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Quarterly Progress Report

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Digital Processing of Landsat MSS and Topographic Data to Improve Capabilities for Computerized Mapping of Forest Cover Types

Contract No. NAS 9-15508

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NASA Lyndon B. Johnson Space Center

Prepared by: Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

Technical Monitor: Dr. D. L. Amsbury
NASA Mail Code SF5
Exploratory Investigations Branch
Houston, Texas 77058

Principal Investigator: Dr. Roger M. Hoffer
Ecosystems Program Leader
LARS/Purdue University
West Lafayette, Indiana 47906

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(E79-10183) DIGITAL PROCESSING OF LANDSAT MSS AND TOPOGRAPHIC DATA TO IMPROVE CAPABILITIES FOR COMPUTERIZED MAPPING OF FOREST COVER TYPES Quarterly Progress Report, 16 Jun. - 15 Sep. G3/43

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I. OVERALL STATUS AND PROGRESS TO DATE

During this reporting period (June 16, 1978 - September 15, 1978) four major activities were accomplished. These activities involved: (A) completion of the data analysis for developing the topographic distribution model, (B) development of procedures to utilize combined topographic and spectral data in the computer classification of digital data, (C) selection and identification of a random sample of test data pixels, and (D) a second field trip to the test site to ground check part of the evaluation sample data and to evaluate an initial classification of the training quadrangles. A description of these activities is given in the following sections.

A. Development of the "Topographic Distribution Model"

The overall objective of this study is to develop and evaluate computer-aided analysis techniques which utilize both digital topographic and spectral data to map individual forest cover types more accurately and reliably than can be achieved through the use of only spectral data. As previously discussed (June, 1978 Quarterly Report) a procedure to accomplish this objective is being developed in two major phases (1) development of the topographic model and (2) development of computer-aided analysis procedures to utilize both topographic and spectral data. The procedure for developing the digital forest topographic model was divided into five steps; the first three were discussed in detail in the previous Quarterly Report (June, 1978). The last two steps, conducting a statistical analysis of the sample data which describes the topographic distribution of the different forest cover types in the study site, and developing the appropriate discriminate functions to distinguish the cover types (species) and evaluate the resulting model, are described in detail in the following sections of this report.

1. Topographic Distribution Results. Once the sample has been selected and each pixel identified as to its dominate cover type, several statistical analyses can be used to describe the distribution of the forest cover types as a function of topography. The literature review (March, 1978 Quarterly Report) indicated that the major source of topographic variability between cover types is elevation. All species have a characteristic elevational zone where individual or groups of species are typically found. The range of the various species have also been shown to be influenced by aspece, particularly in the north-south direction, and slightly by slope.

To graphically show the variation in the topographic location of the various cover types, the distributions can be described by a variety of methods. During this reporting period, software was developed to display the topographic data base for the various cover types in six formats. The data base was generated by obtaining the elevation, slope, and aspect from the digital data tape for the stratified random sample of 4,500 pixels, as discussed in Step 3 of the last quarterly report.

The frequency of the various species along an elevational gradient can be easily plotted to show the basic shape and characteristics of the distribution. Figures 1 - 8 are frequency plots for each of the cover

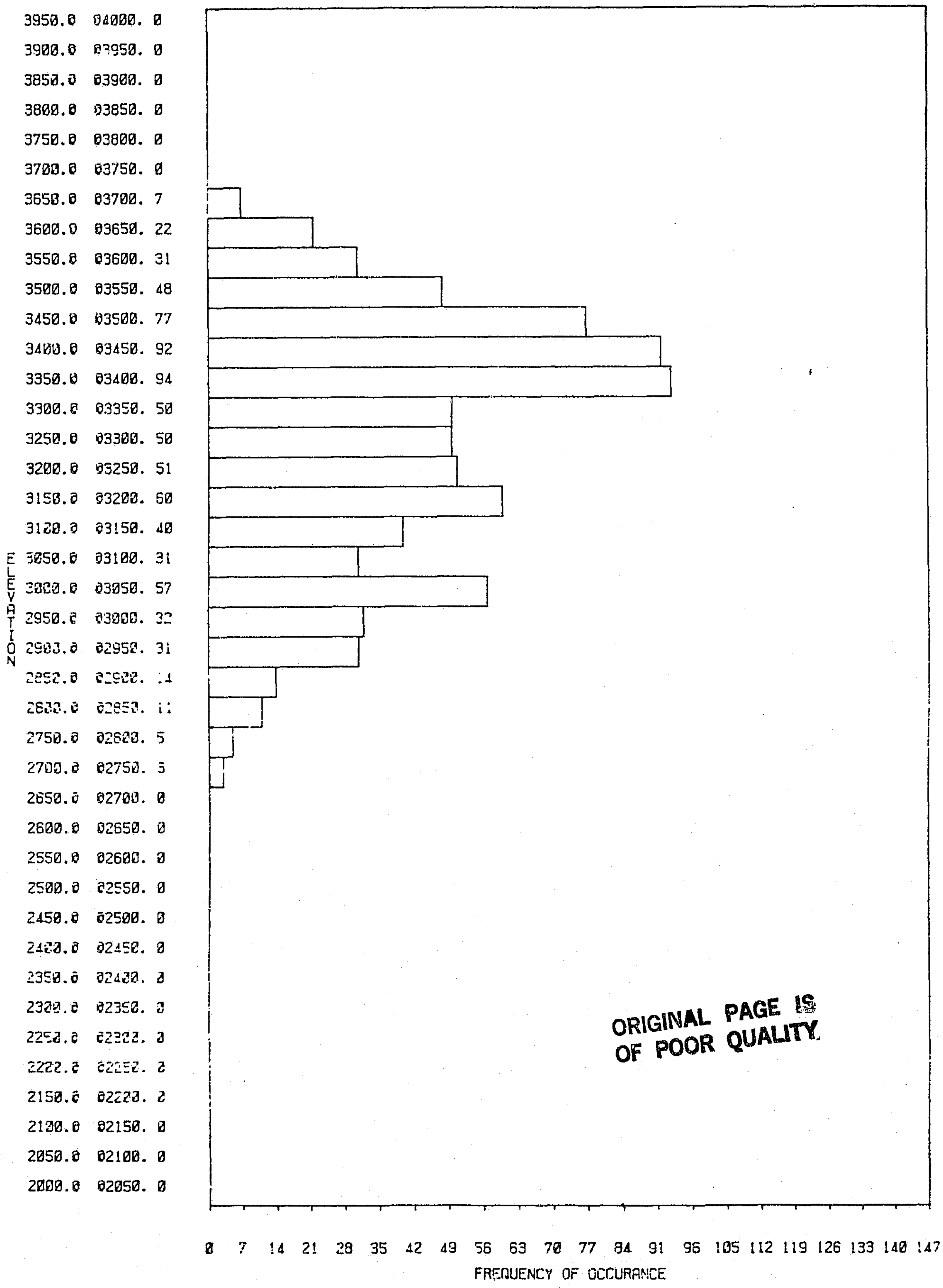

Figure 1. Frequency distribution as a function of elevation for Engelman Spruce and Subalpine Fir.

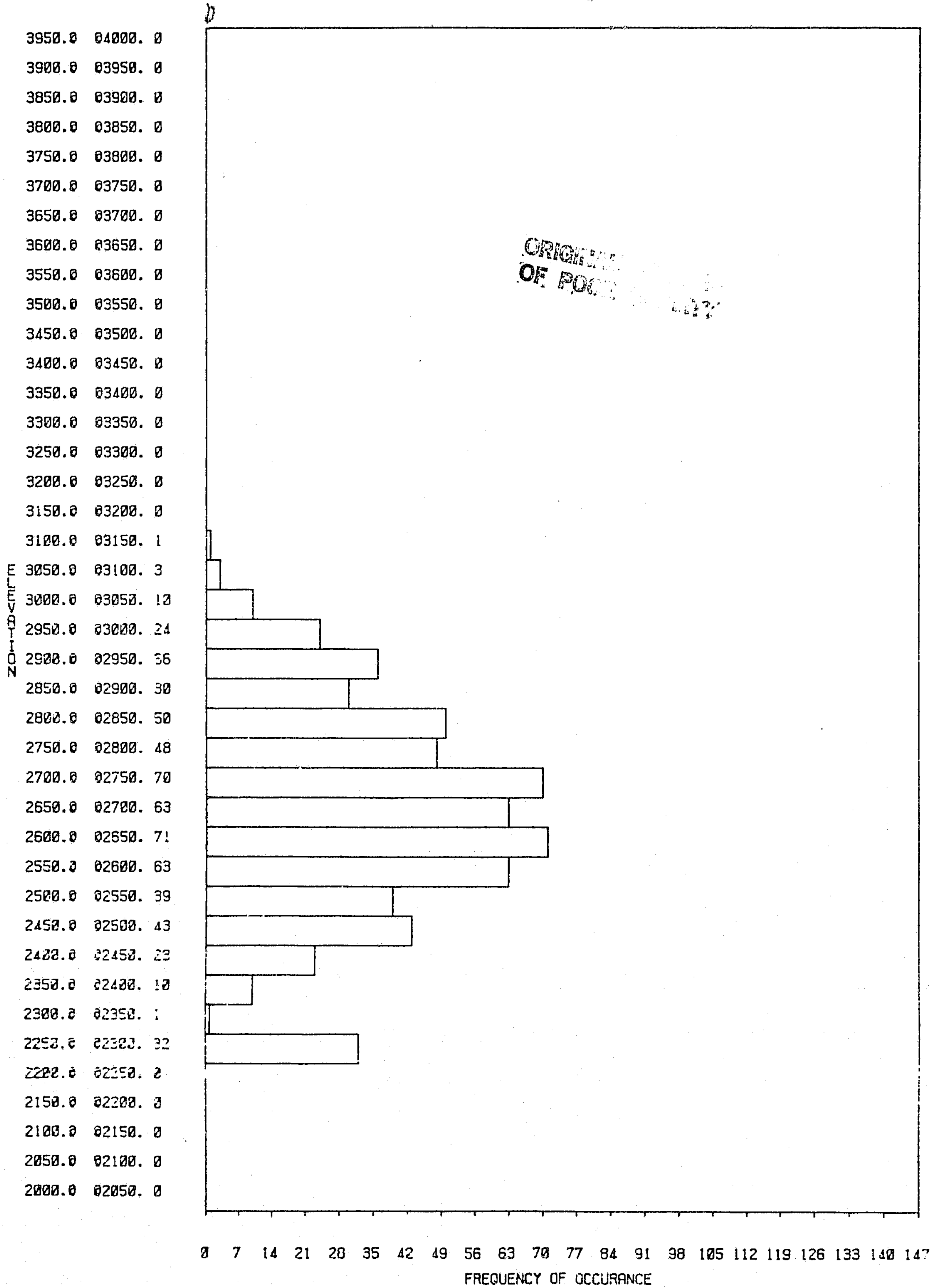

Figure 2. Frequency distribution as a function of elevation for Douglas and White Fir.

