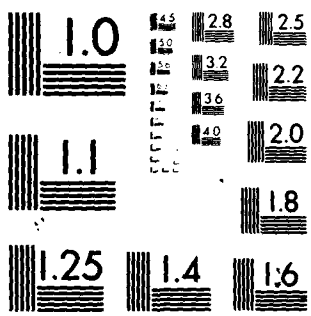
AD-A092 661 ENVIRONMENTAL RESEARCH INST OF MICHIGAN ANN ARBOR RA--ETC F/G 19/1
A CHARACTERIZATION OF WEST GERMAN TERRAIN AND LAND USE IN CONNE--ETC(U)
AUG 80 A LAWSON, Y MORITA DAAK70-78-C-0198
UNCLASSIFIED ERIM-138300-39-T NL

1 OF 1
AD
A092661

END
DATE
FILMED
1 81
DTIC


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

LEVEL II

138300-39-T

AD A092681

A CHARACTERIZATION OF WEST GERMAN TERRAIN AND LAND USE IN CONNECTION WITH MINEFIELD DETECTION

A. LAWSON
Y. MORITA
Radar and Optics Division

August 1980

"Original contains color plates: All DTIC reproductions will be in black and white"

Prepared for
U.S. Army Mobility Equipment
Research and Development Command
Ft. Belvoir, VA

Contract DAAK 70-78-C-0198

ENVIRONMENTAL
RESEARCH INSTITUTE OF MICHIGAN
BOX 8618 • ANN ARBOR • MICHIGAN 48107

80 12 04 134

NOTICES

Sponsorship. The work reported herein was conducted by the Radar and Optics Division of the Environmental Research Institute of Michigan for the U.S. Army Mobility Equipment Research and Development Command under Contract DAAK70-78-C-0198. Contracts and grants to the Institute for the support of sponsored research are administered through the Office of Contracts Administration.

The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

Distribution. Initial distribution is indicated at the end of this document.

Final Disposition. After this document has served its purpose, it may be destroyed. Please do not return it to the Environmental Research Institute of Michigan.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A092 681	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Characterization of West German Terrain and Land Use in Connection with Minefield Detection.		5. TYPE OF REPORT & PERIOD COVERED Technical Report.
		6. PERFORMING ORG. REPORT NUMBER 138300-39-T
7. AUTHOR(s) A. Lawson and Y. Morita		8. CONTRACT OR GRANT NUMBER(s) DAAK70-78-C-0198
9. PERFORMING ORGANIZATION NAME AND ADDRESS Radar and Optics Division, Environmental Research Institute of Michigan, P.O. Box 8618, Ann Arbor, MI 48107		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Mobility Equipment Research and Development Command, Mine Detection Division, Ft. Belvoir, VA 22060		12. REPORT DATE August 1980
		13. NUMBER OF PAGES vii + 43
14. MONITORING AGENCY NAME AND ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Dr. J.R. Gonano was the contract monitor for this project.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Some geographic characteristics of West Germany are described and related to areas suitable for minefields. Typical areas suited for minefields are delineated and analyzed in terms of land use, vegetation and surface geometry (slopes and obstacles).

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

The objective of the minefield detection project is to determine the effectiveness of remote sensing systems and other methods of detecting and identifying mines, minefields, minelaying equipment, or minelaying operations, and to recommend continuing effort on the most promising methods.

Work under the project concerned with each of the concepts to be investigated is being performed in a sequence of four major tasks: (1) identification and screening of promising techniques; (2) preliminary systems analysis and definition of experimental or other data acquisition systems; (3) acquisition of critical data through experiment, literature survey, or access to SCI (Sensitive Compartmented Information); and (4) evaluation of conceptual systems for technical performance and military usefulness.

Dr. J. Roland Gonano monitored the program for MERADCOM; Mr. Henry McKenney was the ERIM Program Manager; and Mr. A. Lawson and Mr. Yuji Morita assisted by Ms. M. Spencer collected, organized, and documented the material in this report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

This report is intended to provide an overview of terrain and land use features in West Germany with the intent of generally delineating and characterizing in a gross sense areas which logically could be used for the emplacement of anti-vehicular minefields. The primary invasion routes from the east, the Northern German Plain, the Fulda Gap and the Hof-Nurnberg Corridor, are described and typical tank-trafficable areas suitable for minefield employment are selected. These typical areas are analyzed in terms of land use, vegetation, and surface geometry. This analysis is particularly oriented to the development of parameters useful in determining the detectability of minefields by remote sensor systems.

2
WEST GERMAN TERRAIN

The terrain of West Germany* is extremely diverse. Nuttonson [1] calls out the "huge stretches of monotonous sands, marshes, bogs and heathlands, colorful wooded highlands of great diversity and infinite variety, beautiful mountain lakes, rivers and countless streams, steep mountains and soft hills, intensively cultivated low-lying plains, mountain valleys and basins, thickly forested and pastoral uplands, high rugged mountains, and deep river valleys".

The constraints on antitank-mine warfare and its detection are determined not only by the native terrain characteristics but also by man's cultural activities which overlay or modify the terrain. The construction of dams, canals, roads, cities and villages, as well as farming, forestry, surface and subsurface mining, and coastal recovery activities are among the most important cultural modifiers.

Our principal interest is focused on three regions which might be appropriate for armored attack routes out of the D.D.R. (East Germany) into the B.R.D (West Germany), one in the Borde region of the North German Plain, one in the Fulda, Kassel, Frankfurt A.M. region and one in the Hof-Nürnberg region (Figure 1). These three invasion routes into West Germany are referred to in this report as the North German Plain, the Fulda Gap and the Hof Corridor, respectively (Figures 2 and 3). The terrain characteristic of these routes is generally described in the following paragraphs as a prelude to the delineation of areas in these invasion routes which are seemingly suitable for the employment of minefields by the invaders.

*Officially West Germany is named the Bundes Republik Deutschland (B.R.D.) which is usually translated as the Federal Republic of Germany (F.R.G. or sometimes G.F.R.) as contrasted to Deutsches Demokratisch Republik (D.D.R.) or German Democratic Republic (G.D.R.).

