SHRP-P-684

Early Analyses of LTPP General Pavement Studies Data:

Data Processing and Evaluation

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Abstract

The purpose of this volume is to provide statistical data that may be used to characterize the nature of the data in the various data sets. The specific data sets are the GPS-1, GPS-2, GPS-3, GPS-4, and GPS-5 data. Data was obtained from the LTPP Data Base (also referred to as the "LTPP Information Management System").

Executive Summary

The purpose of this report is to provide statistical data that may be used to characterize the nature of the data in the various data sets. The specific data sets are the General Pavement Studies (GPS)-1, GPS-2, GPS-3, GPS-4, and GPS-5 data. The actual data evaluations on the various data sets used in the analyses are described in Chapters 5 and 6 of Report SHRP-P-393, Early Analyses of LTPP General Pavement Studies Data, Sensitivity Analyses for Selected Pavement Distresses.

All of the data collected for Long Term Pavement Performance (LTPP) studies are for test sections 500 feet (152.4 meters) in length and the width of the outside traffic lane. All test sections are located in the outside traffic. Data on these test sections were downloaded from the LTPP Data Base (sometimes referred to as the "LTPP Information Management System"). Data obtained directly from the individual Strategic Highway Research Program (SHRP) Regions were estimates of initial Pavement Serviceability Index (PSI) and 18-kip (80kN) Equivalent Single Axle Loads (ESALs) by the individual State Highway Agencies, and current values of International Roughness Index (IRI) and slope variance from monitoring.

In general, the statistical data for the various data sets (one chapter for each) include the following:

1. A table that provides statistical data on the distresses observed on the test sections included in the data set. These statistical data include numbers of test sections displaying the distress of interest and the mean, standard deviation, low value, median value, high value, and range for the distress measurements.

2. Statistical data for those variables identified by a panel of experts as significant to the occurrence of distress of various types. This table includes the same data elements described in Item 1 above.

3. The output from correlation analyses for the significant variables in the hot-mix asphalt concrete (HMAC) pavement data sets, and a table describing the variables appearing in the correlation matrix and identified by brief codes. The output of these tables (see Table 2.4 as an example) have 3 values for each pair of variables analyzed. The top number is the correlation coefficient, for which 1.0 represents perfect correlation. The number just below is the probability that the correlation is not significant. The bottom number is the number of observations, i.e., the number of test sections with both of the data elements in the data set. The output from correlation analyses for the

portland cement concrete (PCC) pavement data sets, have only one number for each pair of variables. This value is the correlation coefficient for that pair of variables.

4. A frequency table by environmental region in Statistical Analysis System© (SAS) format.

5. Scatter plots for selected distresses of interest, plotted against significant independent variables.

6. Numerous distribution plots, boxplots, probability density plots, and normal quantile-quantile plots for both distresses and the more significant independent variables.

7. The appropriate sampling template for each GPS experiment with numbers of test sections in each cell indicated.

There will be a minimum of text in the beginning of each chapter to provide information specific to that particular set of statistical data. It may be convenient to review the list of figures in order to identify what scatter plots and distribution plots have been included and where within the report they are included.

1

Introduction

This report, due to the diversity of the research works and the bulk of the text required to describe them, has been produced in four reports and an Executive Summary. The overall report is entitled "Early Analyses of LTPP General Pavement Studies Data", but each of the individual reports has an additional title as follows:

SHRP-P-392 - Executive Summary

SHRP-P-684 - Data Processing and Evaluation

SHRP-P-393 - Sensitivity Analyses for Selected Pavement Distresses

SHRP-P-394 - Evaluation of the AASHTO Design Equations and Recommended Improvements

SHRP-P-680 - Lessons Learned and Recommendations for Future Analyses of LTPP Data

Each report is written as a "stand alone" document, but it will be useful to refer to the other reports for additional detail.

This document (SHRP-P-684) reports the results from statistical evaluations of Long-Term Pavement Performance (LTPP) data for Strategic Highway Research Program (SHRP) Contract P-020, "Data Analysis", which served as the primary vehicle for harvesting the results from the first five years of the SHRP LTPP studies and transforming this new information into implementable products supporting the LTPP goal and objectives. The research was conducted by Brent Rauhut Engineering Inc. and ERES Consultants, Inc.

The goal for the LTPP Studies, as stated in "Strategic Highway Research Plans", May 1986, is:

> "To increase pavement life by investigation of various designs of pavement structures and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soil and maintenance practices."

LTPP Objectives and Expected Products

The following six objectives were established by the SHRP Pavement Performance Advisory Committee in 1985 to contribute to accomplishment of the overall goal:

1. Evaluate existing design methods.

2. Develop improved design methods and strategies for pavement rehabilitation.

3. Develop improved design equations for new and reconstructed pavements.

4. Determine the effects of: (a) loading, (b) environment, (c) material properties and variability, (d) construction quality, and (e) maintenance levels on pavement distress and performance.

5. Determine the effects of specific design features on pavement performance.

6. Establish a national long-term pavement data base to support SHRP objectives and future needs.

This research was the first to utilize the National Pavement Data Base (later renamed the "LTPP Data Base") to pursue the other objectives. The early products that were expected from this data analysis are listed below and related to project tasks (to be described later):

1. A better understanding of the effects of a broad range of loading, design, environmental, materials, construction and maintenance variables on pavement performance [Task 2].

2. Evaluation of and improvements to the models included in the 1986 AASHTO Pavement Design Guide [Tasks 3 and 4].

3. Evaluation and Improvement of AASHTO overlay design procedures using data from the General Pavement Studies (GPS) [Task 5].

4. Data analysis plans for future analyses as time-sequence data for the GPS and Specific Pavement Studies (SPS) data enter the LTPP Data Base and the LTPP Traffic Data Base to offer opportunities for further insight and design improvements [Task 6].

This project began with development of tentative analysis plans for this initial analytical effort. These plans were presented July 31, 1990 to the SHRP Expert Task Group on Experimental Design and Analysis, and on August 2, 1990 to the highway community in a SHRP Data Analysis workshop. A detailed work plan was developed from the initial plans, in consideration of comments and guidance received from these and subsequent meetings. Guidance was furnished to the contractors throughout the research by a Data Analysis Working Group (composed of SHRP Staff and SHRP Contractors), the Expert Task Group on Experiment Design and Analysis, and the Pavement Performance Advisory Committee.

Research Tasks

The specified tasks for SHRP Contract P-020a were:

Task 1 -	Data Evaluation Procedure and Workshop
Task 1A -	Data Processing and Evaluation
Task 2 -	Sensitivity Analysis of Explanatory Variables in the National Pavement Performance Data Base
Task 3 -	Evaluation of the AASHTO Design Equations
Task 4 -	Improvement of the AASHTO Design Equations
Task 5 -	Evaluate and Improve AASHTO Overlay Procedures Using GPS Data
Task 6 -	Future LTPP Data Analysis Plans

The relationships between the tasks and the general flow of the research appear in Figure 1.1. The task documented in this report is Task 1A. As can be seen, this task provided data and information needed for the remaining tasks.

Data Bases Used in the Analyses

The LTPP Data Base will eventually include data for both General Pavement Studies (GPS) and Specific Pavement Studies (SPS), but only the GPS data was marginally adequate for these early analyses. At the time analysis was initiated (Spring of 1992), the SPS data was only beginning to be entered into the IMS for projects recently constructed, and most of the projects are not yet constructed. It should be noted that all of the data collected for LTPP studies are for test sections 500 feet (152.4 meters) in length and the width of the outside traffic lane. All test sections are located in the outside traffic lane.

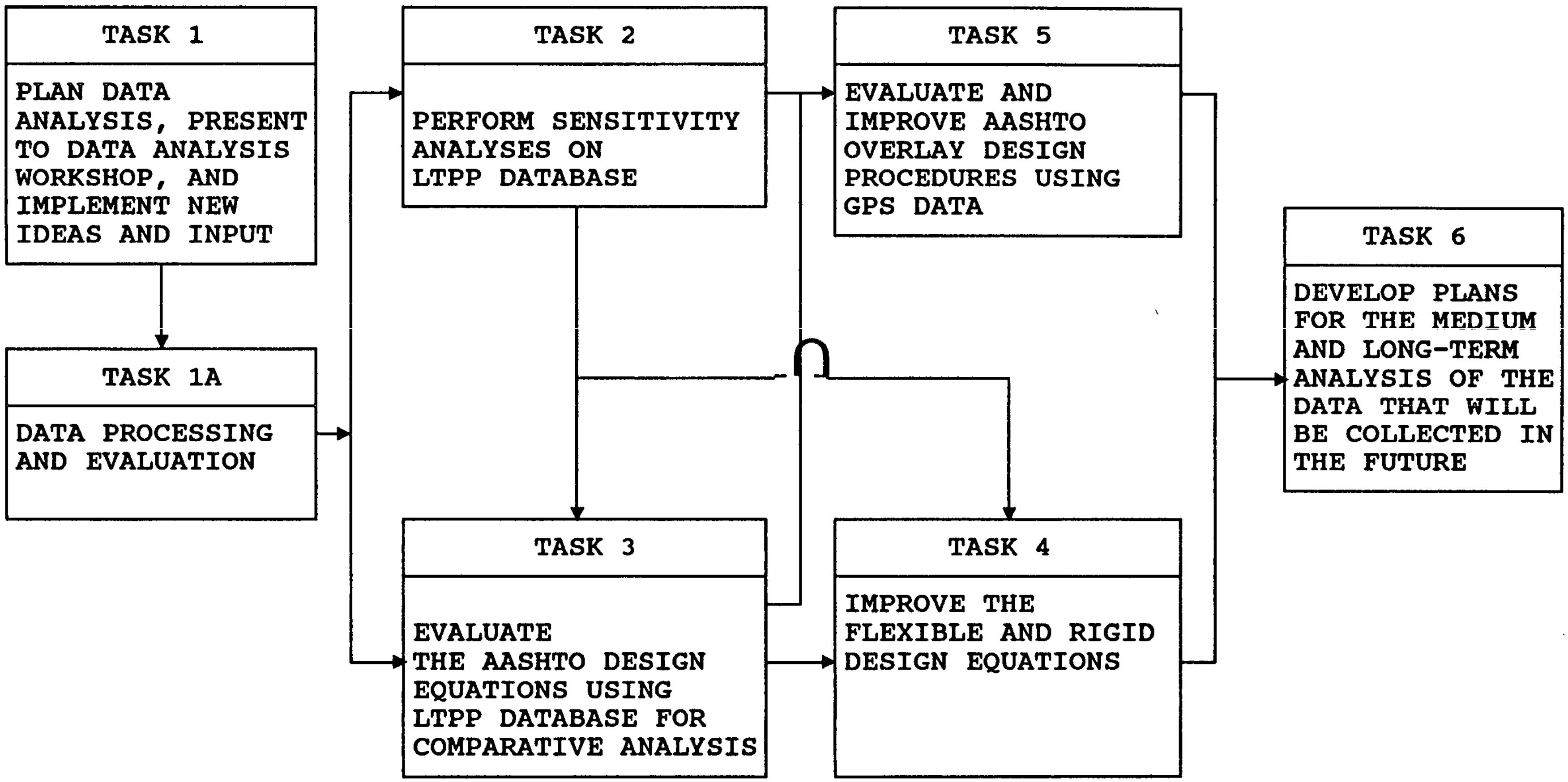

Figure 1.1 General Task Flow Diagram

The GPS experiments are identified and briefly described in Table 1.1. The sensitivity analyses were conducted only for the five data sets for pavements that had not yet been rehabilitated; i.e., were in their first service period before being overlaid or otherwise rehabilitated (GPS-1 through GPS-5). The limited data bases available for the pavements with overlays were used for Task 5, "Evaluate and Improve AASHTO Overlay Procedures Using GPS Data" (see SHRP-P-394, Early Analyses of LTPP General Pavement Studies Data, Evaluation of the AASHTO Design Equations and Recommended Results). There were not sufficient test sections in GPS-6, GPS-7, and GPS-9, for which condition prior to overlay was known, to support development of reasonable predictive models for conducting sensitivity analyses.

It should be noted that some statisticians prefer to call the GPS experimental factorials "sampling templates" rather than experimental factorials, because existing in-service pavements were used instead of test sections that were constructed to satisfy rigorous experiment designs. Instead, the factorials were established to encourage reasonable distributions of parameters expected to be significant and test sections were sought to meet the factorial requirements. The SPS will in fact follow the requirements of designed experiments.

Table 1.1 Listing of SHRP LTPP General Pavement Studies (GPS) Experiments

GPS Experiment Number	Brief Description	No. of Projects in the Data Base
1	Asphalt Concrete Pavement with Granular Base	253
2	Asphalt Concrete Pavement with Bound Base	133
3	Jointed Plain Concrete Pavement (JPCP)	126
4	Jointed Reinforced Concrete Pavement (JRCP)	71
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6A	AC Overlay of AC Pavement (Prior Condition Unknown)	61
6B	AC Overlay of AC Pavement (Prior Condition Known)	31
7A	AC Overlay of Concrete Pavement (Prior Condition Unknown)	34
7B	AC Overlay of Concrete Pavement (Prior Condition Known)	15
9	Unbonded PCC Overlays of Concrete Pavement	28

Data Processing for Flexible Pavements

The bulk of the GPS-1 and GPS-2 data available was downloaded from the LTPP Data Base (sometimes referred to as the "LTPP Information Management System"). Data obtained directly from the individual SHRP Regions were estimates of initial Pavement Serviceability Index (PSI) and 18-kip (80kN) Equivalent Single Axle Loads (ESALs) by the individual State Highway Agencies, and current values of International Roughness Index (IRI) and slope variance from monitoring. These data were located in a great number of files, which could not be used directly for the data analyses. Data was extracted from these files and processed into separate data bases by data type. At this stage, separate data bases were not available for the separate GPS experiments.

The data was then extracted by experiment and combined into one data base for the statistical studies addressed in this volume. The data was sorted for the sensitivity analyses on the flexible pavements according to 12 categories of pavement structures, all from the GPS-1 and GPS-2 data. These 12 categories of pavement structures are listed in Table 1.2, along with identification of total numbers of section with sufficient data for use in the analyses and by numbers of test sections with each of the three distress types for which sensitivity analyses were conducted.

The data base to be used for the evaluation of the AASHTO Design Equation for Flexible Pavements included all of GPS-1 and GPS-2 test sections for which the pertinent data was available. The required data elements included the layer structure, the traffic data, and the performance data. Data for individual layers in the pavement structure were used, as discussed further in Volume 4, to calculate structural numbers for each test section according to AASHTO guidelines. Performance data (slope variance and rut depth) were combined to calculate PSI, utilizing the equation developed for this purpose at the AASHTO Road Test. Traffic data included in this particular data set were limited to the cumulative 18-kip (80kN) ESAL data utilized in the sensitivity analyses. These data elements, along with subgrade and environmental data (where available), were incorporated into a spreadsheet for processing and handling and finally translated to a SAS data set for analysis in SAS.

The processing of the data for use in analyses also included using the data to calculate a number of variables needed. These calculated variables included air voids in HMAC, initial IRI, change in IRI, and cumulative ESALs. Rut depths were calculated from transverse profile data, using software developed by the Texas Research and Development Foundation, on either a four-foot or six-foot straight edge basis. Four-foot (1.22 meters) values were used for evaluation of the AASHTO design equation and six-foot (1.83 meters) values for the sensitivity analyses.

Table 1.2. Categories of Pavement Structures in GPS-1/GPS-2 Data Pool and Numbers of Test Sections for Which Data are Available

Category of Pavement Structure		Total Test Sections Based on Inventory Data	Total Test Sections Based on Available Data	Test Sections with Data for		
				Rutting	Roughness	Transverse Cracking
1.	HMAC on Granular Base	218	202	152	108	85
2.	HMAC on Asphalt Treated Base (ATB) and Granular Base	11	2	2	2	2
3.	Full Depth HMAC With Unstabilized Subgrade	52	50	46	33	22
4.	Full Depth HMAC With Lime Stabilized Subgrade	7	14	14	12	6
5.	Full Depth HMAC With Cement Stabilized Subgrade	3	1	1	1	0
6.	HMAC Over ATB Base With Unstabilized Subgrade	18	27	17	21	8
7.	HMAC Over ATB Base With Lime Stabilized Subgrade	3	3	3	2	0
8.	HMAC Over ATB Base With Cement Stabilized Subgrade	1	0	0	0	0
9.	HMAC with Soil Cement Base	20	16	11	5	8
10.	HMAC with Lean Concrete Base	4	6	5	5	4
11.	HMAC with Cement Aggregate Mixture Base	40	38	31	26	23
12.	HMAC with Pozzolanic Aggregate Mixture Base	2	1	1	0	0
	TOTALS	379	360	283	215	158

Data Processing for Rigid and Overlaid Pavements

BRE staff downloaded the bulk of the GPS-3, GPS-4, GPS-5, GPS-6, GPS-7, and GPS-9 data, sorted by experiment and data type, from the LTPP Data Base. Estimates of initial PSI, current values of IRI and slope variance from monitoring, and estimates of cumulative traffic were obtained from the individual SHRP regions and sorted by experiment. The data sets were then furnished to ERES for their use in the analyses for rigid and overlaid pavements.

For this study, the data from the different files were used to create several data bases for the analyses conducted. Databases were required for the following studies:

- development of distress prediction models for sensitivity analyses,
- evaluation of the AASHTO rigid pavement design equation, and
- evaluation of the revised AASHTO pavement overlay design procedures.

The processing of the data from the different files basically comprised of merging the data into the appropriate databases. In addition, several new variables computed from several of the variables in the original data files were also obtained for these databases. Initially, six databases were obtained for the GPS-3, GPS-4, GPS-5, GPS-6, GPS-7, and GPS-9 experiments using this process.

There were insufficient test sections in the GPS 6, 7, and 9 experiments for development of distress prediction models for those pavement types; therefore, these pavement sections were not included in the data base for the sensitivity analyses. Since the data for these overlaid sections are also not appropriate for the evaluation of the AASHTO rigid pavement design equation, they could only be used for the evaluation of the revised AASHTO pavement overlay design procedures.

In view of this unique use of the data for the pavements with overlays, the databases for these test sections were combined into a single database. The combined database contained complete information for a total of 20 pavements with overlays, comprised of nine GPS-6 pavements, five GPS-7 pavements, and six GPS-9 sections. This combined database was used for the evaluation of the revised AASHTO pavement overlay design procedures. Detailed information on each of the pavement sections in this limited database is presented in Chapter 8 and Appendix C of SHRP-P-394, Early Analyses of LTPP General Pavement Studies Data, Evaluation of the AASHTO Design Equations and Recommended Results. Consequently, no further information is provided on this database in this volume.

The results presented in this volume are from an initial analysis of the data for the GPS-3, 4, and 5 pavement sections that were used for the sensitivity analysis and the evaluation of the AASHTO rigid pavement design equation. Table 1.3 shows the categories of pavement structures that were available in this pool, and the number of test sections in each category that had data available for use in the sensitivity analyses for the four key distress types studied.

Table 1.3 Categories of Pavement Structures in GPS 3, 4, and 5 Data Pool and Numbers of Test Sections for Which Data are Available

Category of Pavement Structure	Total Number of Test Section Based on Inventory Data	Total Number of Test Sections Based on Available Data	Number of Test Sections with Data for Distress Types			
			Joint Faulting	Joint Spalling	Transverse Cracking	Roughness
1. JPCP	128	128	76	118	117	104
2. JRCP	71	71	32	63	54	70
3. CRCP	86	86	–	–	–	82

The database for the evaluation of the AASHTO rigid pavement design equation was also assembled from this pool. However, only the data that included information pertinent to the evaluation were included. A spreadsheet containing information on the test sections and corresponding data that were used in the evaluation is presented in Volume 3.

Statistical Data

The data evaluations conducted on the various data sets used for analyses are described in Chapters 5 and 6 of SHRP-P-393, Early Analyses of LTPP General Pavement Studies Data, Sensitivity Analyses for Selected Pavement Distresses. The purpose of this report is to provide statistical data that may be used to characterize the nature of the data in the various data sets. These specific data sets are the GPS-1, GPS-2, GPS-3, GPS-4, and GPS-5 data.

In general, the statistical data for the various data sets (one chapter for each) include the following:

1. A table that provides statistical data on the distresses observed on the test sections included in the data set. These statistical data include numbers of test sections displaying the distress of interest and the mean, standard deviation, low value, median value, high value, and range for the distress measurements.

2. Statistical data for those variables identified by a panel of experts as significant to the occurrence of distress of various types. This table includes the same data elements described in Item 1 above.

3. The output from correlation analyses for the significant variables in the HMAC pavement data sets, and a table describing the variables (see Table 2.3) appearing in the correlation matrix and identified by brief codes. The output in these tables (see Table 2.4 as an example) have 3 values for each pair of variables analyzed. The top number is the correlation coefficient, for which 1.0 represents perfect correlation. The number just below is the probability that the correlation is not significant. The bottom number is the number of observations; i.e., the number of test sections with both of the data elements in the data set. The output from correlation analyses for the PCC pavements have only one number for each pair of variables. This value is the correlation coefficient for that pair of variables.

4. A frequency table by environmental region in SAS™ format.

5. Scatter plots for selected distresses of interest, plotted against significant independent variables.

6. Numerous distribution plots, boxplots, probability density plots, and normal quantile-quantile plots for both distresses and the more significant independent variables.

7. The appropriate sampling template for the experiment, with numbers of test sections in each cell indicated.

There will be a minimum of text in the beginning of each chapter to provide information specific to that particular set of statistical data. It may be convenient to review the list of figures in order to identify what scatter plots and distribution plots have been included and where within the report they are included.

Metric Conversion Factors

It was decided to simply provide a table of conversion factors from English to metric units, because of the hundreds of figures and tables. These factors appear in Table 1.4.

Table 1.4 Metric Conversion Factors

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25	millimeters	mm
ft	feet	.30	meters	m
yd	yards	0.91	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.84	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (ex-		
°F	Fahrenheit	5/9 (temperature -32)	Celsius	°C
		FORCE		
lb	pound	0.14	Newton	N
k	kip	4.45	kiloNewton	kN
		VISCOSITY		
	poise	0.1	Pascal second	Pa.s
		STRESS		
psi	pound/square inch	6.89	kiloPascal	kPa
pci	pound/cubic inch	8.44	kiloPascal/meter	kPa/m

2

Statistical Data for the GPS-1 Test Sections in the LTPP Data Base

This chapter provides statistical data for the 245 GPS-1 test sections for which data were available in the LTPP Data Base at the time it was downloaded. See the section entitled "Statistical Data" in Chapter 1 for description of statistical data for the following tables and figures.

Figure 2.1 illustrates the experimental design of GPS-1. Figure 2.2 shows the moisture and temperature definitions and other design factors are summarized below:

Traffic rate:	Low - Less than or equal to 85 KESALs/Yr. High - Greater than 85 KESALs/Yr.
AC Stiffness:	Low - Less than or equal to 650 ksi (4,485 kN/m^2). High - Greater than 650 ksi (4,485 kN/m^2).
Base Thickness:	Low - Less than 10.0 in (250 mm). High - Greater than or equal to 10.0 in (250 mm).
AC Thickness:	Low - Less than 3.0 in (70 mm). Medium - 3.0 (70 mm) to 8.0 in (200 mm). High - Greater than 8.0 in (200 mm).

AC THICKNESS	BASE THICKNESS	AC STIFFNESS	WET								DRY							
		TEMPERATURE	Freeze				No Freeze				Freeze				No Freeze			
		SUBGRADE TYPE	Fine		Course		Fine		Course		Fine		Course		Fine		Course	
		TRAFFIC RATE	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Low	Low	Low			1			3	4	1	1		2	1	1		1	
		High	1				2	1	2	6					1		2	
	High	Low	1		2		1	3	2		2	1			2	2	2	1
		High			2	1	1	1	2	2	2	1	2		1			
Medium	Low	Low	1		2		3	3	1	2	1	1	2	1	1	1	2	2
		High	4	1	2	4	2	2	2	3	3	1	2		2	1	1	1
	High	Low	3	2	4	2	3	2	2	1	3	2	3	4		2	2	2
		High	2	1	2	1	2	1	3	1	1			1	2		2	1
High	Low	Low	2	1	4	2	2	2	2	1	1	3	1	3	1		2	3
		High	2	3	1	2	3	1	4	1		2	2			1	1	3
	High	Low		2	1	2		1								1		1
		High	5	2		3	1	2								1	1	

Figure 2.1. Numbers of Test Sections for Each Cell in the GPS-1 Sampling Template

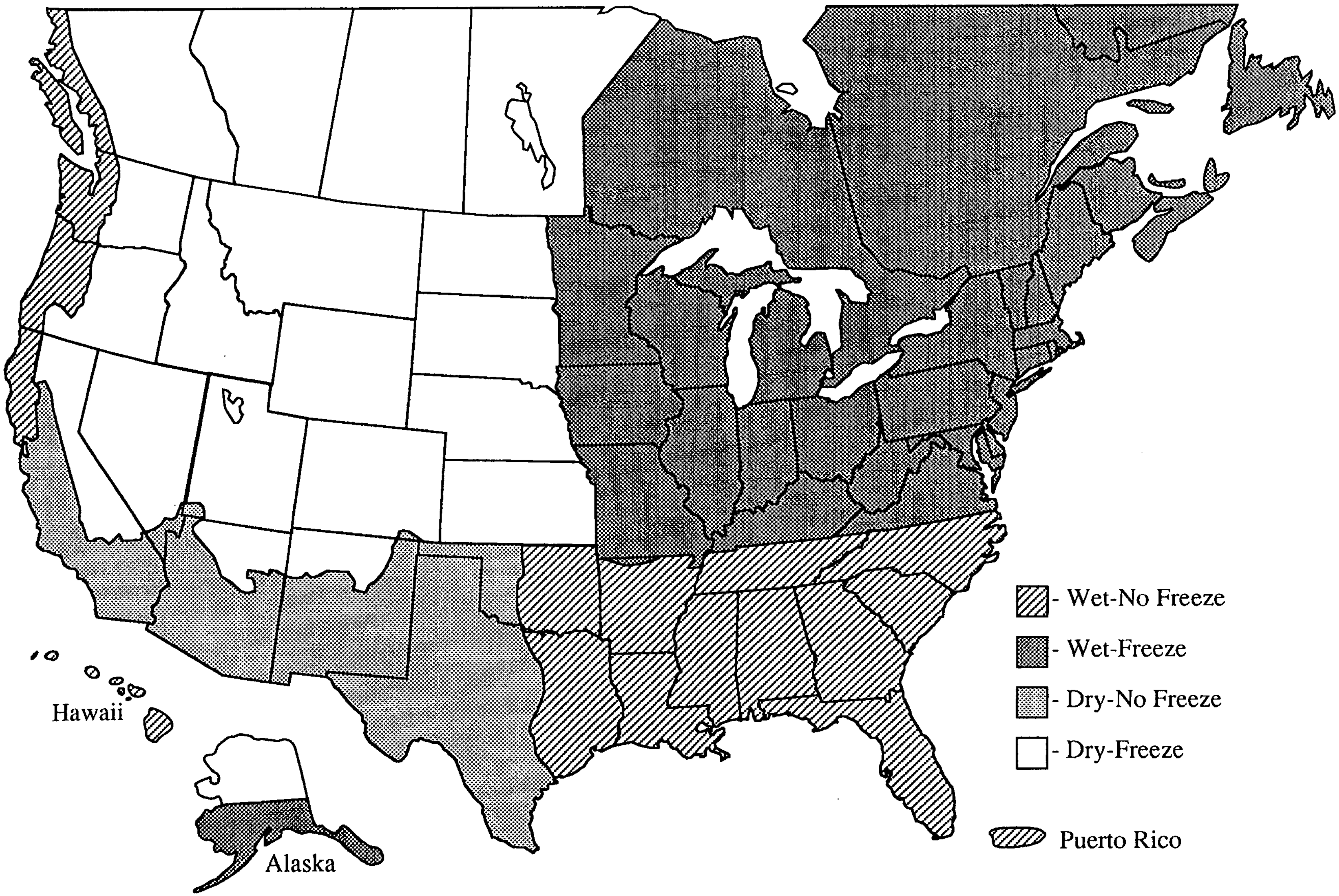


Figure 2.2. Environmental Zones for SHRP-LTPP Studies.

Table 2.1. Various Statistical Values for Distress Variables in the GPS-1 Data Set (246 Test Sections With Distress Data Entered in IMS)

Variable	Units	Sections With Distress	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Transverse Cracking: Low Severity:	No. Cracks	133	22.1	33.8	1	9	288	287
	Lin. Ft.	129	121.8	165	1	58.5	998	997
Moderate Severity:	No. Cracks	55	10.4	28.5	1	4	211	210
	Lin. Ft.	53	65.6	71.6	2	38.6	404	402
High Severity:	No. Cracks	8	5.9	12.6	1	1.5	37	36
	Lin. Ft.	7	15.8	7.5	5	13.5	27	22
Alligator Cracking: Low Severity:	Square Ft.	36	780	933	4	327	3101	3097
Moderate Severity:	Square Ft.	11	460	427	8	453	1290	1282
High Severity:	Square Ft.	1	456	0	456	456	456	0
Raveling & Weathering: Low Severity:	Square Ft.	17	404	1064	4	149	4500	4496
Moderate Severity:	Square Ft.	2	32.4	28.8	12	32.4	53	41
High Severity:	Square Ft.	0	0	0	0	0	0	0

Note: Statistical values only reflect data for those test sections found to have the distress of interest present.

Table 2.2. Statistical Values of Interest for Significant Variables in the GPS-1 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Rut Depth	Inches	188	0.29	0.15	0.05	0.25	0.99	0.94
Initial Roughness (IRI)	Inches/ Mile	163	57	23	14	52	123	109
Measured Roughness (IRI)	Inches/ Mile	227	87	36	36	78	260	224
Measured Friction Number	%	184	46	12	10	47	90	80
Surface Thickness	Inches	241	6.0	3.4	0.8	5.5	16.0	15.2
Granular Base Thickness	Inches	208	9.6	4.6	0.9	8.6	25.8	24.9
Granular Subbase Thickness	Inches	83	13.4	7.8	2.0	12.0	38.2	36.2
Treated Subbase Thickness	Inches	21	7.9	3.1	1.2	7.8	14.4	13.2
Age of Pavement	Years	233	9.6	5.91	1.1	9.0	25.0	24.0
Cumulative KESALS	No.	233	2176	4624	1	689	40326	40325
HMAC Asphalt Viscosity @ 140F	Poise	226	1690	951	288	1692	8422	8134
HMAC Asphalt Content	% by wt.	233	5.2	0.8	2.4	5.1	7.4	5.0
HMAC Air Voids	% by wt.	228	4.7	2.1	0.9	4.5	13.6	12.7
HMAC Aggregate Passing #4 Sieve	% by wt.	213	55.2	9.0	27.4	55.8	82.7	55.3
Comp. of Base (Mod. AASHTO)	%	163	95.0	5.7	76.4	95.2	128.3	51.9
Comp. of Subbase (Mod. AASHTO)	%	72	95.4	7.2	70	96.6	117.5	47.7
In Situ Moisture in Subgrade	%	236	11.7	6.9	0	10.9	36.0	36.0
Subgrade Soil Passing #200 Sieve	% by wt.	232	36.1	27.4	0.4	29.2	97.5	97.1

Continued on Page 22

Table 2.2. Statistical Values of Interest for Significant Variables in the GPS-1 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Plasticity Index of Subgrade	%	236	6.9	9.1	0	3	44	44
Liquid Limit of Subgrade	%	236	17.2	17.7	0	15.5	72	72
Subgrade Soil Finer than 0.02mm	%	218	26.1	20.2	0.7	20.9	91.4	90.7
Freeze Index	°F-Days < 32°F	235	591	822	0	161	3396	3396
No. of Days Min. Temp. < 32°F	No.	235	91.7	65.5	0	86	236	236
No. of Days Max. Temp. > 90°F	No.	235	45.9	46.2	0	37	180	180
No. of Air Freeze-Thaw Cycles	No.	235	72.0	44.4	0	78.0	197	197
Annual Precip.	Inches	235	33.7	16.2	3.0	35.3	84.2	81.2
Average Daily Temp. Range	°F	245	23.5	4.2	13.8	23.0	35.3	21.5
Avg. Min. Temp. (Daily Min. Temps. for Dec., Jan., and Feb.)	°F	245	26.4	15.1	-6.5	26.4	67.5	74.0
Avg. Max Temp. (Daily Max. Temps. (June, July, Aug.)	°F	245	86.3	8.1	60.8	87.9	109	48.2
Avg. Min. Temp. by Month	°F	230	44.5	11.4	22.9	44.74	68.7	45.8
Avg. Max. Temp. by Month	°F	230	68.1	11.9	42.1	70.0	88.5	46.4

Table 2.3. Description of Variables Used in the Correlation Matrix for the GPS-1 Data Set

Variable	Description of Variable
MEAN6	Rut Depth (6-ft. straight edge), inches
I_IRI	Initial IRI value, inches/mile
B_IRI	Measured IRI value, inches/mile
TCRK_T	Total measured Transverse cracking (all severity levels combined) in linear feet
TNO_T	Total number of Transverse cracks identified (all severity levels combined)
AGE	Age of pavement, years
KESALs	Equivalent Single Axle Loads in thousands
SURTH	Surface thickness, inches
GBTHK	Granular Base thickness, inches
GSBTH	Granular Subbase thickness, inches
TSBTH	Treated Subbase thickness, inches
V140	Asphalt cement viscosity @ 140°F, poise
A_CON	Asphalt Content of surface course, % by weight
AV	Air Voids of surface course, % by volume
% 4	Percent Passing the #4 sieve for surface course, by weight
COMPB	Compaction of the Granular Base, % Modified AASHTO
COMPS	Compaction of the Granular Subbase, % Modified AASHTO
% 200	Percent passing the #4 sieve for the subgrade, by weight
MOIST	Insitu Moisture of the subgrade, % by weight
TPREC	Average Annual Precipitation, inches
AVG90	Average number of days with temperature greater than 90°F
AVG32	Average number of days with temperature less than 32°F
FTIN	Freeze Index, degree-days
FRZTH	Average number of Freeze-Thaw Cycles

Table 2.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	MEAN6	I_IRI	B_IRI	TCRK_T	TNO_T	AGE	KESALS	SURTH	GBTHK	GSBTH	SBTHK	V140
MEAN6	1.00000	0.01264	0.22617	0.12962	0.18452	0.25852	0.34363	0.06604	-0.03711	0.11460	-0.36672	-0.04968
	0.0	0.8856	0.0027	0.0762	0.0112	0.0004	0.0001	0.3692	0.6466	0.4185	0.1477	0.5078
	188	132	174	188	188	187	187	187	155	52	17	180
I_IRI	0.01264	1.00000	0.14279	-0.06012	-0.06662	-0.0.723	-0.09346	-0.11832	0.08225	-0.23191	-0.19215	-0.24792
	0.8856	0.0	0.0834	0.4473	0.3996	0.6434	0.2444	0.1362	0.3305	0.0855	0.5105	0.0019
	132	163	148	162	162	157	157	160	142	56	14	155
B_IRI	0.22617	0.14279	1.00000	0.21420	0.14200	0.15873	-0.16558	-0.06299	-0.00993	0.12185	-0.04619	-0.01076
	0.0027	0.0834	0.0	0.0012	0.1329	0.0205	0.0156	0.3513	0.8918	0.3044	0.8467	0.8778
	174	148	227	226	226	213	213	221	190	73	20	207
TCRK_T	0.12962	-0.06012	0.21420	1.00000	0.75630	0.10643	-0.03283	0.08269	-0.13709	0.04113	-0.04753	-0.13429
	0.0762	0.4473	0.0012	0.0	0.0001	0.1059	0.6189	0.2018	0.0489	0.7137	0.8379	0.0442
	188	162	226	246	246	232	232	240	207	82	21	225
TNO_T	0.18452	-0.06662	0.14200	0.75630	1.00000	0.07670	-0.02559	0.00723	-0.05819	0.06498	-0.00108	-0.11342
	0.0112	0.3996	0.0329	0.0001	0.0	0.2445	0.6982	0.9113	0.4049	0.5619	0.9963	0.0896
	188	162	226	246	246	232	232	240	207	82	21	225
AGE	0.25852	-0.03723	0.15873	0.10643	0.07670	1.00000	0.20023	0.08057	-0.03027	0.10752	-0.11361	-0.22162
	0.0004	0.6434	0.0205	0.1059	0.2445	0.0	0.0021	0.2266	0.6752	0.3652	0.6239	0.0011
	187	157	213	232	232	233	233	227	194	73	21	213
KESALS	0.34363	-0.09346	-0.16558	-0.03283	-0.02559	0.20023	1.00000	0.24740	-0.10009	0.23090	0.24240	0.04262
	0.0001	0.2444	0.0156	0.6189	0.6982	0.0021	0.0	0.0002	0.1650	0.0494	0.2898	0.5362
	187	157	213	232	232	233	233	227	194	73	21	213
SURTH	0.06604	-0.11832	-0.06299	0.08269	0.00723	0.08057	0.24740	1.00000	-0.05123	0.05194	0.12007	-0.03992
	0.3692	0.1362	0.3513	0.2018	0.9113	0.2266	0.0002	0.0	0.4624	0.6410	0.6042	0.5504
	187	160	221	240	240	227	227	241	208	83	21	226
GBTHK	-0.03711	0.08225	-0.00993	-0.13709	-0.05819	-0.03027	-0.10009	-0.05123	1.00000	0.10052	-00.09519	-0.01085
	0.6466	0.3305	0.8918	0.0489	0.4049	0.6752	0.1650	0.4624	0.0	0.3844	0.7071	0.8800
	155	142	190	207	207	194	194	208	208	77	18	196

Table 2.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	MEAN6	I_IRI	B_IRI	TCRK_T	TNO_T	AGE	KESALS	SURTH	GBTHK	GSBTH	SBTHK	V140
GSBTH	0.11460	-0.23191	0.12185	0.04113	0.06498	0.10752	0.23090	0.05194	0.10052	1.00000	.	-0.10966
	0.4185	0.0855	0.3044	0.7137	0.5619	0.3652	0.0494	0.6410	0.3844	0.0	.	0.3457
	52	56	73	82	82	73	73	83	77	83	0	76
TSBTH	-0.36672	-0.19215	-0.04619	-0.04753	-0.00108	-0.11361	0.24240	0.12007	-0.09519	.	1.00000	-0.18235
	0.1477	0.5105	0.8467	0.8379	0.9963	0.6239	0.2898	0.6042	0.7071	.	0.0	0.4549
	17	14	20	21	21	21	21	21	18	0	21	19
V140	-0.04968	-0.24792	-0.01076	-0.13429	-0.11342	-0.22162	0.04262	-0.03992	-0.01085	-0.10966	-0.18235	1.00000
	0.5078	0.0019	0.8778	0.0442	0.0896	0.0011	0.5362	0.5504	0.8800	0.3457	0.4549	0.0
	180	155	207	225	225	213	213	226	196	76	19	226
A_CON	-0.03585	0.05012	-0.00598	-0.00048	0.00927	0.00153	-0.13697	-0.35442	0.01467	0.05803	-0.31165	-0.07585
	0.6290	0.5357	0.9309	0.9942	0.8881	0.9819	0.0415	0.0001	0.8363	0.6162	0.1691	0.2637
	184	155	213	233	233	222	222	233	201	77	21	219
AV	-0.24151	0.09074	0.09813	0.02864	0.01233	-0.01938	-0.13514	-0.03190	0.02132	-0.06214	-0.10389	0.05684
	0.0010	0.2646	0.1585	0.6670	0.8531	0.7761	0.0463	0.6318	0.7674	0.5939	0.6629	0.4080
	184	153	208	228	228	218	218	228	195	76	20	214
%4	-0.16561	0.00569	0.00820	0.17999	0.09441	-0.06861	-0.11880	-0.22557	-0.17899	-0.07329	-0.20487	-0.02053
	0.0285	0.9460	0.9094	0.0085	0.1697	0.2171	0.0890	0.0009	0.0156	0.5436	0.4302	0.7724
	175	144	195	213	213	206	206	213	182	71	17	201
COMPB	-0.15449	-0.14771	0.04939	-0.04983	0.01560	-0.12501	-0.13773	-0.20641	0.15422	-0.28442	-0.27790	0.13525
	0.0829	0.1219	0.5497	0.5276	0.8433	0.1249	0.0906	0.0082	0.0501	0.0290	0.3579	0.0966
	127	111	149	163	163	152	152	163	162	59	13	152
COMPS	-0.01525	-0.07508	-0.04240	0.15850	0.09970	-0.08698	-0.30954	0.00466	-0.16456	0.06205	.	-0.14090
	0.9217	0.6081	0.7394	0.1836	0.4047	0.4943	0.0128	0.9690	0.1799	0.6125	.	0.2591
	44	49	64	72	72	64	64	72	68	69	0	66
%200	-0.05089	0.11962	0.06861	0.05872	0.04436	-0.08566	-0.09416	0.18845	0.04133	0.06771	0.21583	0.00496
	0.4963	0.1408	0.3201	0.3743	0.5023	0.2067	0.1650	0.0040	0.5611	0.5558	0.3474	0.9421
	181	153	212	231	231	219	219	232	200	78	21	217

Table 2.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	MEAN6	I_IRI	B_IRI	TCRK_T	TNO_T	AGE	KESALS	SURTH	GBTHK	GSBTH	SBTHK	V140
MOIST	-0.9967	0.15520	0.01376	0.00967	0.02220	-0.07704	-0.11856	0.13614	0.11038	0.05324	0.03595	0.06603
	0.1783	0.0530	0.8407	0.8827	0.7349	0.2519	0.0773	0.0366	0.1160	0.6390	0.8771	0.3285
	184	156	216	235	235	223	223	236	204	80	21	221
TPREC	-0.10722	-0.13802	-0.02653	-0.18646	-0.06762	-0.21071	-0.20277	0.01138	0.17895	0.14991	0.25288	0.13302
	0.1531	0.0858	0.6975	0.0042	0.3030	0.0016	0.0024	0.8640	0.0114	0.1932	0.2687	0.0514
	179	156	217	234	234	222	222	229	199	77	21	215
AVG90	0.24246	0.15843	-0.10110	-0.03796	0.02501	-0.00574	0.37598	-0.07187	0.03908	0.01698	-0.35613	0.03477
	0.0011	0.0482	0.1377	0.5635	0.7035	0.9322	0.0001	0.2788	0.5836	0.8835	0.1131	0.6122
	179	156	217	234	234	222	222	229	199	77	21	215
AVG32	-0.09074	0.02730	0.09711	0.22019	0.07231	0.15103	-0.16516	0.14570	-0.14350	0.01188	0.27145	-0.40189
	0.2271	0.7352	0.1540	0.0007	0.2706	0.0244	0.0137	0.0275	0.0432	0.9184	0.2339	0.0001
	179	156	217	234	234	222	222	229	199	77	21	215
FTIN	-0.03141	0.02762	0.18127	0.29432	0.12210	0.20284	-0.14061	0.09095	-0.12375	-0.03741	-0.14695	-0.36732
	0.6764	0.7322	0.0074	0.0001	0.0622	0.0024	0.0363	0.1702	0.0816	0.7467	0.5250	0.0001
	179	156	217	234	234	222	222	229	199	77	21	215
FRZTH	-0.09163	0.04400	-0.00829	0.12438	0.02496	0.10107	-0.12643	0.16114	-0.13906	-0.03473	0.50890	-0.35354
	0.2225	0.5855	0.9033	0.0574	0.7040	0.1333	0.0600	0.0146	0.0501	0.7643	0.0185	0.0001
	179	156	217	234	234	222	222	229	199	77	21	215

Note: SAS prints out correlation matrices on wide computer paper, so the right-hand columns omitted above appear on the following pages.

Table 2.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	A_CON	AV	%4	COMPB	COMPS	%200	MOIST	TPREC	AVG90	AVG32	FTIN	FRZTH
MEAN6	-0.03585	-0.24151	-0.16561	-0.15449	-0.01525	-0.05089	-0.09967	-0.10722	0.24246	-0.09074	-0.03141	-0.09163
	0.6290	0.0010	0.0285	0.0829	0.9217	0.4963	0.1783	0.1531	0.0011	0.2271	0.6764	0.2225
	184	184	175	127	44	181	184	179	179	179	179	179
I_IRI	0.05012	0.09074	0.00569	-0.14771	-0.07508	0.11962	0.15520	-0.13802	0.15843	0.02730	0.02762	0.04400
	0.5357	0.2646	0.9460	0.1219	0.6081	0.1408	0.0530	0.0858	0.0482	0.7352	0.7322	0.5855
	155	153	144	111	49	153	156	156	156	156	156	156
B_IRI	-0.00598	0.09813	0.00820	0.04939	-0.04240	0.06861	0.01376	-0.002653	-0.10110	0.09711	0.18127	-0.00829
	0.9309	0.1585	0.9094	0.5497	0.7394	0.3201	0.8407	0.6975	0.1377	0.1540	0.0074	0.9033
	213	208	195	149	64	212	216	217	217	217	217	217
TCRK_T	-0.00048	0.02864	0.17999	-0.04983	0.15850	0.05872	0.00967	-0.18646	-0.03796	0.22019	0.29432	0.12438
	0.9942	0.6670	0.0085	0.5276	0.1836	0.3743	0.8827	0.0042	0.5635	0.0007	0.0001	0.0574
	233	228	213	163	72	231	235	234	234	234	234	234
TNO_T	0.00927	0.01233	0.09442	0.01560	0.09970	0.04436	0.02220	-0.06762	0.02501	0.07231	0.12210	0.02496
	0.8881	0.8531	0.1697	0.8433	0.4047	0.5023	0.7349	0.3030	0.7035	0.2706	0.0622	0.7040
	233	228	213	163	72	231	235	234	234	234	234	234
AGE	0.00153	-0.01938	-0.06861	-0.12501	-0.08698	-0.08566	-0.07704	-0.21071	-0.00574	0.15103	0.20284	0.10107
	0.9819	0.7761	0.3271	0.1249	0.4943	0.2067	0.2519	0.0016	0.9322	0.0244	0.0024	0.1333
	222	218	206	152	64	219	223	222	222	222	222	222
KESALS	-0.13697	-0.13514	-0.11880	-0.13773	-0.30954	-0.09416	-0.11856	-0.20277	-0.37598	-0.16516	-0.14061	-0.12643
	0.0415	0.0463	0.0890	0.0906	0.0128	0.1650	0.0773	0.0024	0.0001	0.0137	0.0363	0.0600
	222	218	206	152	64	219	223	222	222	222	222	222
SURTH	-0.35442	-0.03190	-0.22557	-0.20641	0.00466	0.18845	0.13614	0.01138	-0.07187	0.14570	0.09095	0.16114
	0.0415	0.0463	0.0890	0.0906	0.0128	0.0650	0.0773	0.0024	0.0001	0.0137	0.0363	0.0600
	222	218	206	152	64	219	223	222	222	222	222	222
GBTHK	0.01467	0.02132	-0.17899	0.15422	-0.16456	0.04133	0.11038	0.17895	0.03908	-0.14350	-0.12375	-0.13906
	0.8363	0.7674	0.0156	0.0501	0.1799	0.5611	0.1160	0.114	0.5836	0.0432	0.0816	0.0501
	201	195	182	162	68	200	204	199	199	199	199	199

Table 2.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	A_CON	AV	%4	COMPB	COMPS	%200	MOIST	TPREC	AVG90	AVG32	FTIN	FRZTH
GSBTH	0.05803	-0.06214	-0.07329	-0.28422	0.06205	0.06771	0.05324	0.14991	0.01698	0.01188	-0.03741	-0.03473
	0.6162	0.5939	0.5436	0.0290	0.6125	0.5558	0.6390	0.1932	0.8835	0.9184	0.7467	0.7643
	77	76	71	59	69	78	80	77	77	77	77	77
TSBTH	-0.31165	-0.10389	-0.20487	-0.27790	.	0.021583	0.03595	0.25288	-0.35613	0.27145	-0.14695	0.50890
	0.1691	0.6629	0.4302	0.3579	.	0.3474	0.8771	0.2687	0.1131	0.2339	0.5250	0.0185
	21	20	17	13	0	21	21	21	21	21	21	21
V140	-0.07585	0.05684	-0.02053	0.13525	-0.14090	0.00496	0.06603	0.13302	0.03477	-0.40189	-0.36732	-0.35354
	0.2637	0.4080	0.7724	0.0966	0.2591	0.9421	0.3285	0.0514	0.6122	0.0001	0.0001	0.0001
	219	214	201	152	66	217	221	215	215	215	215	215
A_CON	1.00000	-0.01046	0.28986	-0.09659	-0.10482	-0.12006	-0.06478	-0.14068	-0.03105	0.00908	0.02464	-0.01577
	0.0	0.8755	0.0001	0.2288	0.3986	0.0729	0.3302	0.0362	0.6454	0.8930	0.7150	0.8152
	233	227	212	157	67	224	228	222	222	222	222	222
AV	-0.01046	1.00000	0.08255	0.05258	-0.00673	0.06492	0.09583	0.14208	0.04857	-0.20076	-0.09011	-0.24102
	0.8755	0.0	0.2314	0.5172	0.9572	0.3390	0.1538	0.0365	0.4766	0.0030	0.1860	0.0003
	227	228	212	154	66	219	223	217	217	217	217	217
%4	0.28986	0.08255	1.00000	0.05277	0.25659	-0.00151	-0.05919	-0.23435	-0.08585	0.14677	0.20316	0.06930
	0.0001	0.2314	0.0	0.5285	0.0407	0.9829	0.3934	0.0008	0.2244	0.0371	0.0037	0.3271
	212	212	213	145	64	206	210	202	202	202	202	202
COMPB	0.09659	0.05258	0.05277	1.00000	0.12434	0.17151	0.15177	0.03022	-0.01261	-0.12455	-0.06927	-0.11451
	0.2288	0.5172	0.5285	0.0	0.3524	0.0312	0.0546	0.7081	0.8759	0.1214	0.3902	0.1546
	157	154	145	163	58	158	161	156	156	156	156	156
COMPS	-0.10482	-0.00673	0.25659	0.012434	1.00000	-0.01304	-0.15167	-0.15863	0.14036	0.19895	0.14605	0.22800
	0.3986	0.9572	0.0407	0.3524	0.0	0.9153	0.2067	0.1998	0.2573	0.1065	0.2383	0.0635
	67	66	64	58	72	69	71	67	67	67	67	67
%200	-0.12006	0.06492	-0.00151	0.17151	-0.01304	1.00000	0.77266	-0.07775	0.09116	-0.05691	-0.15211	0.04653
	0.0729	0.3390	0.9829	0.312	0.9153	0.0	0.0001	0.2497	0.1769	0.3998	0.0237	0.4913
	224	219	206	158	69	232	232	221	221	221	221	221

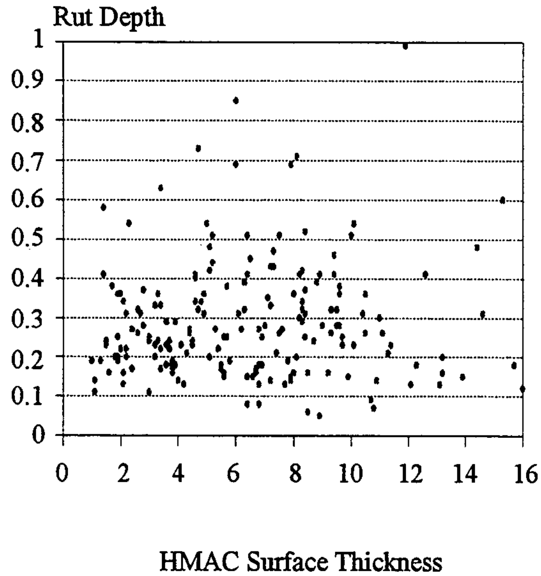
Table 2.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

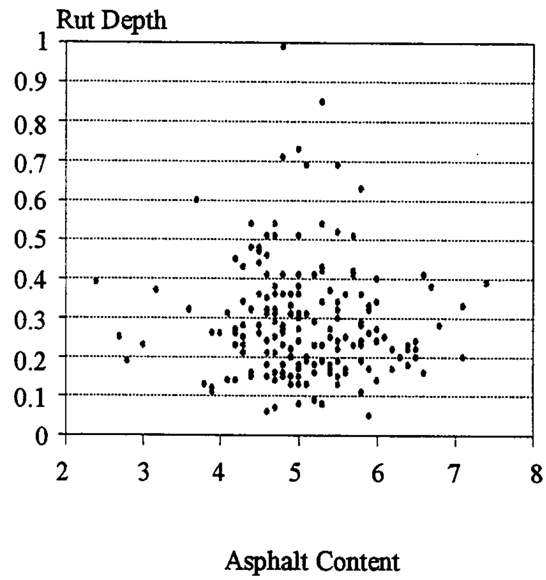
	A_CON	AV	%4	COMPB	COMPS	%200	MOIST	TPREC	AVG90	AVG32	FTIN	FRZTH
MOIST	-0.06478	0.09583	-0.05919	0.15177	-0.15167	0.77266	1.00000	0.06571	0.15925	-0.22081	-0.27890	-0.10050
	0.3302	0.1538	0.3934	0.0546	0.2067	0.0001	0.0	0.3265	0.0168	0.0009	0.0001	0.1329
	228	223	210	161	71	232	236	225	225	225	225	225
TPREC	-0.14068	0.14208	-0.23435	0.03022	-0.15863	-0.07775	0.06571	1.00000	-0.020538	-0.26274	-0.22897	-0.26476
	0.0362	0.0365	0.0008	0.7081	0.1998	0.2497	0.3265	0.0	0.0015	0.0001	0.0004	0.0001
	222	217	202	156	67	221	225	235	235	235	235	235
AVG90	-0.03105	0.04857	-0.08585	-0.01261	0.14036	0.09116	0.15925	-0.20538	1.00000	-0.72158	-0.58145	-0.62703
	0.6454	0.4766	0.2244	0.8759	0.2573	0.1769	0.0168	0.0015	0.0	0.0001	0.0001	0.0001
	222	217	202	156	67	221	225	235	235	235	235	235
AVG32	0.00908	-0.20076	0.14677	-0.12455	0.19895	-0.05691	-0.22081	-0.26274	-0.72158	1.00000	0.81817	0.88620
	0.8930	0.0030	0.0371	0.1214	0.1065	0.3998	0.0009	0.0001	0.0001	0.0	0.0001	0.0001
	222	217	202	156	67	221	225	235	235	235	235	235
FTIN	0.02464	-0.09011	0.20316	-0.06927	0.14605	-0.15211	-0.27890	-0.22897	-0.58145	0.81817	1.00000	0.47604
	0.7150	0.1860	0.0037	0.3902	0.2383	0.0237	0.0001	0.0004	0.0001	0.0001	0.0	0.0001
	222	217	202	156	67	221	225	235	235	235	235	235
FRZTH	-0.01577	-0.24102	0.06930	-0.11451	0.22800	0.04653	-0.10050	-0.26476	-0.62703	0.88620	0.476041	1.00000
	0.8152	0.0003	0.3271	0.1546	0.0635	0.4913	0.1329	0.0001	0.0001	0.0001	0.0001	0.0
	222	217	202	156	67	221	225	235	235	235	235	235

Table 2.5. Frequency Table by Environmental Region for the GPS-1 Data Set (SAS Format)

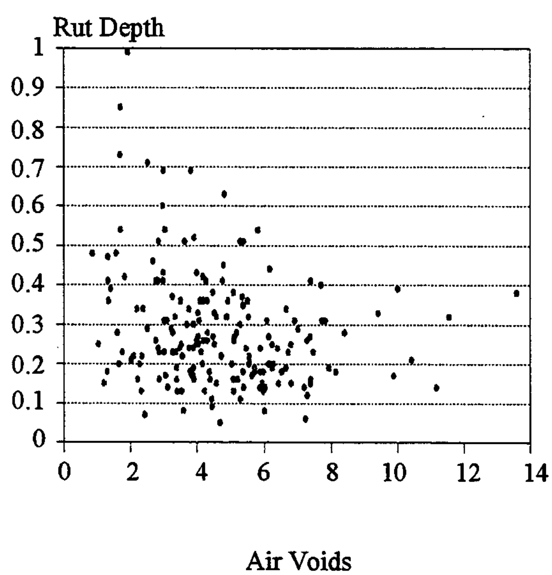
Frequency Percent Row Percent Column Percent	Freeze	No-Freeze	Total
Dry	45 18.22 46.88 40.54	51 20.65 53.13 37.50	96 38.87
Wet	66 26.72 43.71 59.46	85 34.41 56.29 62.50	151 61.13
Total	111 44.94	136 55.06	247 100.00



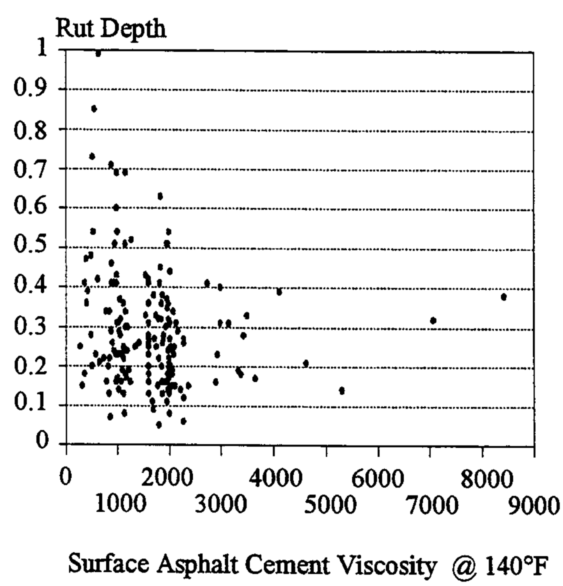
a. Rut Depth vs. HMAC Surface Thick.



b. Rut Depth vs. Asphalt Content

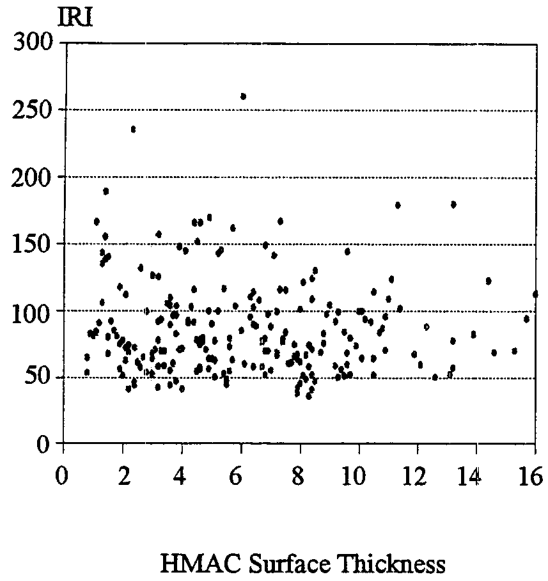


c. Rut Depth vs. Air Voids

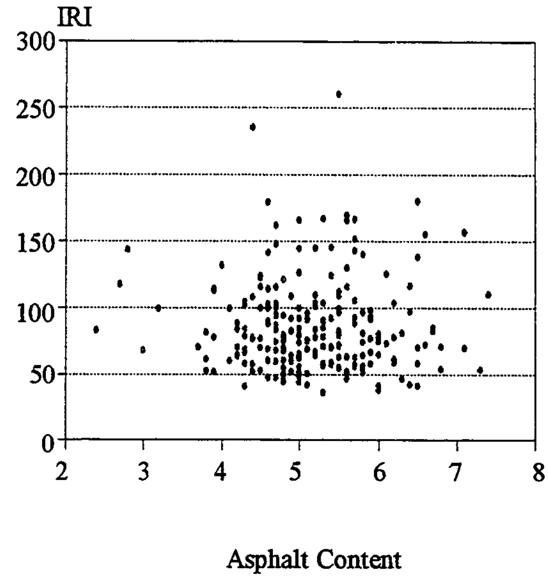


d. Rut Depth vs. Visc. @ 140°F

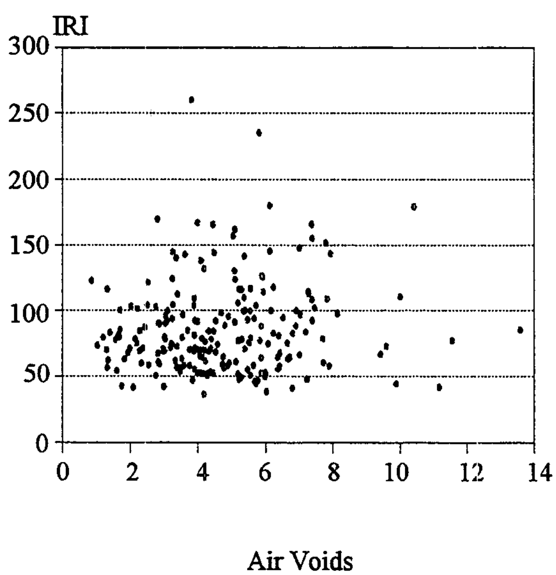
Figure 2.3. Rut Depth Scatter Plots for GPS-1 Test Sections



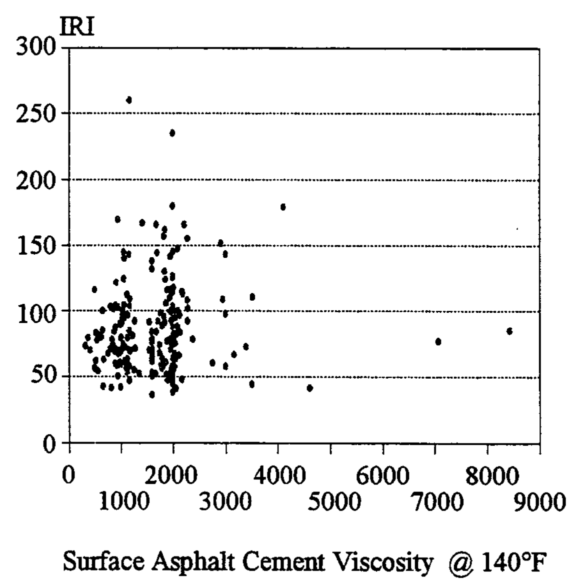
a. IRI vs. HMAC Surface Thick.



b. IRI vs. Asphalt Content

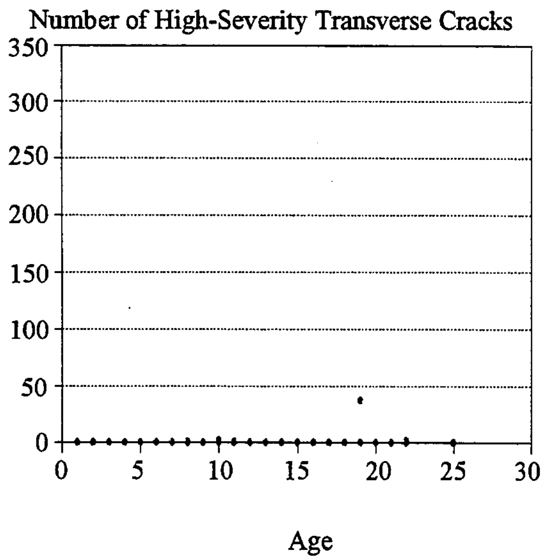


c. IRI vs. Air Voids

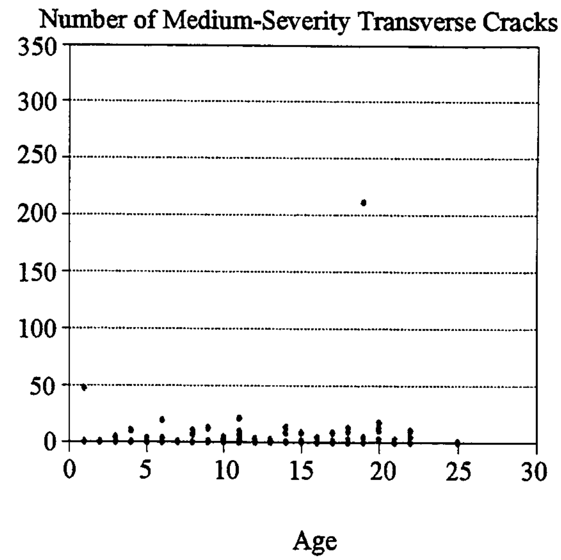


d. IRI vs. Visc. @ 140°F

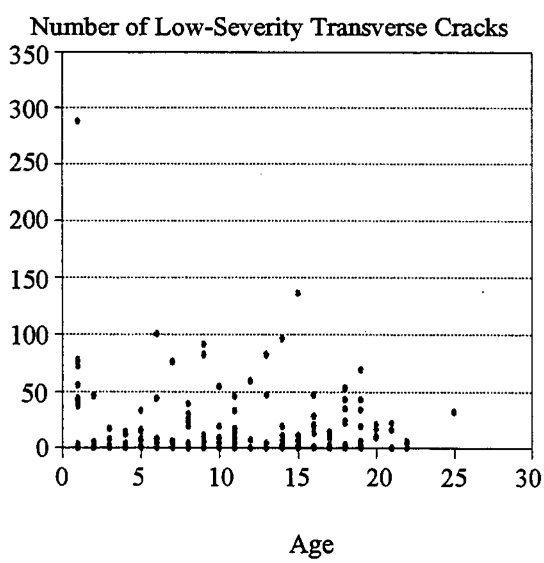
Figure 2.4. IRI Scatter Plots for GPS-1 Test Sections



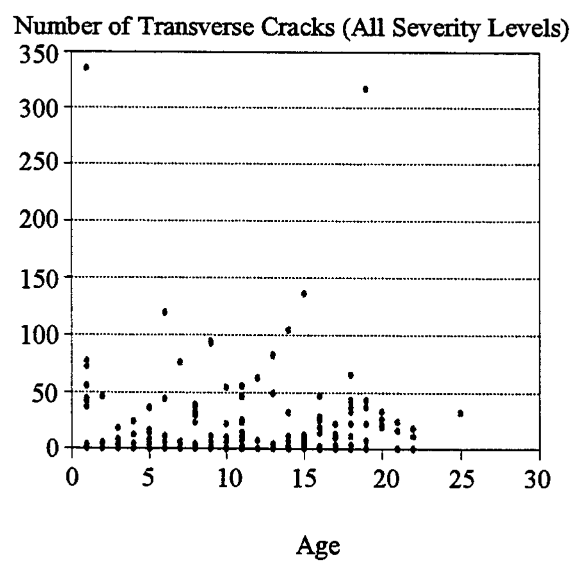
a. High-Severity



b. Medium-Severity

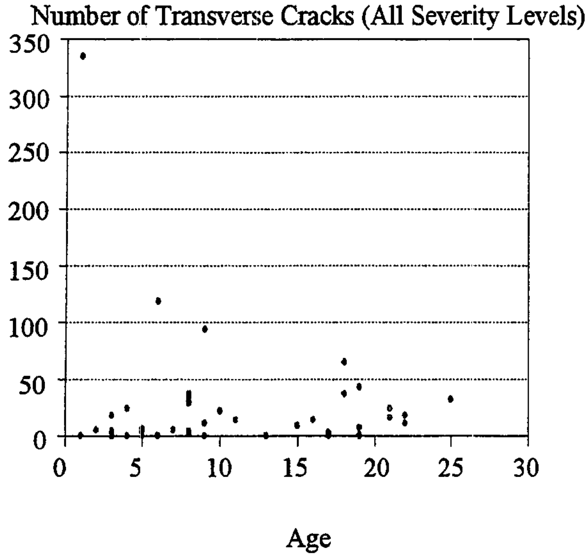


c. Low-Severity

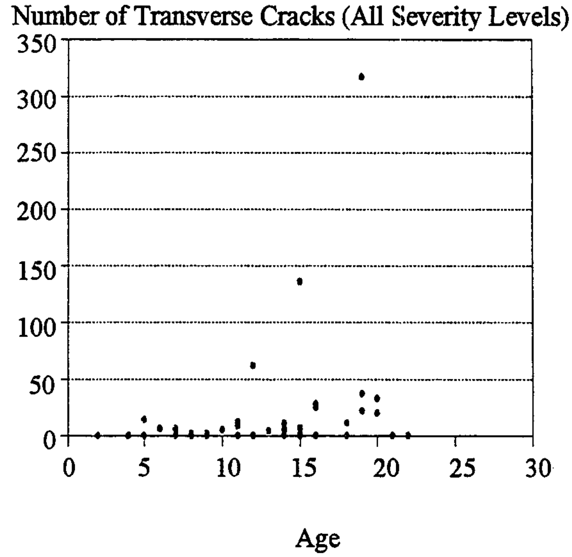


d. All Severity Levels

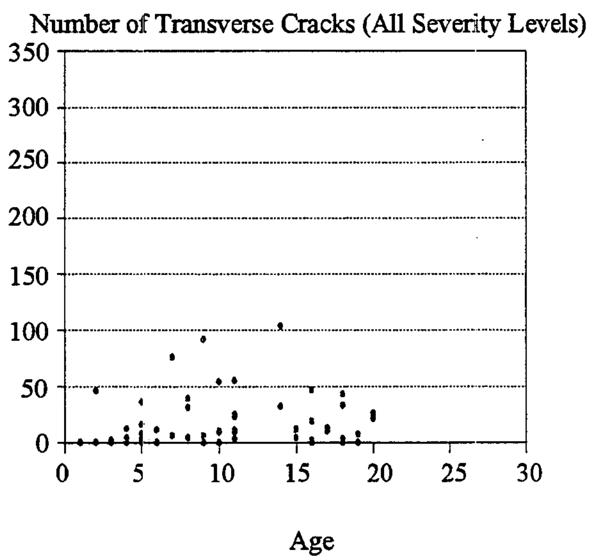
Figure 2.5. Number of Transverse Cracks vs. Age for GPS-1 Test Sections



