Studies on accessibility and availability to computer graphic technology in logging system by simulation model I

Masami SHIBA, Teturo SAKAI,
Toshiaki YAMAMOTO and Isao SASAKI

シミュレーションモデルを用いた集材作業システムへの電算機グラフィック技術の接近性と有効性についての研究 I

芝　正己・酒井徹朗・山本俊明・佐々木功

Rèsumè

The purpose of this paper is to discuss accessibility and availability to computer graphic technology in timber harvesting or fore logging plan by simulation model. This simulation model represents a projected figure (a bird's-eye view), in which geographical lines and geometrical marks correspondingly symbolize topography and vegetation. The projected figure of the proposed logging area was drawn with X-Y plotter on the basis of digital terrain data and stand type data which were obtained through a map on are duced scale, 1/5000.

The situation of the logging area was simulated with overlaying forest roads, cutting boundary lines and skylines with the projected figure according to the proposed logging plan at the 17th compartment in Kyoto University Forest in Ashu.

The problems of plotting output and analytical efficiency are as follows.

I Different efficiency of operating and plotting caused by two types of X-Y plotter.
II Stereoscopical expressiveness of a projection caused by the viewpoint difference.
III Surmounting the limit of the visibility of the project area or land unit.
IV Visual efficiency of the symbolized vegetation expression.
V Visual efficiency of the expression by reducing the projection.
VI Prospective portrayal of the logging area and the situation.

In such a static analysis as the landscape management more progressive studies on above-mentioned problems will enable computer graphic systems to be introduced more extensively. In such a dynamic analysis as the simulation of logging situation, however, some problems of visual expression are proposed.

要　　旨

本報告はシミュレーションモデルを導入した木材収獲作業あるいは事前の伐出作業計画への電算機グラフィック技術の接近性と有効性について検討を加えたものである。このシミュレーションモデルとは，地形を地性線で，森林を幾何記号で象徴した投影図（鳥瞰図）を意味する。伐採予定地の投影図は5千分の1地形図および林相図から得られた数値地形データ，林相データを基にして，X-Yプロッタによって描かれる。伐採地の状況は京都大学芦生演習林17林班の伐出作業計画に基づいて，この投影図上に既設林道，伐区，架線表現を重ね合わせることによりシミュレーションされる。図化出力の問題および解析効果については，次の様な観点から論議される。

Ⅰ　出力用X-Yプロッタの違いによる作業効果と図化効果

Ⅱ　視点の違いによる投影図の立体的表現性

Ⅲ　投影地域の視界限界の克服　Ⅳ　植生表現としてのシンボルマークの視覚効果

Ⅴ　投影図の縮尺による表現効果　Ⅵ　伐採地域の表現

景観施業のような静的な解析においては，上述の問題点をさらに研究していくことで，グラフィックシステムは大いに利用可能であろう。しかしながら伐採地の状況をシミュレーションする様な動的解析においては，いくつかの視覚的問題が残されている。

Introduction

Social needs to immaterial value of forests represented by the public welfare utility, increasingly urge the present forestry production system onward the synthetic multiple-use. To establish this prospective forestry production system or forest control system, it would be better to construct the simulation model under the efficient and systematic information structure and to give access to the optimum control system after supposing every situation.

Logging plan and forest road net-work plan are made within the consideration of the solid geometry of a topography. However it would be practice to grasp proposed area stereoscopically rather than plainly. That is," Human are visual animals ".

With these consideration in mind, a planner imagines the topography and vegetation at proposed area spacially and visually with an electric computer, and can optionally arrange routes of forest road, cutting boundary lines, skyline positions and landing places with commanding program function. In this way, the optimum disposition would be decided. As a result, the field circumstances is drawn indoors and a logging plan and a road net-work plan can be estimated in advance. The projection drawn by this method means the medium landscape between ground and aerial ones.

This paper descrives how to draw the topography, forests and forest roads with an electric computer graphics and to simulate the circumstances of logging area with standing on the proposed logging plan at the 17th compartment in Kyoto University Forest in Ashu. At the same time is discussed the accessibility and availability to computer graphic technology, from logging practice of view.

Today's procedure of computer graphic technology available to solve the forest planning problems

The aim of visual aralysis is to ensure recognition and consideration of the visual qualities of landscape in the process of environmental desing and management. Various researches of forest landscape management have been doing in response to need in our country. Shioda emphasized the necessity for the theoritical natural landscape planning and practically attempted to assess and reduce visual impacts (clear cutting influence) which should be applied to some logging area. Computer graphics as a predictive tool were utilized from the standpoints of both the landscape management and the timber harvesting[1)2)3)].

Konohira and Maeda have been discussing the problems of basic plotting technic in detail, for example, the effective treatment of the hidden lines for topographic expression and symbol marks of vegetation[4)5)6)7)].

Ito has been studying more flexible software to draw a projection by applying graphic display (G.D.P) from landscape architechtonic point of view[8)].

In civil engineering many progressive researches, which are so called an earth movement or an earth desing, have been made[9)10)].

Particularly in the U.S.A., practical and versatile researches have been reported by means of regarding forests as "visual resources"[11)12)13)14)15)16)17)].

Table 1. The constitution of sectional meetings at "A Conference on Applied Techniques for Analysis and Management of the Visual Resource" in Nevada, April 23-25, 1979

(I)	Major challenges in landscape planning ; Simulated field trips
(II)	Technology available to solve landscape problems
	Section A : Descriptive approaches
	Section B : Computerized and quantitative approaches
	Section C : Psychometric and social science approaches
	Section D : Evaluation of visual assessment methods
(III)	Appreciate combinations of technology for solving landscape management problems
	Section E : Surface mining and reclamation
	Section F : Urbanization ; Highway development
	Section G : Recreational development
	Section H : Rural and agricultural development
	Section I : Utility corridors ; Siting of power plants
	Section J : Timber management *
	Section K : Water resource development
	Section L : Outre continental shelf and coastal energy development
(IV)	Landscape management systems
(V)	Legal and policy tools available to use in solving
(VI)	Landscape management problems
(VII)	New dimensions of visual landscape assessment
(VIII)	Future direction for research and management

** Proceedings of OUR NATIONAL LANDSCAPE

*** A Conferennce on Applied Techniques for Analysis and Management of the Visual Resource ***

Table 1 shows the constitution of sectional meetings at "A Conference on Applied Techniques for Analysis and Management of the Visual Resource" in Nevada, April 23-25, 1979.

In our forest management the use of computer for digital information analysis has been spread to a great extent. But the utilization of hardware and software by means of graphic system (G.D.P., C.O.M., etc) is not fully introduced. That is why we are lacking in communication with the information of programing technic, its result, the expression of data structure or data base, the application in each field. It goes without saying that the communication power of graphic information is superior to that of data in figures dealt with by programing languages.

Application to a model area

The proposed logging area at the 17th compartment in Kyoto University Forest in Ashu was selected as the model area.

The 17th compartment is located above Nakayama, in the north slope of the right hand Kami-tani and includes Sawa-dani, Uturo-dani and Kie-dani. It adjoins the 19th compartment to the north and the 20th compartment to the east at Kami-tani and the 18th and the 16th compartment on the borders of the ridge between Kie-dani and Keyaki-dani.

Terasaki attempted to classify the stand type by combining tree species, canopy structure, crown density and tree height as a result of identifying an aerial photograph, in a series of researches of forest productivity in this area[19].

According to this report, except a partial unstocked land, this area is almost covered with compound storied forests which have dense crowns and the stand types consist of needle-leaved forest, mixed forest (needle-leaved forest & broad-leaved forest) , mixed forest (broad-leaved forest & needle-leaved forest) and broad-leaved forest.

I Digital terrain map

A forest standard topographic map on a reduced scale, 1/5000 was used and the unit square area (600m × 600m) including the proposed logging area was covered with a square grid (10m × 10m) and the altitude of each grid point was measured by the metre. As to the coordinate of this digital terrain map East-West direction was set as X-axis, South-North, Y-axis. Matrix digital terrain data (60 × 60) were punched in data cards (FORMAT, 15F5.0) from X-array in due course.

II Coded stand type map

Original stand type map of Kyoto University Forest in Ashu on a reduced scale, 1/5000 was used and the stand types identified every one grid point and divided into 14 kinds of code. This stand type map is classified by the combination of tree species, canopy structure, crown density and tree height.

Table-2 shows the coded stand type classification, Figure 1 shows the original stand type map on a reduced scale, 1/5000 and Figure 2 shows a scatter diagram of the stand types plotted by line printer of an electric computer.

Table 2. The coded stand type classification

Stand type code	Tree species	Canopy structure	Crown density	Tree height
	Unstocked land (Road surface, till slopes and river)			
A	Needle-leaved forest (Artificial)	Single storied		
B	Broad-leaved forest	Compound storied	Dense	Middle
C	Broad-leaved forest	Compound storied	Dense	High
D	Broad-leaved forest	Compound storied	Medium	High
E	Broad-leaved forest	Compound storied	Sparce	Low
F	Mixed forest (Broad-leaved&Needle-leaved)	Compound storied	Dense	High
G	Mixed forest (Broad-leaved&Needle-leaved)	Compound storied	Medium	High
H	Mixed forest (Broad-leaved&Needle-leaved)	Compound storied	Sparce	Middle
I	Needle-leaved forest (Natural)	Compound storied	Dense	High
J	Needle-leaved forest (Natural)	Compound storied	Medium	High
K	Needle-leaved forest (Natural)	Compound storied	Sparce	High
L	Mixed forest (Needle-leaved&Broad-leaved)	Compound storied	Dense	High
M	Mixed forest (Needle-leaved&Broad-leaved)	Compound storied	Medium	Middle