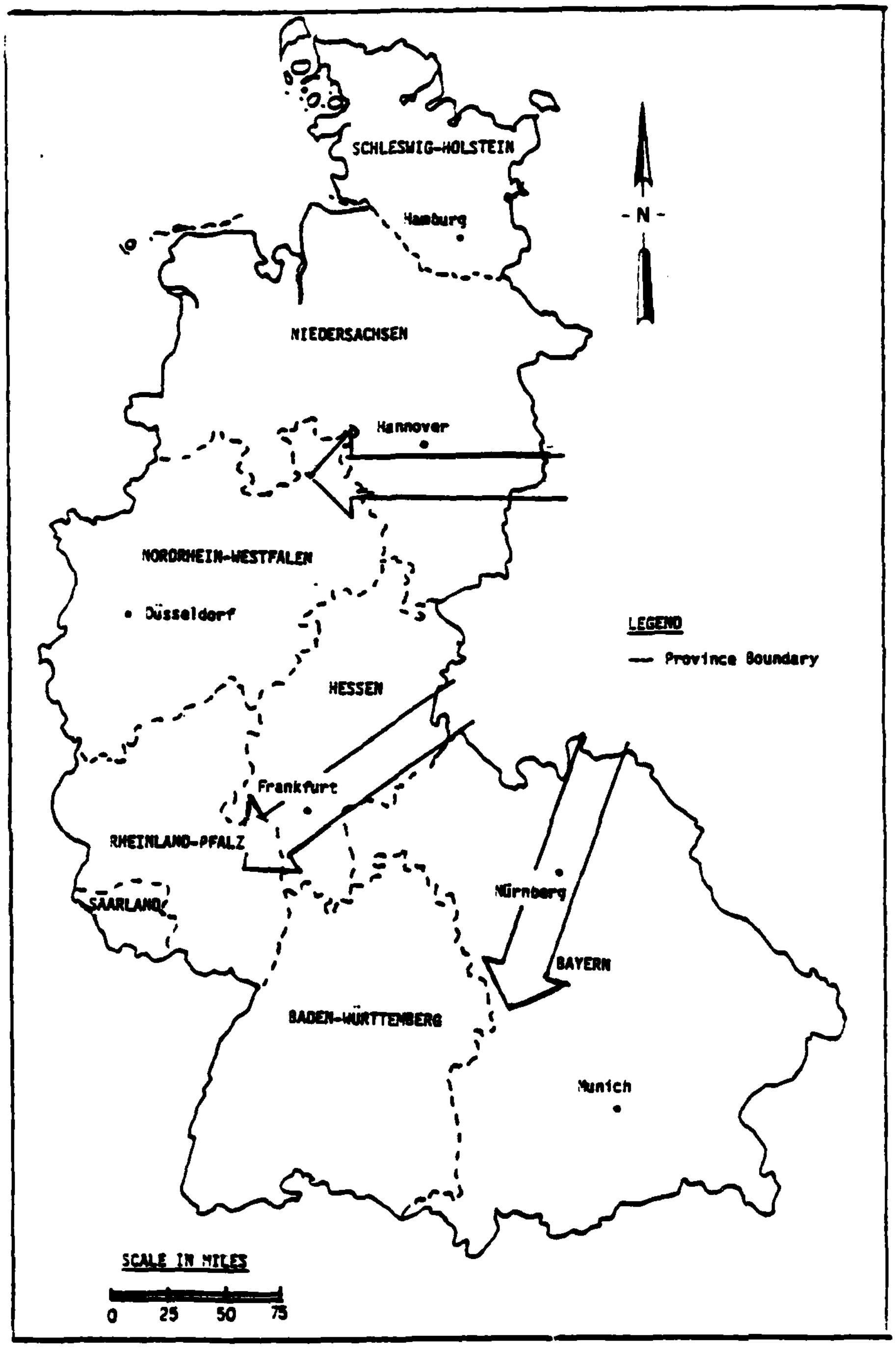


Figure 1. West Germany Showing Potential Invasion Routes

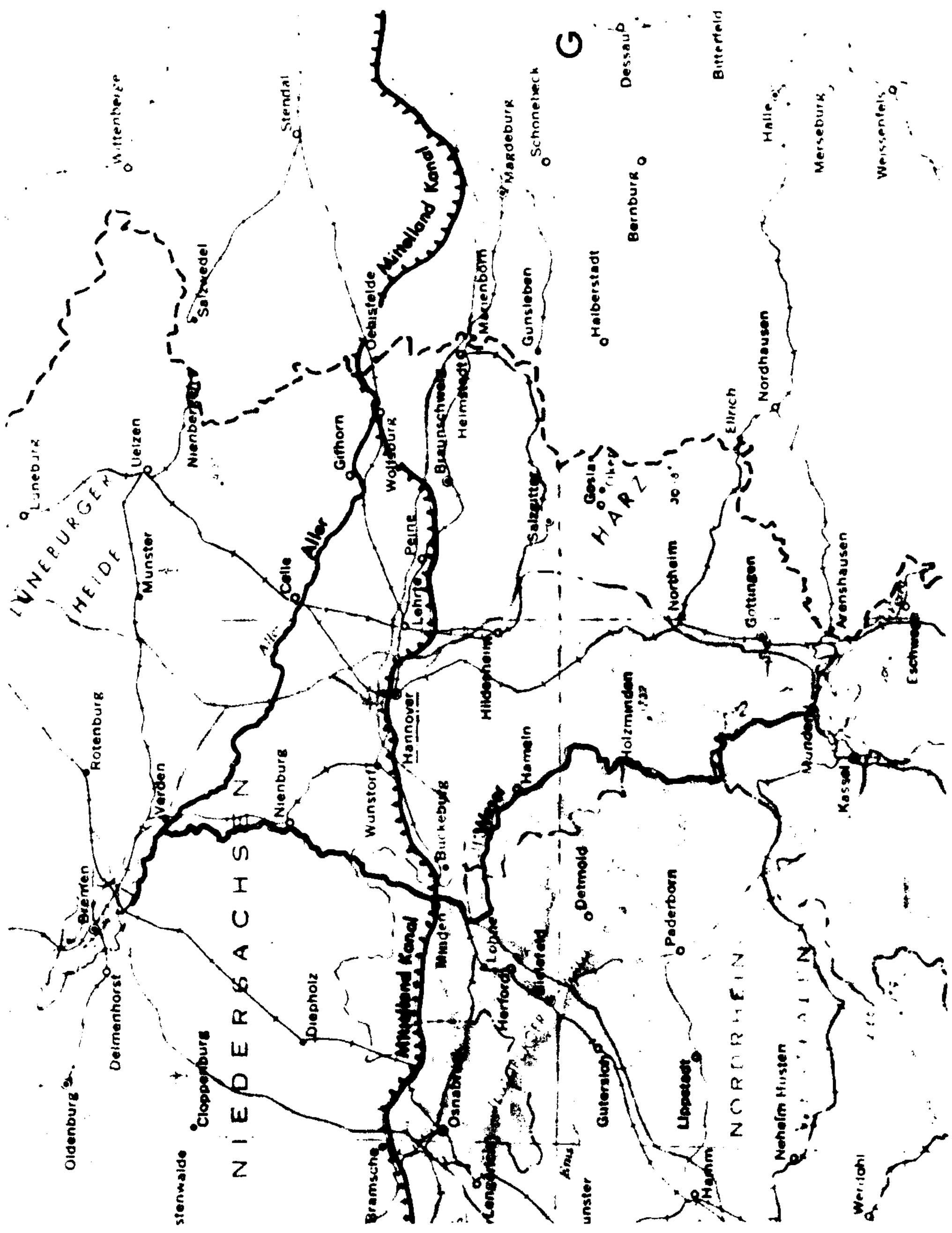


FIGURE 2. RELIEF MAP OF NORTH GERMAN PLAIN

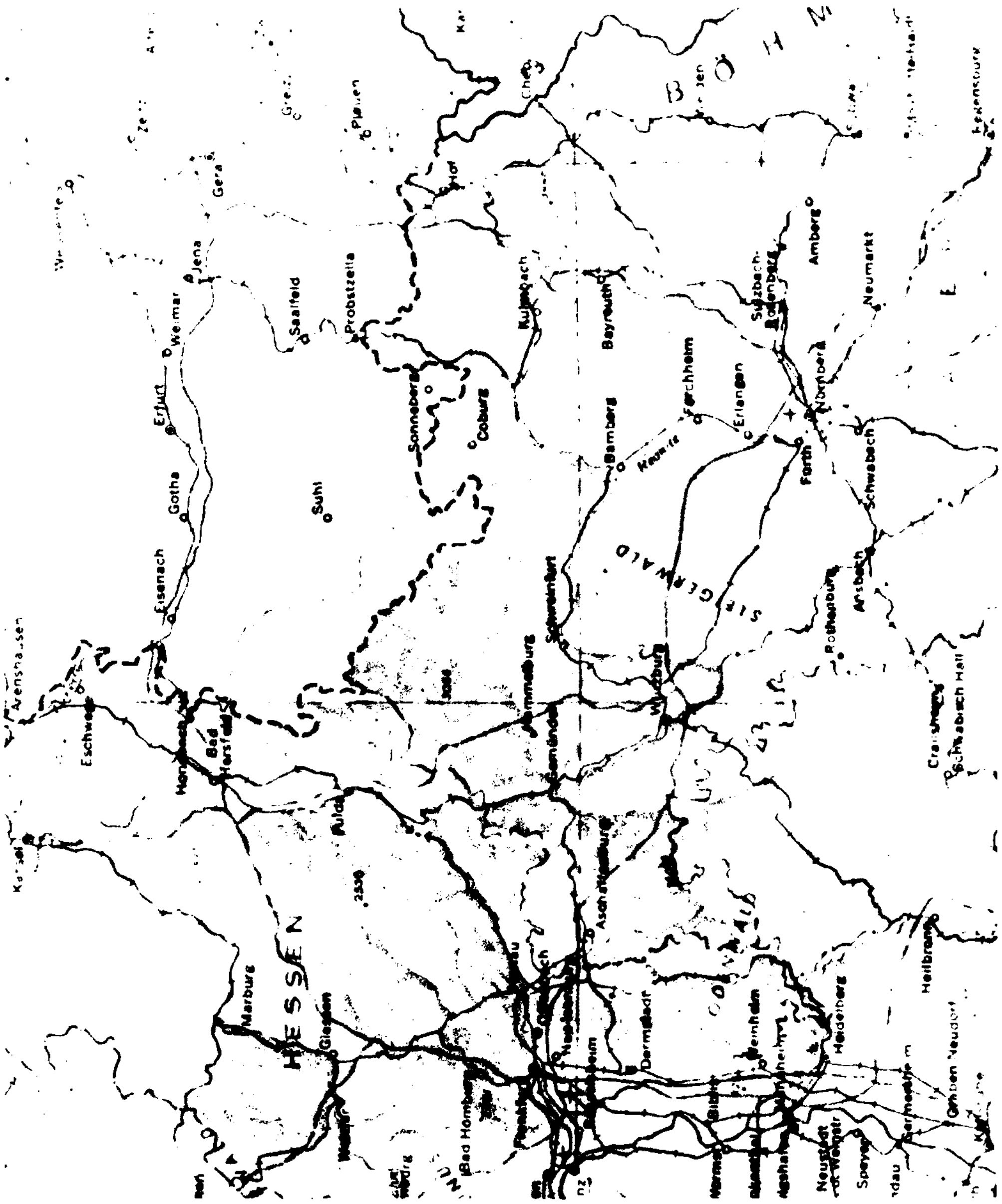


FIGURE 3. RELIEF MAP OF FULDA GAP AND HOF-NÜRNBERG CORRIDOR

2.1 THE NORTH GERMAN PLAIN

The most northerly of the three invasion routes is in the North German Plain and is entered on the route from Helmstedt through Hannover and on towards Minden (Figure 2). This entire region is drained by the Weser or its principal tributaries the Leine, the Fuhse and the Aller Rivers. Even with the extensive network of ditches, it is not drained well enough to dry out all of the swamps and bogs in the area. Yet, especially on the nigh southern side of this route there is much fertile soil, predominantly loess, devoted to farming.

The invasion route is assumed to be anywhere along the frontier north of Gunsleben but south of the Mittelland Canal. (First arrow from top, Figure 1). Here we have ground elevations which may approach 100 m above sea level but soon the terrain becomes very low (elevations less than 30 m) and quite flat except on the extreme left flank of the invasion route where the elevation and roughness increase with proximity to the central highlands. Immediately south of Minden the northwest extension of the Wesergebirge provides some higher ridges (generally running approximately from east by south toward west by north). Forested areas extend to the east and west of Minden southerly of the Mittelland Canal. Extensive farmlands are located to the south of these forested areas and would seem to be a logical choice for the invasion route through this region.

2.2 FULDA GAP

The region of interest in this central highland area (middle arrow, Figure 1) tends to be limited by Kassel in the north, the Rothaargebirge to the northwest, the Westerwald to the west, the Taunus to the southwest, and the D.D.R. border to the east (Figures 4 and 5). This is a plateau of infertile hard rock which is dominated by a number of higher ranges within it and which is sharply dissected