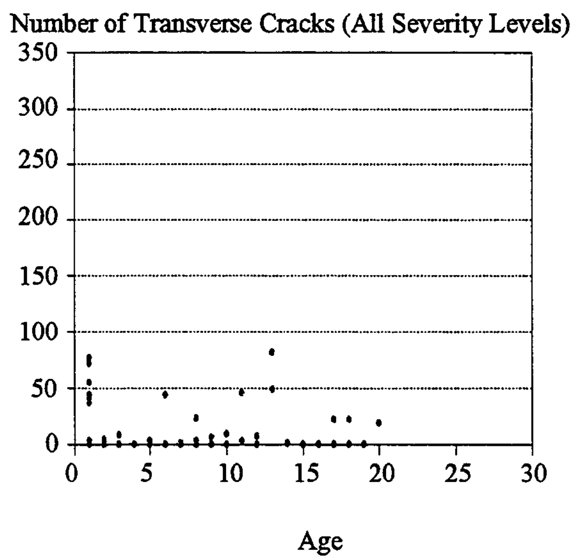
a. **Dry-Freeze**



b. **Dry-No Freeze**



c. **Wet-Freeze**



d. **Wet-No Freeze**

Figure 2.6. Number of Transverse Cracks (All Severity Levels) vs. Age for GPS-1 Test Sections

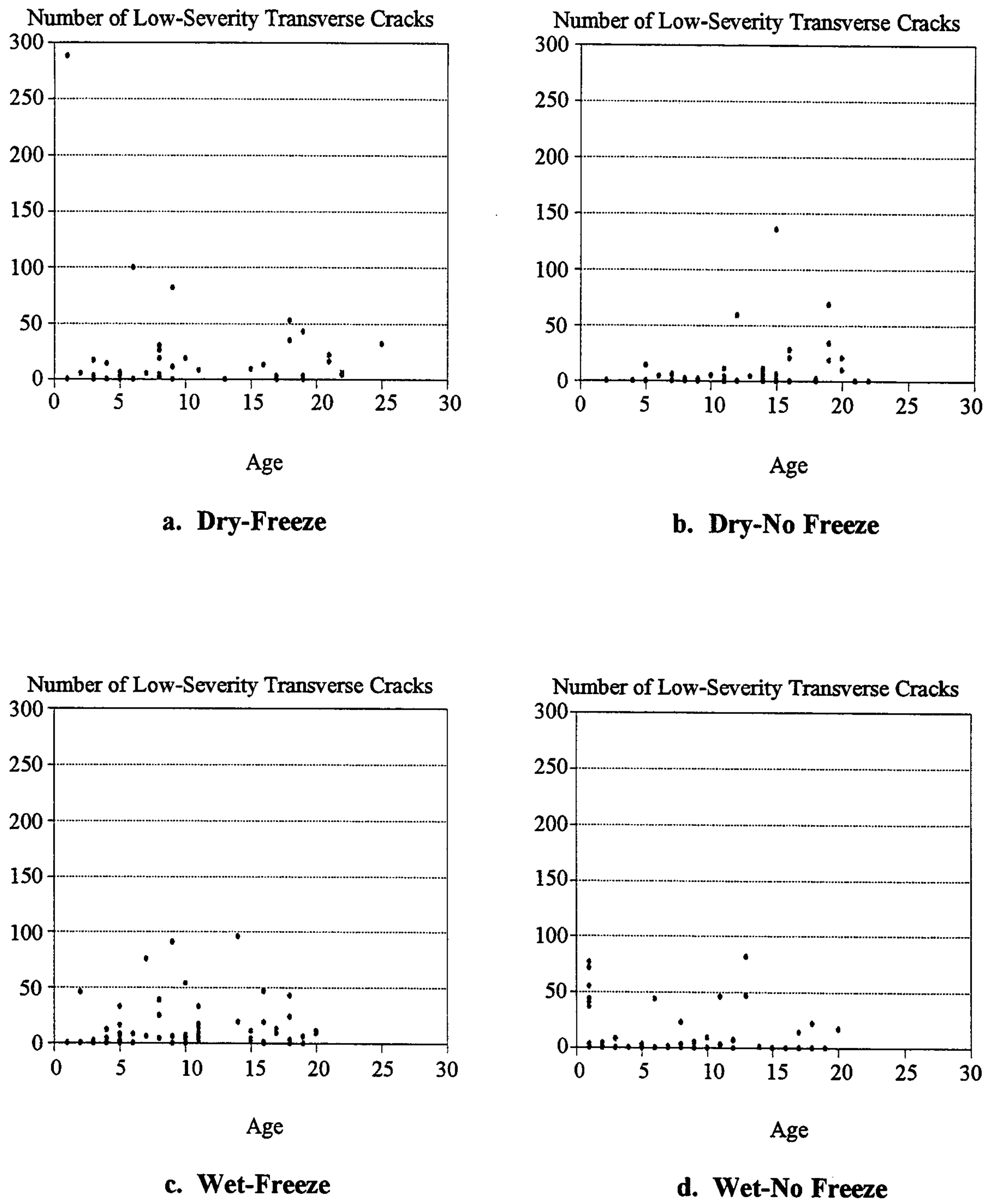


Figure 2.7. Number of Low-Severity Transverse Cracks vs. Age for GPS-1 Test Sections

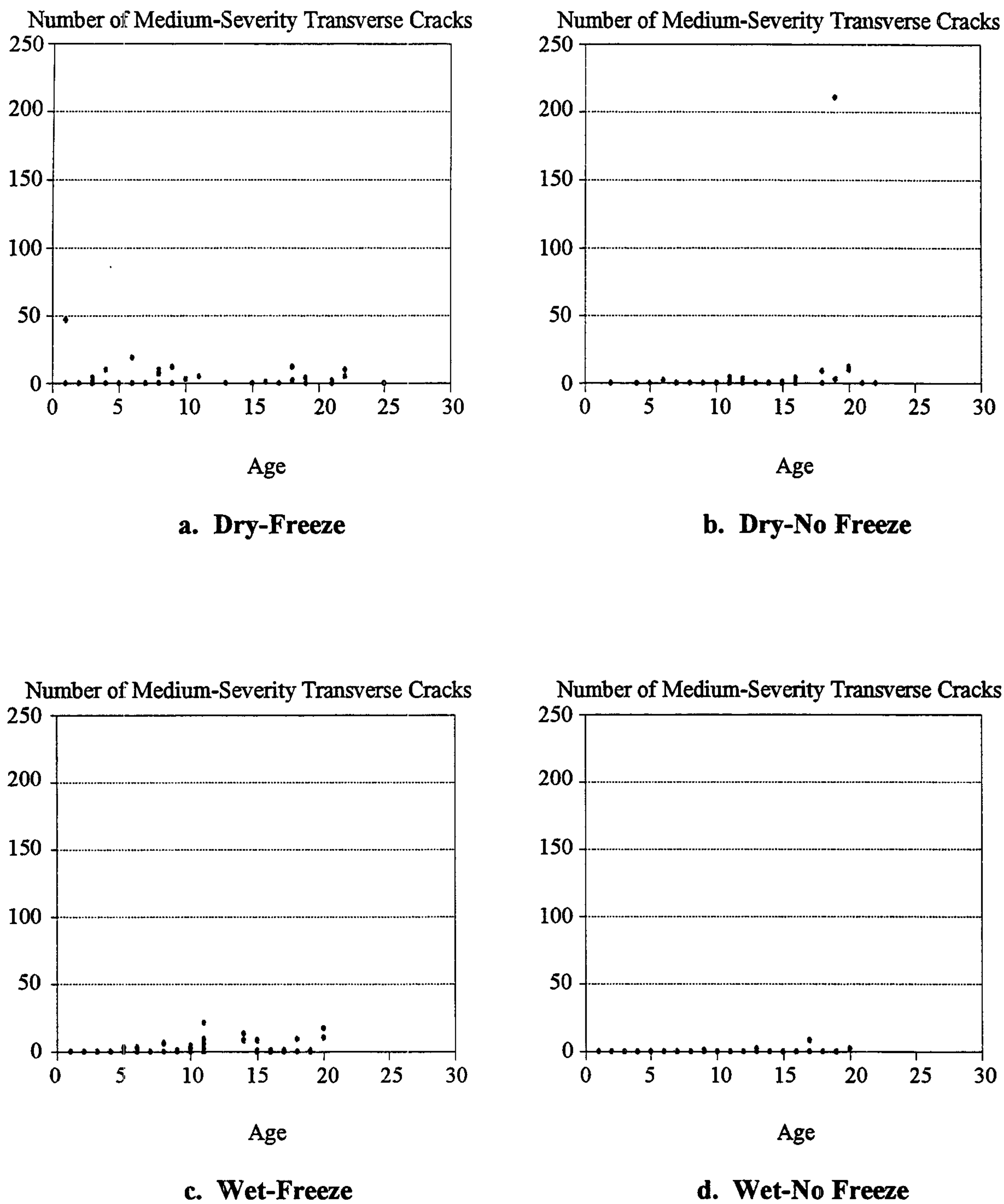


Figure 2.8. Number of Medium-Severity Transverse Cracks vs. Age for GPS-1 Test Sections

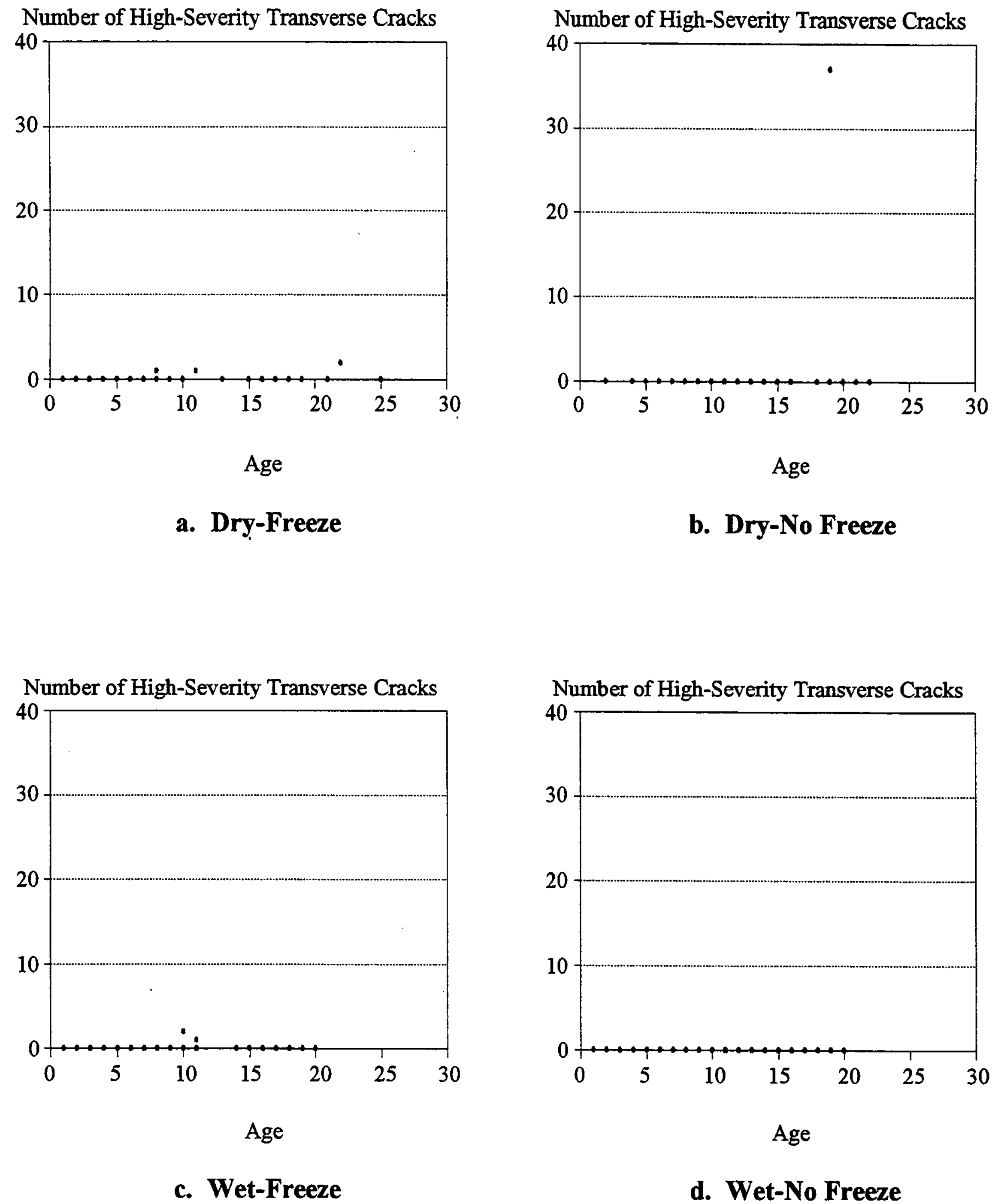


Figure 2.9. Number of High-Severity Transverse Cracks vs. Age for GPS-1 Test Sections

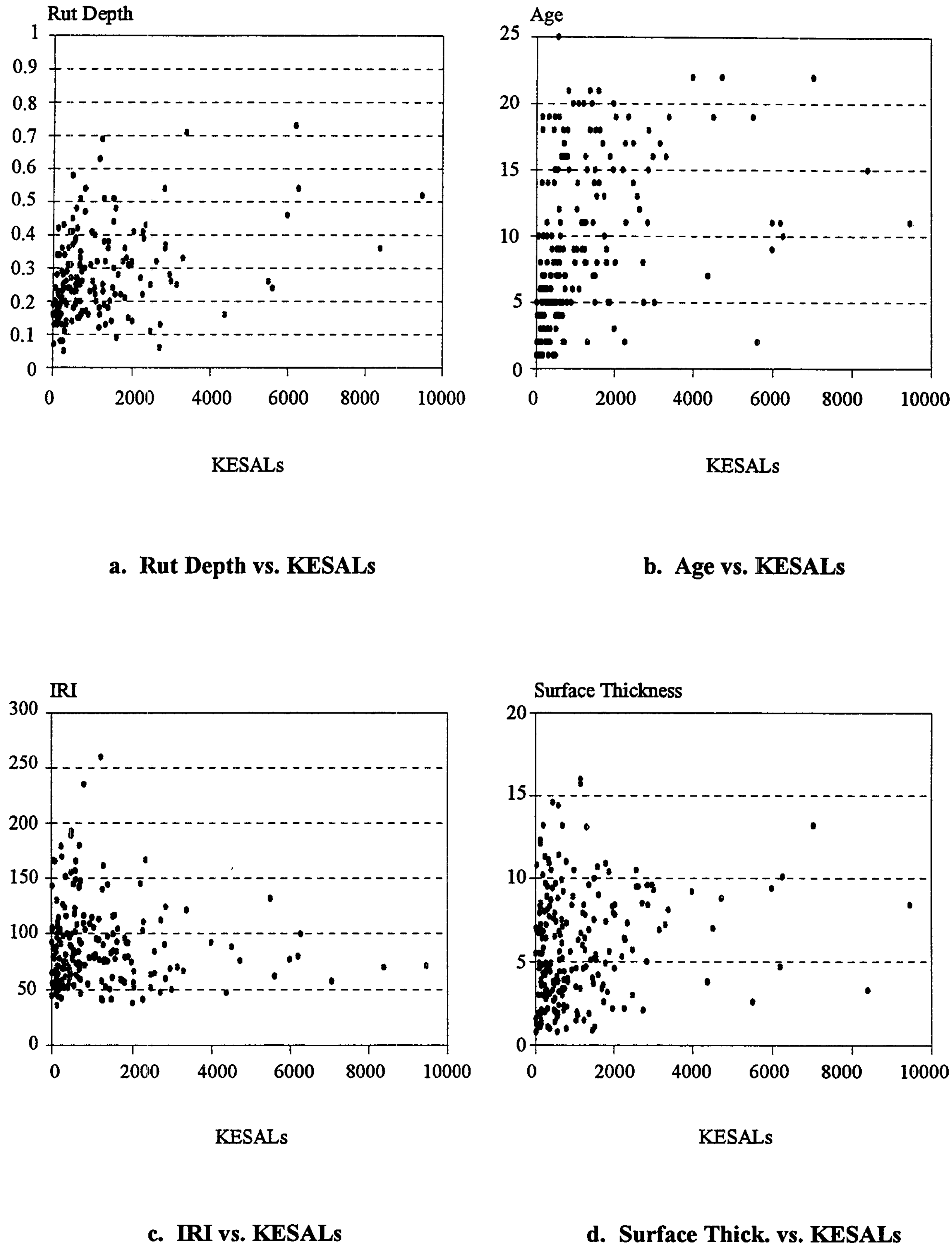
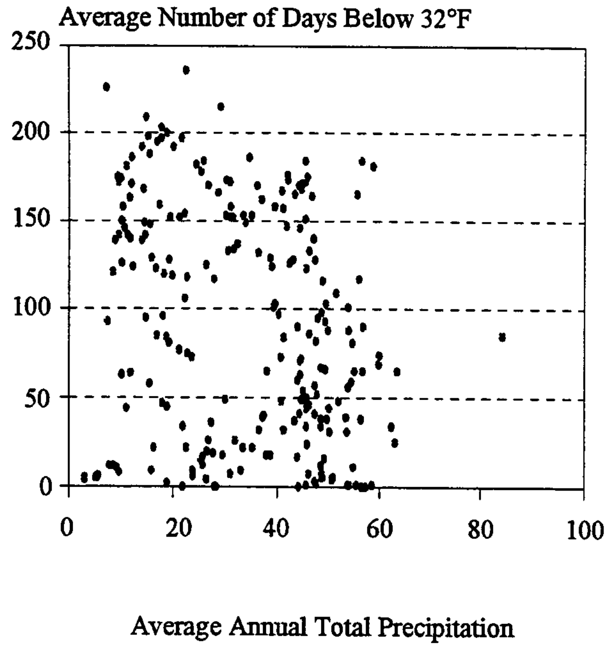
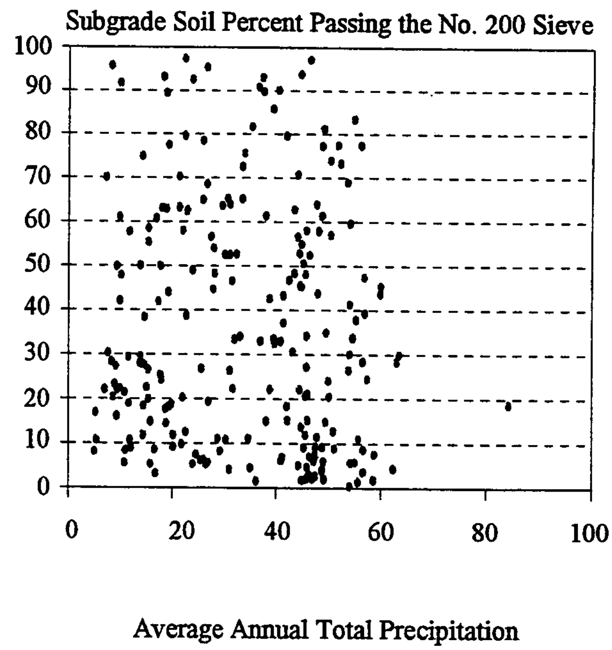


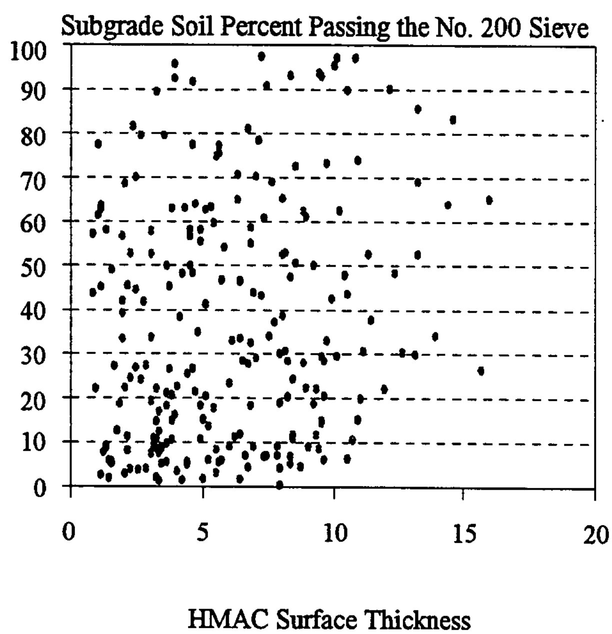
Figure 2.10. Cumulative KESALs Scatter Plots for GPS-1 Test Sections



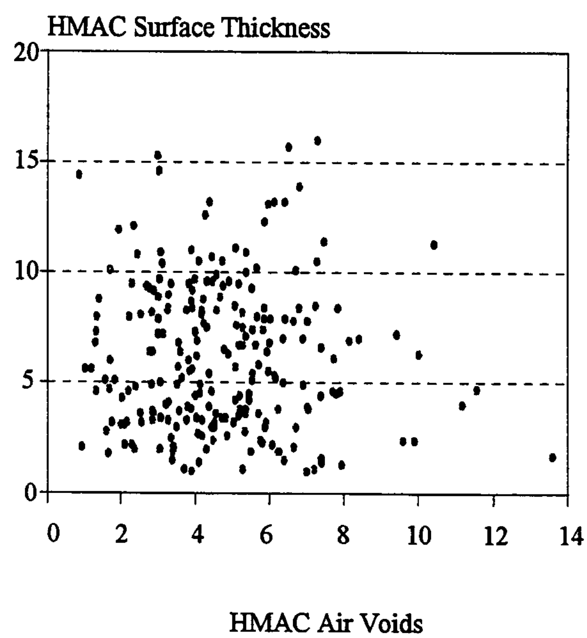
a. **Days <32°F vs. Ann. Prec.**



b. **Subgrade <#200 vs. Ann. Prec.**



c. **Subgrade <#200 vs. HMAC Thick.**



d. **HMAC Thick. vs. HMAC Air Voids**

Figure 2.11. Scatter Plots for GPS-1 Test Sections

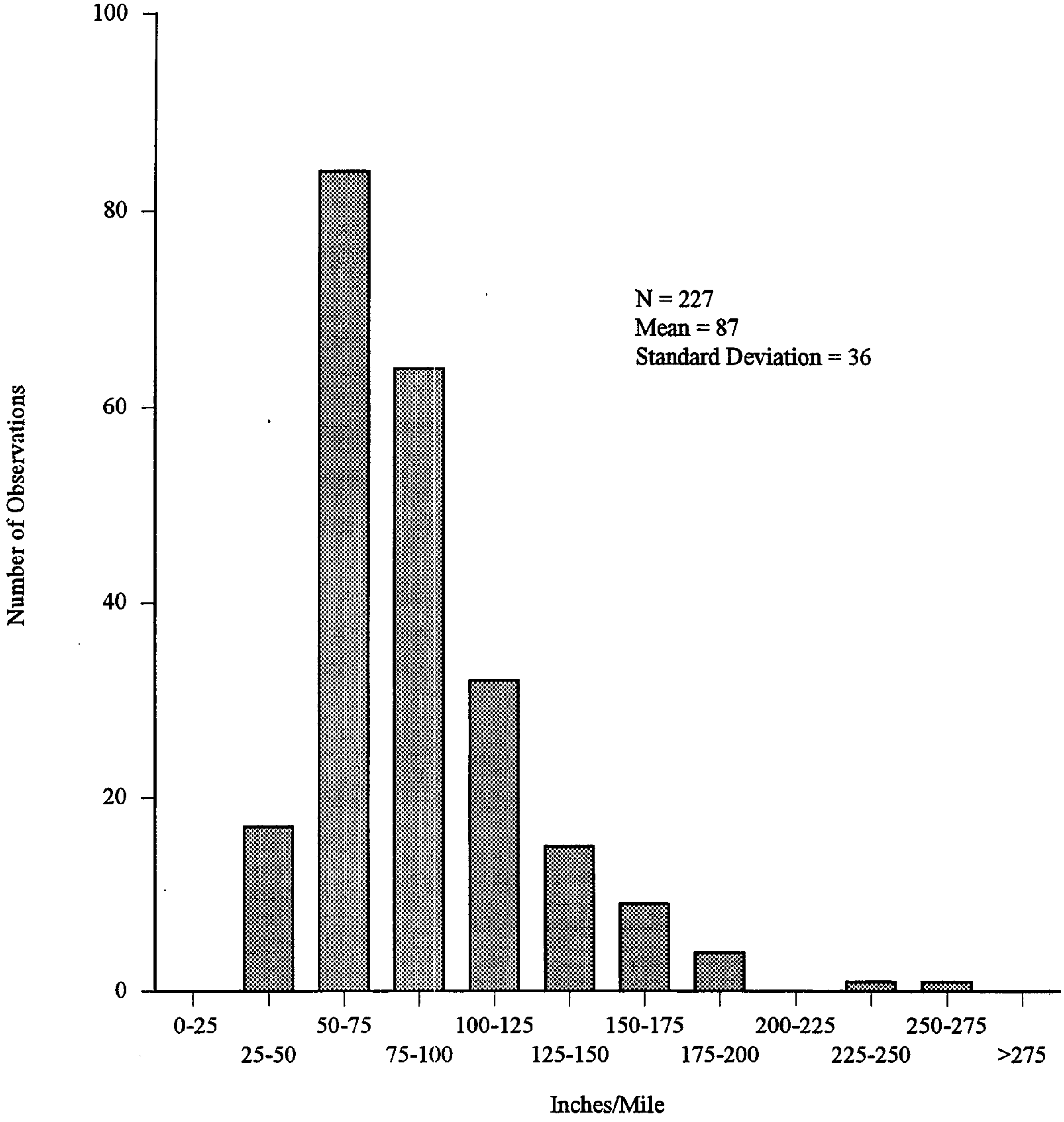
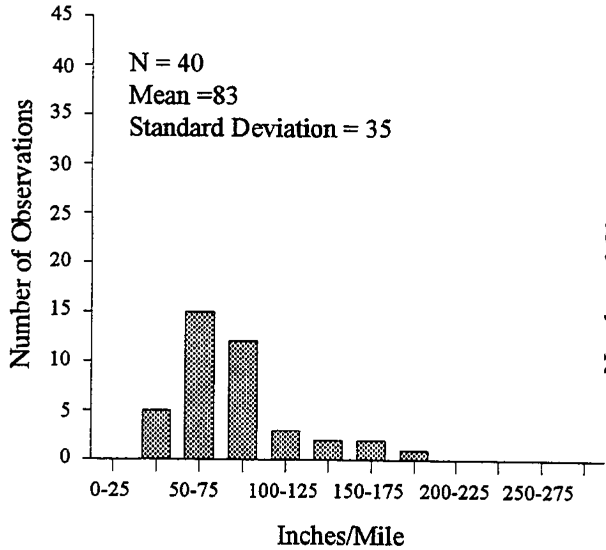
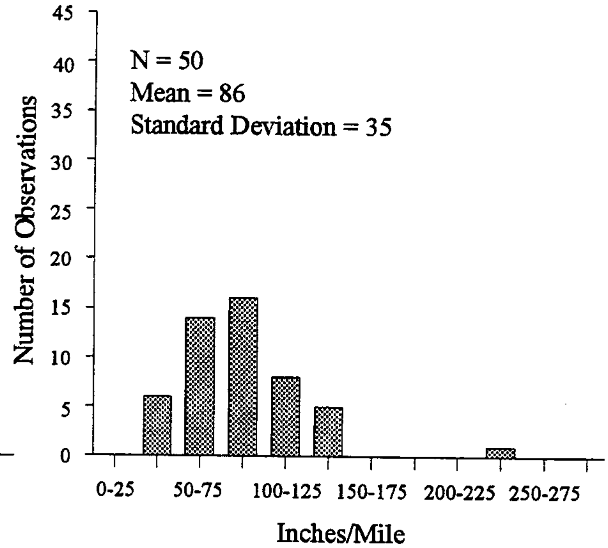


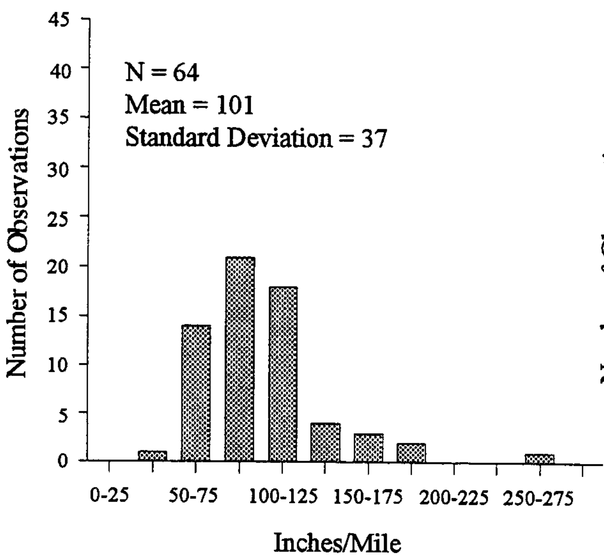
Figure 2.12. Distribution of Measured International Roughness Index (IRI) for GPS-1 Test Sections



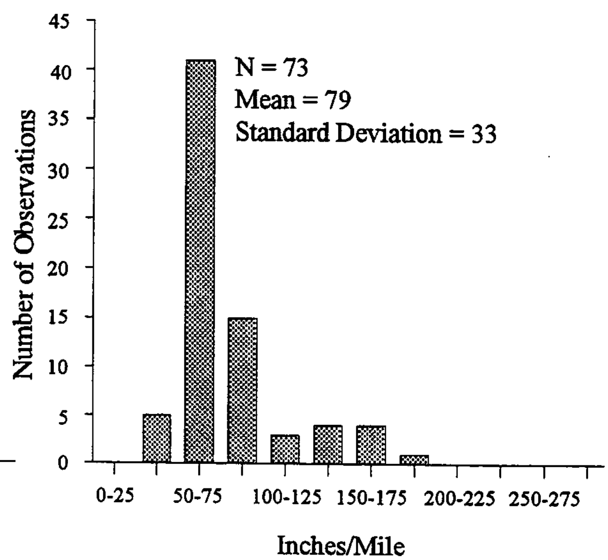
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 2.13. Distributions of Measured International Roughness Index (IRI) by Environmental Regions for GPS-1 Test Sections

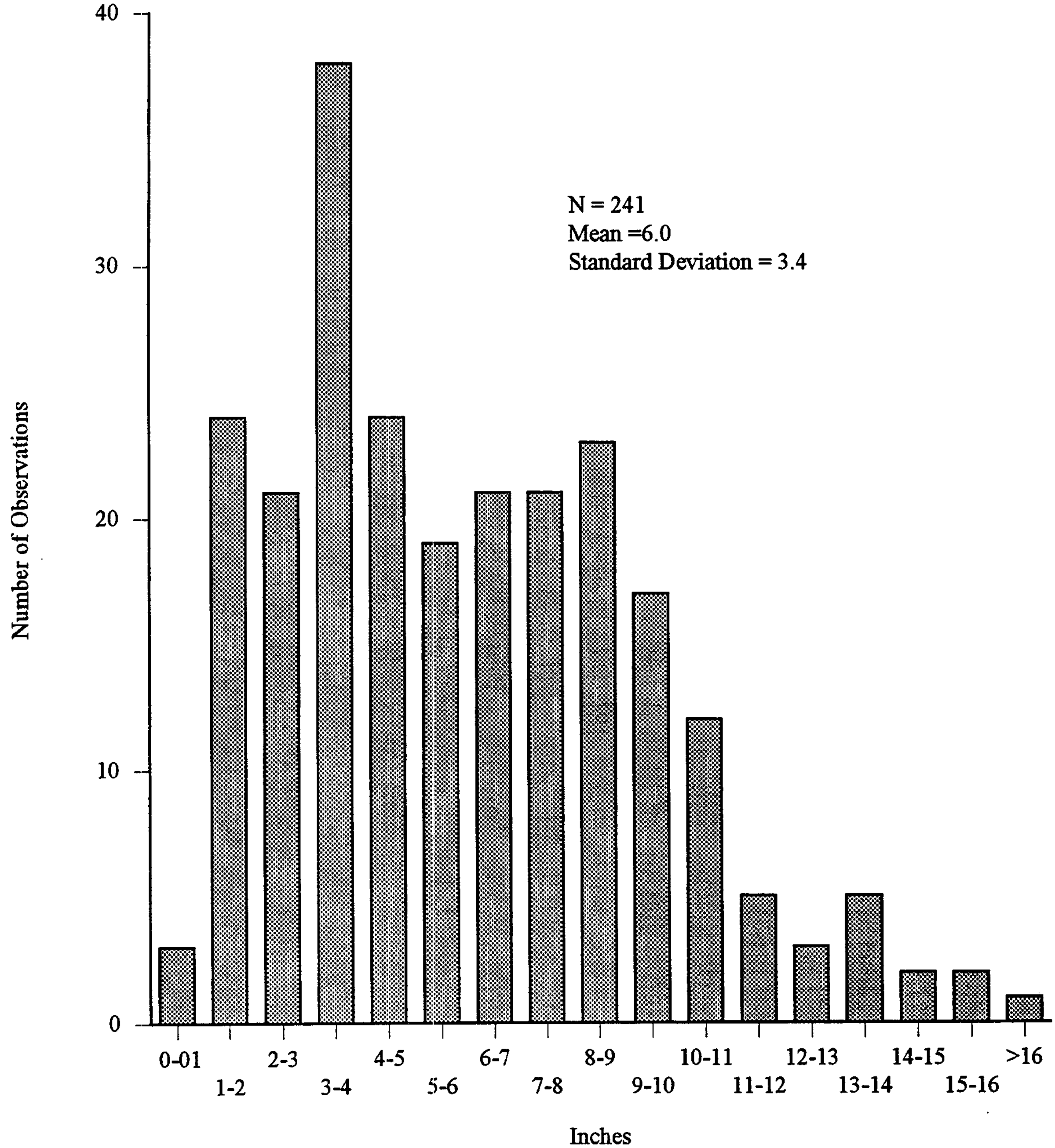


Figure 2.14. Distribution of HMAC Thickness for GPS-1 Test Sections

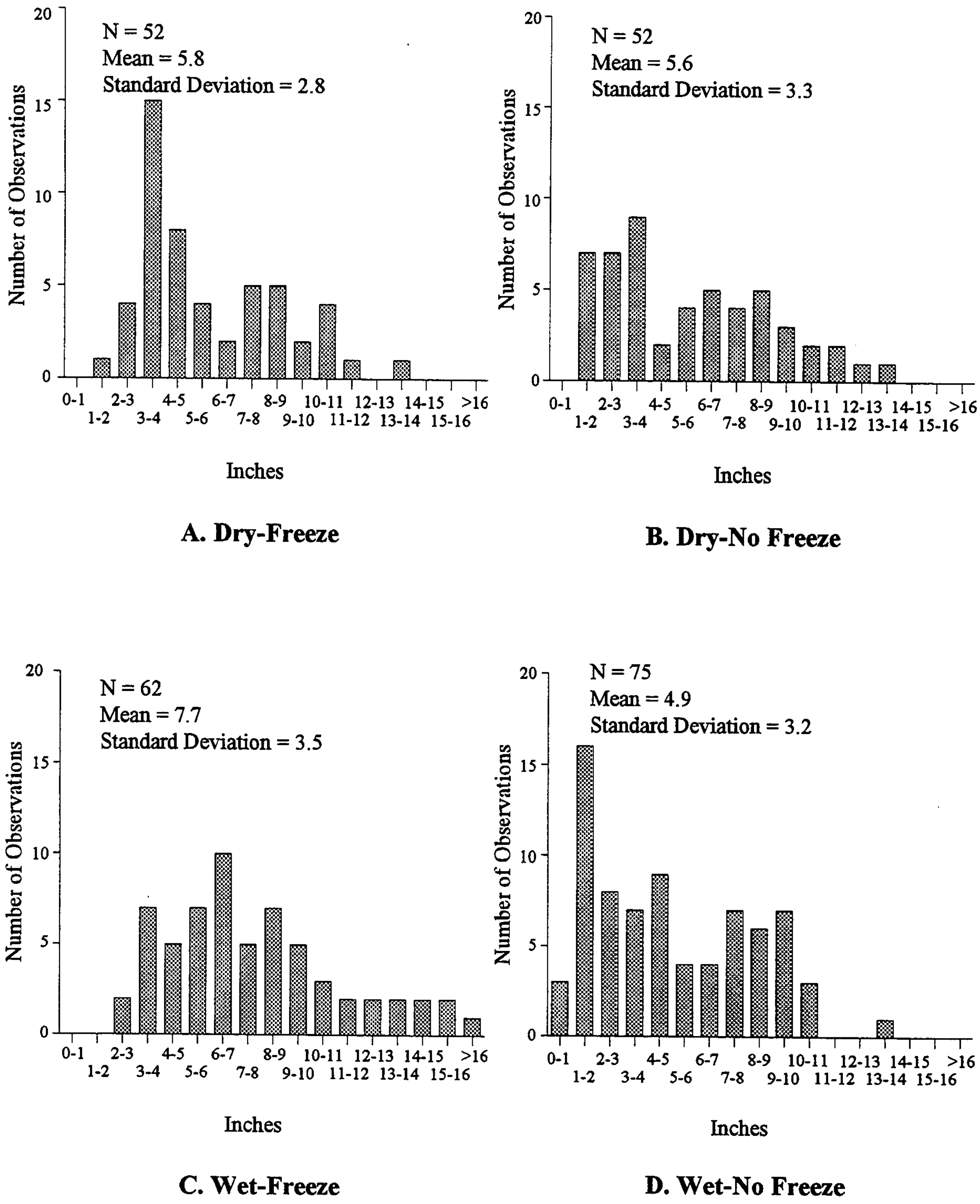


Figure 2.15. Distributions of HMAC Thickness by Environmental Regions for GPS-1 Test Sections

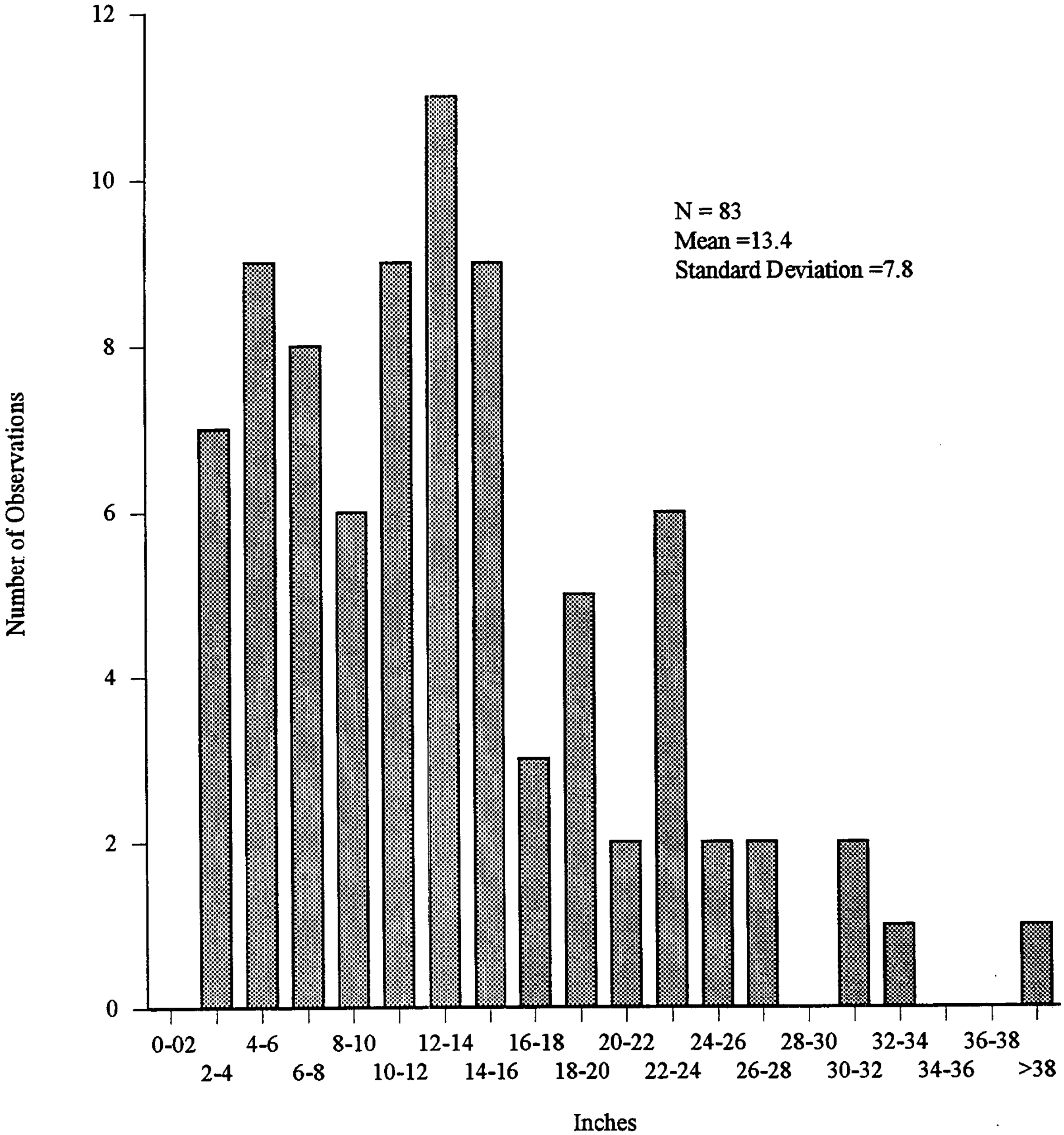


Figure 2.16. Distribution of Granular Subbase Thickness for GPS-1 Test Sections

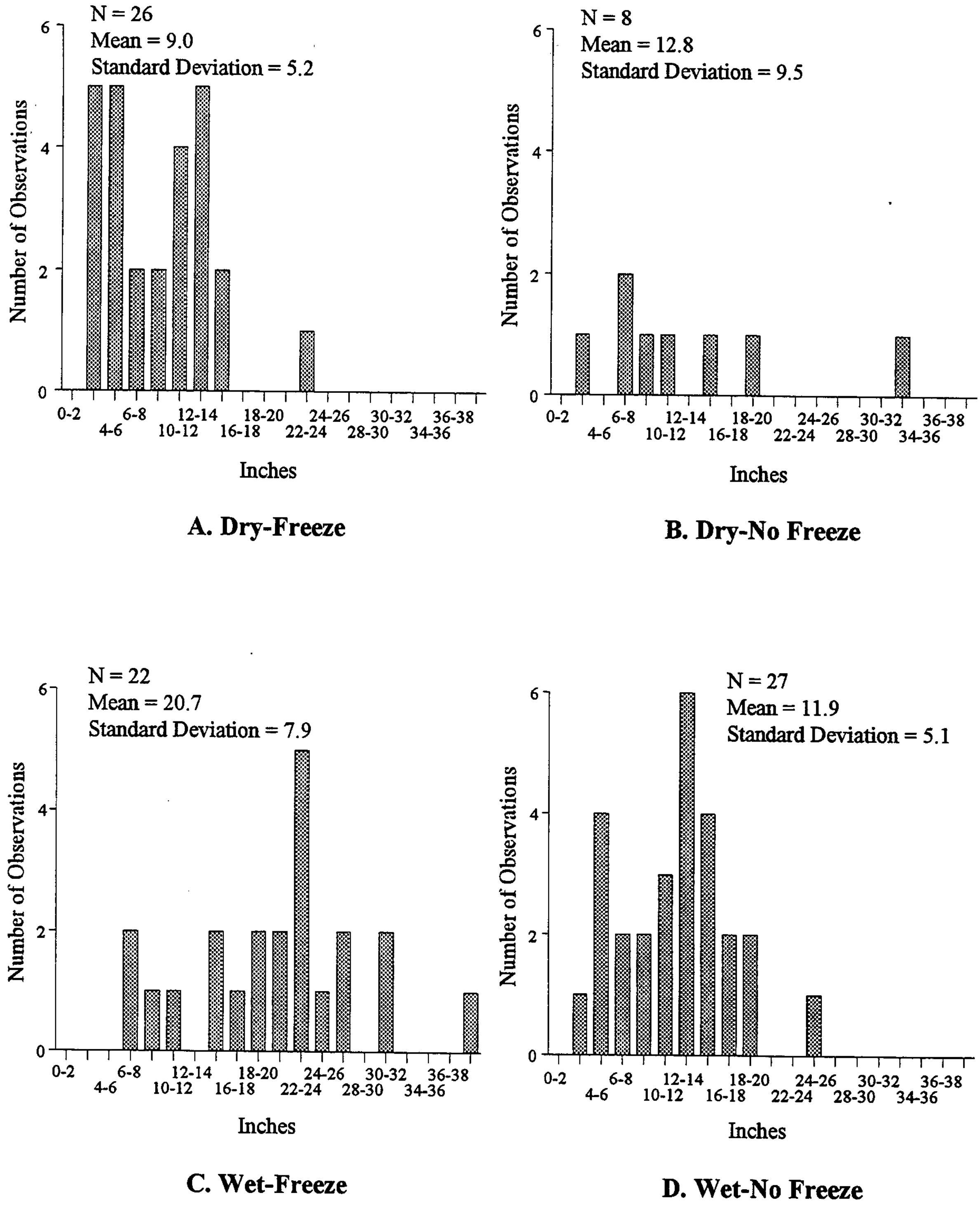


Figure 2.17. Distributions of Granular Subbase Thickness by Environmental Regions for GPS-1 Test Sections

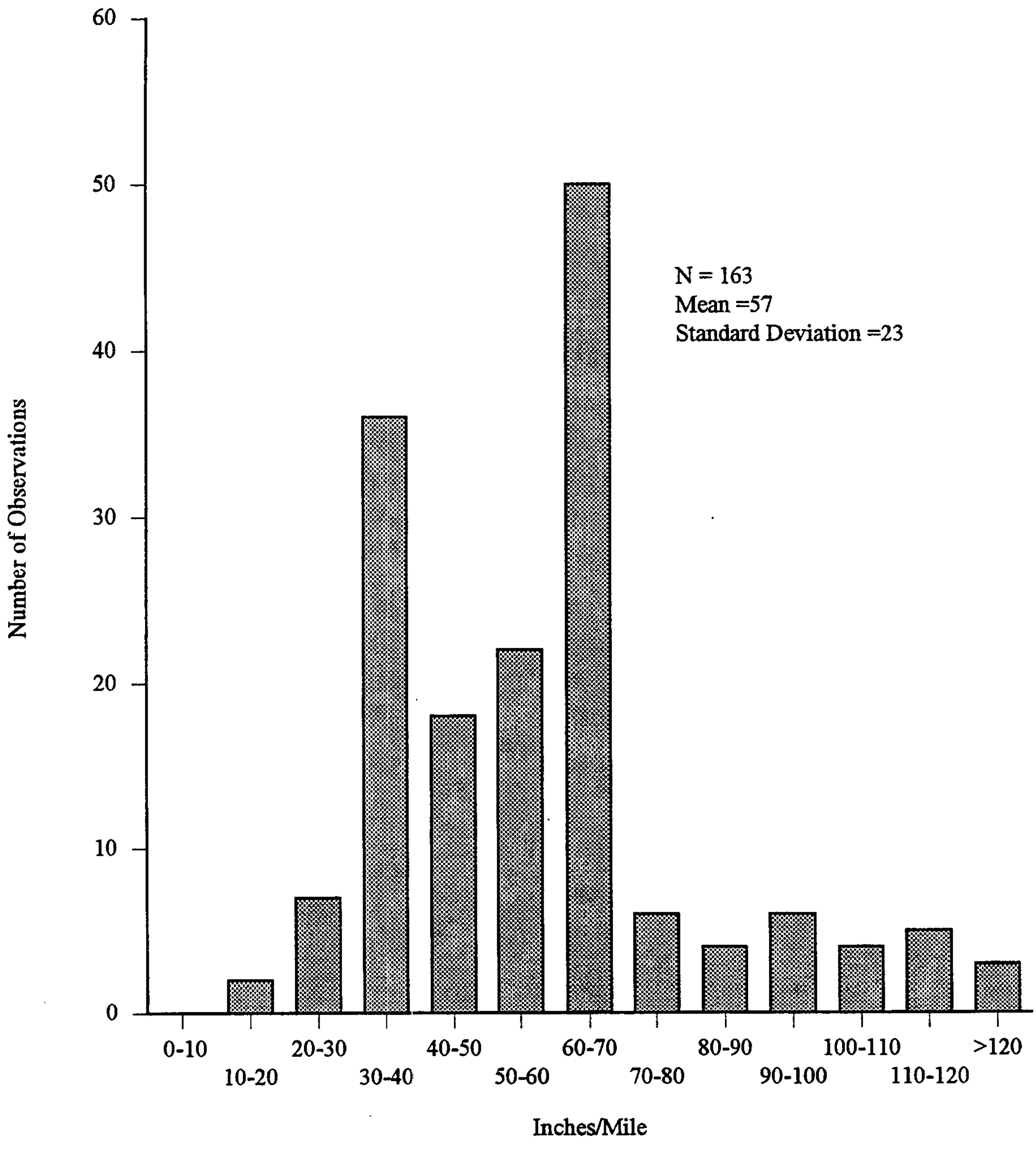


Figure 2.18. Distribution of Initial International Roughness Index (IRI) for GPS-1 Test Sections

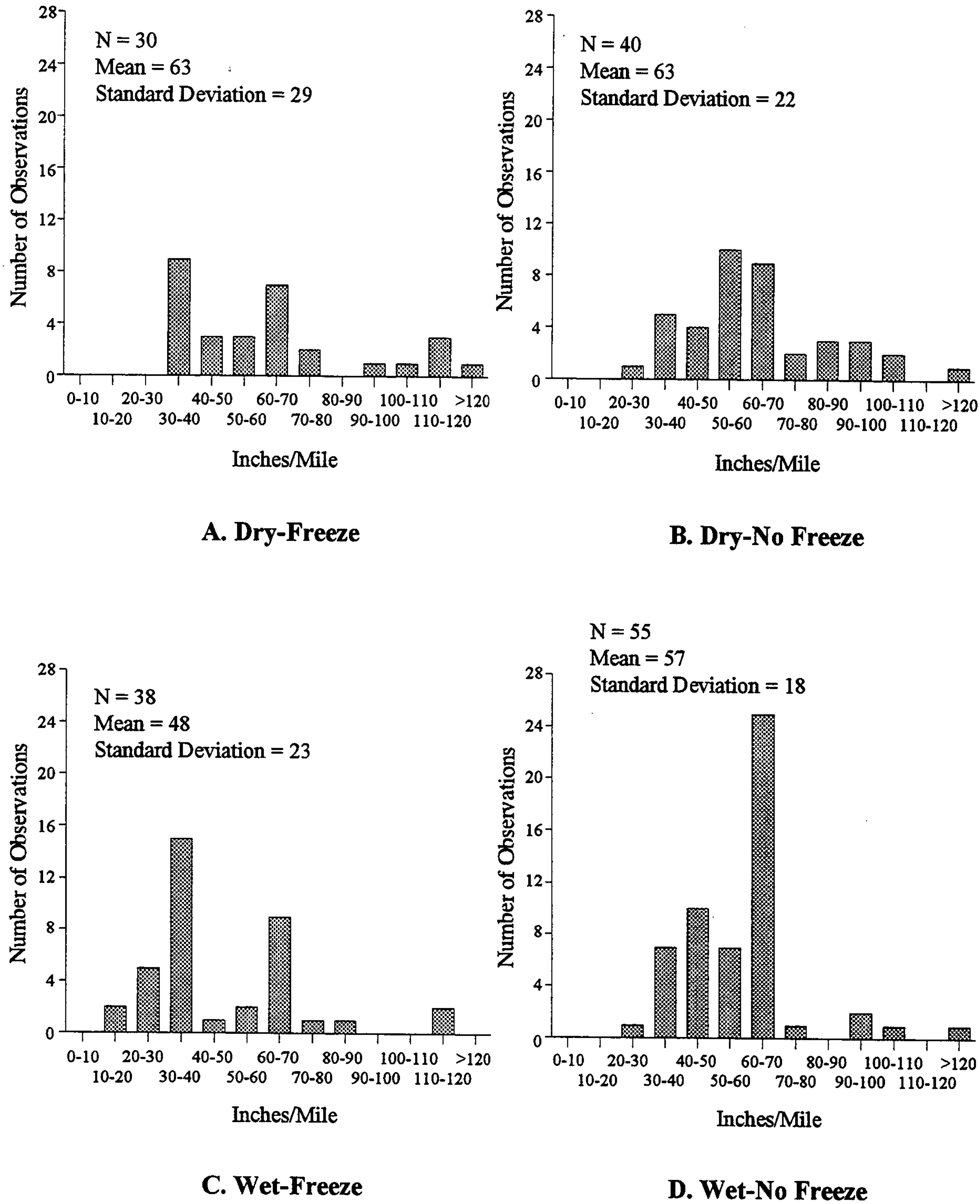


Figure 2.19. Distributions of Initial International Roughness Index (IRI) by Environmental Regions for GPS-1 Test Sections

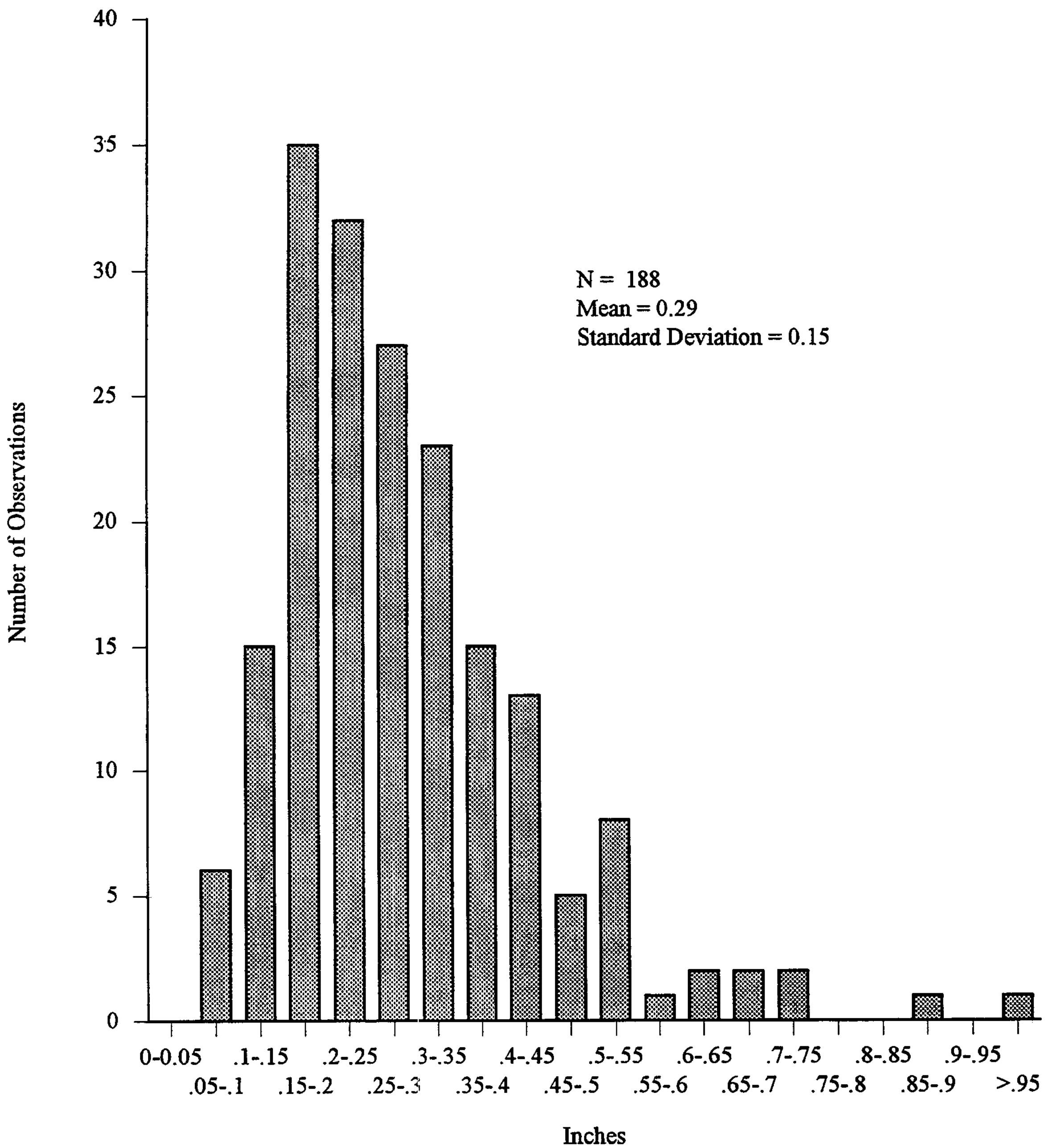


Figure 2.20. Distribution of Rut Depth for GPS-1 Test Sections

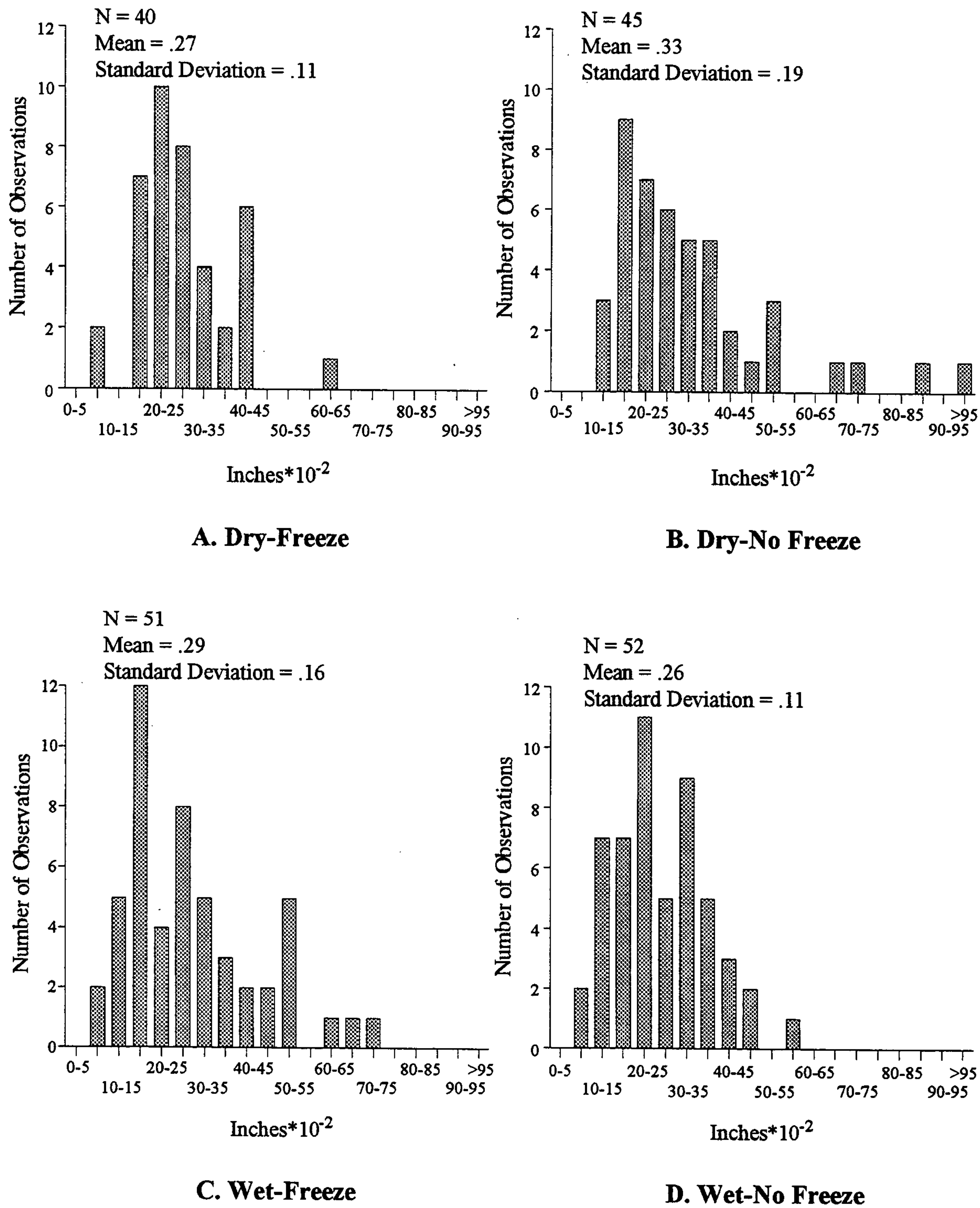


Figure 2.21. Distributions of Rut Depth by Environmental Regions for GPS-1 Test Sections

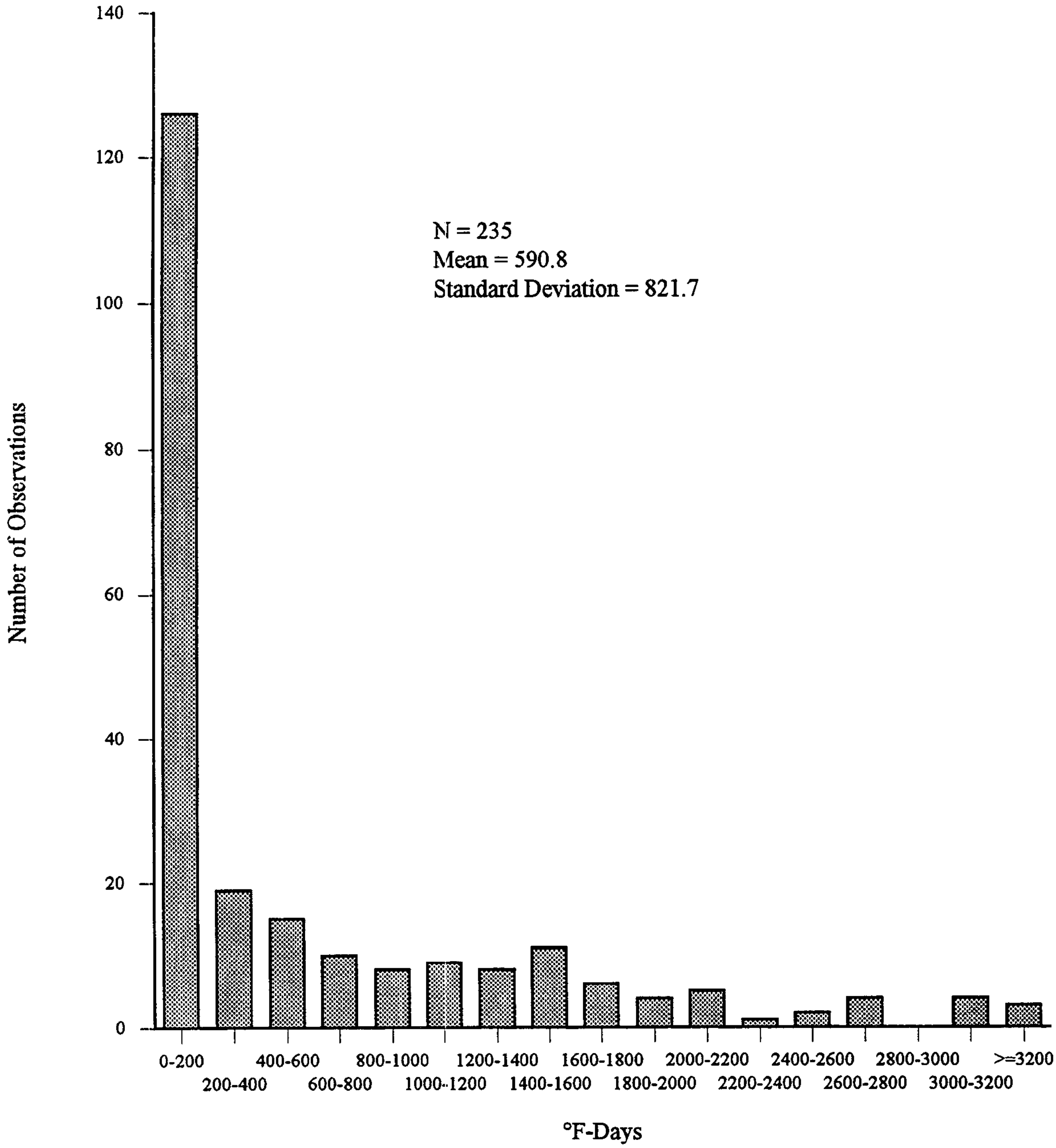


Figure 2.22. Distribution of the Freeze Index for GPS-1 Test Sections

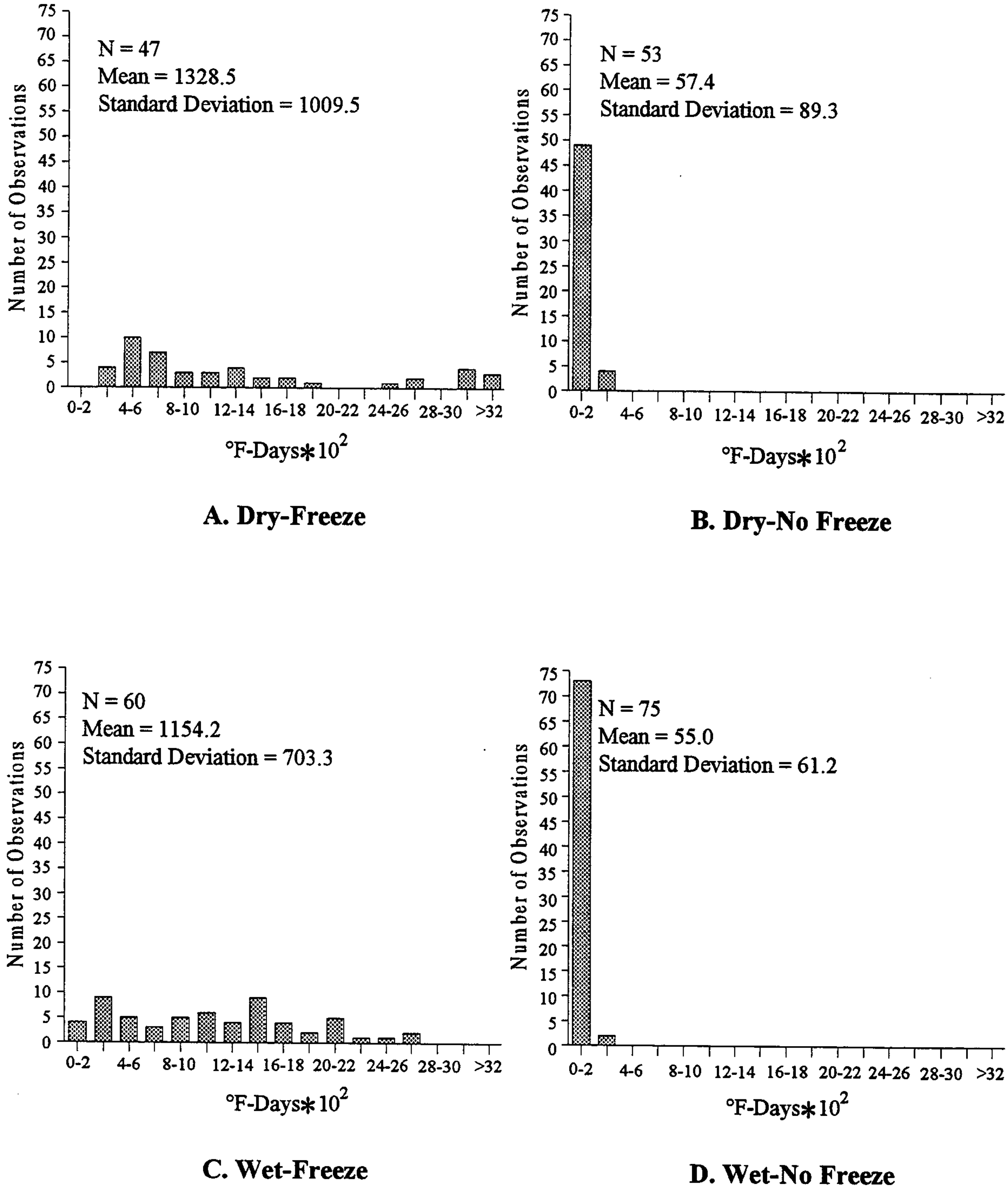


Figure 2.23. Distributions of the Freeze Index by Environmental Regions for GPS-1 Test Sections

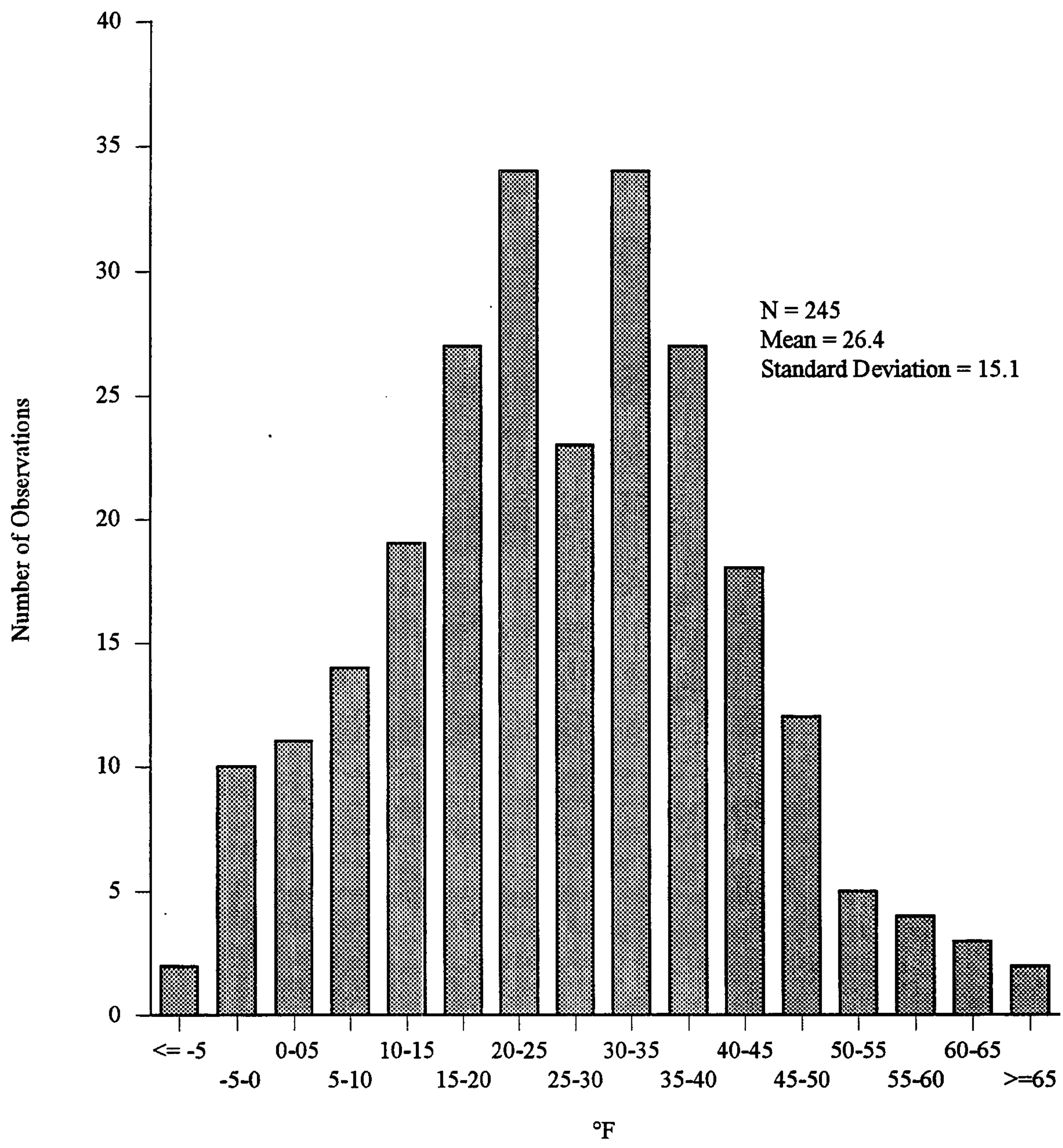


Figure 2.24. Distribution of the Average Annual Minimum Temperature (for the Months of December, January, and February) for GPS-1 Test Sections

