	E-4

Experimenter. One experimenter (E) supervised and controlled testing and data collection procedures. He gave instructions to Os, recorded and scored all data.

Targets. Targets were two persons dressed in either a standard OD fatigue uniform or black pajama-type clothing typical of many Vietnamese (figure 1). The OD uniform consisted of a jacket (not tucked in), trousers and a soft cap Trousers were bloused in standard black combat boots. No insignia were worn. The black pajama-type dress was designed to be a replica of that worn by Vietnamese[1]. Targets wearing both modes of dress were 5 feet, 4 inches and 5 feet, 6 inches in height for the wet season phase and 5 feet, 2 inches and 5 feet, 5 inches for the dry season phase. Targets ranged in weight from 120 to 145 pounds. Faces and all exposed skin surfaces of the targets were blackened with charcoal.

[1] The black clothing was obtained from the Jungle Operations Committee, Army School of the Americas, Fort Sherman, Canal Zone. This clothing is used in simulated RVN village training exercises.



OD FATIGUES

BLACK CLOTHING

Figure 1. Target Dress

Test Sites. Sites used in earlier studies (1 and 5) were also used in the present one. These sites were originally selected to be representative of vegetative variations common to the semievergeen forest of the Canal Zone's Pacific slope. All sites were relatively level to prevent physical terrain features from obscuring targets. During both phases of the study, disturbances of vegetation at the three sites were kept to a minimum necessary to establish O and target positions. Near the end of the wet season study some slight trampling of underbrush was noted. The long period of time between the wet and dry season study phases (October 1967 to April 1969) allowed the underbrush at the sites to recover fully. Site "A" was in the Fort Clayton area, Site "B" near Albrook AFB and Site "C" in an area designated Empire Range (see appendix A for specific map locations). All sites were relatively dense, but varied somewhat in underbrush type (see appendix B for botanical description of sites).

Independent Variables.

a. Season. This study was conducted on the Pacific side of the Canal Zone, where the climate is humid with a dry season of 3 to 4 months duration (January through March or April). Average rainfall during February and March usually is less than 1 inch. Overall brightness is increased through decrease of cloudiness and vegetation, but the vegetation remaining does not allow the brightness to reach levels typical of dry subtropical areas (the vegetation is still very lush in comparison to subtropical regions). For this reason, temperatures within the jungle have never been measured to exceed 96°F or drop below 68°F. Within the wet season 5 months have rainfall that usually average more than 8 inches (October and November usually more than 10 inches per month). The number of days with rain during this season exceeds 20, but rain can be so localized that it is unusual for rain to fall everywhere in the Pacific area on the same day. Vegetation is lush and profuse during the wet season, and the main growth occurs near the beginning of the season. Temperatures during the wet season are in the upper 80s during the days when rain does not occur. During periods of rainfall and at night, temperatures usually drop to the upper 70s. Yearly rainfall (both seasons included) averages about 70 inches.

b. Mode of dress. Standard OD fatigues and black clothing as previously described.

c. Horizontal target placement. Ten radii (paths) extended outward from Os fixed position (figure 2). The Os position was located exactly 30 feet from the ending point of each radius. The true distance from the farthest point of each radius to the O position was 115 feet. The angles of the radii were at a slant to the O position to avoid having Os view down cleared jungle paths. During the construction of these paths along each radius only a small amount of vegetation was cut. This was done in

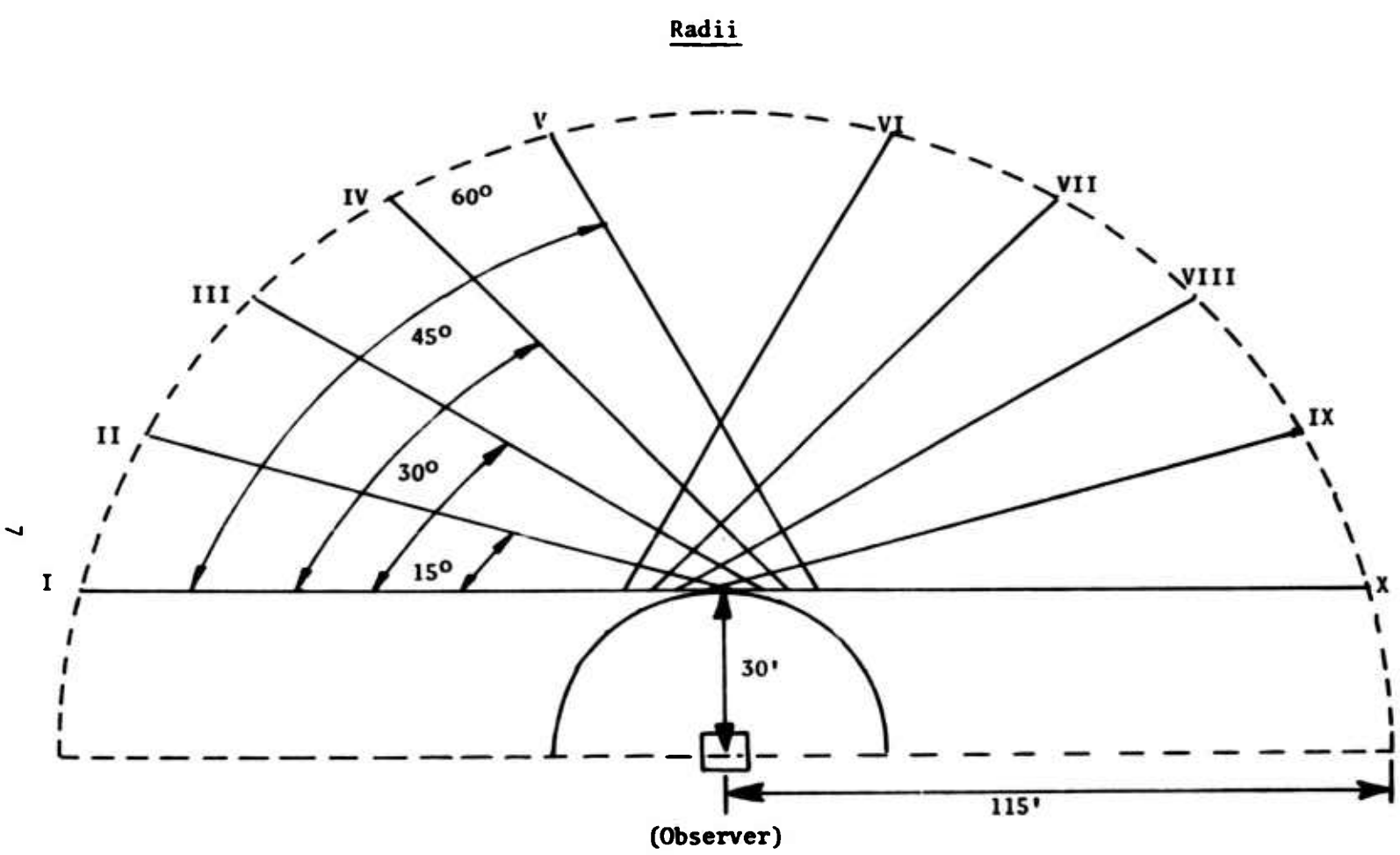


Figure 2. Sketch of the Three Test Sites Showing Target Radii

order to prevent Os receiving strong location cues created by targets moving the underbrush. From the O position these paths could not be discerned. The Os field of search was 180°. All targets actually appeared within a 150° field, but Os were not made aware of this. Camouflaged cloth tape, 2 inches in width, was placed on the ground along the entire length of each radius so that targets could repeatedly follow the same path along any given radius. Distance markers, also obscured from Os view, were placed at 10-foot intervals along each radius so that target distances could be precisely measured. These distances represented radii length from the ending point of the radii. Distances were later converted to true distance from radii to the fixed O position.