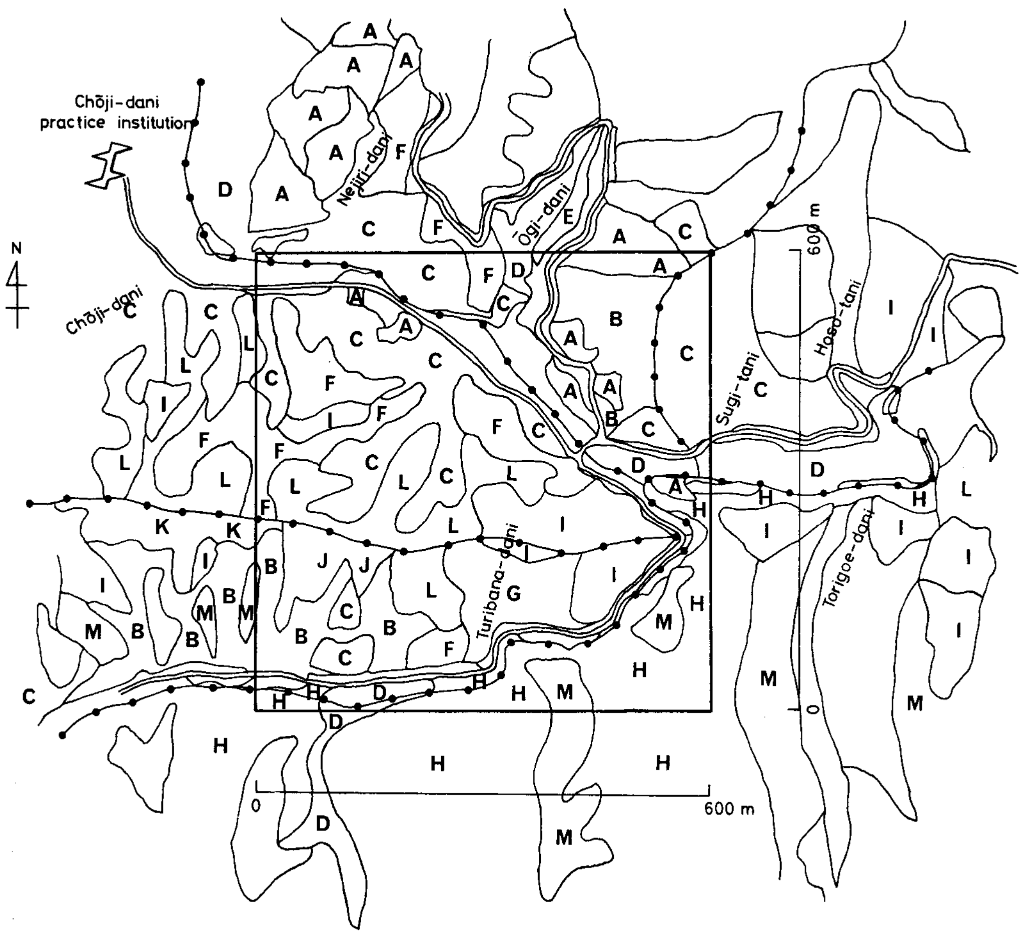


Fig. 1. The original stand type map on a reduced scale, 1/5000

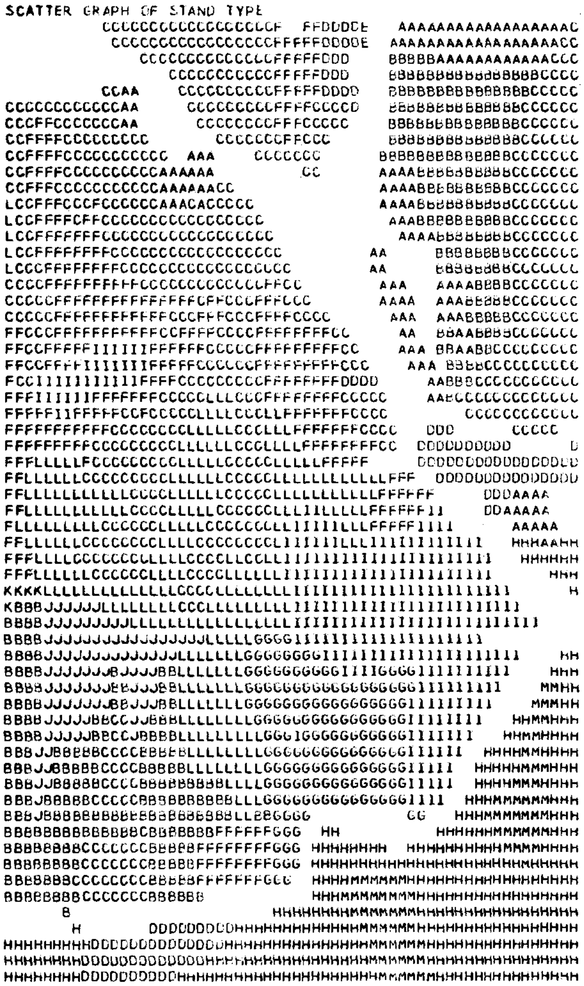


Fig. 2. A scatter diagram of the stand types plotted by line printer of an electric computer

Ⅲ Decision of symbol marks corresponding to stand type codes and SUBPROGRAM SYM

The symbol marks has a great influence on the visual expression of vegetation. The stand type of this area is divided into 14 kinds of code. But actually it is very difficult to express all codes with different symbol marks, because the number of codes of symbol table available to ON-LINE BASIC ROUTINE is limitted and only few symbol codes in this are visually fit for an image of vegetation. These codes except unstocked land's one were expressed with five symbol marks into which tree species were classified One or two symbol mark was plotted on each projected point on the basis of stand type data.

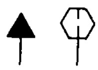
The size of symbol marks, which is theoritically in propotion to the relative distance from a viewpoint, was assumed to be constant in this report. And the transformation of symbol marks by the difference of an angle of depression was disregared.

The symbol mark consisting of two symbol codes of BASIC ROUTINE represents broad-leaved forest (CALL SYMBOL), FUNCTIONAL ROUTINE needle-leaved forest (CALL AROHD), and the combination of two above-mentioned symbol marks mixed forest (CALL

SYMBOL & CALL AROHD).

Table 3 shows the codes of tree species and their symbol marks. SUBPROGRAM SYM was ready for recognizing codes and plotting symbol marks and called optionally in MAINPROGRAM. Table 4 shows this SUBPROGRAM SYM.

Table 3. The codes of tree species and their symbol marks

Stand type code	Classification number**	Symbol mark
	1	no-symbol mark
A	2	
B	3	
C	3	
D	3	
E	3	
F	4	
G	4	
H	4	
I	5	
J	5	
K	5	
L	6	
M	6	

** Classified number in SUBROUTINE SYM

Table 4. SUBPROGRAM SYM for recognizing codes and plotting symbol marks

```
  SUBROUTINE SYM (X,Y,K,I,J)
  DIMENSION X(60,60),Y(60,60),K(60,60)
  IF(K(I,J).EQ. 0) GO TO 1
  IF(K(I,J).EQ. 1) GO TO 2
  IF(K(I,J).EQ. 2) GO TO 3
  IF(K(I,J).EQ. 3) GO TO 3
  IF(K(I,J).EQ. 4) GO TO 3
  IF(K(I,J).EQ. 5) GO TO 3
  IF(K(I,J).EQ. 6) GO TO 4
  IF(K(I,J).EQ. 7) GO TO 4
  IF(K(I,J).EQ. 8) GO TO 4
  IF(K(I,J).EQ. 9) GO TO 5
  IF(K(I,J).EQ.10) GO TO 5
  IF(K(I,J).EQ.11) GO TO 5
  IF(K(I,J).EQ.12) GO TO 6
  IF(K(I,J).EQ.13) GO TO 6
1 CALL SYMBOL (X(I,J),Y(I,J),0.0,17,0.0,-1)
  CALL PLOT (X(I,J),Y(I,J),3)
  RETURN
2 CALL AROHD (X(I,J),Y(I,J),X(I,J),Y(I,J),+0.60,0.20,0.30,16)
  CALL PLOT (X(I,J),Y(I,J),3)
  RETURN
```

```
3 CALL SYMBOL (X(I,J),Y(I,J),0.2,13,0.0,-1)
  CALLL SYMBOL (X(I,J),Y(I,J)+0.2,0.2,1,0.0,-1)
  CALL PLOT (X(I,J),Y(I,J),3)
  RETURN
4 CALL SYMBOL (X(I,J),Y(I,J),0.2,13,0.0,-1)
  CALL SYMBOL (X(I,J),Y(I,J)+0.2,0.2,1,0.0,-1)
  CALL AROHD (X(I,J)+0.1,Y(I,J)+0.1,X(I,J)+0.1,Y(I,J)+0.6,0.20,0.30,11)
  CALL PLOT (X(I,J),Y(I,J),3)
  RETURN
5 CALL AROHD (X(I,J),Y(I,J),X(I,J),Y(I,J)+0.60,0.20,0.30,11)
  CALL  PLOT (X(I,J),Y(I,J),3)
  RETURN
6 CALL AROHD (X(I,J),Y(I,J),X(I,J),Y(I,J)+0.60,0.20,0.30,16)
  CALL SYMBOL (X(I,J)+0.2,Y(I,J)+0.2,0.2,13,0.0,0,-1)
  CALL SYMBOL (X(I,J)+0.1,Y(I,J)+0.4,0.2,1,0.0,-1)
  CALL PLOT (X(I,J),Y(I,J),3)
  RETURN
  END
```

IV A proposed logging plan at the 17th compartment

Clear cutting part (1.84ha) and selection cutting part (6.51ha) are planned to make up of this logging area. Skyline logging system will be taken in this area. Table-5 shows the items of logging plan at the 17th compartment and Figure 3 shows the sutiation of this logging area[20].