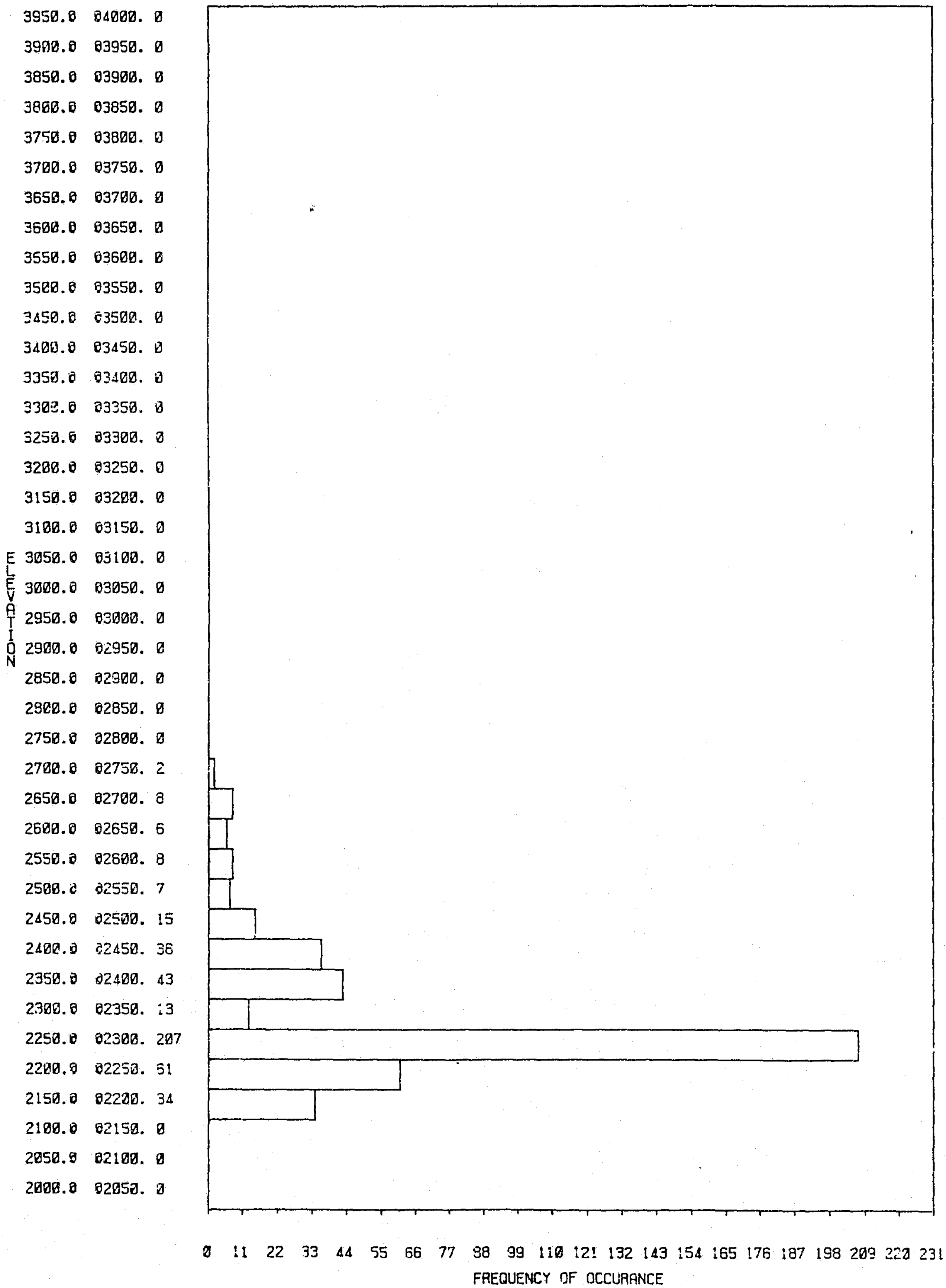

Figure 3. Frequency distribution as a function of elevation for Ponderosa Pine.

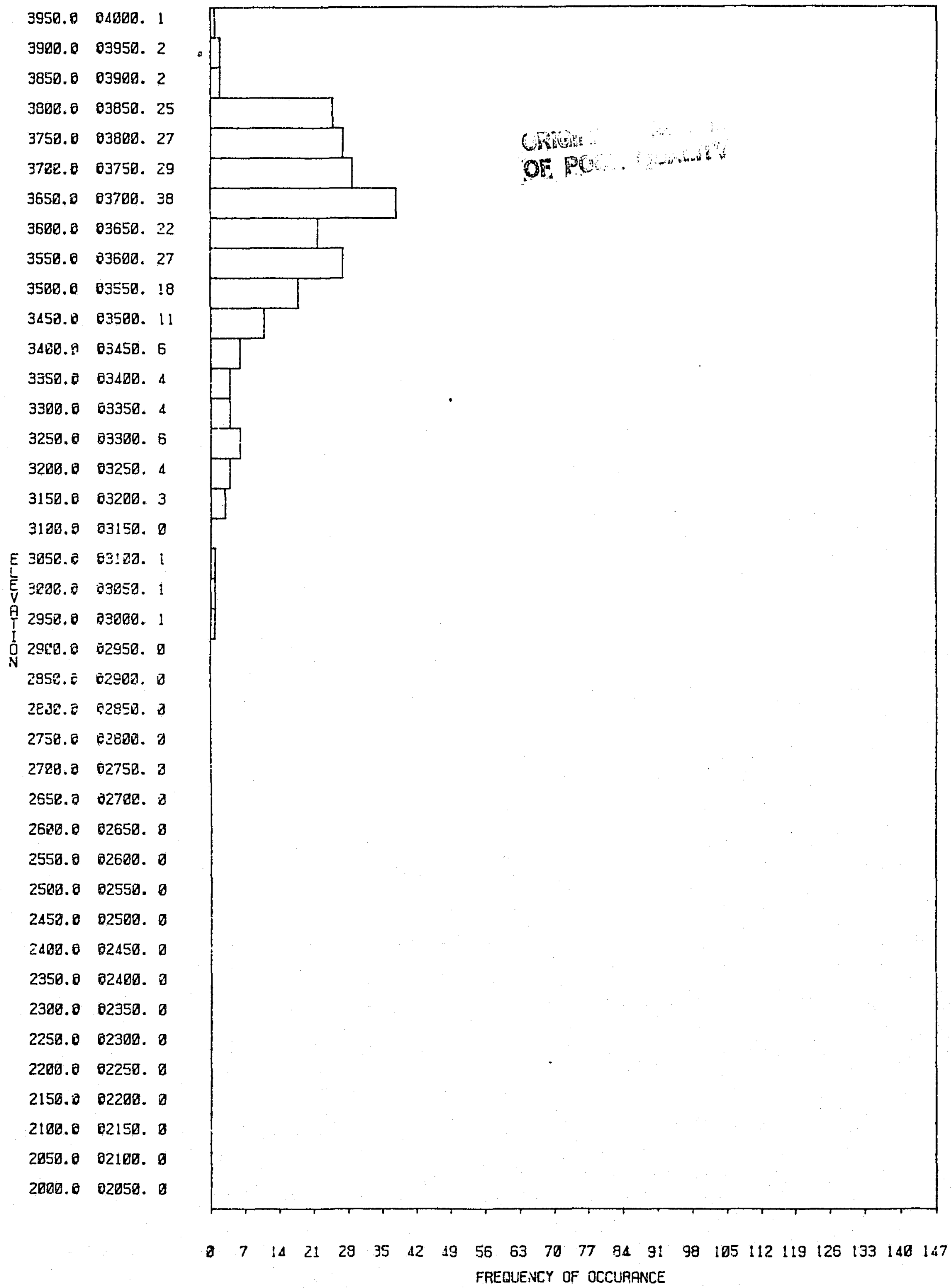

Figure 4. Frequency distribution as a function of elevation for Alpine Willow.