Dependent Variables. Performance measures included detection distances, Os estimated detection distance and detection cues. Detection distance was the true distance between an O and a target at the time of detection[1]. For data summaries throughout the report, detection distances for any given series of trials were computed by obtaining the arithmetic mean of the series.

All Os were required to estimate the distance of targets at time of detection. The purpose of this measure was to determine accuracy of perceived distance in a jungle environment.

When a target was detected, Os were asked what portion(s) of the target they saw first. This information was gathered to investigate whether certain body or uniform cues predominate over others in the detection of moving targets. Such information could possibly aid in target acquisition training and in improving scanning techniques in heavily vegetated areas.

Research Design. Table 2 summarizes the research design for one season. Observers were divided into two groups. One group observed only targets wearing OD fatigues, and the other wearing only black (appendix C). Within groups, each O received 30 trials (three trials per radius). Target sequence was randomized across radii by a table of random numbers. Thus, for each study phase, a total of 1800 observations were made.

Procedure. Two Os were tested on one site each day. The Os were tested one at a time. Each O observed only one type of target (either OD or black depending upon target sequence). Site locations alternated

[1] The study was designed to have targets always moving toward the O position, thus the data did not lend itself to the same type of analysis made for the still target studies wherein 50 percent detection thresholds were determined.

TABLE 2. RESEARCH DESIGN OF ONE SEASON

N Observations by Radius

Site	Target Dress	Number of Os	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
A	OD	10	30	30	30	30	30	30	30	30	30	30	300
	Black	10	30	30	30	30	30	30	30	30	30	30	300
B	OD	10	30	30	30	30	30	30	30	30	30	30	300
	Black	10	30	30	30	30	30	30	30	30	30	30	300
C	OD	10	30	30	30	30	30	30	30	30	30	30	300
	Black	10	30	30	30	30	30	30	30	30	30	30	300
Total N =		60	180	180	180	180	180	180	180	180	180	180	1800

from one test day to the next for a total test time of 30 days per season. All testing occurred within a mid-to-late morning time period. Testing was not conducted during periods of rain. At no time was wind velocity under the jungle canopy high enough to create significant movement of underbrush. In order to control the possible influence of difference in illumination levels and wind speed upon detection distances between one site and the next, sites were changed from one test day to the next.

Each O was told by the E that this was a test of his ability to spot moving targets in the jungle (see detailed instructions in appendix D). The O was familiarized with the particular target to be identified by being shown the target at a close distance for a period of not less than 1 minute. The O was told that the target would appear at any point along the 180° horizontal field of search defined by visible stakes along left and right boundaries. The O was instructed to press a buzzer immediately upon detecting a target, and then point to the target (to assure that O did not make a false detection). The O was instructed to estimate the target distance and tell E what portion or portions of the target were detected first. During this procedure the O was confined to a marked square with sides 3 feet long (figure 3). He was allowed to move in any manner deemed appropriate in attempting to make a detection, but was not allowed to move his head outside of the marked square. The O was fitted with ear protectors to prevent his obtaining localization cues created by noises made by targets moving through the vegetation.

Before the start of each trial E turned O around facing away from the search area. The target took his position at the starting point on a given radius (115 feet away from O). The target gave a signal to E (inaudible to O wearing the ear protectors) that he was in position and ready to start walking along the radius. At this point E turned the O facing the field of search.

The target again signaled E at the start of his movement. When O detected the target he signaled with the buzzer. The target stopped immediately, marked his position, and waited until E recorded the data given by O (see appendix E for data sheet). After the data were recorded, the target measured his distance (point bisecting the vertical plane of his body) from the nearest distance marker along the radius. This information was given E before the start of the next trial. The E then turned O around again, facing away from the field of search, and the target retreated along the radius to resume another radius position for the next given trial. This procedure was repeated until all 30 trials were finished, but O was given a 15-minute rest period after the first 15 trials. Total testing time for each O averaged 50 minutes.

Figure 3. Observer Station

Prior to the start of each study, the E and the individuals serving as targets underwent a 2-week training and rehearsal period to solve procedural difficulties and to assure a smooth, well timed presentation. During this period targets were trained to walk at a relatively stable rate of movement, to avoid shaking or otherwise moving underbrush, and to stop immediately upon hearing the buzzer signal given by Os. Rate of target movement was recorded throughout the study. This was determined by dividing the time the target started movement, and was finally detected, into the distance covered along a radius. The average rate of movement was 2.8 feet per second (a slow walking pace). This pace was closely monitored throughout the study to avoid large differences in rate of movement; a factor that possibly could have biased results.

RESULTS

Most of the tables in the following section show mean detection distances for the various conditions. More detailed data, including standard deviations and ranges, are presented in appendix F. Where appropriate, means were weighted to account for unequal Ns in the wet season data. Unequal Ns for wet season data were due to the fact that the black target dress was not received until 18 Os were tested. Twenty-one of the 42 Os remaining to be tested observed targets wearing the black clothing. A total of 39 Os observed targets wearing OD fatigues.

Wet and Dry Season Detection Distances. Table 3 shows mean detection distances by season and site. Data are also combined across seasons and sites. Combining sites, the mean detection between wet and dry seasons varied only slightly (a difference of just 3.2 feet). When subjected to a t-test seasonal differences were not statistically significant ($t = 1.921$; $P > .05$; $df = 118$). In addition, differences between individual sites were not statistically significant at an acceptable level of confidence except in one case (site C season means--$t = 4.254$; $P < .01$; $df = 38$)

TABLE 3. MEAN DETECTION DISTANCE (FEET) BY SITE AND SEASON

	Season		
Site	Wet	Dry	Both Seasons
A	46.2	44.6	45.4
B	54.0	54.8	54.4
C	57.5	68.0	62.8
All Sites	52.6	55.8	54.2

In an earlier study dealing with detection of motionless targets (5) it was noted that sites A and B were characterized by large amounts of climbing bamboo vines (Arthrostylidium racemiflorum), and that this vine was one of the few types of eye-level vegetation that loses its leaves during the dry season. As previously mentioned, rainfall varies greatly from wet to dry season, but rain from one day to the next can be localized (seldom falling over the entire Pacific area). Although inspection of meteorological data for the seasons (1967 and 1969) indicated that both were "typically" wet or dry in terms of rainfall, not enough locale variations in ground moisture occurred for sites A and B between adjacent seasons to create visually meaningful differences in density of eye-level vegetation. During the dry season it was noted that most of the climbing bamboo remained green, with very little leaf drop, throughout the testing phase. Thus, obscuration levels were about the same for sites A and B regardless of season in which testing was conducted.

From inspection of table 3 it can also be noted that no reversals in site severity for single sites occurred. Differences in density of vegetation from one site to the next remained relatively stable regardless of seasonal influence.