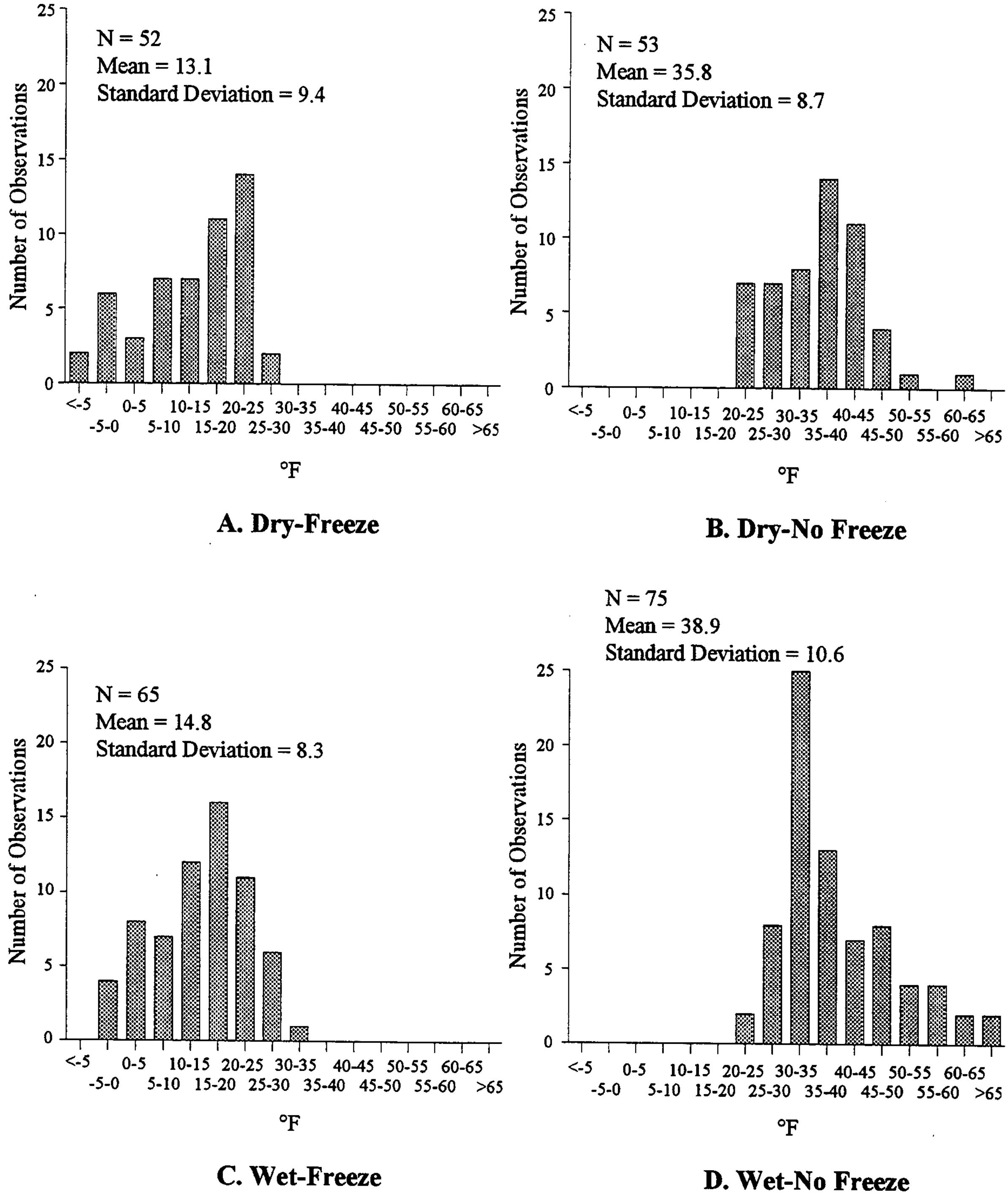


Figure 2.25. Distributions of the Average Annual Minimum Temperature (for the Months of December, January and February) by Environmental Regions for GPS-1 Test Sections

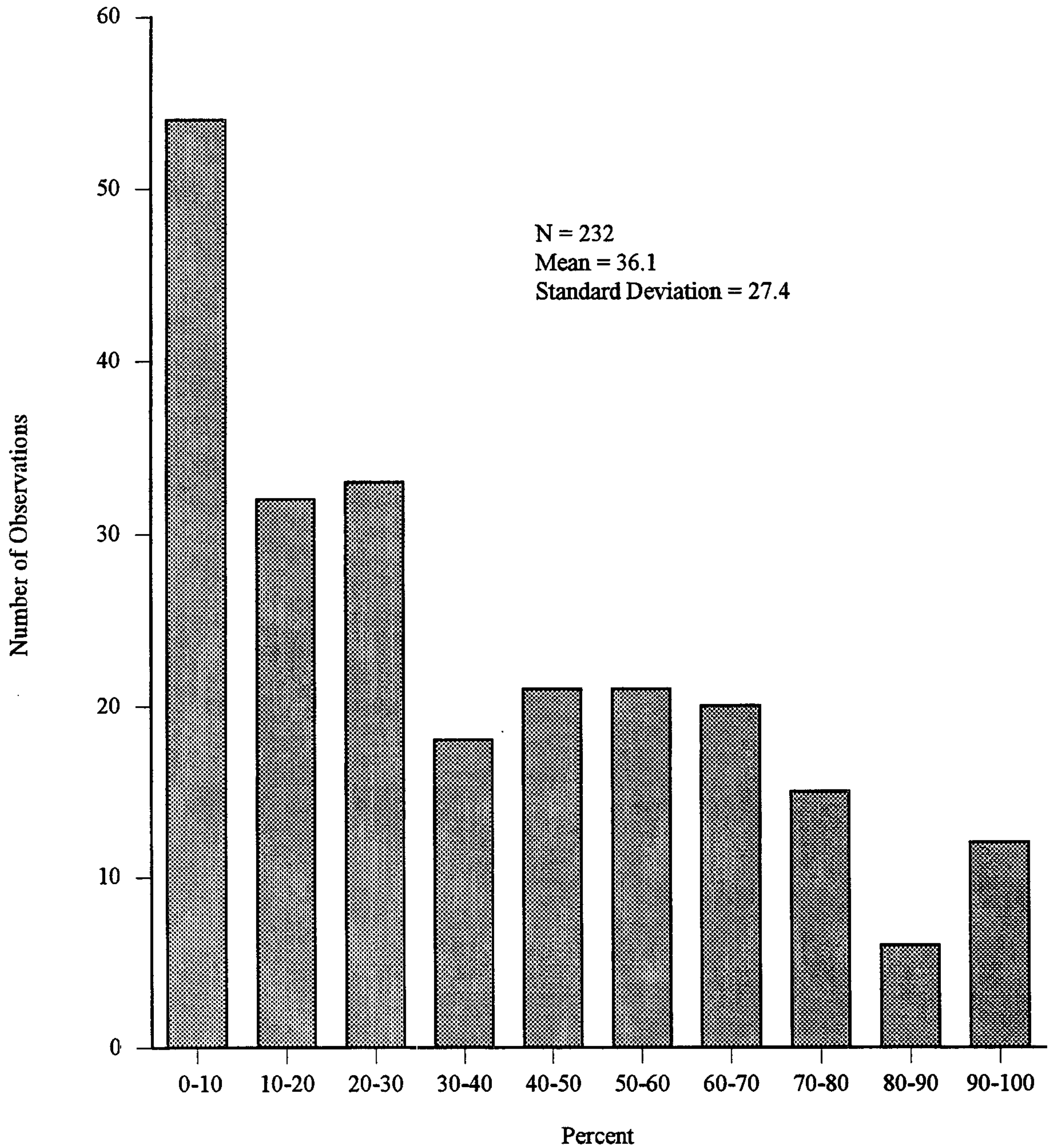


Figure 2.26. Distribution of the Subgrade Passing the Number 200 Sieve for GPS-1 Test Sections

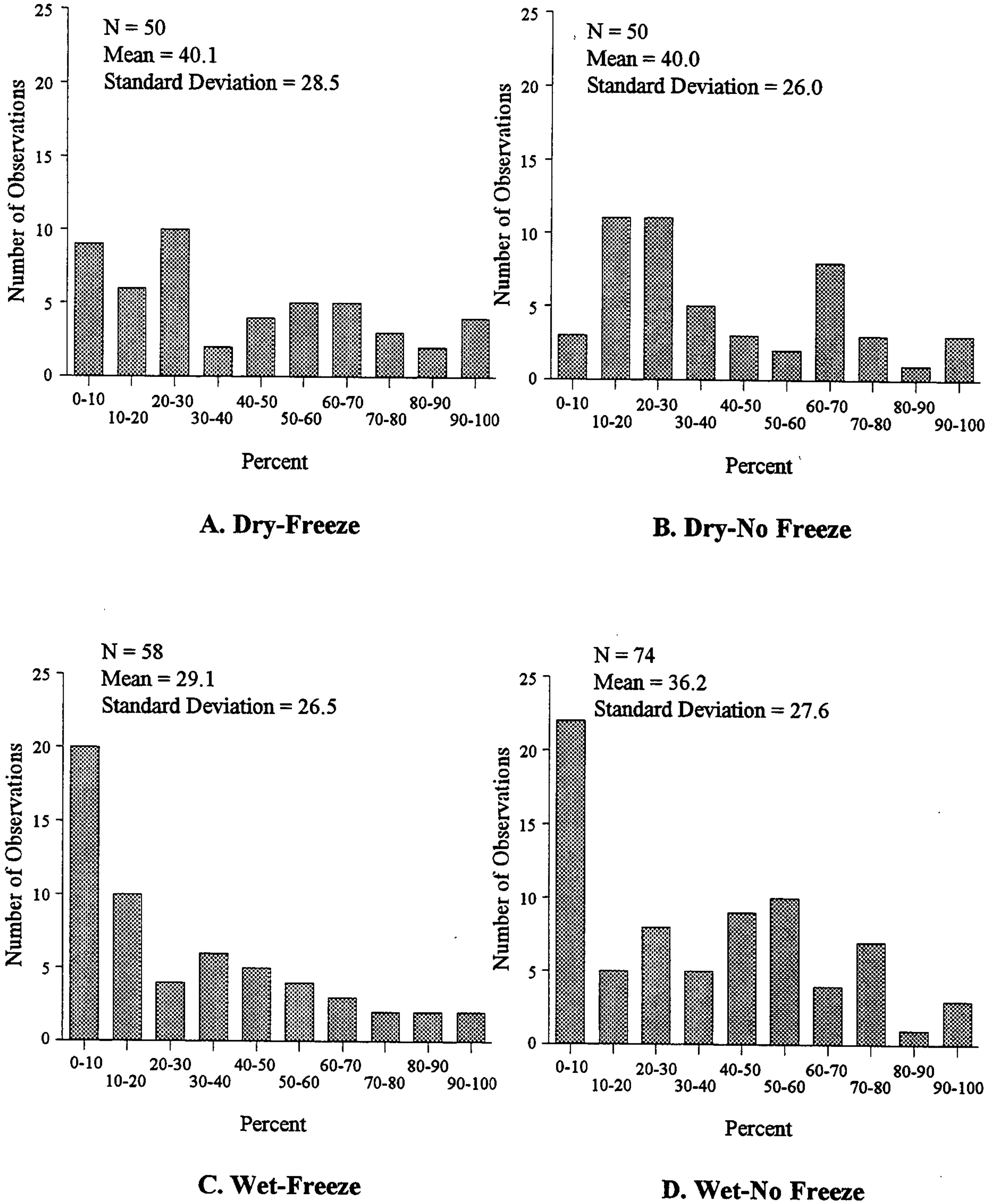


Figure 2.27. Distributions of the Subgrade Passing the Number 200 Sieve by Environmental Regions for GPS-1 Test Sections

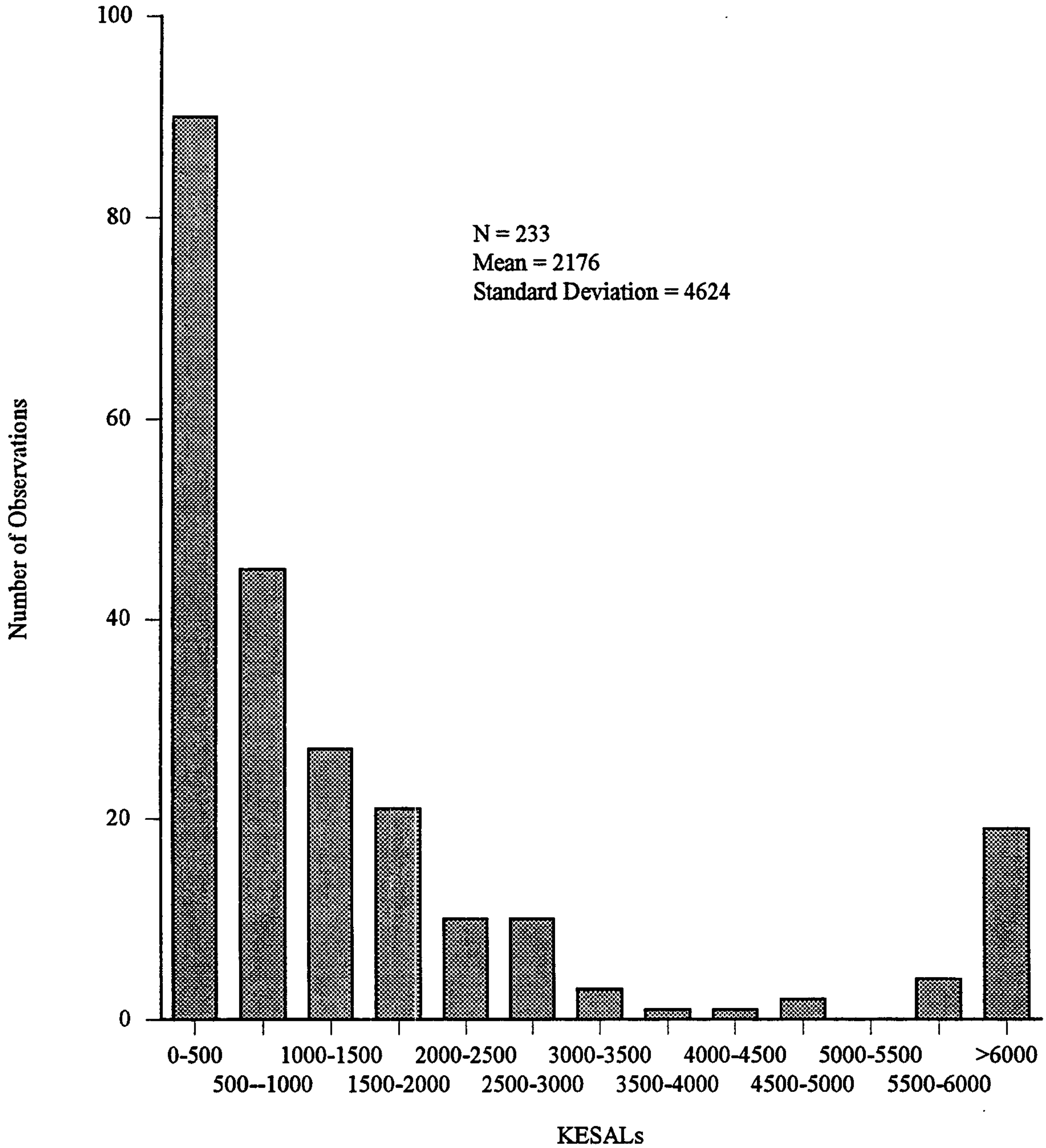
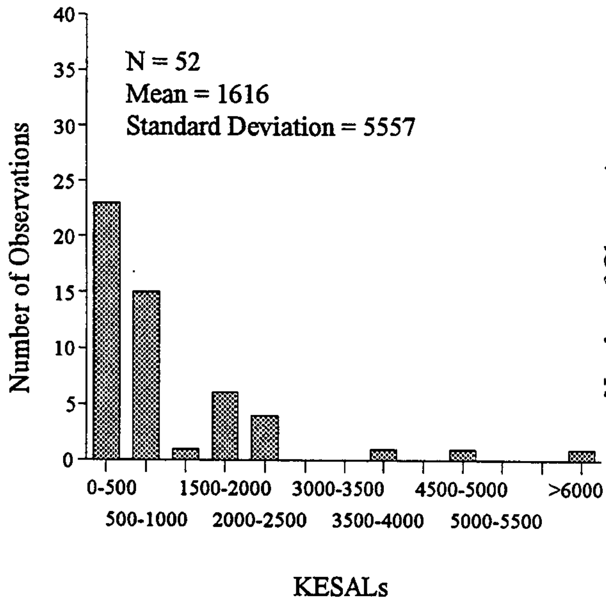
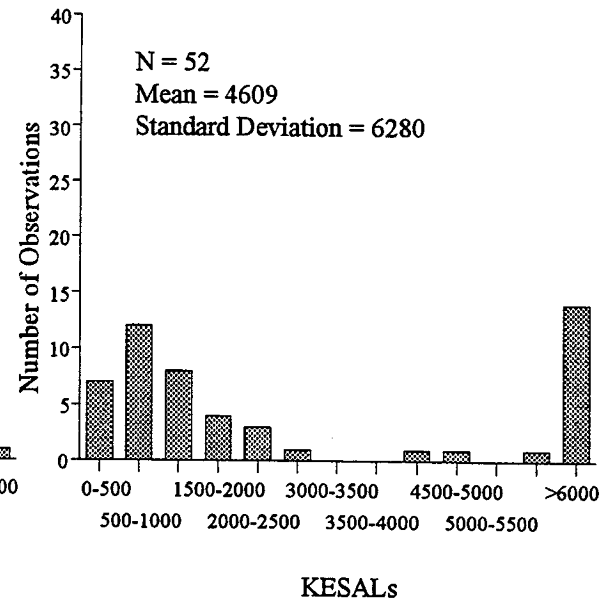


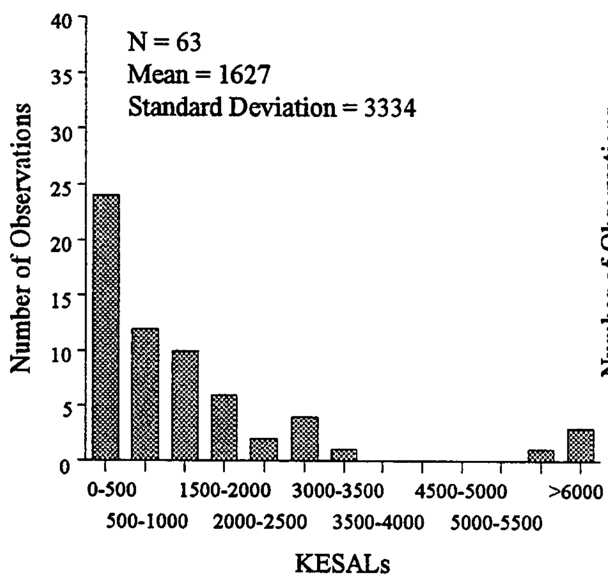
Figure 2.28. Distribution of Cumulative Equivalent Single Axle Loads in Thousands (KESALs) for GPS-1 Test Sections



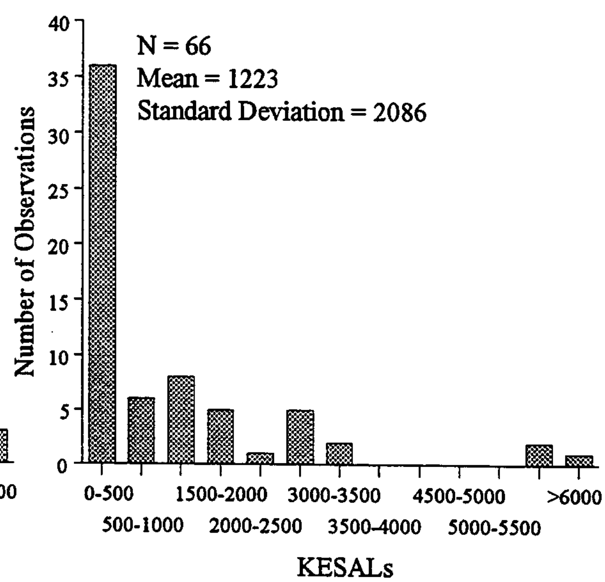
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 2.29. Distributions of Cumulative Equivalent Single Axle Loads in Thousands (KESALs) by Environmental Regions for GPS-1 Test Sections

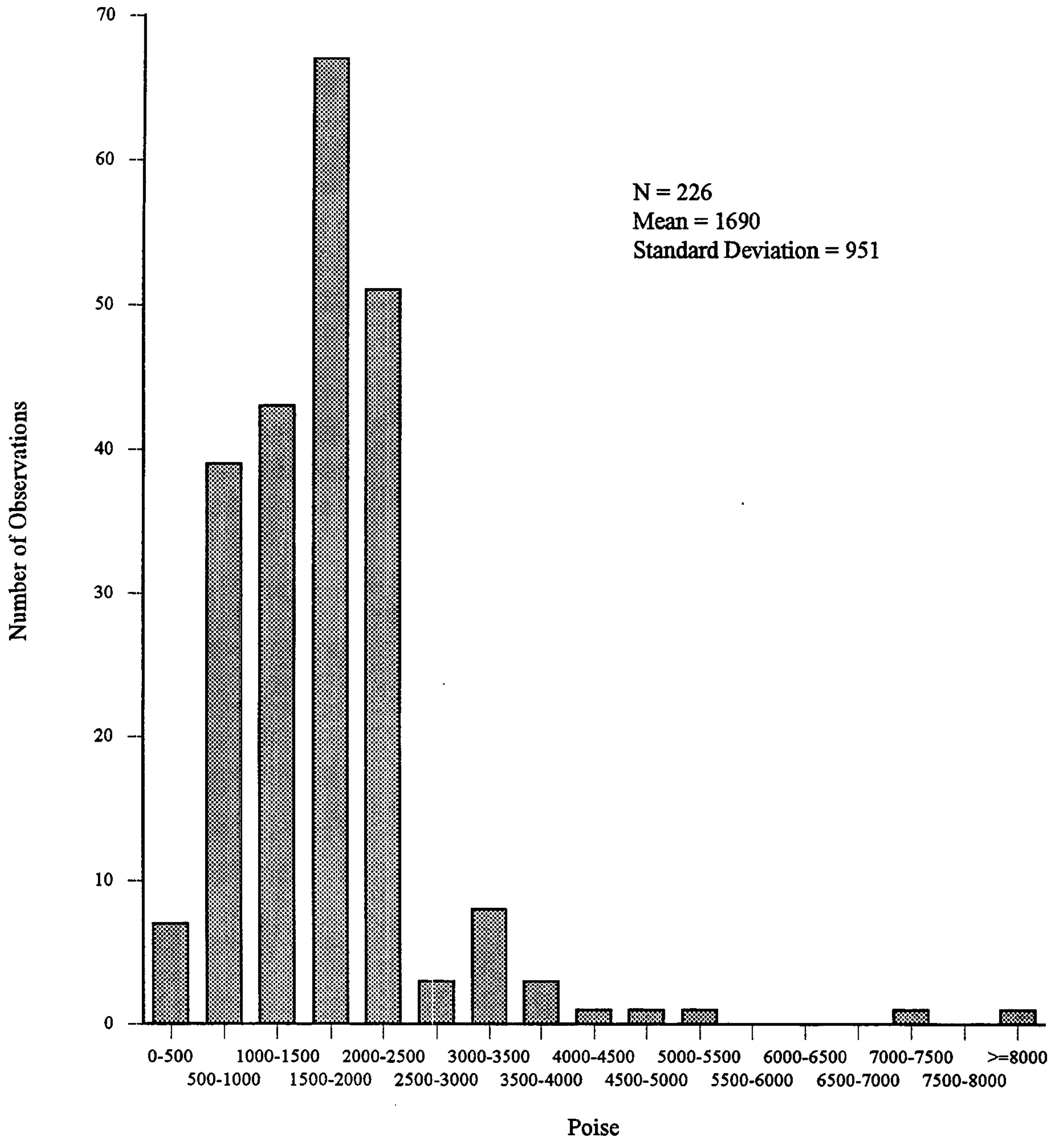


Figure 2.30. Distribution of Asphalt Cement Viscosity at 140°F for GPS-1 Test Sections

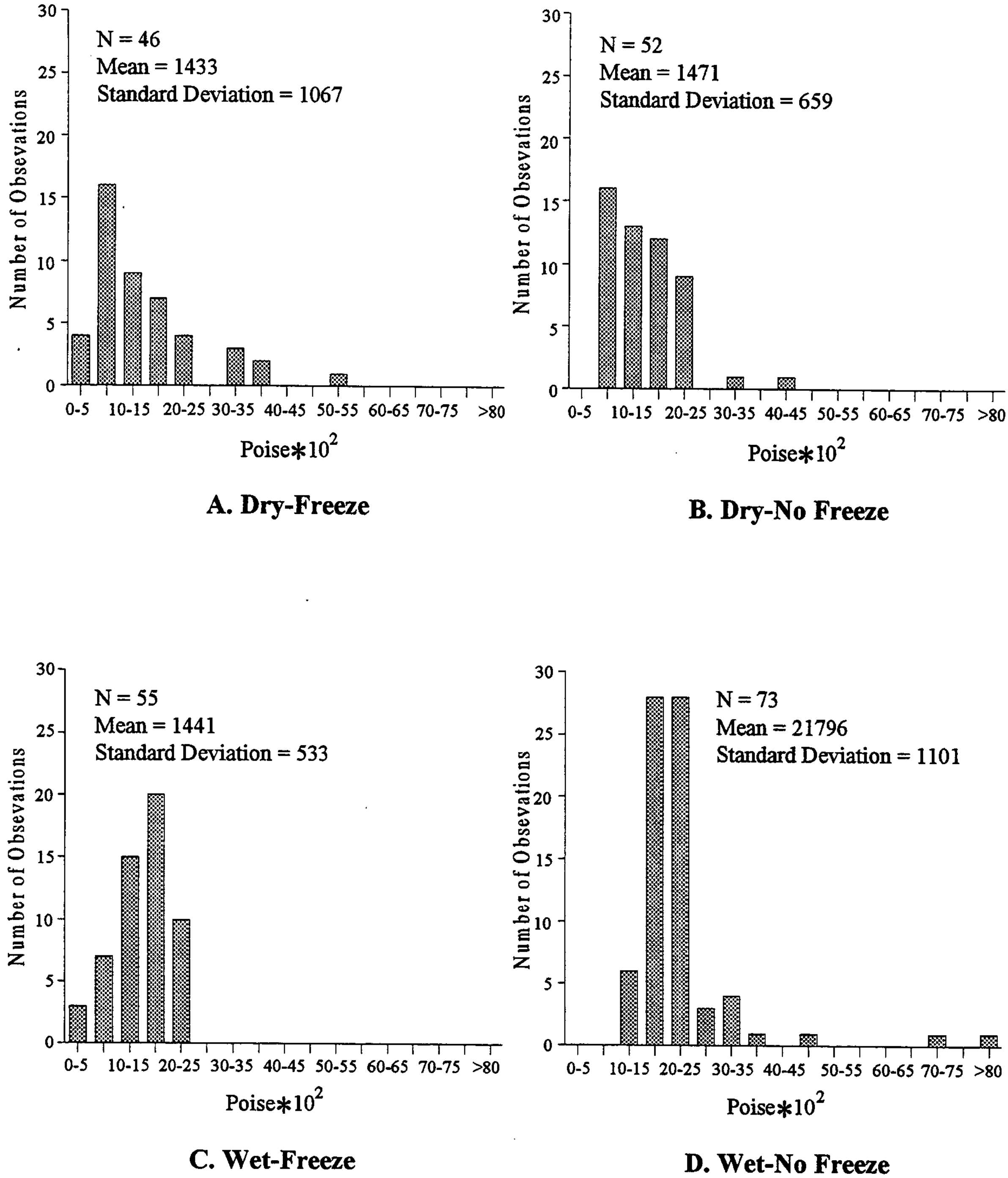


Figure 2.31. Distributions of Asphalt Viscosity at 140°F by Environmental Regions for GPS-1 Test Sections

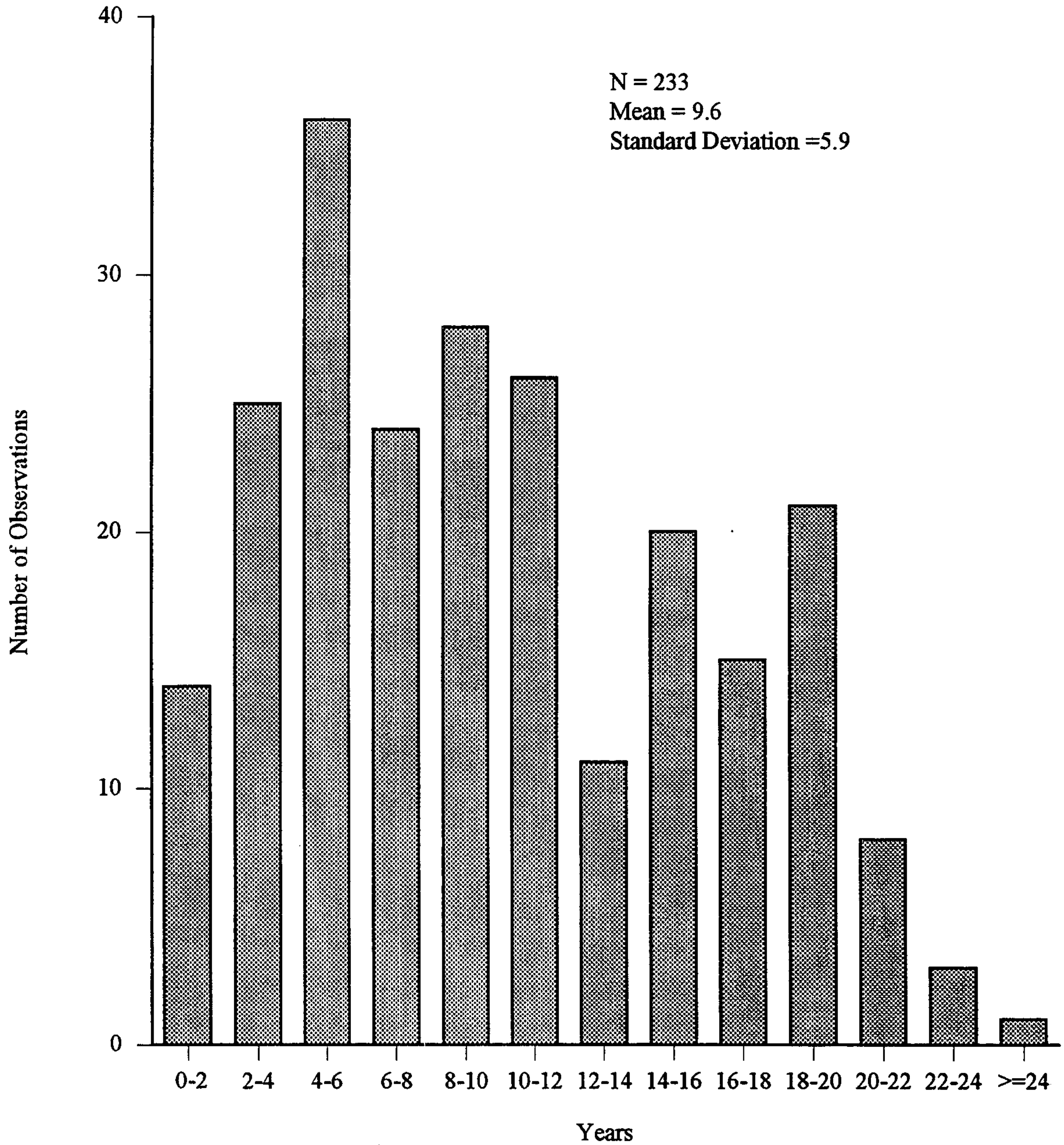


Figure 2.32. Distribution of Age for GPS-1 Test Sections

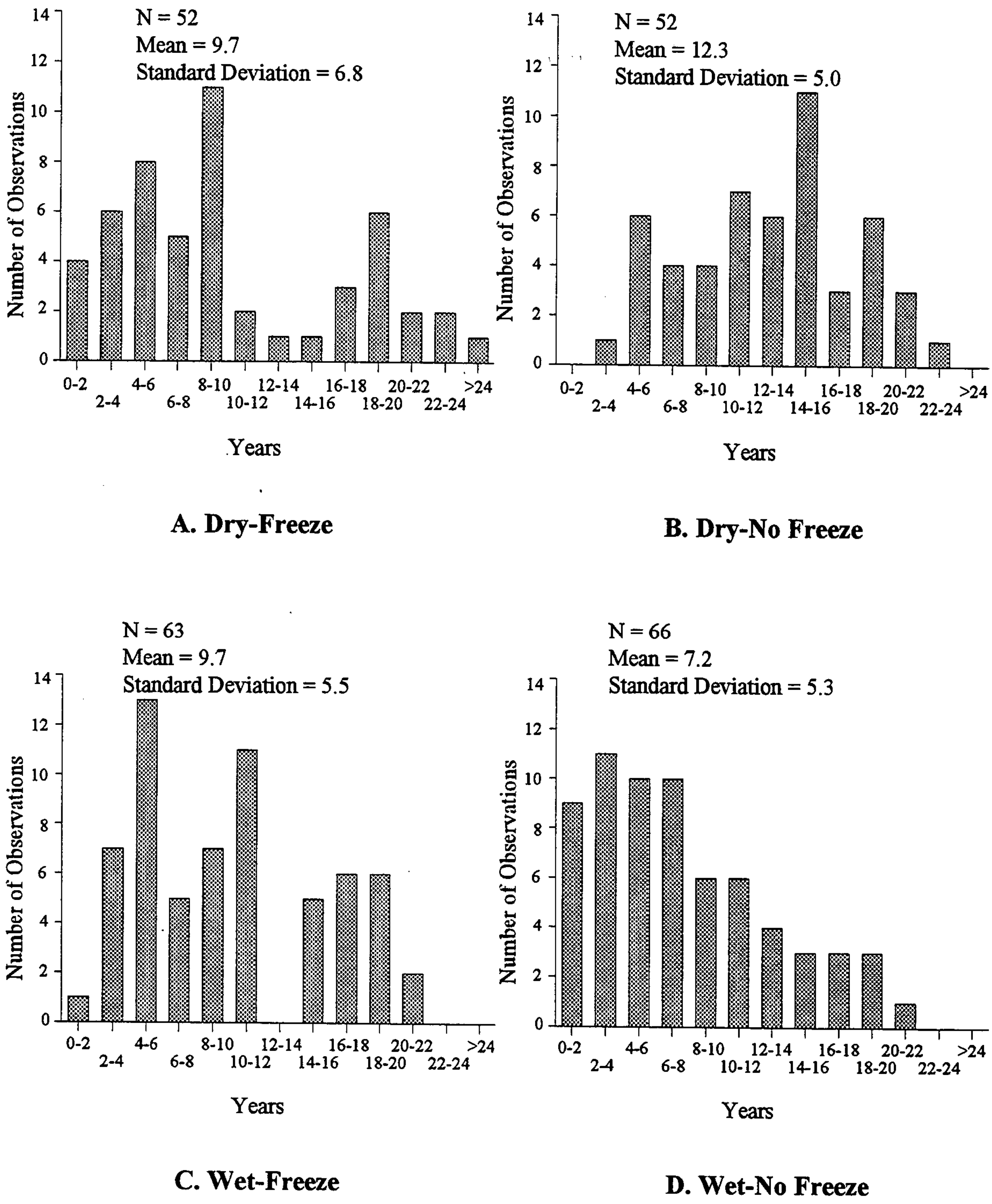


Figure 2.33. Distributions of Age by Environmental Regions for GPS-1 Test Sections

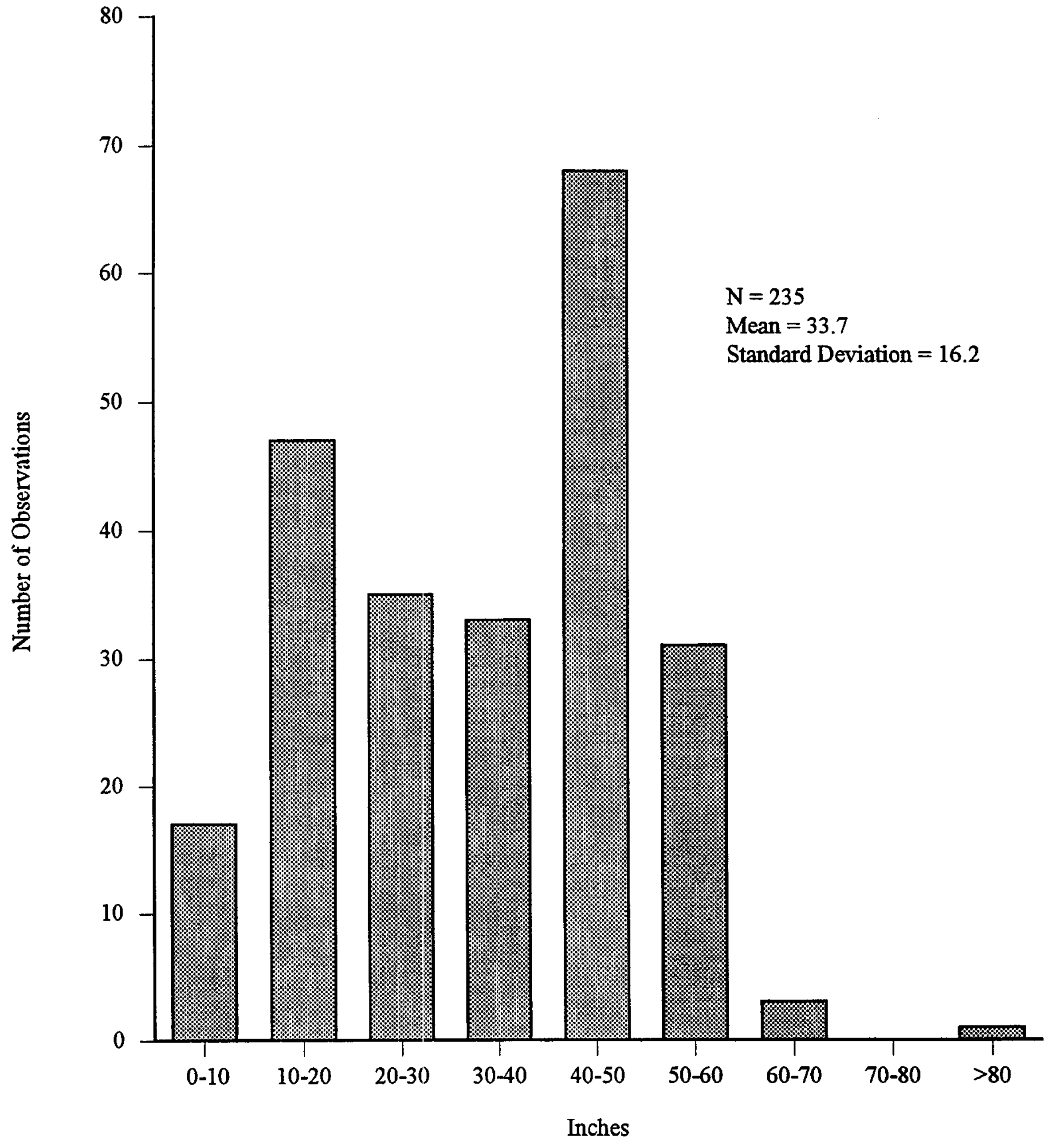


Figure 2.34. Distribution of Average Annual Precipitation for GPS-1 Test Sections

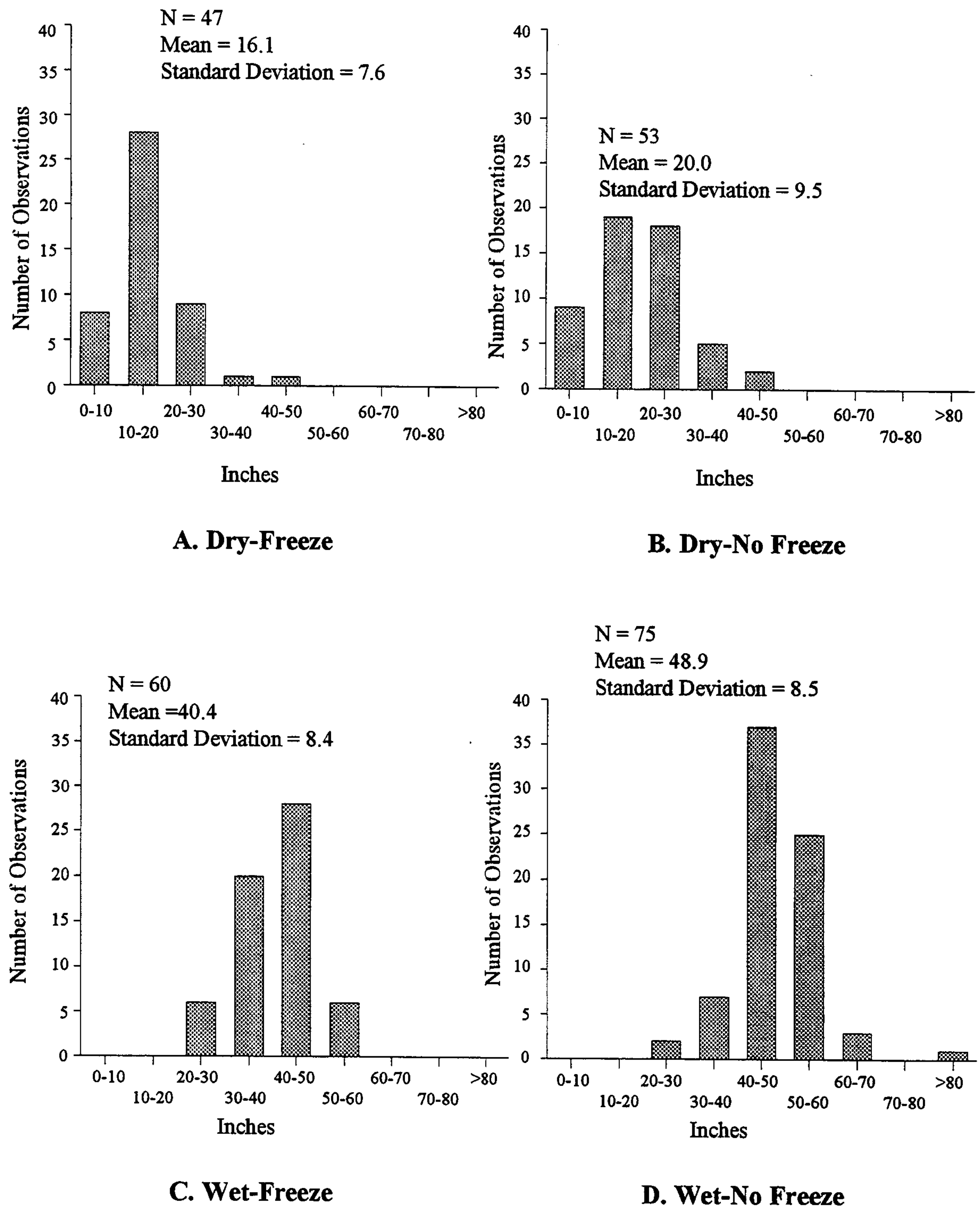


Figure 2.35. Distributions of Average Annual Precipitation by Environmental Regions for GPS-1 Test Sections

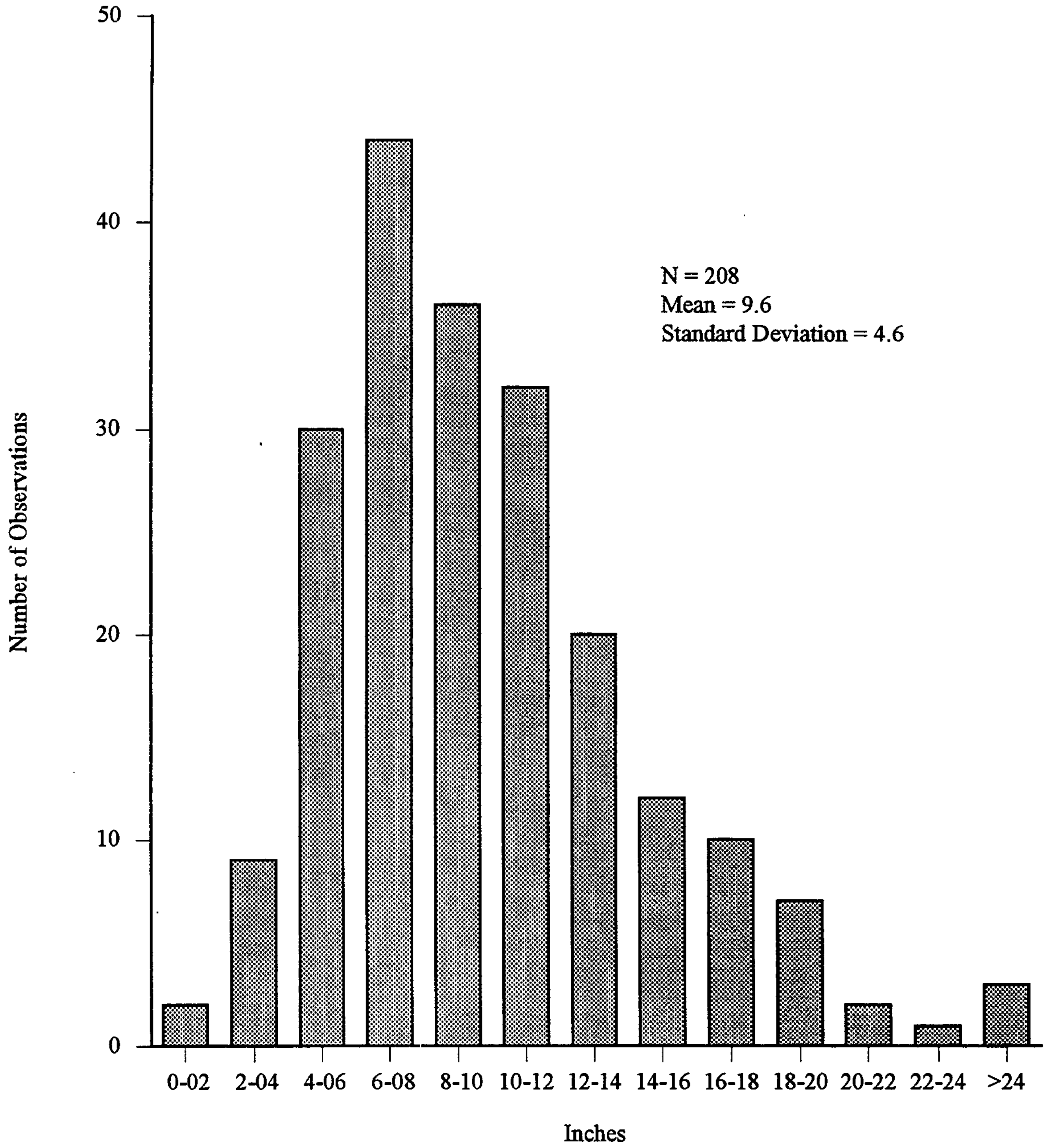


Figure 2.36. Distribution of Granular Base Thickness for GPS-1 Test Sections

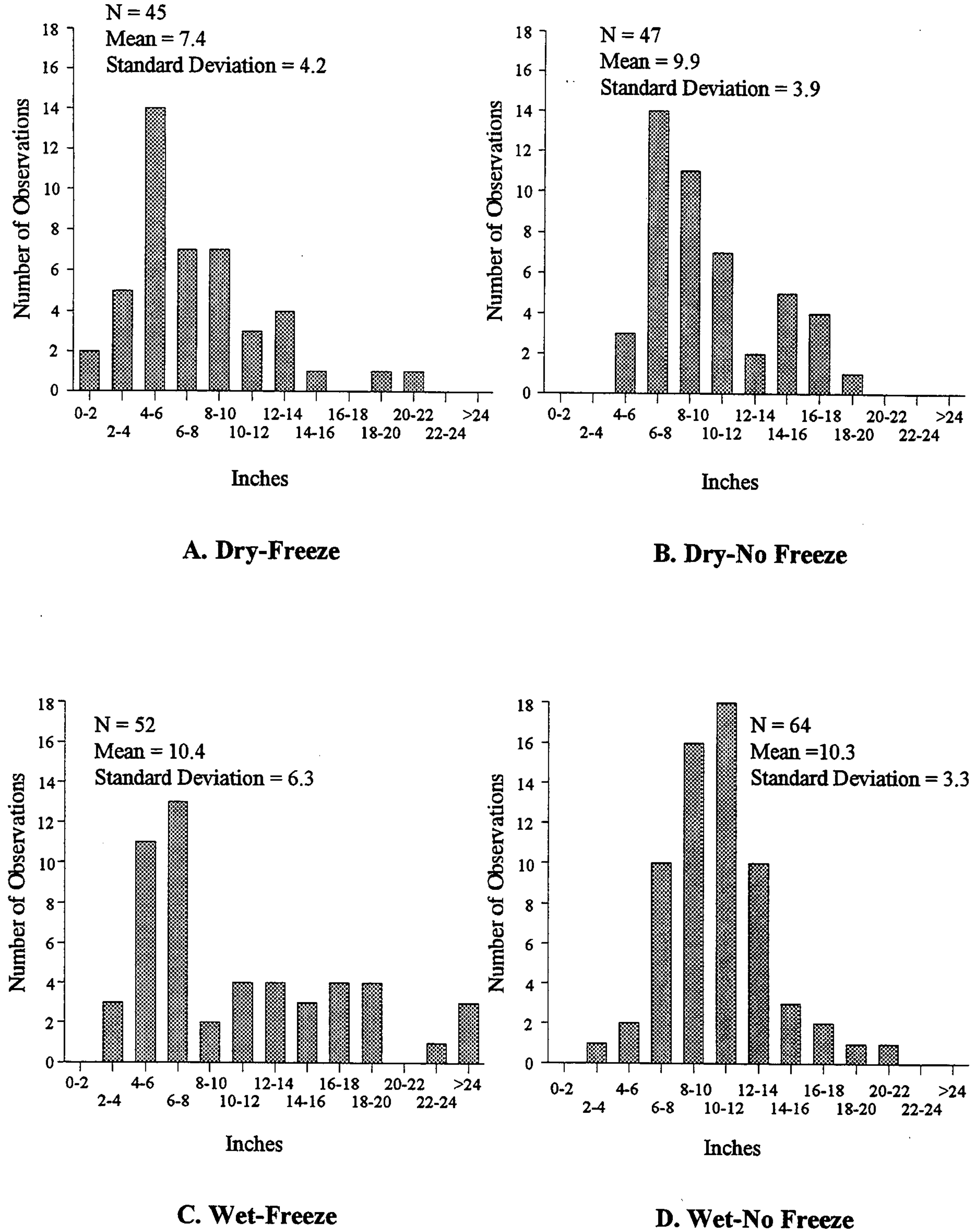


Figure 2.37. Distributions of Granular Base Thickness by Environmental Regions for GPS-1 Test Sections

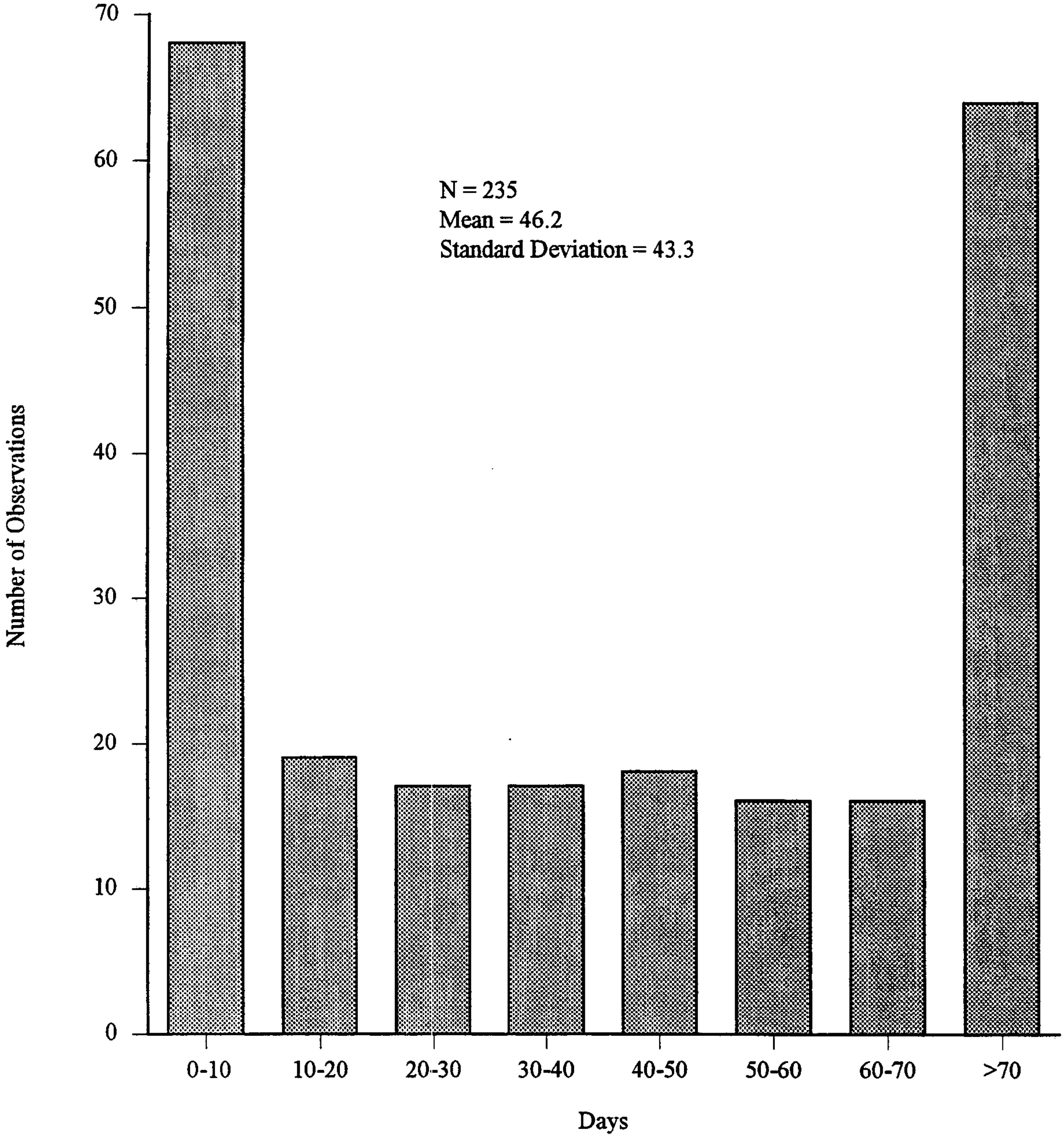
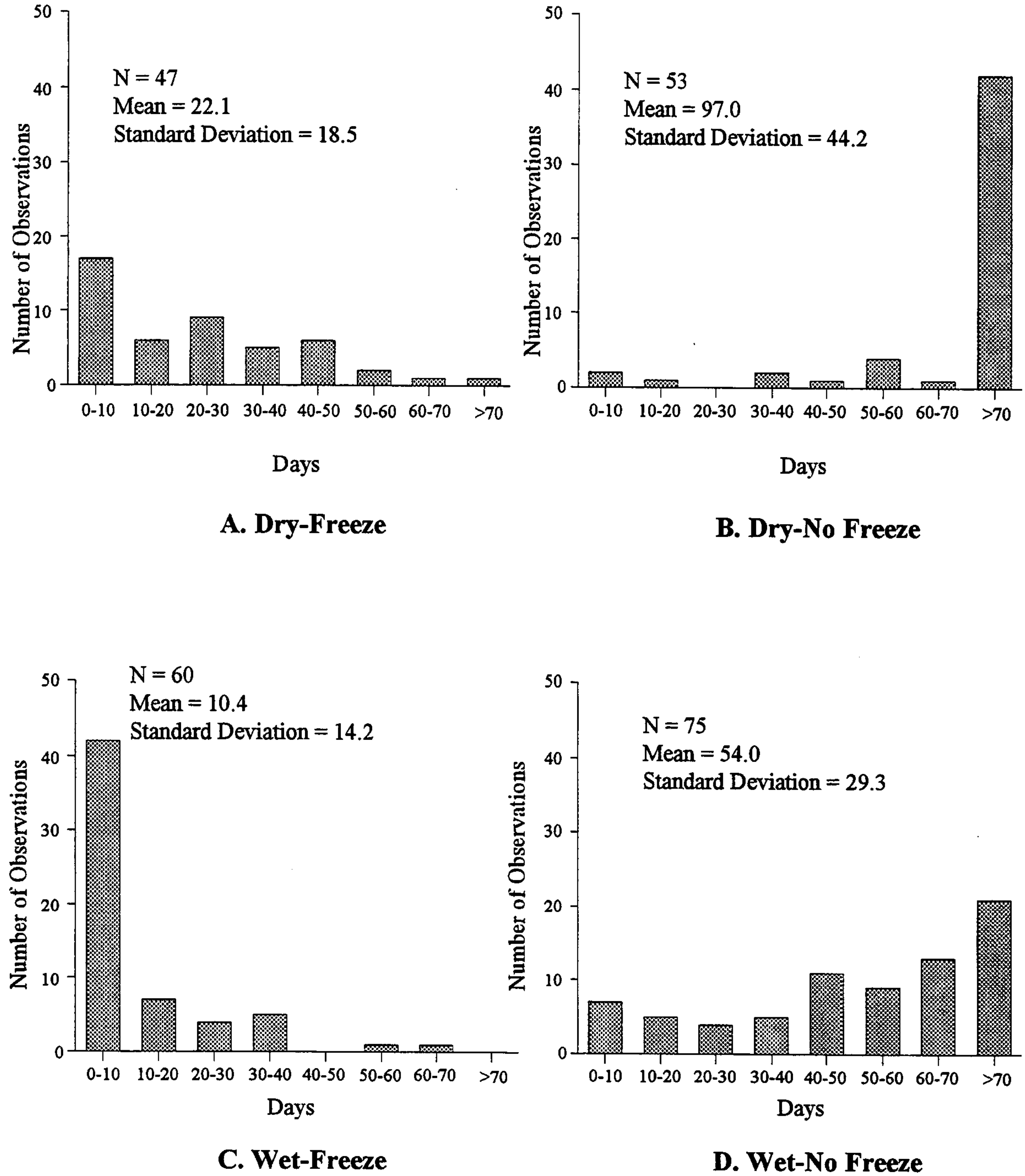


Figure 2.38. Distribution of Annual Average Number of Days Greater Than 90°F for GPS-1 Test Sections



A. Dry-Freeze

B. Dry-No Freeze

C. Wet-Freeze

D. Wet-No Freeze

Figure 2.39. Distributions of the Average Annual Number of Days Greater Than 90°F by Environmental Regions for GPS-1 Test Sections

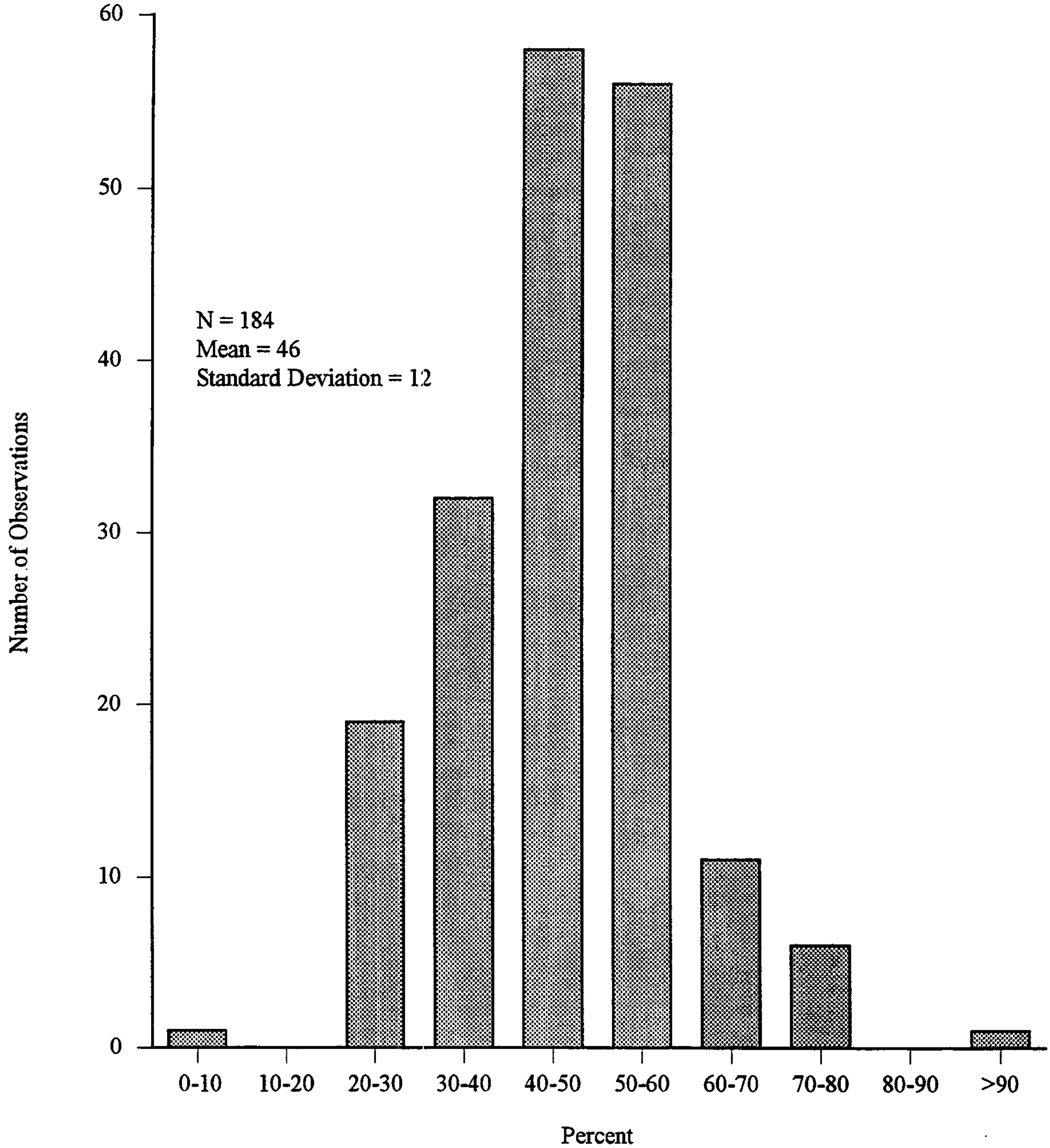


Figure 2.40. Distribution of Friction Number for GPS-1 Test Sections

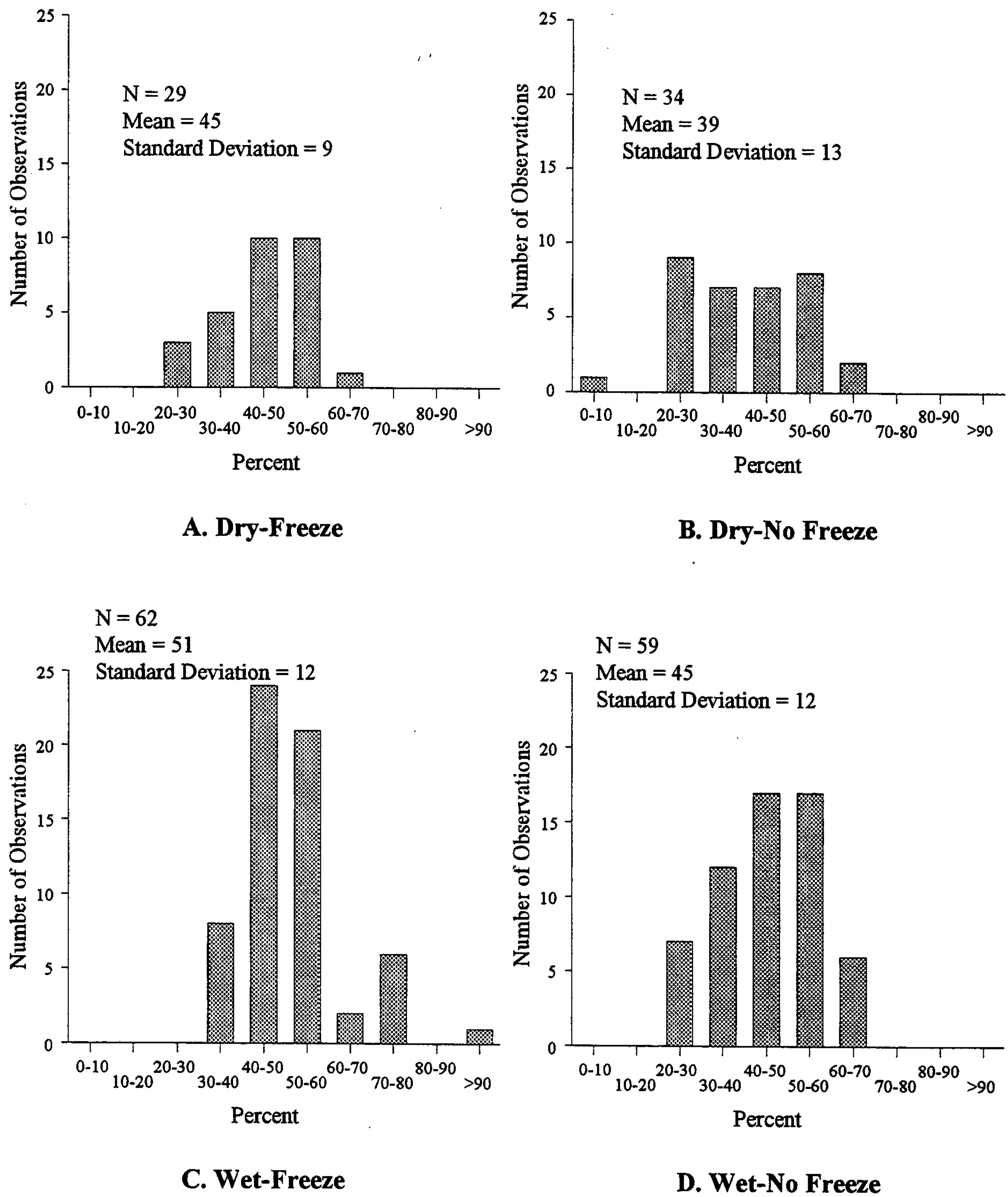


Figure 2.41. Distributions of Friction Number by Environmental Regions for GPS-1 Test Sections