Table 5. The operational items of the proposed logging plan

Operational items	+ Area I +	+ Area II +
Cutting system	Clear cutting	Selection cutting
Cutting area (ha)	1.84	6.51
Cutting stumpage volume (m^3)	536.650	839.707
Terrain condition	Medium (scaffold) Average gradient 28°	
Working process	Felling and bucking --+ Hand prehauling --+ Skyline logging --+ Yard stacking --+ Truck loading --+ Truck transport	
Hand prehauling distance (m)	17	15
Skyline logging distance (m)	70	150
Cable system	Endless Tyler System	
Lateral yarding distance (m)	Less than 50	
Setting-up distance of wire rope line (m)	Skyline 1 : 300 (Rigging-dismantling)	Skyline 2 : 450 (Rigging) Skyline3 : 470 (Resetting-dismantling)

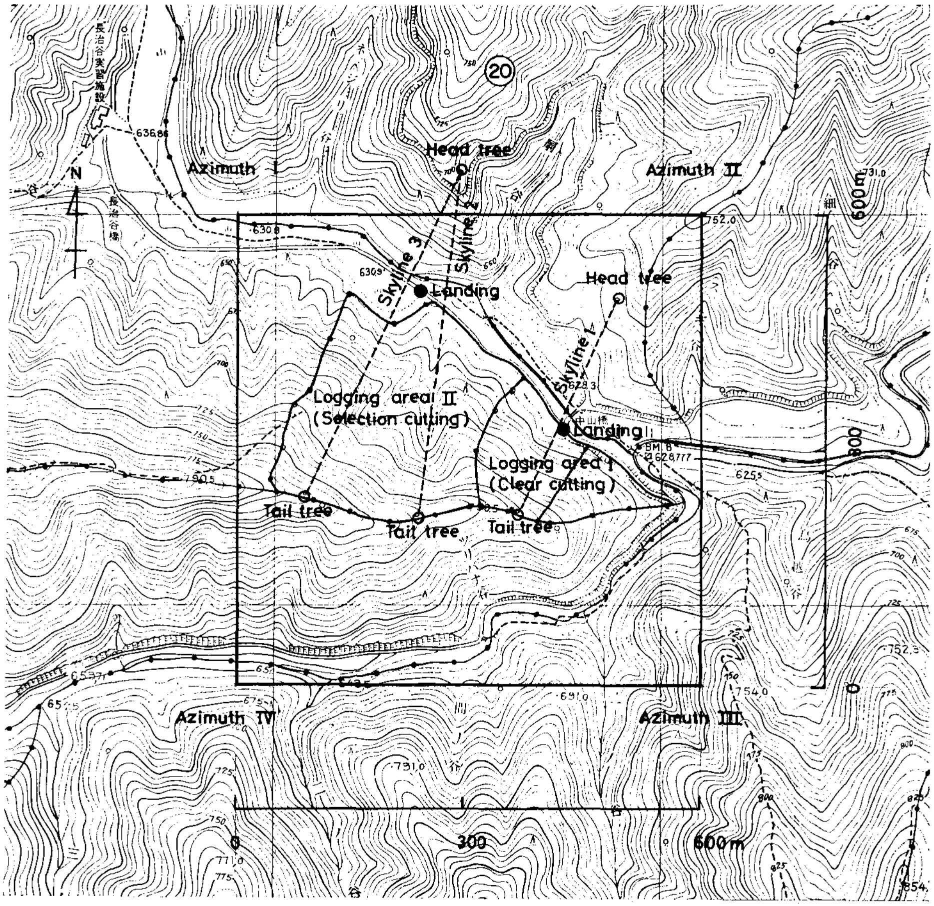


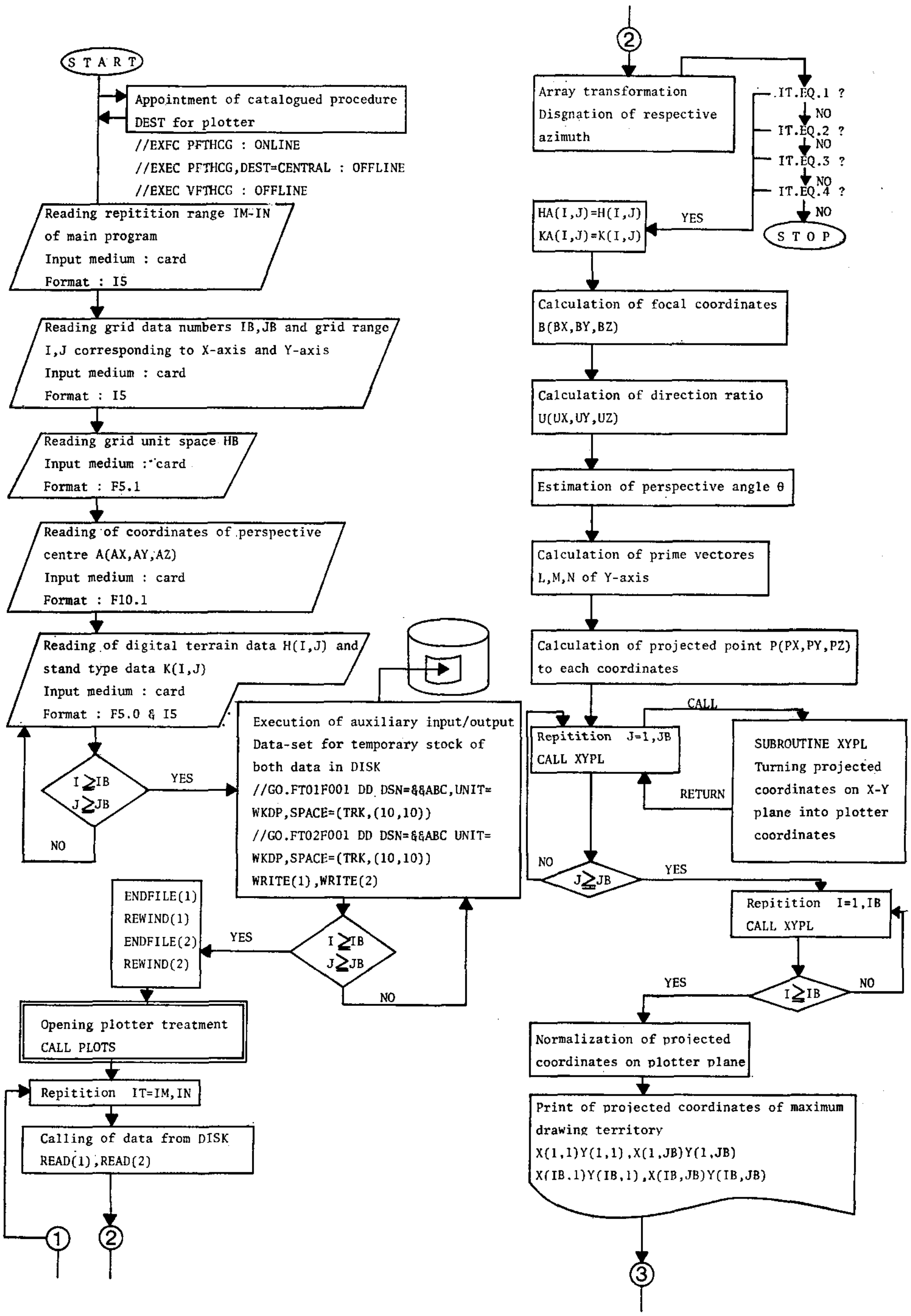
Fig. 3. The proposed logging sutiation at the 17th compartment

Outlines of analytical system and program function

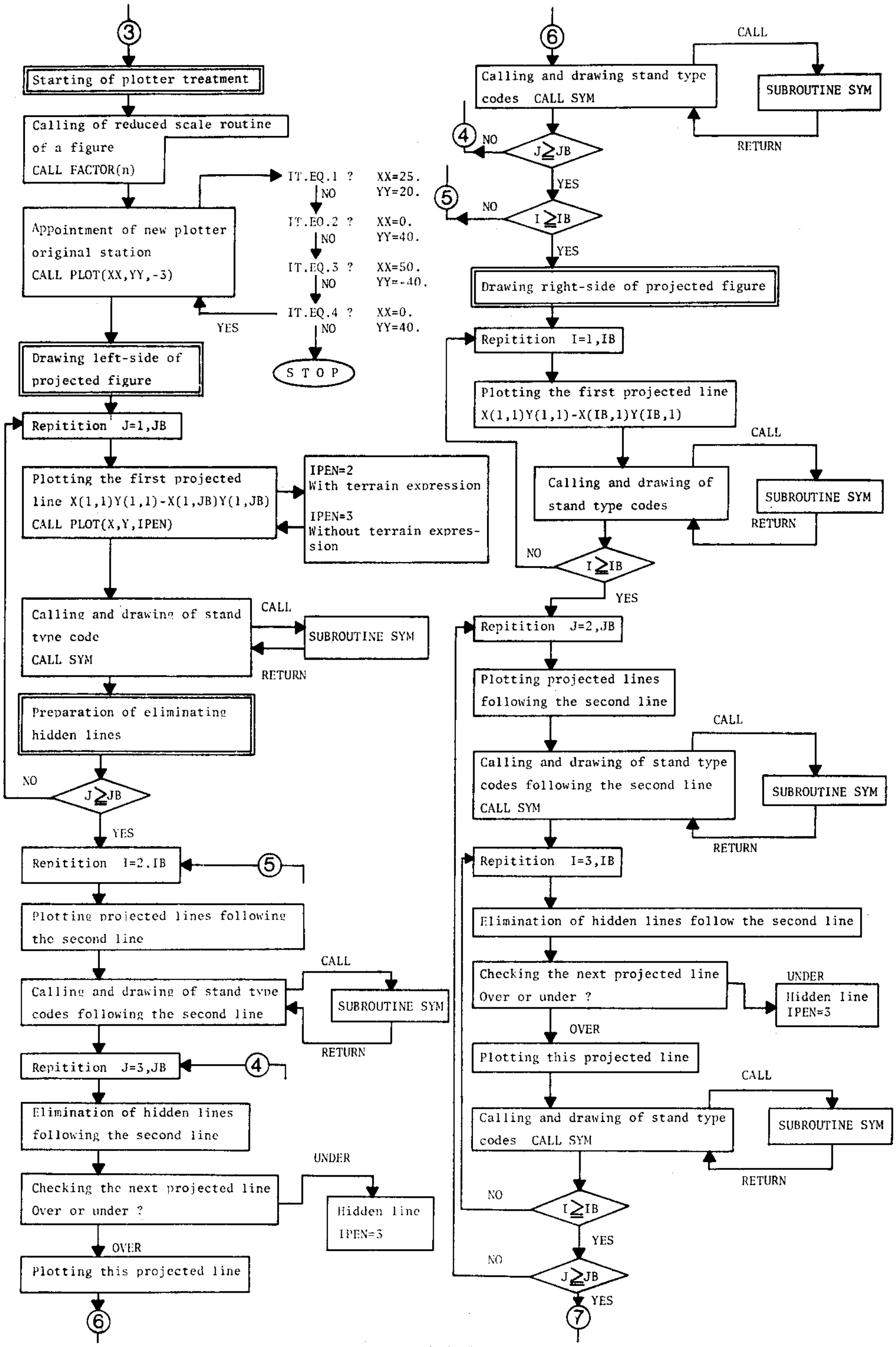
PSSP (Plotter Station System Program) operates as RES exchange branch of main system (M190, OS IV/F4) and is treatable with BACH-JOB. In DATA PROCESSING CENTRE KYOTO UNIVERSITY, there are two types of X-Y potter—ON-LINE PLOTTER (CALCOMP 960+PF-U100) and OFF-LINE PLOTTER (CALCOMP 925/1036) —which can be properly used by appointing the DEST parametre of CATALOGUED PROCEDURE.