Detection Distances By Target Type. The overall difference in detection means between the mode of dress was only 1.2 feet (table 4). Mean detection distance of targets wearing OD fatigues was 54.7 feet as opposed to 53.5 feet for targets wearing black clothing. This difference was not statistically significant ($t = 0.980$; $P > .05$; $df = 118$).

TABLE 4. MEAN DETECTION DISTANCE (FEET) BY TARGET TYPE

	Target Type		
Site	OD Fatigues	Black Clothing	All Targets
A	46.1	44.5	45.4
B	55.2	53.4	54.4
C	62.9	62.5	62.8
All Sites	54.7	53.5	54.2

The preceding table also illustrates that mean detection distances varied little within sites. The largest difference between the sites was for site B (only 1.8 feet). Tests of significance were computed for differences

in detection between target types for the individual wet and dry seasons No significant differences were found, thus wet and dry season data were combined in table 4.

Angle of Target Approach. Mean detection distances were examined by site and within season to determine whether angles of target approach (refer back to figure 2) had a strong influence upon detection. Figures 4 and 5 show mean detection distances by radii and site for the wet and dry seasons. No one radius predominated in terms of best detection angle, nor could consistent left, center or right bias be found in the data concerning the direction of Os field of search

Visibility Gradients. Figure 6 shows the percentage of targets detected by season in intervals of 10 feet (for a more detailed breakout by site and season refer to appendix G). Beyond 70 feet less than 18 percent of the targets were detected, and almost total target obscuration occurred beyond 79 feet in the jungle vegetation.

Cumulative frequency distributions of targets detected, by season, are shown in figure 7. The curves are characteristic of the reverse "S" visibility gradients previously found in studies conducted in a semi-evergreen tropic forest (5) in which targets were motionless. Both curves are very similar, with the wet season curve being slightly lower at the 50 to 59 feet distance intervals and beyond. The rapid fall off in detection rates beyond 70 feet in distance can readily be seen.

Practice Effects. The 30 trials administered to all Os were subdivided into a first, second and third 10-trial series for both seasons (table 5).

TABLE 5. COMPARISON OF TRIALS BY MEAN DETECTION DISTANCE (FEET) FOR DETERMINATION OF PRACTICE EFFECTS

Trials	Wet	Dry	Combined
First 10	51.7	56.9	54.2
Second 10	52.9	54.8	53.8
Third 10	53.4	55.0	54.2

From inspection of the above table it is concluded that practice did not improve detection performance during the course of the experiment. Wet season mean detection distances do increase slightly from the first to the third 10-trial series, however the differences between these means were not statistically significant.