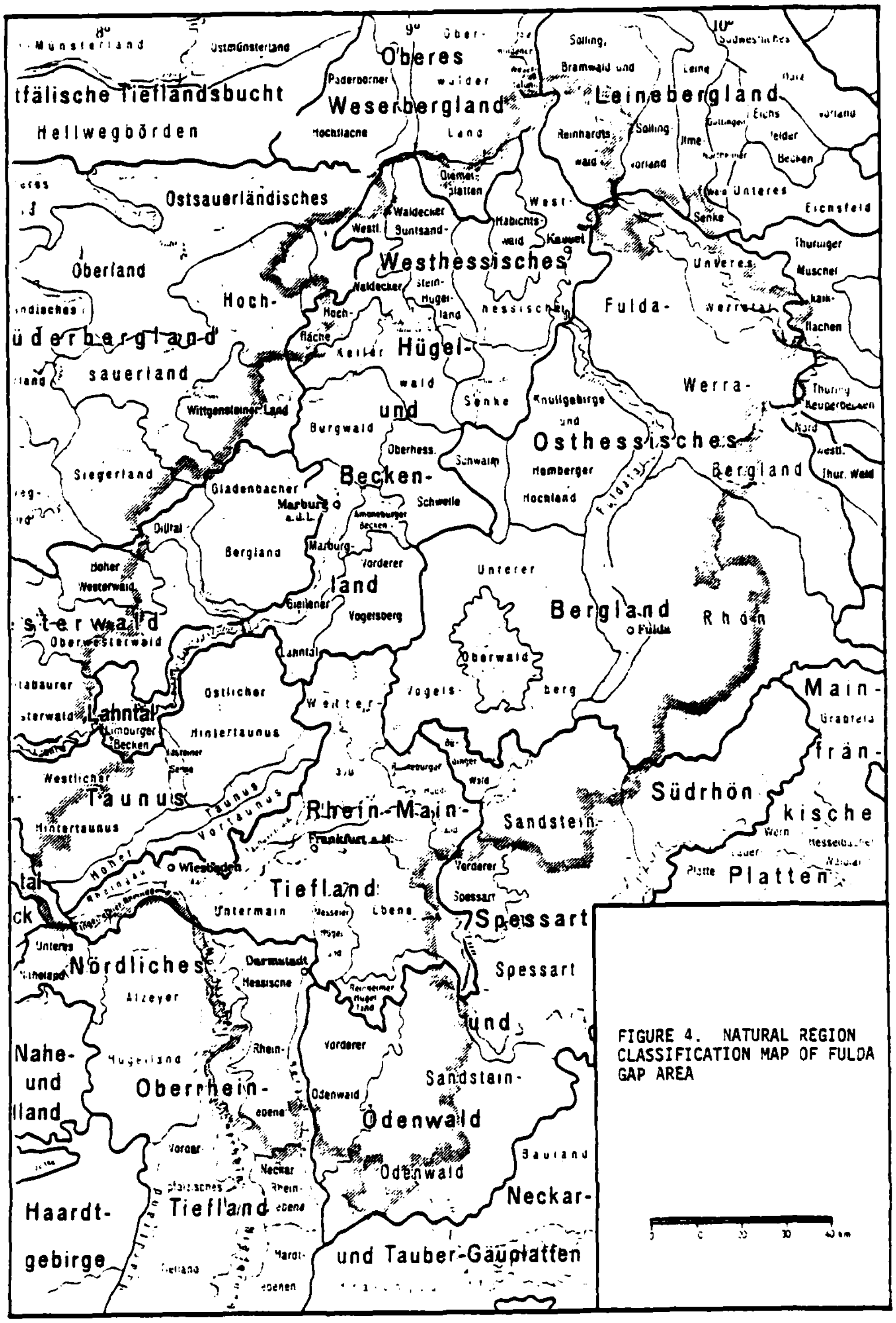


FIGURE 4. NATURAL REGION CLASSIFICATION MAP OF FULDA GAP AREA

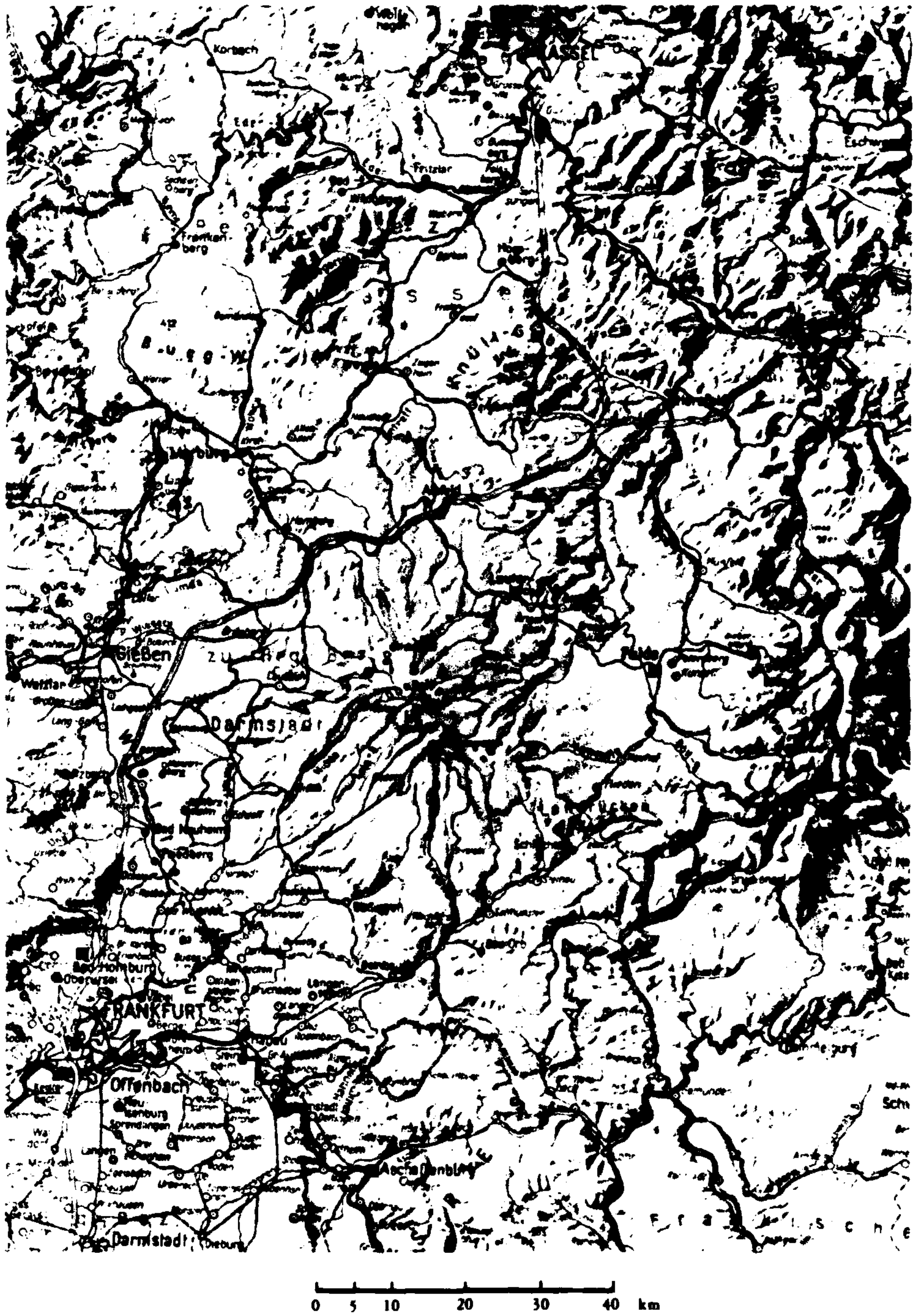


FIGURE 5. RELIEF MAP OF FULDA GAP AREA

by a number of rivers. The slopes are said to be "crisscrossed" by countless streams. After radiating outward to the Main River or northward toward confluences with the Weser River and thence to the sea. It is this process which has made these highlands easier to traverse south to north than east to west.

The highest point in the central highlands, at about 1140 m, is Brocken in the Harg Mountains immediately to the northeast of our area of interest. But the Kassel-Fulda-Frankfurt region has the Wasserkuppe at 950 m and many others that rival it. Wasserkuppe is in the Rhon, a large tertiary volcanic mass which also has the Kreuz and Kammersfeld peaks at 928 m, the Heidelstein at 926 m, the Eiernauck at 910 m, and the Stirnberg at 902 m.

If not the highest, the Vogelsberg still tends to dominate because of its central location. It forms the southwestern end, as the Rhon forms the southeastern end, of the East Hessen Highland (Osthessisches Bergland). Like the Rhon it is the remains of a tertiary volcano. The central region, known as the Oberwald contains the local high points of the Taufstein at 774 m, the Honerods-K. at 763, the SiehenAhorn at 755, the Herchenhainer Hohe at 733, and the Nessel-B. at 715 m.

Immediately to the north of the Vogelsberg is the Knullgebirge and Homberger Highland. The Eisenberg peaks at 636 m and the Knull Kopfenen itself is at 634 m.

The Fulda-Werra-Bergland lies both to the north and east and it has peaks over 700 m.

The Fuldatal region, that is the Fulda River valley, separates the Rohn and the Fulda-Werra-Bergland on the right-hand from the Vogelsberg and the Knullgebirge and Homberger Highland on the left. The Fulda and the rivers into which it empties determine a principal north-south route through the central highlands. From Bad Hersfeld through Bebra, to Kassell and on toward Hannover; also south through Fulda and on toward Schweinfurt.

A natural path from Bad Hersfeld to the southwest is offered by the large scale saddle between the high points of the Oberwald and those of the Knullgebirge and Homburger Highland. The route passes Alsfeld and proceeds on toward Giessen. As Giessen is neared the route must swing more to the south as it parallels the course of the Wetter River. The river keeps to the east of the Taunus Mountains as it flows down to its meeting with the Main at Frankfurt.

Unlike the relatively recent land masses we have been discussing, the Taunus Mountains are ancient; being formed when old Devonian beds were forced into deep folds. Here, as in the other land about the Rhine these folds run from west-southwest to east-northeast.

The other land masses may lack folding but they exhibit much faulting; most northwest of Fulda and to the southwest and southeast of Kassel.

Access from the east to the natural routes we have described has not been defined quite so clearly by nature. One promising route parallels the Horsel River as it flows past Eisenach down to the Werra River. This route keeps you well to the north and west of the end of the Thuringerwald. Once reaching the Werra, the route follows it to the west and southwest (upstream) as far as Gerstungen. The route then leaves the river and continues more or less directly to Bad Hersfeld. This route was the most attractive when autobahns were being planned and it still is attractive. There are collateral routes available, mostly to the north but some even to the south.

Consistent with the abundance of tertiary volcanoes, much of the terrain is defined by basaltic lava flows. Toward Eisenach and toward Hamburg these flows are interstratified with lignite fields of some commercial value. And atop most of this rock is brown forest soil with mountain brown forest soil above Vogelsberg and the Rhon.

Windblown silt from the terminal faces of glaciers, or loess, has been deposited in the Fulda Valley and in a region generally to the northwest of a line from Kassel to Frankfurt. Beyond this (to the northwest) are found fluvioglacial deposits (i.e., those deposited by a glacier but transported further and selectively deposited by melt water).

The natural woods tend to be mountain beech and pine at the highest levels. As we descend we note the addition of some upland oak. In the lowest regions, near Frankfurt, we find some poorly drained regions of boreal forests.

When cleared, the upland regions, if suitable for any agricultural pursuits, are usually limited to meadows, and milk cows abound. In some southerly slopes, terraces may be cut for vineyards. Most upland is left wooded however.

The river valleys are blessed with more and better soil and milder climate. In these regions agriculture may be pursued intensively.

2.3 THE HOF CORRIDOR

The terrain in which the Hof-Nurnberg routes are located is predominantly richly forested highlands. (Bottom arrow, Figure 1.) In general, little soil overlays the rock. A notable exception borders the region to the southeast where a tongue of river-deposited alluvial soil descends from Weiden to the Donau River around Regensburg. Agricultural activities are not extensive. Grains predominate among the crops and rye among the grains. A lesser amount of land with wheat is found and the land's productivity tends to increase as we move south toward the Donau. The oat production is more common toward the north of the region. Potato production is considerable with the heaviest concentration in the Weiden-Donau riverine deposits mentioned above and about the Main and its larger tributaries to the west. Sugar beet production shows the same distribution but it is a much less significant crop. The limited availability of meadow and pasture land greatly restricts the amount of cattle which can be supported. What there is increases in density toward the southwest of this region.

To the immediate north and west of Regensburg there are pine and mixed pine forests. These seem to be associated with the previously mentioned alluvial soil. The limited flood plain area about the Main and the Regnitz supports vegetation associated with moist broad-leaved forest land. The land east of the Regnitz, south of the Main, and west of the line from Nürnberg to Kulmbach support oak forests. Most of the land in this area, however, is covered with mountain beech and pine.

The general topographic nature of this terrain is best visualized as a radiating pattern of mountainous areas and rivers (Figures 6 and 7). At the center is the Fichtelgebirge Range (about 50 km south of Hof). The Naab River drains to its south-southwest. To the southeast stretches the Böhmerwald (Bohemian Plateau). The Eger River drains to the east. To the northeast stretches the Erzgebirge. The Saale River drains to the north. To the west-northwest stretches the Thuringer Wald (Thuringian uplands). Finally, the Main Rivers drains to the west.

The Fichtelgebirge is an impressive mountain range roughly centered in the triangle formed by the cities of Bayreuth (341 m), Marktredwitz (~550 m), and Münchberg (533 m). The highest peak is the Schneeberg at 1053 m. The Oschenkopf is high at 1023 m and numerous peaks exceed 800-m elevations. The principal highways leading south from Hof and bypassing the Fichtelgebirge to the west toward Bayreuth and to the east toward Marktredwitz are generally at elevations well in excess of 500 m in this vicinity.