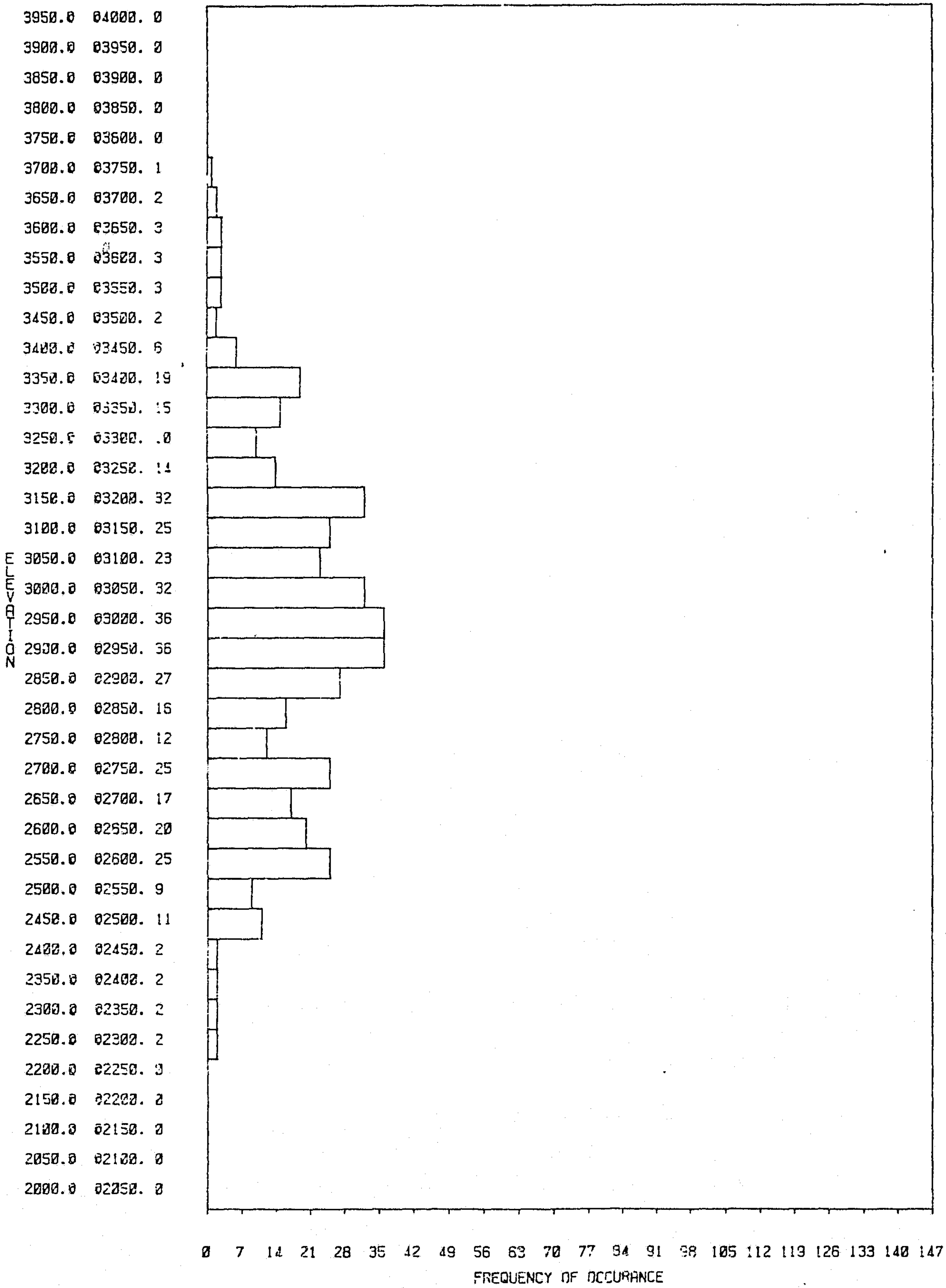

Figure 5. Frequency distribution as a function of elevation for Aspen.

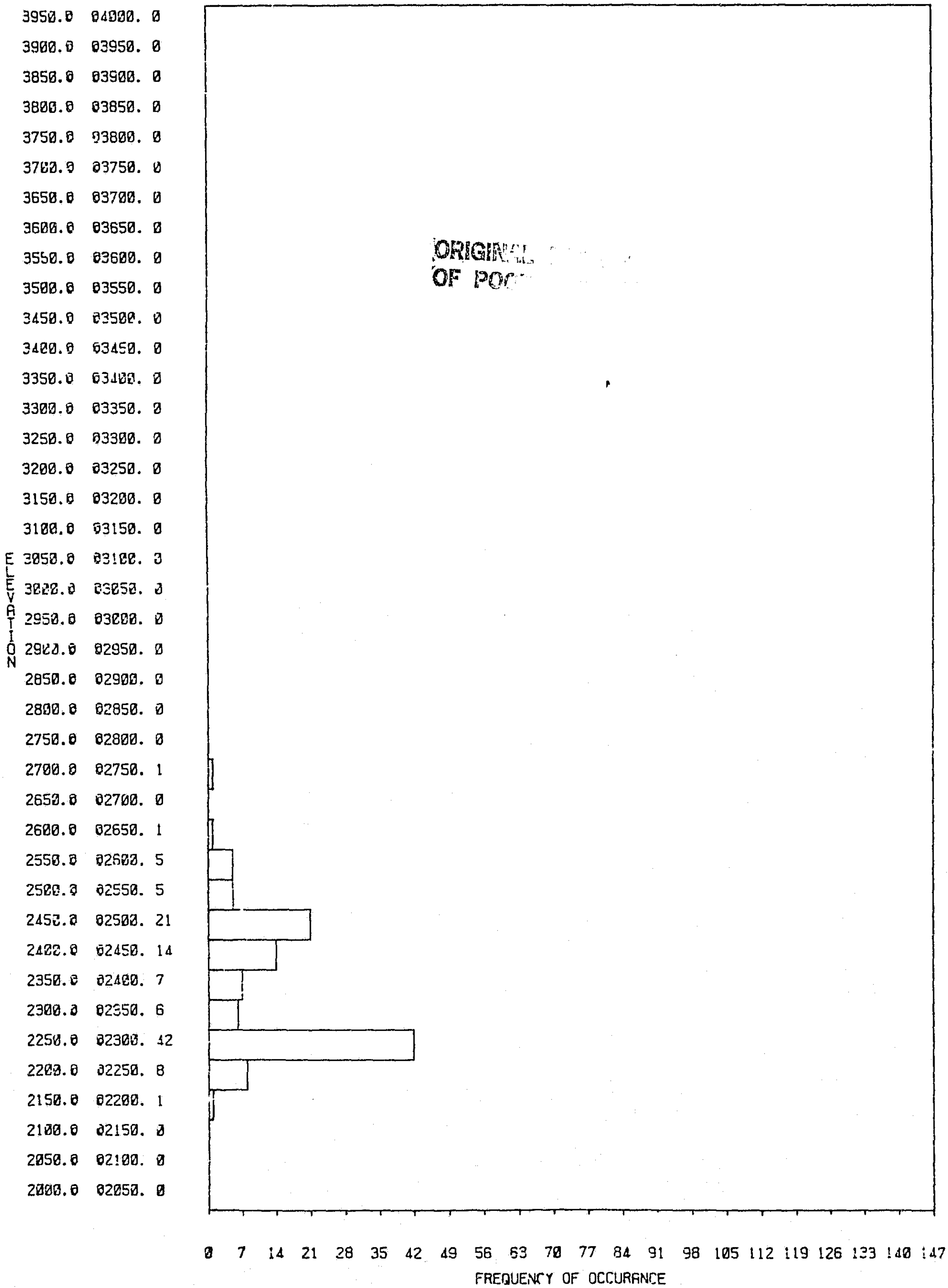

Figure 6. Frequency distribution as a function of elevation for Oak.

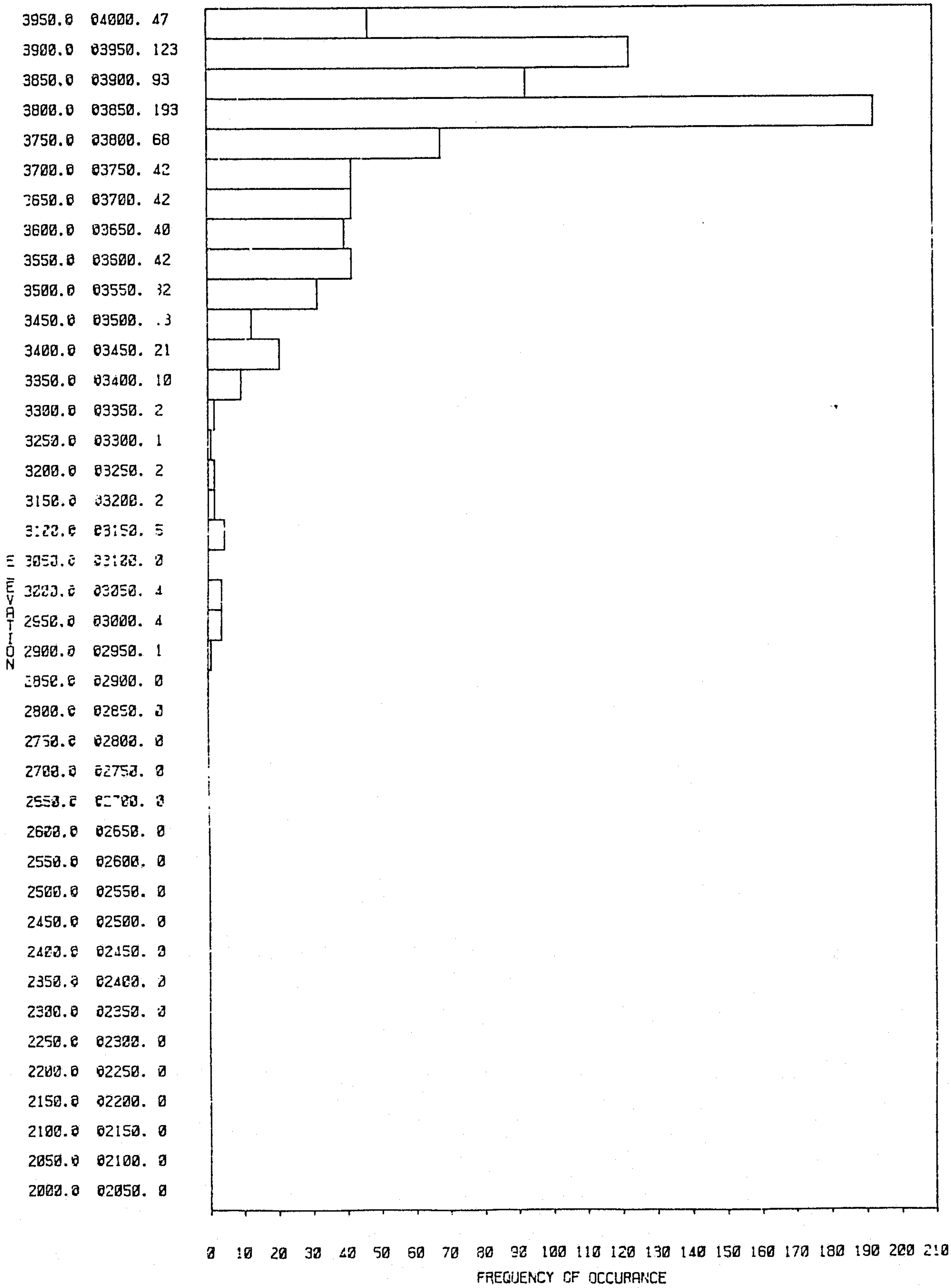

Figure 7. Frequency distribution as a function of elevation for Tundra.