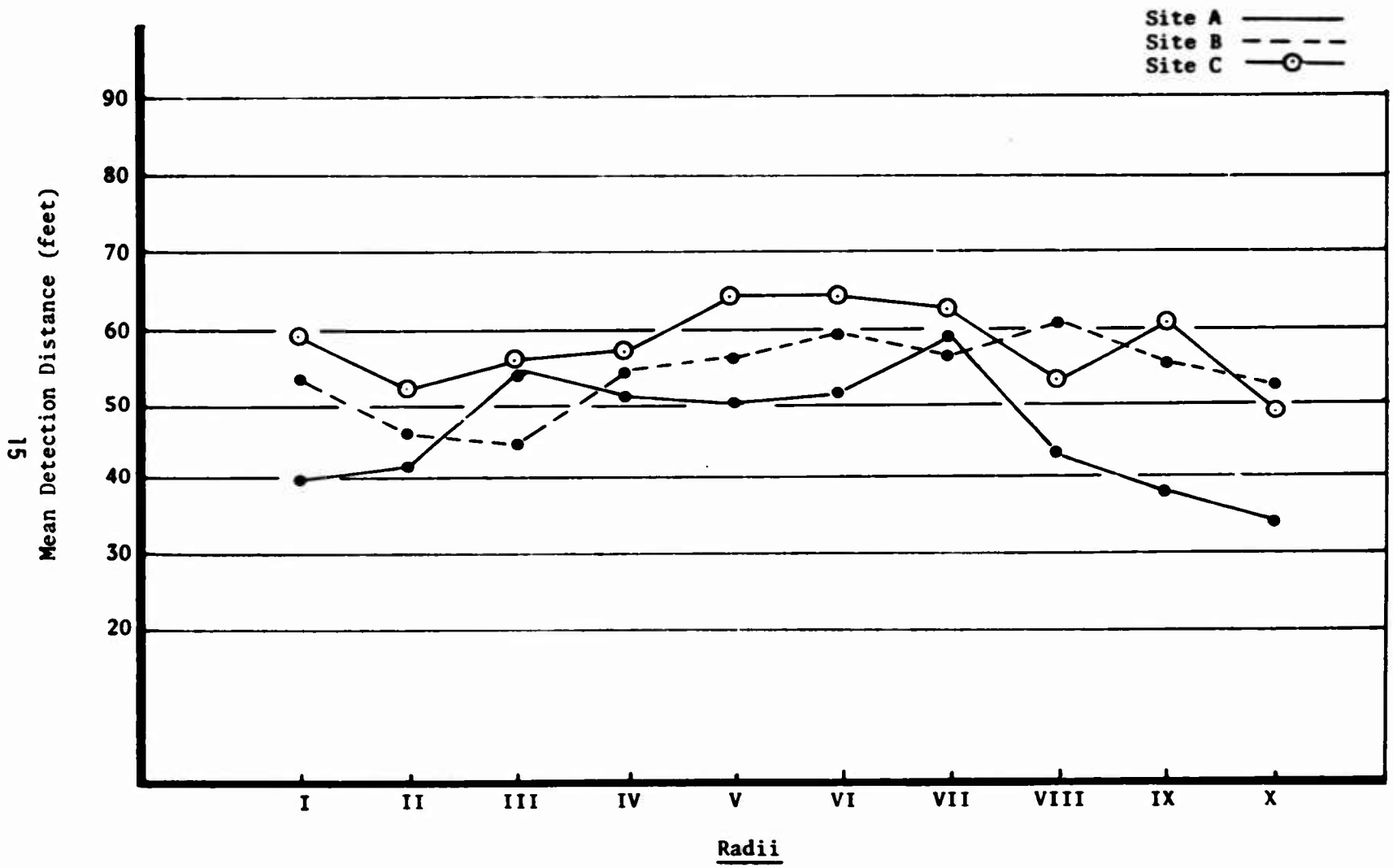


Figure 4. Wet Season Mean Detection Distances by Site and Radii

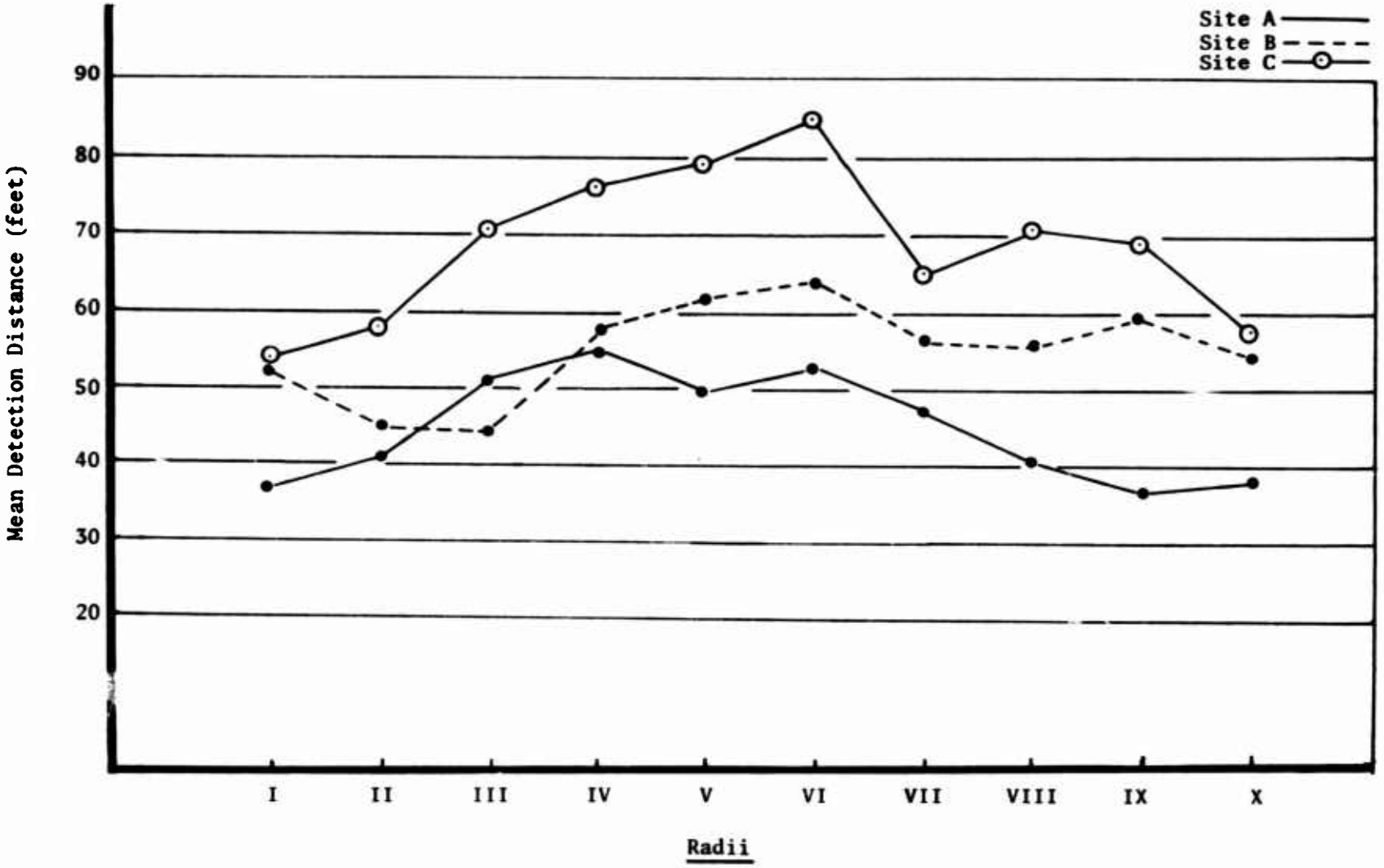


Figure 5. Dry Season Mean Detection Distances by Site and Radii

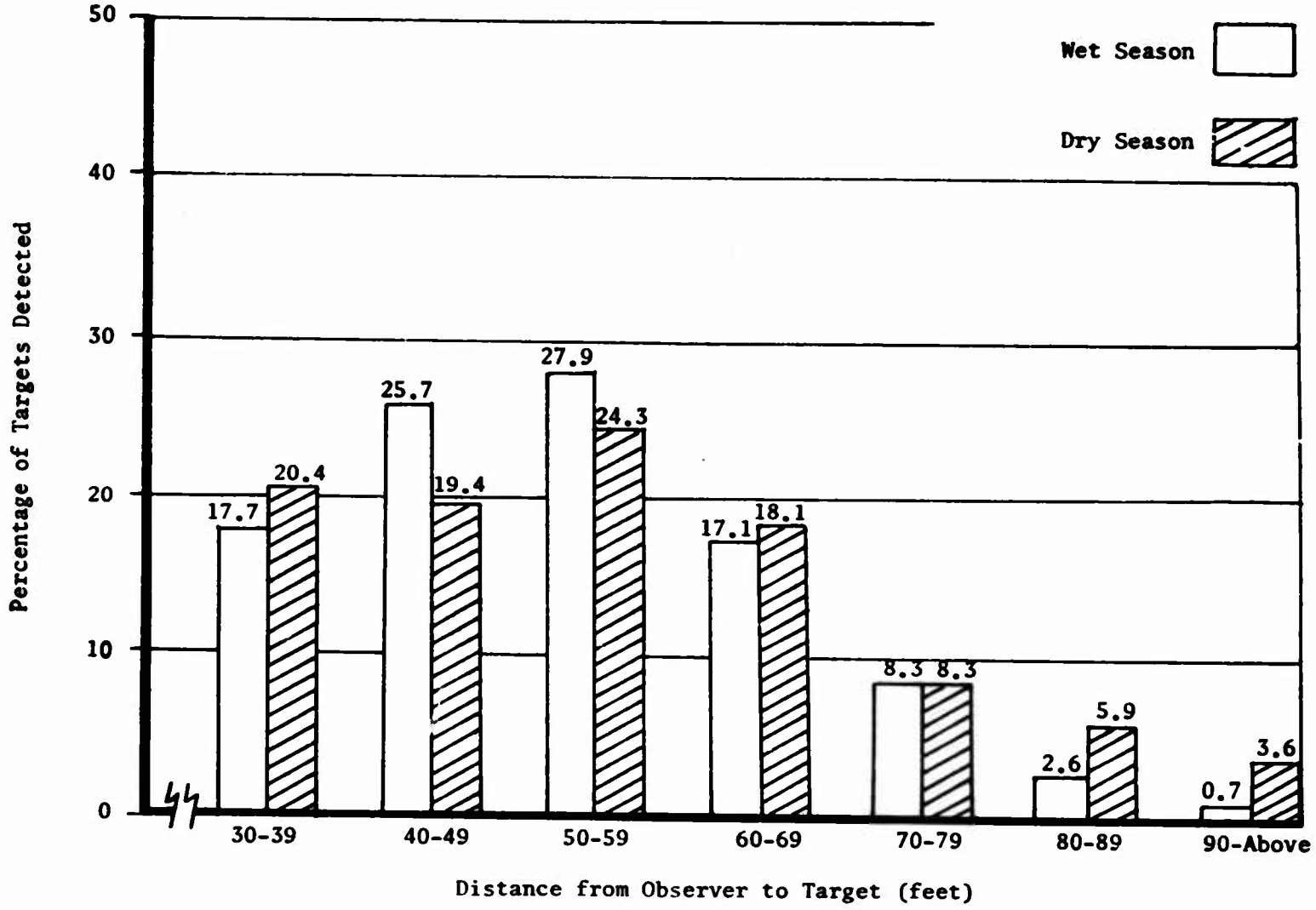


Figure 6. Comparison of Percentage of Targets Detected at Given Distances by Season