The Böhmerwald (Bohemian Plateau) impacts our area of interest only at its extreme western edge. Here we have some bordering ranges or subranges which are terminated by the Naab River.

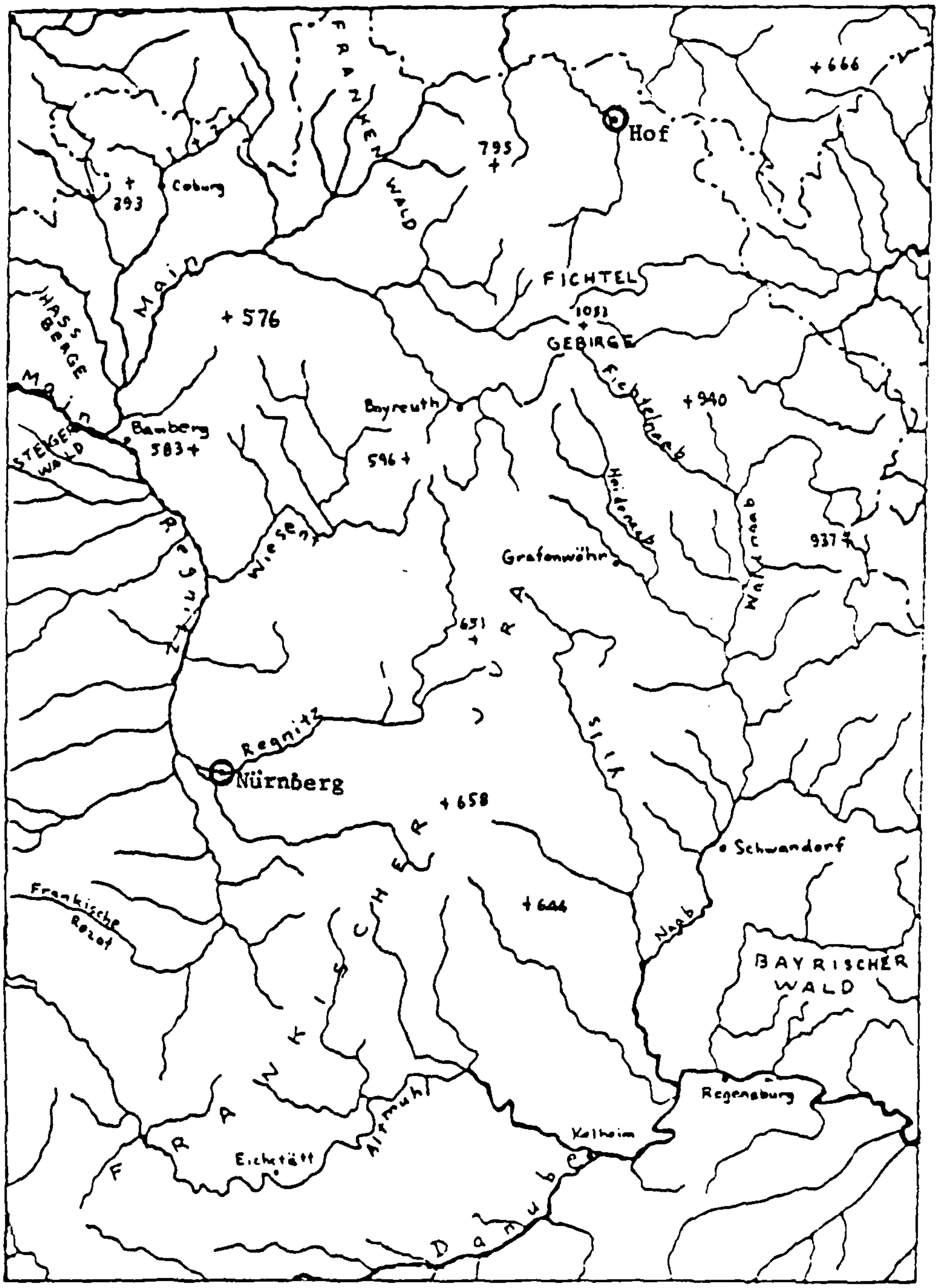


FIGURE 6. HOF-NÜRNBERG CORRIDOR

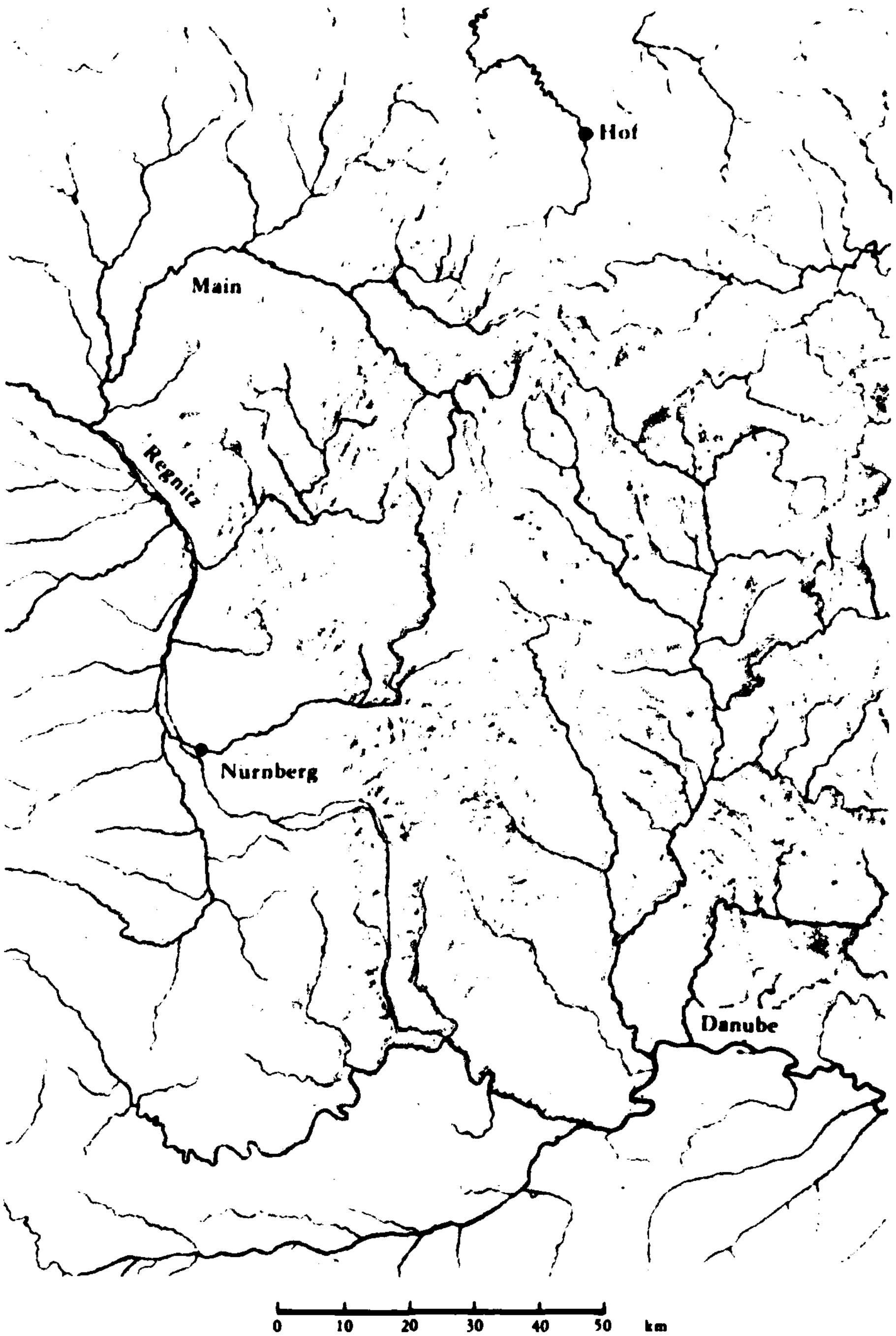


FIGURE 7. RELIEF MAP OF HOF-NÜRNBERG CORRIDOR

The Bayerischer Wald (Bavarian Range) parallels the Donau (Danube) River and hence extends from the Naab to the east-southeast. It has peaks which exceed 1400 m in height. Unless thrusts are extended as far south as Regensburg this range will have no impact on an attack. Just to the north of the Regen River, however, we encounter the Oberpfalzerwald. This range parallels the Naab for most of its length essentially following the Czechoslovakian border. It has peaks exceeding 1000 m but 900-m peaks are far more typical. The Oberpfalzerwald is very heavily forested and especially in the area east of Weiden, forestry is of great economic importance. At the extreme northern end of Oberpfalzerwald, nestled in between it and the Fichtelgebirge, lies the Steinwald. The Steinwald is a small range, about 15 km in length, but it has several peaks about 800 m and the Platte rises to 940 m. This small range is immediately south of Marktredwitz.

The Erzgebirge lies generally to the east-northwest of the Fichtelgebirge. It contains peaks above 1200 m but these are some distance away inside the DDR. The western extremity of this range is the Elstergebirge. This smaller subrange abuts the road from Selb to Marktredwitz and has several peaks at about 700 m.

The Thüringerwald is a major range extending to the northwest from the Fichtelbirge to Eisenach. It lies principally in the D.D.R. but its southern margin provides the terrain at the border and at its southeastern end it terminates in the Frankenwald. This Frankenwald is within the B.R.D.; its center being only about 20 km to the northwest of Münchberg.

The Fränkische Alb begins at the south of the Fichtelgebirge and reaches to the Donau River in the south. It is limited toward the southwest by the Wörnitz River which separates it from the Schwäbische Alb. On the east the Naab River separates it from the ranges associated with the Böhmerwald. The Fränkische Alb is composed of a porous mesozoic rock with a general tilt such that the gentler dip slopes stretch down toward the Donau in the south to southeast direction. The steeper scarp slopes thus face toward the north to northwest. Most of the drainage thus at least starts toward the south to southeast even for tributaries of the Main which will eventually carry the water westward. This land mass is rather thoroughly dissected by the large number of tributaries involved in its drainage. The Fränkische Alb is drained on the east by the Naab and its tributaries including the Fichtelnaab, Heidenaab, and Vils into the Donau. The south is drained into the Donau by the Schwarze Laber, the Altmunl, and the Wörnitz. The west is drained by tributaries of the Main River including the Roter Main and Regnitz and its tributaries which include the Rauhe Ebrach, Aisch, Wiesent, Zenn, Pegnitz, Bibert, Rednitz, Schwaczach, and Regat. The elevation varies considerably. In the north, several peaks exceed 800 m, the general elevation is around 500 m, and the lowest elevations are reached in relatively narrow river valleys such as that of the Roter Main where Bayreuth is at an elevation of only 341 m.

Toward the south we find Nürnberg on the Regnitz at 330 m and Regensburg on the Donau at 322 m. The terrain in between rises considerably with much of the land above 500 m and several peaks above 600 m (including Poppberg at 657 m).