The former was introduced, being superior to the latter as concerns a plotting speed and simplicity of handling. This program consists of one MAINPROGRAM and two SUBPROGRAMS which correspondingly have the function of coordinates transformation and the function of identifying stand type codes and plotting symbol marks[18].

Figure 4 shows the analytical system and the flowchart of this program[21][22][23].



START
Appointment of catalogued procedure DEST for plotter
//EXEC PFTHCG : ONLINE
//EXEC PFTHCG,DEST=CENTRAL : OFFLINE
//EXEC VFTHCG : OFFLINE
Reading repitition range IM-IN of main program
Input medium : card
Format : I5
Reading grid data numbers IB,JB and grid range I,J corresponding to X-axis and Y-axis
Input medium : card
Format : I5
Reading grid unit space HB
Input medium : card
Format : F5.1
Reading of coordinates of perspective centre A(AX,AY,AZ)
Input medium : card
Format : F10.1
Reading of digital terrain data H(I,J) and stand type data K(I,J)
Input medium : card
Format : F5.0 & I5
I≧IB J≧JB
YES
NO
Execution of auxiliary input/output Data-set for temporary stock of both data in DISK
//GO.FT01F001 DD DSN=&&ABC,UNIT=WKDP,SPACE=(TRK,(10,10))
//GO.FT02F001 DD DSN=&&ABC UNIT=WKDP,SPACE=(TRK,(10,10))
WRITE(1),WRITE(2)
ENDFILE(1)
REWIND(1)
ENDFILE(2)
REWIND(2)
Opening plotter treatment
CALL PLOTS
Repitition IT=IM,IN
Calling of data from DISK
READ(1),READ(2)
1
2
Array transformation
Disgnation of respective azimuth
IT.EQ.1 ?
IT.EQ.2 ?
IT.EQ.3 ?
IT.EQ.4 ?
STOP
HA(I,J)=H(I,J)
KA(I,J)=K(I,J)
Calculation of focal coordinates B(BX,BY,BZ)
Calculation of direction ratio U(UX,UY,UZ)
Estimation of perspective angle θ
Calculation of prime vectores L,M,N of Y-axis
Calculation of projected point P(PX,PY,PZ) to each coordinates
Repitition J=1,JB
CALL XYPL
CALL
RETURN
SUBROUTINE XYPL
Turning projected coordinates on X-Y plane into plotter coordinates
J≧JB
Repitition I=1,IB
CALL XYPL
I≧IB
Normalization of projected coordinates on plotter plane
Print of projected coordinates of maximum drawing territory
X(1,1)Y(1,1),X(1,JB)Y(1,JB)
X(IB,1)Y(IB,1),X(IB,JB)Y(IB,JB)
3



3
Starting of plotter treatment
Calling of reduced scale routine of a figure CALL FACTOR(n)
IT.EQ.1 ? XX=25. YY=20.
NO
IT.EQ.2 ? XX=0. YY=40.
NO
IT.EQ.3 ? XX=50. YY=-40.
NO
IT.EQ.4 ? XX=0. YY=40.
NO
STOP
YES
Appointment of new plotter original station CALL PLOT(XX,YY,-3)
Drawing left-side of projected figure
Repitition J=1,JB
Plotting the first projected line X(1,1)Y(1,1)-X(1,JB)Y(1,JB) CALL PLOT(X,Y,IPEN)
IPEN=2 With terrain expression
IPEN=3 Without terrain expression
Calling and drawing of stand type code CALL SYM
CALL
SUBROUTINE SYM
RETURN
Preparation of eliminating hidden lines
NO
J≧JB
YES
Repitition I=2,IB
5
Plotting projected lines following the second line
Calling and drawing of stand type codes following the second line
CALL
SUBROUTINE SYM
RETURN
Repitition J=3,JB
4
Elimination of hidden lines following the second line
Checking the next projected line Over or under ?
UNDER
Hidden line IPEN=3
OVER
Plotting this projected line
6
6
Calling and drawing stand type codes CALL SYM
CALL
SUBROUTINE SYM
RETURN
4
NO
J≧JB
YES
5
NO
I≧IB
YES
Drawing right-side of projected figure
Repitition I=1,IB
Plotting the first projected line X(1,1)Y(1,1)-X(IB,1)Y(IB,1)
Calling and drawing of stand type codes
CALL
SUBROUTINE SYM
RETURN
NO
I≧IB
YES
Repitition J=2,JB
Plotting projected lines following the second line
Calling and drawing of stand type codes following the second line CALL SYM
CALL
SUBROUTINE SYM
RETURN
Repitition I=3,IB
Elimination of hidden lines follow the second line
Checking the next projected line Over or under ?
UNDER
Hidden line IPEN=3
OVER
Plotting this projected line
Calling and drawing of stand type codes CALL SYM
CALL
SUBROUTINE SYM
RETURN
NO
I≧IB
YES
NO
J≧JB
YES
7

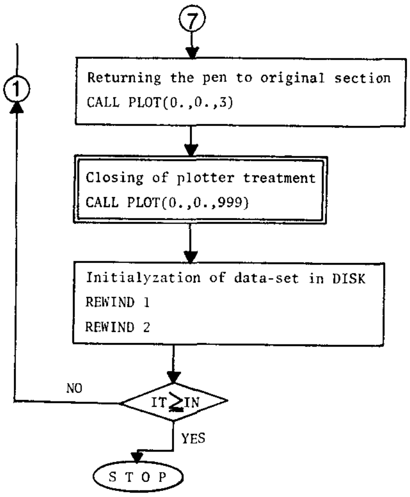


Fig. 4. The analytical system and the flowchart of this program

Efficiency of plotting and analysis

The points at issue were as follows. I Different efficiency of operating and plotting caused by two types of X-Y plotter. II Stereoscopical expressiveness of a projection caused by the viewpoint difference. III Surmounting the limit of the visibility of the project area or land unit. IV Visual efficiency of the symbolized vegetation expression. V Visual efficiency of the expression by reducing the projection. VI Prospective portrayal of the logging area and the situation.

I Different efficiency of operating and plotting caused by two types of Y-Y plotter.

Two types of X-Y plotter, which can be optionally selected with the CATALOGUED PROCEDURE, have different capacities concerning a step-size, the number of pens, plotting area, and accelaration. It took 25 seconds (TOTAL CPU TIME) to calculate 60×60 matrix data with C-JOB and 90 minutes to draw a projection with ON-LINE PLOTTER or OFF-LINE PLOTTER, 4 hours with PRINTER PLOTTER. A projection drawn by X-Y plotter was clearer than that of printer plotter.

Although the plural colored pens are set in X-Y plotters, the colors visually had little effect on a projection. As FUNCTIONAL ROUTINE in SUBPROGRAM SYM becomes a load to the plotting speed, BASIC ROUTINE is better to express symbol marks than FUNCTIONAL ROUTINE.

II Stereoscopical expressiveness of a projection caused by the viewpoint difference.

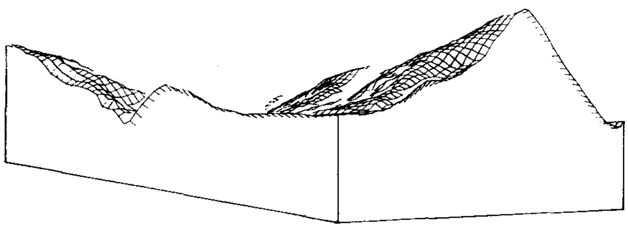
The viewpoint difference has a great influence on a hidden line treatment. The higher a viewpoint becomes, the clearer the aspect of topography appears but the less solidity it has.

In case an angle of depression θ exceeded 40°, the relief of topography was lost and the projected figure looked plain. In addition it was impossible to indicate some special point on this projection. On the contrary, in case of lower viewpoint the efficiency of visual expression increased. But in treating hidden lines there were some problems: spreading the tip of lines, snapping of lines, crossing of lines. In case of the extremely low viewponit they were remarkably apt to happen. From the standpoint of landscape management it serves the purpose to lower a viewpoint. The siutable viewpoint is put on the ground, for example a forest road, a mountain top, a mountain side.

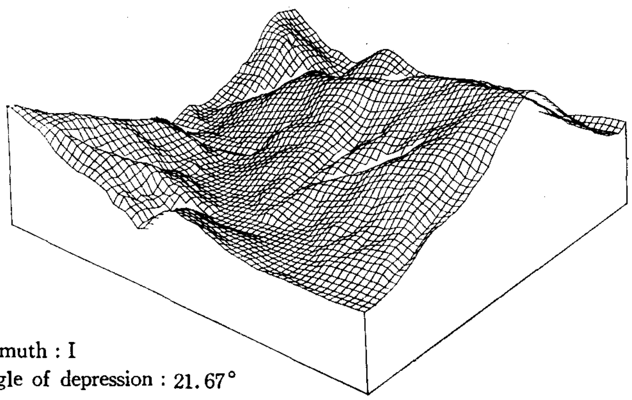
In a logging plan, however, it is more important to grasp the all over aspect of topography and the situation of logging area. Therefore the proper height of a viewpoint is necessarry for the effective expression.