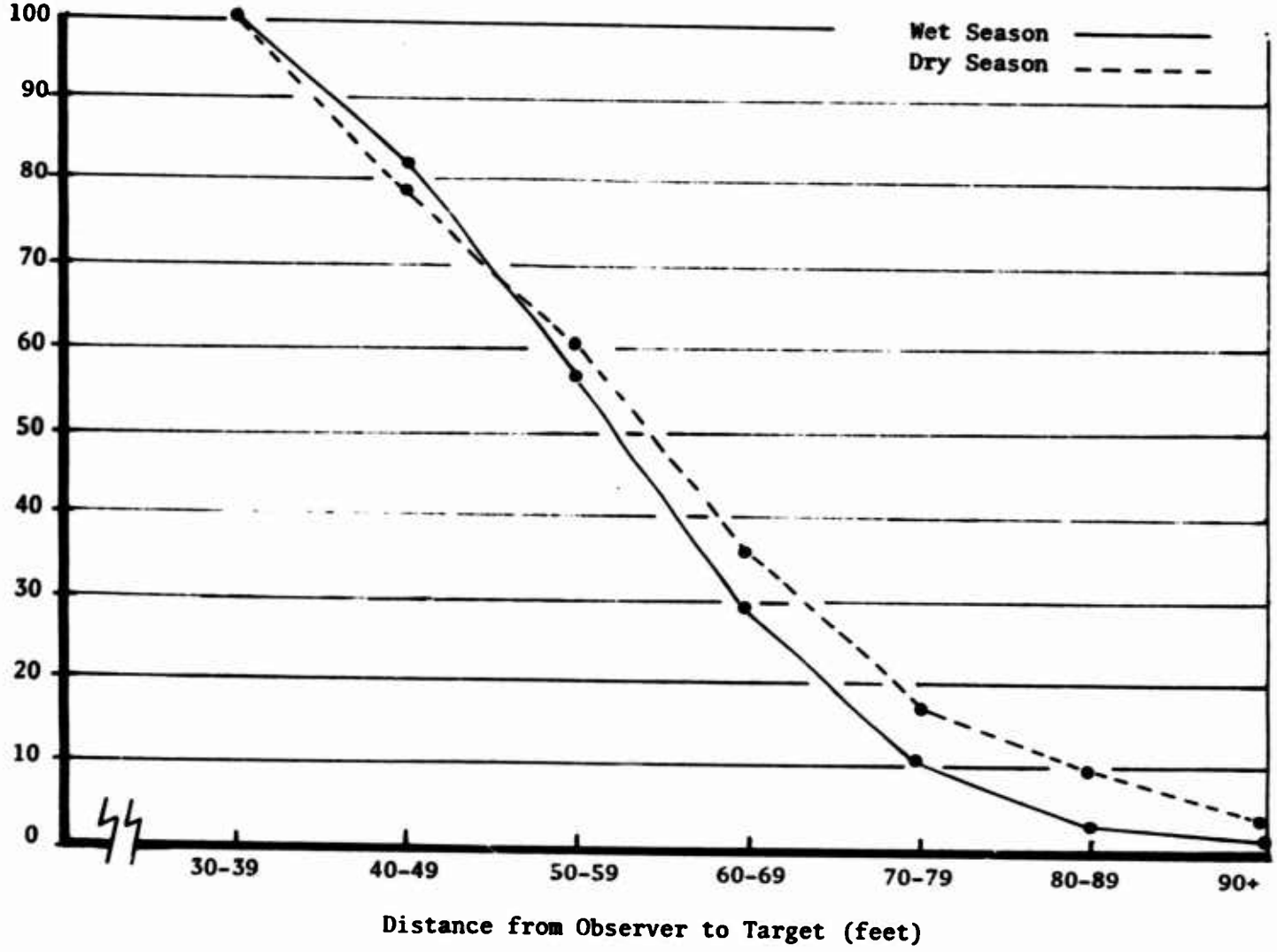


Figure 7. Comparison of Visibility Gradients for Dry and Wet Season

Distance Estimates. These data were obtained to determine whether "consistent" errors of over or under estimation existed. In the earlier studies on motionless targets it was found that Os who used the metric system tended to overestimate the true distance, and Os using feet in their estimates tended to underestimate the true distance (3). The Os were asked only to estimate in feet for the present study. Figure 8 shows that, as for the case of motionless targets, Os tend to underestimate distance when using the English system of feet. While only slightly over 41 percent of the targets were detected at 49 feet and below, Os estimated target distance below 49 feet for 60 percent of all trials. Although comparisons were not made on a trial-by-trial basis, the data provide strong evidence that the tendency to underestimate target distance in feet holds true for moving target detections in tropic forests.

Detection Cues. Each O was asked to tell E what portion of the target was first detected for all completed detection trials. Responses were categorized into single cues, but multiple cues were given in many instances (e.g., "head and shoulders"). Multiple cues were broken down into single categories listed in table 6).

TABLE 6. DISTRIBUTION OF DETECTION CUES BY SEASON

Cue	Season			
	WET		DRY	
	N	%	N	%
Trunk	464	21.6	456	23.9
Legs	315	14.7	365	19.1
Face	89	4.1	71	3.7
Head	555	25.9	406	21.2
Shoulders	302	14.1	178	9.3
Arms	241	11.2	124	6.5
Boots	22	1.0	5	0.3
Clothing	25	1.2	50	2.6
Entire Person	132	6.2	255	13.4
TOTAL	2145	100.0	1910	100.0