To the west of the Bayreuth to Nürnberg road and enclosed by the loop of the Main River and the Regnitz River is another portion displaying great variability. On the river at Bamberg the elevation is only 262 m and similarly at many other points on the rivers and tributaries similar elevations below 300 m are to be found. Away from the rivers the land quickly rises to over 400 m and much of the land is above 500 m. Some peaks are found which exceed 500 m.

Note that the terrain found within the Fränkische Alb probably best typifies that found in the Hof-Nürnberg corridor. Some paths to the west might be somewhat lower and more level; some to the north somewhat higher and rougher; but most of the paths are in this land mass.

2.4 SOVIET SCENARIOS FOR THE EMPLOYMENT OF MINEFIELDS

To appreciate how the Soviet invaders might use minefields in connection with the West German terrain encountered along the three invasion routes, we must consider Soviet mines of interest and the Soviet philosophy for the use of these mines in minefields. The mines of concern are the anti-tank (AT) and anti-vehicular (AV) mines used by the Soviet Warsaw Pact Bloc. Several mine types are of specific interest, particularly the East German PM-60 and the Soviet TM-46. Minefield characteristics include a description of the individual mine and its distinguishing features, the use of the mine in a minefield, the doctrine, tactics and methods of minefield employment, the scenario for its use, and the characteristics of the region where it is employed. Four scenarios have been defined as representative of Soviet use of minefields. These scenarios are typical examples of minefield doctrine, tactics, and methods of Soviet use, together with typical equipments, time frames and areas involved. Some of the basic characteristics of the four scenarios are given in Figure 8.

The general features of these scenarios which reflect importantly in this study are summarized as follows:

1. These scenarios occur only in tank-trafficable terrain.
2. They are extensive in area. The smallest minefield (Scenario C) is 0.5 hectare in area, the largest (Scenario B) is 15 hectares in area.
3. Individual minefields may extend to one km in length.

As a consequence of the scenarios we may restrict our consideration to those areas in West Germany along the invasion routes which meet the trafficability, areal and size constraints of the scenarios.

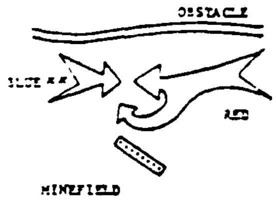
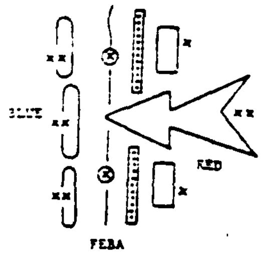
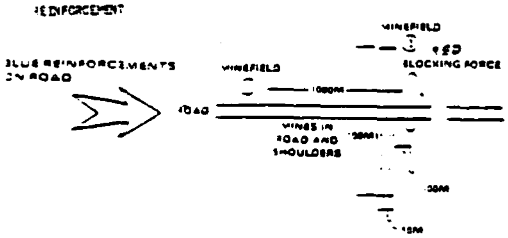
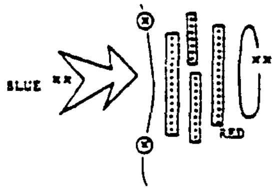
MINE WARFARE MISSION	DOCTRINE AND TACTICS	TYPE OF OPERATION	LENGTH OF TIME MINE FIELD IN PLACE	TYPE OF MINES	NUMBER OF MINES
A. PROTECT MOST EXPOSED FLANK DURING MEETING ENGAGEMENT		OFFENSIVE	[illegible]	PM 60 SURFACE (Plastic)	545 (50 x 1000 meters area)
B. PROTECT SHOULDERS DURING BREAKTHROUGH (ECONOMY OF FORCE)		OFFENSIVE	20 HOURS	TM 46 SURFACE (Metal)	750 (150 x 1000 meters area)
C. BLOCK ENEMY REINFORCEMENT		OFFENSIVE	8 HOURS	TM 46 SURFACE (Metal) PM-60 BURIED (Plastic)	60 (50 x 100 meters area) 7 within 50 meter radius
D. SUPPORT PREPARED DEFENSE		DEFENSIVE	INDEFINITE	TM 46 (Metal) or TMN 5 (Metal)	545 (150 x 100 meters)

FIGURE 8. FOUR MAJOR SCENARIOS FOR SOVIET MINE WARFARE OPERATIONS

2.5 DESCRIPTION OF AREAS SUITABLE FOR MINEFIELD USE BY INVADERS

Considering the trafficability, areal and size constraints imposed by the four scenarios together with the terrain features of the invasion routes, it is logical to categorize the terrain along the invasion routes in terms of land use. Certain land usage is compatible with the four scenarios, other land usage is not. For example, farmland is generally tank-trafficable and field sizes are such that one or more fields can accommodate minefield lengths and areas characterized in the minefield scenarios. On the other hand, forests are usually tank trafficable only on access roads and trails where minefields such as those delineated by the scenarios are generally not warranted nor possible. Since land-usage information is available for West Germany and a reasonable match can be established between it and potential occurrence of invader minefields, land usage will be explored as an indicator of typical areas where invader minefields may be expected.

Figure 9 presents the pattern of land usage for West Germany in a gross sense. The forest and farmland areas are depicted. In addition the farmland is subdivided into areas of permanent pasture; mixed cropland and pasture; wheat and sugar beets; potatoes, rye and barley; market gardening; vineyards and hops. The three invasion routes of concern in this study are also delineated in this figure.

The North German Plain invasion route (upper arrow) generally traverses farmland where wheat and sugar beets are main crops.

The Fulda Gap invasion route (middle arrow) generally traverses farmlands principally devoted to permanent pasture and mixed cropland and pasture in the northeastern portion of the invasion route and wheat and sugar beets in the southwestern portion.

The Hof Corridor invasion route (lower arrow) generally traverses farmlands principally devoted to permanent pasture and mixed cropland and pasture for the main portion of the route. In the vicinity of Nürnberg the main farmland crops are potatoes, rye and barley.

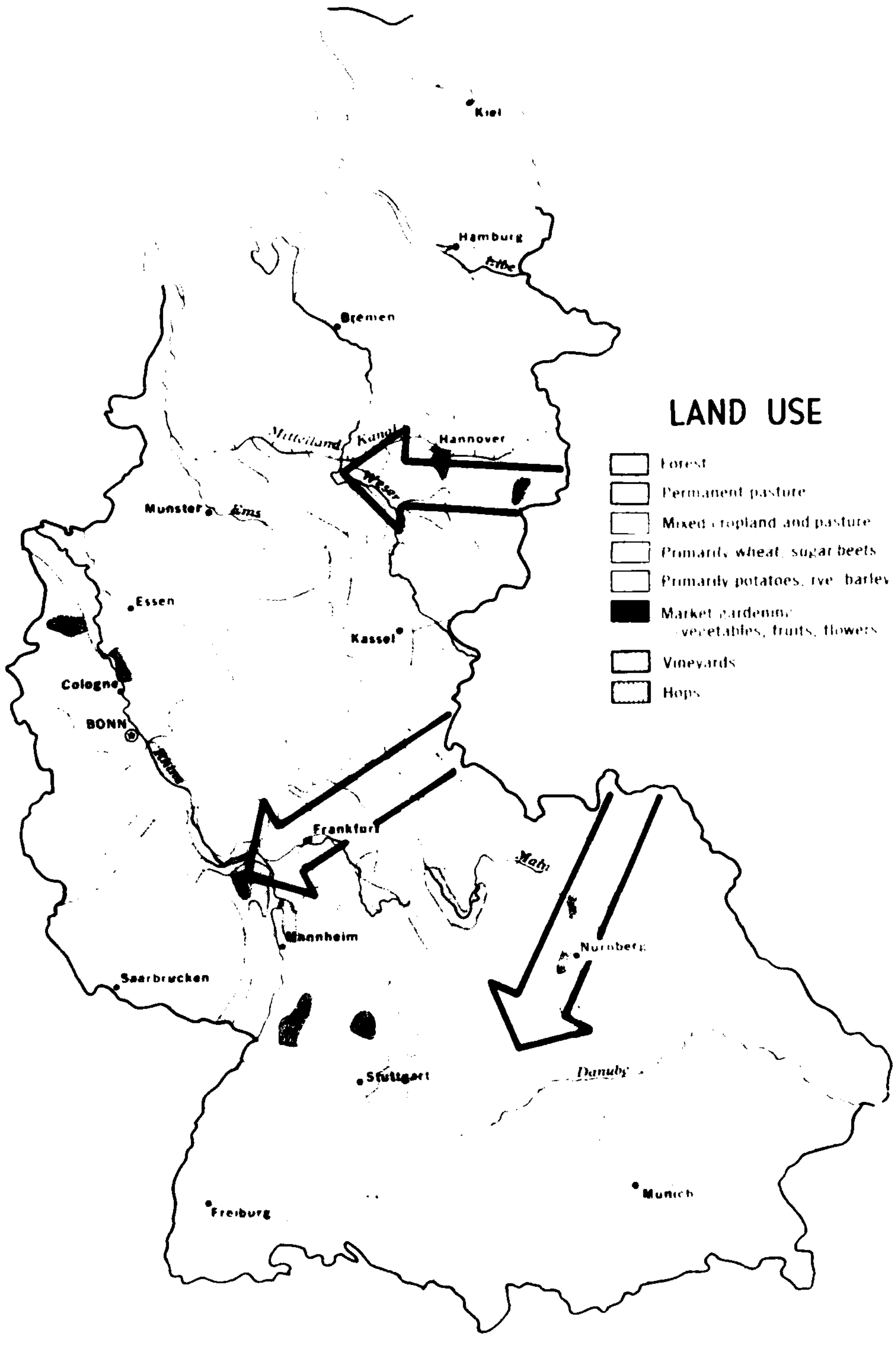


FIGURE 9. WEST GERMAN LAND USE

Other important land usage factors are of concern in determining potential minefield locations: (1) cropping operations are usually conducted on lowlands or gently sloping areas which are trafficable for the machinery used in cropland farming operations, (2) generally pasturage is conducted on steeper slopes or poorer soils where cropping operations are more difficult, (3) forest areas are generally regions where the terrain is too difficult for farming operations or where soil or other conditions are not conducive to cropping or pasturage, (4) generally urban areas are not appropriate to the four scenarios selected as being representative of Soviet use of minefields, (5) existing main traffic routes provide convenient means for invasion forces and the usage of these routes will probably entail protective minefields to hinder efforts to deny use of these routes.

In addition, it must be considered that minefields are only one of many types of barriers used on the battlefield. These barriers may be classed as natural or artificial. We may expect the Soviets to take advantage of natural barriers in their military operations and to augment them with artificial barriers if this seems advantageous to them. Examples of natural barriers are mountains, seas, lakes, rivers, creeks, forests, steep declivities, and swamps. (Lakes, rivers, creeks and swamps may be trafficable in northern regions during winter time.) These natural barriers tend to proscribe the choice of invasion routes. In addition to natural barriers there are man-made barriers which may affect choice of invasion routes and the consequent use of minefields. Examples of such artificial barriers are dams, canals, ditches, cities and villages, mining operations, and military barriers (which include minefields).