We had come to the conclusion that the most suitable angle of depression θ was approximately from 30° to 40°.

Figure 5 shows the stereoscopical expressiveness of a projection caused by the viewpoint difference.



Azimuth : I
Angle of depression : 5.64°



Azimuth : I
Angle of depression : 21.67°

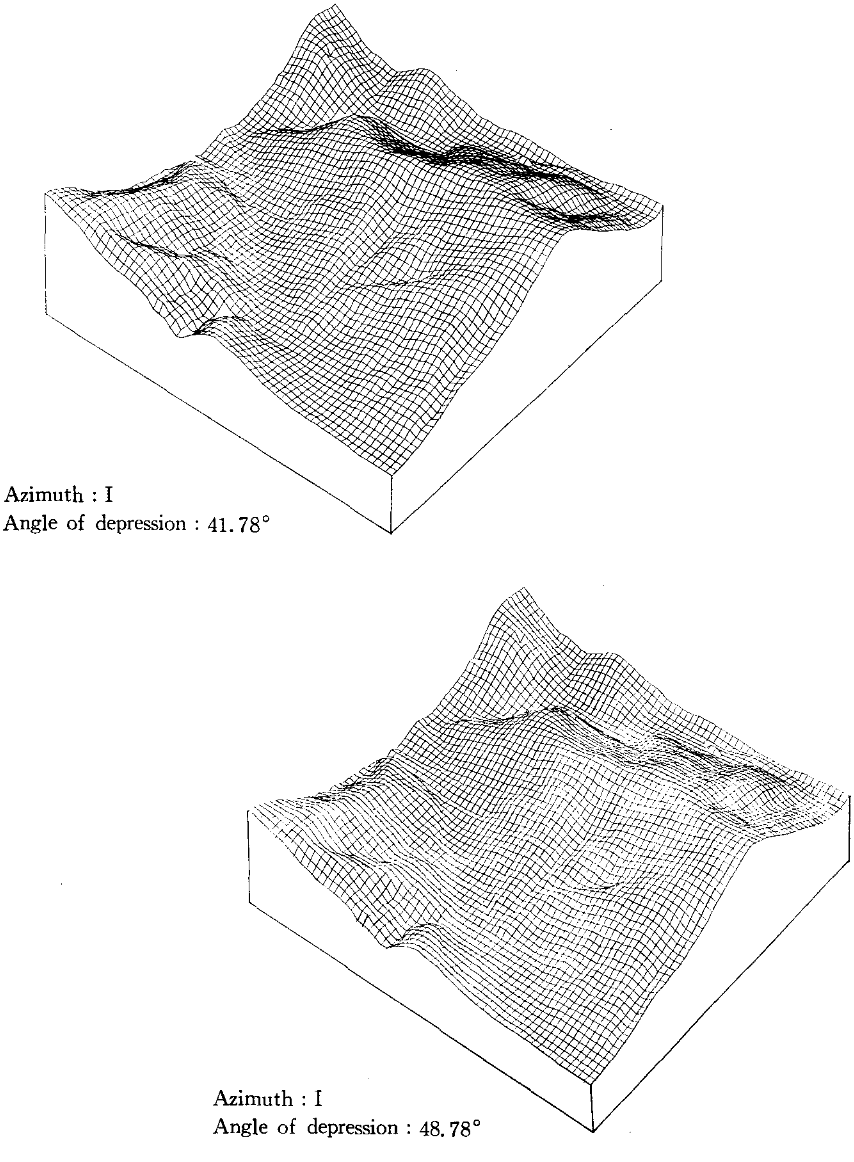


Fig. 5. The stereoscopical expressiveness of a projection caused by the viewpoint difference

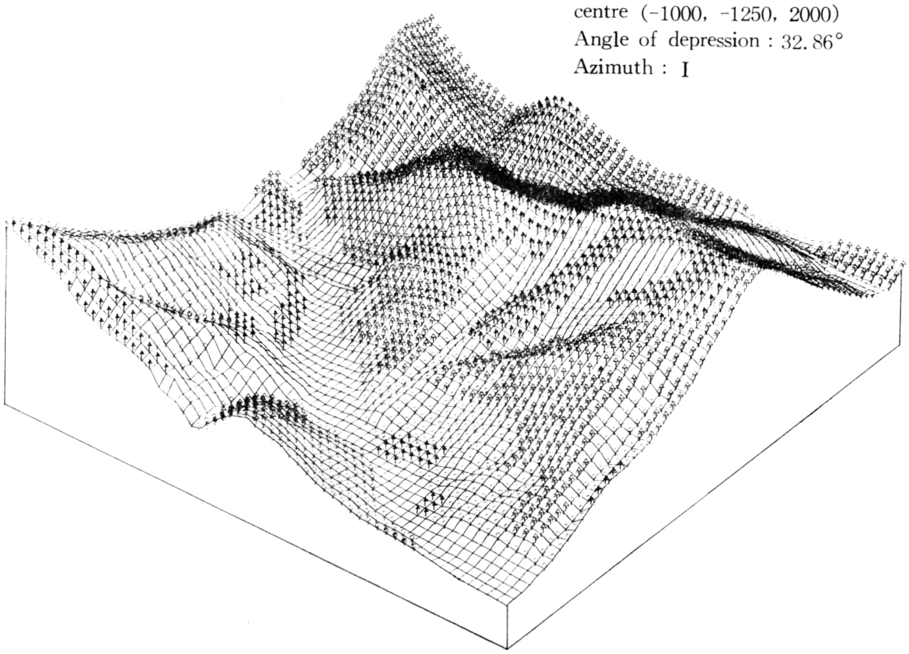
Ⅲ Surmounting the limit of the visibility of the project area or land unit.

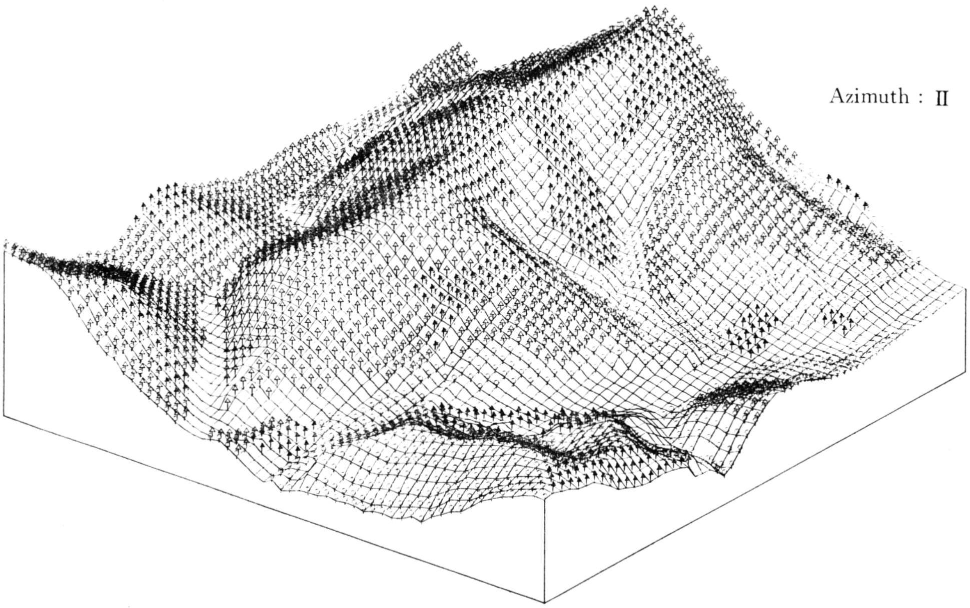
A projection from four grid corners was regarded as the azimuth difference. So arrays of digital terrain and stand type data were transformed.

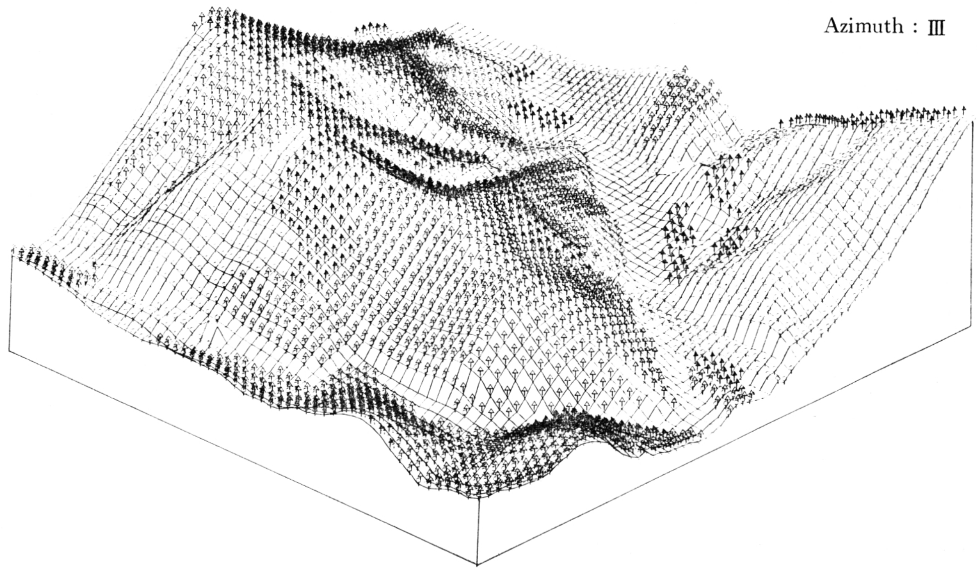
Logging area faces the north slope of the large ridge which is located in the centre of this model area and the forest roads make a long circuit of this ridge. In this topography the limitation of azimuth causes some inconveniences.

Figure 6 shows the landscape of this model area from the four azimuth.