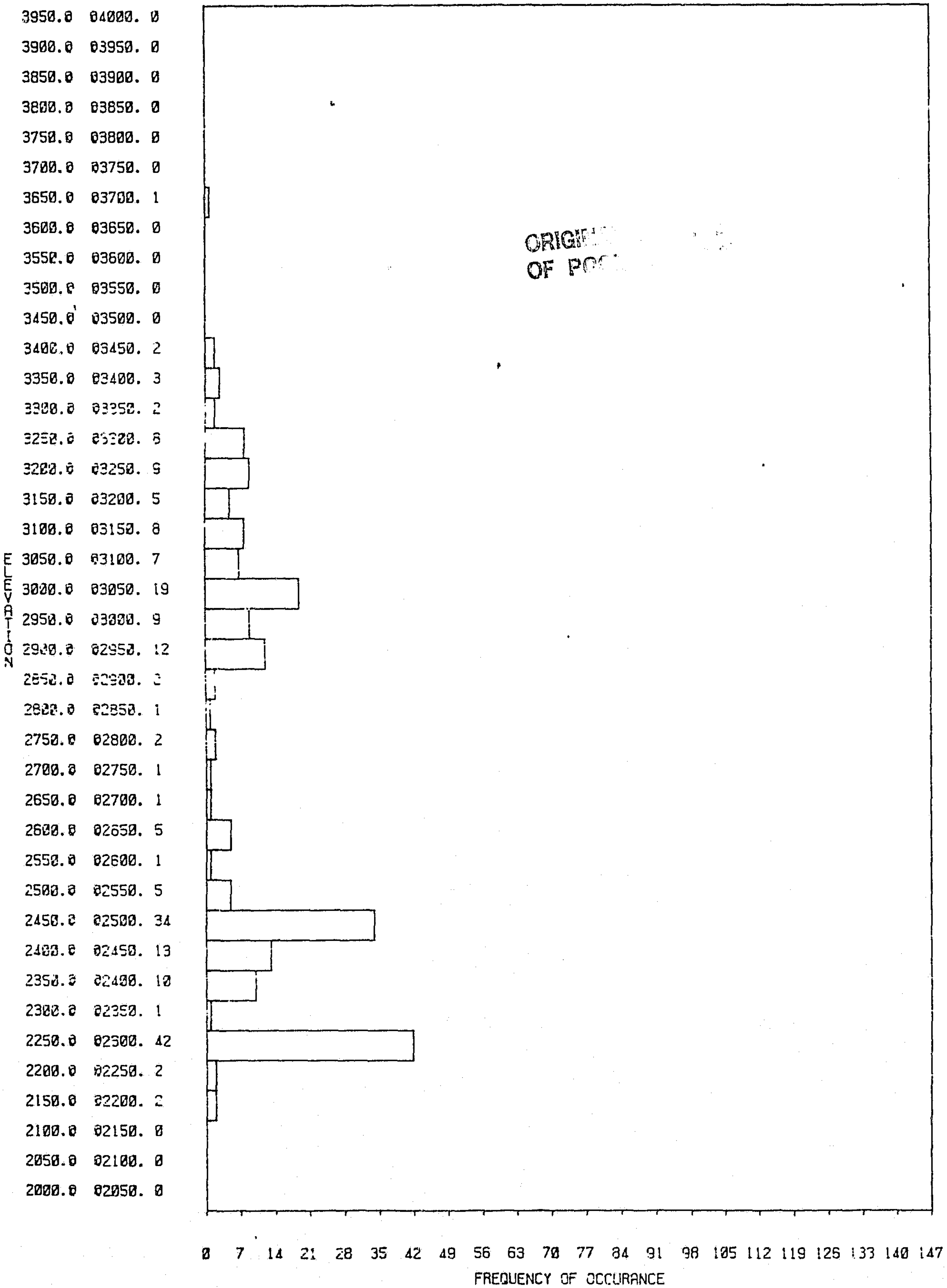

Figure 8. Frequency distribution as a function of elevation for Grassland.

types of interest as a function of elevation. The elevation is divided into 50 meter zones, and the number of occurrences within each zone is shown. Examination of the curves indicates that most of the distributions are approximately normally distributed. The exceptions are the Ponderosa pine, oak and grassland cover types. The Ponderosa pine and oak distributions are skewed to lower elevations. This is due to the relatively small amount of the test site found below 2250 meters and a complete lack of elevations below 2150 meters within the seven quadrangles used in developing the model. The grassland cover types is very general and is found at most elevations below timber line, without having a specific elevation preference. The histograms also indicate that each cover type has a characteristic elevation zone which varies considerably among the various coniferous and deciduous species. Figure 9 combines the distributions of the coniferous species as described by their means, variances, and sample sizes (normalized curves). This figure shows that the various species have statistically significant different means (F = 4547) but that some overlap exists between species (i.e., transitions zones).

A second variable in the topographic distributions of cover types to be investigated is aspect. Figures 10 - 12 are polar plots of the distribution of spruce-fir (Figure 10), Douglas and white fir (Figure 11), and Ponderosa pine (Figure 12) as a function of elevation and aspect. Examination of the figures indicates that for each species the "typical" elevation range varies as a function of aspect. In each case, the average elevation is higher on the southern aspects than on the northern aspects. There seems to be very little difference in elevations between east and west aspects. These figures also illustrate the different ranges in elevation of each species. Similar results are evident for the deciduous species. Figures 10 - 12 also show that the model has a good representation of data for each species in all aspects; i.e., each species occurs in every aspect zone with about equal frequency of occurrence.

To simplify the distribution of the species as a function of elevation and aspect, the aspect data was collapsed to a linear scale (north = 0, south = 180, and east and west are both 90). Figure 13 illustrates the variation in elevation along the north-south aspect variable for all three coniferous species. In each case the average elevation by regression analysis is higher on the southern aspects than the northern, by an average of 70 meters (225 feet). Essentially, Figure 13 shows the key results of Figures 10 - 12 in a more easily visualized format.

A third variable to be studied in the topographic distribution model is slope. The data for Figure 13 was divided into three slope classes 1-7^{0}, 8-17^{0}, and 18-70^{0} and a regression analysis run for each species. Figure 14 shows the differences in elevation on various aspects for the three slope classes. For each species there is not a significant difference between the slope classes, particularly the two lower slope classes. This indicates that slope does not seem to significantly effect the distribution of the various cover types. This does not imply, however, that slope is not an important factor affecting the spectral response of Landsat data.

2. Discriminate Analysis Results. The purpose of the discriminate analysis is to (1) determine which variables are significant in distinguishing the various classes (species), (2) determine an appropriate