Terrain slope, regularity and soil characteristics are factors which are typically inherent to land use considerations. We may consider that if these factors are acceptable for mechanized farming operations that they are also acceptable for military vehicular transit. Consequently we may consider all farmlands as areas potentially suitable for the location of invader minefields.

Table 1 categorizes West German land use. It shows the extent of farmland and thereby provides insight into the overall percentage of land useful for potential invader minefield sites. About 32 percent of the land is arable and another 21 percent is meadow or grassland. If the non-agricultural land is excluded from the total, roughly 60 percent of the land may be expected to be tank-trafficable and therefore eligible as potential sites for minefields.

TABLE 1
WEST GERMANY LAND USE*

Use	Hectares	Percent
Arable Land	7,890,000	31.9
Meadows/Grasslands	5,212,000	21.1
Market Gardens, Gardens	516,000	2.1
Fruit Trees, Vines, Bushes	152,000	0.6
Rough Grazing Land	682,000	2.8
Woods and Forest	7,109,000	28.7
Non-Agricultural Land	3,173,000	12.8
Totals	24,734,000	100.0

* World Atlas of Agriculture, Volume 1, Europe.

3 DELINEATION OF TYPICAL AREAS REPRESENTATIVE OF MINEFIELD-SUITABLE AREAS

A broad characterization of West German terrain along potential invasion routes from the Warsaw Pact countries into West Germany was given in the previous section. General guidelines were also provided for placing this characterization into the context of anti-tank and anti-vehicular minefield operations as practiced by the Soviet/Warsaw Pact armed forces. In this section the three invasion routes will be examined in more detail with the objective of delineating typical areas representative of minefield suitable areas (from the Soviet/Warsaw Pact standpoint) along the three invasion routes.

A number of 100 hectare areas were randomly selected along the three invasion routes from the Soviet Bloc into West Germany. These areas were examined for urbanization and those areas which appeared to be over 25 percent urbanized were excluded since generally urban areas are not appropriate to the four scenarios selected as being representative of Soviet use of minefields. The areas were also examined for degree of forestation. None were found to be completely forested. The number of areas surviving this initial screening is deemed sufficient to provide reasonable confidence that the areas are representative of the region along the invasion routes. It is intended that these representative areas will be further analyzed in terms of their features which may affect minefield detection.

3.1 NORTH GERMAN PLAIN

The first invasion route, the route through the North German Plain extends through the province of Niedersachsen into the province of Nordrhein - Westfalen (Figure 1). Along this route sixteen 100 hectare (1 sq km) typical areas were selected and examined in detail to note the presence, length and/or area of both natural and man-made objects such as rivers, creeks, roads, swamps, woods, buildings, farms, bridges, etc. An analysis was made of these areas to indicate the number or densities of these objects in order to obtain insight regarding how much of the land is used for a given purpose. Table 2 synopsizes this analysis. If we examine the average of the 100 hectare areas analyzed along the North German Plain invasion route, we find that it generally coincides with area 6 of Table 2. On this basis, it seems logical that area 6 is reasonably representative of the typical area along the North German Plain invasion route wherein the invader might locate his minefields.

In the development of Table 2 a listing was made of characteristic natural and man-made features which seemingly could affect the location and disposition of invader anti-tank minefields. The occurrence and extent of these features are listed for each of the sixteen representative areas.

An analysis of Table 2 indicates that approximately 65 percent of the total area of the sixteen selected 100 hectare areas is tank-trafficable (defined as *farmland and open land; scrub and pasture;* and meadowland). The average slope of the selected areas is approximately 2 percent, the average minimum altitude is 63 m; the average maximum altitude is 103 m. The area of the average wooded portion of the selected areas is approximately 14 hectares. Swamps and bogs average almost 13 hectares. Note that one selected area (area 13) consists entirely of peat and bog land.

Based on an examination of Table 2, the 100 hectare area 6 appears to be reasonably representative of the North German Plain invasion route.

3.2 FULDA GAP

An examination of the Hessen map, Figure 4, shows that there are a large number of small towns and villages distributed throughout the countryside. A large number of secondary roads, particularly

TABLE 2
MAN-MADE AND NATURAL FEATURES IN SAMPLED AREAS OF NORTH GERMAN PLAN

Feature		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total	Avg
Primary Roads	km		2.24	1.12	5.90	-	--	-	-	--	--			--	1.1	-	1.9	12.26	0.77
Improved Secondary Roads	km	--			-		--	--	-	-		--	-	1.3	2.4	3.4	0.7	7.80	0.49
Unimproved Secondary Roads	km	3.9	1.56	3.14	8.64	5.09	5.71	5.51	5.45	--	5.27	5.30	8.6	5.5	1.4	1.7	2.2	70.97	4.44
Road Intersections																			
Prim. & Prim. Interchange	No.	-	2.0		-	--	--	-	--	--	--	--	--	--	--	--	3.0	5.0	0.31
Prim. & Secon. Interchange	No.	-	6.0	3.0	2.0	--	--	--	--	--	--	--	--	--	6.0	--	5.0	22.0	1.38
Sec. & Secon. Interchange	No.	6.0	11.0	6.0	27.0	8.0	10.0	9.0	11.0	19.0	11.0	12.0	21.0	3.0	4.0	10.0	8.0	176.0	11.0
Railroads	km	--	-	--	--	--	--	--	--	--	--	--	--	--	--	--	-	-	
High Tension Lines	km	1.02	1.01	-	--	0.62	1.1	1.02	--	--	--	--	--	--	--	--	--	4.79	0.30
Rivers	km	--	1.18	--	--	0.71	--	--	--	--	--	1.7	--	--	-	1.05	-	4.64	0.29
Creeks	km	0.7	--	--	--	--	--	--	--	0.48	--	-	1.3	--	--	-	--	2.48	0.16
Bridges	No.		3.0		--	--	--	--	--	--	--	1.0	--	-	--	1.0	--	5.0	0.31
Peat & Bog	Ha	--	-		--	--	--	--	--	--	--	--	--	100.0	3.5	6.0	-	109.5	6.84
Meadow	Ha	--	-	1.1	0.2	-	--	--	--	--	--	--	--	--	28.0	27.2	28.0	84.7	5.29
Swamps	Ha	9.0	7.0	--	-	8.3	5.4	--	--	--	0.5	44.0	1.8	--	15.0	13.0	-	104.0	6.5
Scrub & Pasture																			
Deciduous	Ha	--	-	13.2	--	--	--	--	--	--	--	--	--	--	0.5	-		13.7	0.86
Coniferous	Ha	--	--	--	-	--	--	--	--	--	--	--	--	-	--	-	--		
Woods																			
Deciduous	Ha	40.0	9.0	1.0	-	-	7.7	--	--	21.5	29.0	-	28.0	--	1.5	0.5	--	138.2	8.64
Coniferous	Ha	--	--	--	--	-	2.9	--	--	22.4	--	--	--	--	--	--	-	25.3	1.58
Mixed	Ha	--	-	-	52.0	--	--	--	-	22.5	8.5	--	20.0	--	-	--	-	103.0	6.44
Village	Ha	-	13.0	-	--	--	6.7	--	9.3	3.2	1.0	12.8	--	--	7.5	3.0	8.0	64.5	4.03
Drains	Ha			-	-	-	-	--	--	1.2	--	0.74	--	--	0.8	2.6	0.5	5.84	0.37
Isolated Bldgs	No.	9.0	3.0	4.0	--	-	-	-	--	--	--	-	13.0	1.0	24.0	5.0	17.0	76.0	4.75
Slope (Est. Avg.)	°	0	0	2.3	4.28	1.50	0.8	0.82	0.27	9.0	3.6	0.15	8.8	1.0	1.0	1.0	1.0		2.16
Peak Slope (Est.)	°	1.25	0.25	4.5	13.8	3.3	3.0	1.67	0.83	20.0	24.0	0.35	18.6	--	5.0	1.5	5.0		6.46
Max Altitude	m	57.5	62.0	100.0	126.0	85.1	71.0	80.4	79.7	270.0	136.0	57.2	303.0	51.0	61.0	51.0	61.0		103.24
Min Altitude	m	52.3	60.0	67.6	70.0	70.2	67.0	73.8	77.2	150.0	70.0	56.2	200.0	51.0	48.0	48.0	49.0		75.64
Total Tank Trafficable Area	Ha	51.0	61.0	99.0	48.0	91.7	77.3	100.0	90.7	30.4	61.0	43.2	50.2	--	82.0	67.5	92.0	1015.0	65.3

* Tank-trafficable area includes (1) scrub and pasture, (2) meadow, and (3) farmland, open and other. Area in third category is not separately listed in Tables 2, 3, & 5.

unimproved ones connect these villages and primary roads together. From Table 3, it can be seen that on the average almost 8 km of secondary roads can be expected to exist in 1 sq. km. The large number of road intersections indicate that many alternate routes are possible between most points without resorting to cross-country travel. Gullies appear to be only several hundred meters in length and average length is about 200 m. Man-made embankments may prove to be more of an impediment to cross country travel than gullies since their total length is three and one-half times the total for the gullies.

Trafficability on much of the land should be good. The sampled areas appear to be well drained and swampland represents only a very small percentage of the total area. Woods represent a significant percentage of some of the areas, for example, areas 4, 11, 13, 14, and 15 where woods occupy 57 to 93 percent of each square kilometer area. On the other hand, 8 of the 16 sampled areas have small stands of woods or none at all and the remaining 3 areas have intermediate stands. In other words, considerable open areas exist in which vehicles can maneuver.

Another way of obtaining a "feel" of the character of the land is to examine farm sizes. The number of farms and their sizes in Hessen for the years 1950, 1960, and 1970 are given in Table 4. The same data have been plotted in Figure 10 in terms of percentage of total farm area. The striking factor is the small size of the average farm. That there has been a consolidation of farms from 1950 to 1970 is evident both in terms of numbers and area. It is likely that there has been further consolidation since 1970 and that the average farm size has increased.