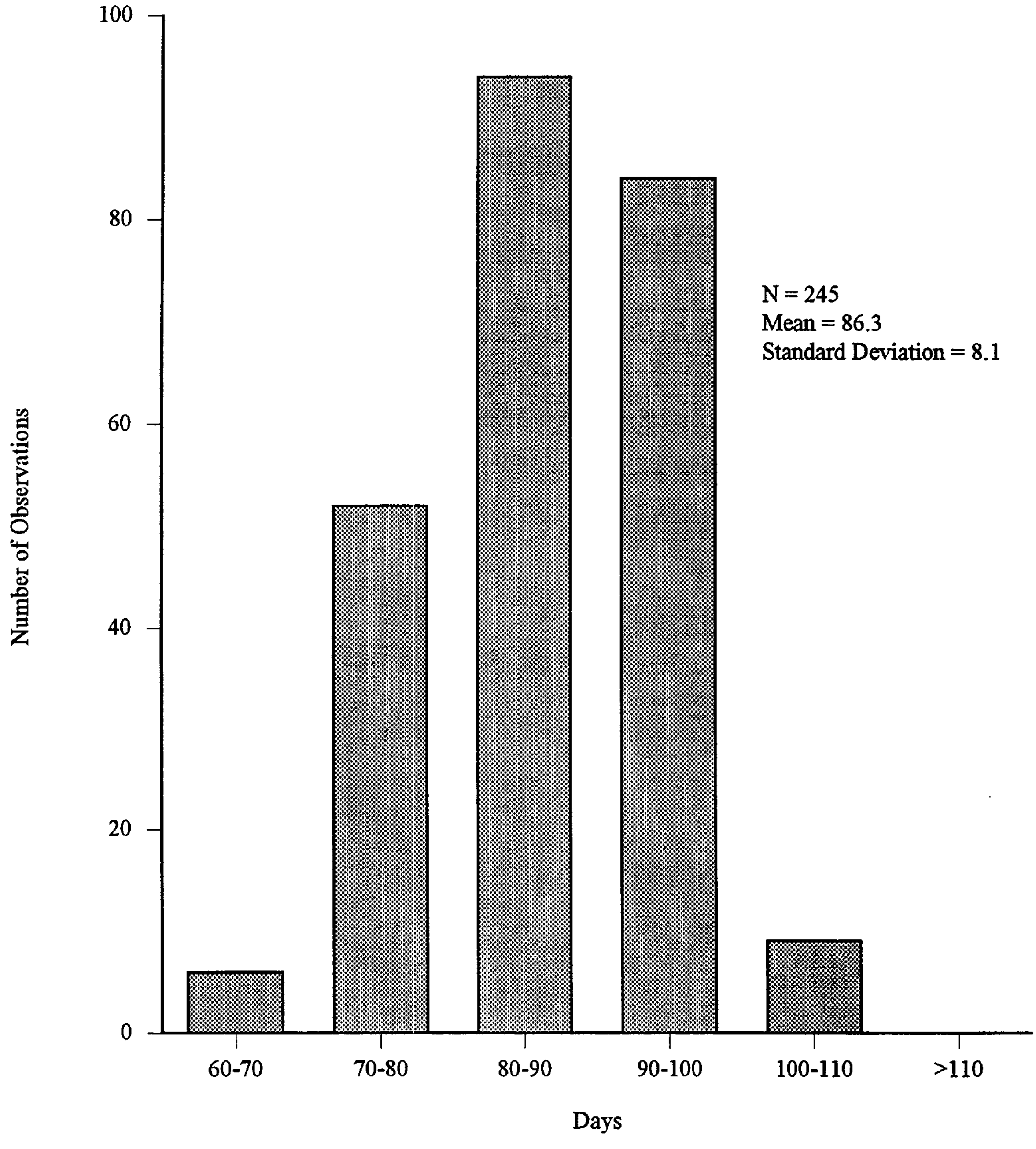
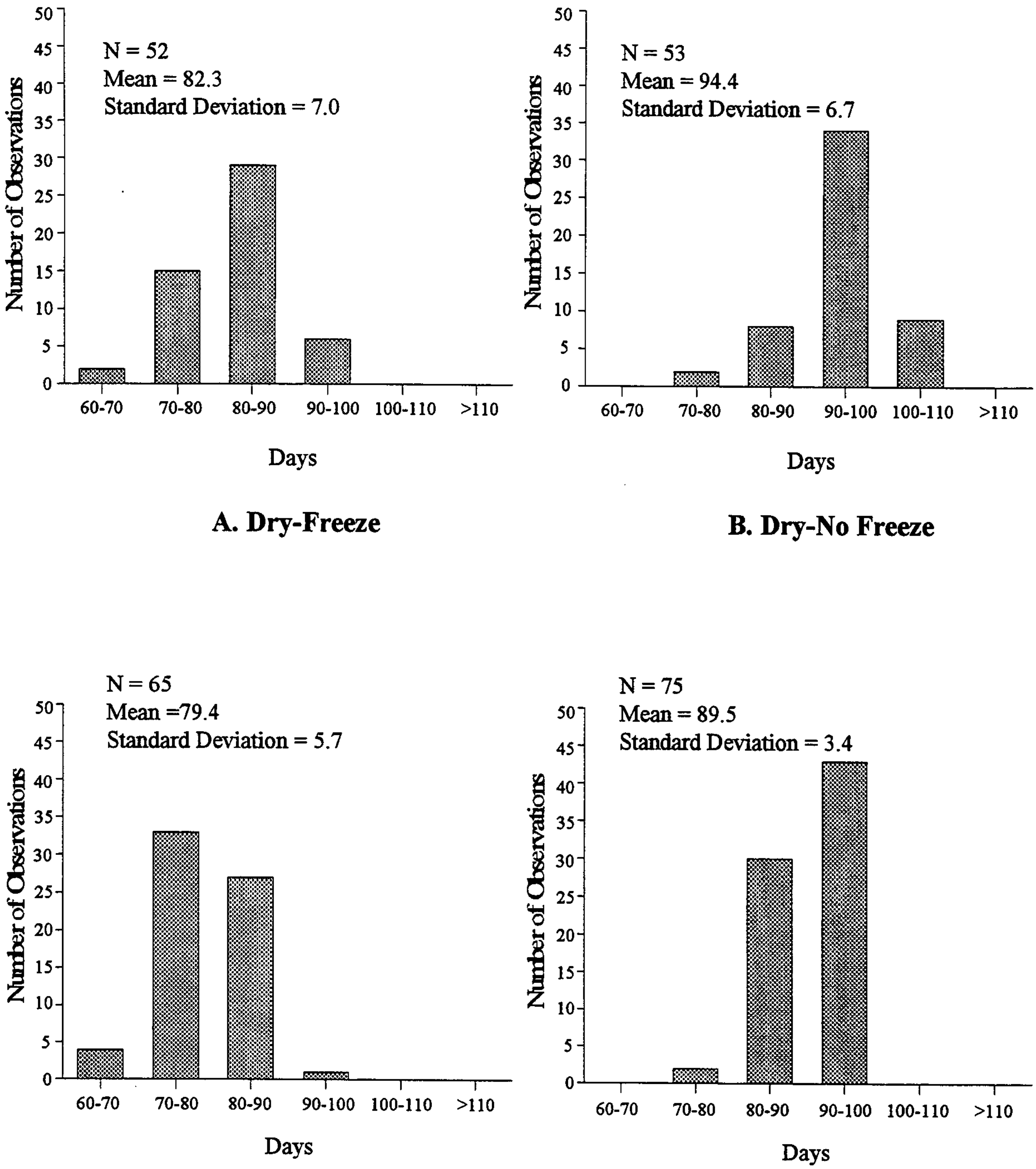


Figure 2.42. Distribution of Average Annual Maximum Temperature (for the Months of June, July and August) for GPS-1 Test Sections



A. Dry-Freeze

B. Dry-No Freeze

C. Wet-Freeze

D. Wet-No Freeze

Figure 2.43. Distributions of Average Anuual Maximum Temperature (for the Months of June, July and August) by Environmental Regions for GPS-1 Test Sections

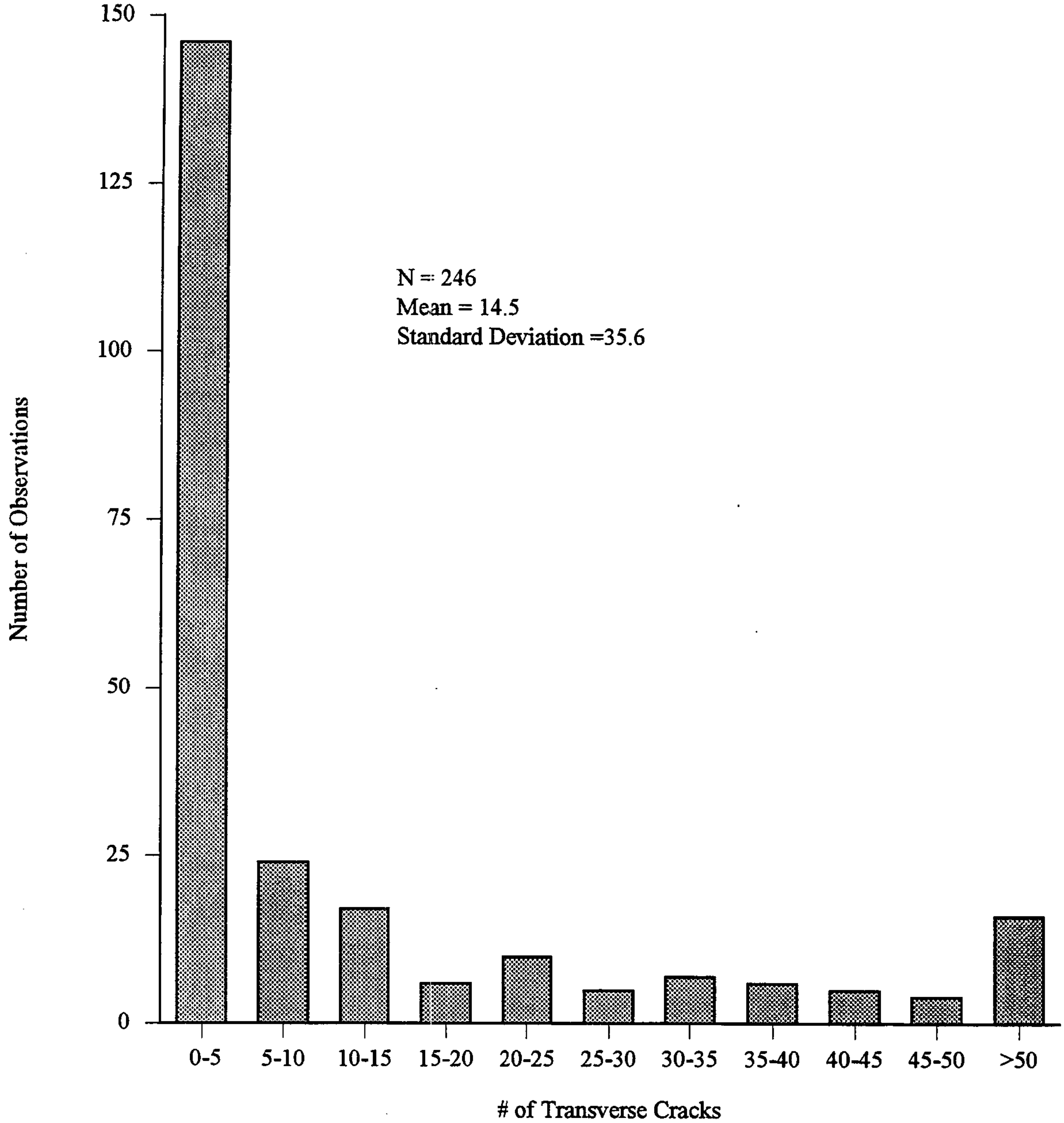


Figure 2.44. Distribution of the Number of Transverse Cracks for GPS-1 Test Sections

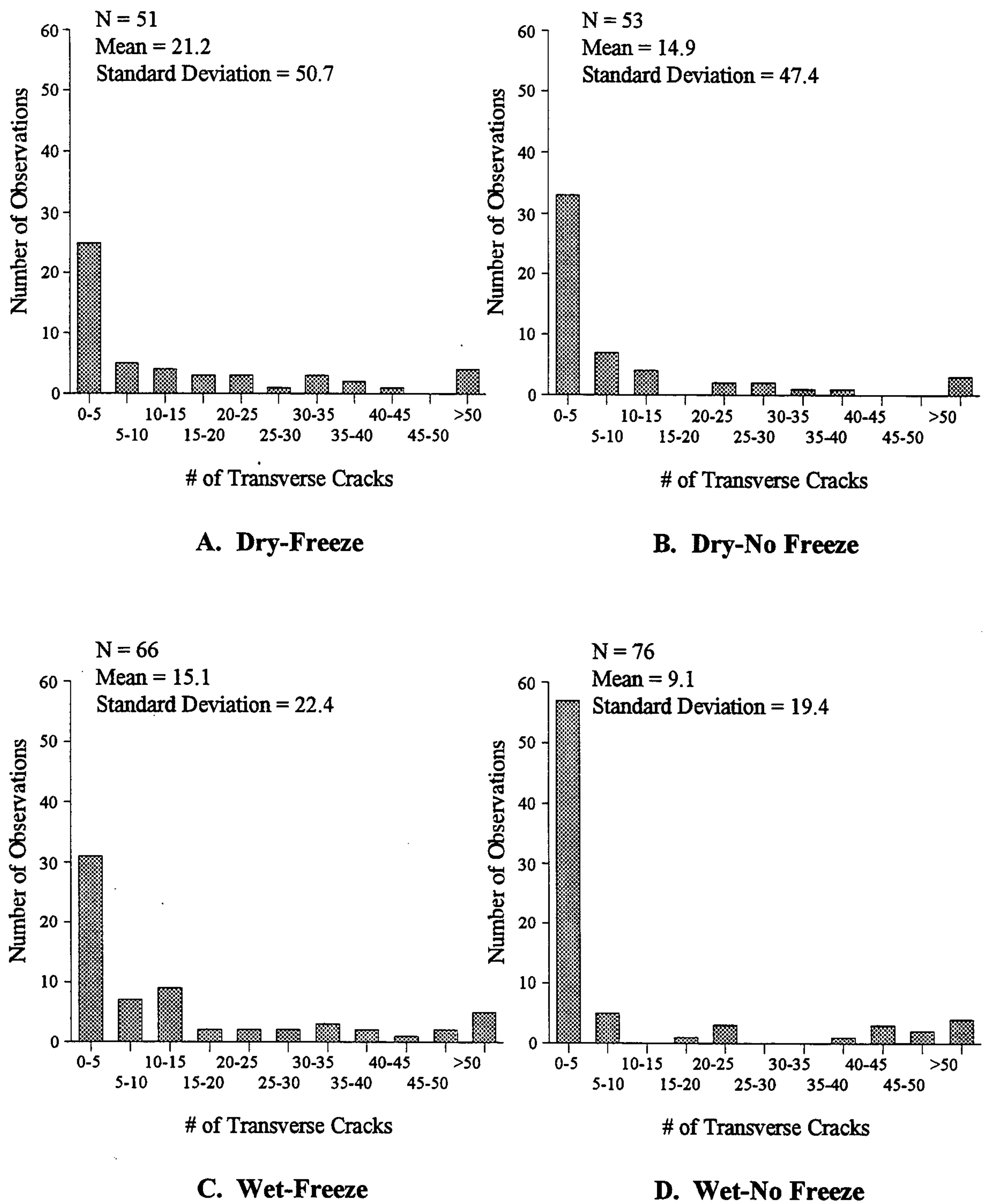


Figure 2.45. Distributions of Number of Transverse Cracks By Environmental Regions for GPS-1 Test Sections

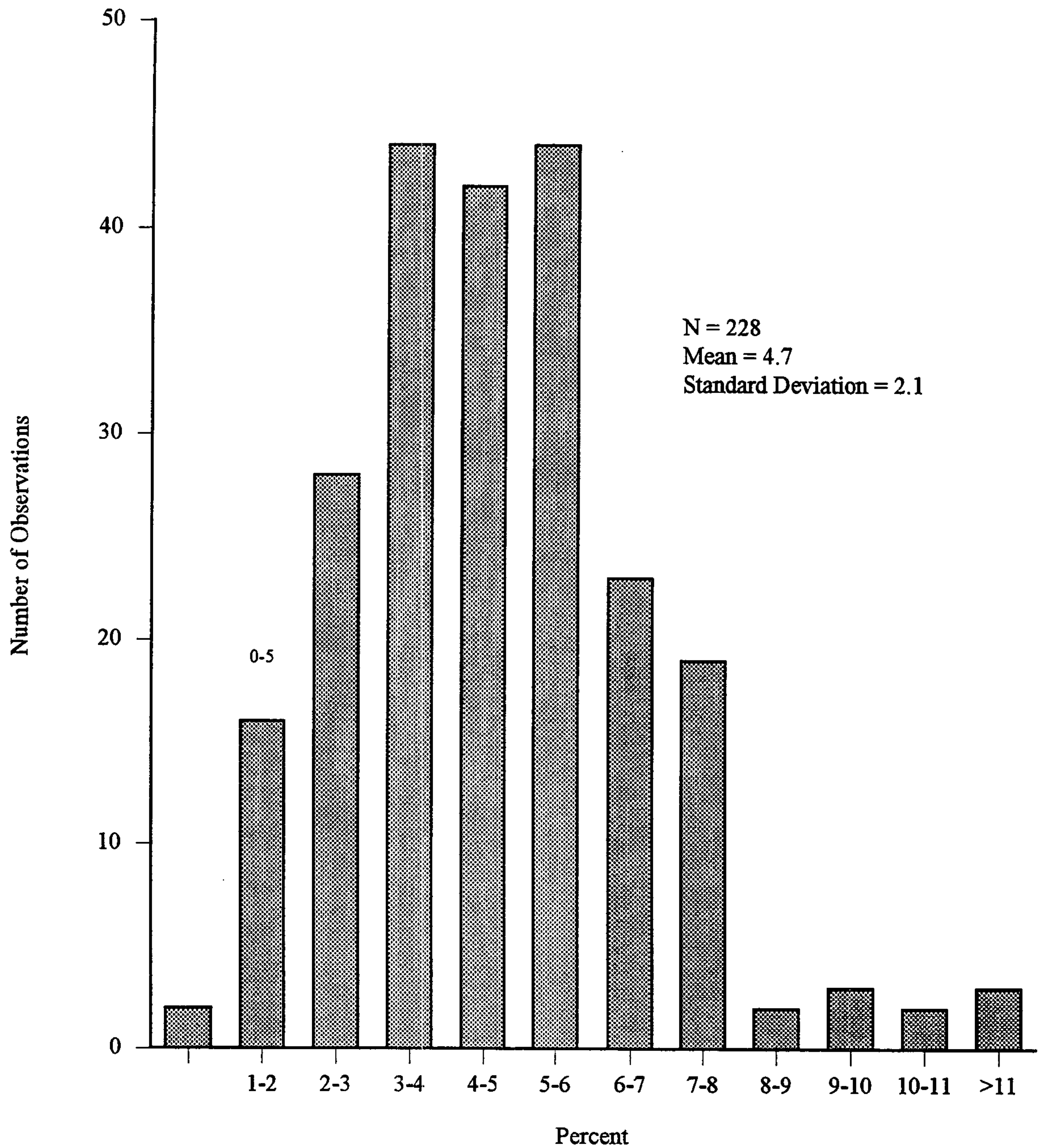


Figure 2.46. Distribution of HMAC Air Voids for GPS-1 Test Sections

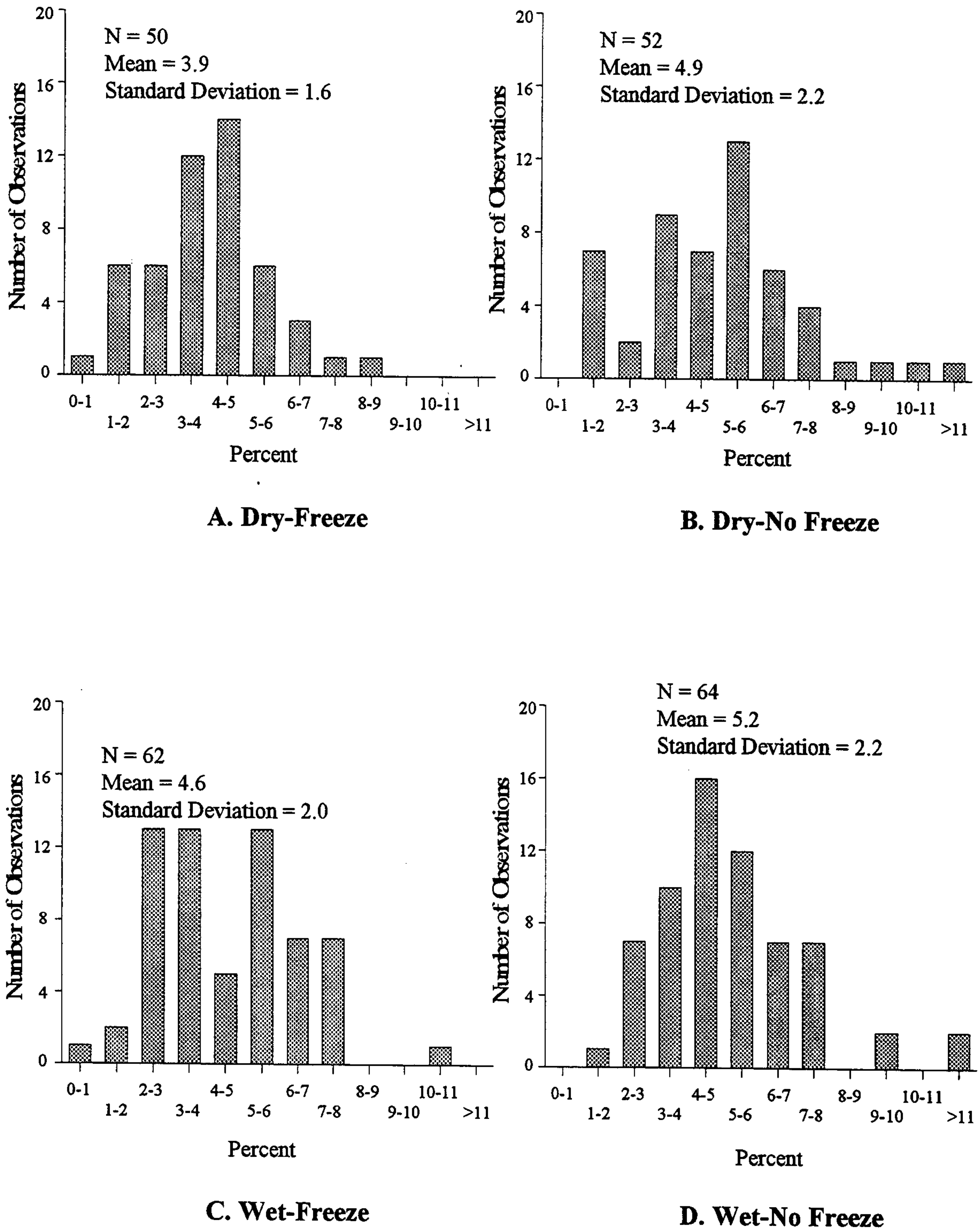


Figure 2.47. Distributions of HMAC Air Voids by Environmental Regions for GPS-1 Test Sections

3

Statistical Data for the GPS-2 Test Sections in the LTPP Data Base

This chapter provides statistical data for the 128 GPS-2 test sections for which data were available in the LTPP Data Base. See the section entitled "Statistical Data" in Chapter 1 for a description of the statistical data included in the following tables and figures.

Figure 3.1 illustrates the experimental design for GPS-1. Refer to figure 2.2 for definition of the environmental variables. The other design factors are summarized below.

Traffic Rate:	Low - Less than or equal to 85 KESAL/Yr. High - Greater than 85 KESAL/Yr.
Surface Thickness:	Low - Less than or equal to 4.5 in (110 mm). High - Greater than 4.5 in (110 mm).
Base Thickness:	Low - Less than to 8.0 in (200 mm). High - Greater than or equal to 8.0 in (200 mm).
Binder Type:	Bituminous Treated Non-Bituminous Treated

MOISTURE			WET								DRY							
TEMPERATURE			Freeze				No Freeze				Freeze				No Freeze			
SUBGRADE TYPE			Fine		Course		Fine		Course		Fine		Course		Fine		Course	
TRAFFIC RATE			Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
BINDER TYPE	**BASE THICKNESS**	**SURFACE THICKNESS**																
Bituminous	Low	Low	4		3	2	5	4	2	2	1			2	2	2	1	
		High	1	1	1		1	1	1		2	1		2				1
	High	Low	2			1	1	1	2	3	2	2				1		
		High	2		1		2	2	1	2						1		2
Non-Bituminous	Low	Low					3	2	2				1	1			1	1
		High	2	2	2	1	2	3	3	2	1				1		1	
	High	Low	3	1			4	1	2	2	1	1	2	1		3	1	1
		High	2		1	1	1	4	1	1		2				2		1

Figure 3.1. Numbers of Test Sections for Each Cell in the GPS-2 Sampling Template

Table 3.1 Statistical Values of Interest for Significant Variables in the GPS-2 Data Set (130 Test Sections With Distress Data Entered in IMS)

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Transverse Cracking: Low Severity:	No. Cracks	127	13.8	22.9	0	2	122	122
	Lin. Ft.	127	88.9	144.0	0	4.1	697	697
Moderate Severity:	No. Cracks	127	1.6	4.7	0	0	39	39
	Lin. Ft.	127	15.5	42.0	0	0	260	260
High Severity:	No. Cracks	127	0.5	4.3	0	0	48	48
	Lin. Ft.	127	5.0	51.0	0	0	573	573
Alligator Cracking: Low Severity:	Square Ft.	127	19.7	92.4	0	0	640	640
Moderate Severity:	Square Ft.	127	6.1	33.3	0	0	246	246
High Severity:	Square Ft.	127	0.4	4.7	0	0	53	53
Raveling & Weathering: Low Severity:	Square Ft.	127	53.7	383.1	0	0	3500	3500
Moderate Severity:	Square Ft.	127	28.2	310.6	0	0	3500	3500
High Severity:	Square Ft.	127	0	0	0	0	0	0

Note: Statistical values only reflect data for those test sections found to have the distress of interest present.

Table 3.2. Statistical Values of Interest for Significant Variables in the GPS-2 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Rut Depth (6')	Inches	116	0.23	0.12	0.07	0.19	0.65	0.58
Initial Roughness (IRI)	Inches/ Mile	92	56	22	0	60.5	114	114
Measured Roughness (IRI)	Inches/ Mile	118	77	28	31	74	184	153
Transverse Cracking: Low Severity:	No. Cracks	127	13.8	22.9	0	2	122	122
	Lin. Ft.	127	88.9	144	0	4.1	697	697
Moderate Severity:	No. Cracks	127	1.6	4.7	0	0	39	39
	Lin. Ft.	127	15.5	42	0	0	260	260
High Severity:	No. Cracks	127	0.5	4.3	0	0	48	48
	Lin. Ft.	127	5.0	51.0	0	0	573	573
Alligator Cracking: Low Severity:	Square Ft.	127	19.8	92.4	0	0	640	640
Moderate Severity:	Square Ft.	127	6.1	33.3	0	0	246	246
High Severity:	Square Ft.	127	0.4	4.7	0	0	53	53
Raveling & Weathering: Low Severity:	Square Ft.	127	53.7	383	0	0	3500	3500.0
Moderate Severity:	Square Ft.	127	28.18	310.590	0	0	3500.0	3500
High Severity:	Square Ft.	127	0	0	0	0	0	0
Measured Friction Number	%	77	46	10	22	46	92	71
Surface Thickness	Inches	116	5.3	3.0	0.7	4.6	15.3	14.6
Bound Base Thickness	Inches	110	7.2	2.7	1.8	6.6	16.4	14.6
Granular Subbase Thickness	Inches	55	10.8	8.3	0.8	7.3	40.7	39.9

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Table 3.2. Statistical Values of Interest for Significant Variables in the GPS-2 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Treated Subbase Thickness	Inches	16	6.4	2	4.5	6.0	13.1	8.6
Age of Pavement	Years	121	10.1	6.2	1.0	9.0	25.0	24.0
Cumulative KESALS	No.	121	2172	3464	37	673	14757	14719.7
Asphalt Viscosity @ 140F - Surface	Poise	112	1996	848	326	1993	6957	6631
Asphalt Content - Surface	% by wt.	116	5.0	0.8	3.2	5.0	6.8	3.6
Air Voids - Surface	% by wt.	110	5.2	2.3	0.91	5.2	12.7	11.8
HMAC Aggregate Passing #4 Sieve - Surface	% by wt.	113	55.8	11.4	0	55.3	100	100
Asphalt Viscosity @ 140F - Bit. Base	Poise	21	1940	301	1168	2000	2613	1445
Asphalt Content Bit. Base	% by wt.	21	4.5	1.2	2.4	4.5	7.4	5.0
Air Voids - Bit. Base	% by wt.	21	7.2	3.9	3.20	6.3	16.9	13.7
Emulsion	% by wt.	4	4.6	1.3	3.0	4.8	5.8	2.8
% Cement - Cement Treated Base	% by wt.	61	5.9	1.8	3.0	6.0	10.0	7.0
Compaction of Subbase (Mod. AASHTO)	%	38	93.2	6.91	76.7	95.4	103.8	27.1
In Situ Moisture in Subgrade	% by wt.	113	13.3	6.8	2.7	12.5	38.4	35.8
Subgrade Soil Passing #200 Sieve	% by wt.	111	41.6	25.6	0.9	40.0	95.2	94.3
Plasticity Index of Subgrade	%	113	7.9	8.6	0	6	45	45

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Table 3.2. Statistical Values of Interest for Significant Variables in the GPS-2 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Liquid Limit of Subgrade	%	113	20.4	16.5	0	24	65	65
Subgrade Soil Finer than 0.02 mm	%	107	29.1	18.3	2.6	25.2	82.0	79.5
Freeze Index	°F-Days < 32F	122	392.1	598.6	0	150	3133	3133
No. of Days Min. Temp. < 32°F	No.	122	81.7	57.5	0	72	206	206
No. of Days Max. Temp. > 90°F	No.	122	45.1	32.8	0	41	159	159
Number of Air Freeze-Thaw Cycles	No.	122	70.3	41.9	0	71	170	170
Annual Precipitation	Inches	122	39.7	17.8	5.9	44.3	71.3	65.4
Average Daily Temp. Range	°F	128	23.7	4.1	11.5	23.6	34.4	22.9
Avg. Annual Min. Temp. (Daily Min. Temps. for Dec., Jan., and Feb.)	°F	128	27.8	11.7	-3.9	28.0	64.0	67.9
Avg. Annual Max. Temp. (Daily Max. Temps. for June, July and Aug.)	°F	128	87.2	6.8	65.2	88.9	106.0	40.8
Avg. Min. Temp. by Month	°F	115	44.9	9.9	5.9	46.2	66.9	61.0
Avg. Max. Temp. by Month	°F	115	68.57	9.92	25.7	70.6	87.5	61.8

Table 3.3. Description of Variables Used in the Correlation Matrix for the GPS-2 Data Set

Variable	Description of Variable
MEAN6	Rut Depth (6-ft. straight edge), inches
I_IRI	Initial IRI value, inches/mile
B_IRI	Measured IRI value, inches/mile
TCRK_T	Total measured Transverse cracking (all severity levels combined) in linear feet
TNO_T	Total number of Transverse cracks identified (all severity levels combined)
AGE	Age of pavement, years
KESALs	Equivalent Single Axle Loads in thousands
SURTH	Surface thickness, inches
TBTHK	Treated Base thickness, inches
GSBTH	Granular Subbase thickness, inches
V140	Asphalt cement viscosity @ 140°F, poise
A_CON	Asphalt Content of surface course, % by weight
AV	Air Voids of surface course, % by weight
% 4	Percent Passing the #4 sieve for surface course, by weight
A_CONB	Asphalt Content of the Base, % by weight
AVB	Air Voids of the Base, % by volume
% 200	Percent passing the #4 sieve for the subgrade, by weight
MOIST	Insitu Moisture of the subgrade, % by weight
TPREC	Average Annual Precipitation, inches
AVG90	Average number of days with temperature greater than 90°F
AVG32	Average number of days with temperature less than 32°F
FTIN	Freeze Index, degree days
FRZTH	Average number of Freeze-Thaw Cycles
%CEM	Portland Cement Content of Base, % by weight

Table 3.4. Correlation Analysis for Significant Variables in the GPS-2 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	MEAN6	I_IRI	B_IRI	TCRK_T	TNO_T	AGE	KESALS	SURTH	TBTHK	GSBTH	V140	A-CON
MEAN6	1.00000 0.0 116	0.01489 0.8944 82	0.28118 0.0029 110	0.07011 0.4545 116	0.17429 0.0613 116	0.22605 0.0181 109	0.09334 0.3344 102	0.03816 0.7034 96	-0.01136 0.9125 45	-0.11322 0.4590 98	0.06128 0.5489 102	0.08701 0.3845
I_IRI	-0.01489 0.8944 82	1.00000 0.0 92	0.01109 0.9212 82	0.26454 0.0108 92	0.21112 0.0434 86	0.02976 0.7856 86	0.11111 0.3085 86	-0.28057 0.0102 83	0.23771 0.0326 81	-0.26375 0.1147 37	-0.13710 0.2223 81	0.25130 0.0219 83
B_IRI	0.28118 0.0029 110	0.01109 0.9212 82	1.00000 0.0 118	0.36334 0.0001 118	0.35677 0.0001 118	0.25053 0.0083 110	-0.00408 0.9663 110	-0.09800 0.3223 104	0.03568 0.7273 98	-0.1116 0.9400 48	-0.01099 0.9136 100	0.02224 0.8227 104
TCRK_T	0.07011 0.4545 116	0.26454 0.0108 92	0.36334 0.0001 118	1.00000 0.0 130	0.92095 0.0001 130	0.12707 0.1649 121	-0.08563 0.3504 121	-0.26325 0.0043 116	0.03693 0.7017 110	0.02329 0.8660 55	-0.09873 0.3004 112	0.03078 0.7429 116
TNO_T	0.17429 0.0613 116	0.21112 0.0434 92	0.35677 0.0001 118	0.92095 0.0001 130	1.00000 0.0 130	0.17877 0.0498 121	-0.07679 0.4025 121	-0.16436 0.0779 116	-0.04252 0.6592 110	-0.00573 0.9669 55	-0.03435 0.7192 112	-0.00872 0.9260 116
AGE	0.22605 0.0181 109	0.02976 0.7856 86	0.25053 0.0083 110	0.12707 0.1649 121	0.17877 0.0498 121	1.00000 0.0 121	0.36121 0.0001 121	-0.06140 0.5279 108	-0.08527 0.3941 102	-0.29324 0.0331 53	-0.09813 0.3217 104	-0.05586 0.5658 108
KESALS	0.09334 0.3344 109	0.11111 0.3085 86	-0.00408 0.9663 110	-0.08563 0.3504 121	-0.07679 0.4025 121	0.36121 0.0001 121	1.00000 0.0 121	0.07031 0.4696 108	0.05336 0.5942 102	-0.04547 0.7465 53	-0.10881 0.2716 104	-0.01140 0.9068 108
SURTH	0.03816 0.9125 102	-0.28057 0.0326 83	-0.09800 0.7273 104	-0.26325 0.7017 116	-0.16436 0.6592 116	-0.06140 0.3941 108	0.07031 0.5942 108	1.00000 0.0583 116	-0.18109 0.0 110	-0.17461 0.8356 55	0.23533 0.2683 112	-0.42338 0.0689 116
TBTHK	-0.01136 0.9125 96	0.233771 0.0326 81	0.03568 0.7273 98	0.03693 0.7017 110	-0.04252 0.6592 110	-0.08527 0.3941 102	0.05336 0.5942 102	-0.18109 0.0583 110	1.00000 0.0 110	0.02920 0.8356 53	-0.10850 0.2683 106	0.17410 0.0689 110
GSBTH	-0.11322 0.4590 45	-0.26375 0.1147 37	-0.01116 0.9400 48	0.02329 0.8660 55	-0.00573 0.9669 55	-0.29324 0.0331 53	-0.04547 0.7465 53	-0.17461 0.2023 55	0.02920 0.8356 53	1.00000 0.0 55	-0.12253 0.3774 54	0.02114 0.8782 55

Table 3.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	MEAN6	I_IRI	B_IRI	TCRK_T	TNO_T	AGE	KESALS	SURTH	TBTHK	GSBTH	V140	A_CON
V140	0.06128 0.5489 98	-0.13710 0.2223 81	0.01099 0.9136 100	-0.09873 0.3004 112	-0.03435 0.7192 112	-0.09813 0.3217 104	-0.10881 0.2716 104	0.23533 0.0125 112	0.10850 0.2683 106	-0.12253 0.3774 54	1.00000 0.0 112	-0.21740 0.0213 112
A_CON	0.08701 0.3845 102	0.25130 0.0219 83	0.02224 0.8227 104	0.03078 0.7429 116	-0.00872 0.9260 116	-0.05586 0.5658 108	-0.01140 0.9068 108	-0.42338 0.0001 116	0.17410 0.0689 110	0.02114 0.8782 55	-0.21740 0.0213 112	1.00000 0.0 116
AV	-0.16933 0.0991 96	0.03177 0.7825 78	0.06979 0.4947 98	0.01529 0.8740 110	0.052912 0.5830 110	0.01906 0.8492 102	0.00973 0.9226 102	0.07332 0.4465 110	-0.15098 0.1260 104	-0.10615 0.4493 53	0.01133 0.9082 106	-0.25103 0.0082 110
%4	0.17830 0.0774 99	0.22520 0.0432 81	0.03007 0.7653 101	0.03428 0.7185 113	-0.02549 0.7887 113	-0.05784 0.5578 105	-0.19580 0.0453 105	-0.31363 0.0007 113	0.06097 0.5327 107	0.04507 0.7462 54	-0.07714 0.4231 110	0.29984 0.0013 113
A_CONB	0.42155 0.0814 18	0.59670 0.0243 14	-0.66983 0.0024 18	0.18065 0.4333 21	0.16981 0.4618 21	0.22439 0.3707 18	0.06512 0.7974 18	-0.29811 0.1893 21	0.37311 0.0957 21	0.35803 0.2088 14	-0.02080 0.9287 21	0.53669 0.0121 21
AVB	-0.00231 0.9927 18	0.35673 0.2106 14	-0.49912 0.0350 18	-0.26610 0.2436 21	-0.29096 0.2007 21	0.26239 0.2928 18	-0.13056 0.6056 18	0.00183 0.9937 21	-0.00364 0.9875 21	0.08712 0.7671 14	0.07907 0.7333 21	0.18648 0.4183 21
%200	0.11273 0.2691 98	-0.27681 0.0135 79	0.09771 0.3335 100	0.12614 0.1871 111	0.11628 0.2242 111	0.03756 0.7050 104	-0.19273 0.0500 104	0.11651 0.2233 111	-0.06686 0.4980 105	-0.13258 0.3537 51	-0.04556 0.6412 107	-0.15958 0.0943 111
MOIST	0.17192 0.0888 99	-0.07498 0.5059 81	0.05030 0.6156 102	0.07404 0.4357 113	0.06416 0.4996 113	-0.01689 0.8642 105	-0.12279 0.2121 105	0.06392 0.5012 113	0.17123 0.0778 107	-0.25384 0.0694 52	-0.03355 0.7291 109	-0.01594 0.8669 113
TPREC	-0.12903 0.1771 111	-0.28048 0.0093 85	-0.23028 0.0141 113	-0.15133 0.0961 122	-0.10106 0.2680 122	-0.07594 0.4240 113	-0.22276 0.0177 113	0.22048 0.0212 109	-0.31326 0.0012 104	-0.20486 0.1535 50	0.44068 0.0001 105	-0.24470 0.0103 109
AVG90	-0.05411 0.5727 111	0.15265 0.1631 85	-0.05650 0.5523 113	-0.00419 0.9634 122	0.03955 0.6654 122	0.02079 0.8270 113	0.15595 0.0991 113	-0.08800 0.3628 109	-0.06798 0.4929 104	-0.03694 0.7990 50	0.03682 0.7092 105	0.00314 0.9741 109

Table 3.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	MEAN6	I_IRI	B_IRI	TCRK_T	TNO_T	AGE	KESALS	SURTH	TBTHK	GSBTH	V140	A_CON
AVG32	0.19702	0.09704	0.20964	0.16848	0.13588	-0.09134	-0.19784	-0.05273	0.18403	0.18965	-0.29545	0.17069
	0.0382	0.3769	0.0258	0.0636	0.1356	0.3360	0.0357	0.5861	0.0615	0.1871	0.0022	0.0760
	111	85	113	122	122	113	113	109	104	50	105	109
FTIN	0.21590	0.02919	0.22772	0.17826	0.09437	-0.02964	-0.17087	-0.11290	0.09926	0.29968	-0.34736	0.16196
	0.0229	0.7909	0.0153	0.0495	0.3012	0.7553	0.0704	0.2425	0.3161	0.0345	0.0003	0.0925
	111	85	113	122	122	113	113	109	104	50	105	109
FRZTH	0.14298	0.12990	0.15539	0.12130	0.13003	-0.10725	-0.16889	-0.02292	0.22441	0.04970	-0.20472	0.15729
	0.1344	0.2361	0.1003	0.1832	0.1534	0.2582	0.0737	0.8130	0.0220	0.7318	0.0362	0.1024
	111	85	113	122	122	113	113	109	104	50	105	109
%CEM	-0.00525	0.38080	-0.00631	0.24536	0.22993	-0.30178	-0.29866	0.12796	0.16777	0.25694	0.12194	-0.15407
	0.9697	0.0090	0.9625	0.0588	0.0772	0.0225	0.0240	0.3565	0.2298	0.3034	0.3892	0.2660
	55	46	58	60	60	57	57	54	53	18	52	54

Table 3.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	AV	%4	A_CONB	AVB	%200	MOIST	TPREC	AVG90	AVG32	FTIN	FRZTH	%CEM
MEAN6	-0.16933	0.17830	0.42155	-0.00231	0.11273	0.17192	-0.12903	-0.05411	0.19702	0.21590	0.14298	-0.00525
	0.0991	0.0774	0.0814	0.9927	0.2691	0.0888	0.1771	0.5727	0.0382	0.0229	0.1344	0.9697
	96	99	18	18	98	99	111	111	111	111	111	55
I_IRI	0.03177	0.22520	0.59670	0.36573	-0.27681	-0.07498	-0.28048	0.15265	0.09704	0.02919	0.12990	0.38080
	0.7825	0.0432	0.0243	0.2106	0.0135	0.5059	0.0093	0.1631	0.3769	0.7909	0.2361	0.0090
	78	81	14	14	79	81	85	85	85	85	85	46
B_IRI	0.06979	0.03007	-0.66983	-0.49912	0.09771	0.05030	-0.23028	-0.05650	0.20964	0.22772	0.15539	-0.00631
	0.4947	0.7653	0.0024	0.0350	0.3335	0.6156	0.0141	0.5523	0.0258	0.0153	0.1003	0.9625
	98	101	18	18	100	102	113	113	113	113	113	58
TCRK_T	0.01529	0.03428	0.18065	-0.26610	0.12614	0.07404	-0.15133	-0.00419	0.16848	0.17826	0.12130	0.24536
	0.8740	0.7185	0.4333	0.2436	0.1871	0.4357	0.0961	0.9634	0.0636	0.0495	0.1832	0.0588
	110	113	21	21	111	113	122	122	122	122	122	60
TNO_T	0.05291	-0.02549	0.16981	-0.29096	0.11628	0.06416	-0.10106	0.03955	0.13588	0.09437	0.13003	0.22993
	0.5830	0.7887	0.4618	0.2007	0.2242	0.4996	0.2680	0.6654	0.1356	0.3012	0.1534	0.0772
	110	113	21	21	111	113	122	122	122	122	122	60
AGE	0.01906	-0.05784	0.22439	0.26239	0.03756	-0.01689	-0.07594	0.02079	-0.09134	-0.02964	-0.10725	-0.30178
	0.8492	0.5578	0.3707	0.2928	0.7050	0.8642	0.4240	0.8270	0.3360	0.7553	0.2582	0.0225
	102	105	18	18	104	105	113	113	113	113	113	57
KESALS	0.00973	-0.19580	0.06512	-0.13056	-0.19273	-0.12279	-0.22276	0.15595	-0.19784	-0.17087	-0.16889	-0.29866
	0.9226	0.0453	0.7974	0.6056	0.0500	0.2121	0.0177	0.0991	0.0357	0.0704	0.0737	0.0240
	102	105	18	18	104	105	113	113	113	113	113	57
SURTH	0.07332	-0.31363	-0.29811	0.00183	0.11651	0.06392	0.22048	-0.08800	-0.05273	-0.11290	-0.02292	0.12796
	0.4465	0.0007	0.1893	0.9937	0.2233	0.5012	0.0212	0.3628	0.5861	0.2425	0.8130	0.3565
	110	113	21	21	111	113	109	109	109	109	109	54
TBTHK	-0.15098	0.06097	0.37311	-0.00364	-0.06686	0.17123	-0.31326	-0.06798	0.18403	0.09926	0.22441	0.16777
	0.1260	0.5327	0.0957	0.9875	0.4980	0.0778	0.0012	0.4929	0.0615	0.3161	0.0220	0.2298
	104	107	21	21	105	107	104	104	104	104	104	53
GBTHK	-0.10615	0.04507	0.35803	0.08712	-0.13258	-0.25384	-0.20486	-0.03694	0.18965	0.29968	0.04970	0.25694
	0.4493	0.7462	0.2088	0.7671	0.3537	0.0694	0.1535	0.7990	0.1871	0.0345	0.7318	0.3034
	53	54	14	14	51	52	50	50	50	50	50	18

Table 3.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

	AV	%4	A_CONB	AVB	%200	MOIST	TPREC	AVG90	AVG32	FTIN	FRZTH	%CEM
V140	0.011333	-0.07714	-0.02080	0.07907	-0.04556	-0.03355	0.44068	0.03682	-0.29545	-0.34736	-0.20472	0.12194
	0.9082	0.4231	0.9287	0.7333	0.6412	0.7291	0.0001	0.7092	0.0022	0.0003	0.0362	0.3892
	106	110	21	21	107	109	105	105	105	105	105	52
A_CON	-0.25103	0.29984	0.53669	0.18648	-0.15958	-0.01594	-0.24470	0.00314	0.17069	0.16196	0.15729	-0.15407
	0.0082	0.0013	0.0121	0.4183	0.0943	0.8669	0.0103	0.9741	0.0760	0.0925	0.1024	0.2660
	110	113	21	21	111	113	109	109	109	109	109	54
AV	1.00000	0.10518	-0.41856	-0.10634	-0.06110	0.11043	0.21029	0.10705	-0.31564	-0.24035	-0.29330	-0.18453
	0.0	0.2764	0.0663	0.6554	0.5358	0.2575	0.0330	0.2818	0.0012	0.0145	0.0026	0.1995
	110	109	20	20	105	107	103	103	103	103	103	50
%4	0.10518	1.00000	0.34059	0.34994	-0.03681	0.06496	0.10767	0.13538	-0.07580	0.01232	-0.11597	0.01045
	0.2764	0.0	0.1308	0.1199	0.7053	0.5002	0.2719	0.1664	0.4400	0.9003	0.2365	0.9414
	109	113	21	21	108	110	106	106	106	106	106	52
ACONB	-0.41856	0.34059	1.00000	0.46777	-0.20142	-0.19882	0.19760	0.48121	-0.37649	-0.39430	-0.36915	1.00000
	0.0663	0.1308	0.0	0.0325	0.4083	0.4007	0.3906	0.0272	0.0925	0.0769	0.0996	
	20	21	21	21	19	20	21	21	21	21	21	2
AVB	-0.10634	0.34994	0.46777	1.00000	-0.23234	-0.14779	0.57678	0.05224	-0.26301	-0.33896	-0.24351	-1.00000
	0.6554	0.1199	0.0325	0.0	0.3385	0.5341	0.0062	0.8221	0.2494	0.1328	0.2875	
	20	21	21	21	19	20	21	21	21	21	21	2
%200	-0.06110	-0.03681	-0.20142	-0.23234	1.00000	0.65620	0.13350	-0.13061	0.08706	0.02527	0.07429	0.15263
	0.5358	0.7053	0.4083	0.3385	0.0	0.0001	0.1767	0.1863	0.3795	0.7990	0.4536	0.2705
	105	108	19	19	111	111	104	104	104	104	104	54
MOIST	0.11043	0.06496	-0.19882	-0.14779	0.65620	1.00000	0.13791	-0.09894	0.02033	-0.07416	0.08426	0.11381
	0.2575	0.5002	0.4007	0.5341	0.0001	0.0	0.1586	0.3129	0.8361	0.4499	0.3905	0.4126
	107	110	20	20	111	113	106	106	106	106	106	54
TPREC	0.21029	0.10767	0.19760	0.57678	0.13350	0.13791	1.00000	-0.05885	-0.44604	-0.37385	-0.42971	0.23312
	0.0330	0.2719	0.3906	0.0062	0.1767	0.1586	0.0	0.5196	0.0001	0.0001	0.0001	0.0730
	103	106	21	21	104	106	122	122	122	122	122	60
AVG90	0.10705	0.13538	0.48121	0.05224	-0.13061	-0.09894	-0.05885	1.00000	-0.59569	-0.54919	-0.48896	-0.01725
	0.2818	0.1664	0.0272	0.8221	0.1863	0.3129	0.5196	0.0	0.0001	0.0001	0.0001	0.8959
	103	106	21	21	104	106	122	122	122	122	122	60

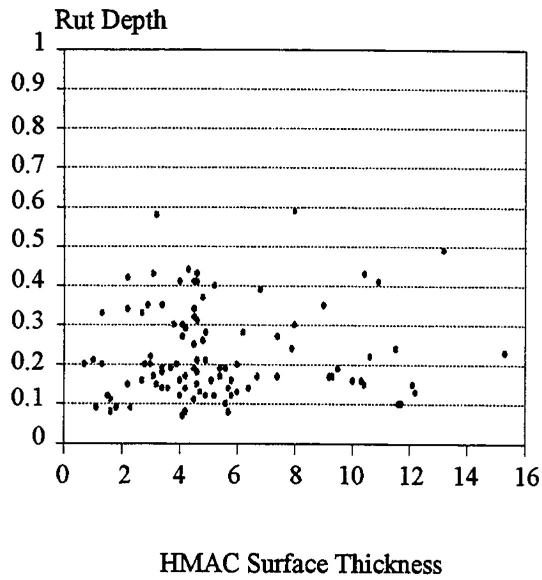
Table 3.4. Correlation Analysis for Significant Variables in the GPS-1 Data Set (SAS Format)

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho=0/Number of Observations

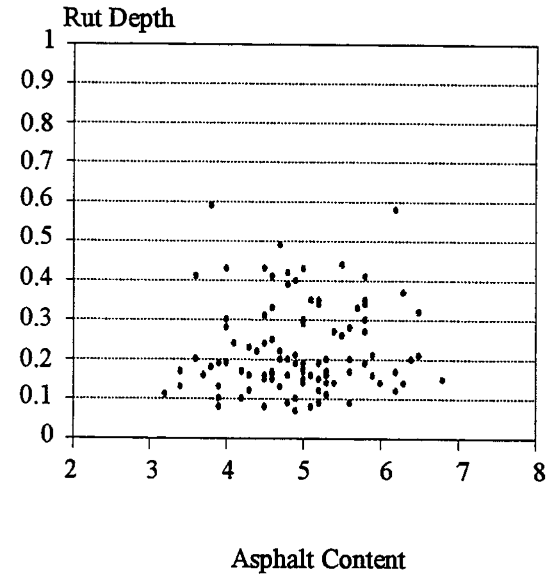
	AV	%4	A_CONB	AVB	%200	MOIST	TPREC	AVG90	AVG32	FTIN	FRZTH	%CEM
AVG32	-0.31564	-0.07580	-0.37649	-0.26301	0.08706	0.02033	-0.44604	-0.59569	1.00000	0.81919	0.91644	0.20840
	0.0012	0.4400	0.0925	0.2494	0.3795	0.8361	0.0001	0.0001	0.0	0.0001	0.0001	0.1101
	103	106	21	21	104	106	122	122	122	122	122	60
FTIN	-0.24035	0.01232	-0.39430	-0.33896	0.02527	-0.07416	-0.37385	-0.54919	0.81919	1.00000	0.53634	0.21421
	0.0145	0.9003	0.0769	0.1328	0.7990	0.4499	0.0001	0.0001	0.0001	0.0	0.0001	0.1003
	103	106	21	21	104	106	122	122	122	122	122	60
FRZTH	-0.29330	-0.11597	-0.36915	-0.24351	0.07429	0.08426	-0.42971	-0.48896	0.91644	0.53634	1.00000	0.16921
	0.0026	0.2365	0.0996	0.2875	0.4536	0.3905	0.0001	0.0001	0.0001	0.0001	0.0	0.1962
	103	106	21	21	104	106	122	122	122	122	122	60
%CEM	-0.18453	0.01045	1.00000	-1.00000	0.15263	0.11381	0.23312	-0.01725	0.20840	0.21421	0.16921	1.00000
	0.1995	0.9414			0.2705	0.4126	0.0730	0.8959	0.1101	0.1003	0.1962	0.0
	50	52	2	2	54	54	60	60	60	60	60	60

Table 3.5. Frequency Table by Environmental Region for the GPS-2 Data Set (SAS Format)

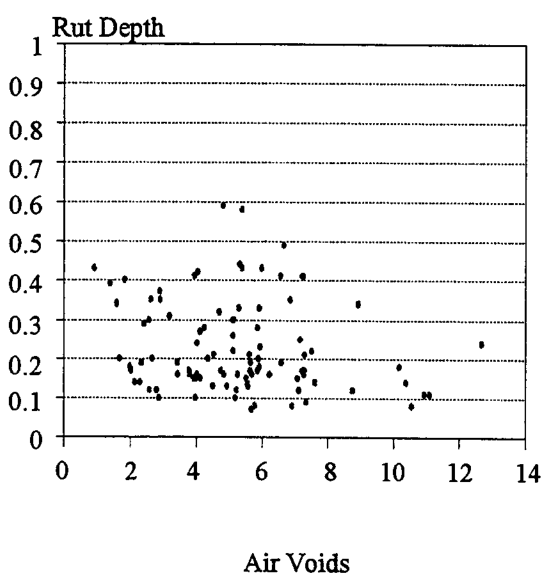
Frequency Percent Row Percent Column Percent	Freeze	No-Freeze	Total
Dry	21 16.15 48.84 42.00	22 16.92 51.16 27.50	43 33.08
Wet	29 22.31 33.33 58.00	58 44.62 66.67 72.50	87 66.92
Total	50 38.46	80 61.54	130 100.00



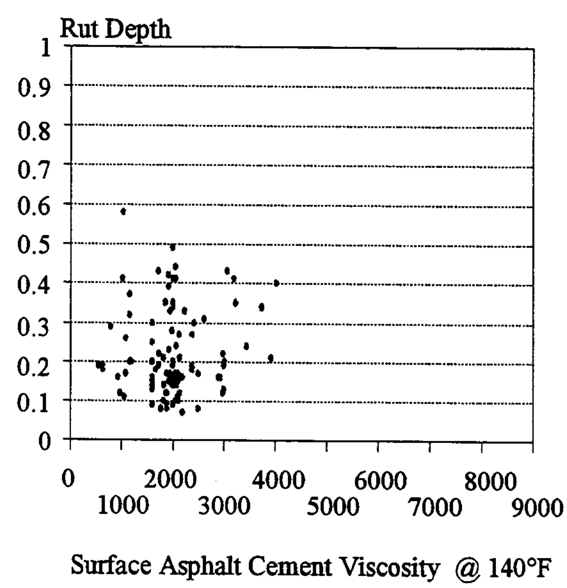
a. **Rut Depth vs. HMAC Surface Thick.**



b. **Rut Depth vs. Asphalt Content**

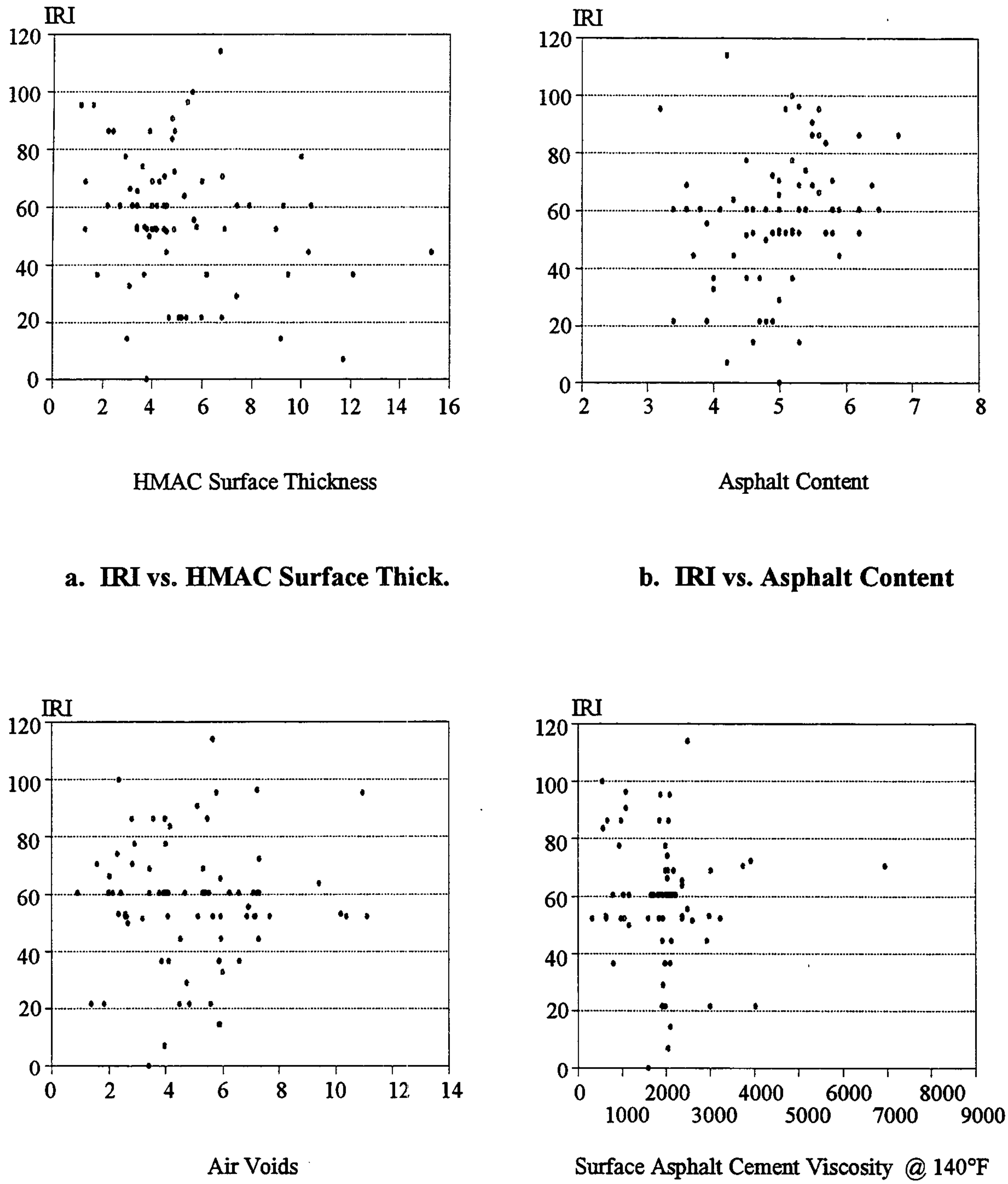


c. **Rut Depth vs. Air Voids**



d. **Rut Depth vs. Visc. @ 140°F**

Figure 3.2. Rut Depth Scatter Plots for GPS-2 Test Sections



a. IRI vs. HMAC Surface Thick.

b. IRI vs. Asphalt Content

c. IRI vs. Air Voids

d. IRI vs. Visc. @ 140°F

Figure 3.3. IRI Scatter Plots for GPS-2 Test Sections

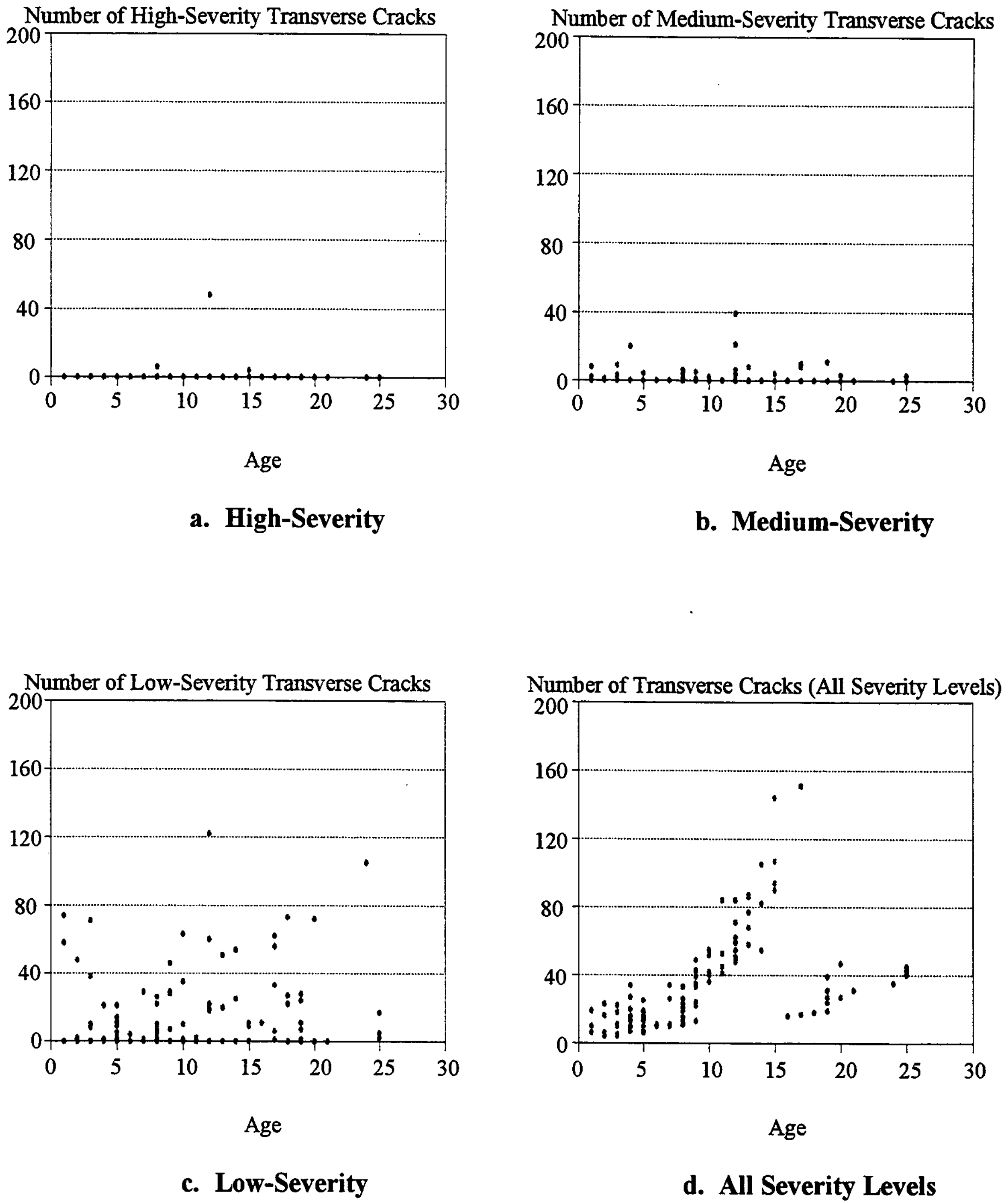
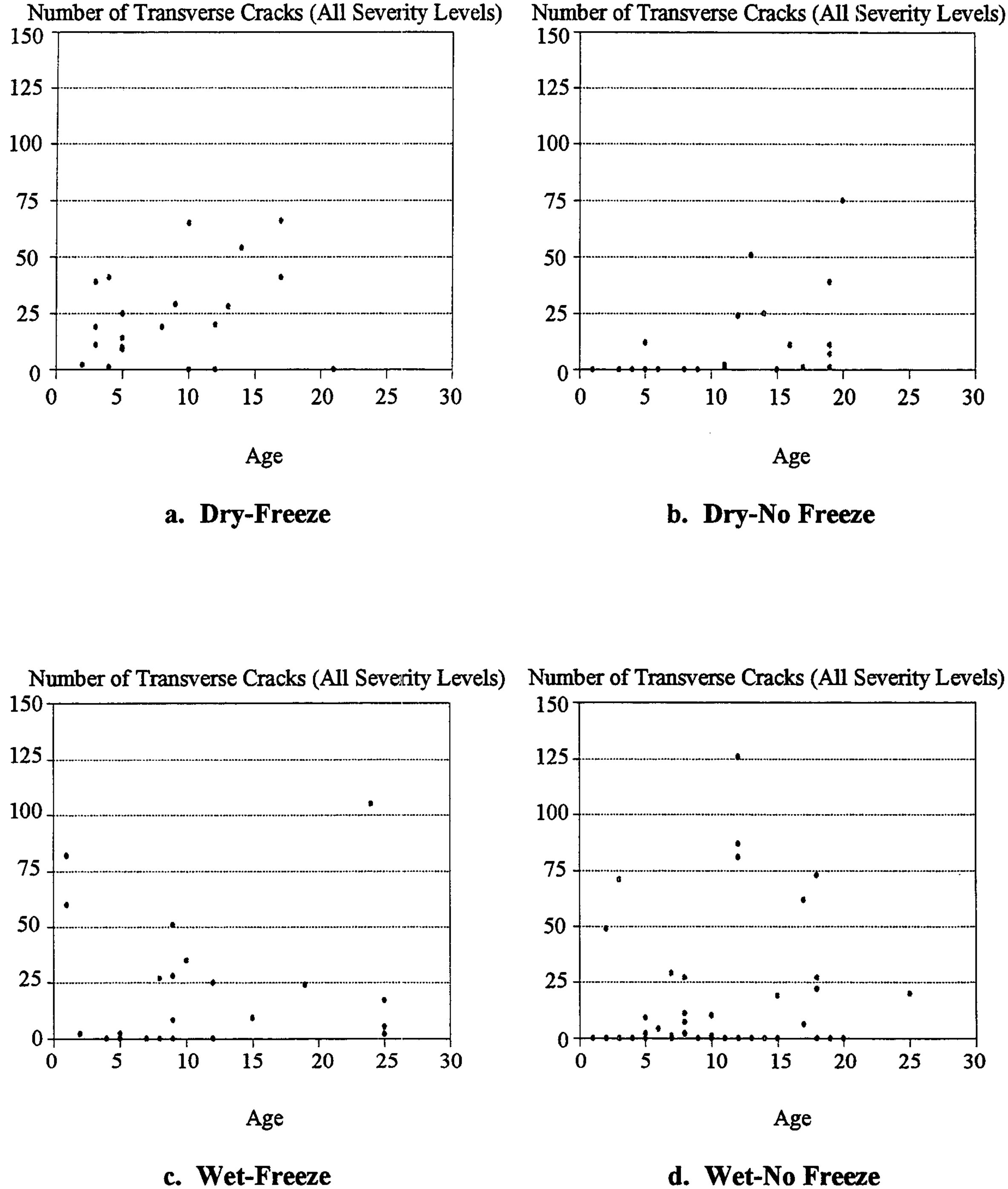


Figure 3.4. Number of Transverse Cracks vs. Age for GPS-2 Test Sections



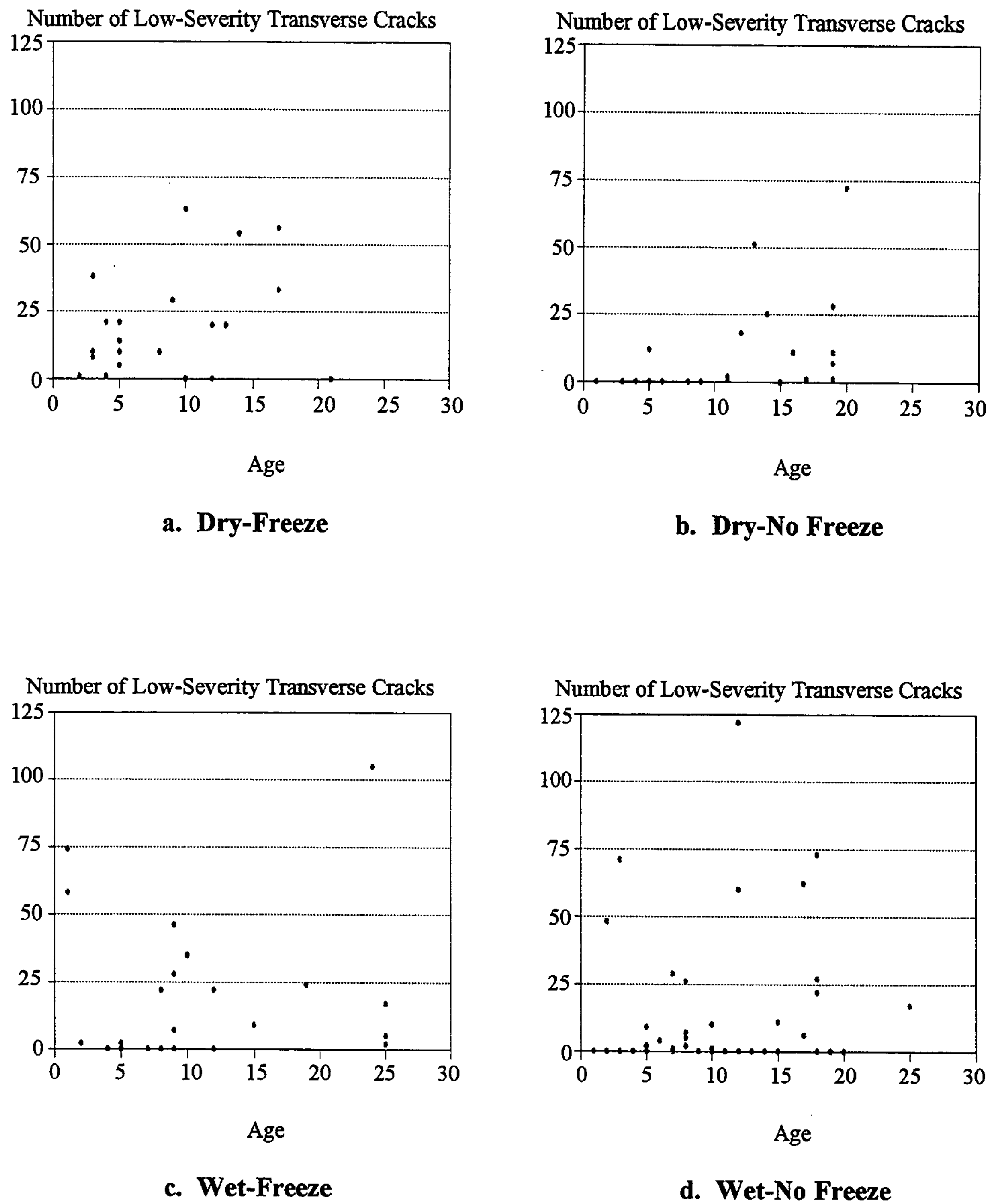
a. Dry-Freeze

b. Dry-No Freeze

c. Wet-Freeze

d. Wet-No Freeze

Figure 3.5. Number of Transverse Cracks (All Severity Levels) vs. Age for GPS-2 Test Sections



a. **Dry-Freeze**

b. **Dry-No Freeze**

c. **Wet-Freeze**

d. **Wet-No Freeze**

Figure 3.6. Number of Low-Severity Transverse Cracks vs. Age for GPS-2 Test Sections