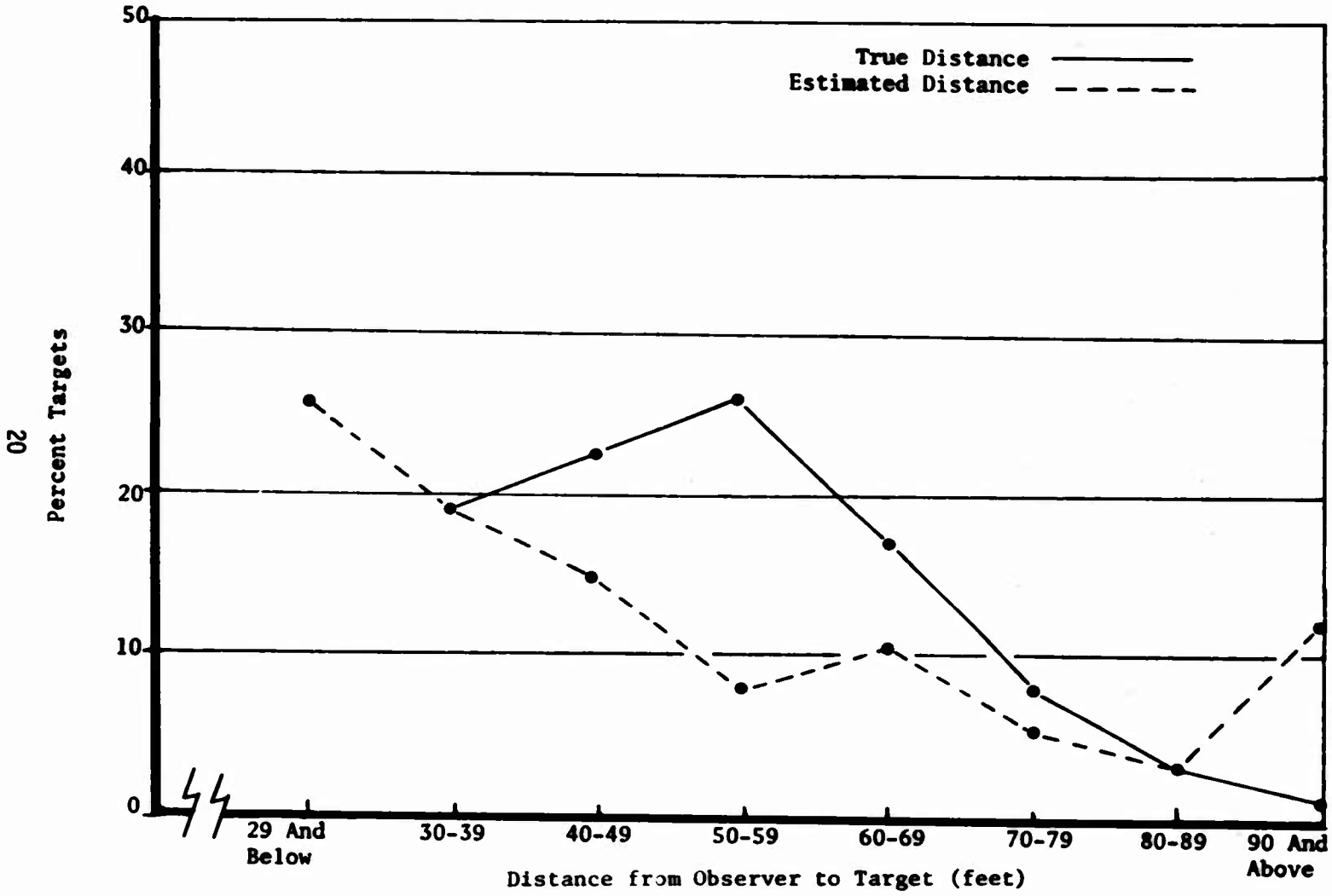
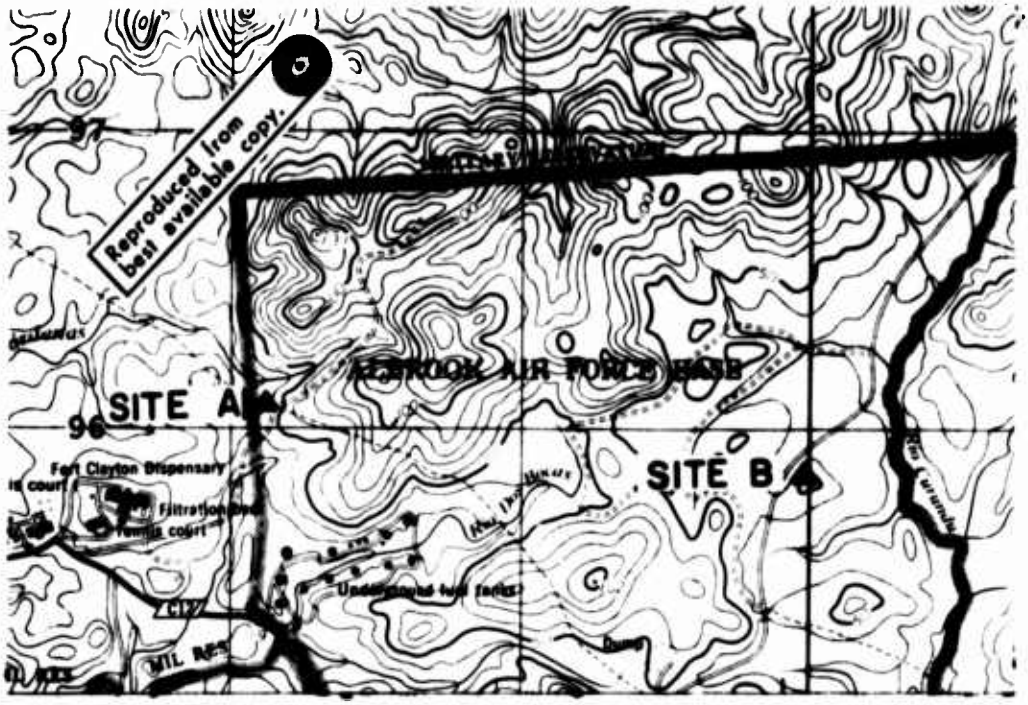


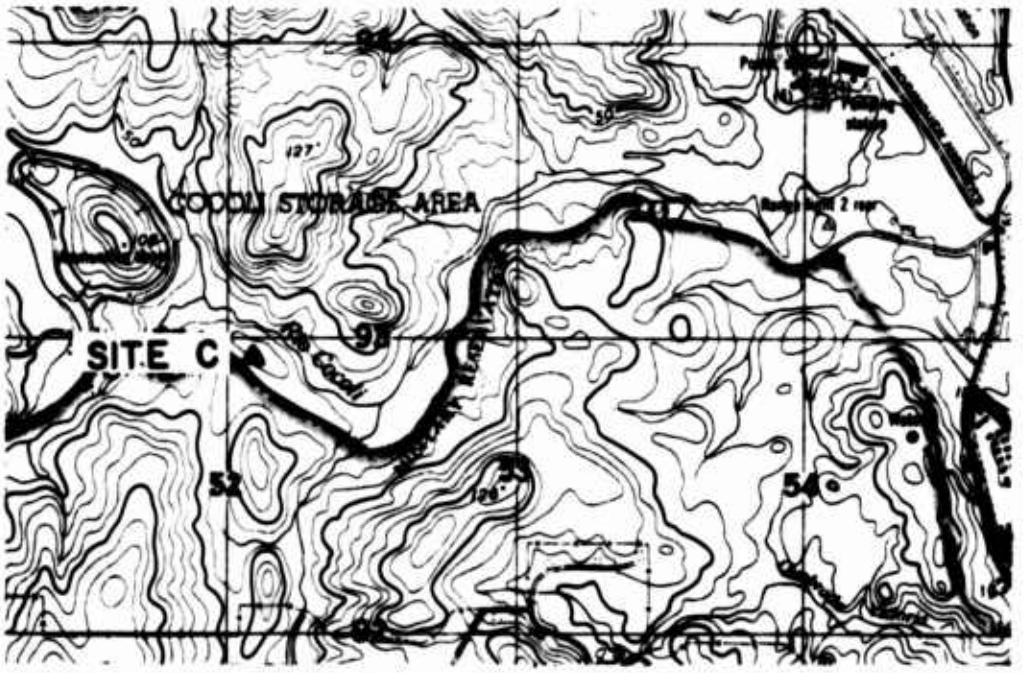
Figure 8. Percentage of True Target Detection Distances and Estimated Target Distances for Wet and Dry Season Data Combined.

All Os indicated that detection of movement first directed them to the target location, thus the above cues represent what Os first identified after the target was detected, although not in the same proportional sequence for both seasons. The trunk, legs and head of the target accounted for almost two-thirds of the detection cues, regardless of season (62.2 percent and 64.2 percent of total for wet and dry seasons, respectively). A Chi-square test between seasonal variation in distributions of cues was not significant ($\chi^2 = 6.942$; $P>5\%$ $df = 8$).