They completely display the whole aspect of this area without hidden parts caused by the limitation of azimuth.







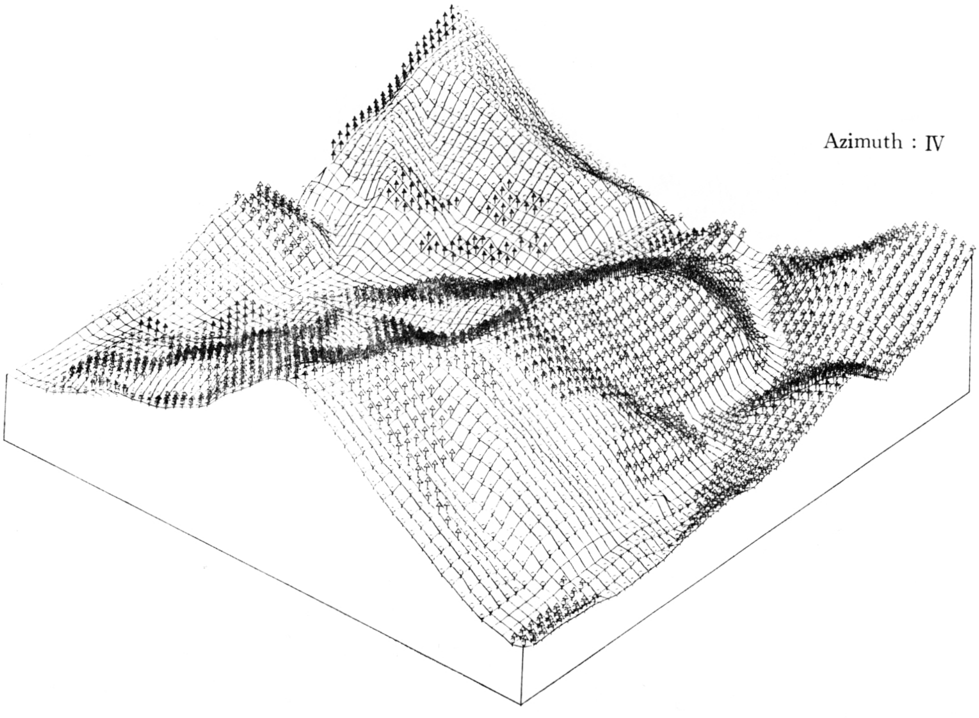


Fig. 6. The landscape of this model area from the four azimuth

IV Visual efficiency of the symbolized vegetation expression.

It was comparatively easy to identify, from a high viewpoint, stand type and the distinction of unstocked land and forest. But near a ridge the overlapping of symbol marks made a forest look denser as it was. A high viewpoint is better for the identification of stand type but is destitute of visual expression.

As the efficiency of hidden line treatment takes away the overlapping of symbol marks, a low viewpoint has a great effect on the expression of forest.

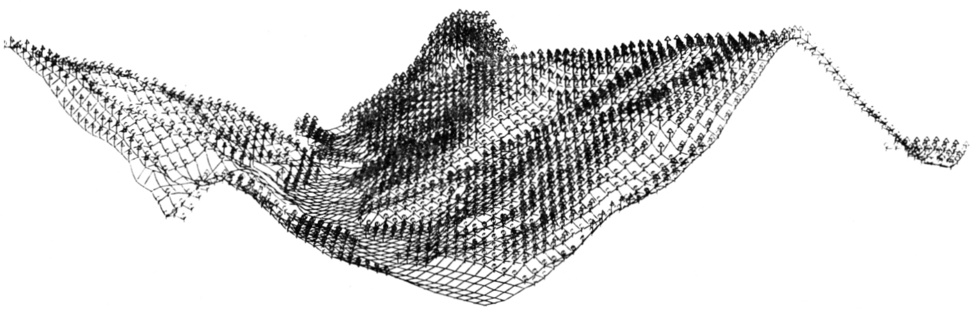
The identification of stand type, however, becomes difficult. Without the expression of topography, stand type was more easily identified and forests were effectively expressed.

The density of symbol marks sometimes makes us feel as if forests were dense at a steep slope and sparse at a hilly place. Moreover the feeling of distance on a projection was scarcely given because the size of symbol marks was constant irrespective of the distance from a viewpoint.

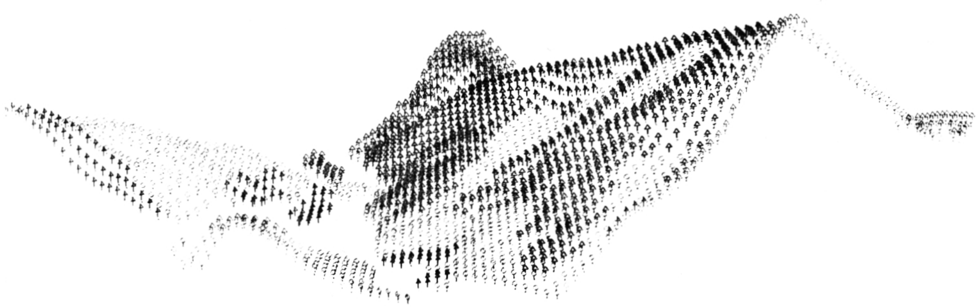
Figure 7 shows the visual efficiency of the forest by eliminating the topographic expression.

Coordinates of perspective centre (-1000, -1000, 1000)
Angle of depression : 9.35°

Azimuth : I



Azimuth : I



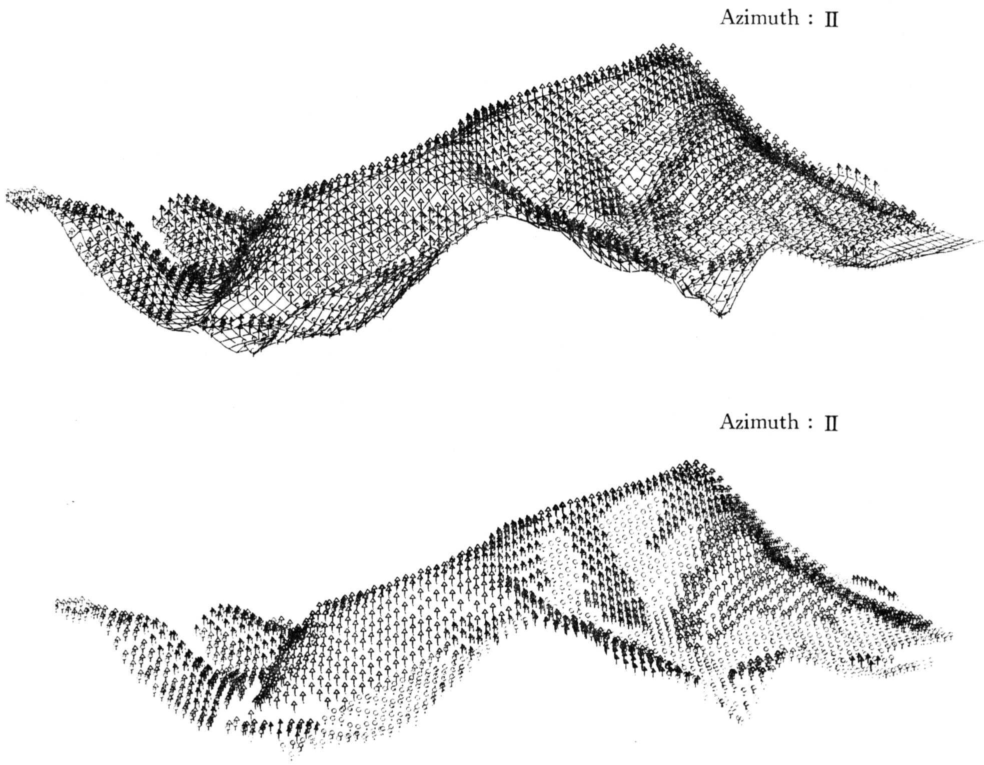


Fig. 7. The visual efficiency of the forest by eliminating the topographic expression

V Visual efficiency of the expression by reducing the projection.

REDUCING ROUTINE (CALL FACTOR) is called in program. The reducing of projected figures had little influence on the visual expression of topography. But the proper reduction was effective in the visual expression of forest. This efficiency was depended on the density of symbol marks.

VI Prospective portrayal of the logging area and the situation.

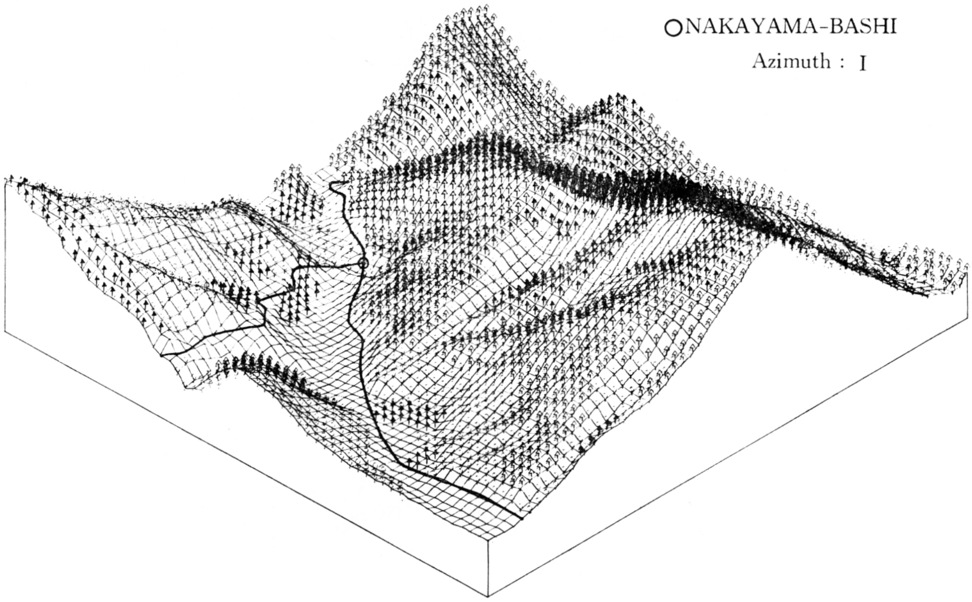
Forest roads, cutting boundary lines and skylines were plotted on the projection from an angle of depression $\theta = 40°$, by conecting each grid coordinate with a straight line. The location and the form of cutting area could be distinguished on it. Skylines were plotted by conecting coordinates of a head tree and a tail tree with a curved line. The forest roads have already existed as one actual part of landscape in this area.