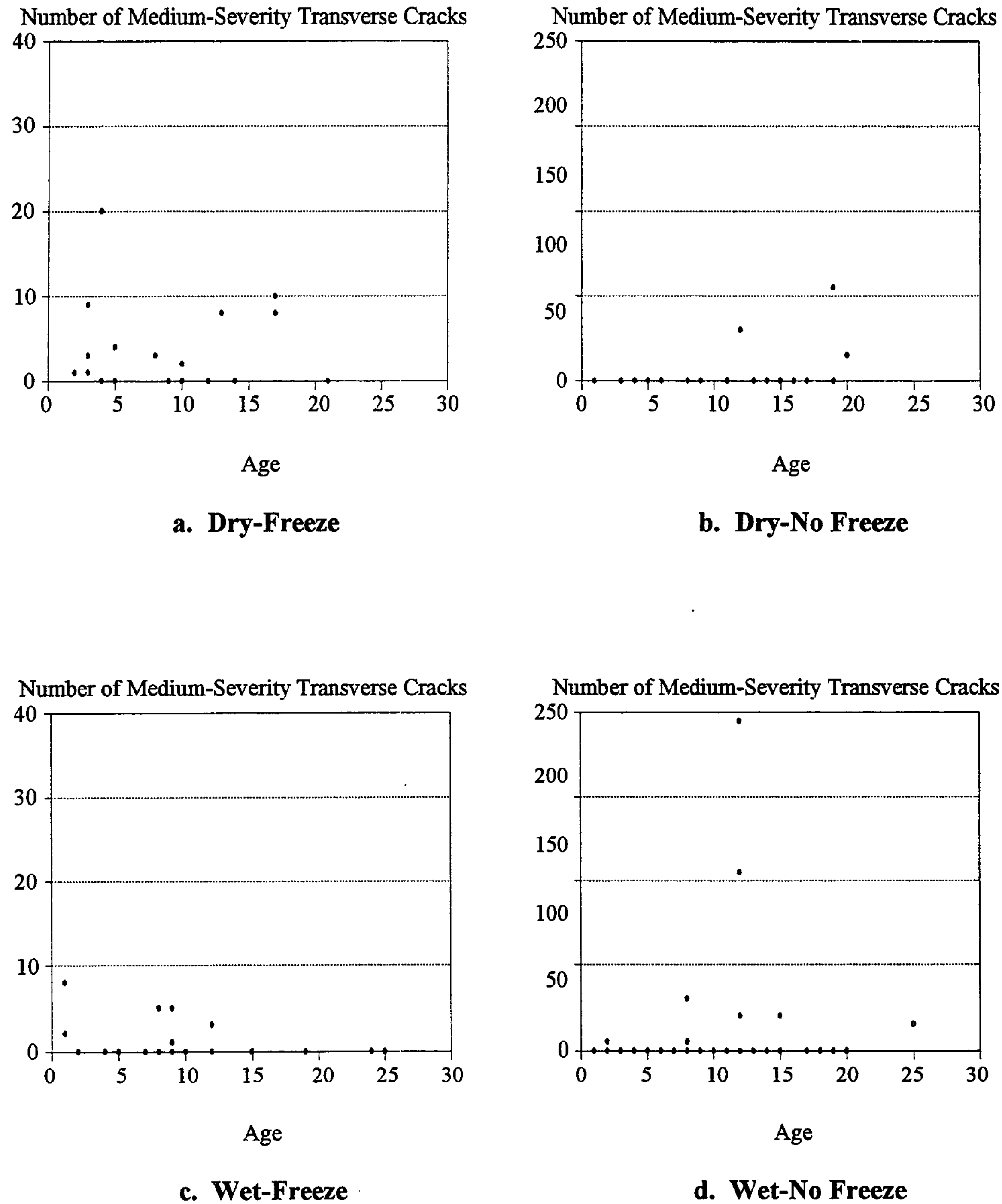


Figure 3.7. Number of Medium-Severity Transverse Cracks vs. Age for GPS-2 Test Sections

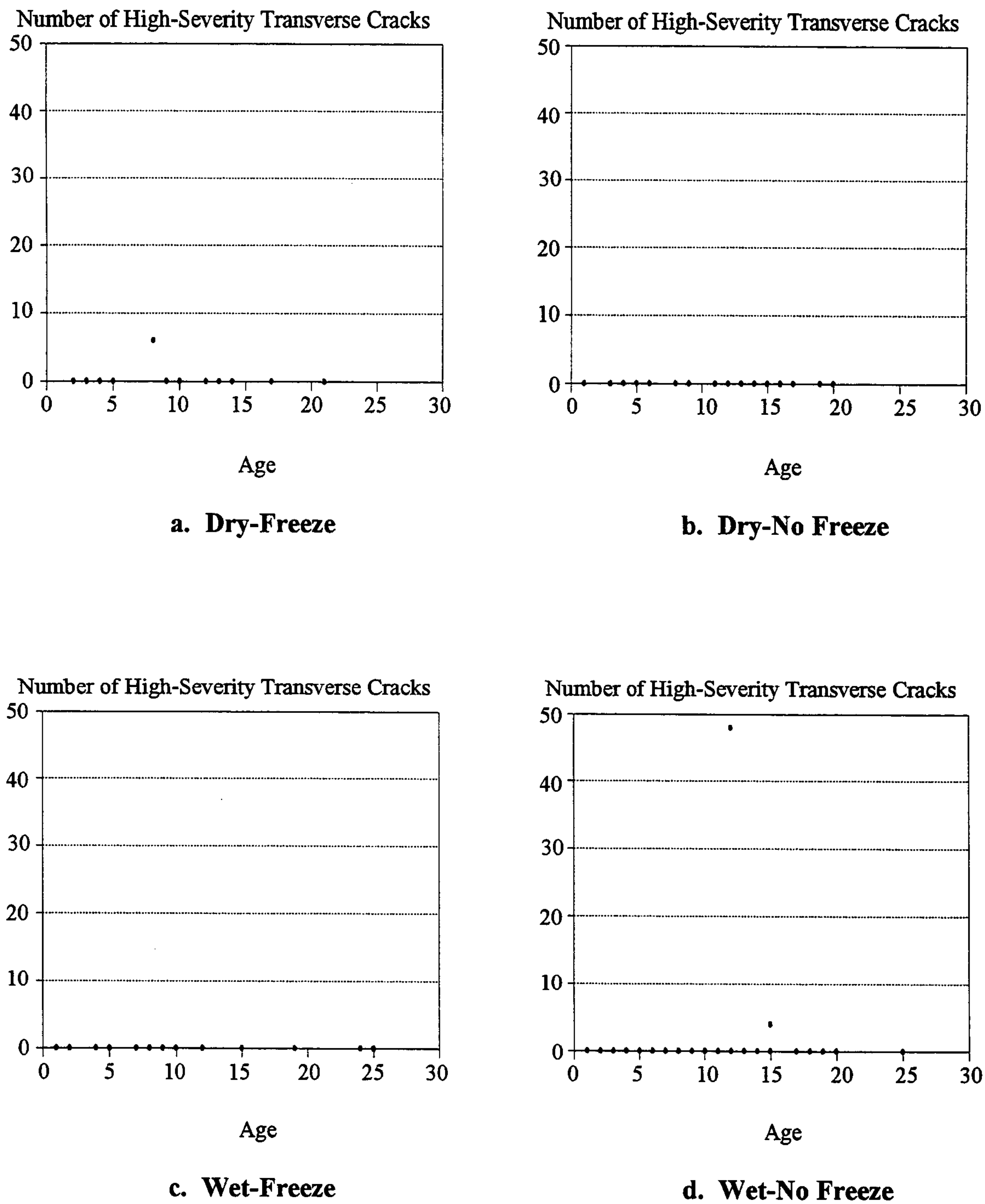
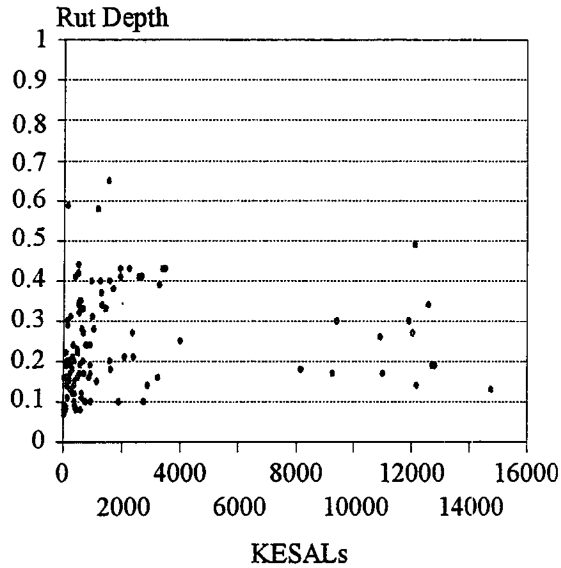
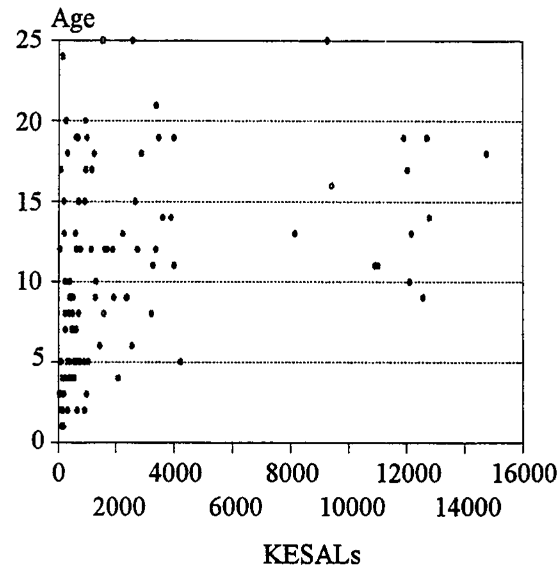


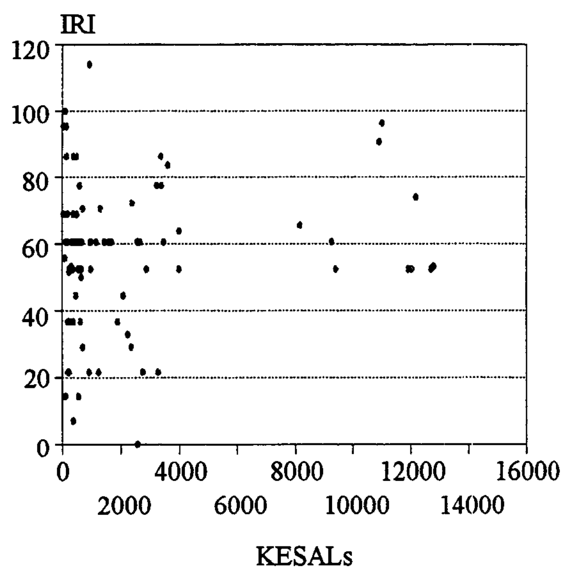
Figure 3.8. Number of High-Severity Transverse Cracks vs. Age for GPS-2 Test Sections



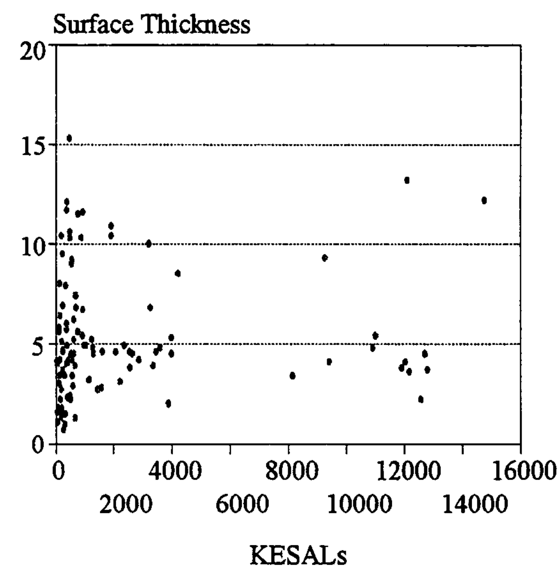
a. Rut Depth vs. KESALs



b. Age vs. KESALs



c. IRI vs. KESALs



d. Surface Thick. vs. KESALs

Figure 3.9. KESALs Scatter Plots for GPS-2 Test Sections

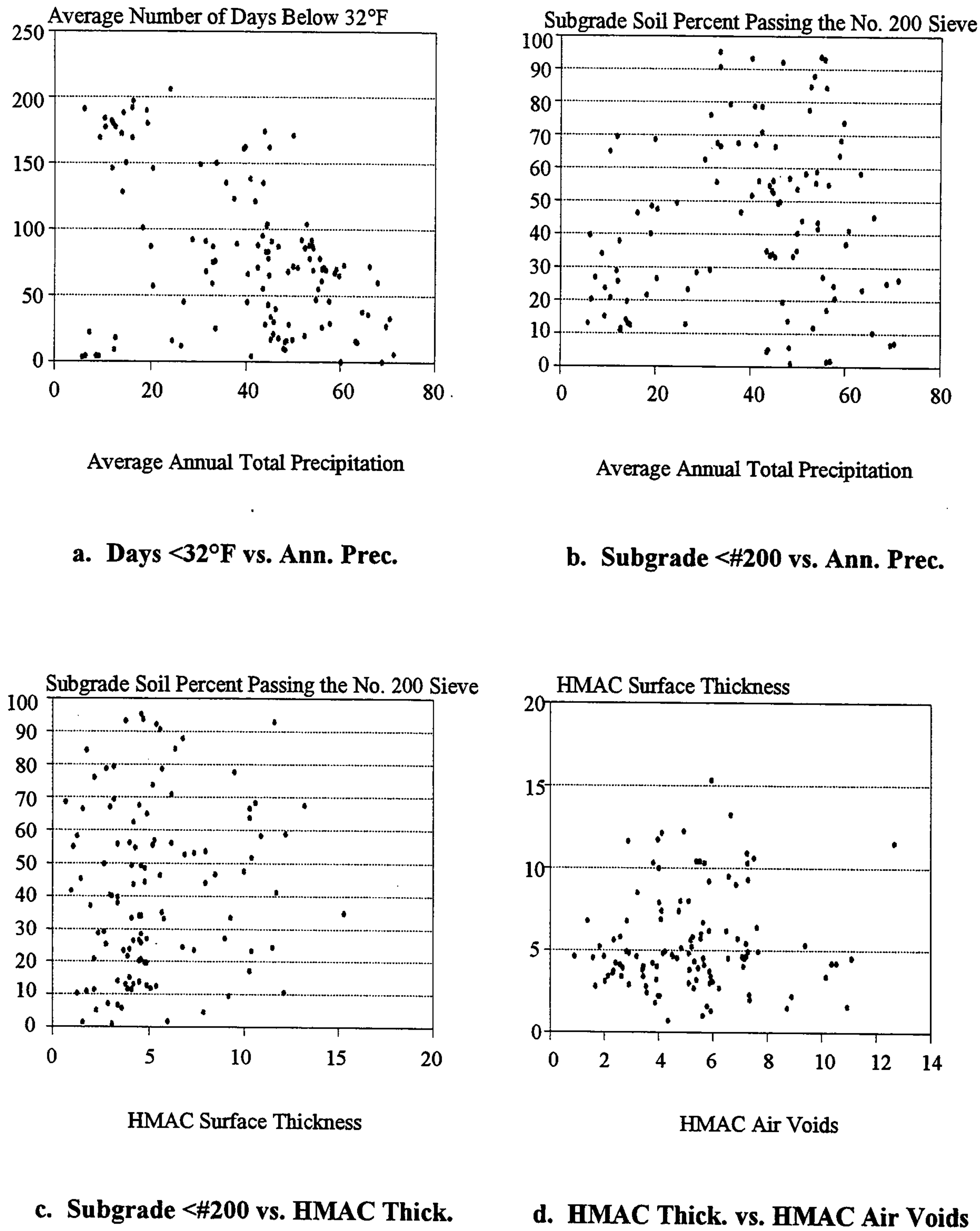


Figure 3.10. Scatter Plots for GPS-2 Test Sections

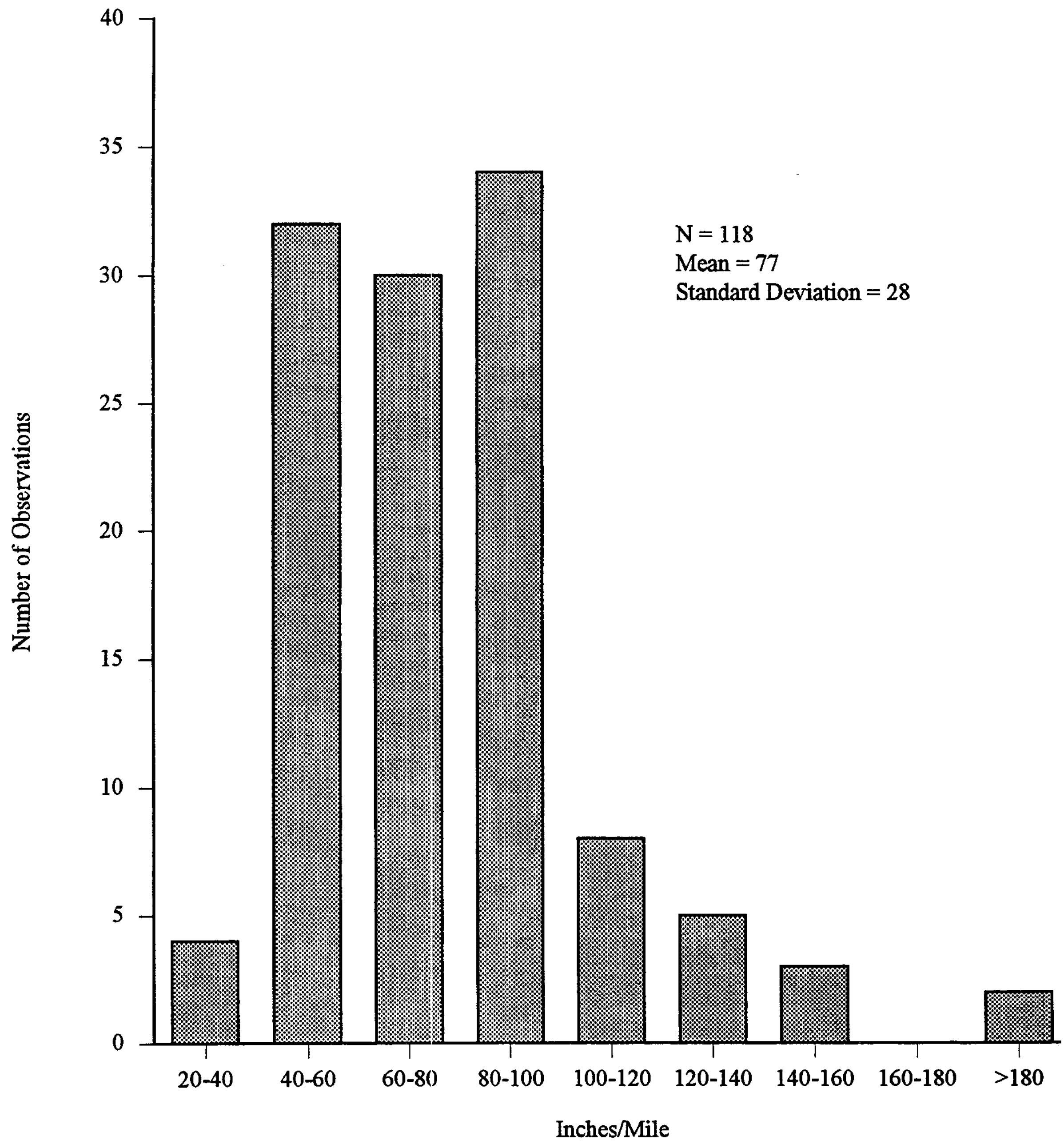


Figure 3.11. Distribution of Measured International Roughness Index for GPS-2 Test Sections

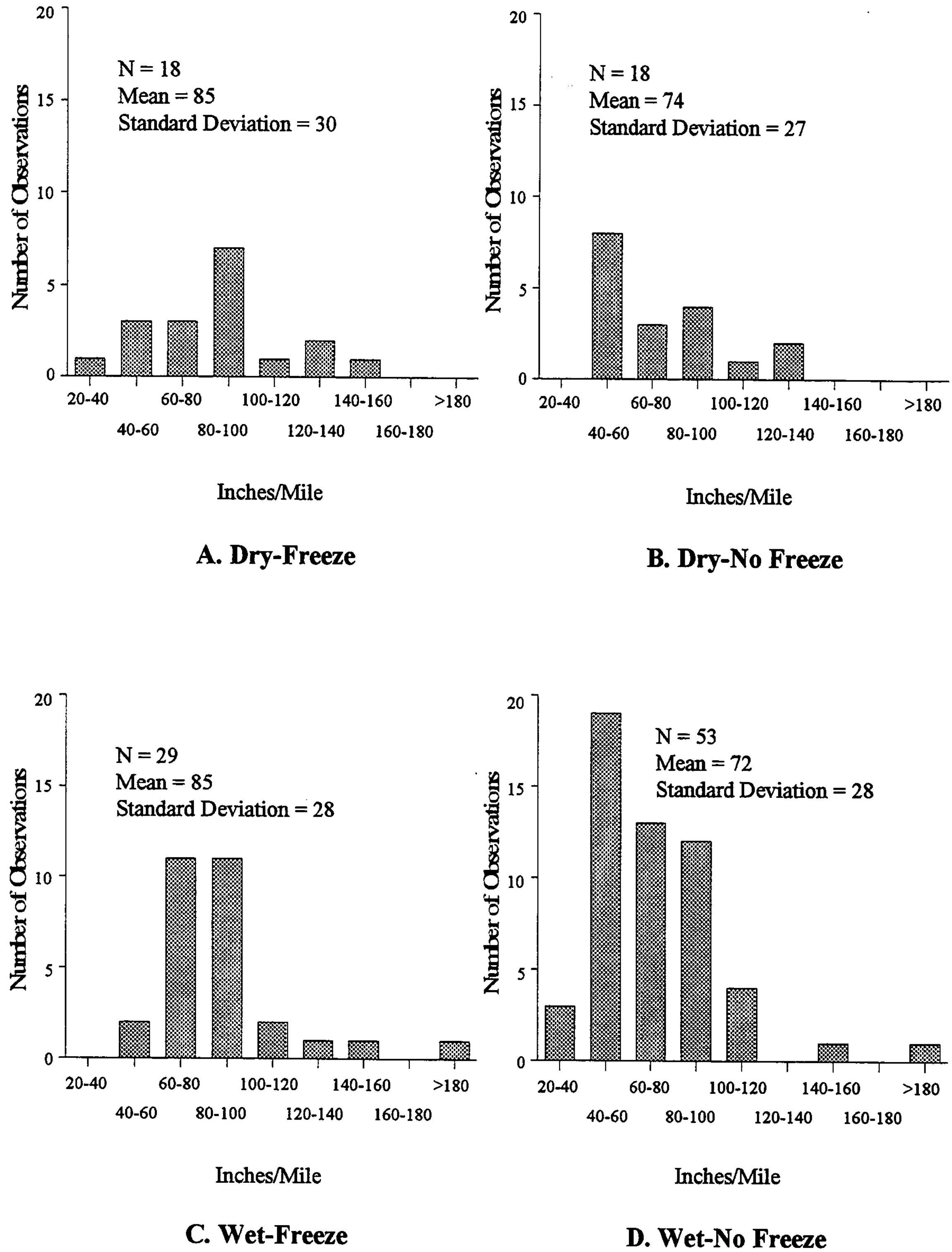


Figure 3.12. Distributions of Measured International Roughness Index (IRI) by Environmental Regions for GPS-2 Test Sections

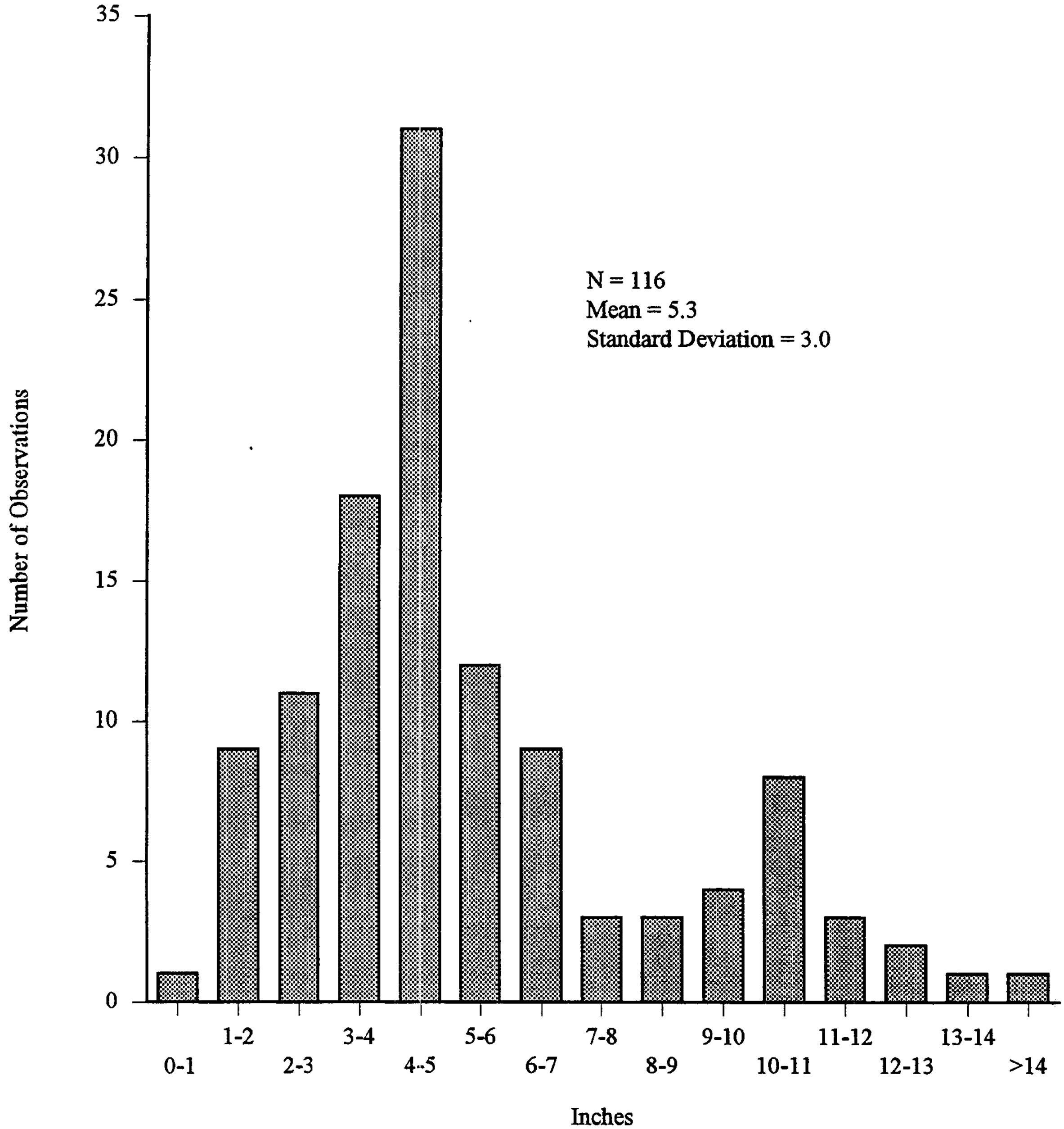
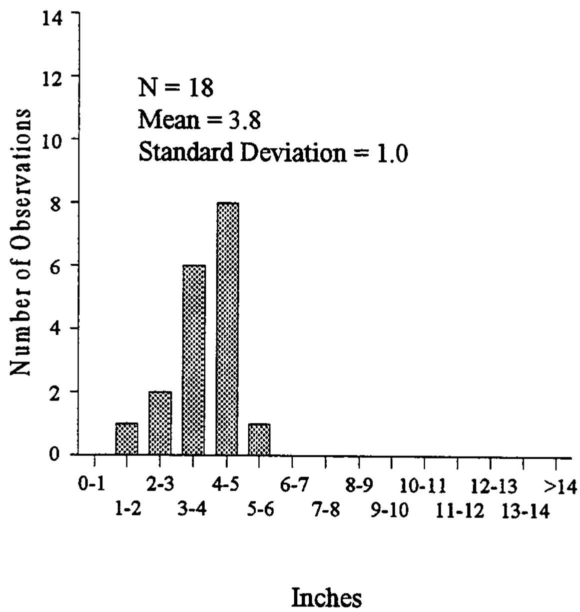
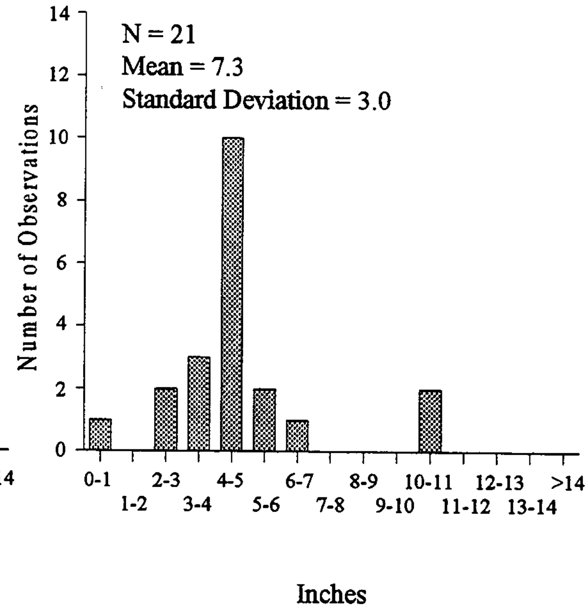


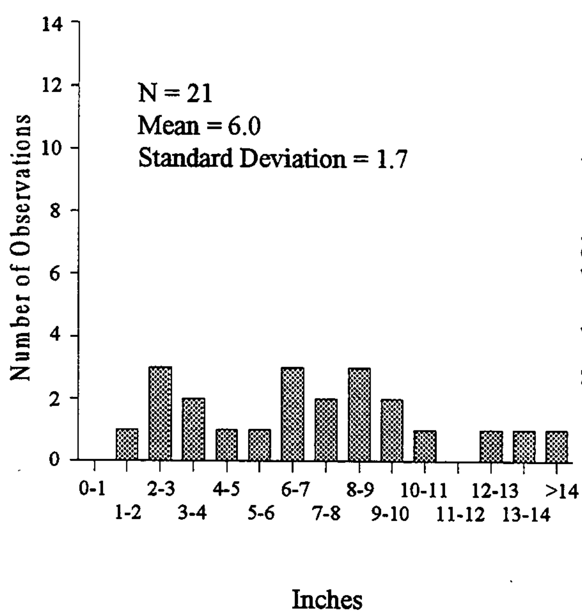
Figure 3.13. Distribution of HMAC Thickness for GPS-2 Test Sections



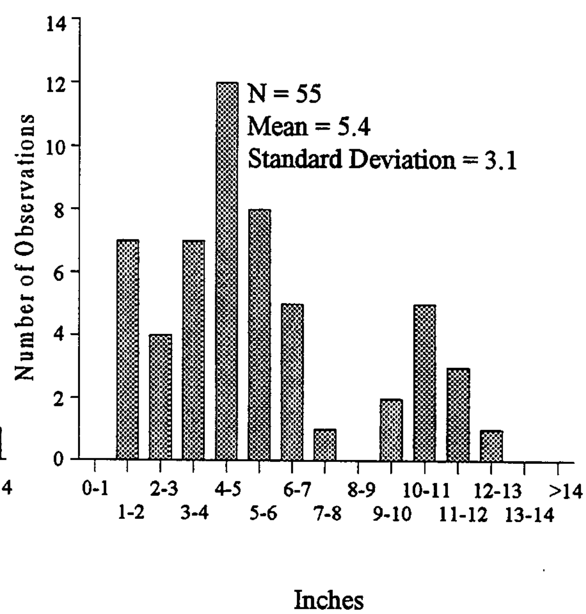
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 3.14. Distributions of HMAC Thickness by Environmental Regions for GPS-2 Test Sections

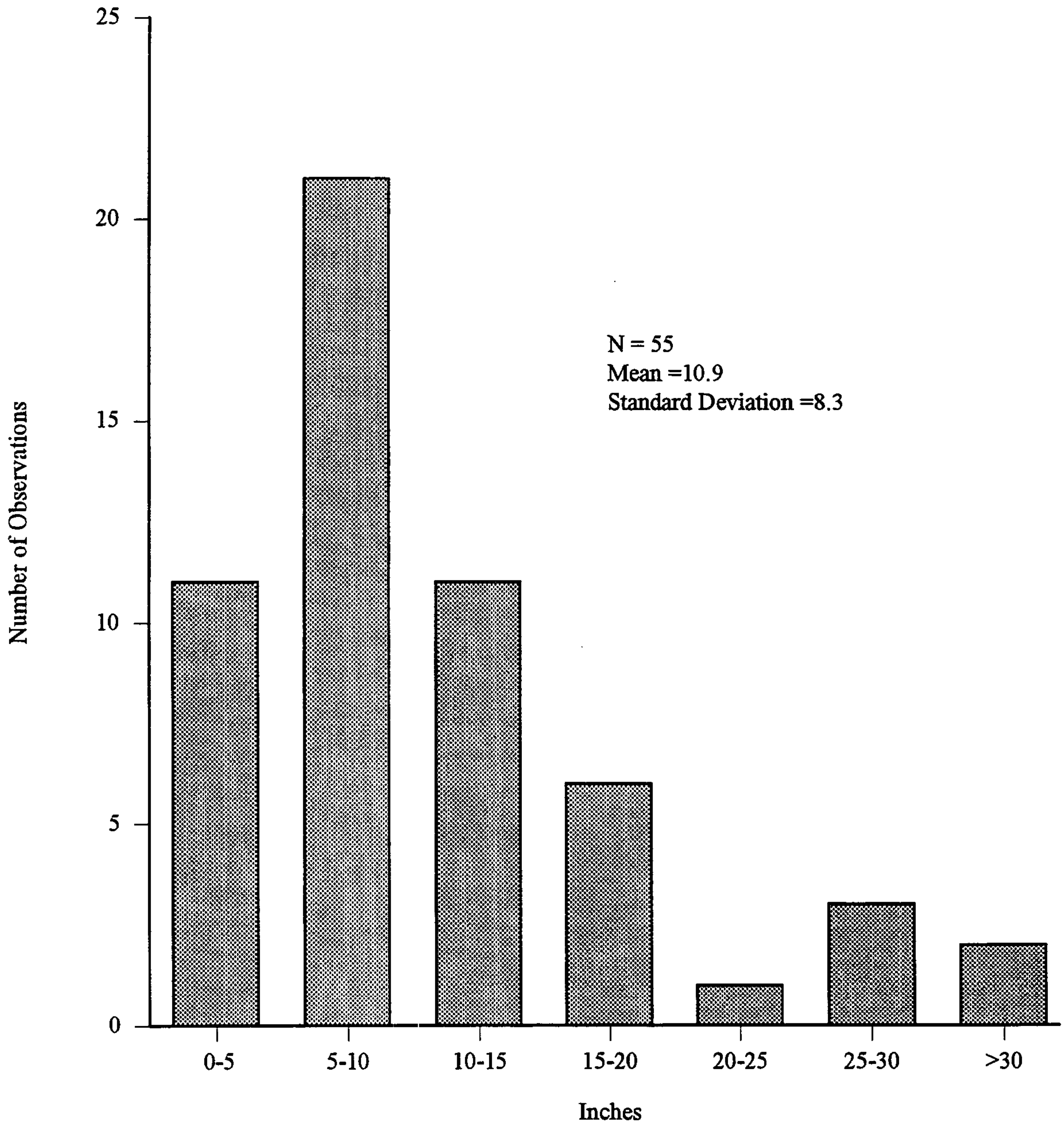


Figure 3.15. Distribution of the Granular Subbase Thickness for GPS-2 Test Sections

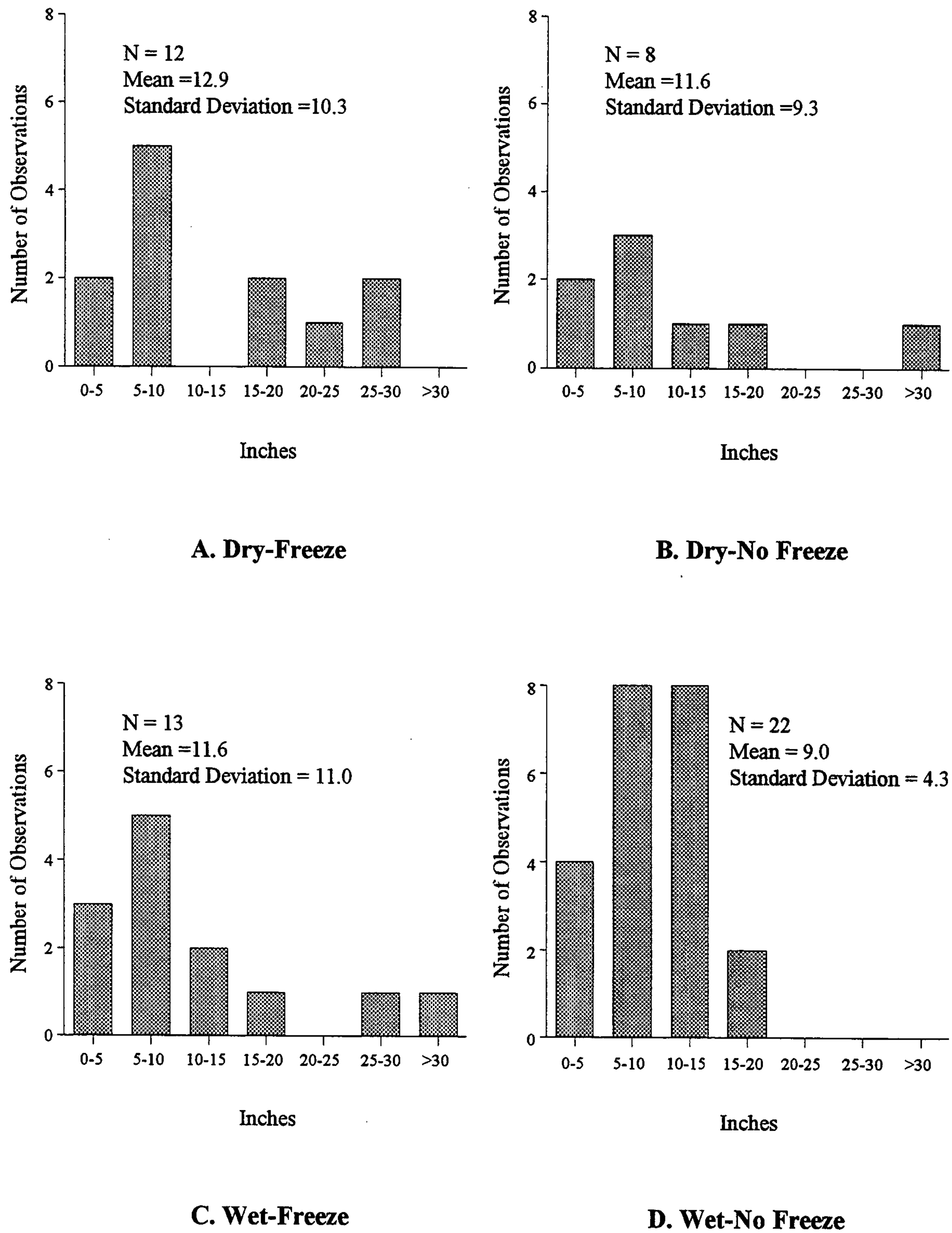


Figure 3.16. Distributions of Granular Subbase Thickness by Environmental Regions for GPS-2 Test Sections

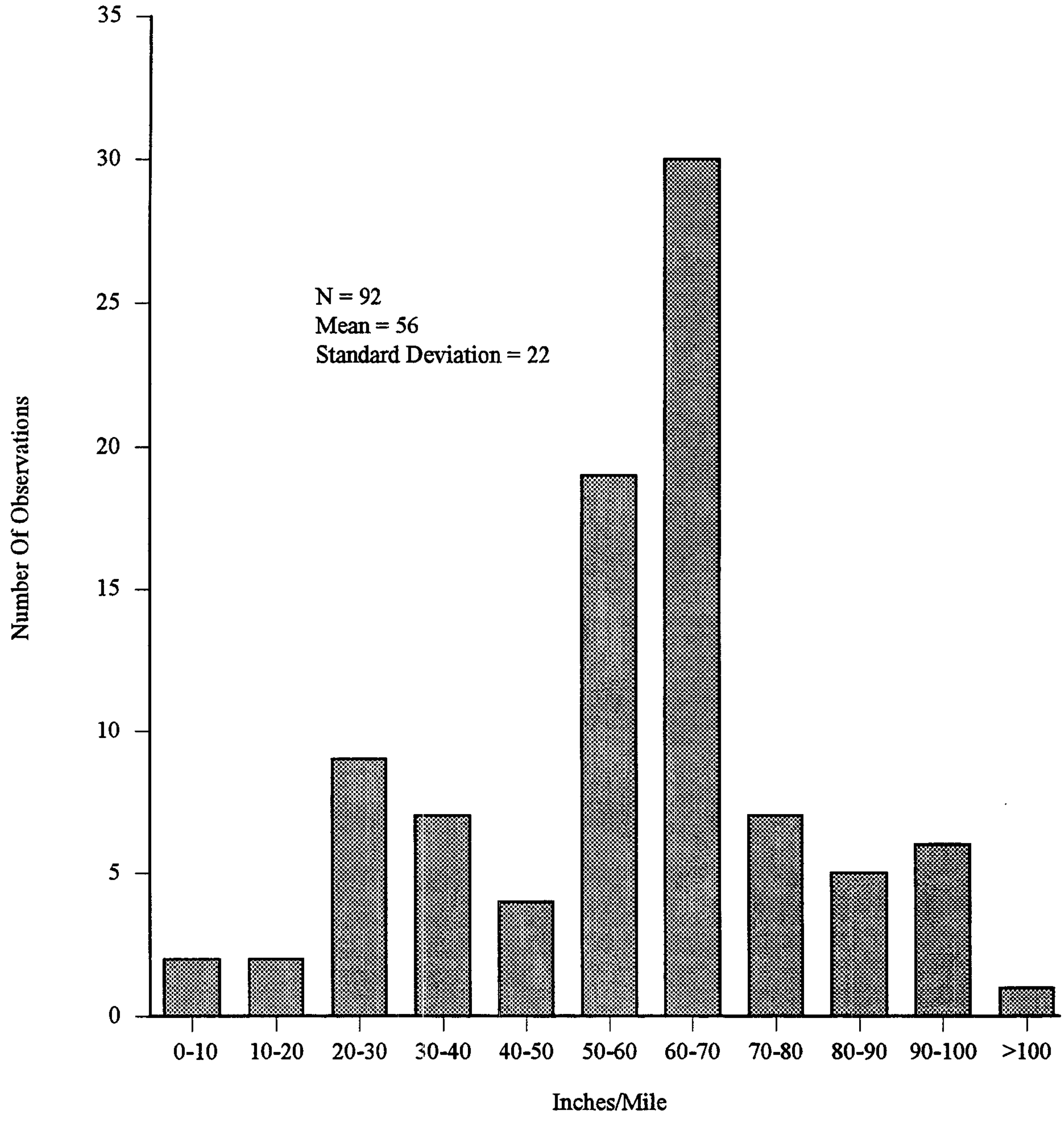


Figure 3.17. Distribution of Initial International Roughness Index (IRI) for GPS-2 Test Sections

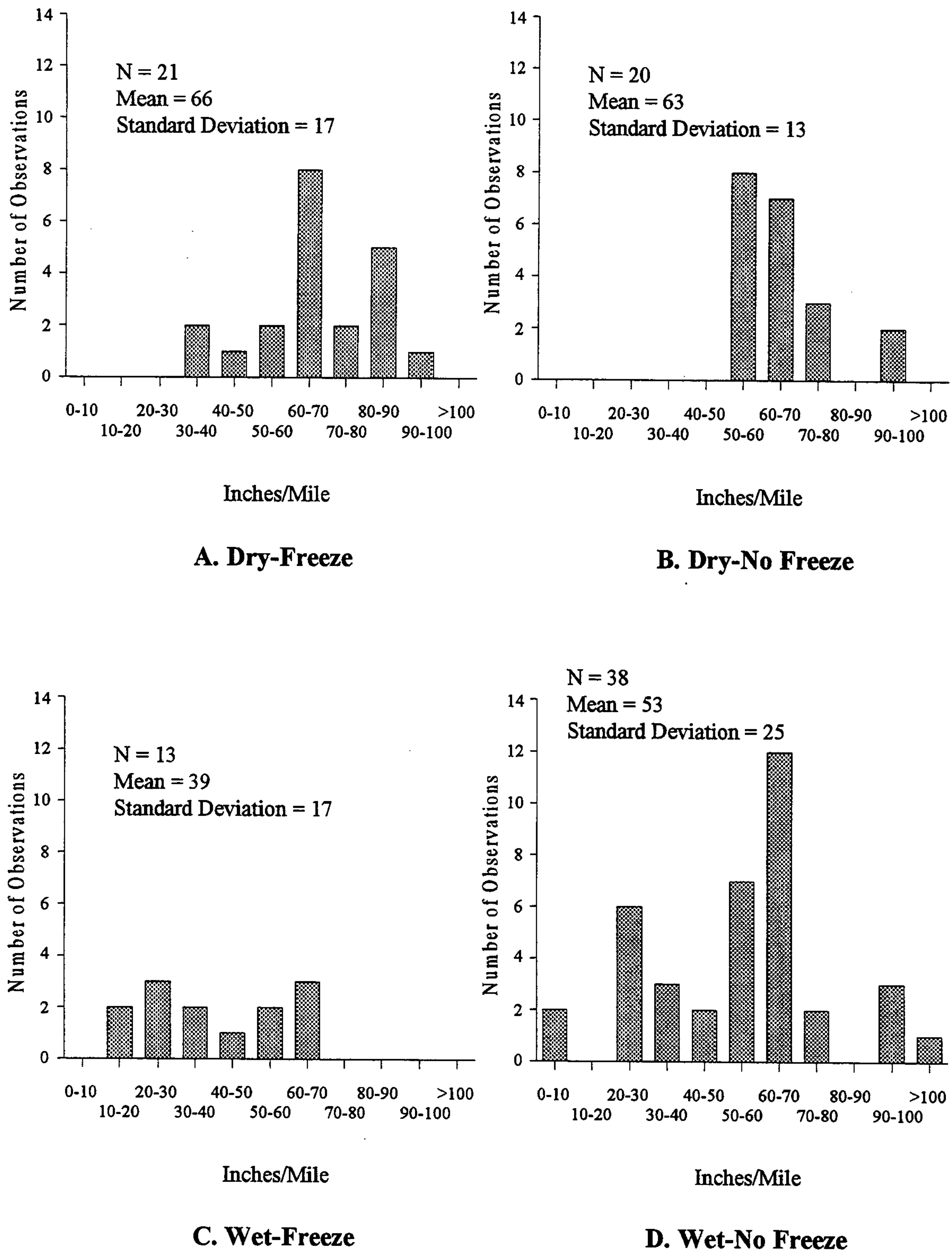


Figure 3.18. Distributions of Initial International Roughness Index (IRI) by Environmental Regions for GPS-2 Test Sections

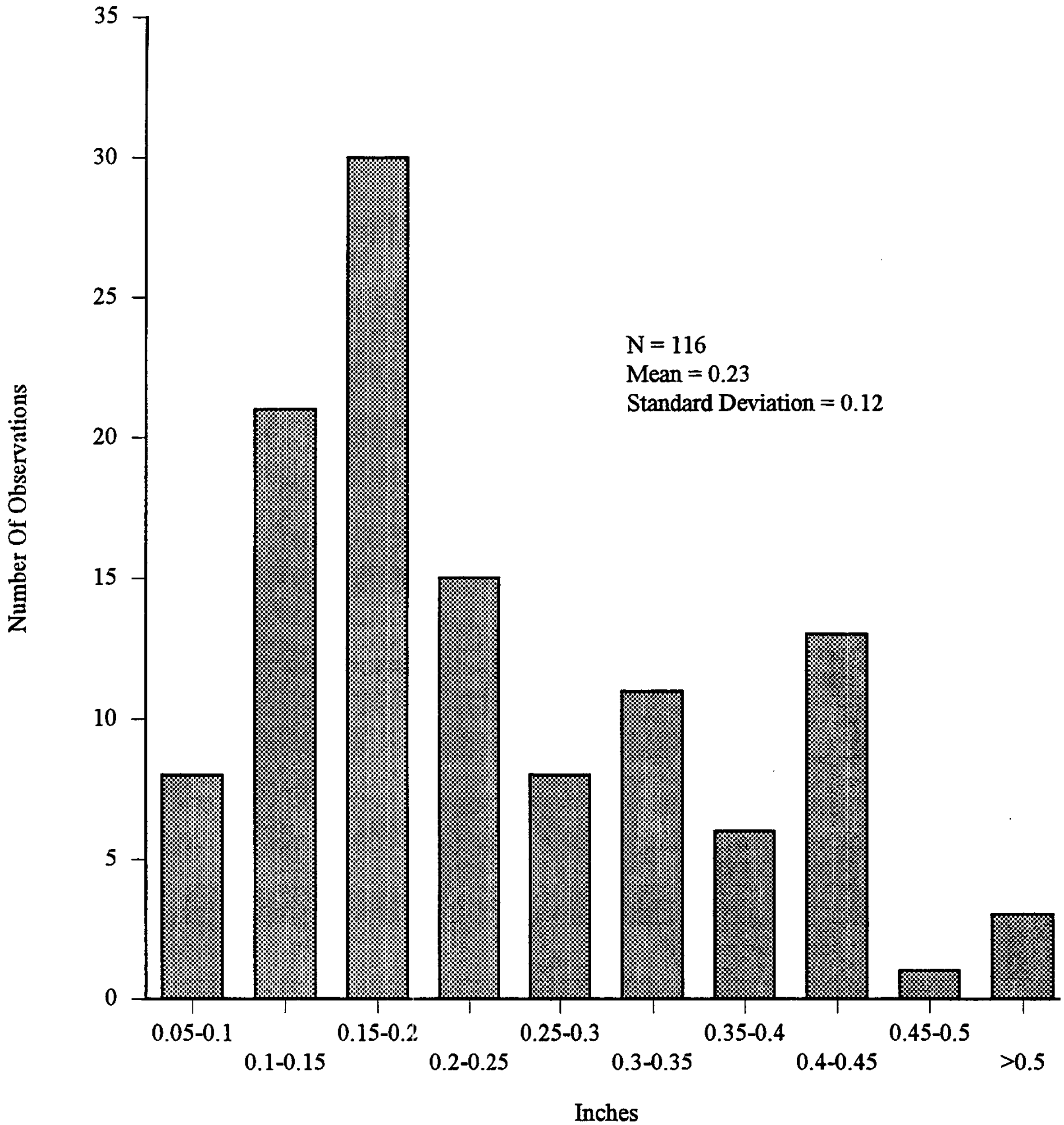


Figure 3.19. Distribution of Rut Depth for GPS-2 Test Sections

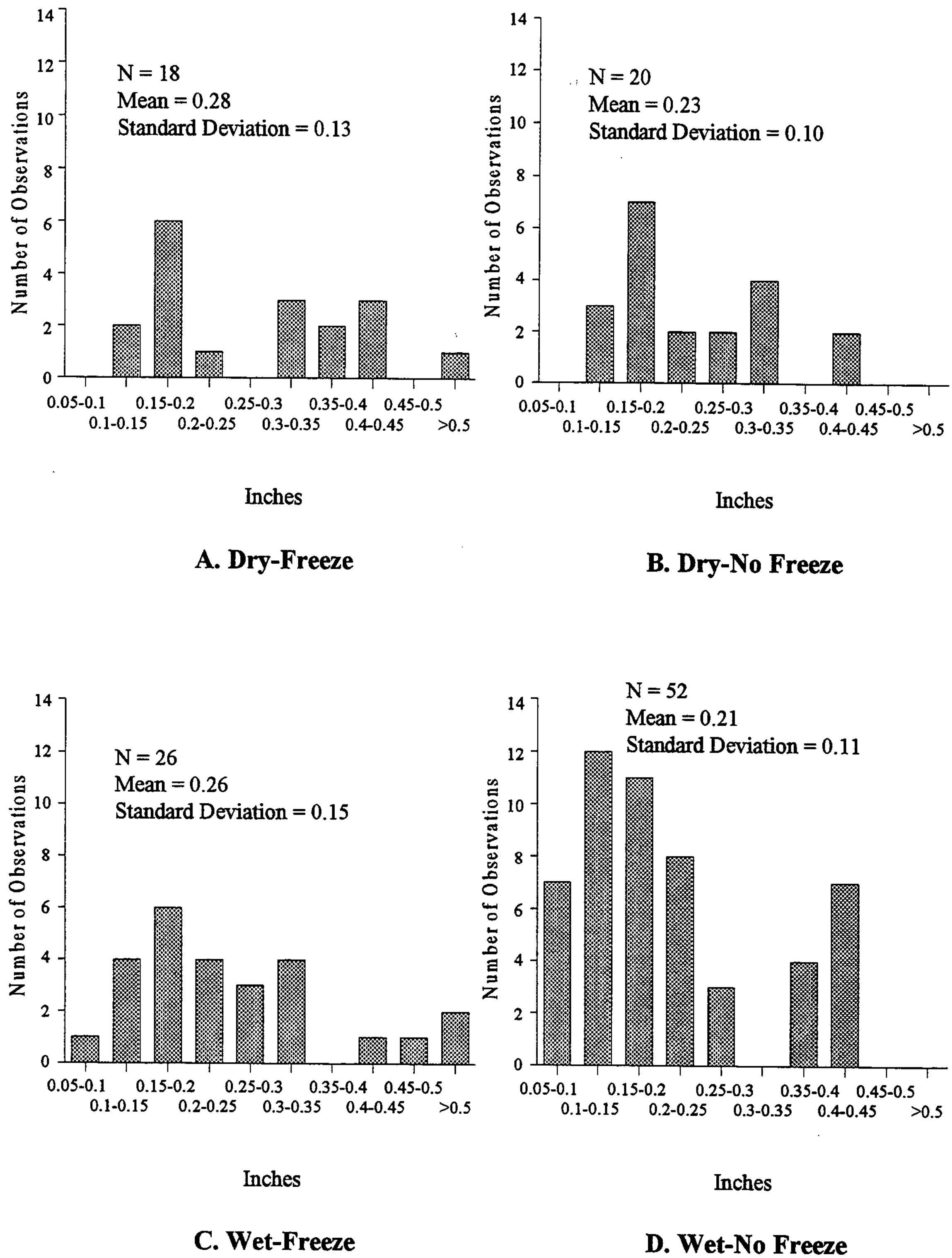


Figure 3.20. Distributions of Rut Depth by Environmental Regions for GPS-2 Test Sections

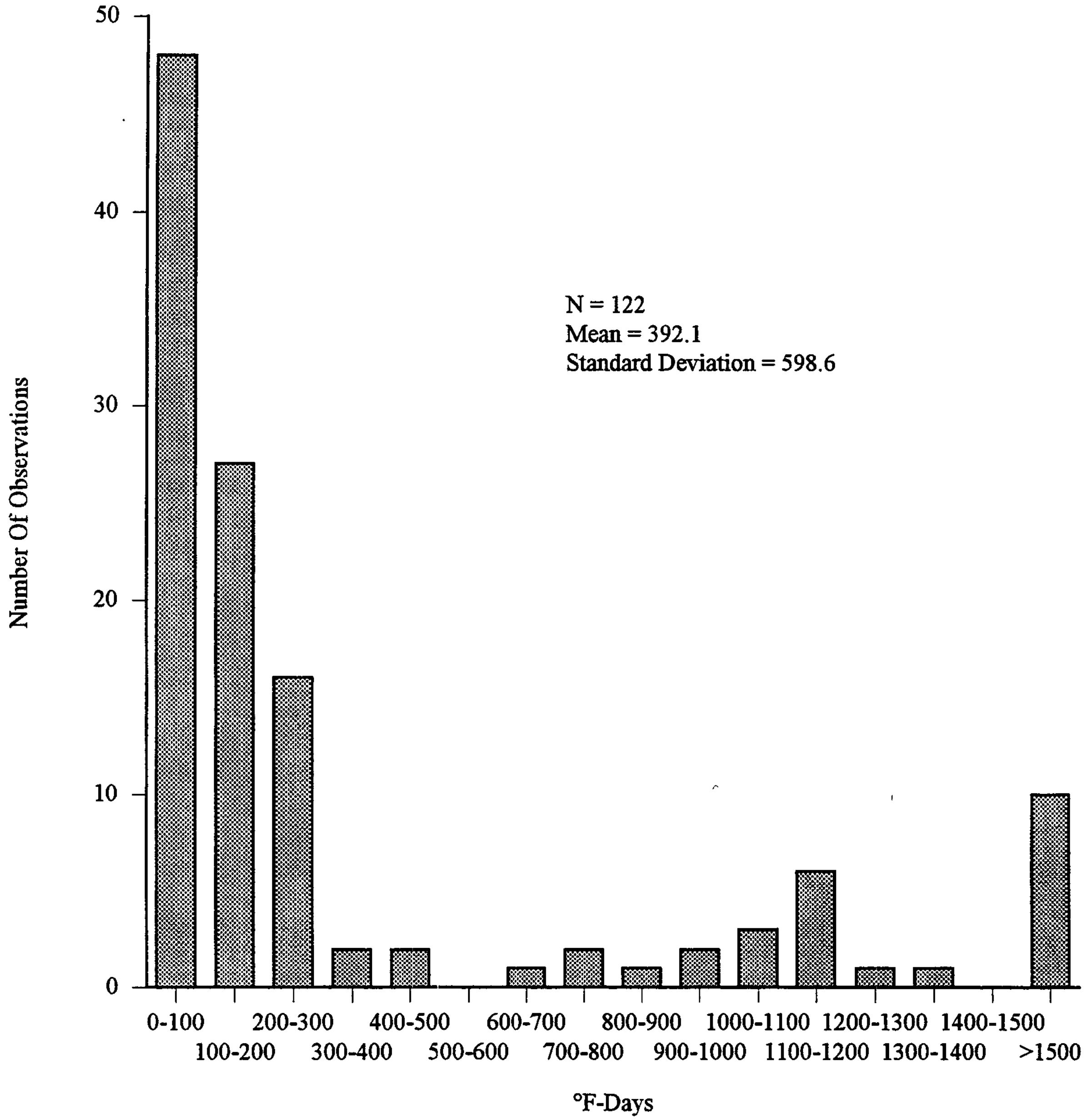


Figure 3.21. Distribution of Freeze Index for GPS-2 Test Sections

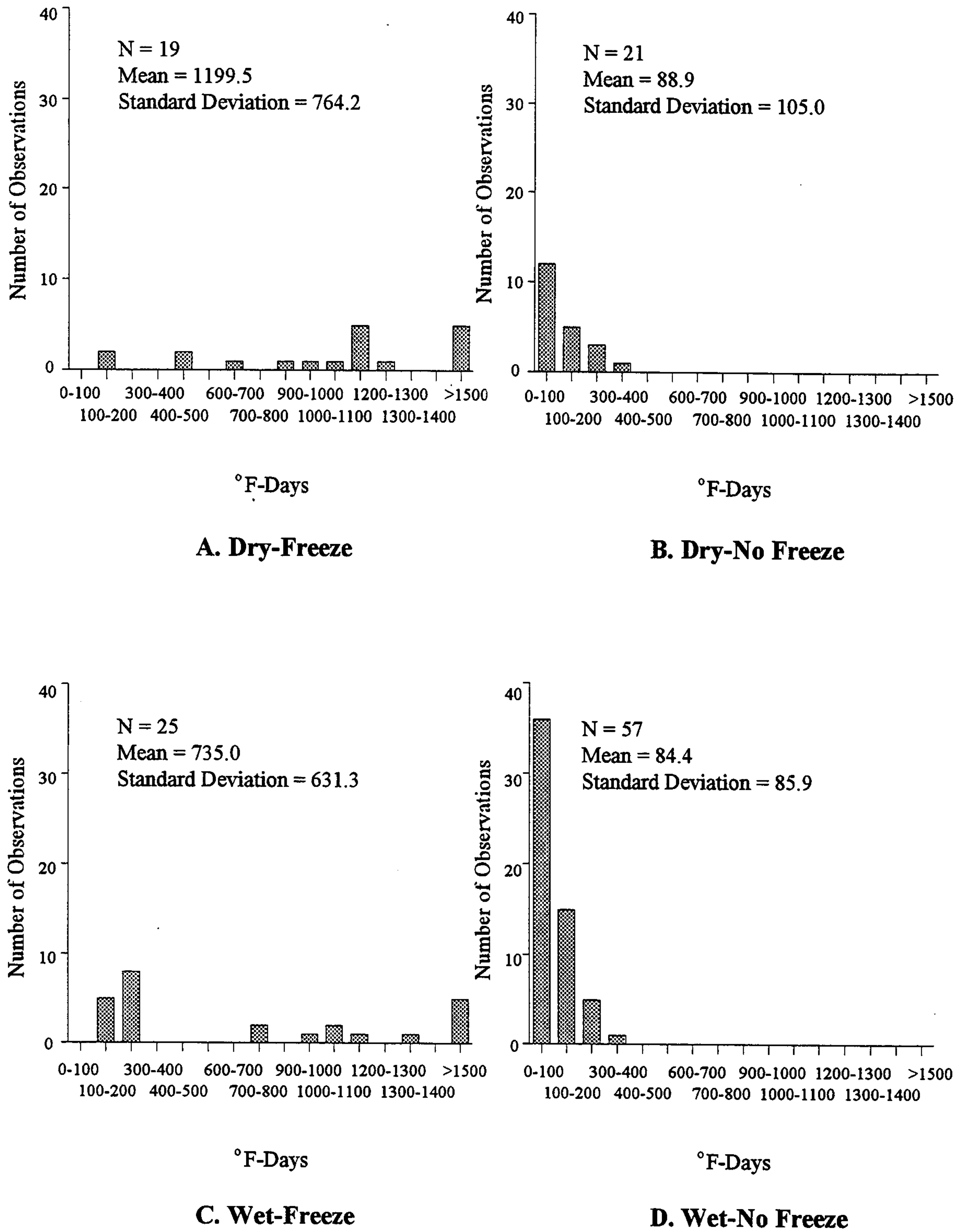


Figure 3.22. Distributions of Freeze Index by Environmental Regions for GPS-2 Test Sections

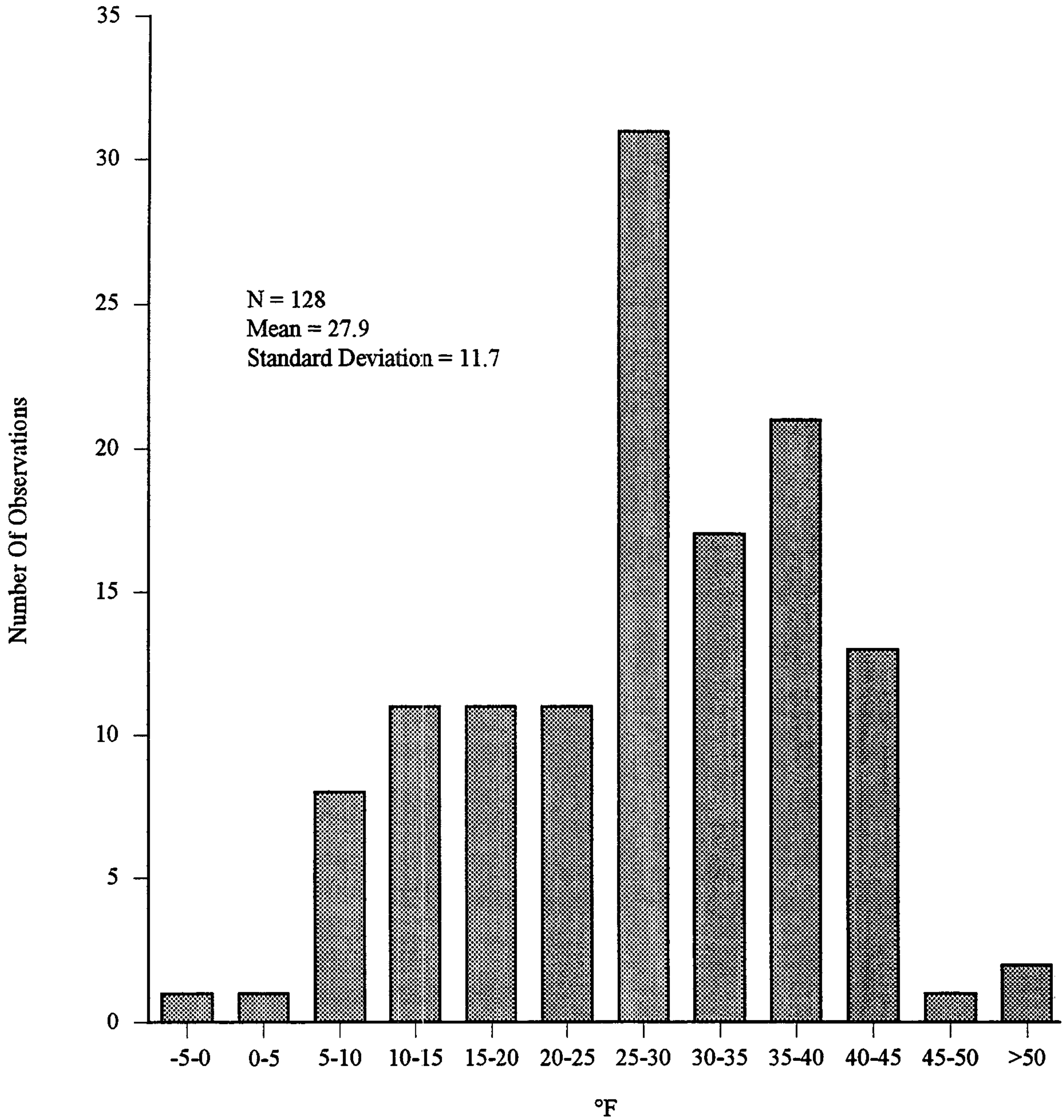


Figure 3.23. Distribution of Average Annual Minumum Temperature (for the Months of December, January and February) for GPS-2 Test Sections

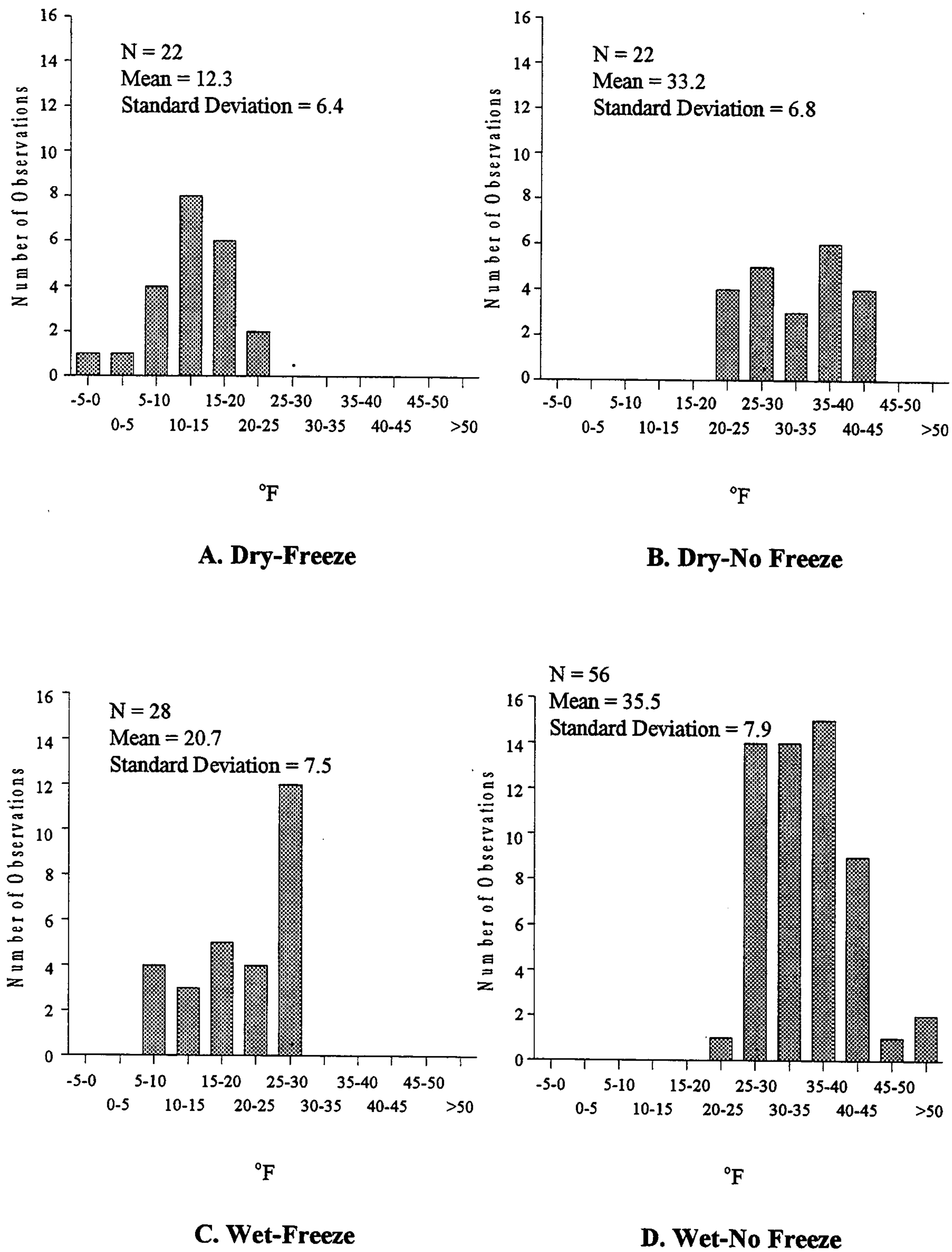


Figure 3.24. Distributions of Average Annual Minumum Temperature (for the Months of December, January and February) by Environmental Regions for GPS-2 Test Sections