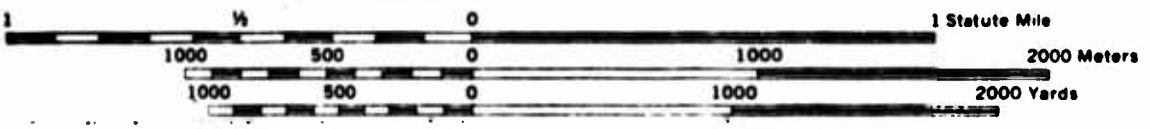
APPENDIX A



SITE LOCATION (Fort Clayton, Panama, Canal Zone, Series E866 Sheet 4243 II SE Edition 1-AMS)



Scale 1:25,000



SITE LOCATION (Panama, Panama, Series E866, Sheet 4242 I NE Edition 1-AMS)

APPENDIX B

VEGETATION DESCRIPTION OF SITES

Fort Clayton Site (Site A)

Type: Pacific Semievergreen Seasonal Forest

Canopy: This canopy was very irregular, with no definitely established canopy, but with larger trees to 70 feet. Smaller trees occupy the gaps, extending 55 to 60 feet Stem diameters of canopy species were 10 to 14 inches Canopy coverage is so sparse that only 45 to 50 percent ground surface is shaded. Principal canopy species were:

Anacardium	excelsum	espave
Annona	spp	annona
Bursera	simiruba	gumbolimbo
Cecropia	spp	guarumo
Lafoensia	punicifolia	amarillo

Subcanopy: This layer, extending to 30 feet, is made up of saplings of annona and espave. Scattered shrubs (rubials) occur, along with much climbing bamboo, Chusquea Simpliciflora, and vines.

Ground Cover: From ground to 30 feet, there is a moderately dense tangle of vines and liana, supported by small shrubs and trees. Some larger lianas are 4 inches in diameter. Scattered ferns (to 3 feet) are the only true ground cover

General Note: This forest is an irregular, submature formation that has been repeatedly disturbed. Though the larger trees must approach 70 to 75 years of age, the complex itself is immature, and probably is no more than 40 years old. The poor canopy development allows light to penetrate to the ground, which has generated a rank, profuse growth of vines, lianas, shrubs, and climbing bamboos. In terms of density, this site has an understory thicker than site C, but more sparse than site B.

Albrook Air Force Base Site (Site B)

Type: Pacific Semievergreen Seasonal Forest (Second-growth)

Canopy: Canopy trees at this site were younger than at sites A and C, averaging only 55 feet in height, and shading only 60 percent of the ground surface. Stem diameters of canopy species were from 4 to 9 inches. Principal species making up the canopy were, in order of importance:

Brusera	simiruba	gumbolimbo
Xylopia	aromatica	malagueto

Cecropia	spp	guarumo
Luehea	speciosa	guacimo
Miconia	spp	dos caras

Subcanopy: A heavy, dense understory of shrubs, vines, and seedling trees occupies the area between ground level and 30 feet. More than 90 percent of the ground surface is shaded by this vegetation layer. Principal species are:

Scheelia	zonensis (young)	palma real
Anacardium	excelsum (young)	espave
Annona	hayesii	custard-apple
Posoqueria	latifolia (shrub)	borajo
Hirtella	racemosa (shrub)	
Arthrostylidium	racemiflorum	climbing bamboo
Costus	spicatus (herb)	cana de Cristo
Carludovica	palmata (clumps)	Panama hat palm

Ground Cover: Understory and ground cover are mingled all the way into the subcanopy. Young palms and low ferns (to 3 feet) occur, but vines, lianas, and climbing bamboo are the principal components.

General Note: The vegetation on this site is a younger (25 to 35 years) forest than that occurring on site C. This type of young second-growth forest occurs over wide areas of the humid tropics where land has been cleared, then left fallow to revegetate.

As at the Fort Clayton site, however, the greatest hindrances to visibility in this area were the numerous vines and lianas. Hanging from the trees and shrubs, these features formed a web throughout the entire site. Some of the lianas were up to 5 inches thick, but most of the vines were less than one-half inch in diameter. Many of the smaller vines presented hazards in the form of long spines and needles. All of them had many leaves, most of which were green.

Empire Range Site (Site C)

Type: Pacific Semievergreen Seasonal Forest

Canopy: Trees making up the canopy were 8 to 13 inches in diameter, and averaged 83 feet in height. Scattered emergents extend to 104 feet. Actual ground area covered by tree canopy was approximately 75 percent. Fifty-five percent of tree species in this type are deciduous. Principal species making up the canopy were, in order of numercical occurrence:

Terminalia	amazonia	amarillo real
Scheelea	zonensis	palma real
Chrysophyllum	cainito	star-apple

Luehea	seemannii	guacimo
Anacardium	excelsum	espave

Subcanopy: This vegetative layer, extending to 25 feet, shaded some 90 percent of the ground. Principal species were:

Trichospermum mexicanum		
Annona	hayesii	custard-apple
Bactris spp		black-palm
Scheelia	zonensis (young)	palma real

Understory: This extremely dense vegetative layer, to 12 feet in height, was made up of vines and shrubs with a conspicuous component of young palms. Principal species were:

Arthrostylidium	racemiflorum	climbing bamboo
Miconia spp		dos caras
Rubiaceae		rubials
Piper spp		pepper bush

General Note: This vegetative type is typical of large areas of the Central American tropics. It is an older stage (75 to 85 years) of vegetative succession on disturbed land. The high percentage of deciduous vegetation, which extends to the understory layer, emphasizes its seasonal variability. The true evergreen aspect of this site is maintained by the large numbers of Bactris and Scheelia palms with their long fronds.

APPENDIX C

SEQUENCE OF OBSERVERS, SITE, UNIFORM, BY TEST DAY

WET SEASON

OBS	DAY	SITE	UNIF	OBS	DAY	SITE	UNIF	OBS	DAY	SITE	UNIF
1	1	A	OD	21	11	C	BK	41	21	B	BK
2	1	A	OD	22	11	C	OD	42	21	B	OD
3	2	C	OD	23	12	B	BK	43	22	A	BK
4	2	C	OD	24	12	B	OD	44	22	A	OD
5	3	B	OD	25	13	A	BK	45	23	C	BK
6	3	B	OD	26	13	A	OD	46	23	C	OD
7	4	A	OD	27	14	C	BK	47	24	B	BK
8	4	A	OD	28	14	C	OD	48	24	B	OD
9	5	C	OD	29	15	B	BK	49	25	A	BK
10	5	C	OD	30	15	B	OD	50	25	A	OD
11	6	B	OD	31	16	A	BK	51	26	C	BK
12	6	B	OD	32	16	A	OD	52	26	C	OD
13	7	A	OD	33	17	C	BK	53	27	B	BK
14	7	A	OD	34	17	C	OD	54	27	B	OD
15	8	C	OD	35	18	B	BK	55	28	A	BK
16	8	C	OD	36	18	B	OD	56	28	A	OD
17	9	B	OD	37	19	A	BK	57	29	C	BK
18	9	B	OD	38	19	A	OD	58	29	C	OD
19	10	A	BK	39	20	C	BK	59	30	B	BK
20	10	A	OD	40	20	C	OD	60	30	B	OD