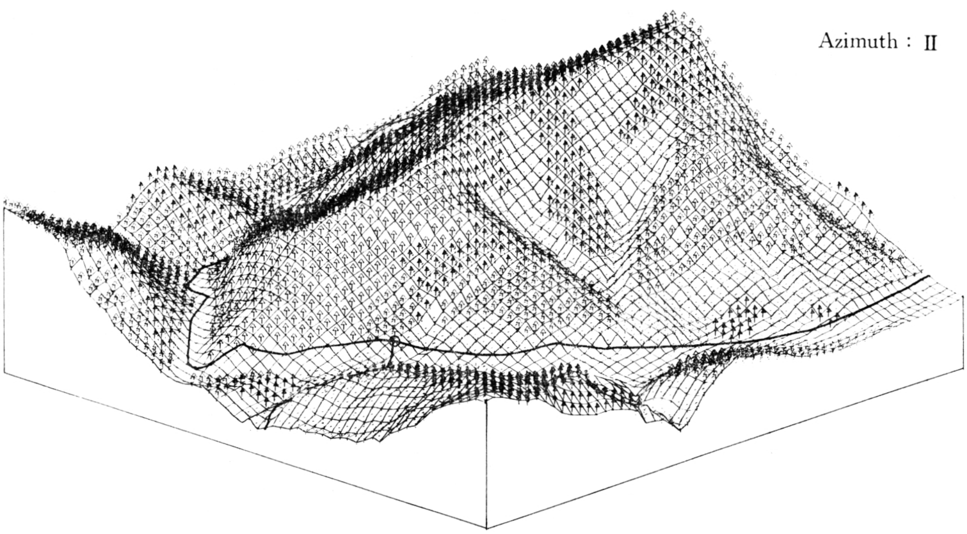
On the other hand, the cutting area is conception. From a visual point of view, therefore, it is undesirable to plot it linearly on the projection, because it is not until forest is cut that the cutting area appears as an actual existence.

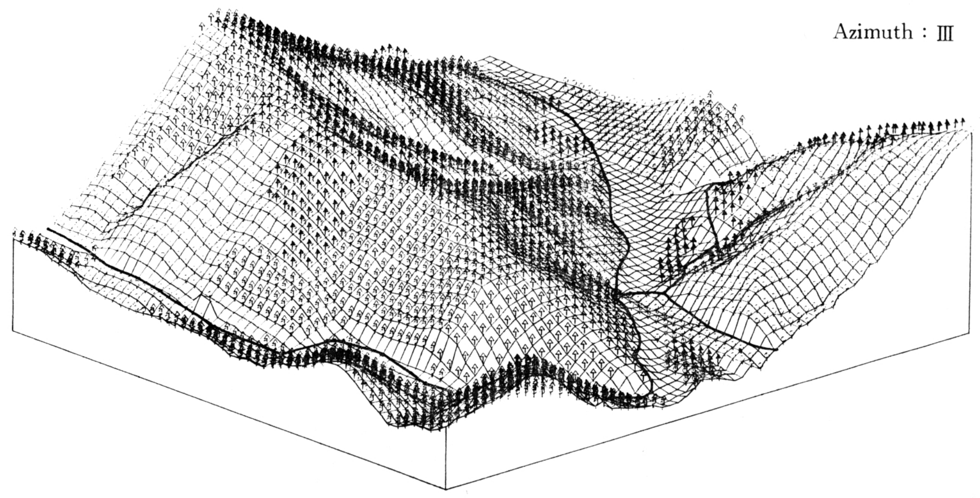
But inserting cutting boundary lines were available to a logging plan though there were some problems of visual landscape expression.

Figure 8 shows the visual efficiency of the expression of forest road and Figure 9 shows the prospective portrayal of the proposed logging area and the situation.

Coordinates of perspective centre (-3000, -3000, 3000)
Angle of depression : 26.40°







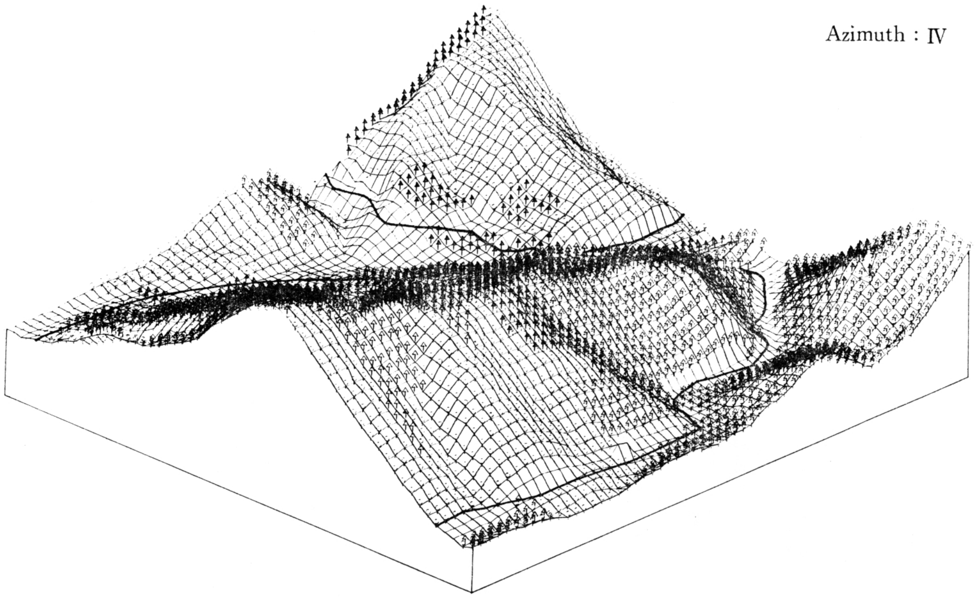
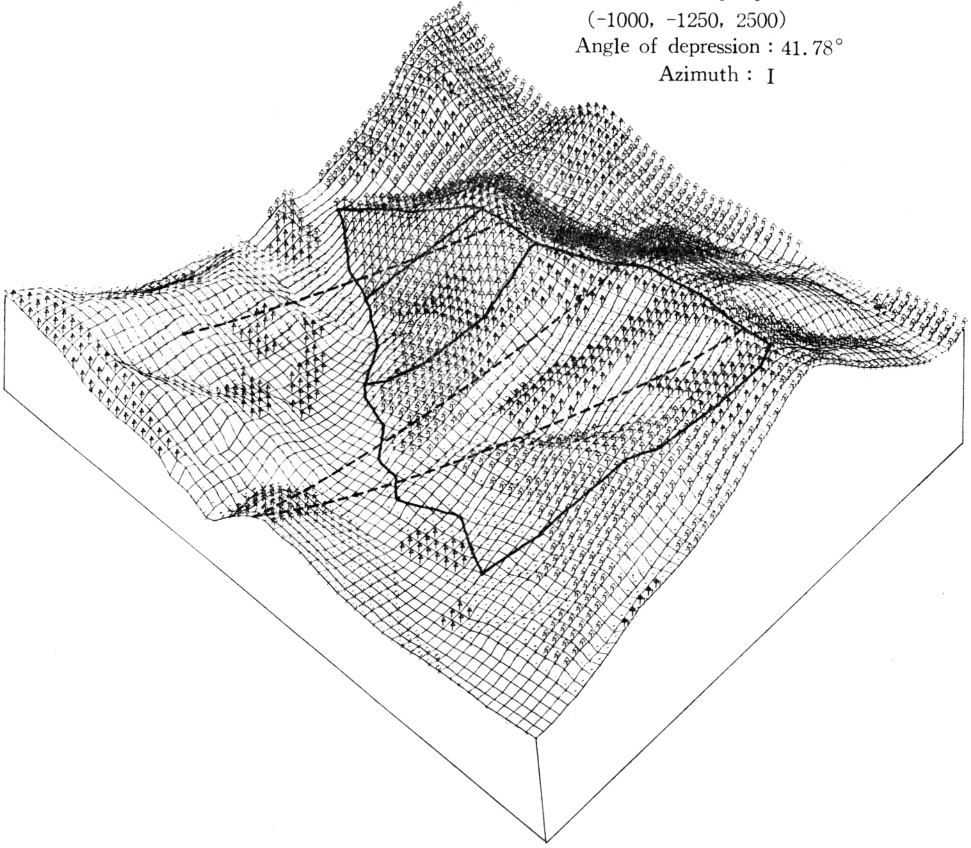
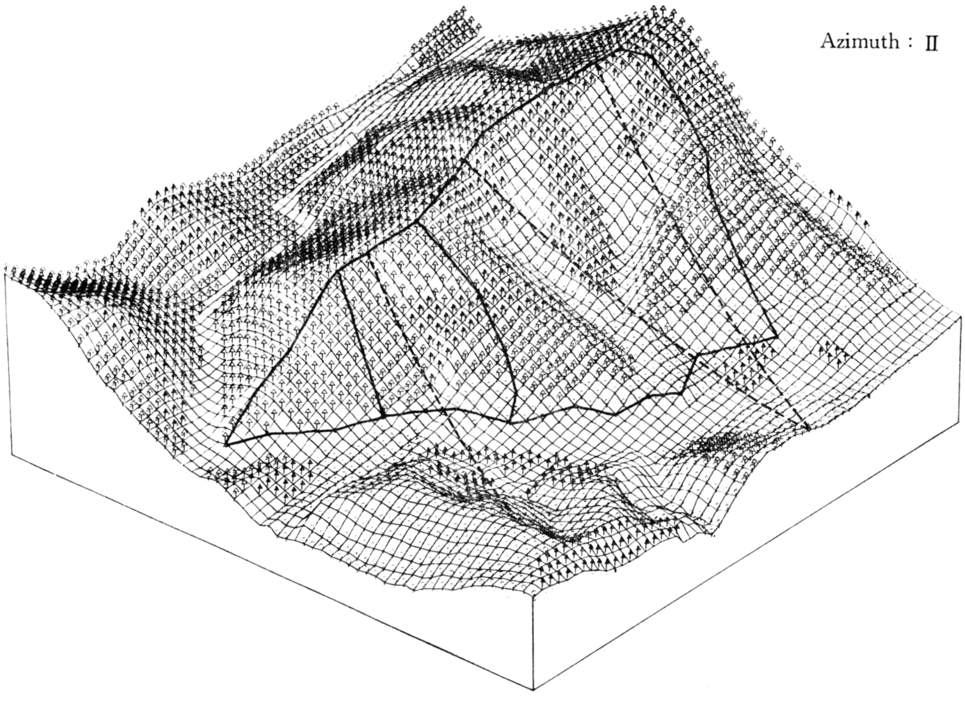