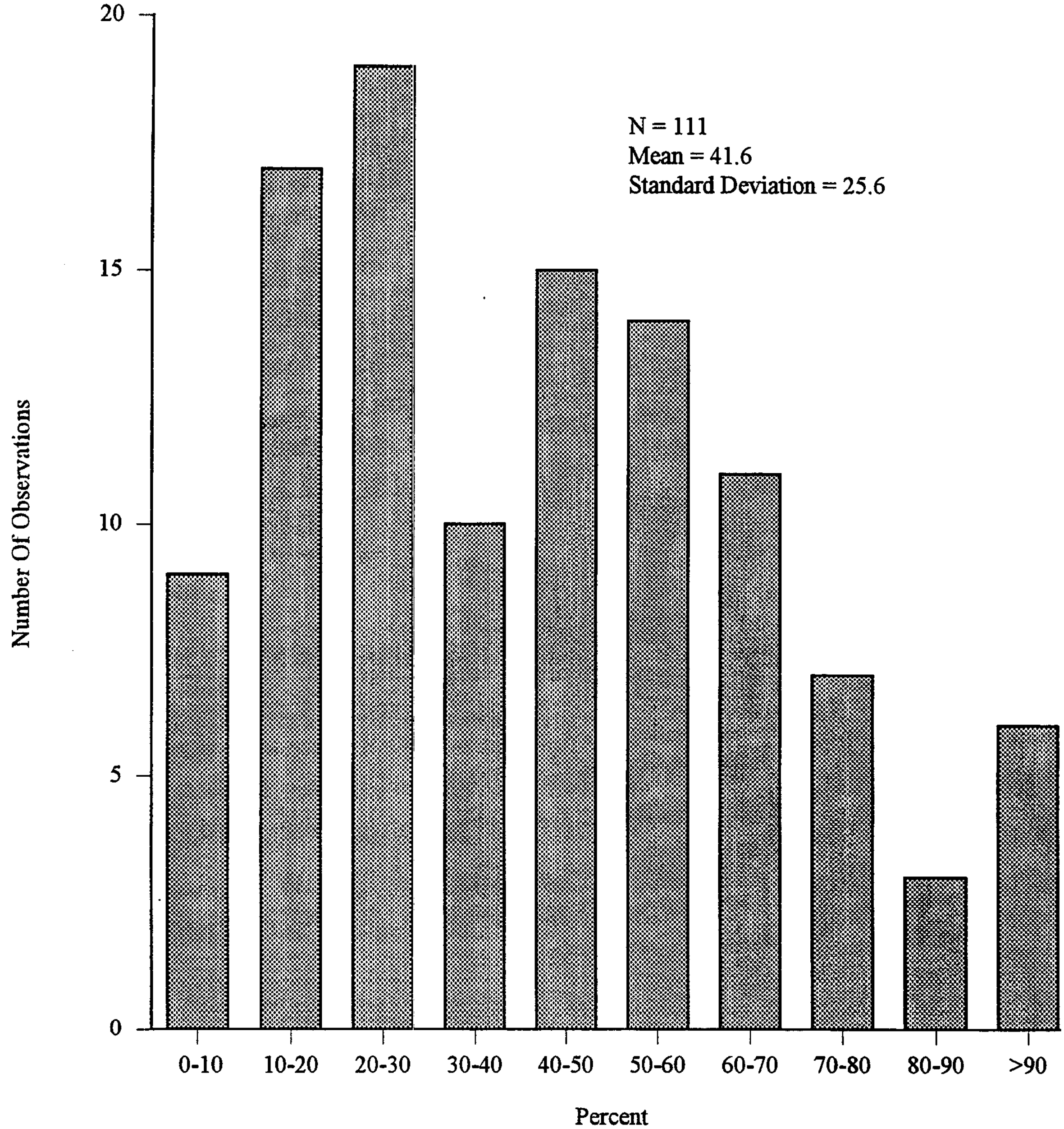
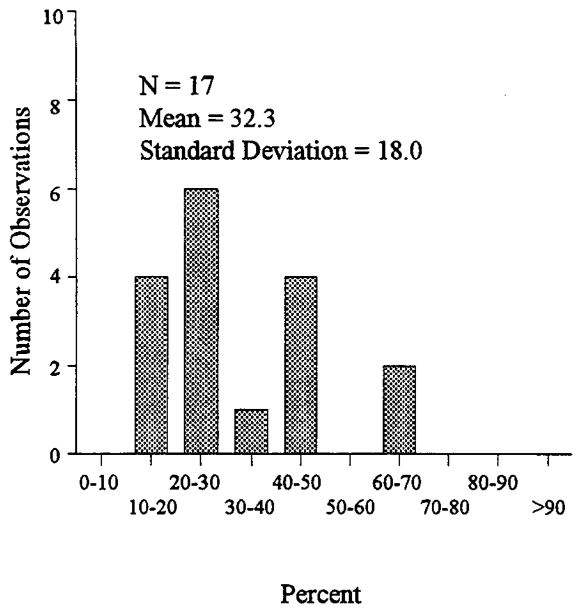
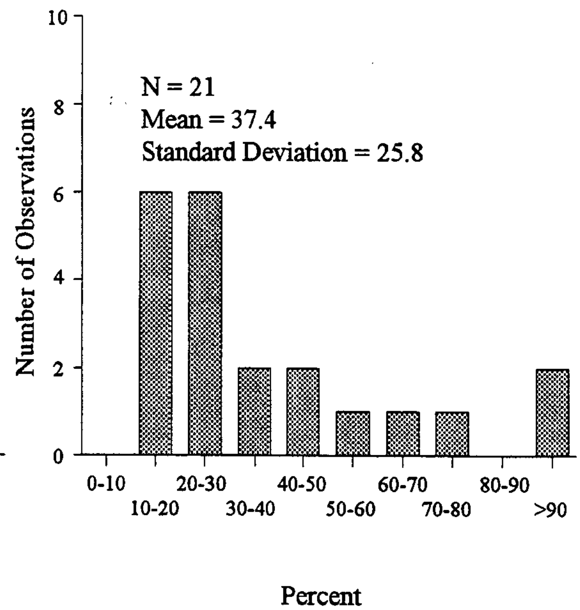


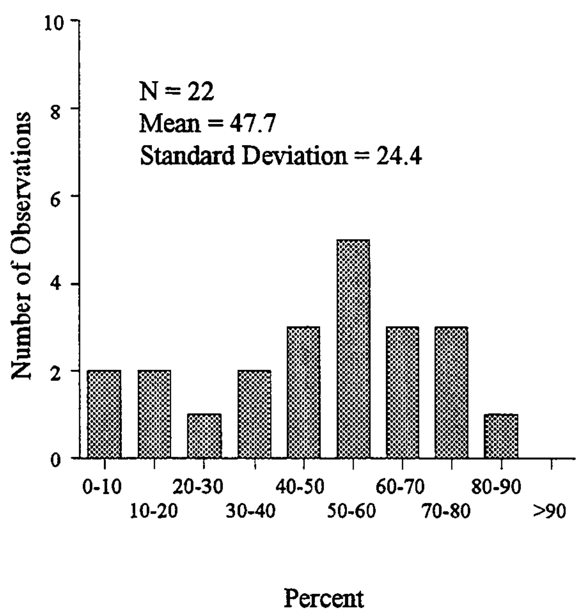
Figure 3.25. Distribution of Subgrade Passing the Number 200 Sieve for GPS-2 Test Sections



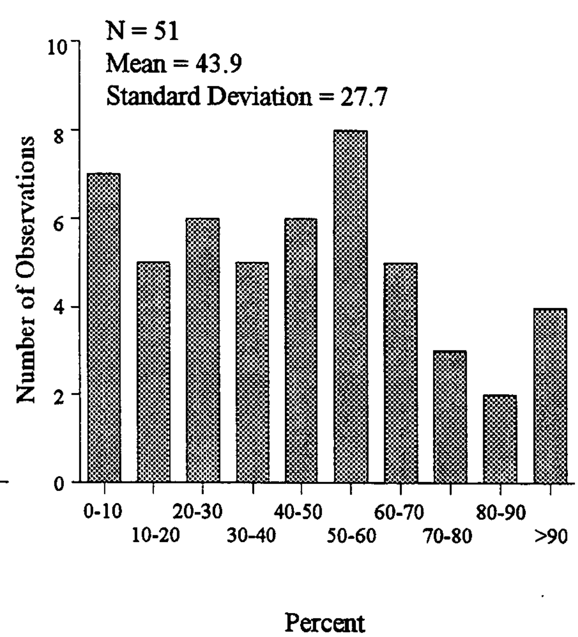
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 3.26. Distributions of Subgrade Passing the Number 200 Sieve by Environmental Regions for GPS-2 Test Sections

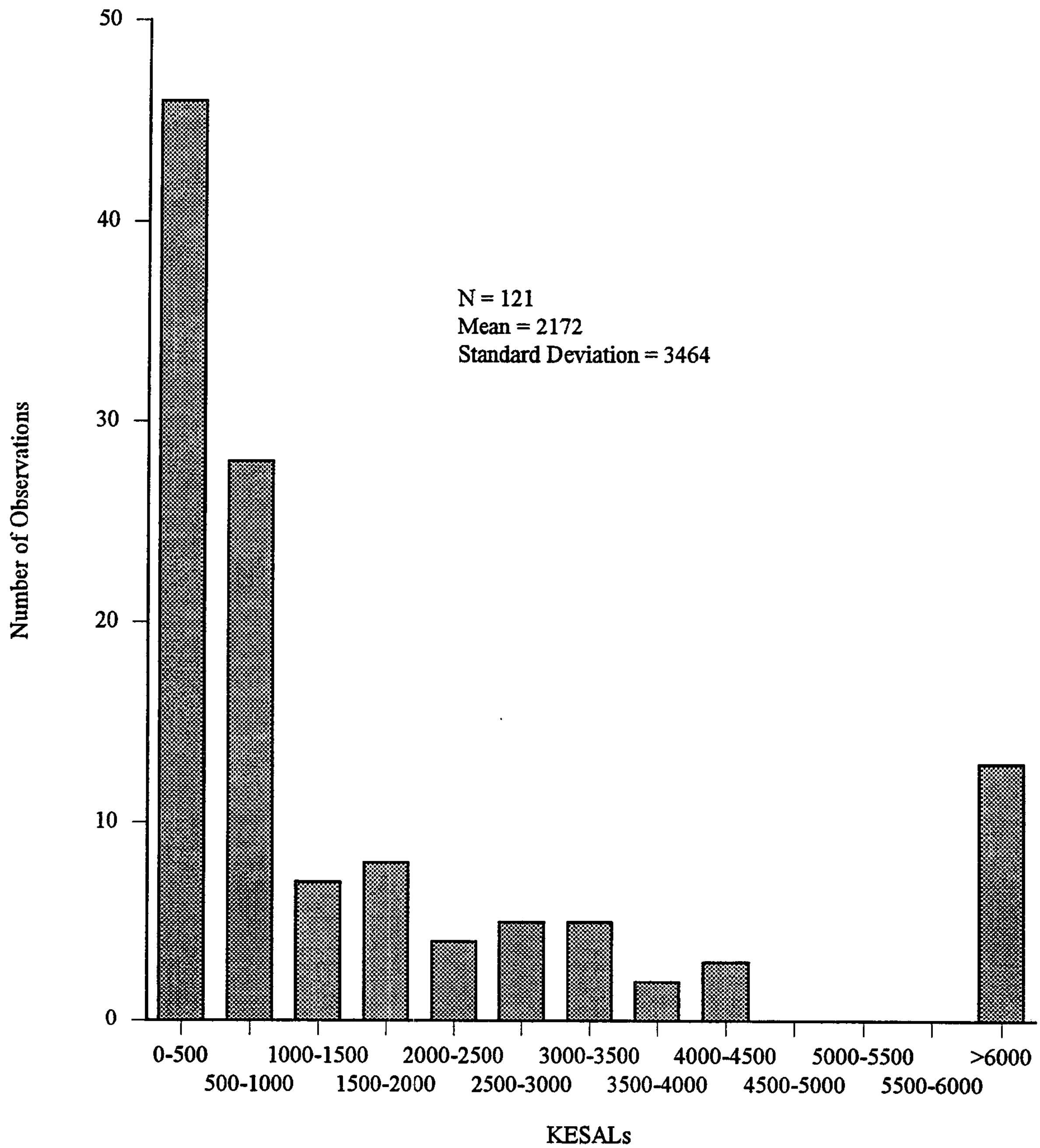


Figure 3.27. Distribution of Cumulative Equivalent Single Axle Loads in Thousands (KESALs) for GPS-2 Test Sections

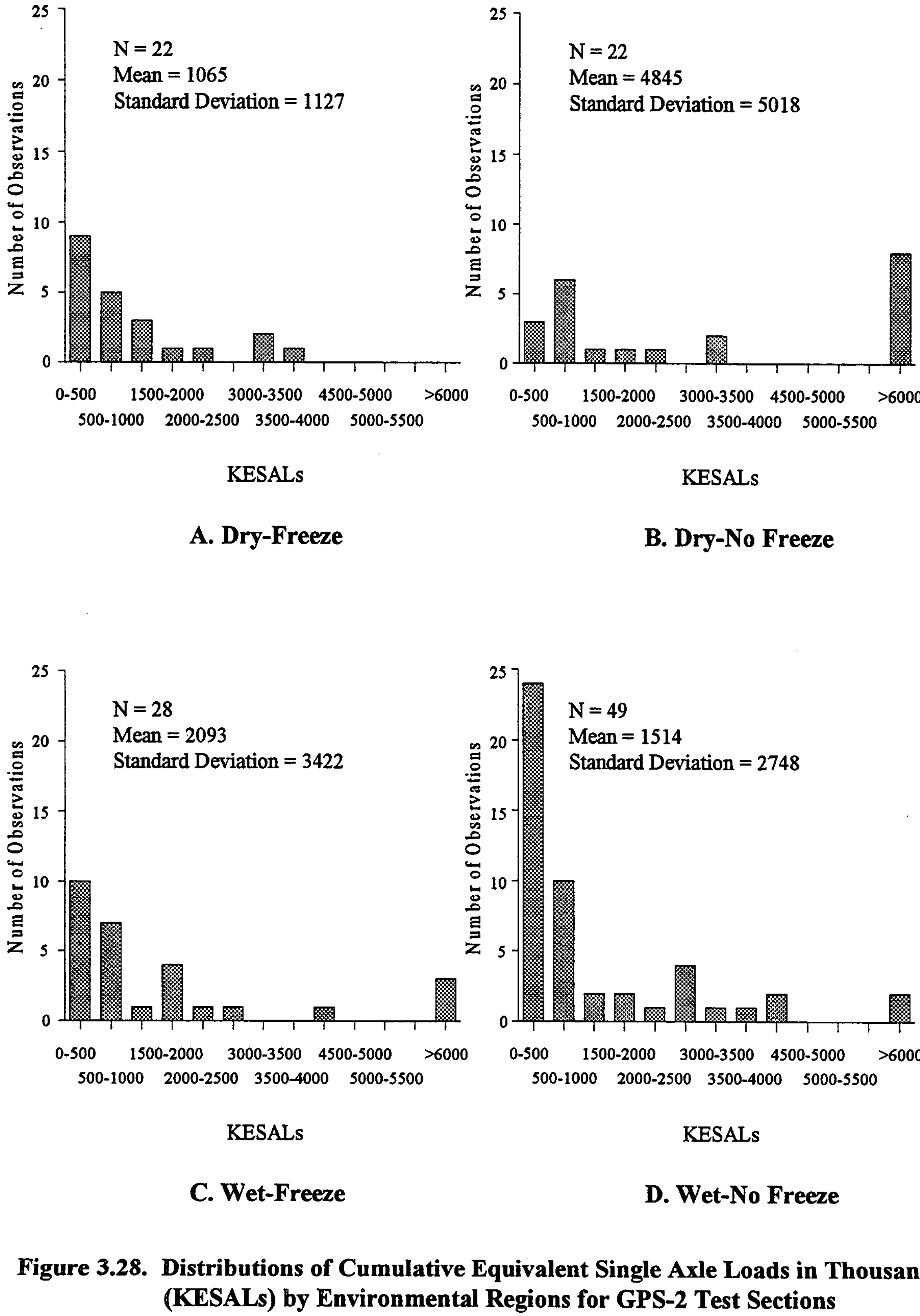


Figure 3.28. Distributions of Cumulative Equivalent Single Axle Loads in Thousands (KESALs) by Environmental Regions for GPS-2 Test Sections

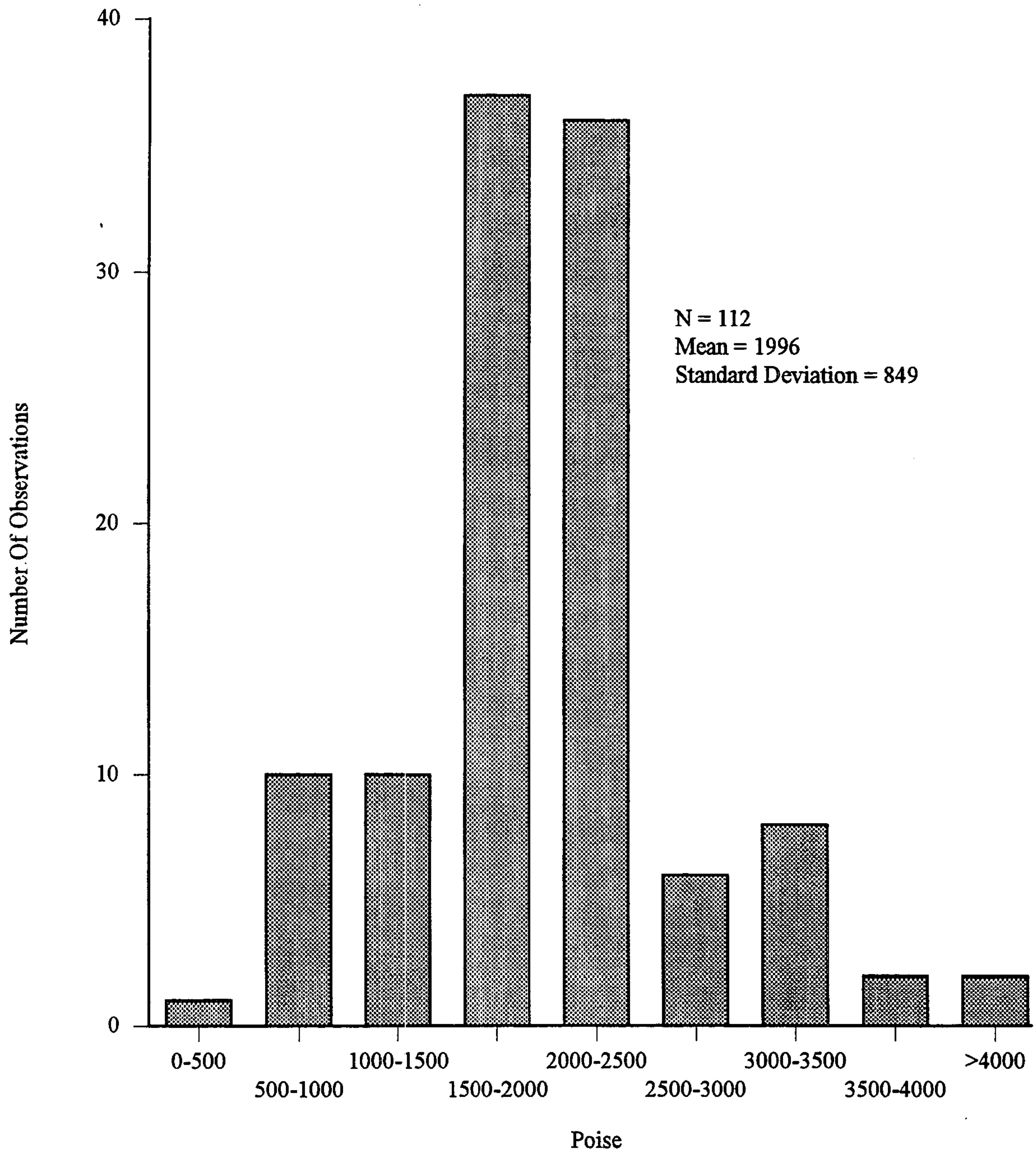


Figure 3.29. Distribution of Asphalt Cement Viscosity at 140°F for GPS-2 Test Sections

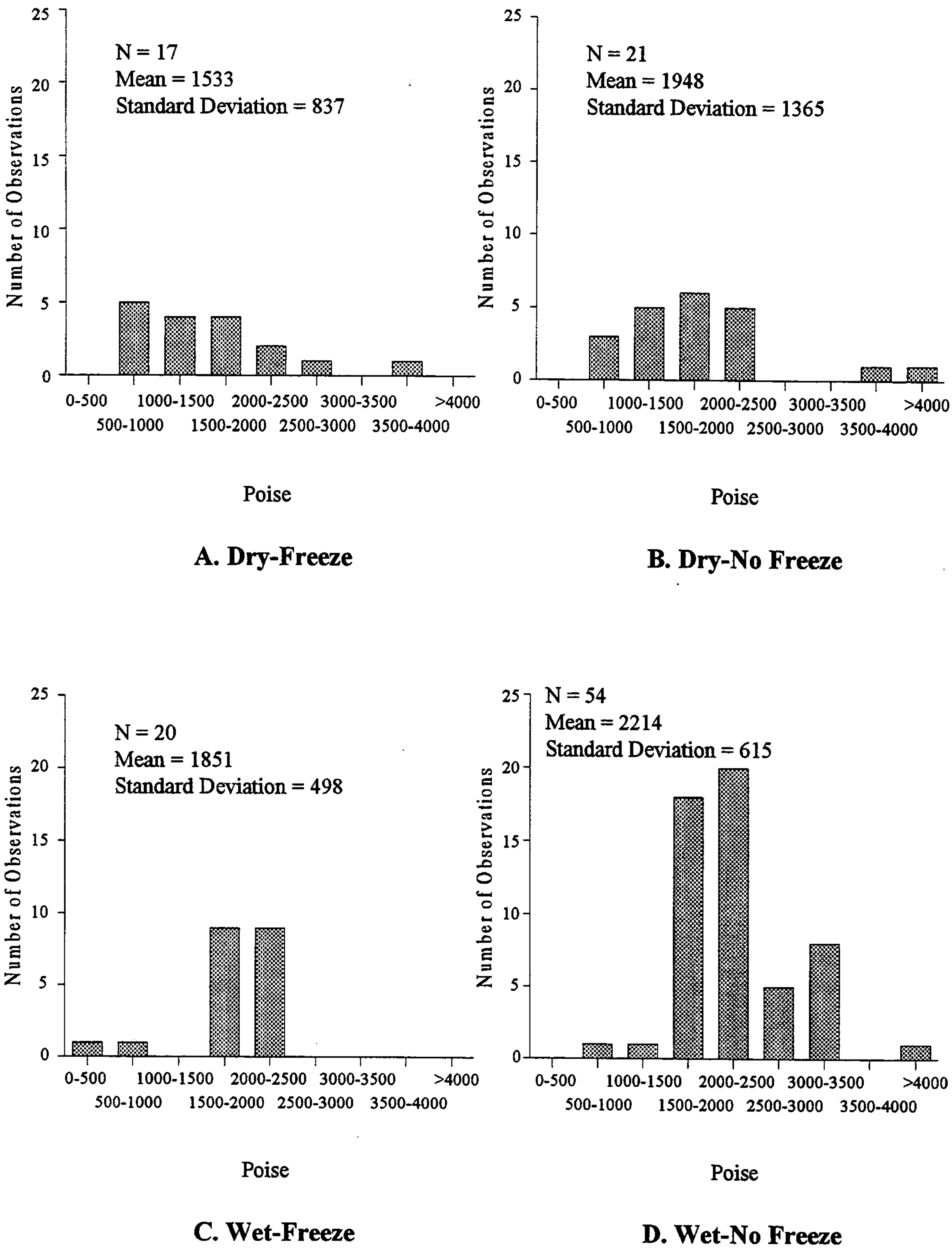


Figure 3.30. Distributions of Asphalt Cement Viscosity at 140°F by Environmental Regions for GPS-2 Test Sections

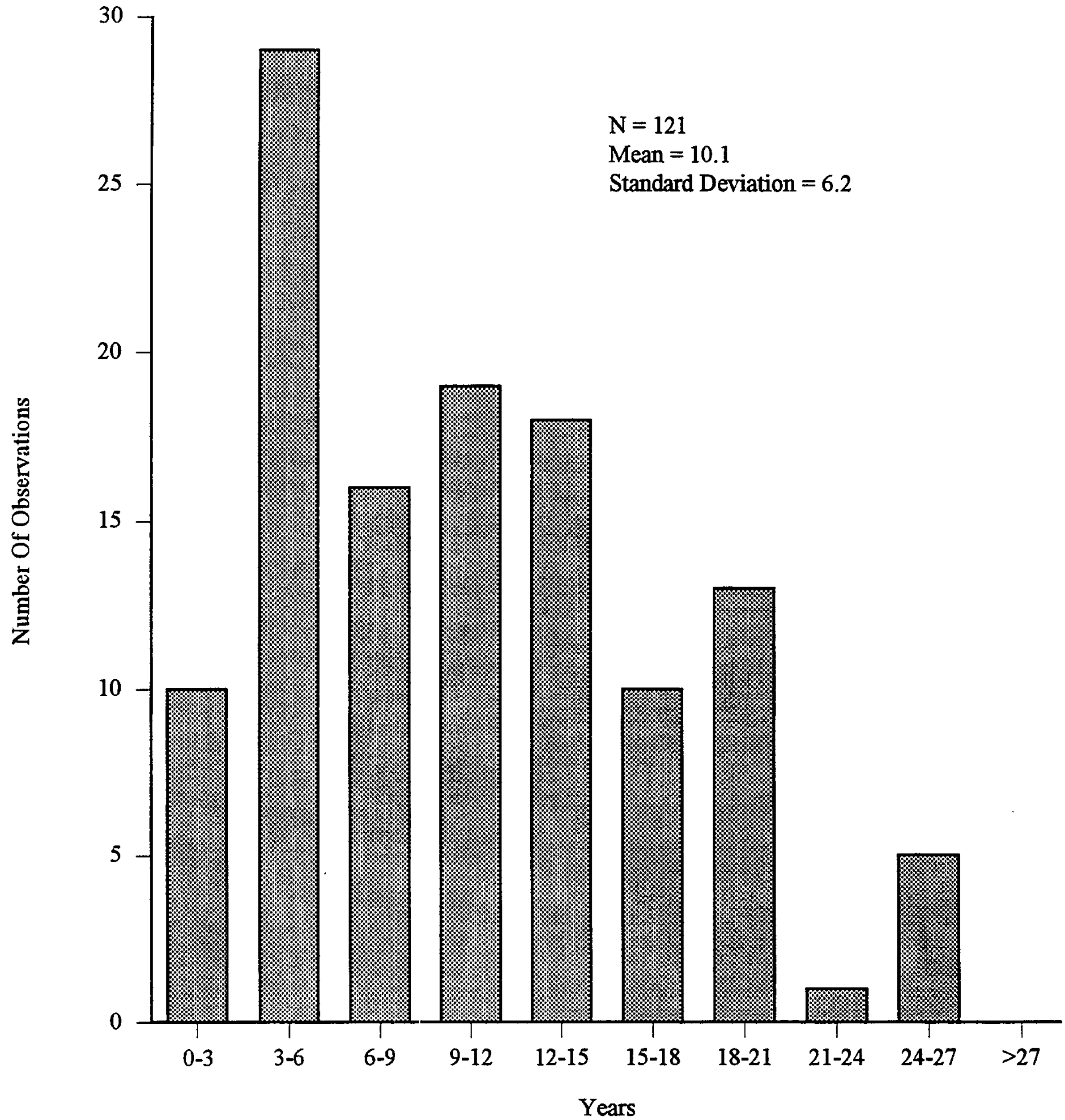


Figure 3.31. Distribution of Age for GPS-2 Test Sections

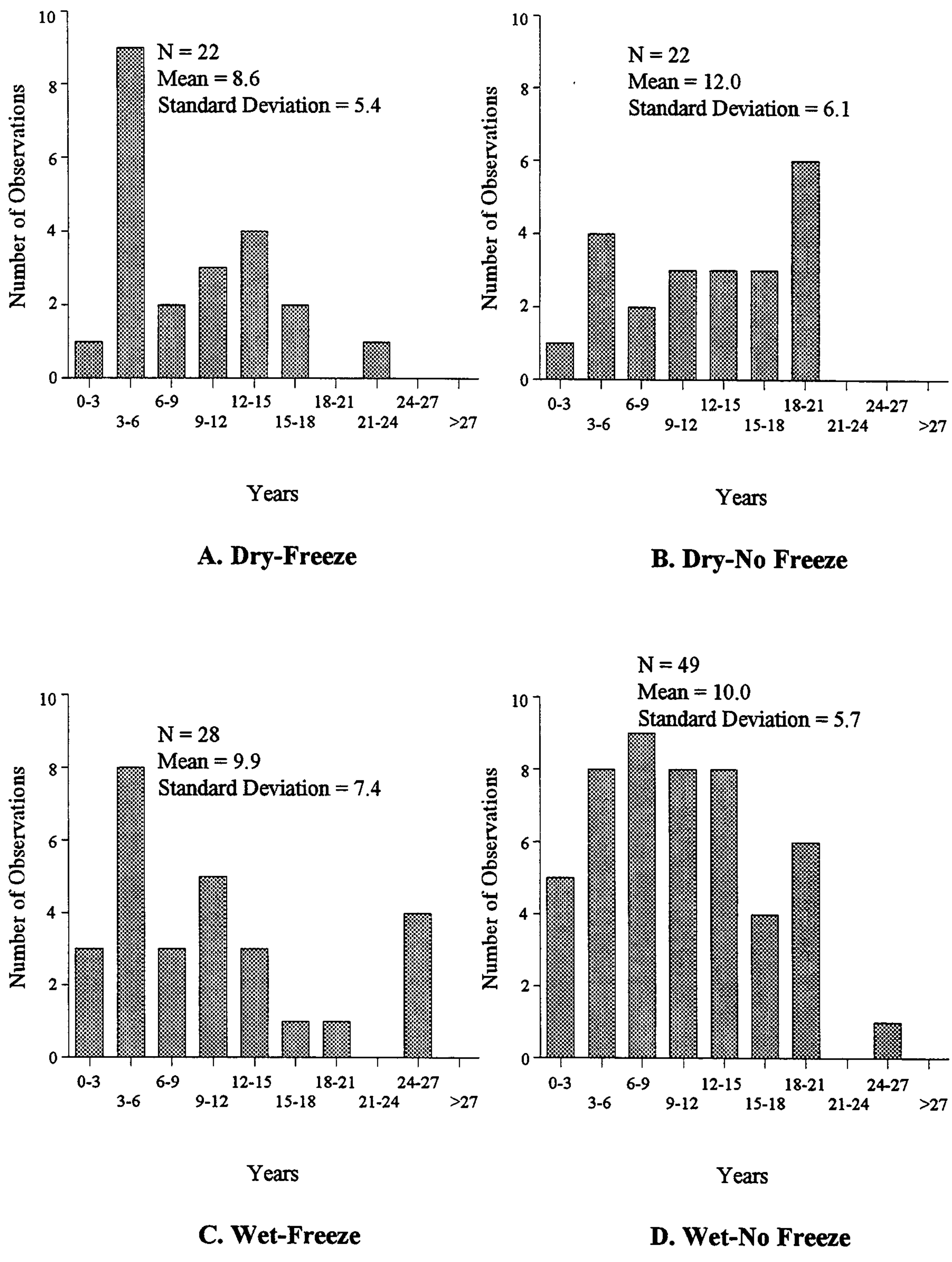


Figure 3.32. Distributions of Age by Environmental Regions for GPS-2 Test Sections

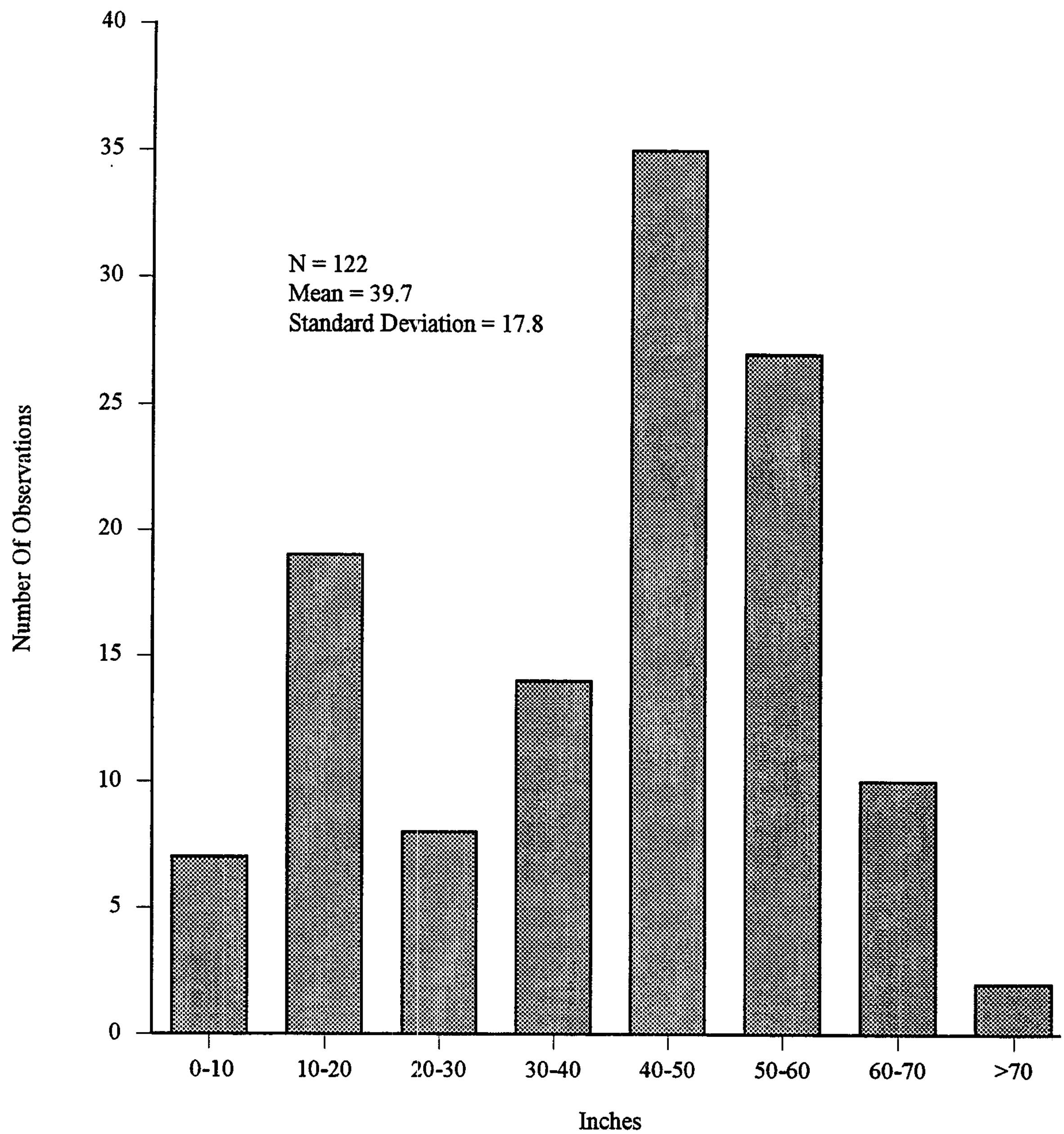


Figure 3.33. Distribution of Annual Average Precipitation for GPS-2 Test Sections

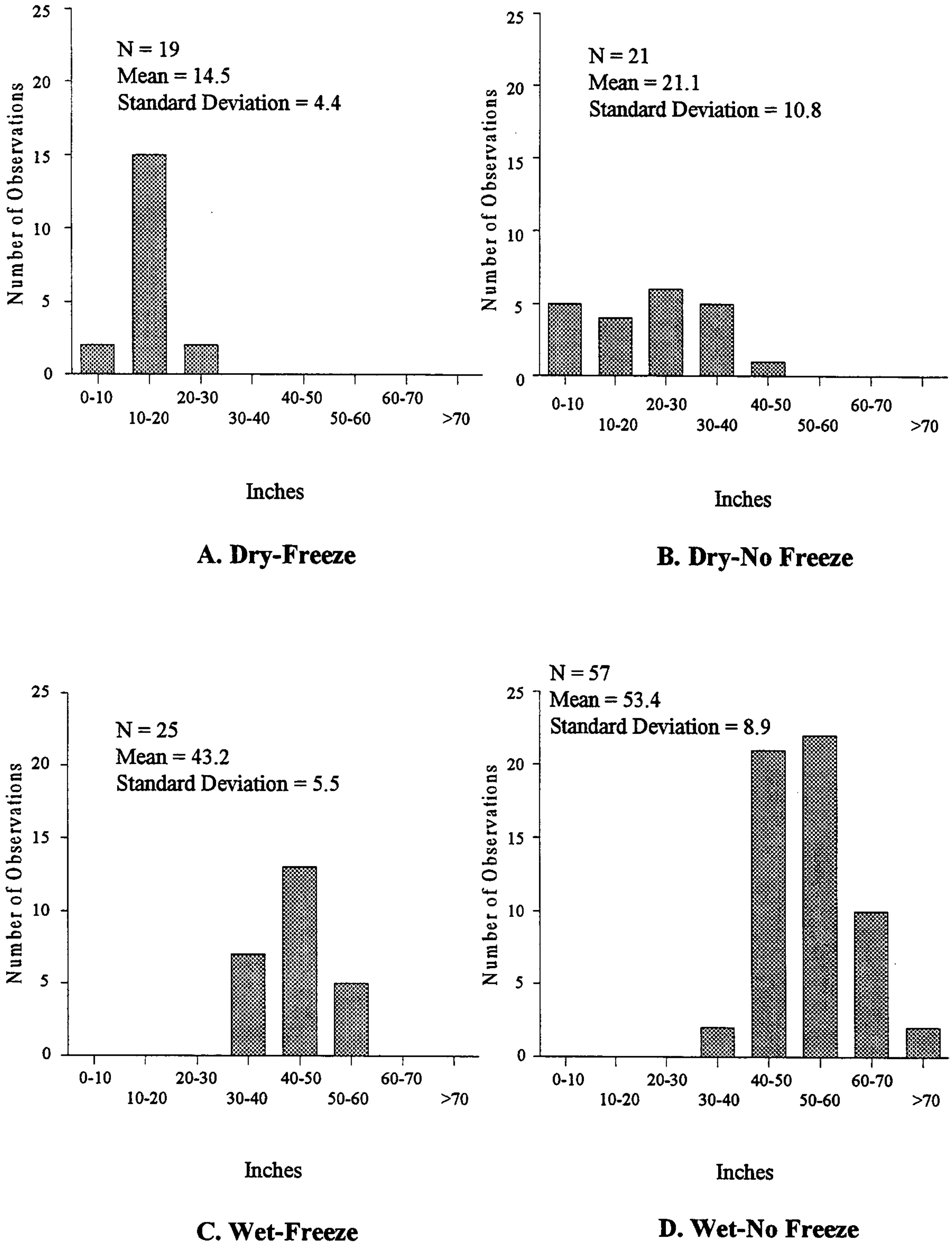


Figure 3.34. Distributions of Annual Average Precipitation by Environmental Regions for GPS-2 Test Sections

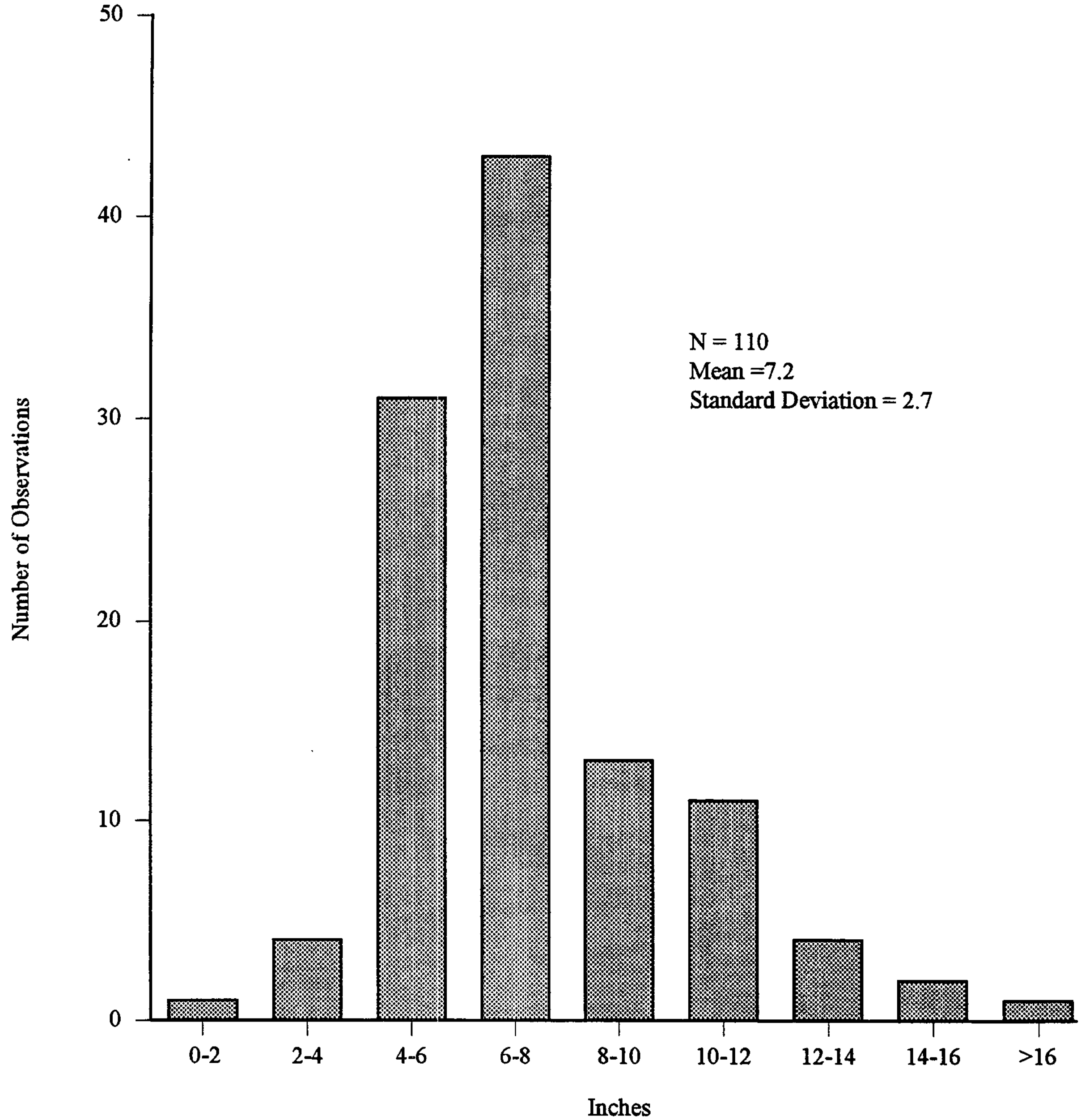
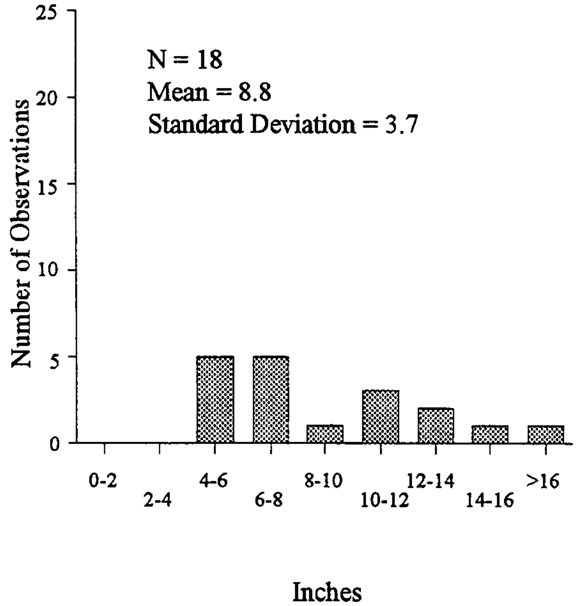
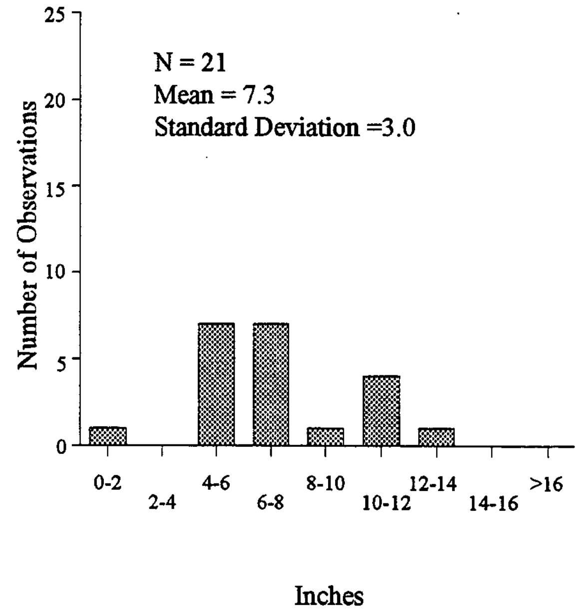


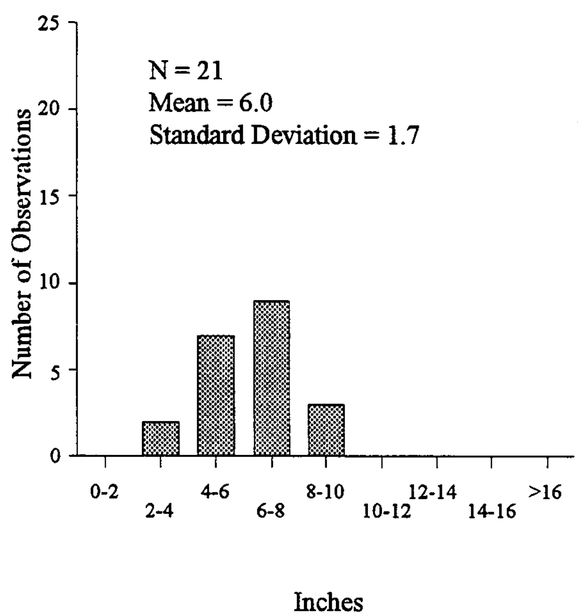
Figure 3.35. Distribution of the Treated-Base Thickness for GPS-2 Test Sections



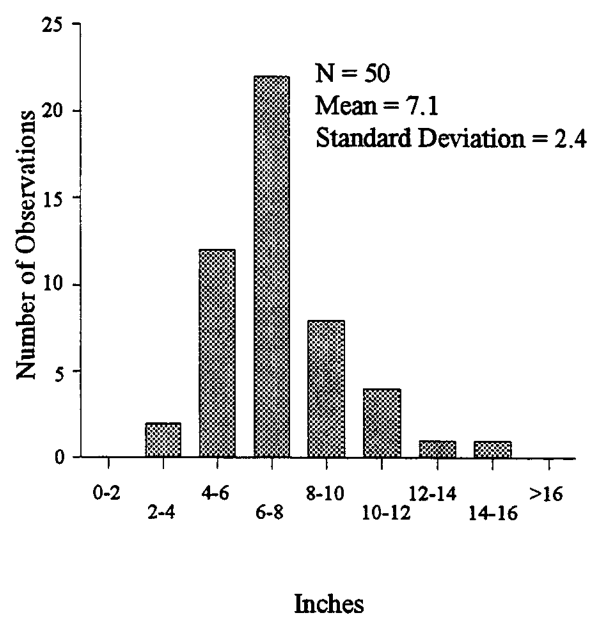
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 3.36. Distributions of Treated-Base Thickness by Environmental Regions for GPS-2 Test Sections

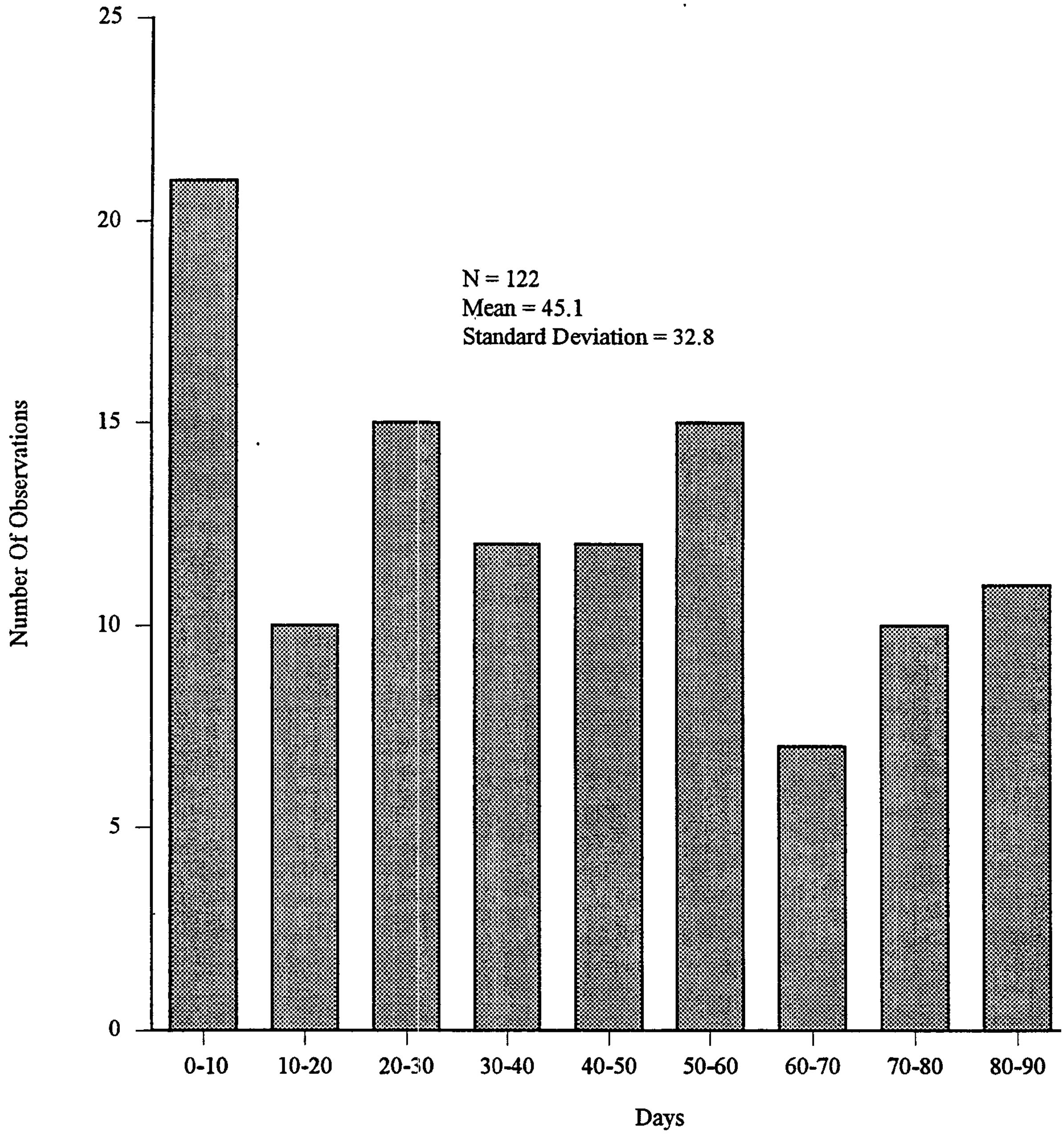
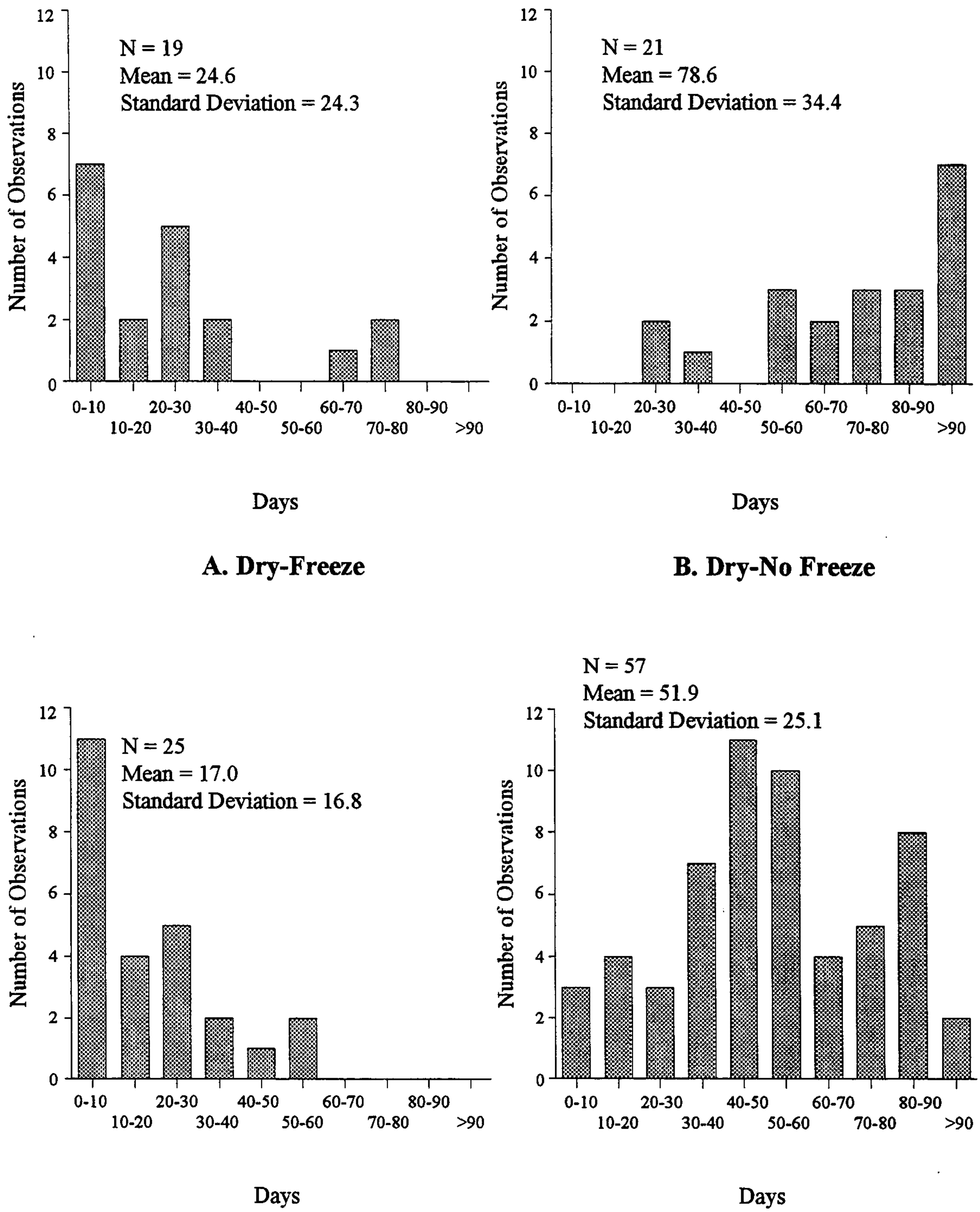


Figure 3.37. Distribution of Annual Average Number of Days Greater Than 90°F for GPS-2 Test Sections



A. Dry-Freeze

B. Dry-No Freeze

C. Wet-Freeze

D. Wet-No Freeze

Figure 3.38. Distributions of Annual Average Number of Days Greater Than 90°F by Environmental Regions for GPS-2 Test Sections

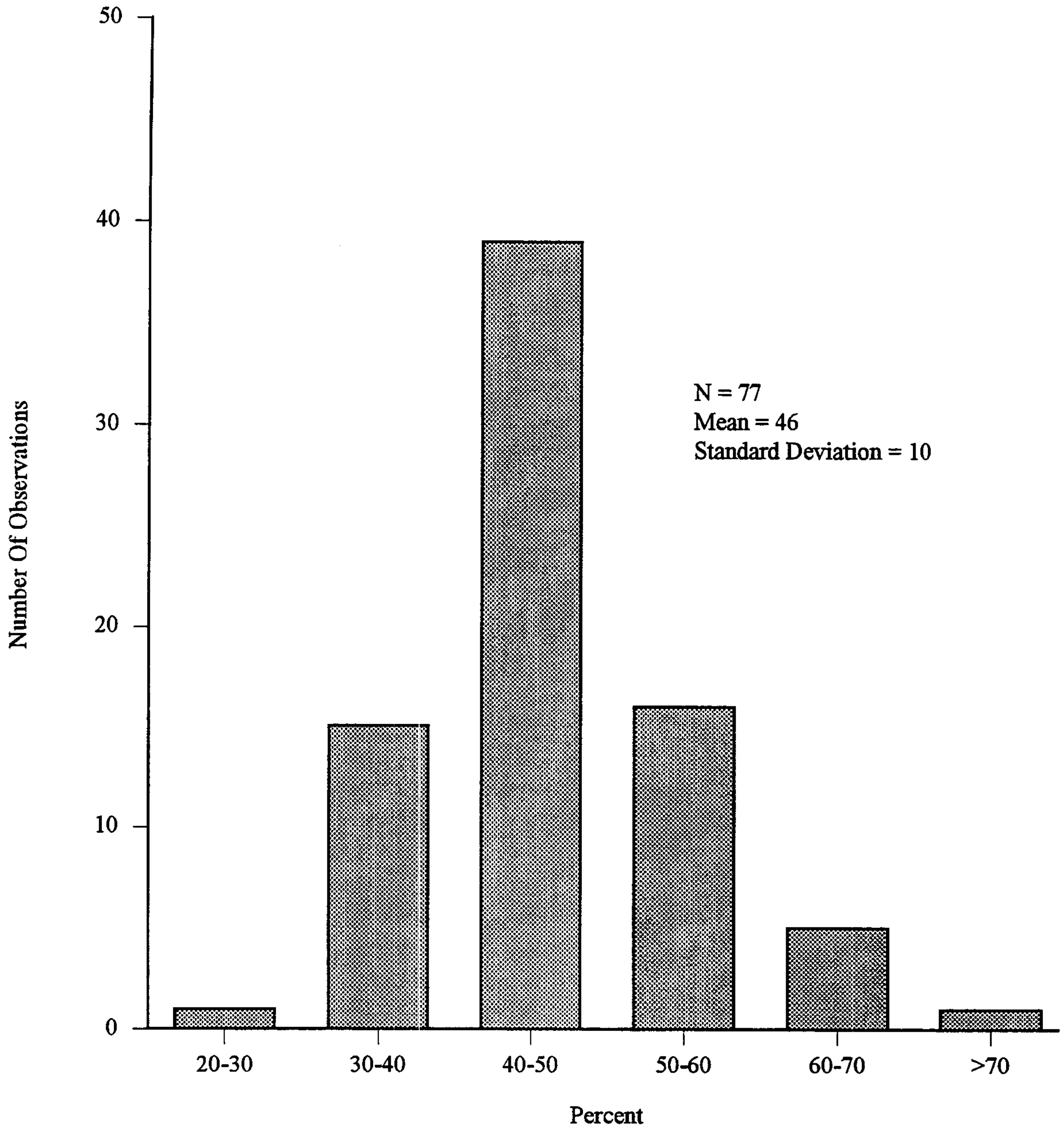


Figure 3.39. Distribution of Friction Number for GPS-2 Test Sections

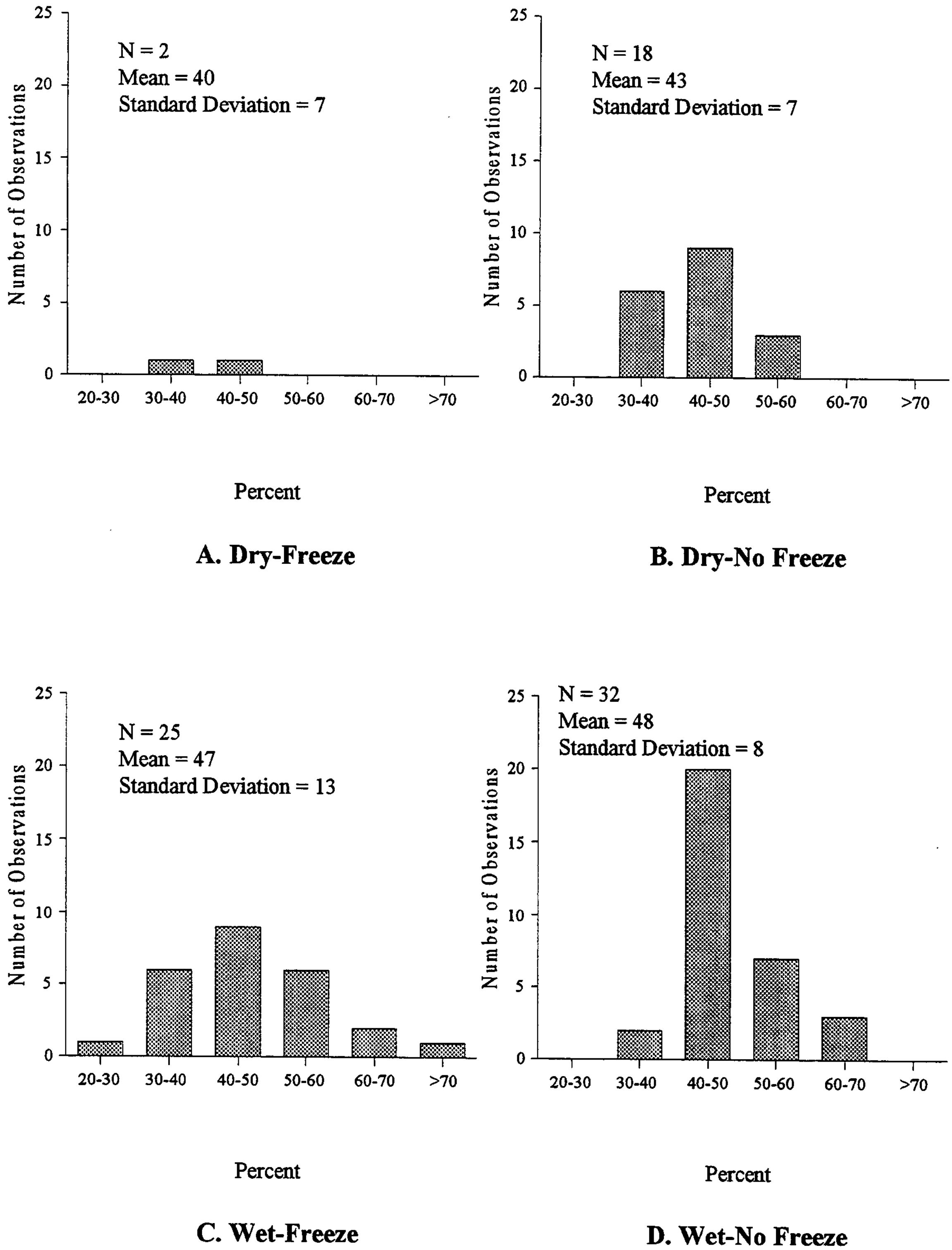


Figure 3.40. Distributions of Friction Number by Environmental Regions for GPS-2 Test Sections

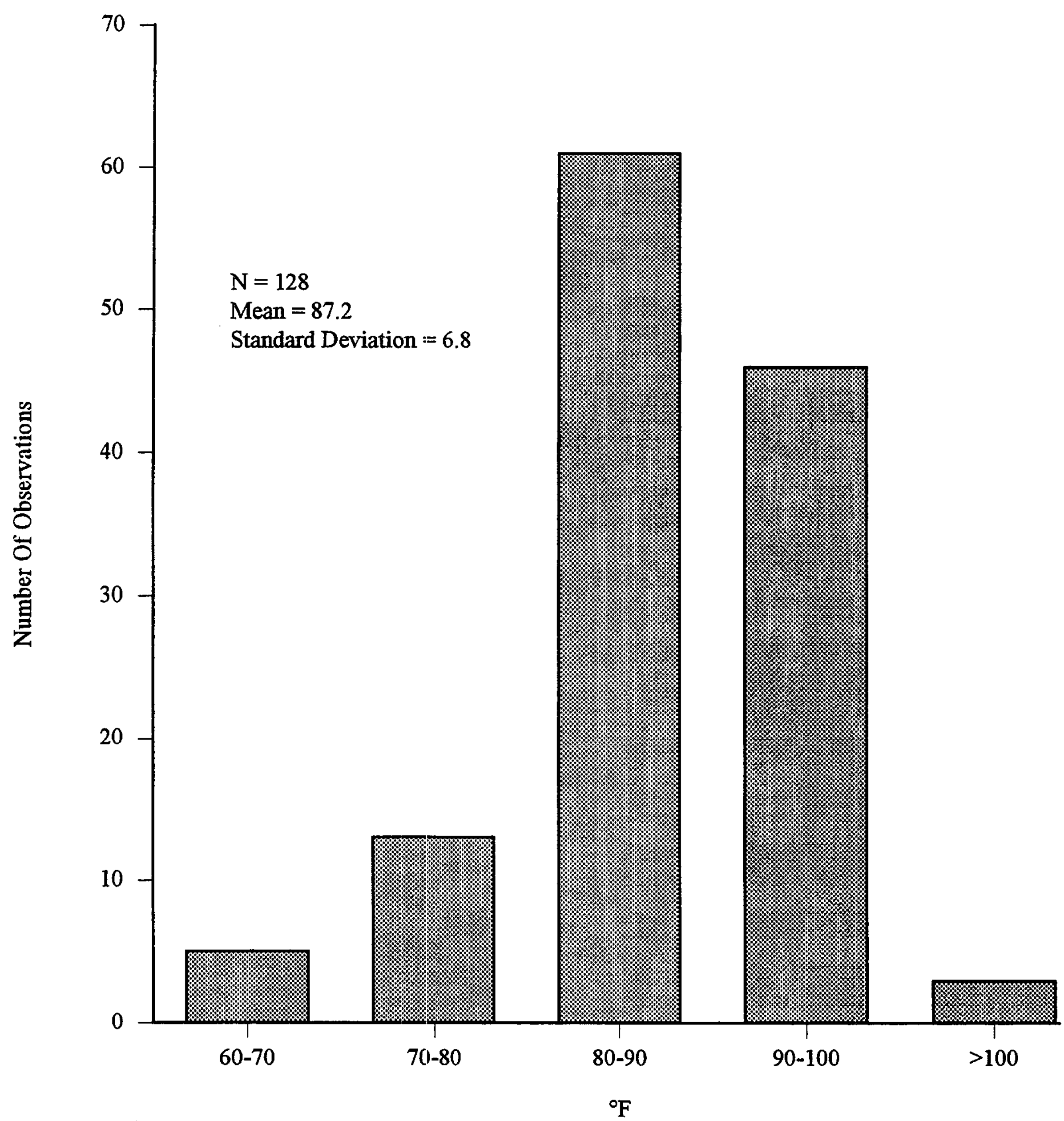
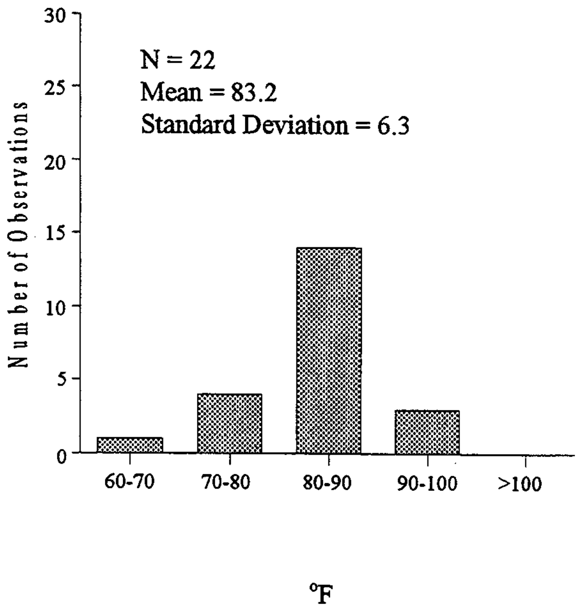
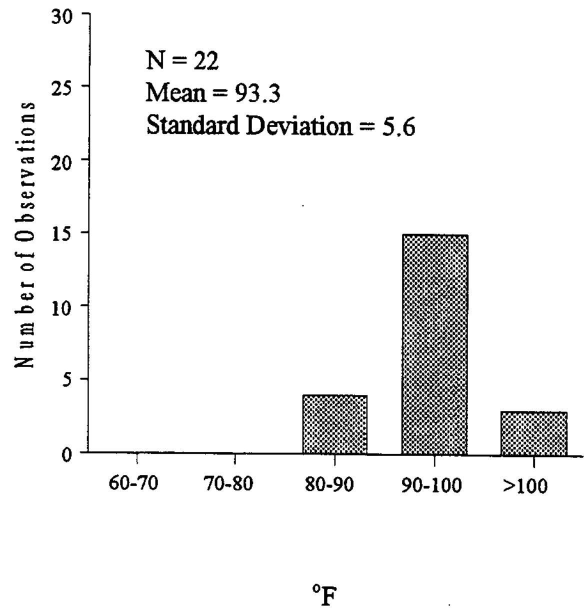


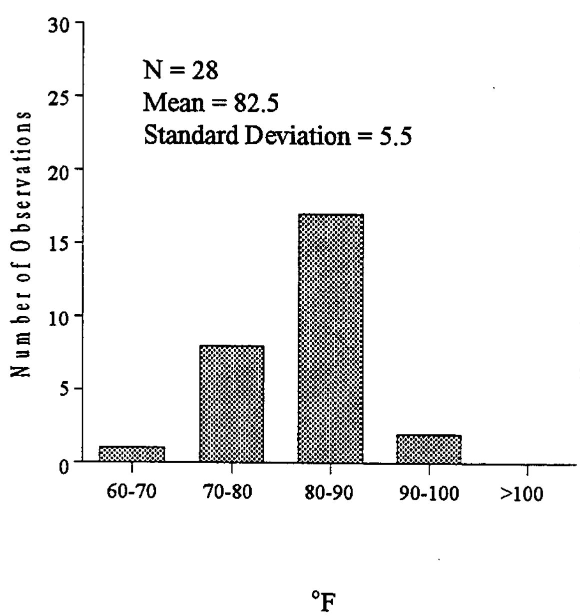
Figure 3.41. Distribution of Average Annual Maximum Temperature (for the Months of June, July and August) for GPS-2 Test Sections