In 1950, the three smallest farm categories occupied 56.3 percent of the land and the next two categories, 10-20 hectares, and 20-50 hectares, 36.4 percent. By 1970, the first three categories occupied only 30.3 percent of the land and the next two categories 62.6 percent. The number and sizes of those farms larger than 50 hectares

TABLE 3
MAN-MADE AND NATURAL FEATURES IN SAMPLED AREAS OF HESSEN

Feature		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total	Avg.
Primary Roads	km	0.1		1.5		1.1	2.2	0.1	0.9	1.1	1.4		1.1	--	-		1.1	11.0	0.69
Improved Secondary Roads	km	0.9	0.7	1.4	1.5		2.5	0.7	0.8	1.1	1.2		0.4	1.5	1.4	0.5	1.3	15.9	1.00
Unimproved Secondary Roads	km	6.9	0.2	3.3	10.3	5.1	2.3	5.3	7.1	8.7	6.4	12.0	8.4	10.1	9.6	6.7	10.8	121.2	7.58
Road Intersections																			
Prim. & Second Interchange	No.	-				1.0	1.0	-	--	--	--							2.0	0.13
Regular	No.		2.0				1.0		-	--	1.0	-	3.0	--	--		1.0	8.0	0.5
Prim. & Second	No.	3.0	3.0	5.0		4.0	1.0	3.0	6.0	5.0	-	4.0	--	--	-	6.0		41.0	2.56
Sec. & Second	No.	17.0	44.0	9.0	26.0	15.0	12.0	18.0	24.0	45.0	24.0	35.0	10.0	46.0	34.0	21.0	51.0	451.0	28.2
Railroads	km	0.4	0.7	-		0.8	-	1.0		1.2		--	1.0	--	-	-		5.1	0.32
High Tension Lines	km	1.2		1.5		2.0	2.4	--	2.0	--	--	-	--	--	--	--	1.0	10.1	0.63
Fencing	km	-		--		-	1.3	-	--	--	--	--	0.4	--	1.2	0.4		3.3	0.21
Gullies, Number	No.	5.0	9.0	4.0	6.0	2.0	2.0	5.0	4.0	2.0	1.0	2.0	-	2.0	3.0	1.0	1.0	49.0	3.06
Total Length	km	2.1	1.1	0.9	0.7	0.6	0.6	0.9	1.1	0.2	0.1	0.4	-	0.3	0.4	0.2	0.5	10.3	0.65
Steep Embankments, Man Made	km	0.3	0.1	0.9	0.3	3.0	4.2	2.7	2.8	4.9	8.1	0.5	4.0	0.4	0.7	1.2	1.0	35.3	2.21
Natural	km	--			-	-	0.3	-	0.1	--	--	--	0.9	--	--	0.3		1.6	0.10
Rivers	km	-	--	0.2		1.2	--	1.3	--	1.1	1.2	--	0.8	-	-			5.8	0.36
Creeks	km			-	0.6	-	--	-	--	--	--	--	--	--	1.3			1.9	0.12
Bridges	km			--	-		--		-	--	1.0	--	-	-	--			1.0	0.06
Ponds, Number	No.	-			6.0	1.0	-		--	1.0	--	--	-					8.0	0.5
Area	Ha	-			0.6	0.4	-	-	--	0.2	--	--	--	--	-			1.2	0.08
Swamp	Ha					-	-	-	--	6.0	--	--	--	-	--			6.0	0.38
Scrub & Pasture																			
Deciduous	Ha	2.5	20.0	2.0		4.0	-	1.9	--	3.0	1.0	-	2.5	-	9.0	17.0	7.0	66.9	4.18
Coniferous	Ha			-		--				--	--	-	1.0		-		-	1.0	0.06
Wood., Deciduous	Ha					17.0			-	0.5	--	-	-	--	19.0	54.0		90.5	5.66
Coniferous	Ha	-			57.0	11.0		-	12.5	-		69.0	28.0		33.0			210.5	13.16
Mixed	Ha				33.0	11.0	1.0		-	--	26.0	24.0	5.0	87.0	24.0	4.0		193.0	12.06
Garden	Ha	0.1	1.5	1.5	3.0	0.7	--	1.5	--	--	--	-			-	--		8.3	0.52
Sand	Ha			-	-	--	-		-	--	5.0	5.0	8.0	5.0	5.0	7.0		35.0	2.19
Heaths	Ha			0.3	-	0.3		0.3	-	1.1	1.2	-	0.8	-	0.5	0.06	1.3	6.4	0.40
Isolated Bldgs.	No.	8.0		1.0	--	2.0	30.0	3.0	4.0	6.0	4.0	--	4.0		-	8.0		70.0	4.38
Slope (Est. Avg.)		9.0	8.0	8.0	20.0	10.0	10.0	10.0	10.0	12.0	13.0	20.0	10.0	-	27.0	15.0	5.0		11.69
Peak Slope		80.0	40.0	40.0	75.0	25.0	60.0	40.0	60.0	40.0	50.0	40.0	40.0		40.0	30.0			41.25
Max. Altitude	m	324.0	318.0	261.0	350.0	282.0	275.0	265.0	307.0	265.0	311.0	365.0	331.0	440.0	275.0	[illegible]	176.0		300.6
Min. Altitude	m	202.0	215.0	191.0	215.0	197.0	205.0	200.0	205.0	220.0	220.0	225.0	220.0	270.0	140.0	160.0	136.0		201.31
Total Tank Trafficable Area*	%	100.0	100.0	100.0	31.1	60.6	99.0	100.0	88.5	93.3	74.0	7.0	67.0	13.0	63.0	12.0	100.0	1138.6	71.2

* Tank-trafficable area includes (1) scrub and pasture, (2) meadow, and (3) farmland, open and other. Area in third category is not separately listed in Tables 2, 3, & 5.

TABLE 4.

FARM SIZES IN HESSEN

Farm Size Hectares*	Number of Farms			Total Area, Hectares		
	1950	1960	1970	1950	1960	1970
0-2	88,522	63,621	38,547	88,720 (1.0)	63,015 (1.0)	38,447 (1.0)
2-5	63,685	44,754	27,449	206,663 (3.2)	146,040 (3.3)	90,419 (3.3)
5-10	36,462	28,963	18,604	257,124 (7.1)	208,900 (7.2)	133,238 (7.2)
10-20	18,606	23,430	20,952	250,213 (13.4)	320,022 (13.7)	303,654 (14.5)
20-50	3,975	4,577	9,093	106,455 (26.8)	120,656 (26.4)	238,730 (26.3)
50-100	429	406	423	29,887 (69.7)	28,080 (69.2)	28,801 (68.1)
Over 100	259	194	201	42,150 (162.7)	31,796 (163.9)	32,806 (163.2)
Total	211,938	165,945	115,269	981,212 (4.6)	918,509 (5.5)	866,097 (7.5)

* 1 Hectare is 10,000 sq m or 2.47 acres.

The numbers in parentheses indicate the average farm size.

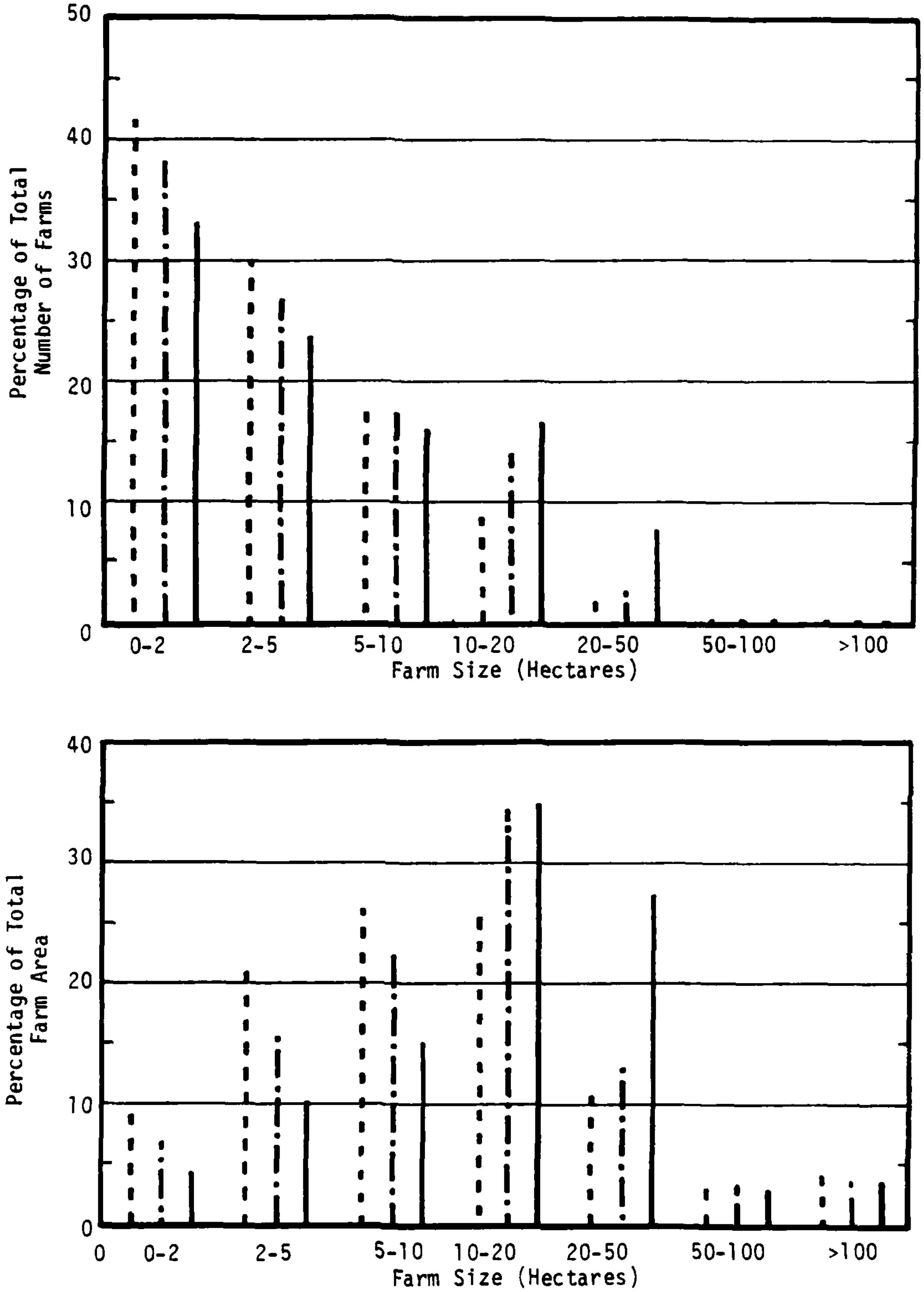


Figure 10. Distribution of Farms and Farm Sizes in Hessen

1950 - - - - - - 1960 —— · —— 1970 ————

did not change appreciably over the two decades and the land occupied by large farms accounts for under 8 percent of the total area farmed both in 1950 and 1970. In other words, farms exceeding 50 hectares in size are rare; most are under 15 hectares.

The large number of small farms indicate that there may be many fences and hedges. The large number of secondary roads are also required to provide ready access to these farms.

An analysis of Table 3 indicates that slightly over 70 percent of the total area of the sixteen selected 100 hectare areas is tank-trafficable. The average slope of the selected areas is approximately 12 percent, the average minimum altitude is 201 m; the average maximum altitude is 308 m. The area of the average wooded portion of the selected areas is approximately 30.8 hectares, the area of the average farmland portion of the selected areas is approximately 40.1 hectares.

Based on an examination of Table 3 the 100 hectare areas 6 and 10 appear to be reasonably representative of the Fulda Gap invasion route.

That 70 to 80 percent of the land in the Fulda area is tank-trafficable is supported from the map analysis above and by an examination of sixteen photographs each representing an area slightly larger than 1 km square and with the squares randomly distributed in the Fulda area. These photographs are available in a report concerned with the detection of armor [2]. An examination of these photographs indicates that about 80 percent of the total area appears tank-trafficable.