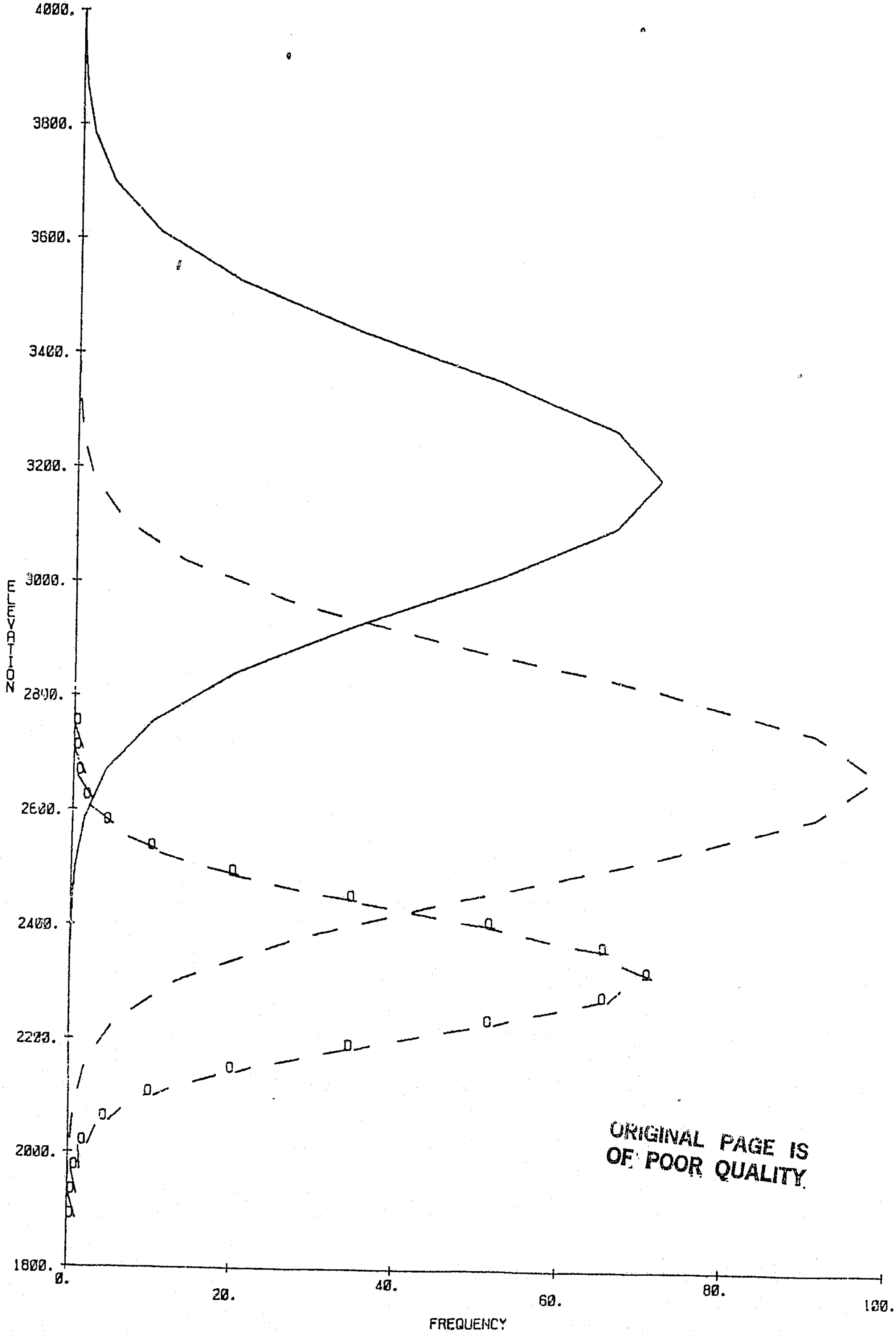

Figure 9. Gausian curves of frequency along the elevational gradient for —— Engelman Spruce & Subalpine Fir, ---- Douglas & White Fir, θ-θ- Ponderosa Pine.

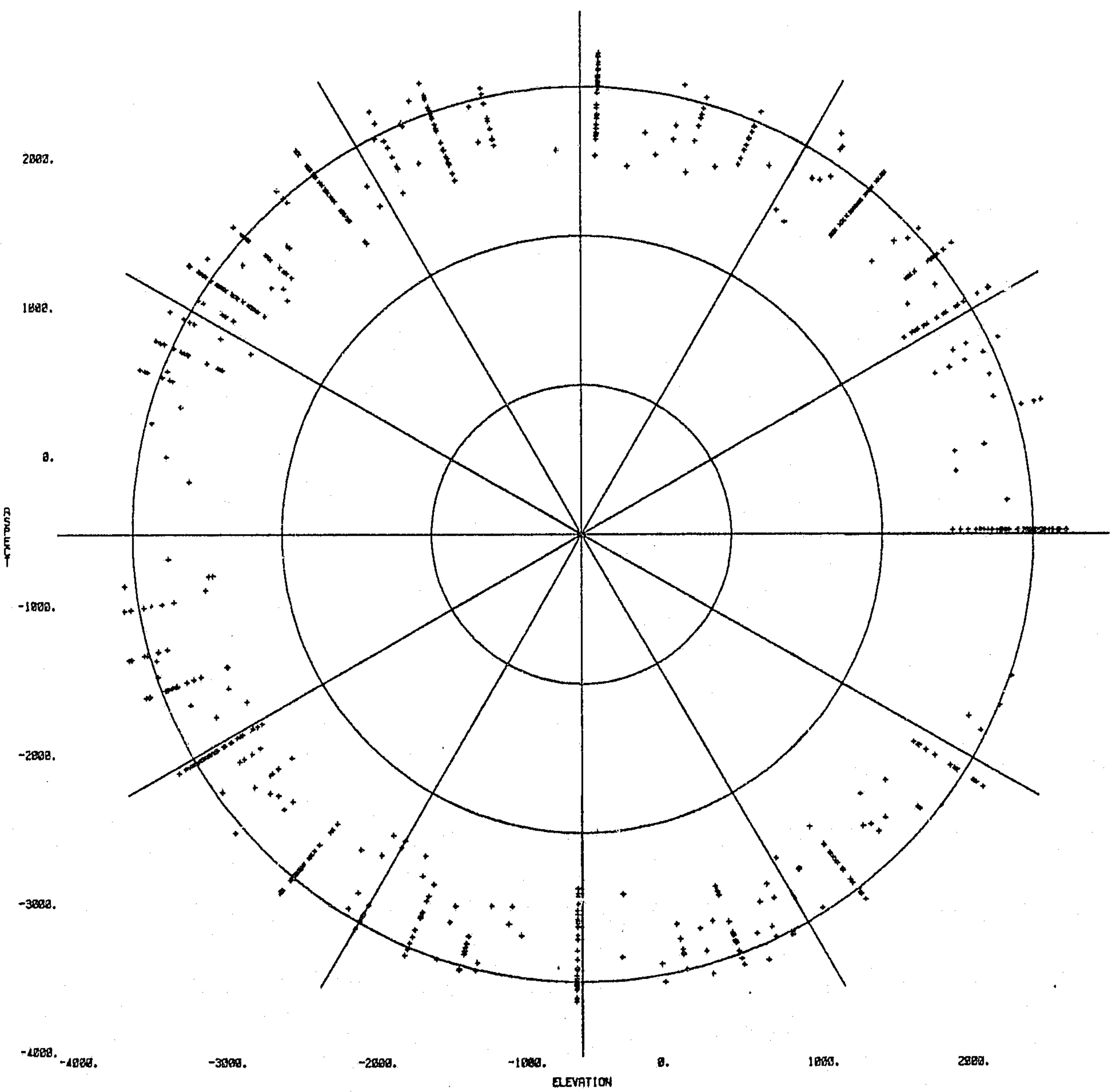

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Figure 10. Polar plot of elevation and aspect for Engelman Spruce and Subalpine Fir.

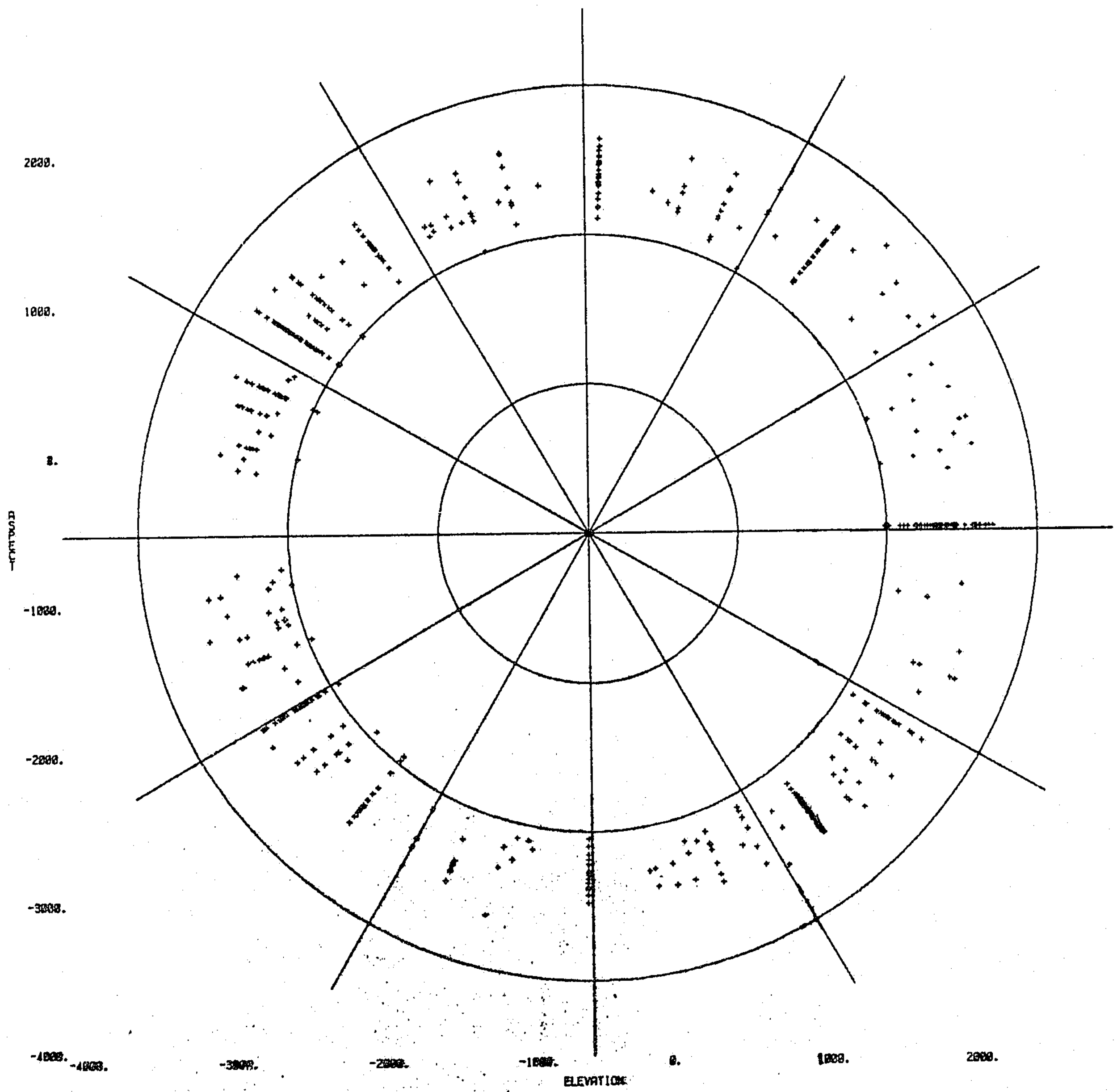

Figure 11. Polar plot of elevation and aspect for Douglas and White Fir.