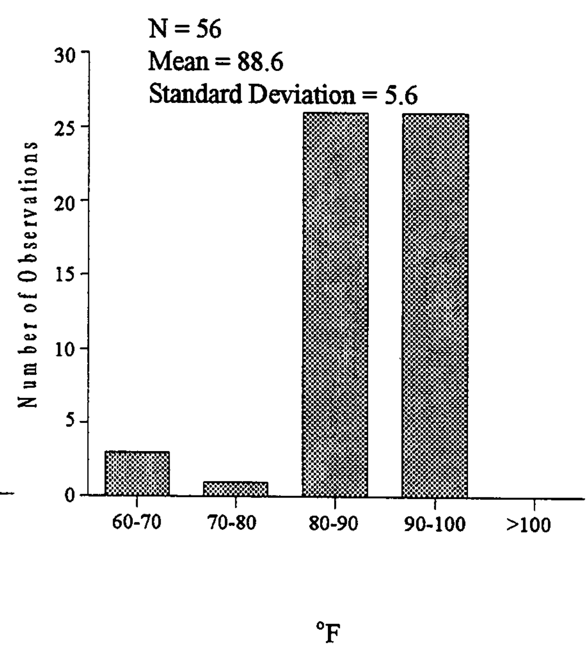
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 3.42. Distributions of Average Annual Maximum Temperature (for the Months of June, July and August) by Environmental Regions for GPS-2 Test Sections

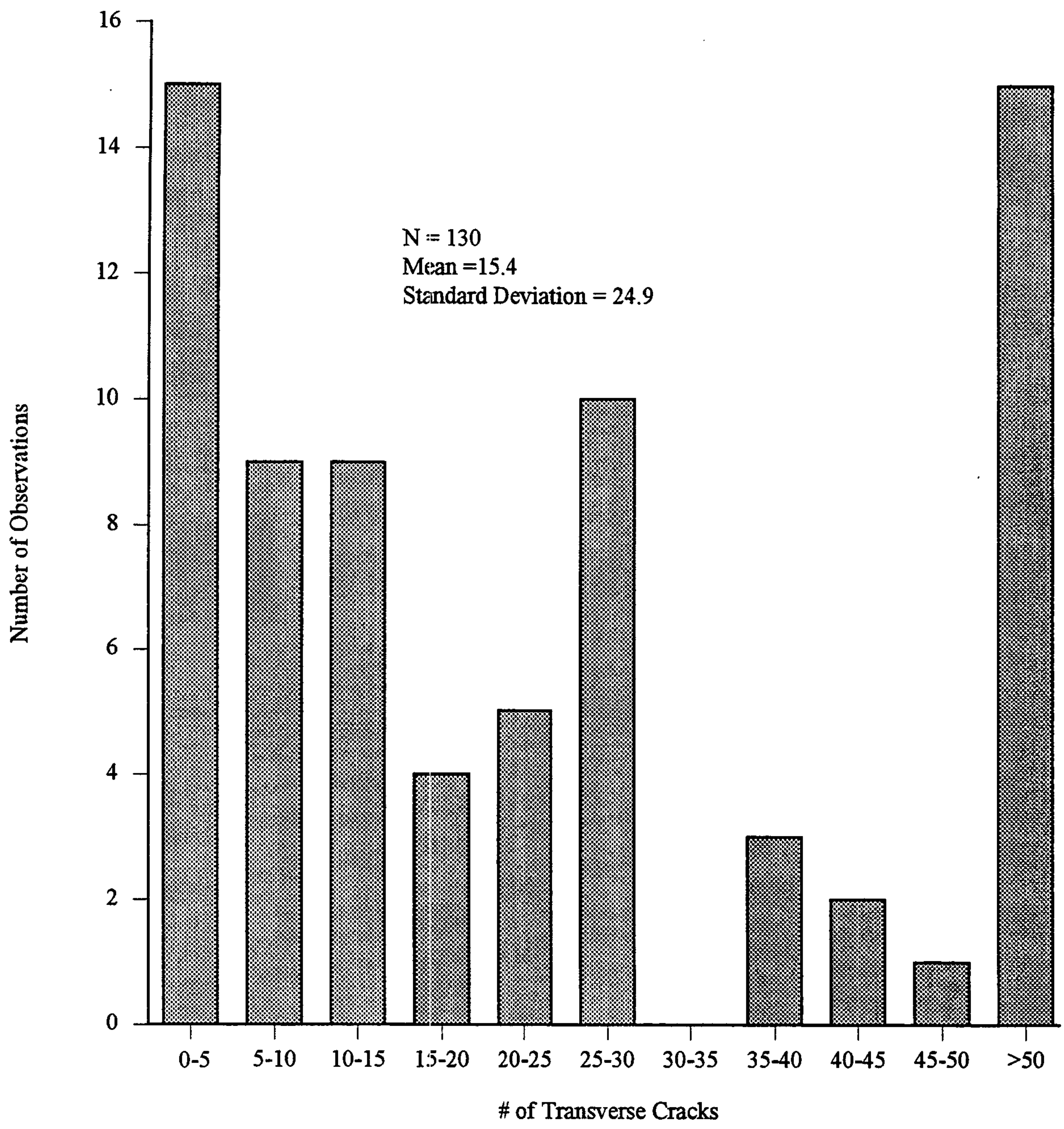
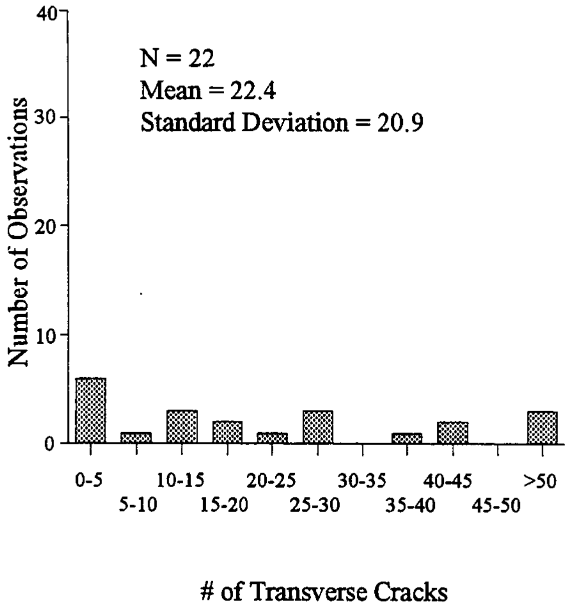
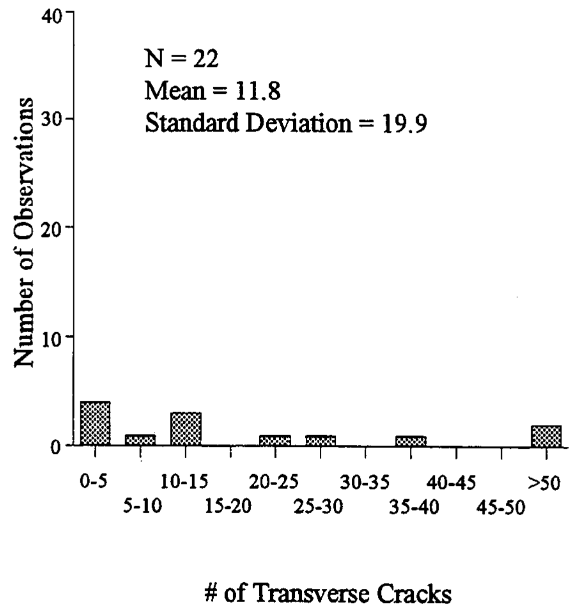


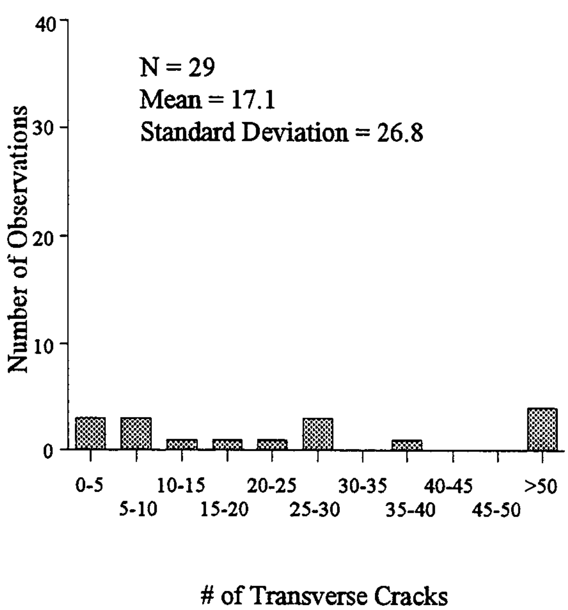
Figure 3.43. Distribution of the Number of Transverse Cracks for GPS-2 Test Sections



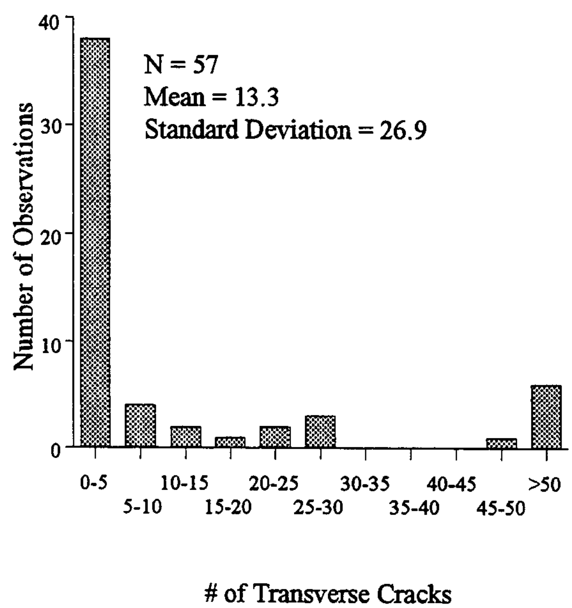
A. Dry-Freeze



B. Dry-No Freeze



C. Wet-Freeze



D. Wet-No Freeze

Figure 3.44. Distributions of Number of Transverse Cracks by Environmental Regions for GPS-2 Test Sections

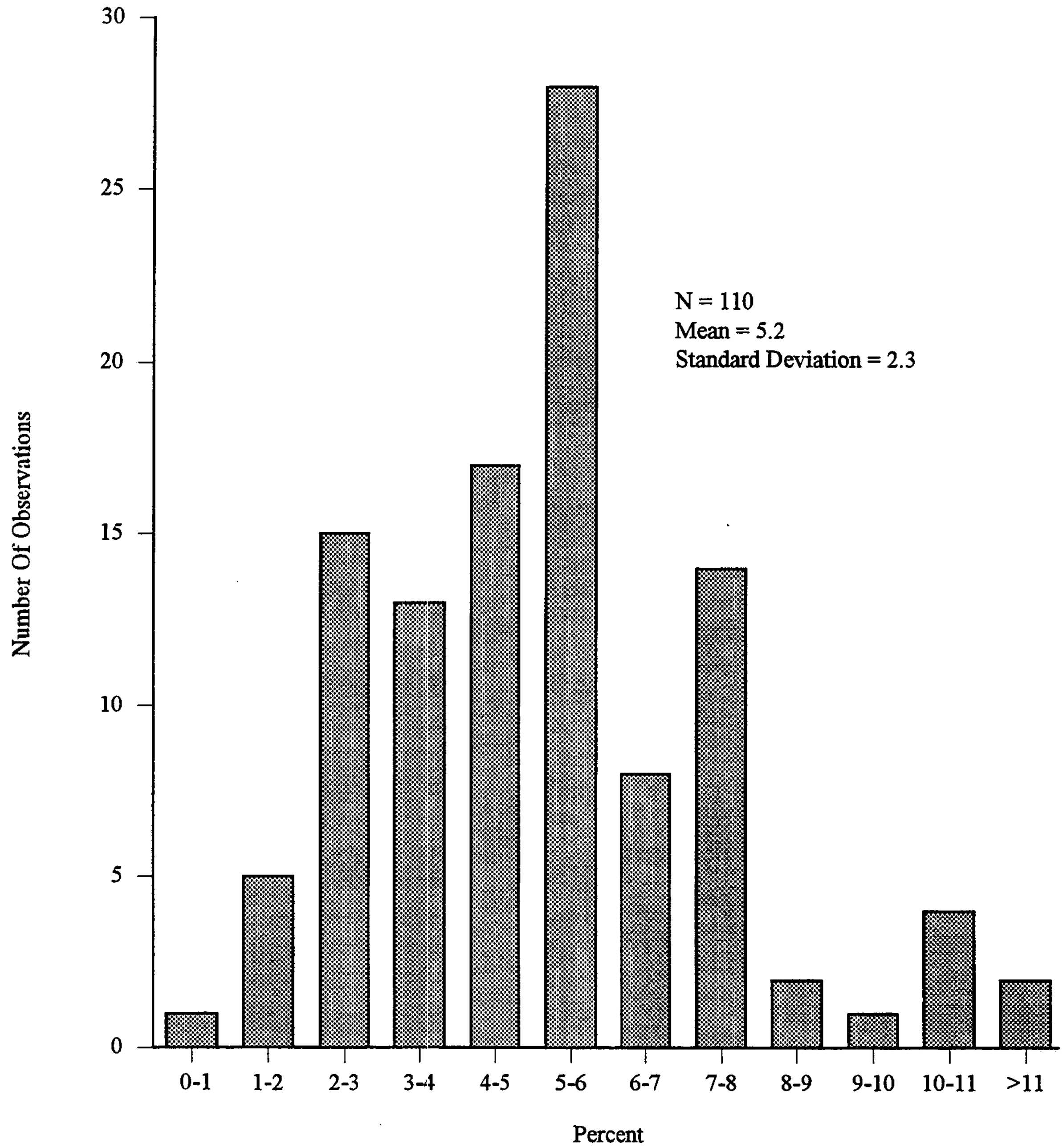


Figure 3.45. Distribution of HMAC Air Voids for GPS-2 Test Sections

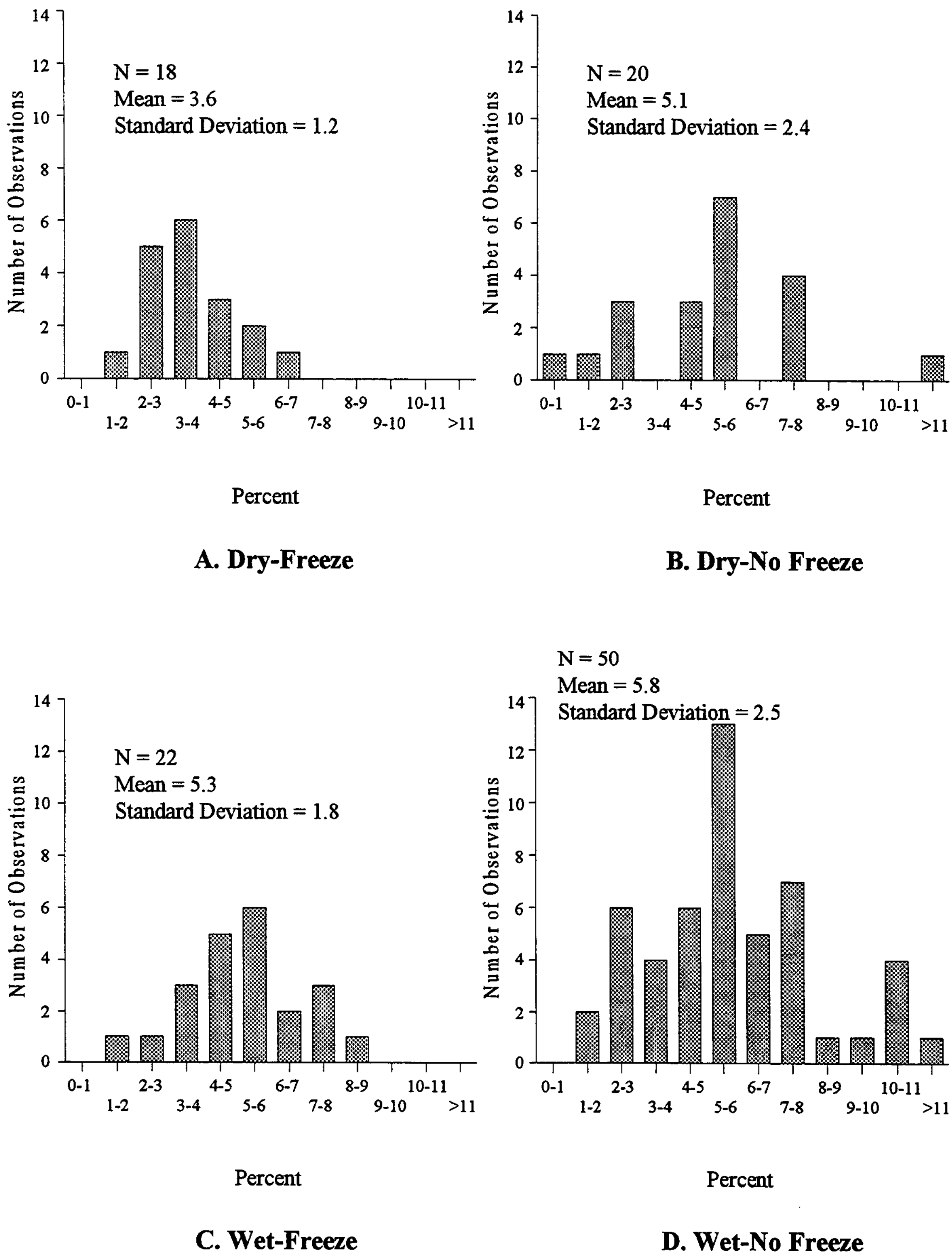


Figure 3.46. Distributions of HMAC Air Voids by Environmental Regions for GPS-2 Test Sections

4

Statistical Data for GPS-3 Test Sections

Statistical information on the 128 GPS-3 concrete pavement test sections for which data was available is provided in this chapter. The information includes statistical information on the key distress/roughness variables, and the significant variables of interest for the GPS-3 pavement sections. Specifically, they include tables that give information on the number of sections for each variable for which data was available, the mean, standard deviation, the minimum value, the median value, the maximum value, and range of the variable. A table that shows the correlations between the various significant variables, distresses, and roughness is also provided.

In addition, a number of plots are also provided that show the distribution of the various variables, distresses, and roughness. For each significant variable or distress/roughness a histogram, boxplot, probability density plot, and normal quantile-quantile plot are provided. For some of these variables or distresses/roughness, histograms that show their distribution by the four SHRP climatic regions, and scatter plots that show the relationship between the variable or distress/roughness and other selected variables or distresses/roughness, are also provided. For brevity, this latter information is not provided for all the variables or distresses/roughness.

Table 4.1 is a template that shows the number of test sections in each cell of the experiment design for the GPS-3 experiment. Environmental factors are defined in Figure 2.2 of Chapter 2. Other factors are summarized as follows:

Traffic Rate:	L - Less than 200 KESAL/Yr. H - Greater than or equal to 200 KESAL/Yr.
Dowels:	N - No Y - Yes
PCC Thickness:	L - Less than 9.5 in. (240 mm) H - Greater than 9.5 in. (240 mm)
Base Type:	Granular Stabilized

Table 4.4 relates the variable names used in the correlation table and statistical plots to variable decriptions.

Table 4.1 Number of Test Sections in Each Cell of the GPS-3 Sampling Template

Moisture			Wet								Dry							
Temperature			Freeze				No Freeze				Freeze				No Freeze			
Subgrade Type			F		C		F		C		F		C		F		C	
Traffic Rate			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Base Type	PCC Thickness	Dowels	Number of JPCP Sections in the Data Set															
Granular	L	N	1	3	2	2		1	3	1	2		2	3				
		Y	2	3	2		2	1			1						1	
	H	N	1	2	1			1			4	1	2	4				1
		Y	1	2	1			2		1		1				1		
Stabilized	L	N	1	2	2		2	2	2	2	1		2	2	2	1	2	2
		Y	2	3			2	2	1	1		1						
	H	N						2		2	1	3	1	5		2	1	2
		Y	2	2		1	1	2	1	2		1					1	

Table 4.2 Statistical Values for Distress/Roughness Variables in the GPS-3 Data Set

Variable	Units	Sections With Distress	Mean	Standard Deviation	Low Value	Median Value	High Value	Range
Faulting	Inches	76	0.037	0.056	-0.03	0.01	0.28	0.31
Spalling:	No. Spalls	91	6.00	7.61	2	4	30	28
Low Severity:	Lin. Ft.	118	16.22	35.07	0.00	3.12	16.22	16.22
	No. Spalls	91	0.38	1.39	0	0	12	12
Moderate Severity:	Lin. Ft.	118	0.73	3.12	0.00	0.00	28.21	28.21
	No. Spalls	91	0.04	0.33	0	0	3	3
High Severity:	Lin. Ft.	118	0.12	1.08	0.00	0.00	11.49	11.49
Transverse Cracking: Low Severity:	No. Cracks	15	2.33	2.79	0	1	8	8
	Lin. Ft.	117	2.76	12.33	0.00	0.00	94.98	94.98
Medium Severity:	No. Cracks	15	2.07	4.23	0	1	15	15
	Lin. Ft.	117	2.46	14.18	0.00	0.00	112.30	112.3
	No. Cracks	15	2.07	5.15	0	0	20	20
High Severity:	Lin. Ft.	117	2.58	21.70	0.00	0.00	232.00	232.00
Roughness (IRI)	Inches/Mile	104	110.40	41.02	48.89	97.85	245.00	196.11

Table 4.3 Statistical Values of Interest for Significant Variables in the GPS-3 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
PCC Thickness	Inches	114	9.50	1.27	6.30	9.34	14.28	7.98
Base Thickness	Inches	122	4.83	1.99	0.00	4.80	11.5	11.5
Subbase Thickness	Inches	122	4.28	9.10	0.00	0.00	72.00	72.00
KESALs per Year	No.	111	4,565	1860	34	229	1326	1292
Pavement Age	Years	111	11.04	6.05	1.24	9.96	29.82	28.58
Air Freeze-Thaw Cycles	No.	125	76.5	41.0	0	84	169	169
Freezing Index	Degree Days	125	651	704.2	0	478	3396	3396
No. of Days Temp. > 90°F	No.	125	38	34.3	0	30	176	176
No. of Days Temp. < 32°F	No.	125	99	60.2	0	116	203	203
Average Min. Temp. by Month	°F	121	19.41	14.99	-10.04	17.47	65.19	75.23
Average Max. Temp. by Month	°F	121	88.54	5.69	72.74	89.39	103.10	33.36
Average Monthly Precipitation	Inches	125	2.67	1.27	0.36	2.78	5.70	5.34
Average Yearly Precipitation	Inches	125	32.07	15.19	17.10	39.50	67.90	50.80
Wet Days in Year	No.	125	113.6	38.1	23	123	219	196
Dowel Diameter	Inches	47	1.15	0.22	0.25	1.25	1.50	1.25
Dowel Length	Inches	43	18.21	3.47	8.00	18.00	30.00	22.00
Dowel Spacing	Inches	37	6.36	1.47	4.5	6.0	12.0	7.5
Joint Spacing	Feet	125	16.74	3.65	11.4	15.5	30.0	18.6
Subgrade Soil Passing #200	Percent	118	40.20	26.76	1.30	37.55	98.40	97.10

Continued on Page 142

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Backcalculatd Static k-value	pci	114	161.90	94.0	33.11	139.60	534.90	501.79
PCC Elastic Modulus	$x10^6$, psi	114	4.50	0.84	2.82	4.39	6.80	3.98
PCC 28-day Flexural Strength	psi	107	721.4	109.95	542	695	1040	498
PCC Compressive Strength	psi	104	7508	1321	4730	7425	12360	7630
PCC Indirect Tensile Strength	psi	114	619.6	122.05	423	595	993	570

Table 4.4 Nomenclature Used for Correlation Table and Statistical Plots

Variable	Description of Variable
FAULT	Faulting, inches
TSPALLNO	Total number of spalled joints (all severities)
SPALL.H.NO	Number of high severity spalled joints
SPALL.M.NO	Number of low severity spalled joints
SPALL.L.NO	Number of low severity spalled joints
TSPALLFT	Total measured joint spalling (all severities) in linear feet
SPALL.H.FT	Measured high severity spalling in linear feet
SPALL.M.FT	Measured medium severity spalling in linear feet
SPALL.L.FT	Measured low severity spalling in linear feet
TCRACKNO	Total number of transverse cracks (all severities)
TCRACK.H.NO	Number of high severity transverse cracks
TCRACK.M.NO	Number of medium severity transverse cracks
TCRACK.L.NO	Number of low severity transverse cracks
TCRACKFT	Total measured transverse cracking (all severities) in linear feet
TCRACK.H.FT	Measured high severity transverse cracking in linear feet
TCRACK.M.FT	Measured medium severity transverse cracking in linear feet
TCRACK.L.FT	Measured low severity transverse cracking in linear feet
AVE.IRI or IRI	Measured average IRI value, inches/mile
AVE.SV	Measured average slope variance
THICK	Measured PCC layer thickness, inches
BASETHK	Measured base thickness, inches
SBASETHK	Measured subbase thickness, inches
YRL.KESAL or YRKESAL	Cumulative 18-kip ESALs per year, thousands
AGE	Pavement age, years
FT	Average number of air freeze-thaw cycles
FI	Freezing index, degree days
DAYS90	Number of days with temperature greater than 90°F
DAYS32	Number of days with temperature lower than 32°F
MAXTEMP	Average monthly maximum temperature, °F

Continued on Page 144

Table 4.4 Nomenclature Used for Correlation Table and Statistical Plots

MINTEMP	Average monthly minimum temperature, °F
YRL.PRECIP or YRPRECIP	Average precipitation by year, inches
PRECIP	Average precipitation by month, inches
DAYSWET	Average number of wet days
DOWDIA	Dowel diameter, inches
JTSPACE	Joint spacing, feet
PM200	Subgrade soil passing the #200 sieve, percent by weight
KSTATIS	Backcalculataed modulus of subgrade reaction, psi/inch
EPCC	Measured PCC layer elastic modulus, psi
FLEX28	PCC layer 28-day flexural strength, psi
COMPSTR	PCC layer compressive strength, psi
TENSTR	PCC layer indirect (split) tensile strength, psi

Table 4.5 Correlation Matrix for Significant Variables in GPS-3 Data Set

	FAULT	TSPALLNO	TSPALLFT	TCRACKNO	TCRACKFT	IRI	THICK	BASETHK	SBASETHK	KSTATIC	YRKESAL	FT
FAULT	1.000	-0.629	-0.541	-0.213	-0.199	0.974	0.144	-0.358	-0.439	-0.442	0.108	-0.213
TSPALLNO	-0.629	1.000	0.883	-0.449	-0.428	-0.636	-0.501	-0.020	0.098	0.441	-0.622	0.711
TSPALLFT	-0.541	0.883	1.000	-0.358	-0.337	-0.485	-0.349	-0.227	-0.035	0.607	-0.513	0.827
TCRACKNO	-0.213	-0.449	-0.358	1.000	0.998	-0.240	0.759	0.071	-0.231	0.425	0.821	-0.645
TCRACKFT	-0.199	-0.428	-0.337	0.998	1.000	-0.230	0.772	0.046	-0.278	0.462	0.823	-0.636
IRI	0.974	-0.636	-0.485	-0.240	-0.230	1.000	0.178	-0.265	-0.321	-0.473	0.148	-0.127
THICK	0.144	-0.501	-0.349	0.759	0.772	0.178	1.000	0.175	-0.295	0.251	0.958	-0.346
BASETHK	-0.358	-0.020	-0.227	0.071	0.046	-0.265	0.175	1.000	0.810	-0.452	0.326	-0.126
SBASETHK	-0.439	0.098	-0.035	-0.231	-0.278	-0.321	-0.295	0.810	1.000	-0.563	-0.119	0.090
KSTATIC	-0.442	0.441	0.607	0.425	0.462	-0.473	0.251	-0.452	-0.563	1.000	0.104	0.184
YRKESAL	0.108	-0.622	-0.513	0.821	0.823	0.148	0.958	0.326	-0.119	0.104	1.000	-0.542
FT	-0.213	0.711	0.827	-0.645	-0.636	-0.127	-0.346	-0.126	0.090	0.184	-0.542	1.000
FI	-0.136	0.019	0.036	-0.446	-0.495	0.007	-0.275	0.545	0.833	-0.638	-0.206	0.402
MAXTEMP	-0.262	0.287	0.216	0.429	0.474	-0.382	0.130	-0.347	-0.587	0.761	0.091	-0.285
MINTEMP	0.110	-0.333	-0.383	0.689	0.716	-0.027	0.382	-0.318	-0.611	0.425	0.429	-0.758
DAYS90	-0.324	-0.010	-0.089	0.770	0.794	-0.451	0.392	-0.177	-0.473	0.660	0.407	-0.551
DAYS32	-0.124	0.406	0.508	-0.663	-0.684	0.007	-0.335	0.175	0.462	-0.258	-0.436	0.861
YRPRECIP	0.325	-0.893	-0.804	0.486	0.449	0.338	0.263	0.091	0.139	-0.413	0.469	-0.787
PRECIP	0.326	-0.894	-0.803	0.486	0.449	0.340	0.264	0.090	0.138	-0.413	0.470	-0.786
JTSPACE	-0.005	-0.457	-0.399	0.694	0.701	-0.032	0.319	-0.059	-0.206	0.255	0.480	-0.807
PM200	0.856	-0.343	-0.302	-0.335	-0.309	0.868	0.264	-0.103	-0.340	-0.377	0.154	0.101
EPCC	0.538	-0.289	-0.061	-0.225	-0.220	0.672	0.415	0.110	-0.017	-0.291	0.299	0.375
DAYSWET	0.587	-0.884	-0.654	0.166	0.132	0.672	0.271	0.015	0.124	-0.542	0.385	-0.390

Table 4.5 Correlation Matrix for Significant Variables in GPS-3 Data Set

	FI	MAXTEMP	MINTEMP	DAYS90	DAYS32	YRPRECIP	PRECIP	JTSPACE	PM200	EPCC	DAYSWET
FAULT	-0.136	-0.262	0.110	-0.324	-0.124	0.325	0.326	-0.005	0.856	0.538	0.587
TSPALLNO	0.019	0.287	-0.333	-0.010	0.406	-0.893	-0.894	-0.457	-0.343	-0.289	-0.884
TSPALLFT	0.036	0.216	-0.383	-0.089	0.508	-0.804	-0.803	-0.399	-0.302	-0.061	-0.654
TCRACKNO	-0.446	0.429	0.689	0.770	-0.663	0.486	0.486	0.694	-0.335	-0.225	0.166
TCRACKFT	-0.495	0.474	0.716	0.794	-0.684	0.449	0.449	0.701	-0.309	-0.220	0.132
IRI	0.007	-0.382	-0.027	-0.451	0.007	0.338	0.340	-0.032	0.868	0.672	0.672
THICK	-0.275	0.130	0.382	0.392	-0.335	0.263	0.264	0.319	0.264	0.415	0.271
BASETHK	0.545	-0.347	-0.318	-0.177	0.175	0.091	0.090	-0.059	-0.103	0.110	0.015
SBASETHK	0.833	-0.587	-0.611	-0.473	0.462	0.139	0.138	-0.206	-0.340	-0.017	0.124
KSTATIC	-0.638	0.761	0.425	0.660	-0.258	-0.413	-0.413	0.255	-0.377	-0.291	-0.542
YRKESAL	-0.206	0.091	0.429	0.407	-0.436	0.469	0.470	0.480	0.154	0.299	0.385
FT	0.402	-0.285	-0.758	-0.551	0.861	-0.787	-0.786	-0.807	0.101	0.375	-0.390
FI	1.000	-0.906	-0.892	-0.814	0.801	0.063	0.063	-0.565	-0.019	0.391	0.331
MAXTEMP	-0.906	1.000	0.797	0.873	-0.718	-0.230	-0.231	0.564	-0.303	-0.603	-0.591
MINTEMP	-0.892	0.797	1.000	0.885	-0.978	0.341	0.340	0.810	-0.128	-0.496	-0.062
DAYS90	-0.814	0.873	0.885	1.000	-0.830	0.086	0.085	0.667	-0.429	-0.627	-0.371
DAYS32	0.801	-0.718	-0.978	-0.830	1.000	-0.449	-0.447	-0.854	0.135	0.524	-0.012
YRPRECIP	0.063	-0.230	0.341	0.086	-0.449	1.000	1.000	0.620	-0.070	-0.054	0.834
PRECIP	0.063	-0.231	0.340	0.085	-0.447	1.000	1.000	0.620	-0.068	-0.051	0.836
JTSPACE	-0.565	0.564	0.810	0.667	-0.854	0.620	0.620	1.000	-0.307	-0.439	0.238
PM200	-0.019	-0.303	-0.128	-0.429	0.135	-0.070	-0.068	-0.307	1.000	0.773	0.311
EPCC	0.391	-0.603	-0.496	-0.627	0.524	-0.054	-0.051	-0.439	0.773	1.000	0.457
DAYSWET	0.331	-0.591	-0.062	-0.371	-0.012	0.834	0.836	0.238	0.311	0.457	1.000

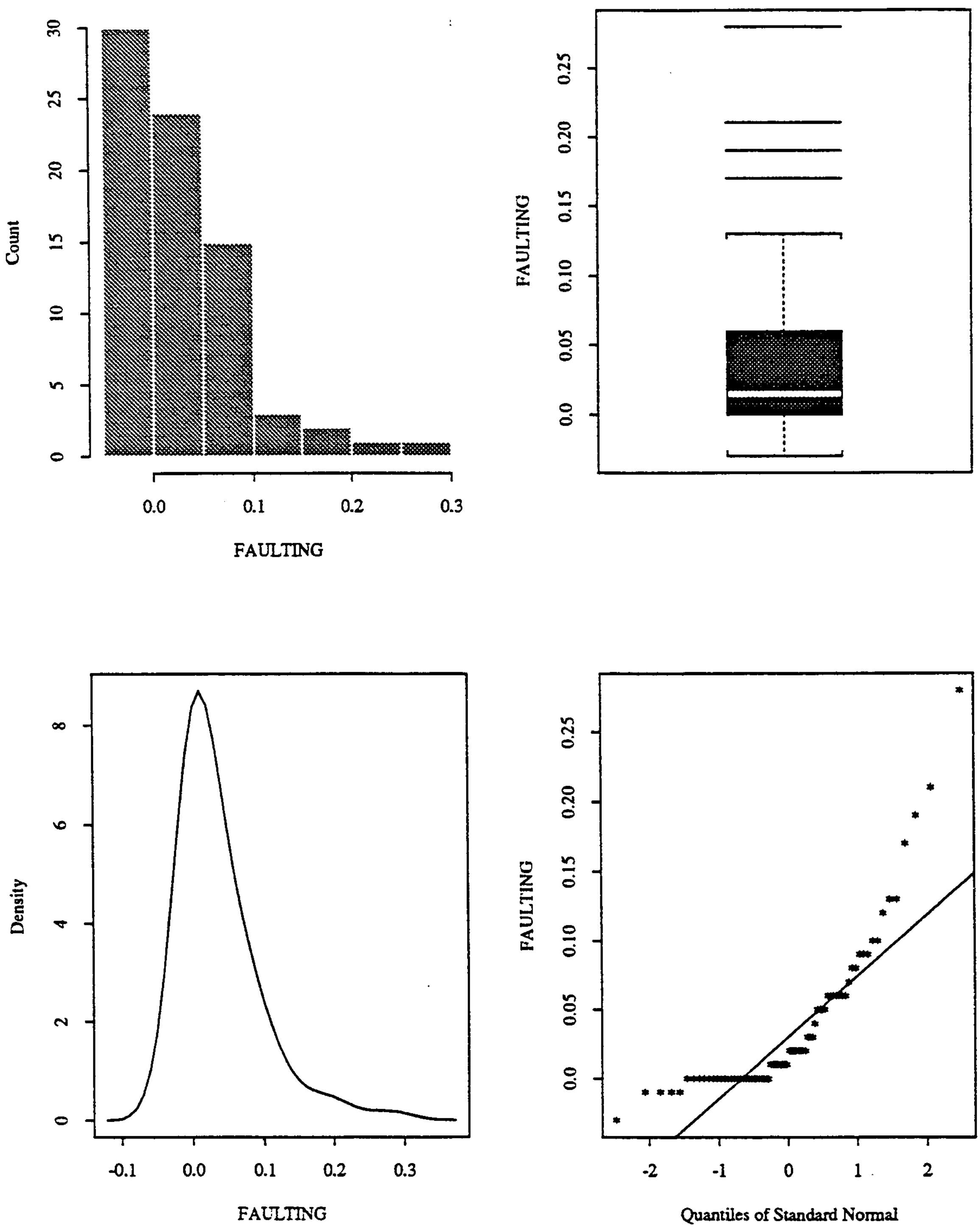


Figure 4.1 Statistical Distribution of Faulting for GPS-3 Sections

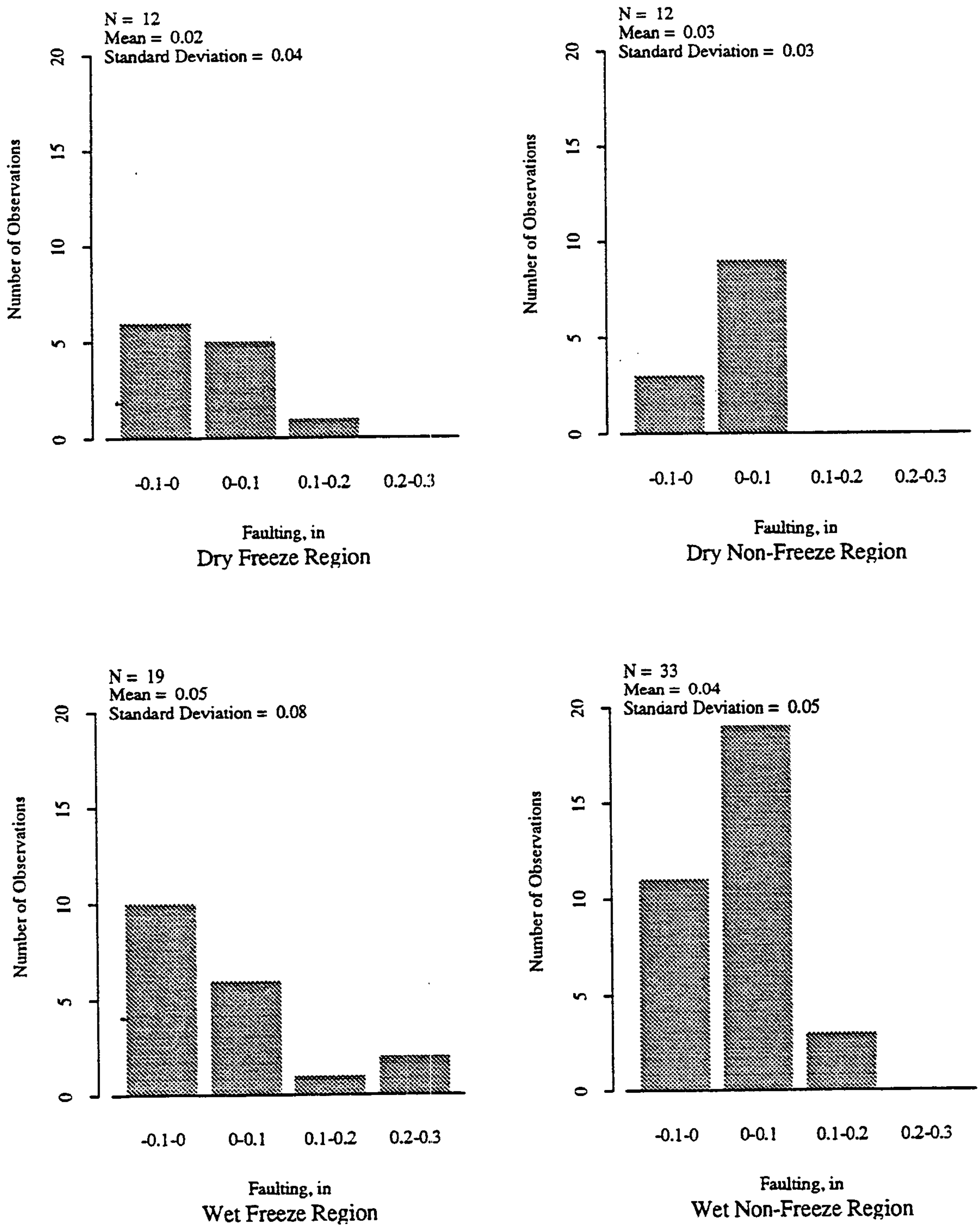
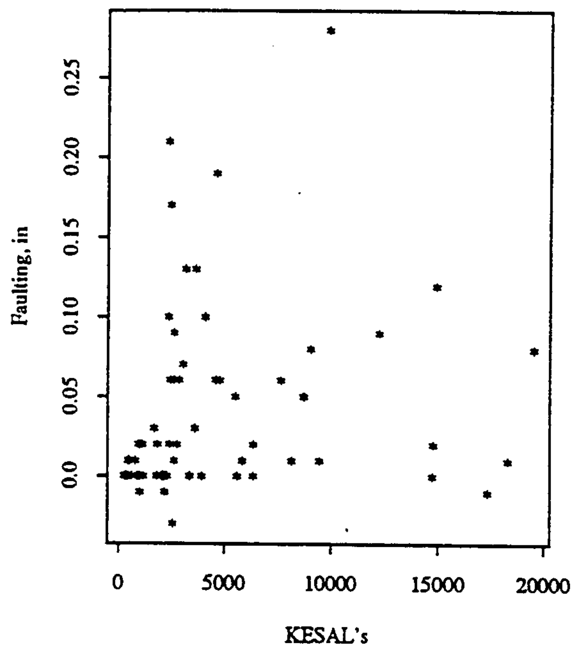
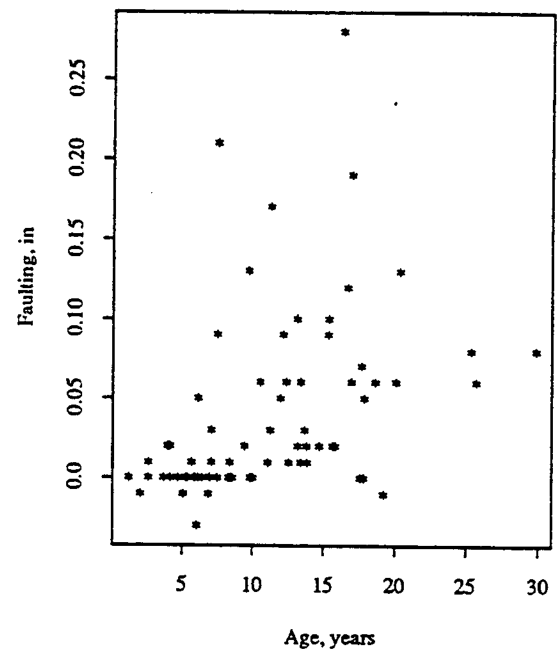


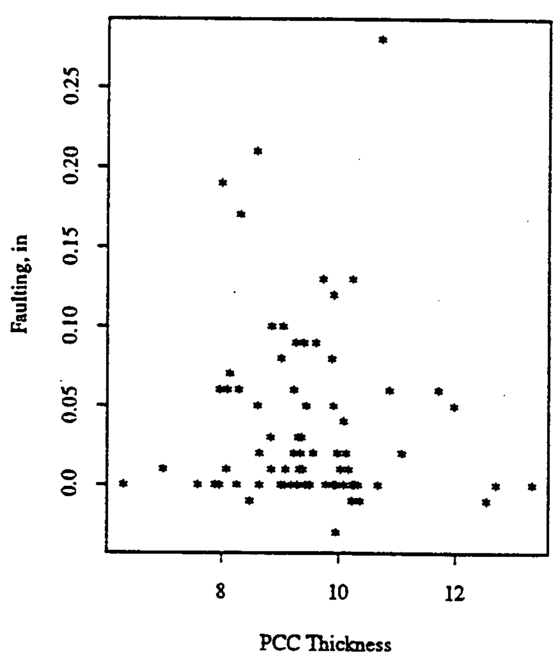
Figure 4.2 Distribution of Faulting by Environmental Regions for GPS-3 Sections



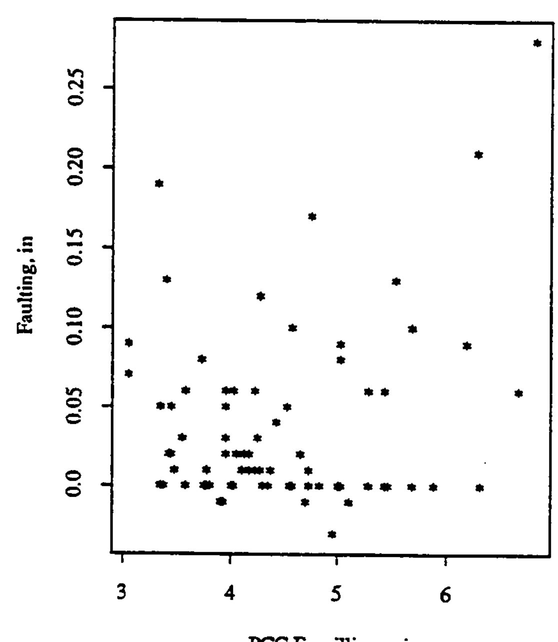
Faulting vs. KESALs



Faulting vs. Pavement Age



Faulting vs. PCC Thickness



Faulting vs. PCC Elastic Modulus

Figure 4.3 Faulting Scatter Plot for GPS-3 Sections

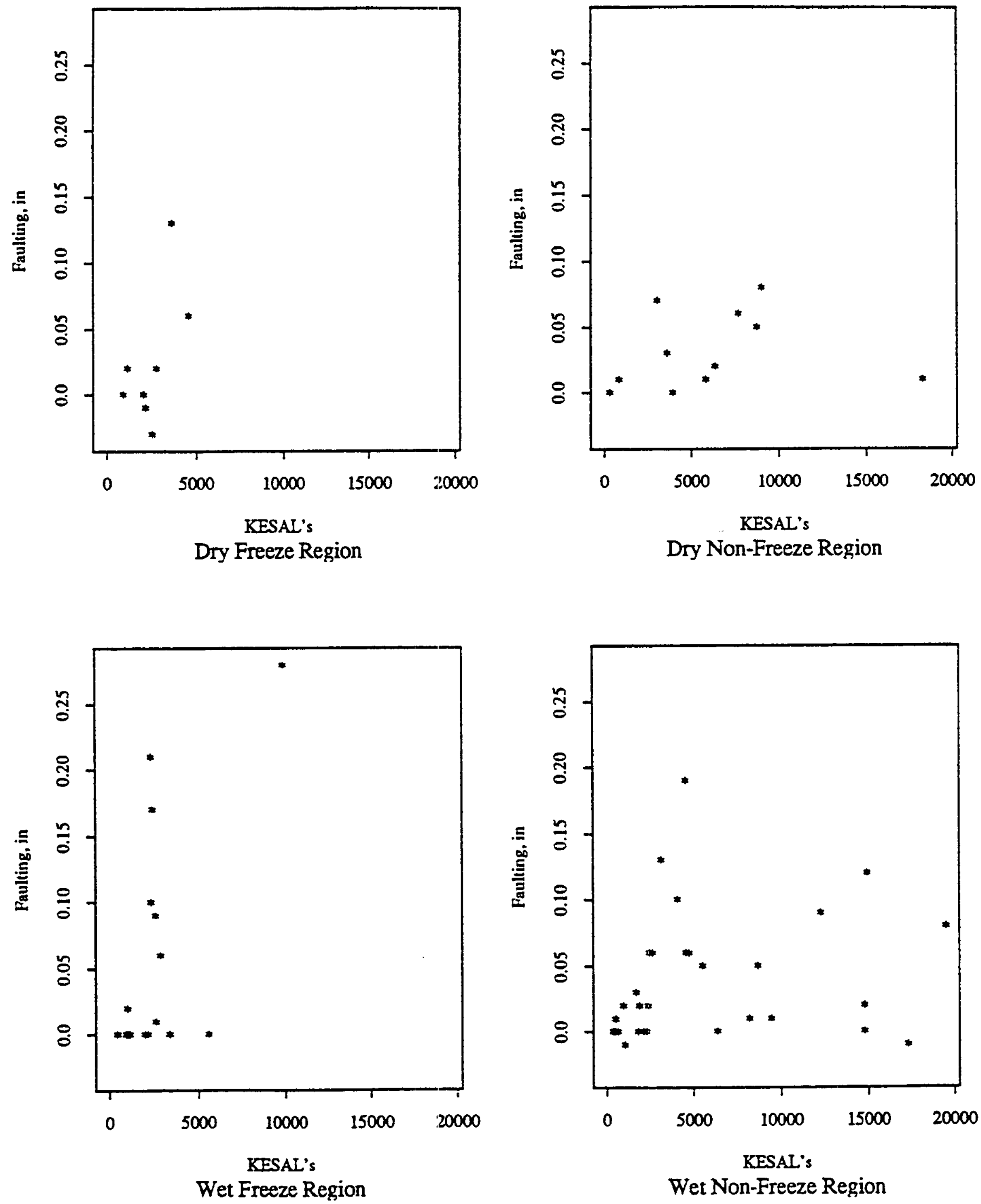


Figure 4.4 Faulting vs. KESALs Scatter Plots for GPS-3 Sections

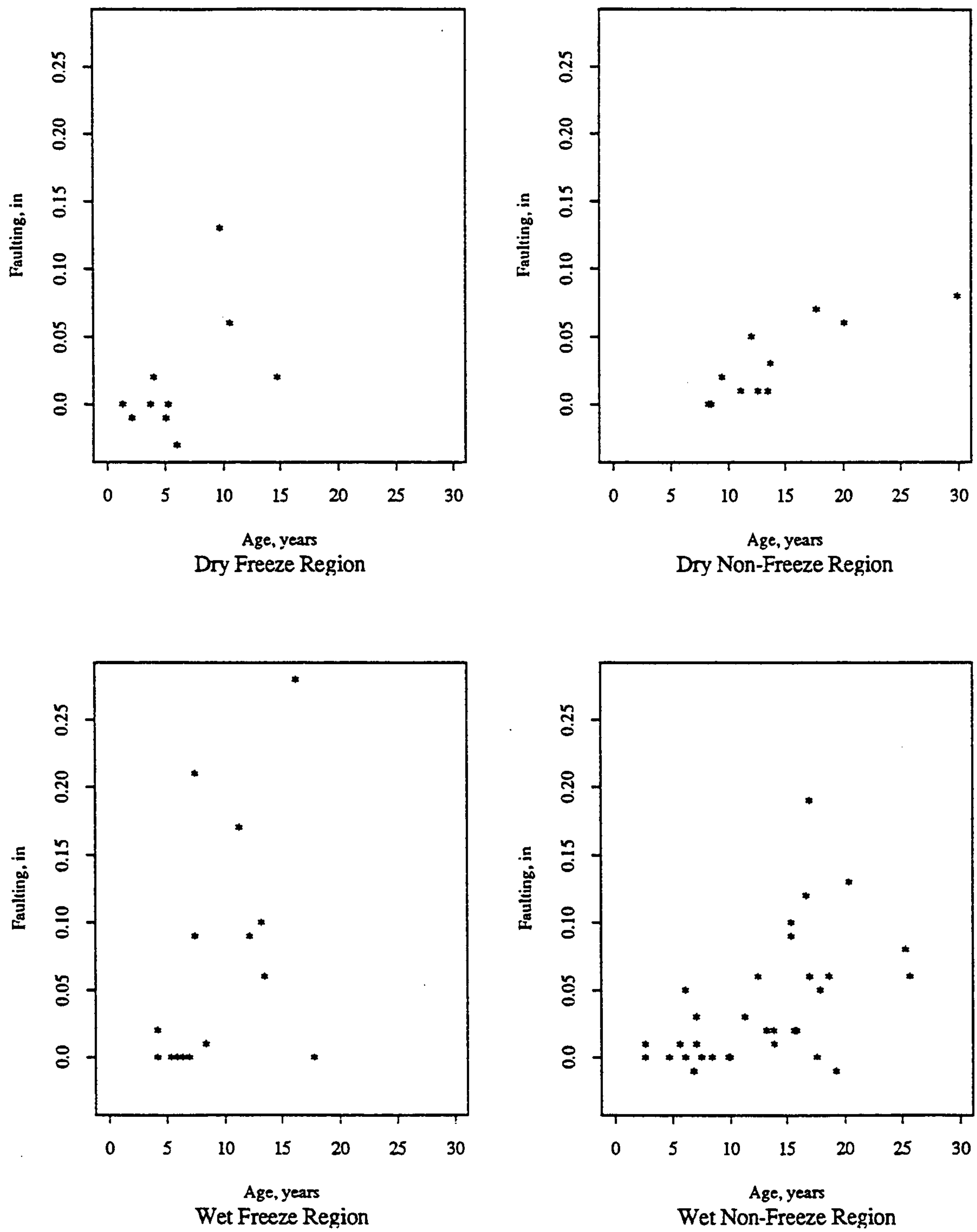


Figure 4.5 Faulting vs. Pavement Age Scatter Plots for GPS-3 Sections

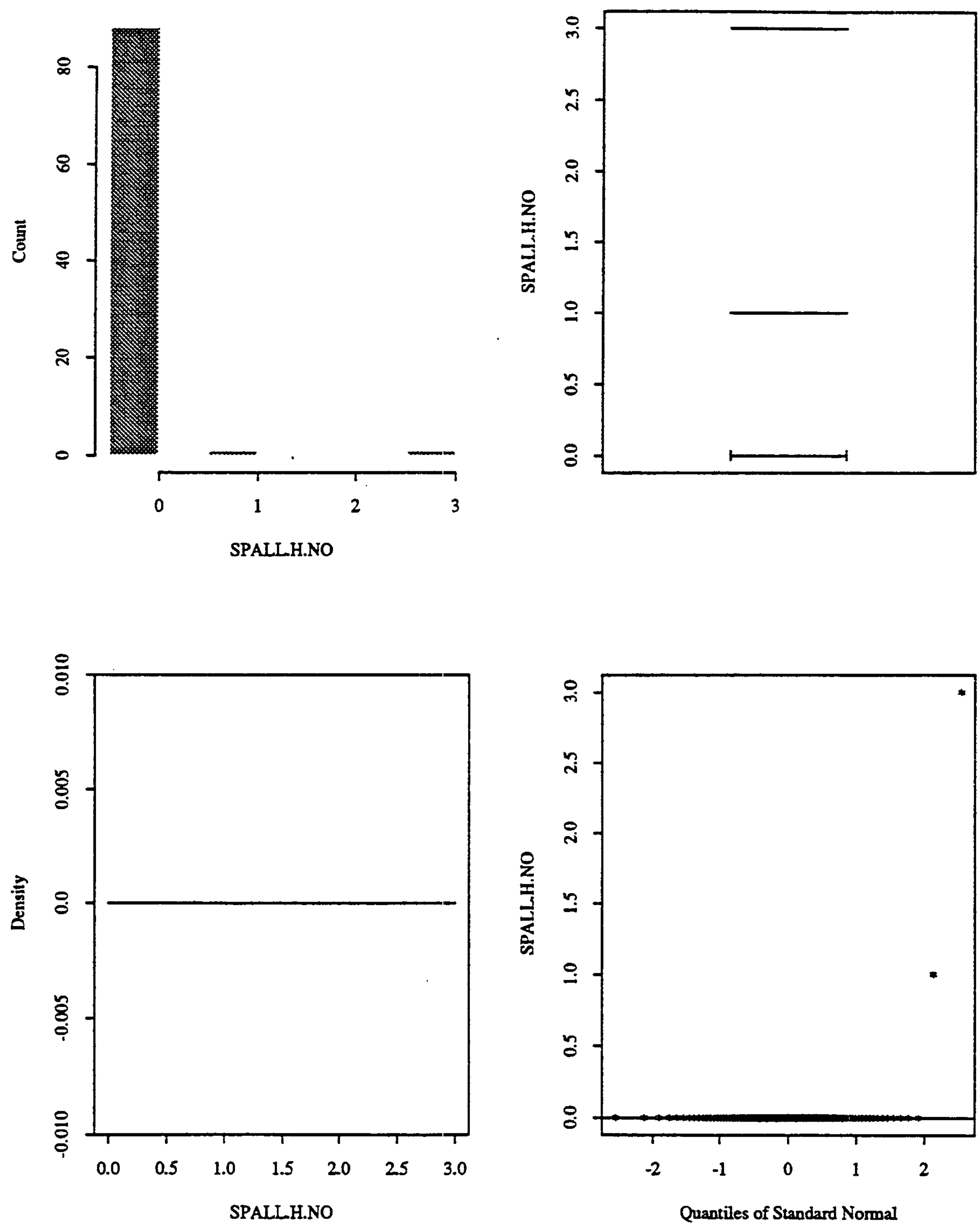


Figure 4.6 Statistical Distribution of High Severity Spalling for GPS-3 Sections

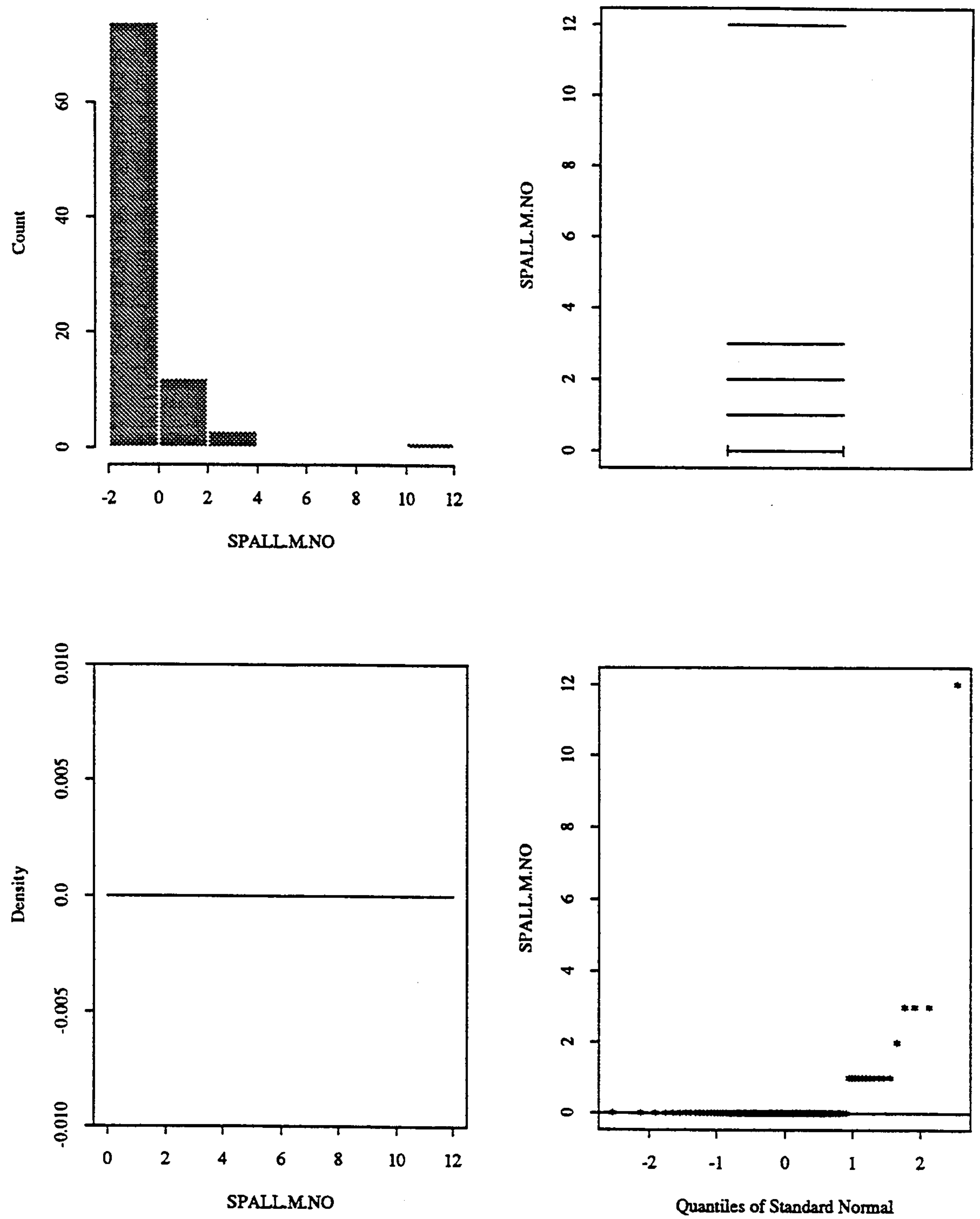


Figure 4.7 Statistical Distribution of Medium Severity Spalling for GPS-3 Sections

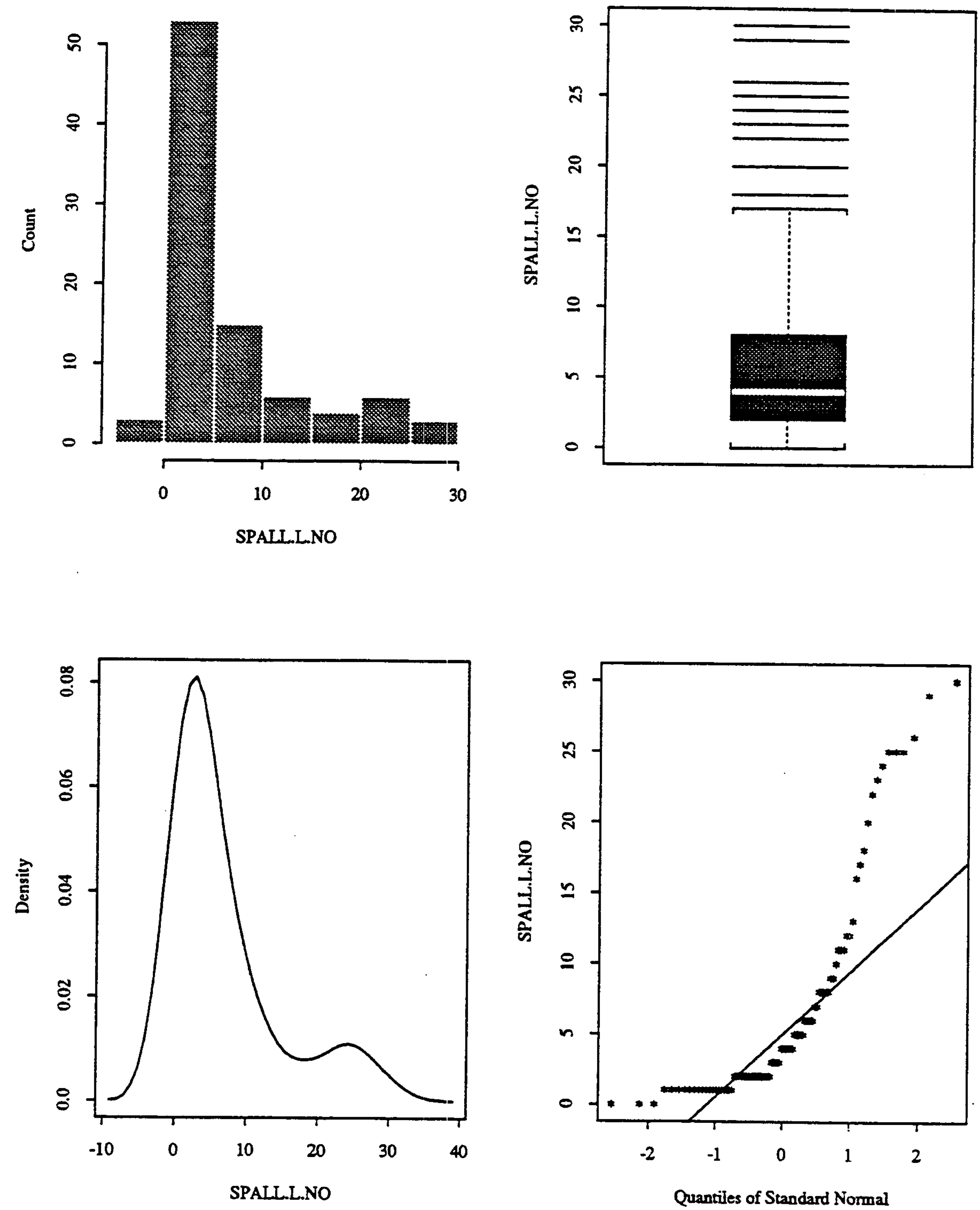


Figure 4.8 Statistical Distribution of Low Severity Spalling for GPS-3 Sections

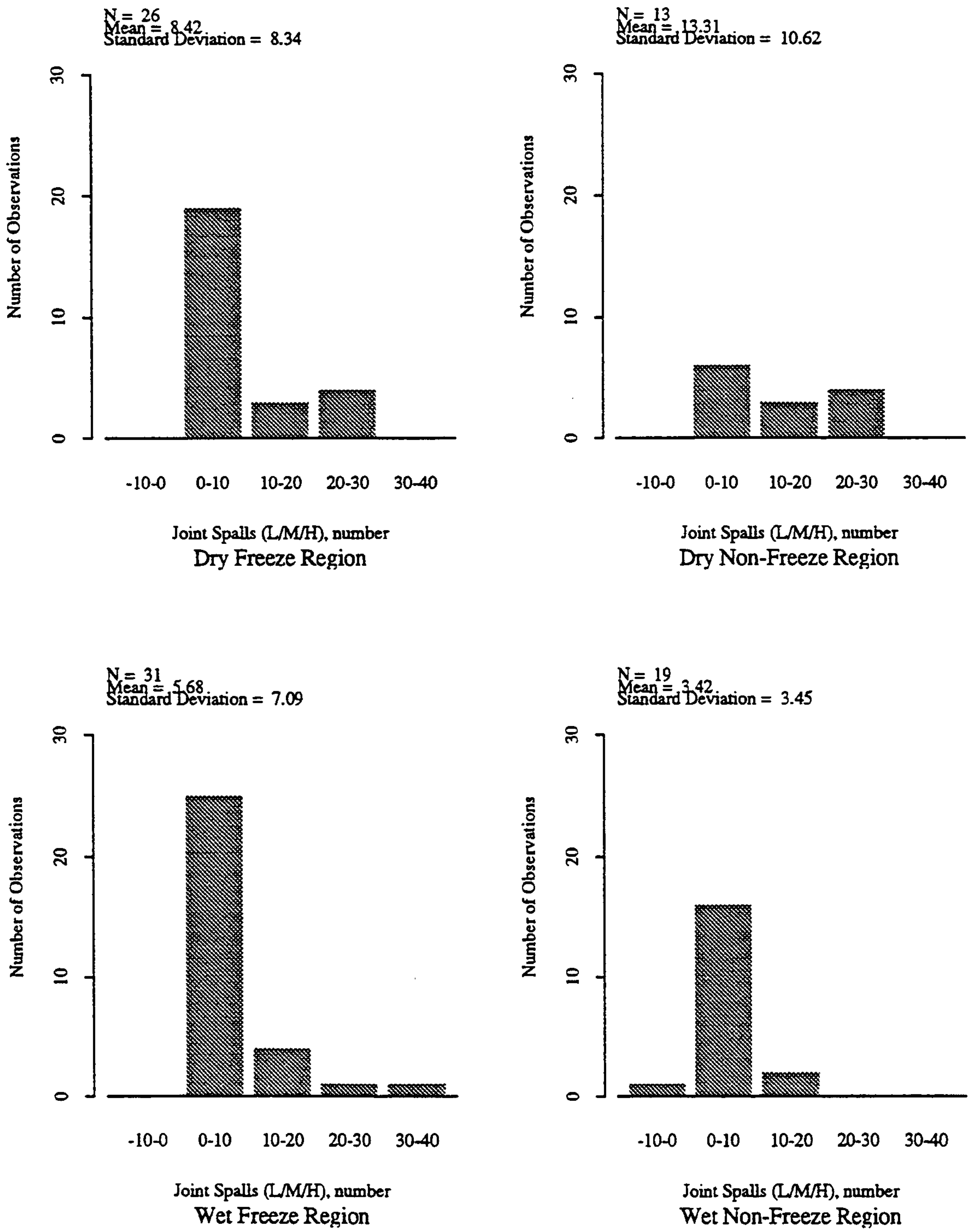


Figure 4.9 Distribution of Joint Spalling by Environmental Regions for GPS-3 Sections

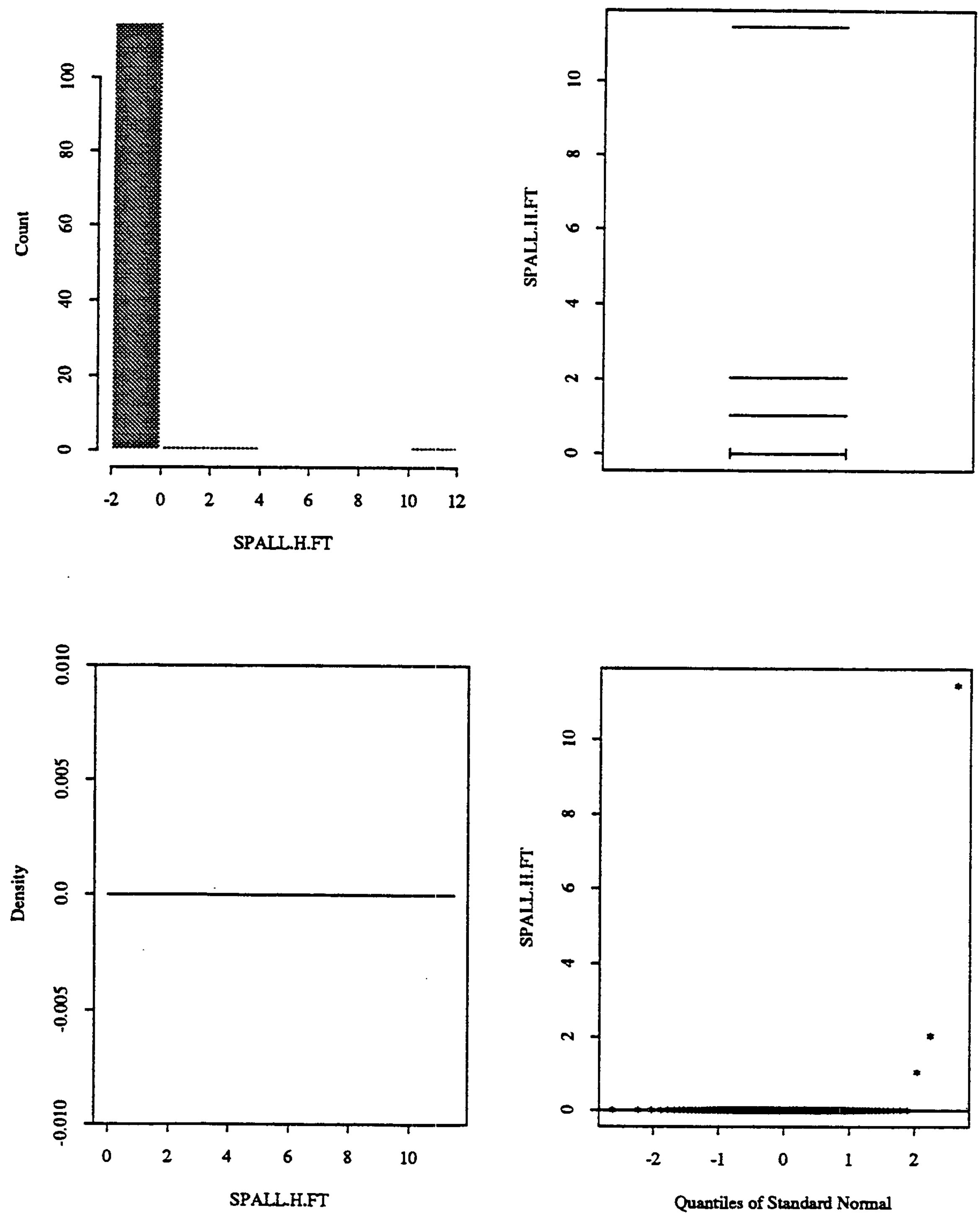


Figure 4.10 Statistical Distribution of High Severity Spalling for GPS-3 Sections, ft