3.3 THE HOF CORRIDOR

The Hof Corridor invasion route lies in the province of Bayern. As in the Fulda Gap invasion route there are a large number of towns and villages distributed throughout the invasion route. These towns and villages are generally connected by primary roads augmented by a large number of secondary roads. Since this invasion route encompasses extensive farmlands, the secondary roads provide access to them.

Trafficability on much of the land should be good since the sampled areas appear to be well drained and swampland represents only a very small percentage. Woods represent a significant percentage of some of the areas, for example, randomly selected areas 2, 6, 8, and 11, where woods occupy 46 to 93 percent of each square kilometer area. On the other hand, 10 of the 16 sampled areas have only small stands of woods or none at all. Accordingly, considerable open areas exist in which vehicles can maneuver.

In many respects the Hof invasion route resembles the Fulda invasion route and this is reflected in the similarity of the characteristics reflected in Tables 3 and 5.

An analysis of Table 5 indicates that slightly over 70 percent of the total area of the sixteen selected 100 hectare areas is tank-trafficable. The average slope of the selected areas is approximately 6 percent; the average minimum altitude is 434 m; the average maximum altitude is 500 m. The area of the overall wooded portion of the selected areas is approximately 27 hectares, the area of the average farmland portion of the selected areas is approximately 72 hectares.

Based on an examination of Table 5 the 100 hectare areas number 10 and 13 appear to be reasonably representative of the Hof Corridor invasion route.

TABLE 5
MAN-MADE AND NATURAL FEATURES IN SAMPLED AREAS OF HOF-NÜRNBERG

Feature		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total	Avg
Primary Roads	km					.	.	0.45		-	--	-		-	-			0.45	0.03
Improved Secondary Road.	km					.	.		--	--	-	.	--	1.0	1.3	0.88	0.6	3.78	0.24
Unimproved Secondary Roads	km	2.3	1.72	1.83	2.3	1.54	1.67		1.3	2.44	1.45	1.00	0.98	-	.			18.53	1.16
Rivers	km	0.72		0.7	0.3	-	-	--	-	-	--	--	--	.	0.1	1.1	.	2.92	0.18
Creeks	km				.	1.72	--	-	--	0.85	0.55	--	--	--	--		-	3.12	0.20
Ponds, Number	No.			1.0	-	2.0	--	-	-	--	--	--	--	--	--	-	--	3.0	0.19
Area	ha	--		0.5	.	1.65	-	--	--	--	--	--	--	--	--	--		2.15	0.13
Woods	ha	11.0	92.5	13.2	5.3	35.15	64.0	--	93.0	--	35.0	46.0	8.5	12.5	-	10.0	7.5	433.65	27.10
Villages	ha			.		.	--	--	--	--	--	--	--	--	4.0	7.0		11.0	0.69
Isolated Bldg.	No.			11.0	9.0	7.0		--	--	-	3.0	--	--	4.0	--	.	--	34.0	2.13
Slope (Est. Avg.)	.	2.9	11.5	3.3	8.3	1.7	8.3	6.4	6.5	6.1	7.5	8.0	2.3	5.0	7.4	5.5	4.4		5.93
Peak Slope	.	14.7	24.2	8.3	19.2	9.5	26.3	18.0	25.0	22.7	25.0	25.0	12.5	12.5	16.7	20.0	25.0		19.04
Max. Altitude	m	570.0	798.0	630.0	570.0	310.0	452.0	381.0	352.0	474.0	375.0	460.0	350.0	610.0	594.0	555.0	630.0		500.7
Min. Altitude	m	475.0	642.0	600.0	446.0	286.0	367.0	292.0	300.0	412.0	308.0	340.0	305.0	550.0	520.0	500.0	596.0		433.7
Total Tank Trafficable Area*	ha	89.0	7.5	86.3	94.7	61.2	36.0	100.0	7.0	100.0	65.0	54.0	91.5	87.5	96.0	83.0	92.5	1151.2	72.0

* Tank-trafficable area includes (1) scrub and pasture, (2) meadow, and (3) farmland, open, and other. Area in third category is not separately listed in Tables 2, 3, & 5.

4
ANALYSIS OF TYPICAL AREAS IN TERMS OF FACTORS AFFECTING MINEFIELD DETECTION

One of the major terrain related factors affecting remote minefield detection performance is sensor accessibility. Sensor accessibility as used in this report refers to the feasibility of observing a target without interference from intervening materials or structures. The principal terrain related factors affecting sensor accessibility are topography and vegetation. These factors are generally discussed in Reference 3.

Another major terrain related factor affecting remote minefield detection is the apparent contrast to the sensor existing between the target and the background. In our particular case the background is that which is to be expected along the three invasion routes of interest.

A third terrain related aspect affecting remote minefield detection system performance is the effect of topography and vegetation on the overall remote minefield detection system. For example, terrain can greatly influence flight regimes and electronic lines of sight. These aspects are specifically discussed in References 4 and 5.

Consideration of these factors will be specifically applied to some of the typical areas representative of the three invasion routes which were selected in Section 3. The resultant implications affecting remote minefield detection will also be discussed.

In the application of these factors to the typical areas the following guidelines have been established as reasonably in consonance with the four scenarios envisioned for the invasion routes into West Germany. Typically minefields occur in tank-trafficable areas and because of their extent are typically located in open areas or fields. Open fields include crop land, pasture, meadows and low open areas such as scrub. Bogs and marshes are considered as unsuitable sites for minefields. Densely forested areas with high vegetation are also considered as unsuitable sites for minefields.

Considering these guidelines, the general relationship between terrain features and remote minefield detection factors appear as illustrated by Table 6. Sensory access and background factors are typically linked to the vegetation characteristic of farmlands (crops and pasture) and low scrub. Sensory access is also associated with terrain slope although some sensors can be used so that they are relatively insensitive to slope. System factors are typically linked to major terrain features which can affect flight regimes or mask lines of sight (optical or electronic). Accordingly system factors are strongly linked to altitude, slope and the existence of high vegetation such as forested areas.

An examination of the area typical of the North German Plain (area 6) in terms of these relationships reveals that land usage for crops and pasture comprises about 77 percent of the total area. Accordingly this area is available for potential minefield sites and this area plus the area of the roads is available for tank traffic. Crops typical of the North German Plain invasion route are primarily wheat and sugar beets (see Figure 9). These crops will be the principal determinants of sensory access to minefields located along this invasion route. Further these same vegetational covers will be a major determinant of the background to be expected. The average slope (0.8 percent) and peak slopes (3.0 percent) and range of altitudes to be expected indicate that terrain slope will not be a major factor influencing remote minefield detection along this invasion route.

A similar examination of the Fulda Gap invasion route and its typical 100 hectare area 10 indicates that about 6 percent of the area is cropland and pasture. Main crops are wheat and sugar beets

TABLE 6.

GENERAL RELATIONSHIPS BETWEEN TERRAIN FEATURES AND REMOTE MINEFIELD DETECTION FACTORS

Terrain Features	Remote Minefield Detection Factors		
	Sensory Access	Background	System
Land Usage			
Crops	X	X	
Pasture	X	X	
Scrub	X	X	
Forest			X
Other			
Altitudes			
Minimum			X
Maximum			X
Slopes			
Minimum	X		X
Maximum	X		X
Average	X		X

(see Figure 9). Additionally a significant portion of the farmland is devoted to pasture. In this area sensory access to minefields and minefield background will be principally determined by these three vegetational covers --- wheat, sugar beets, and pasture. The average slope (13 percent) and peak slope (50 percent) are significantly different from those of the North German Plain. The ruggedness of this terrain will distinctly limit tank trafficability and the consequent choice of sites for minefields. The range of ground elevations from 220 to 311 m combined with the range of slopes expected will affect flight regimes and electronic lines of sight.

Examination of the Hof Corridor and its typical 100 hectare area 10 indicates that about 65 percent of the area is cropland and pasture. Main crops are potatoes, rye and barley. There is a significant portion of the farmland devoted to permanent pasture. In addition there are small areas devoted to market gardening. In this area sensory access to minefields and minefield background will be principally determined by these four major vegetational covers - potatoes, rye, barley, and pasture. The average slope (7.5 percent) and peak slope (25 percent) are intermediate to those of the North German Plain and the Fulda Gap. Although the minimum altitude (308 m) and maximum altitude (375 m) are highest of the three invasion routes, it is expected that overall effect on flight regimes and electronic lines of sight may be less than in the Fulda area.

5
FINDINGS AND RECOMMENDATIONS

The previous discussion leads to the following findings and recommendations.

5.1 TANK-TRAFFICABLE AREAS

Tank-trafficable areas in the North German Plain, Fulda Gap and Hof Corridor invasion routes range from 65 percent to about 80 percent of the total invasion route area respectively. Most of the tank-trafficable area is farmland suitable for the siting of minefields.

5.2 KEY FACTORS IN MINEFIELD DETECTION

Key factors in the remote detection of minefields are sensor accessibility, contrast between target and background and the effect of topography and vegetation on remote minefield detection system parameters.

5.3 VEGETATION COVER

For the farmland area the principal determinants of sensor accessibility and contrast are the vegetative cover. The vegetative cover is principally farm crops and pasture. Major farm crops are wheat, sugar beets, potatoes, rye, and barley. Test arrays should include these crops and pasture for the determination of sensor accessibility and target contrast.

5.4 TOPOGRAPHY

Topography ranges from flatlands in the North German Plain to forested mountains with intervening farmland valleys in the Fulda Gap, with Hof Corridor being intermediate to these extremes. The slopes and range of altitudes can be expected to influence flight regimes and electronic lines of sight and other remote minefield detection system parameters dependent on specific circumstances.

REFERENCES

1. M.Y. Nuttonson, "Ecological Crop Geography of Germany and Its Agro-Climatic Analogues in North America," American Institute of Crop Ecology, Washington DC, 1949.

2. "Artillery-Delivered Armor-Defeating Mechanisms (U)," Final Report on Contract DAAA21-73-C-0532 (Item Nomenclatures: SADARM, AMCMS, Code: 662693kk44499), Chrysler Corporation Defense Division, March 1974, SECRET.

3. Y. Morita, "Effects of Resolution, Field of View and Vegetation on Sensor Access (U)," Report No. 138300-59-T, Environmental Research Institute of Michigan, Ann Arbor, MI, July 1980, UNCLASSIFIED.

4. Y. Morita, H. McKenney, "An Assessment of Technical Factors Influencing the Potential Use of RPVs for Minefield Detection (U)," Report No. 138300-57-T, Environmental Research Institute of Michigan, Ann Arbor, MI, July 1980, UNCLASSIFIED.

5. Y. Morita, H. McKenney, "An Assessment of Technical Factors Influencing the Potential Use of Weapons Locating Radars for Minefield Detection (U)," Report No. 138300-61-T, Environmental Research Institute of Michigan, Ann Arbor, MI, July 1980, SECRET.

DISTRIBUTION LIST

U.S. Army Mobility Equipment Research and Development Command — 8 copies
Mine Detection Division
DRDME-ND (Dr. J.R. Gonano)
Fort Belvoir, VA 22060

END

DATE FILMED

1 81

DTIC