DRY SEASON

1	1	A	OD	21	11	B	OD	41	21	C	OD
2	1	A	BK	22	11	B	BK	42	21	C	BK
3	2	B	OD	23	12	C	OD	43	22	A	OD
4	2	B	BK	24	12	C	BK	44	22	A	BK
5	3	C	OD	25	13	A	OD	45	23	B	OD
6	3	C	BK	26	13	A	BK	46	23	B	BK
7	4	A	OD	27	14	B	OD	47	24	C	OD
8	4	A	BK	28	14	B	BK	48	24	C	BK
9	5	B	OD	29	15	C	OD	49	25	A	OD
10	5	B	BK	30	15	C	BK	50	25	A	BK
11	6	C	OD	31	16	A	OD	51	26	B	OD
12	6	C	BK	32	16	A	BK	52	26	B	BK
13	7	A	OD	33	17	B	OD	53	27	C	OD
14	7	A	BK	34	17	B	BK	54	27	C	BK
15	8	B	OD	35	18	C	OD	55	28	A	OD
16	8	B	BK	36	18	C	BK	56	28	A	BK
17	9	C	OD	37	19	A	OD	57	29	B	OD
18	9	C	BK	38	19	A	BK	58	29	B	BK
19	10	A	OD	39	20	B	OD	59	30	C	OD
20	10	A	BK	40	20	B	BK	60	30	C	BK

APPENDIX D

INSTRUCTIONS GIVEN TO SUBJECTS

This is a research test conducted by the United States Army Tropic Test Center

We are trying to see how well you can detect moving targets in the jungle. You will see one of these fellows (demonstrate) moving somewhere between nine o'clock (point) and three o'clock (point) There will be only one target at a time. You will be wearing these earguards and standing facing me inside this cloth square (point). When I give you the signal you will turn around and search for the target . may crouch, kneel or even lie down, providing you don't move your head outside the square. If you spot him press this button immediately (demonstrate), point to him and tell me how far away you think he is. Also tell me what portion of the man you saw first - head, shoulder, clothes, etc.

There will be 30 trials in all and the test will last about an hour and a half. Remember just as soon as you spot him or think you spot him press this button. Are there any questions?

APPENDIX E

SCORE SHEET

JUNGLE VISION VIII

EXPERIMENTER _____ OBSERVER _____ DATE _____

START TIME _____ SITE _____ UNIFORM _____

Trial	Lane	Detection Distance	Det Time Sec	Cue	Wind	Scan Time Sec	Trial	Lane	Detection Distance	Det Time Sec	Cue	Wind	Scan Time Sec
1	V						16	IV					
2	IV						17	II					
3	X						18	I					
4	VIII						19	III					
5	I						20	X					
6	VII						21	VII					
7	VI						22	VIII					
8	VIII						23	VII					
9	III						24	X					
10	VI						25	IX					
11	IX						26	VI					
12	IV						27	II					
13	II						28	I					
14	V						29	III					
15	IX						30	V					

END TIME _____

Remarks: Record any unusual events which might have influenced the outcome of the test including the attitude of the observer, performance of the targets, unusual weather conditions, etc., _____

_____

_____

Cue Code:
- T = Trunk
- L = Legs
- F = Face
- H = Head
- S = Shoulders
- A = Arms
- B = Boots
- C = Clothing
- E = Entire person

Wind Code:
- 0 = Calm - Smoke rises vertically.
- 1 = Light Air - Wind direction shown by smoke drift but not by vanes.
- 2 = Slight breeze - Wind felt on face; leaves rustle; ordinary vane moved by wind.
- 3 = Gentle breeze - Leaves and twigs in constant motion; wind extends light flag.
- 4 = Moderate breeze - Small branches are moved.

APPENDIX F

SUMMARY DATA ON VISUAL DETECTIONS (FEET)

Radii

	I	II	III	IV	V	VI	VII	VIII	IX	X	Total Sites
Dry Season - Uniforms Combined											
Mean	47.3	48.1	55.6	62.9	62.9	66.9	55.7	55.1	54.2	49.5	55.8
SD	12.3	12.1	15.4	16.3	16.3	18.6	9.2	16.8	17.4	15.1	16.5
Range - High	76.6	103.9	106.6	98.7	102.3	100.9	76.3	105.0	87.3	102.3	106.6
- Low	30.0	31.4	31.0	31.6	30.0	30.0	32.8	30.2	30.2	30.2	30.0
Wet Season - Uniforms Combined											
Mean	50.7	46.3	51.0	53.7	56.7	58.6	59.2	52.4	51.9	45.5	52.6
SD	13.9	10.7	10.6	14.6	12.5	13.4	9.6	13.0	14.1	13.0	13.0
Range - High	79.9	79.4	88.2	98.2	106.1	92.1	92.0	98.9	83.0	107.9	107.9
- Low	30.3	30.6	32.6	30.9	34.5	30.3	32.3	33.2	32.0	30.3	30.3
Seasons - Uniforms Combined											
Mean	49.0	47.2	53.3	58.3	59.8	62.8	57.4	53.8	53.0	47.5	54.2
SD	13.6	9.9	10.5	11.9	12.2	12.6	9.2	12.2	13.2	13.0	12.4
Range - High	79.9	103.9	106.6	98.7	106.1	100.9	92.0	105.0	87.3	107.9	107.9
- Low	30.0	30.6	31.0	30.9	30.0	30.0	32.3	33.2	30.2	30.2	30.0

APPENDIX G

PERCENTAGE OF TARGETS DETECTED AT GIVEN DISTANCES BY SITE AND SEASON

Distance (feet)	Site A		Site B		Site C		All Sites	
	Wet Season (%)	Dry Season (%)	Wet Season (%)	Dry Season (%)	Wet Season (%)	Dry Season (%)	Wet Season (%)	Dry Season (%)
30-39	36.5	49.0	11.5	8.5	5.0	3.8	17.7	20.4
40-49	27.7	19.0	29.7	27.7	19.8	11.5	25.7	19.4
50-59	20.8	21.2	30.0	31.7	32.9	20.2	27.9	24.3
60-69	10.0	6.8	13.8	23.5	27.5	23.8	17.1	18.1
70-79	3.5	3.0	10.5	6.3	11.0	15.5	8.3	8.3
80-89	1.5	0.8	3.7	2.0	2.5	15.0	2.6	5.9
90-above	0.0	0.2	0.8	0.3	1.3	10.2	0.7	3.6
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

APPENDIX H

LITERATURE CITED

1. Dobbins, D. A., and M. Gast. Jungle Vision I: Effects of Distance, Horizontal Placement, and Site on Personnel Detection in a Semideciduous Tropical Forest, U. S. Army Tropic Test Center Report, Fort Clayton, Canal Zone, April 1964.

2. Dobbins, D. A., and M. Gast. Jungle Vision II: Effects of Distance, Horizontal Placement, and Site on Personnel Detection in an Evergreen Rainforest, U. S. Army Tropic Test Center Research Report, Fort Clayton, Canal Zone, November 1964.

3. Dobbins, D. A., M. Gast, and C. M. Kindick. Jungle Vision III: Effects of Seasonal Variation on Personnel Detection in an Evergreen Rainforest, U. S. Army Tropic Test Center Research Report, No. 3, Fort Clayton, Canal Zone, May 1965.

4. Dobbins, D. A., and C. M. Kindick. Jungle Vision VI: A Comparison Between the Detectability of Human Targets and Standard Visibility Objects in an Evergreen Rainforest, U. S. Army Tropic Test Center Research Report, No. 6, Fort Clayton, Canal Zone, February 1966.

5. Dobbins, D. A., R. Ah Chu, and C. M. Kindick. Jungle Vision VII: Seasonal Variations in Personnel Detectability in a Semideciduous Tropical Forest, U. S. Army Tropic Test Center Research Report, No. 8, Fort Clayton, Canal Zone, January 1967.