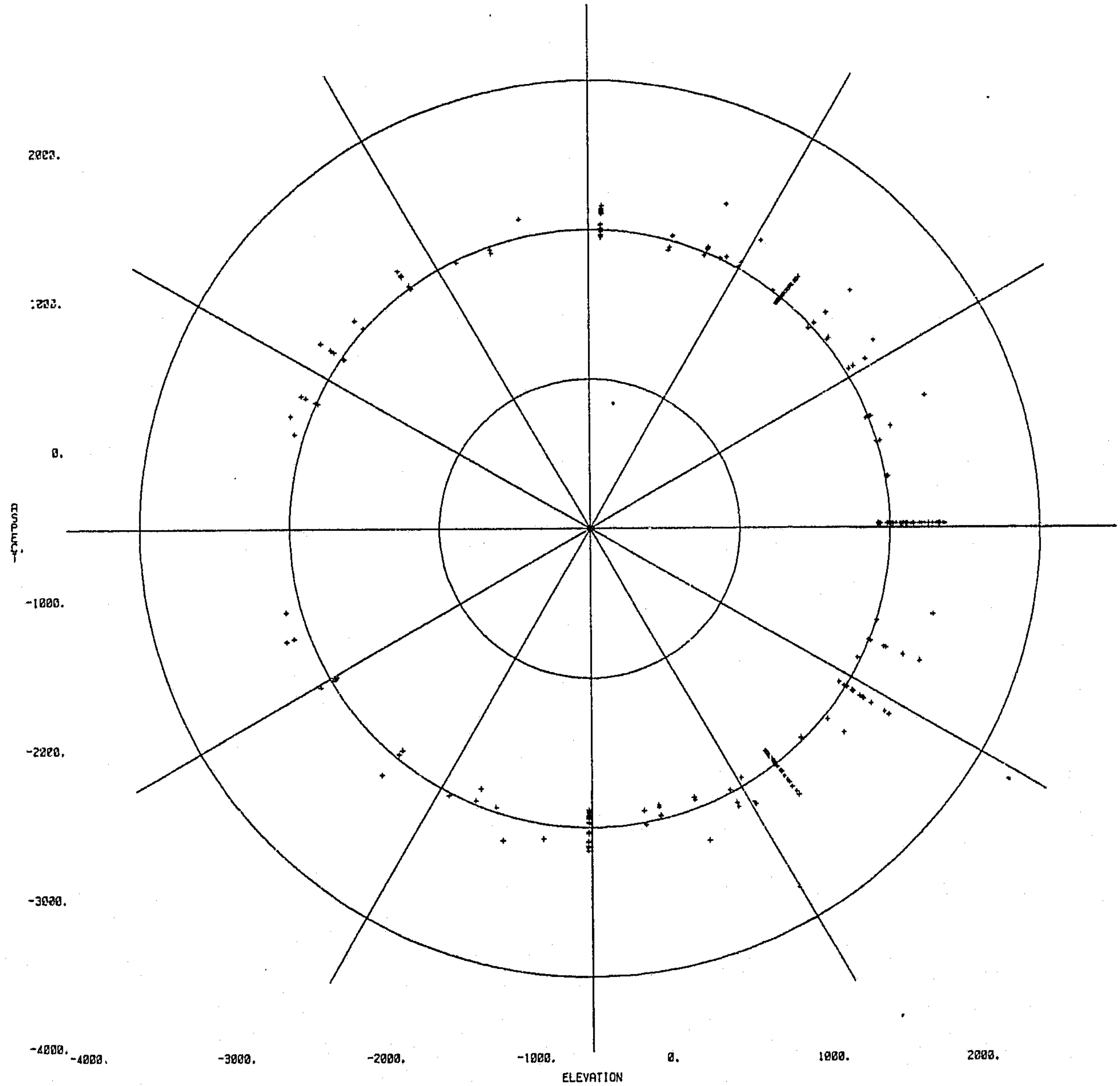

Figure 12. Polar plot of elevation and aspect for Ponderosa Pine.

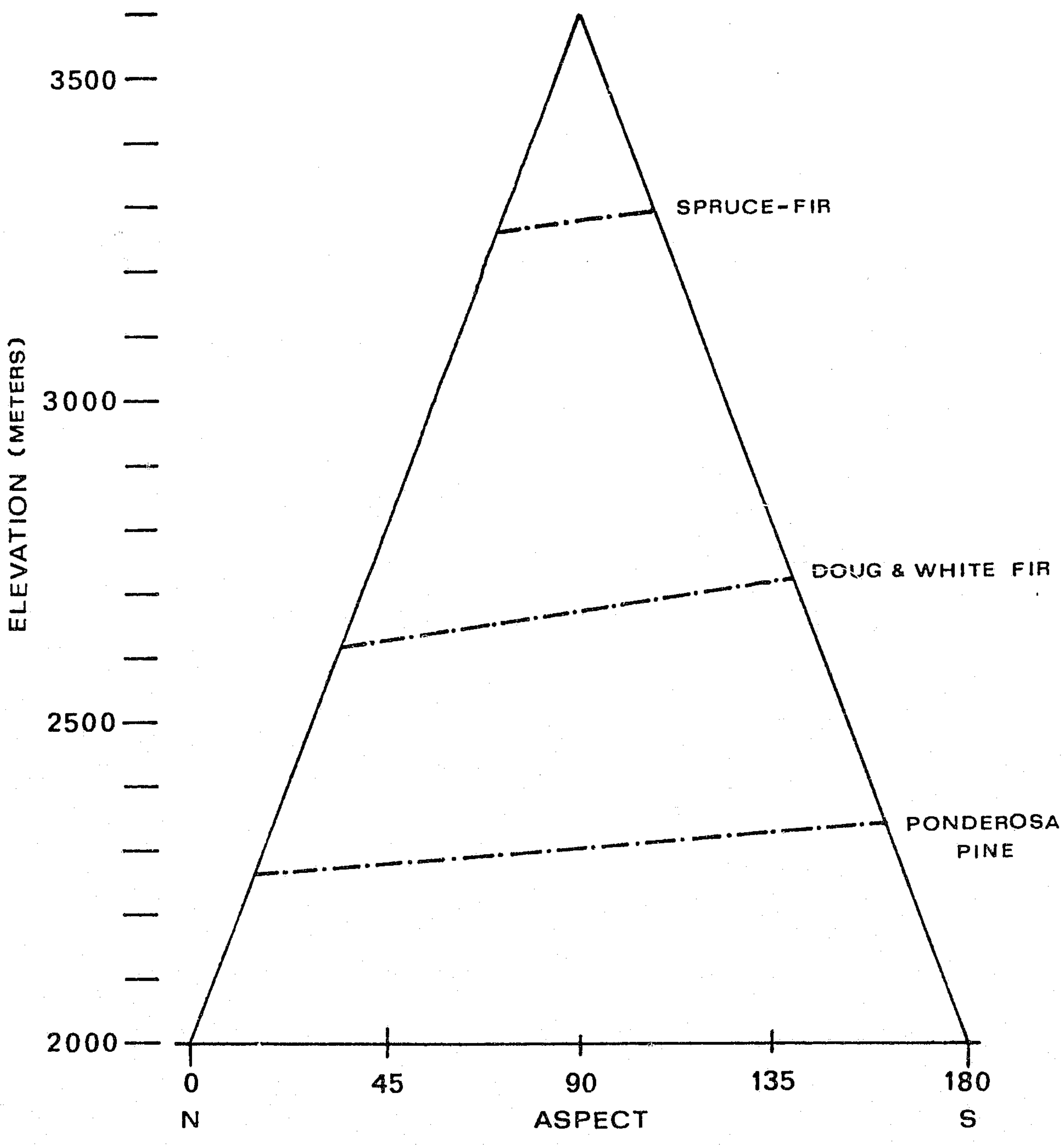

Figure 13. Regression line of elevation verse aspect for Spruce-Fir, Douglas & White Fir, and Ponderosa Pine.