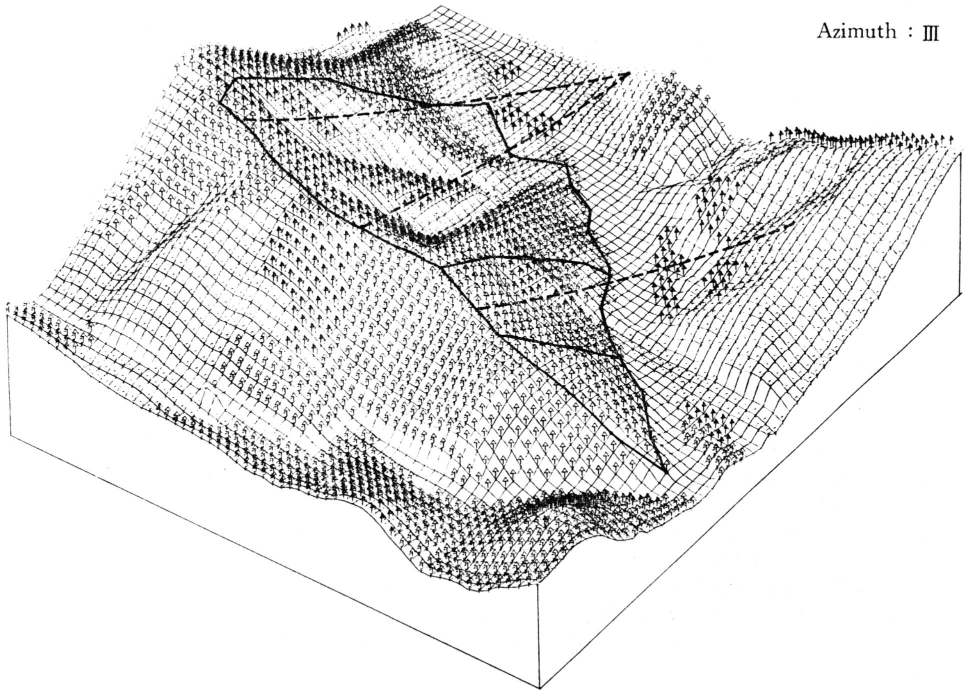
Fig. 8. The visual efficiency of the expression of forest road

Coordinates of perspective centre
(-1000, -1250, 2500)
Angle of depression : 41.78°
Azimuth : I



Azimuth : II





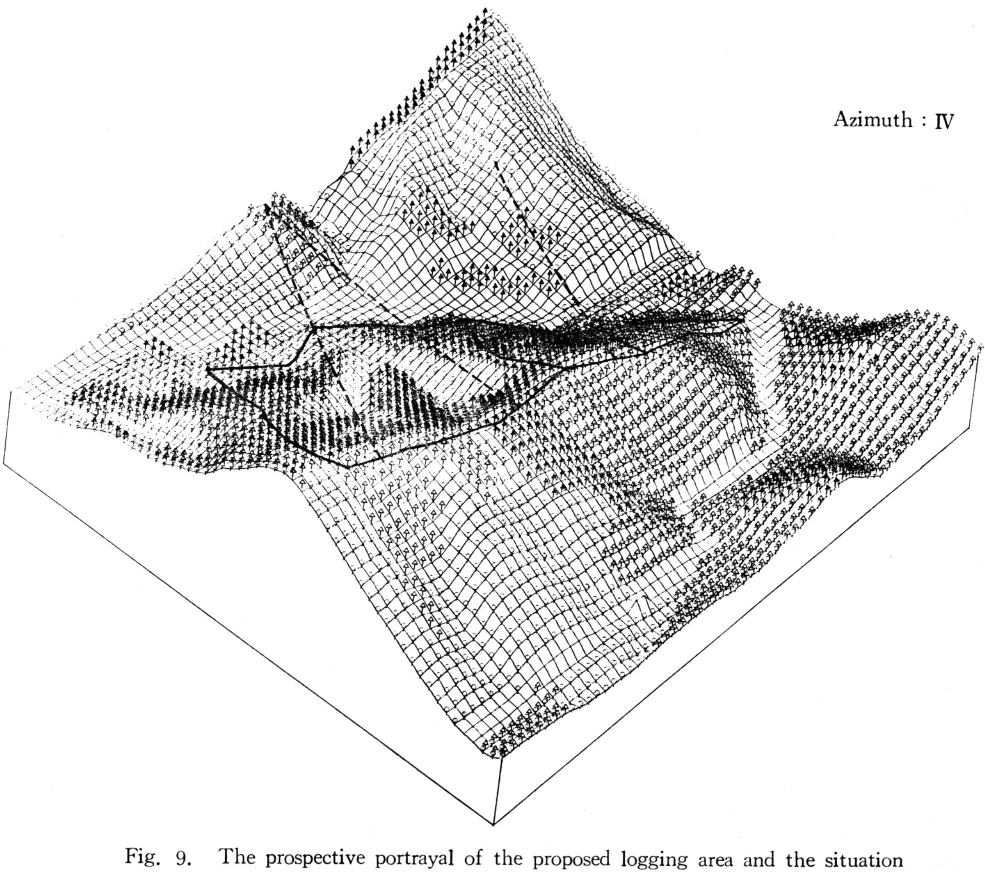


Fig. 9. The prospective portrayal of the proposed logging area and the situation

Acknowledgement

The authors express appreciation to Professor Saburo Kawanabe, D. Agr. and Technical Official Akihiro Makise, Kyoto University Forest Station, for their kind cooperation on data of the proposed logging plan at the 17th compartment in Kyoto University Forest in Ashu, and heartily thank Associate Professor Yoshio Fujii, D. Agr. and Assistant Shiro Furutani, Department of Forestry, Faculty of Agriculture, Kyoto University, for their advise and instruction.

Literature cited

1) S. SHIODA: Handbook for forestry practice., Asakura Press Co., Tokyo, p.427-459 (1972)
2) S. SHIODA: Approach to planning of landscape management by electric computer., Reports of Forest Landscape Planning Laboratory, Tokyo Uni., (1976)
3) M. KAJIMA and J. A. WAGNER: Computer-Generated Drawings of Ground Form and Vege tation., J. of Forestry, (1972)
4) Y. KONOHIRA: Drawing of a bird's-eye view of a mountainous topography., Chubu Branch Meeting of Japanese Forestry Society, (1976)
5) Y. KONOHIRA and M. MATUI: Drawing of a bird's-eye view of a forest, Bull. Shinsyu Uni. Agri., (1976)
6) H. MAEDA: Stereoscopical expression of topography by electric computer. Graduation thesis of Shinsyu University, (1973)
7) Planning Section of Maebashi Regional Forest office: Studies on methodology of forest plan establishment., (1976)
8) T. ITO: An application of interactive graphic to landscape planning., Japan Institute of Land scape Architecture, (1980)
9) T. MARUYASU, S. MURAI and S. OHBAYASHI: Formation of a strip digital terrain model for the purpose of highway design., Shashin Sokuryo, Vo.10, No.2 (1971)
10) T. MARUYASU and S. MURAI: A study on fore evaluation in earth design by simulation model. Shashin Sokuryo, Vo.10, No.2 (1971)
11) M. ANGELO: The use of computers in the visual analysis of landscape alternations., U. S. F. S. Incline Village, Nevada (1979)
12) M. ANGELO: Using computer graphics in the visual analysis of the Sunshine Ski Area expan sion., U. S. F. S. Pac. S. W. For. and Range Exp. St. (1975)
13) R. H. TWITO: Plotting landscape of clearcutunit's. USDA Forest Service General Technical Report PNW-71 (1978)
14) M. R. TRAVIS, G. H. ELSNER, W. D. LVERSON, C. G. JHONSON: Computation of seen areas, slope, and aspect for land-use planning. USDA Forest Service General Technical Reaort PNW-11 (1975)
15) T. C. DANIEL and H. SCHROREDER: Predicting perceived beauty of forest landscape. Proceedings of OUR NATIONAL LANDSCAPE, Incline Village, Nevada (1979)
16) W.R. BACON and A. D. TOWOMBOLY: Visual management system and timber management application. Proceeding of OUR NATIONAL LANDSCAPE, Incline Village, Nevada (1979)
17) W. TLUSTY: The role of the landscape architect in applied forest landscape management. Proceeding of OUR NATIONAL LANDSCAPE, Incline Village, Nevada (1979)
18) T. TAJIMA: Computer drawing. Korona Press Co., Tokyo, p.75-245 (1979)
19) Y. TERASAKI: Stand inventory data of Kyoto University Forest in Ashu.
20) M. FUJIWARA, J. KODAMA and A. MAKISE: Factor table of logging operation at 17th compartment.
21) DATA PROCESSING CENTRE KYOTO UNIVERSITY: Manual of X-Y plotter use. K-UG-013-2 (1978)
22) Yoshizawa Business Machines Co.,: Plotter programing, -basic software-. (1973)
23) Yoshizawa Business Machines Co.,: CALCOMP software manual. (1973)