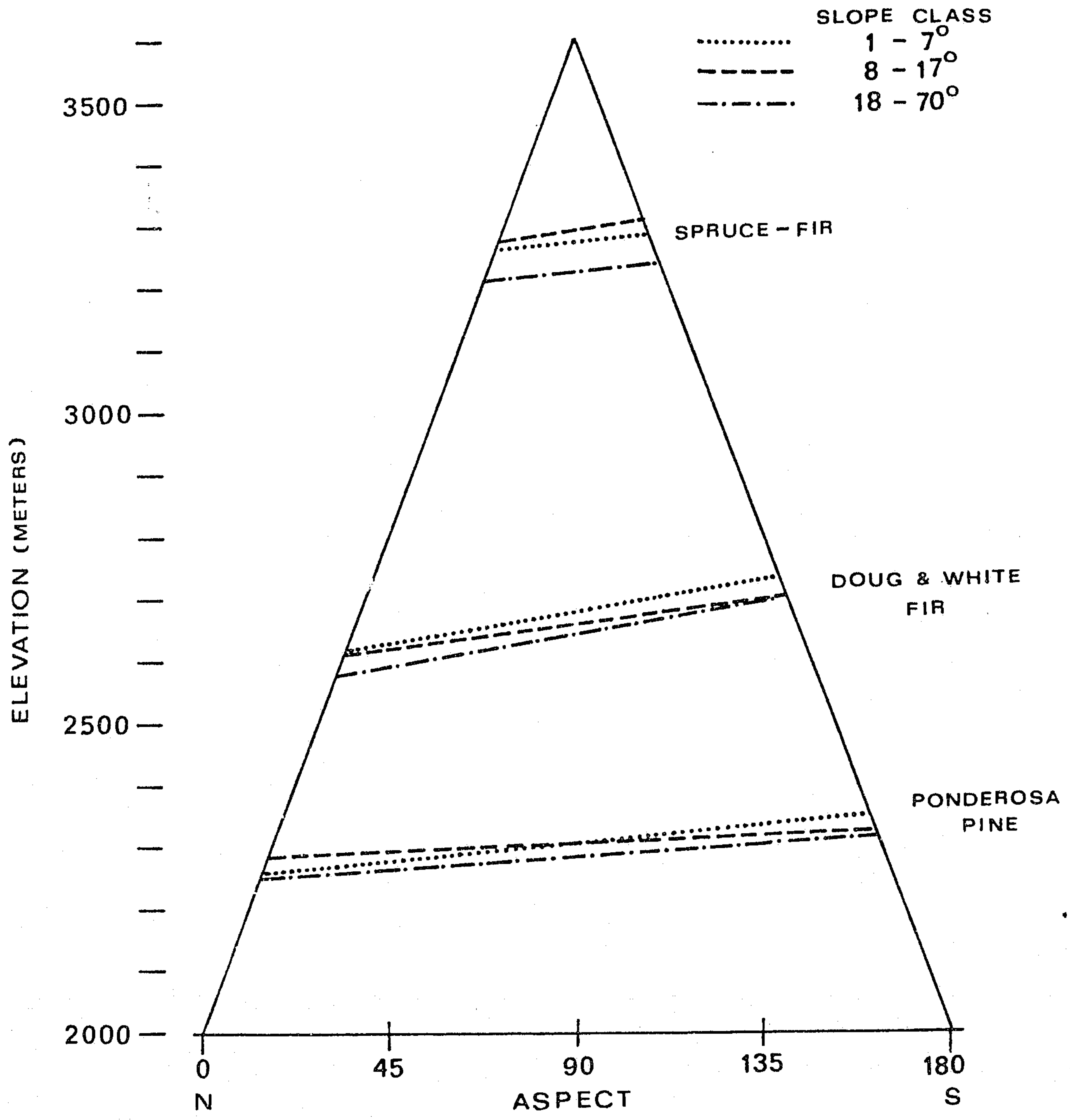

Figure 14. Regression line of elevation verse aspect with 3 slope classes for Spruce-Fir, Douglas & White Fir, and Ponderosa Pine.

discriminate function to distinguish the classes and (3) classify the training sample data to estimate the potential for distinguishing the various species within each major cover type category, using only the topographic data.

The individual cover types of the vegetative categories, i.e., species, were grouped into the three Level 2 categories (coniferous forest, deciduous forest, and herbaceous) and the SPSS discriminate function (Nie, et.al. 1975) was run on each category. To double check the results of the previous statistical analysis of the topographic data, all variables were input to the discriminate function. The processor was allowed to select the significant variables and perform the classification of the training sample.

The variables used in each case were elevation, aspect (0-180), and slope, thereby enabling the results of the regression analysis to be confirmed. Table 1 is the results of a classification for the training sample of the three categories when equal a priori probabilities are assigned to each class. The range of accuracies for the various species is from 70.8% to 100% with the average near 89%. In each case the middle class (elevational) was classified less accurately than the other two classes, mainly due to the fact that the middle class is flanked by two transition zones. To help improve the training procedure, the sample size for each class was used as a weight in the classification algorithm (a Bayssian type classifier). The results are in Table 2 for the weighted classifications, and indicate that in most cases, the classifications are improved. The range of the accuracies was reduced (75.0% to 100%) with most tending to be closer to the overall average of 90%. Care must be taken when interpreting these results since they are only for distinguishing the various species within one major category using only the topographic data, and are only training data results. Therefore, these accuracy figures are not what would be expected in the final classifications when separating categories and species using both spectral and topographic data. However, the results do indicate that the topographic data can be used to accurately distinguish the various species (Level 3) within one category (Level 2), which cannot be accomplished using only the spectral data (ref. Hoffer, 1975).

B. Computer-aided Analysis Techniques for Utilizing Combined Spectral and Topographic Data

The second major phase of this project involves the utilization of the information derived from the distributions (model results) as ancillary information in the pattern recognition approach for classifying multispectral scanner data (Landsat MSS) in conjunction with digital topographic data. In this quarterly report, the procedures to be compared will be defined and described, but not evaluated. The basic approach to pattern recognition can be divided into two sections, (1) training and (2) classification. Both sections will be discussed and the various possible approaches defined for each.

1. Training Procedure. The defined objective was to develop the spectral and topographic distributions (training) independently, using two different approaches, a Multi-Cluster Blocks approach for the spectral data and a statistical stratified (topographically) random sample for the topographic data. However, each training approach can be used to estimate the statistical distribution for both the spectral and topographic data. In

addition, the statistical development of the topographic model supplies a set of data points that could be used in developing the spectral training statistics, along the lines of a P-1 type analysis approach (Wills, et.al., 1977). As a result, four different approaches for developing the training statistics for both the topographic and spectral data can be defined and compared. Each of these four approaches will be discussed in this report, and the evaluation of all approaches will be discussed in the next report.

In the first approach, the topographic statistics are developed totally independent of the spectral data. The topographic statistics are calculated from the stratified (topographically) random sample of single pixels, which are identified, in this case using the INSTARR cover type maps with field checking. In other words, the "Topographic Distribution Model" results are used to provide the topographic training data. The spectral statistics are developed using a Multi-Cluster Blocks (MCB) approach (or Modified Clustering) (Fleming et.al., 1975). This approach was found to be the best out of six procedures compared on an adjacent study area (Fleming and Hoffer, 1977). The procedure basically involves selecting a series of small blocks (roughly 2000 pixel each), clustering them individually, identifying the cluster classes on a ZTS (Zoom Transfer Scope) using aerial photography, and then pooling the numerous cluster classes into the desired spectral-informational classes.

The second approach for developing the training statistics can be accomplished using just the Multi-Cluster Blocks spectral analysis. With this approach the cluster classes are used as in the first approach to obtain the spectral classes, but then the topographic statistics are calculated for the spectral-informational classes instead of using the topographic model.

A third training approach can be defined by reversing the previous procedure and using only the data points selected for the topographic model. The sample data are divided into the desired informational classes and statistics are claculated for both the spectral and topographic data.

The fourth approach for developing the training statistics is a combination of the first and third approaches. The topographic model is developed from the sample of points and is used to develop the topographic statistics. The spectral analysis uses a Multi-Cluster Blocks approach, but makes use of the points from the topographic model to identify the cluster classes. Also, since the points are selected over a quadrangle sizes area, the blocks are increased in size to cover one entire quadrangle (i.e., blocks = quandrangles). This is along the line of a P-1 type approach, but utilizes several training areas (in this case, seven).

2. Classification Procedure. The objective of the classification step is to integrate the spectral and topographic distributions into a multidimensional classification. Once the statistical distributions (training statistics) have been developed, the classification of the data set can be accomplished by any one of several different approaches. The major difficulty is that the spectral classes and topographic classes do not match the informational classes. In other words, there is not one topographic class and one spectral class for each informational class.

The purpose of the classification step is to logically combine the spectral and topographic classes to obtain the desired informational classes. Several different approaches have been developed and will be described and discussed in this report. The evaluation of the various procedures will be discussed in the next report.

The classification procedure can vary in two basic was; (a) the mathematics and logic of the algorithm used and (b) the type of data utilized by the algorithm. In this study, two basic types of algorithms will be compared - single stage and multi-stage (multilayered) classifiers. Both are maximum likelihood perpoint classifiers, which differ only in the logic for making the decisions (classifications). The single stage classifier is the most commonly used, the "standard" LARSYS algorithm known as *CLASSIFYPOINTS (Phillips, 1973). The multistage classifier was developed by Wu, Haska, and Swain over the last several years at LARS. Both of the classifiers can be modified to utilize weighting factors for the classes, resulting in a Bayes type classifier. Thus, four slightly different classification algorithms can be evaluated.

Several types of data to be used by the classification algorithm can be compared. The various data types involve allowing the algorithms to use only selected channels of the available statistics. Many combinations are possible, but the four major variations to be compared will utilize the spectral data only (base-line classification), spectral data plus elevation, spectral data plus all topographic data, and a principle components transformation of both the spectral and topographic data. The spectral data used alone will indicate the base line classification accuracy when not utilizing the topographic data. The spectral plus elevation data will indicate the improvement in results from using the elevation data. The spectral plus all topographic data will estimate the maximum accuracy using all available data. The principle component data will be run to determine if the number of classification channels can be reduced to decrease classification time without significantly reducing classification accuracy. Figure 15 shows a matrix of possible classification procedures that will be evaluated during the next quarterly reporting period.

One of the major efforts in developing the classification procedures used in this report involves the programming that is required to modify the layered classifier so that the algorithm will be able to accept both spectral and topographic statistics data decks. This work has involved considerable effort, and is nearly complete at this time.

C. Definition of Test Data Set

The third major activity during the current reporting period involved the development of the test data set to be used in evaluating the final classification results. Because of the complexity of the test site and insuing complexity of statistical sampling procedures, it was determined that the best approach would be to utilize individual Landsat pixels for the test data set. Discussions with Drs. Anderson and Pillai of the Purdue Statistics Department were of great help in establishing acceptable statistical procedures for developing the test data set. An initial set of 300 pixels per quadrangle (a total of 2100 pixels over the seven test quadrangles) were randomly selected. The software developed and reported during the second quarterly progress report was then utilized to plot the

			DATA TYPE			
CLASSIFICATION ALGORITHM	stages	weights	spectral only	spectral and evevation	spectral and topographic	principle components
	single	w/				
		w/o				
	multiple	w/				
		w/o				

Figure 15. Matrix of Classification Procedures

location of these pixels for each of the test quadrangles. Tentative identification was made for each of the pixels using the INSTAAR cover type maps. Pixels which fall too close to borders between two cover types to allow positive identification were excluded from the population being considered, thus reducing the inference space of the accuracy estimates. This results in a slight decrease from the possible 2100 potential test pixels. Three hundred test pixels per quadrangle had been defined to provide a random sample of sufficient size to achieve plus or minus 5% error of estimate at the 95% confidence level. The decrease in the number of pixels due to edge pixels would still allow this error of estimate to be achieved unless more than one-sixth of the total potential test pixels were rejected.

During the July field trip, one of the major goals was to locate and field check as many of the test pixels as possible. Following the field work, a detailed photointerpretation was undertaken to establish positive identification of all test pixels. The areas which had been field checked were used to establish confidence in the photointerpretation activity. However, the INSTAAR type maps were also used as a back-up to the photointerpretation work. The photointerpretation was carried out with a 1:24,000 line printer printout of the quadrangle of interest which was aligned with a 1:120,000 color infrared aerial photo of the same area. The X-Y coordinate of each test pixel was then located on the aerial photography and interpreted. Stand density, as well as cover type, were recorded for each of the test pixels.

D. Second Field Trip

In July, a field trip was conducted by Mike Fleming, Ross Nelson, and Roger Hoffer. The purpose was to conduct an evaluation of the preliminary classification results and to check the cover type identification of test data points. The work was carried out from July 10 to July 22, and proved to be most worthwhile. Five major activities were carried out during this time.

Of primary importance, a preliminary classification using the layered classifier had been completed prior to the time of the field trip for all of the quadrangles designated as training quads. These maps had been developed using the Landsat spectral data to classify major cover types (deciduous forest, coniferous forest, herbaceous vegetation, water, and barren or exposed soil or rock outcrops). The topographic data was then used to subdivide the coniferous and deciduous forest cover groups into the individual forest cover types. Because the spectral data was used to group the data into such major categories, and the individual forest cover types were defined primarily as a function of topographic position, this procedure tended to produce a cover type map having fairly homogenous stands with very little of the "salt and pepper" effect which is often noted in conventional per-point classifications using only the spectral data when individual forest cover types are being classified. While based on a large number of spectral training classes in the field, the cover type classifications of these maps were checked. Specific note was made of boundaries between the individual coniferous forest cover types and between the deciduous forest cover types on the classification map, and the locations where these boundaries occured were field checked. It was found that the boundary between aspen and oak and the boundary between the spruce/fir and the Douglas fir cover types both needed to be adjusted to higher elevations. Since the initial classifications were carried out using an equal probability of occurance for all of the cover types, by using a weighted probability (a Baysian classification), it is believed that the classification performance will be improved and a more accurate reflection of the actual location of the boundaries between the individual forest cover types will be achieved.

The second major activity involved field checking the test sample points. A random sample of 300 pixels in each of the seven test quadrangles had been defined to provide an adequate sample for an effective statistical evaluation. Prior to the field trip, digital maps were obtained (using the programs described in the second quarterly report) on which the 300 test pixels had been randomly located. These were then overlayed with the acetate cover type maps, and all points which could be reached by road were circled for field checking. In this manner approximately 20 to 30 percent of all of the individual pixels to be used in the test evaluation procedure were field checked. There seemed to be little question that the use of the aerial photography, in combination with INSTAAR-developed cover type maps, would allow a high degree of accuracy and reliability in identifying the cover type of individual test pixels throughout the study site.

The third major activity involved correction of the INSTAAR cover type maps. Basically this involved the constant evaluation of the type maps for various forest cover types as we were traveling the various roads. Any improvements or corrections that needed to be made, were noted on the maps. In general, the INSTAAR cover type maps were reasonably accurate as far as identification was concerned but there were a number of places where the boundaries between different cover types were inaccurate. In some of the lower elevation areas, somestands had been mapped as the pinion-juniper cover type where there was very little of this cover type present when field checked. Also many areas had been designated as a mixed conifer cover type, but by going to these areas in the field a more specific identification, in terms of the actual species present could be made, thus achieving a much more refined cover type map.

All of these first three activities were achieved primarily by traveling most of roads that were passable in the study aera, specifically, the ten quadrangles in the southern portion of the San Juan National Forest, the Howardsville quadrangle outside of Silverton, and the three quadrangles in the Rio Grande National Forest.

The fourth major activity involved an aircraft flight over the study area. This was conducted on Tuesday of the second week of the field work, under ideal weather conditions. On this flight a number of the areas that had been visited on the ground during the first week were double checked, and a further evaluation of some of the boundary delineations on the type maps was obtained. The flight also proved very worthwhile for evaluating the layered classification results. Several specific areas had been delineated for checking and evaluation from the air. A number of color and color infrared photos were taken of some of these areas for later correlation with the classifications type maps and to obtain additional information to photographically describe the characteristics of the test site area.

The fifth major activity involved meeting with U.S. Forest Service personnel to discuss our activities and evaluate the results thus far. The primary contact has been Mr. Hank Bond, who is at the San Juan National Forest office in Durango. We met briefly with him on three separate occasions to discuss various aspects of the project. He seemed pleased and impressed with the quality and accuracy of the layered classification results (based upon a qualitative evaluation of a few of the areas with which he was very familiar). He was also very helpful in defining the Forest Service needs in terms of the cover types which they would like to see on the final classification results. This has enabled us to modify our "classification tree", and will enable the results of this project to be more useful to the Forest Service, both from the standpoint of allowing them to better assess the current capabilities and limitations of remote sensing technology and also by providing a more useful output product to them.

In summary, it was an extremely busy two weeks of work, but proved to be most worthwhile and timely. After the field work, we could proceed with a much higher degree of confidence in the photointerpretation activities, both for the identification of cover types in the test data sets and the development of the topographic "Correction Model Technique" (Method 3).

The results of this field trip confirm the need for adequate field work to be mixed with the analysis activities so that the results are more reliable and so that the personnel involved in carrying out the analysis can proceed with a greater degree of confidence in the interpretation of aerial photos and in conducting the computer analysis.

II. PROBLEMS ENCOUNTERED

No problems of major consequence developed during this reporting period. Modifications to the layered classifier software was slower than anticipated because of the unexpected resignation of the student programmer who had been working on this phase of the project. This problem has been resolved and the programming work is progressing satisfactorily. It is anticipated that the multiple statistics decks capability for the layered classifier will be debugged and the program running correctly by September 30, and the weighting capability for the layered classifier will be available by October 31.

III. PERSONNEL STATUS

During this reporting period, Dr. Hoffer completed his sabbatic work in Ft. Collins. There have been some changes in personnel doing the computer programming and software revisions. The personnel involved on the project during the past quarter were as follows (average percentage time over the three months):

Dr. V. Anderson	6%	M. Fleming	95%
Dr. L. Bartolucci	21%	B. Freestone	39%
J. Cain	25%	Dr. R. Hoffer	78%
J. Etheridge	7%	N. Kline	2%

(continued)

S. Klosowski	2%	Dr. K. Pillai	6%
L. Lang	2%	B. Prather	17%
R. Nelson	81%	I. Tendam	17%
Dr. J. Peterson	3%		

IV. EXPECTED ACCOMPLISHMENTS

During the next quarter, the software modifications to layered classifier will be completed and the entire series of classification sequences described previously in Figure 15 will be conducted. These results will be evaluated and the recommended procedure defined. A second major activity will involve the completion of the "Correction Model Technique" approach and evaluation of these results. The third major activity of the quarter will involve writing of the annual report summarizing the research activities of this first year of the project. Work will also be initiated on defining the test site locations for the evaluation of the recommended procedure in other geographic areas.

Table 1. DISCRIMINATE ANALYSIS FOR THE TOPOGRAPHIC MODEL
(Equal Probability)

Coniferous Forest

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 1	GP. 2	GP. 3
GROUP 1 SPRUCE - FIR	806.	729. 90.4%	77. 9.6%	0. 0.0%
GROUP 2 DOUG & WHITE FIR	617.	21. 3.4%	513. 83.1%	83. 13.5%
GROUP 3 P. PINE	440.	0. 0.0%	39. 8.9%	401. 91.1%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 88.19%

Deciduous Forest

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 6	GP. 7	GP. 8
GROUP 6 ALP-WILL	232.	219. 94.4%	13. 5.6%	0. 0.0%
GROUP 7 ASPEN	432.	51. 11.8%	306. 70.8%	75. 17.4%
GROUP 8 OAK	111.	0. 0.0%	1. 0.9%	110. 99.1%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 81.94%

Herbaceous

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 9	GP. 10	GP. 11
GROUP 9 GRASS	99.	99. 100.0%	0. 0.0%	0. 0.0%
GROUP 10 MEADOW	108.	17. 15.7%	87. 80.6%	4. 3.7%
GROUP 11 TUNDRA	787.	0. 0.0%	30. 3.8%	757. 96.2%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 94.87%

Table 2. DISCRIMINATE ANALYSIS FOR THE TOPOGRAPHIC MODEL (Weighted Probability)

Coniferous Forest

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 1	GP. 2	GP. 3
GROUP 1 SPRUCE - FIR	806.	740. 91.8%	66. 8.2%	0. 0.0%
GROUP 2 DOUG & WHITE FIR	617.	24. 3.9%	526. 85.3%	67. 10.9%
GROUP 3 P. PINE	440.	0. 0.0%	43. 9.8%	397. 90.2%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 89.26%

Deciduous Forest

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 6	GP. 7	GP. 8
GROUP 6 ALP-WILL	232.	213. 91.8%	19. 8.2%	0. 0.0%
GROUP 7 ASPEN	432.	36. 8.3%	373. 86.3%	23. 5.3%
GROUP 8 OAK	111.	0. 0.0%	8. 7.2%	103. 92.8%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 88.90%

Herbaceous

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 9	GP. 10	GP. 11
GROUP 9 GRASS	99.	99. 100.0%	0. 0.0%	0. 0.0%
GROUP 10 MEADOW	108.	17. 15.7%	81. 75.0%	10. 9.3%
GROUP 11 TUNDRA	787.	0. 0.0%	19. 2.4%	768. 97.6%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 95.37%

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