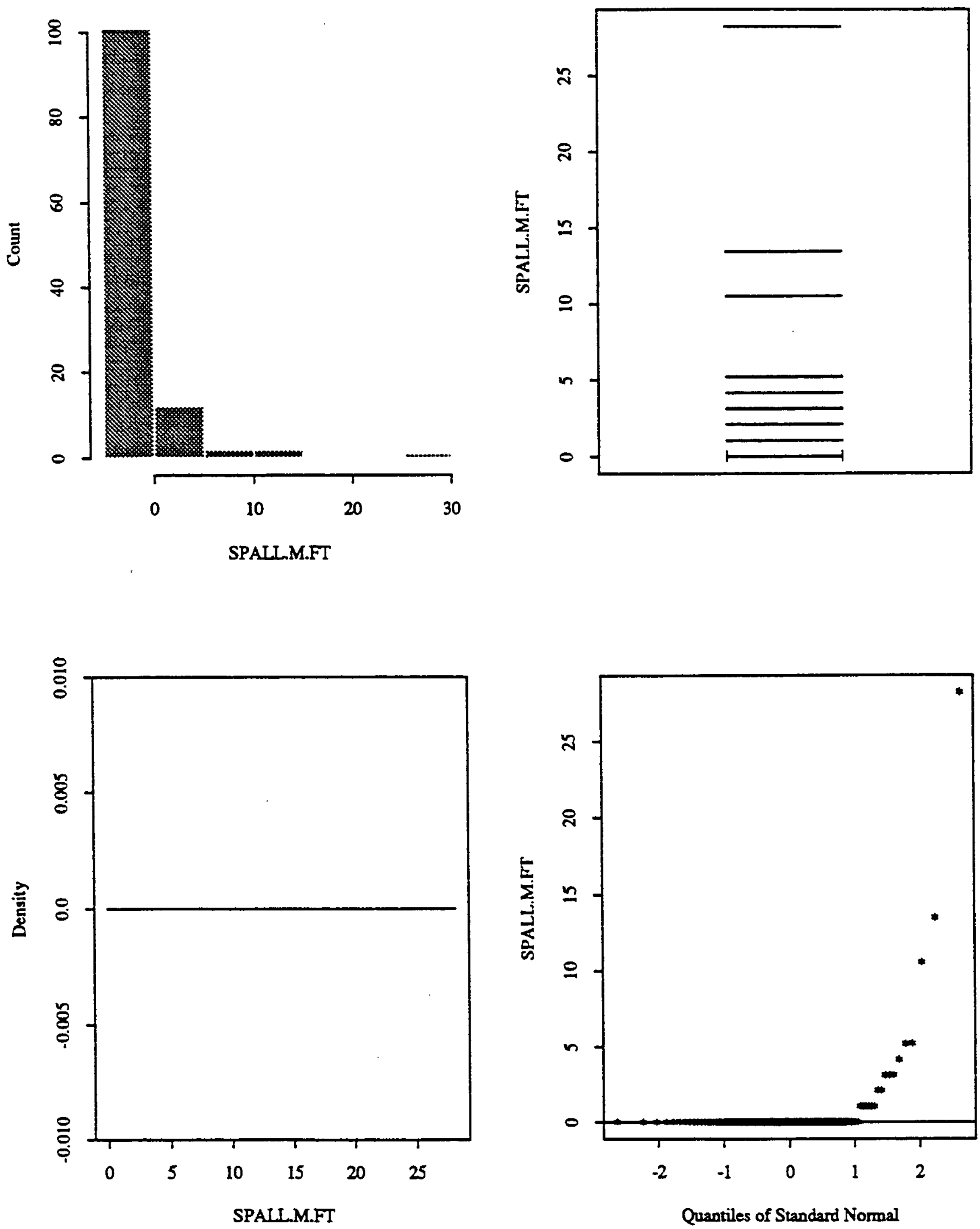


Figure 4.11 Statistical Distribution of Medium Severity Spalling for GPS-3 Sections, ft

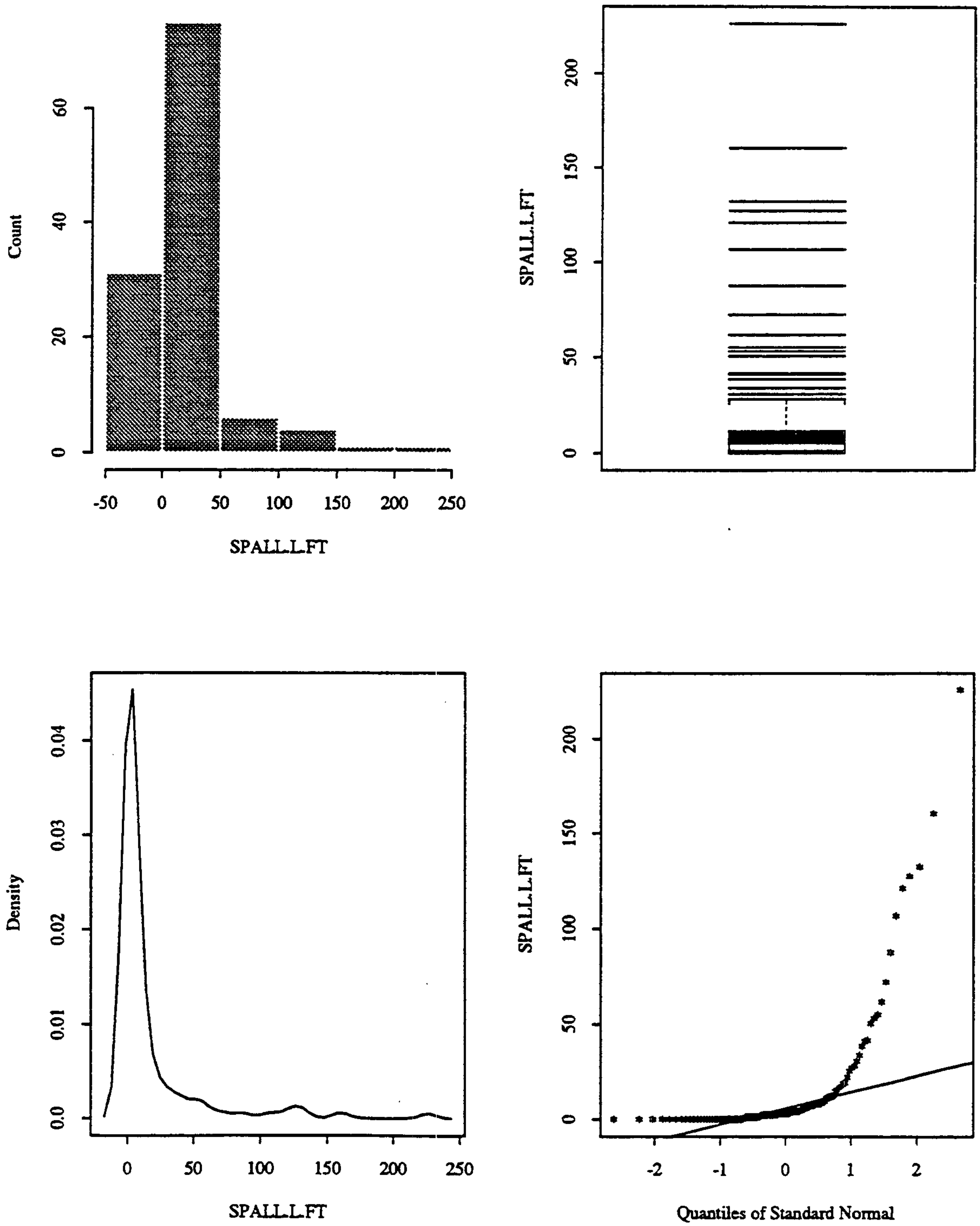


Figure 4.12 Statistical Distribution of Low Severity Spalling for GPS-3 Sections, ft

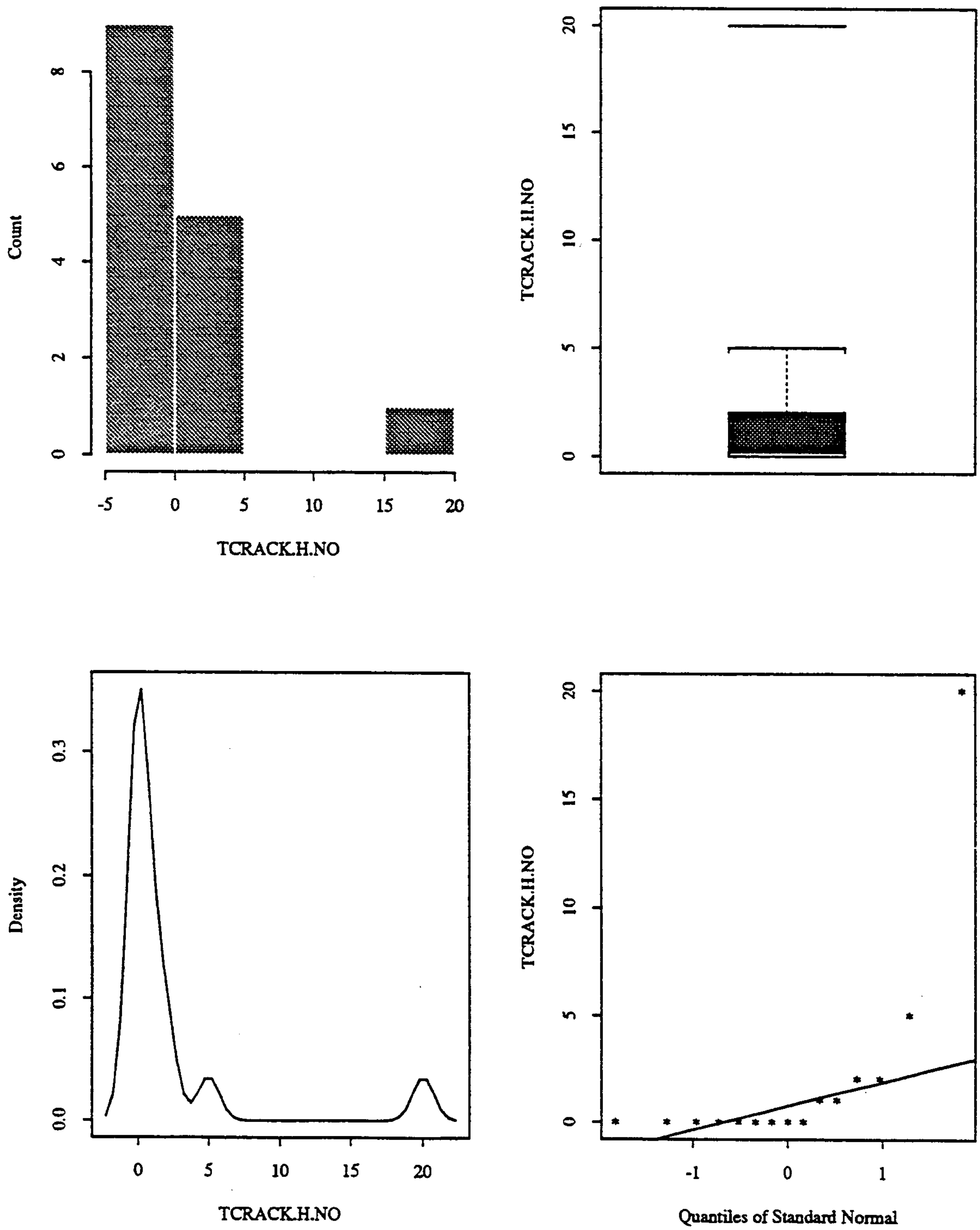


Figure 4.13 Statistical Distribution of High Severity Transverse Cracking for GPS-3 Sections, Number

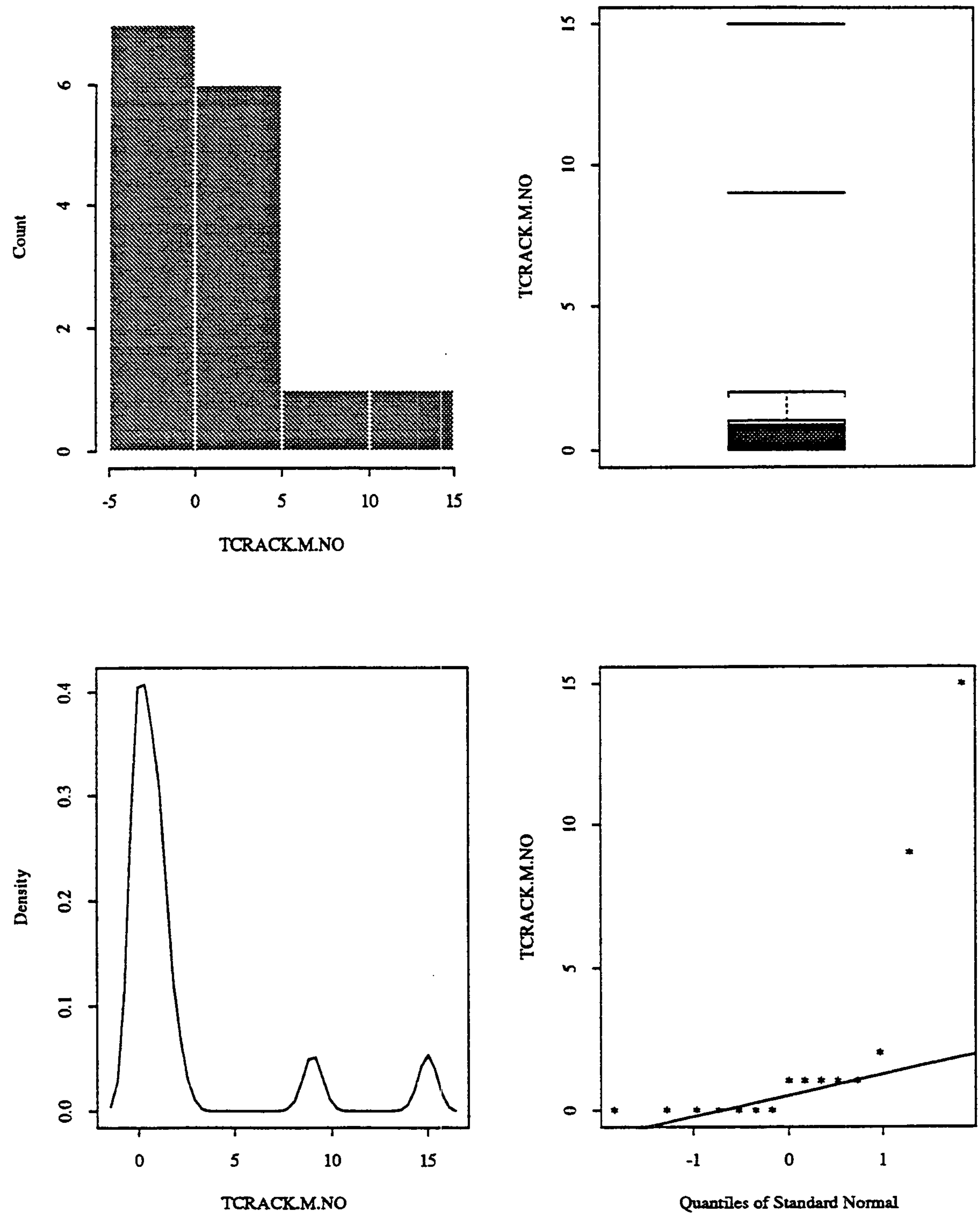


Figure 4.14 Statistical Distribution of Medium Severity Transverse Cracking for GPS-3 Sections, Number

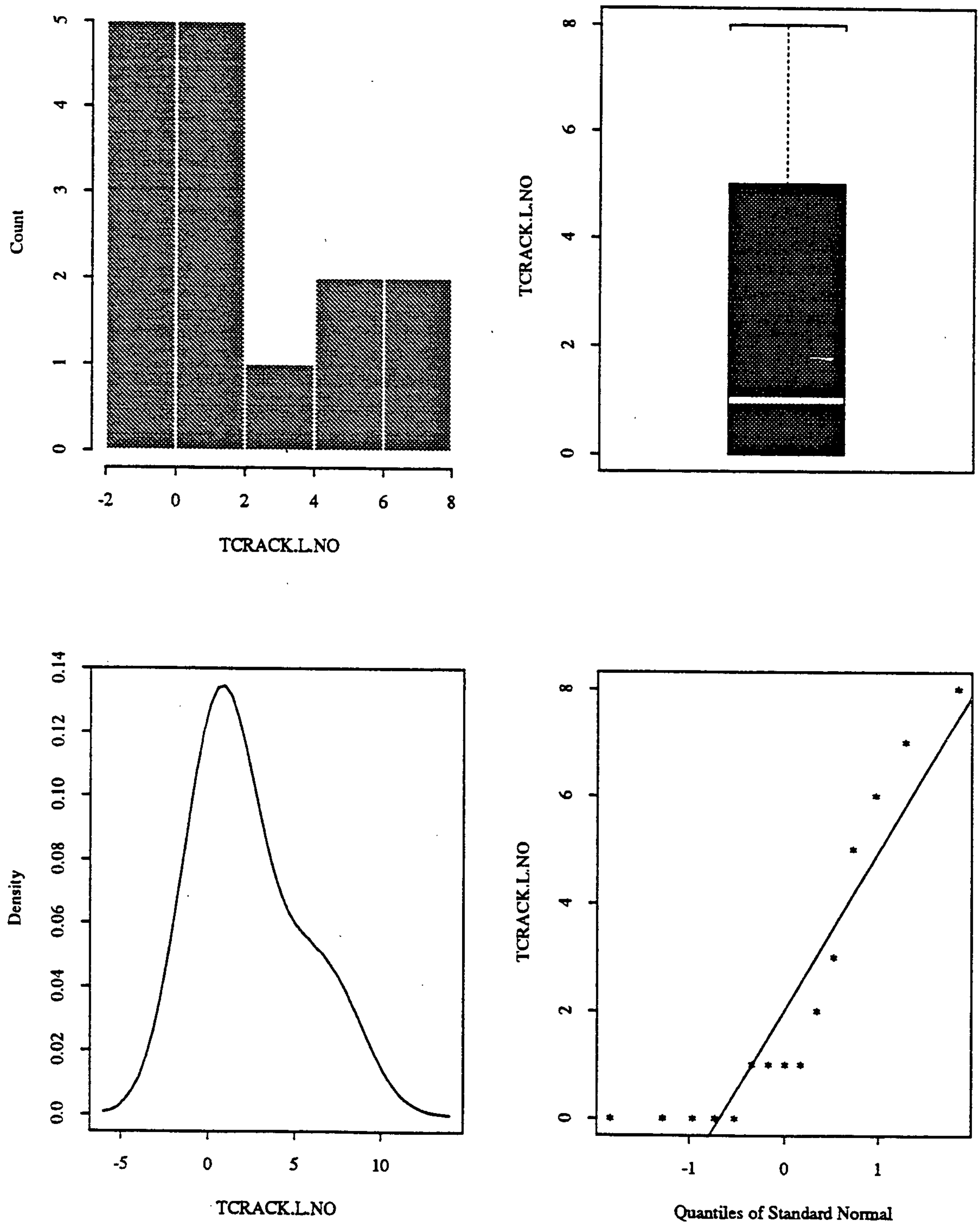


Figure 4.15 Statistical Distribution of Low Severity Transverse Cracking for GPS-3 Sections, Number

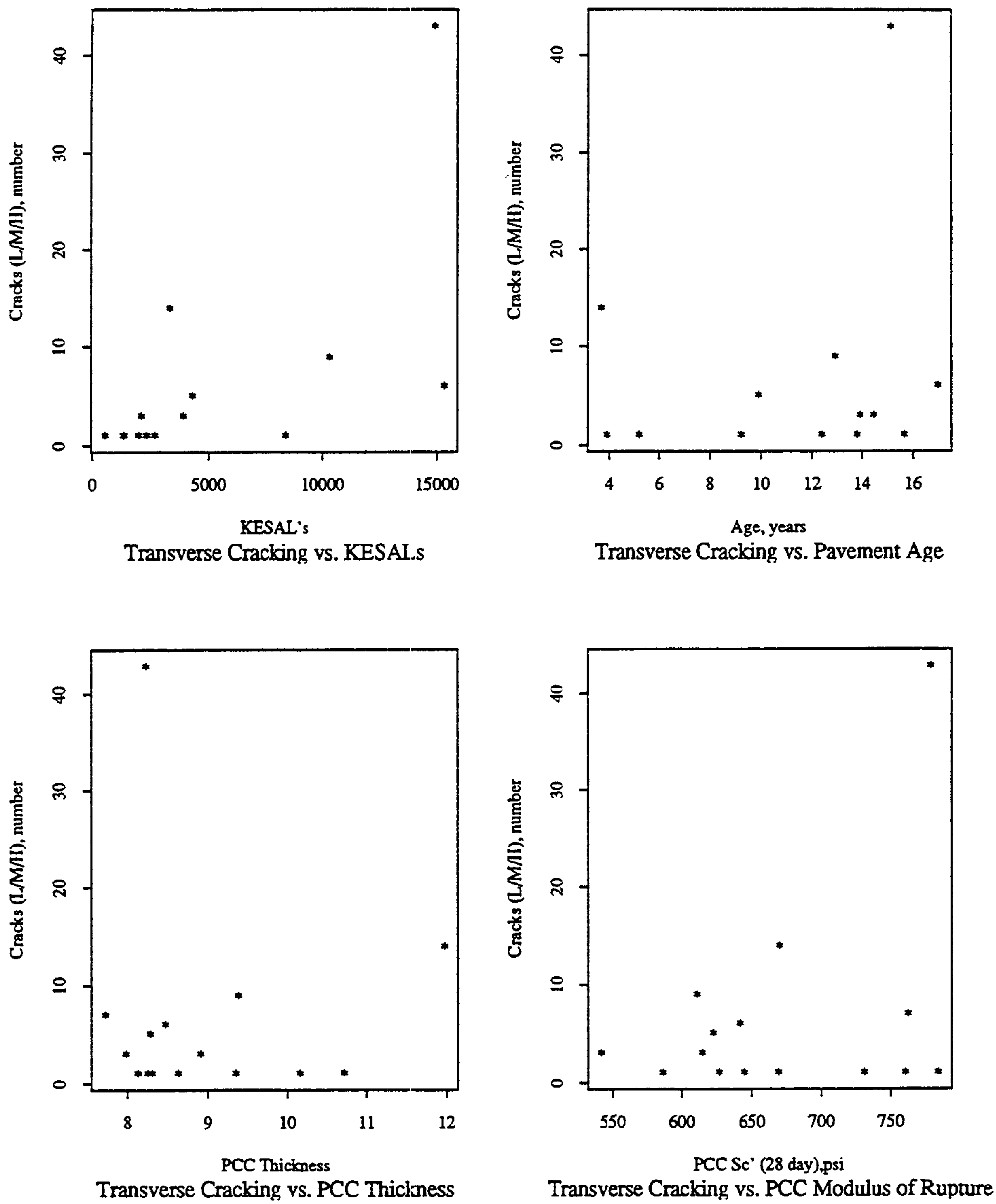


Figure 4.16 Transverse Cracking Scatter Plot for GPS-3 Sections

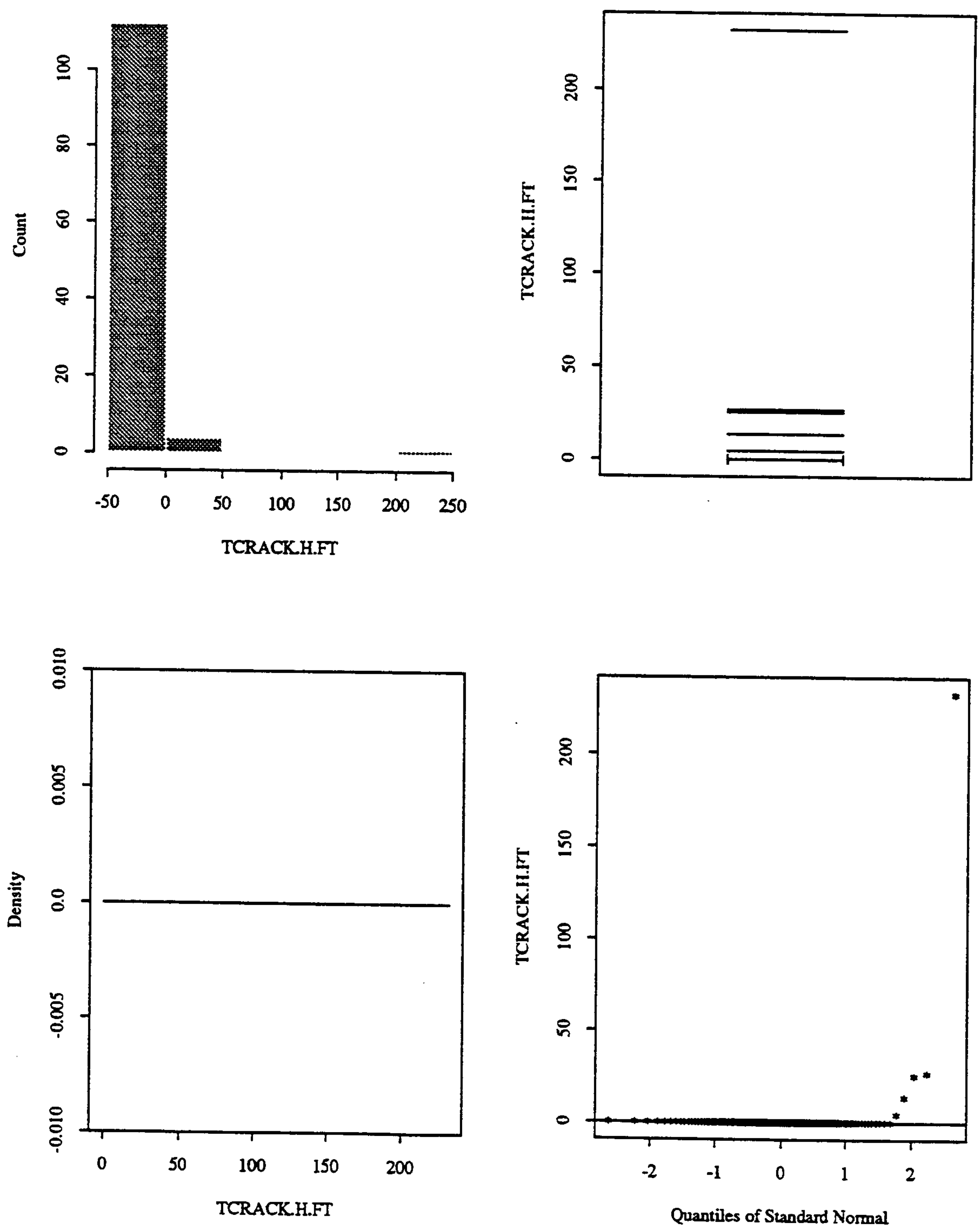


Figure 4.17 Statistical Distribution of High Severity Transverse Cracking for GPS-3 Sections, ft

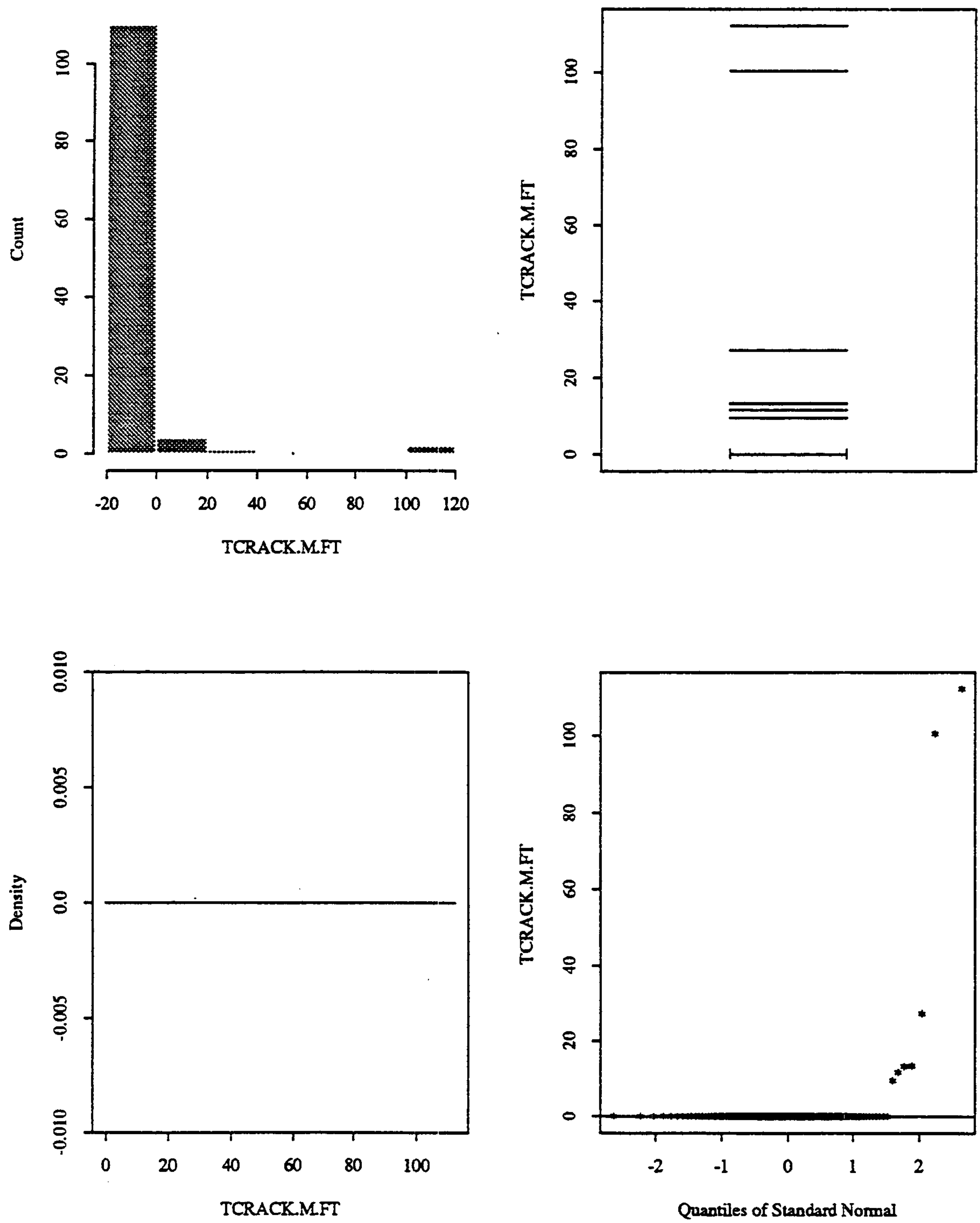


Figure 4.18 Statistical Distribution of Medium Severity Transverse Cracking for GPS-3 Sections, ft

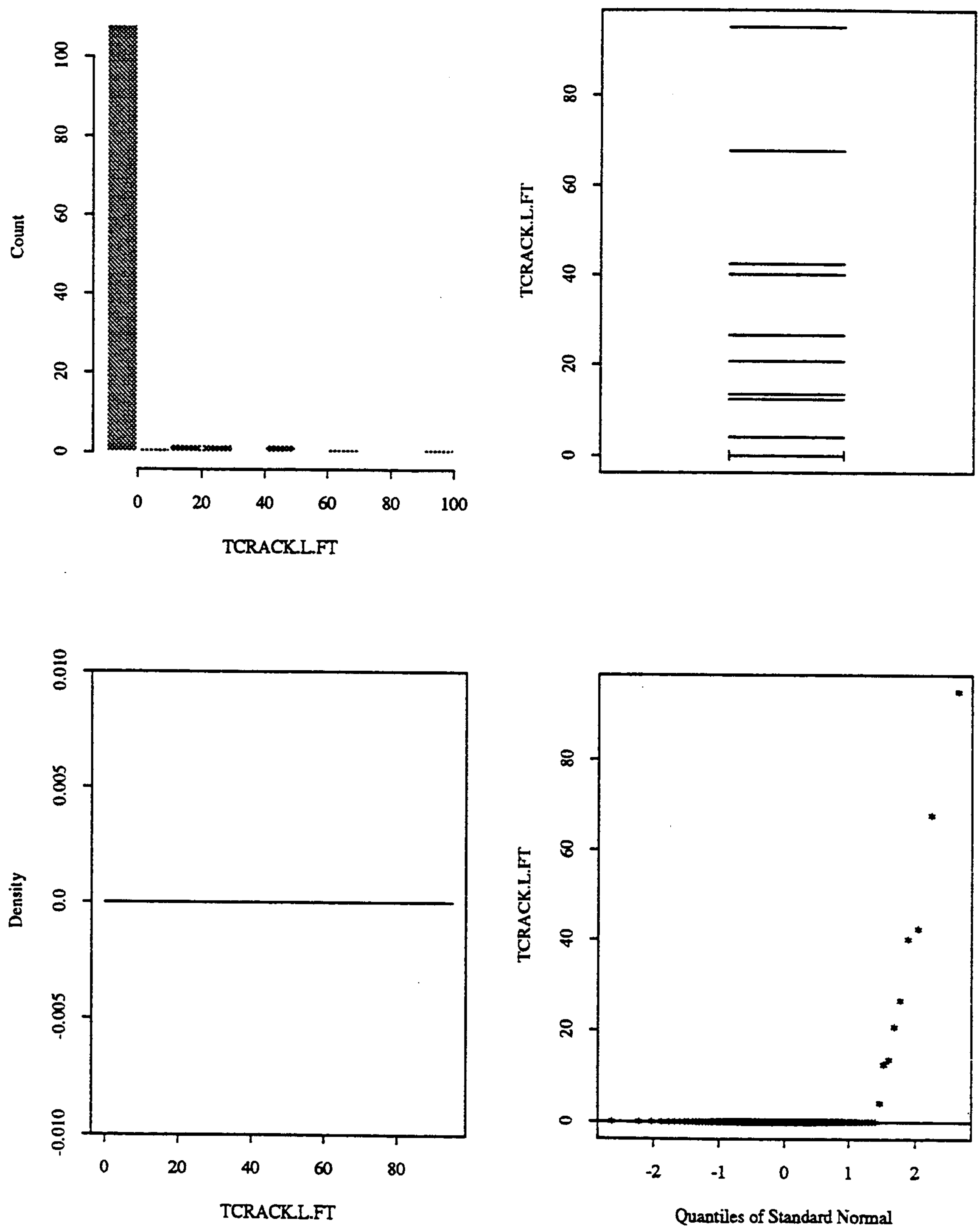


Figure 4.19 Statistical Distribution of Low Severity Transverse Cracking for GPS-3 Sections, ft

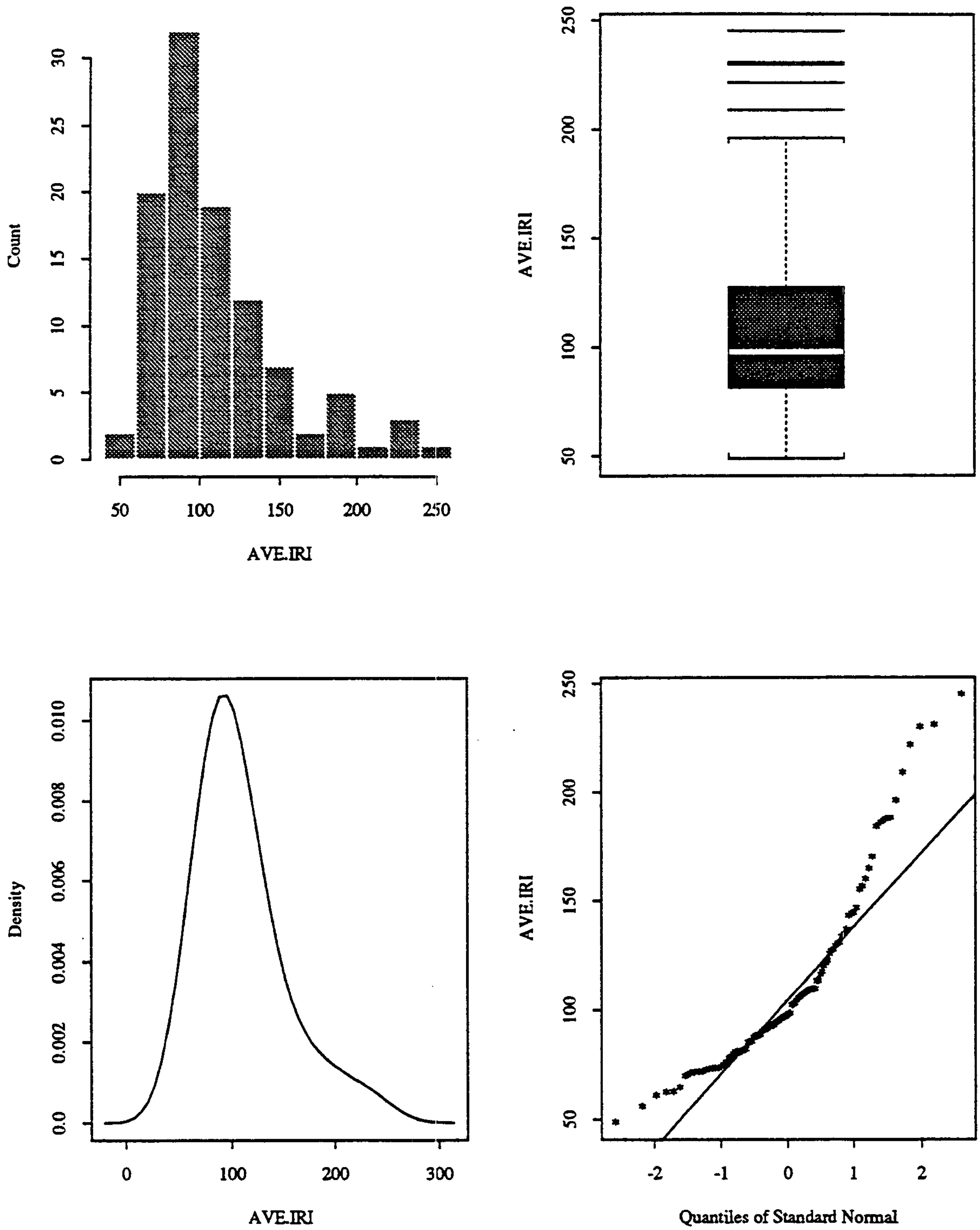


Figure 4.20 Statistical Distribution of Average IRI for GPS-3 Sections, in/mile

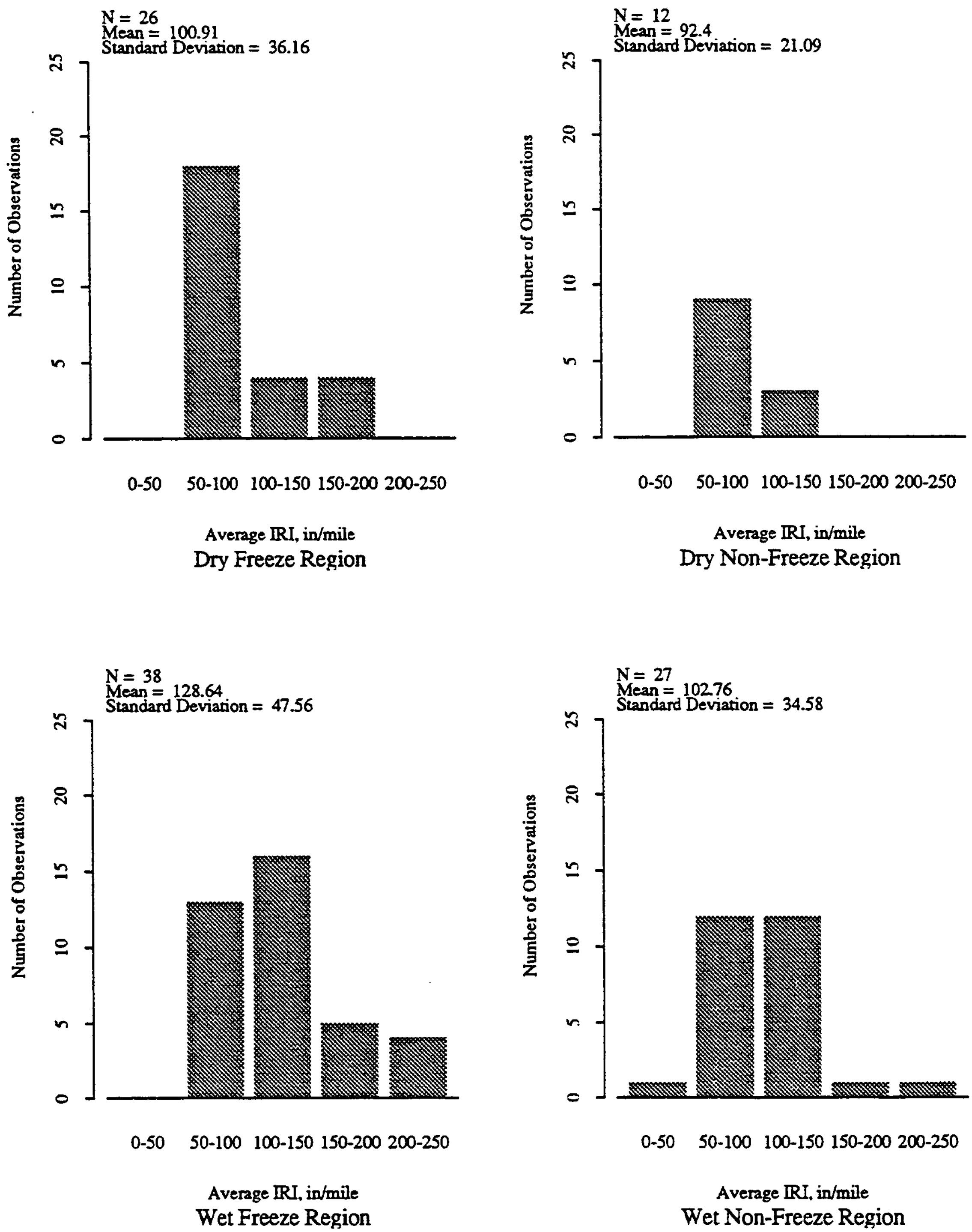


Figure 4.21 Distribution of Average IRI by Environmental Regions for GPS-3 Sections

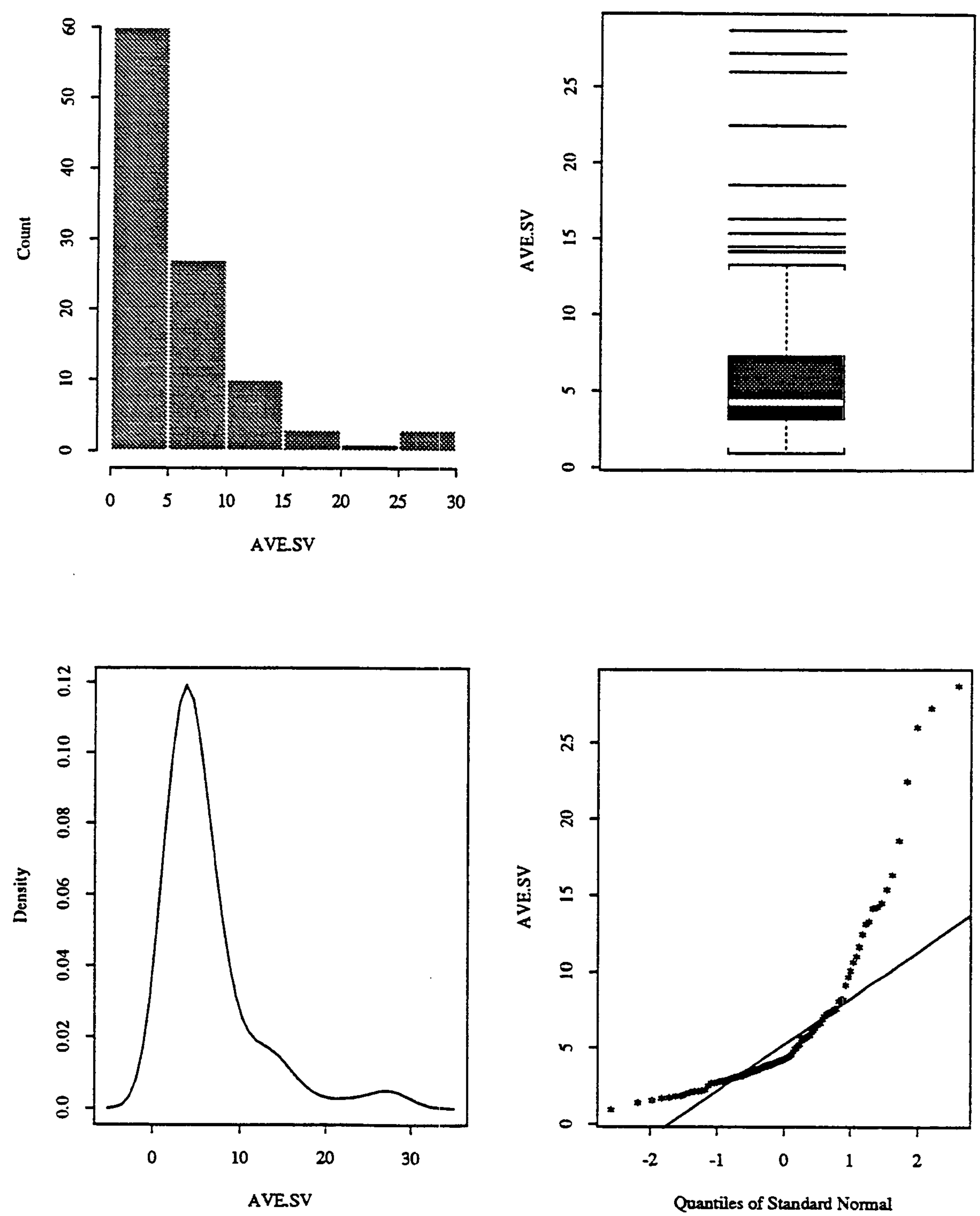


Figure 4.22 Statistical Distribution of Average Slope Variance in GPS-3 Sections

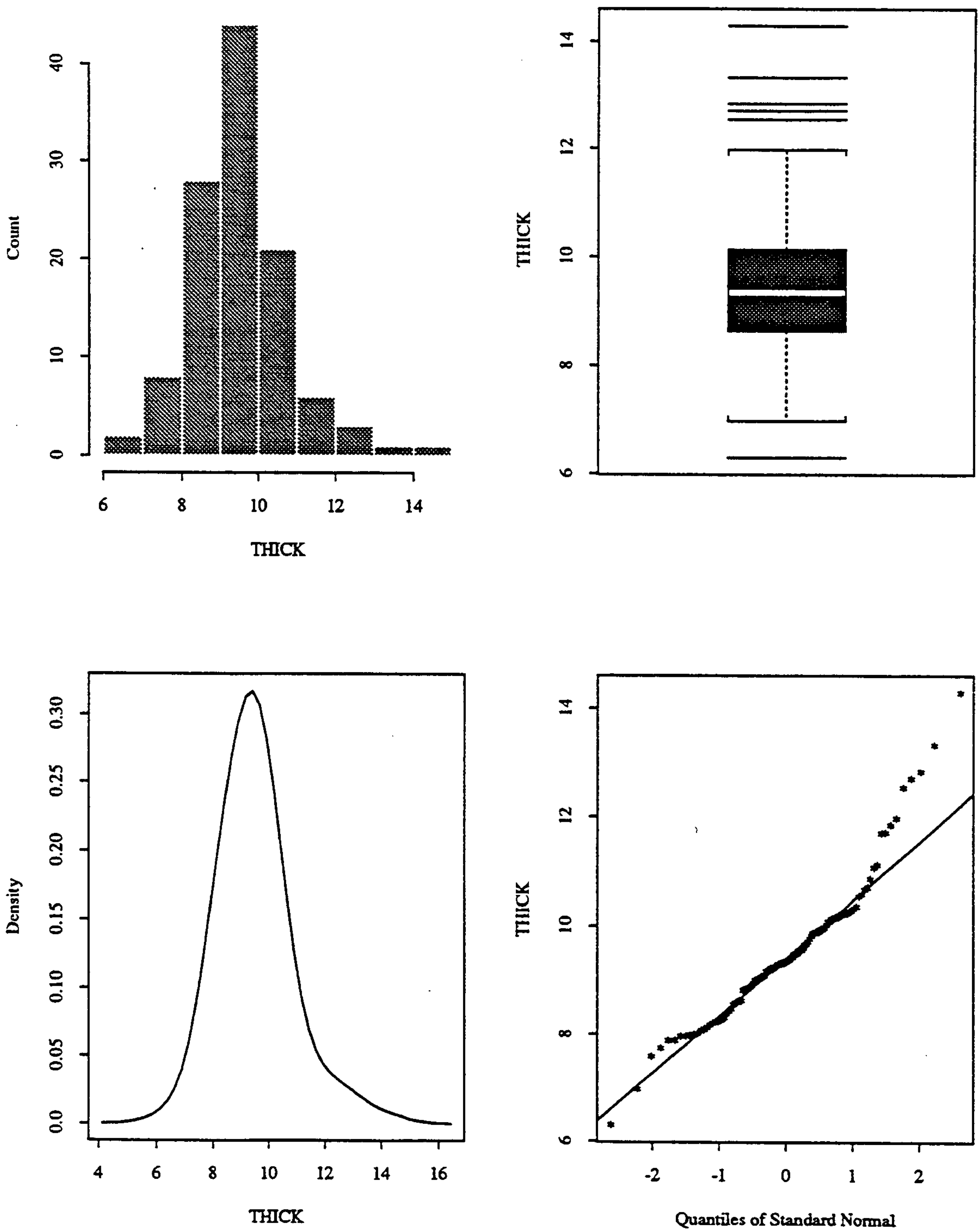


Figure 4.23 Statistical Distribution of PCC Thickness for GPS-3 Sections

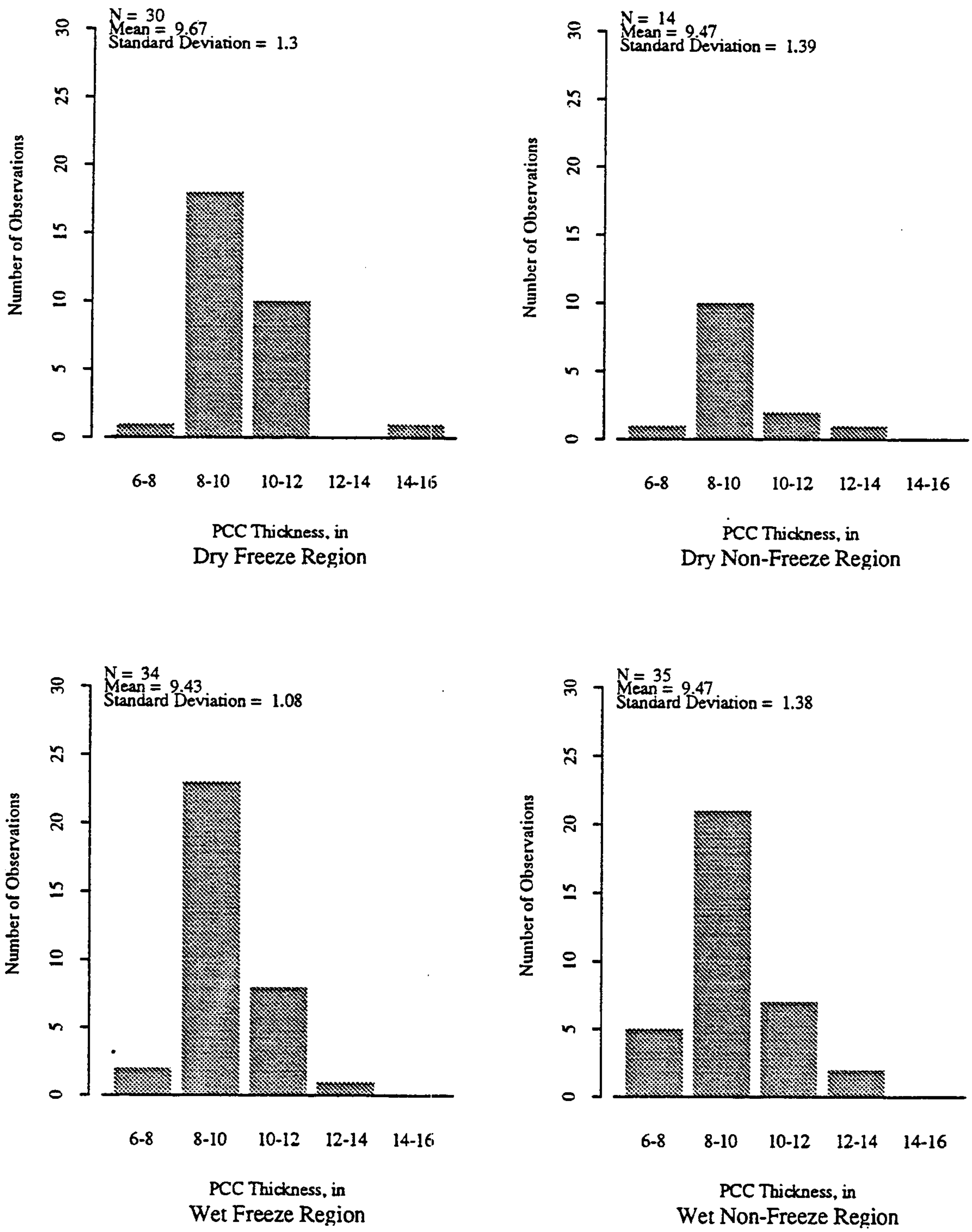


Figure 4.24 Distribution of PCC Thickness by Environmental Regions for GPS-3 Sections

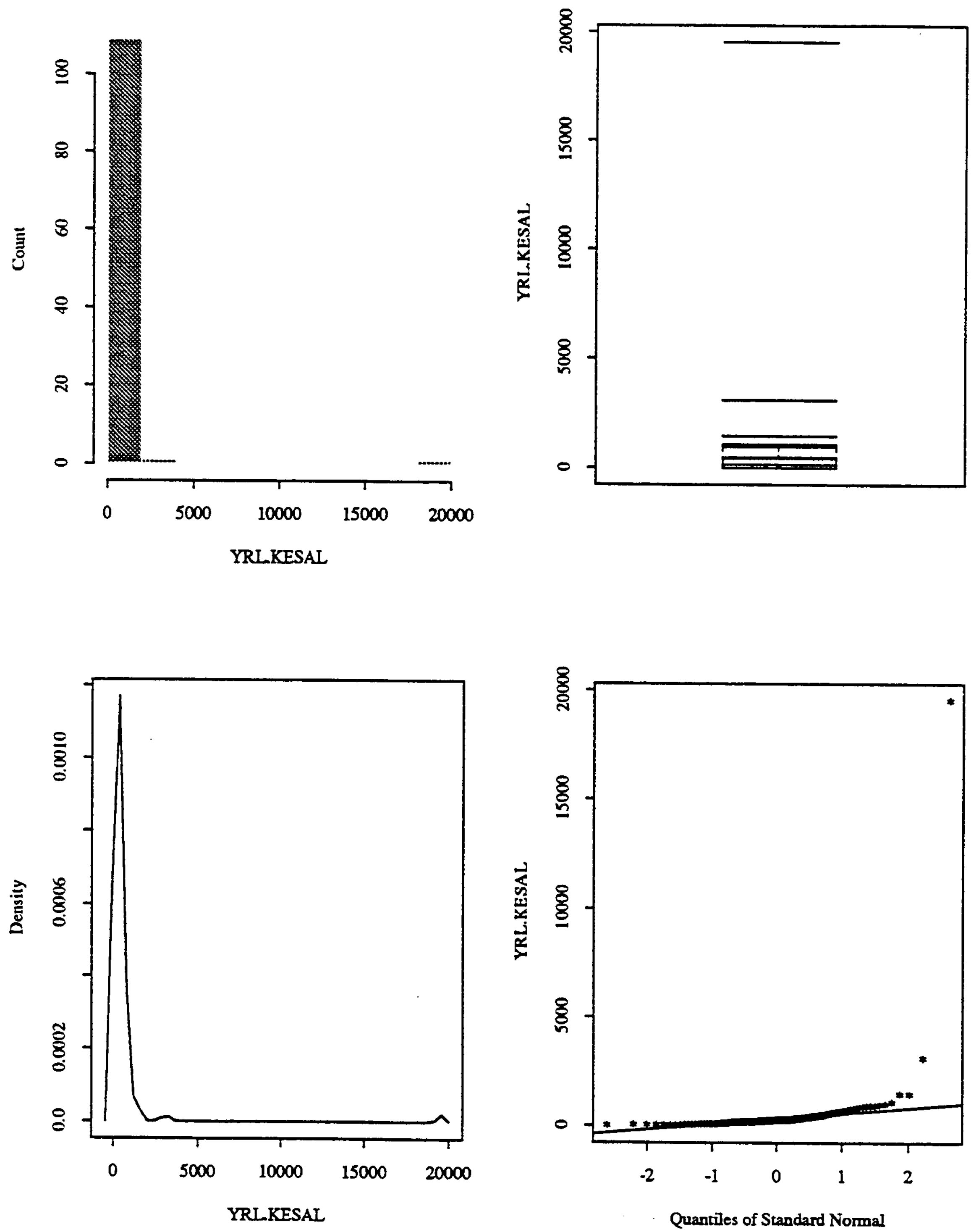


Figure 4.25 Statistical Distribution of KESALs/Year for GPS-3 Sections

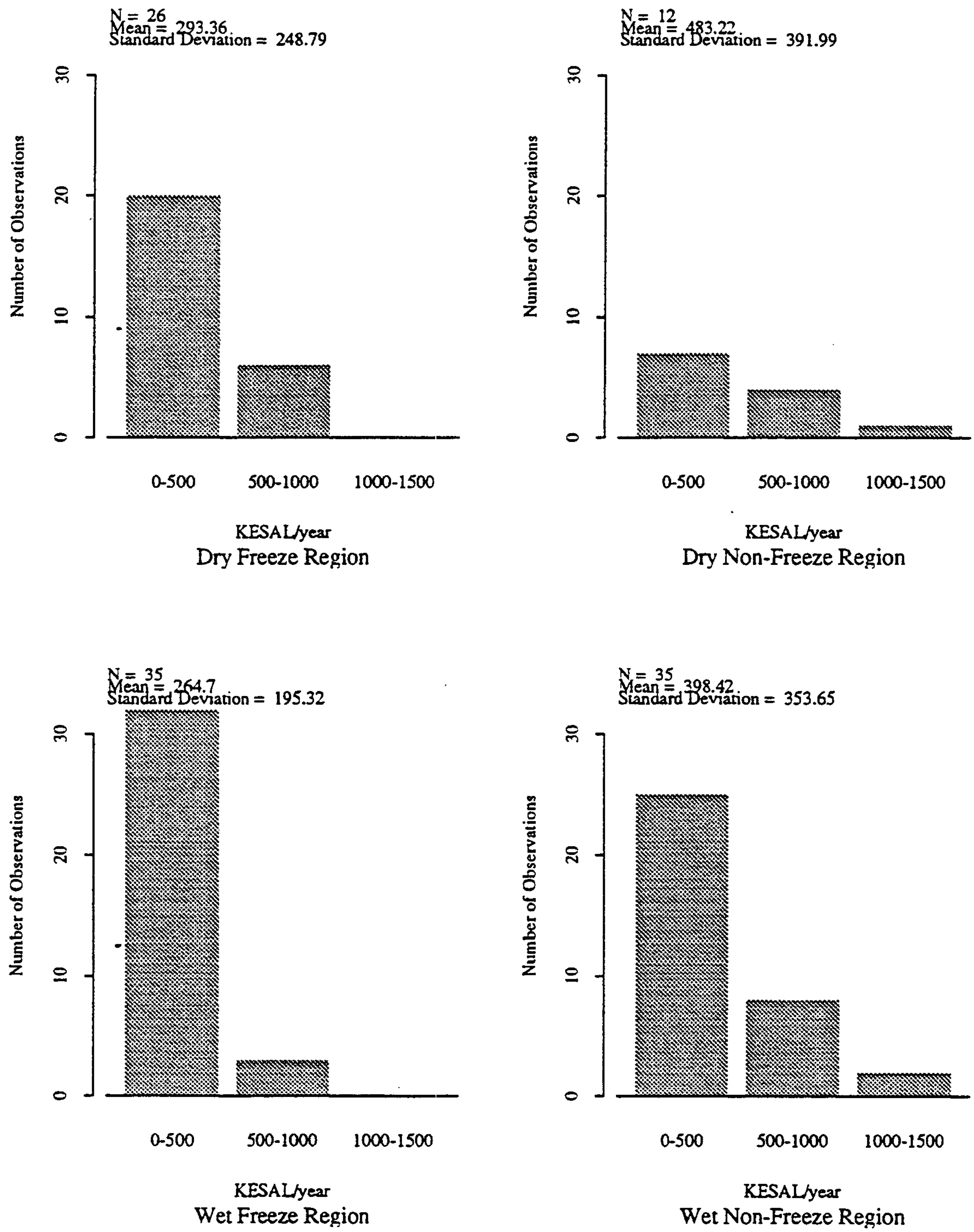


Figure 4.26 Distribution of KESALs/Year by Environmental Regions for GPS-3 Sections

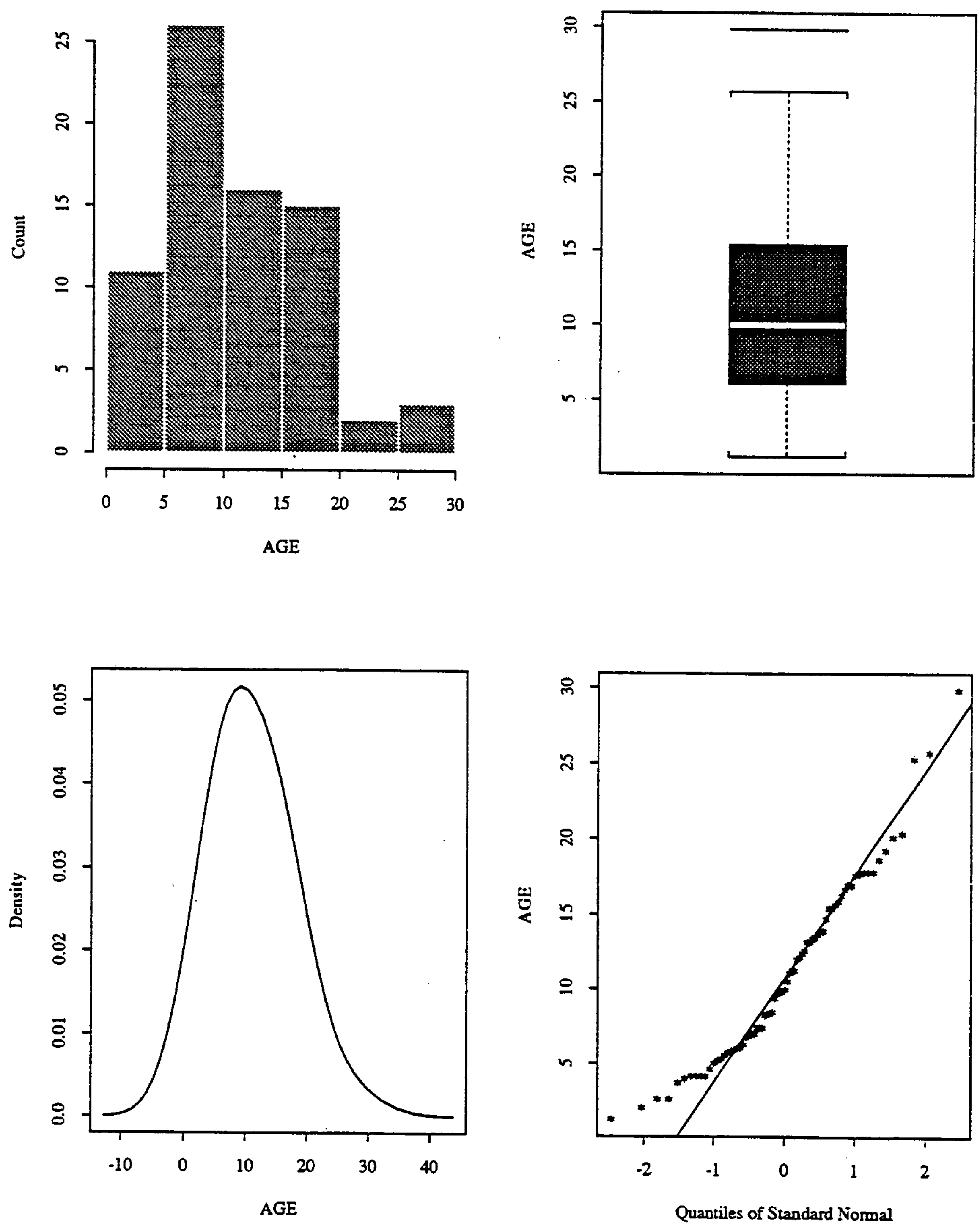


Figure 4.27 Statistical Distribution of Pavement Age for GPS-3 Sections, Years

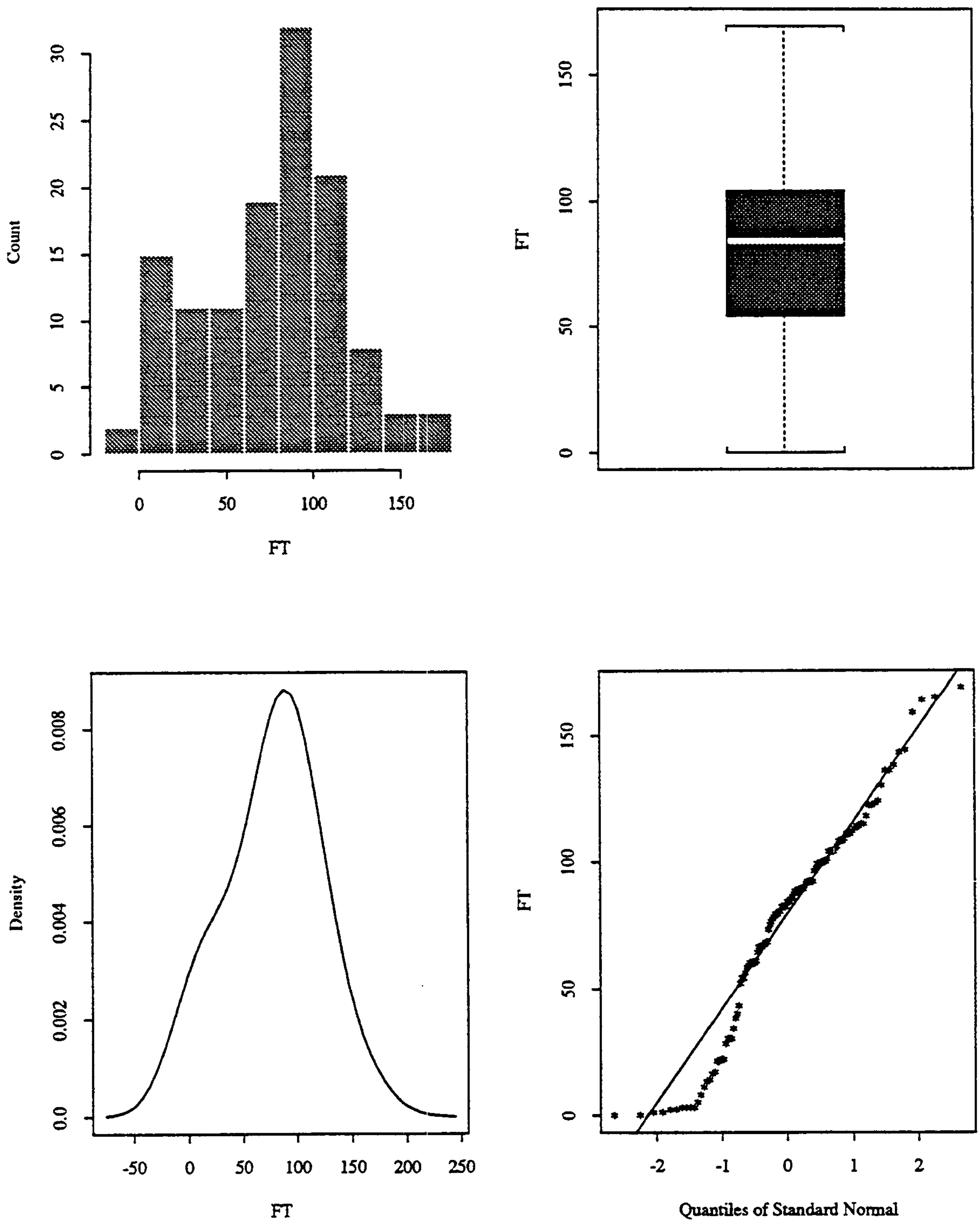


Figure 4.28 Statistical Distribution of Freeze-Thaw Cycle for GPS-3 Sections, Number

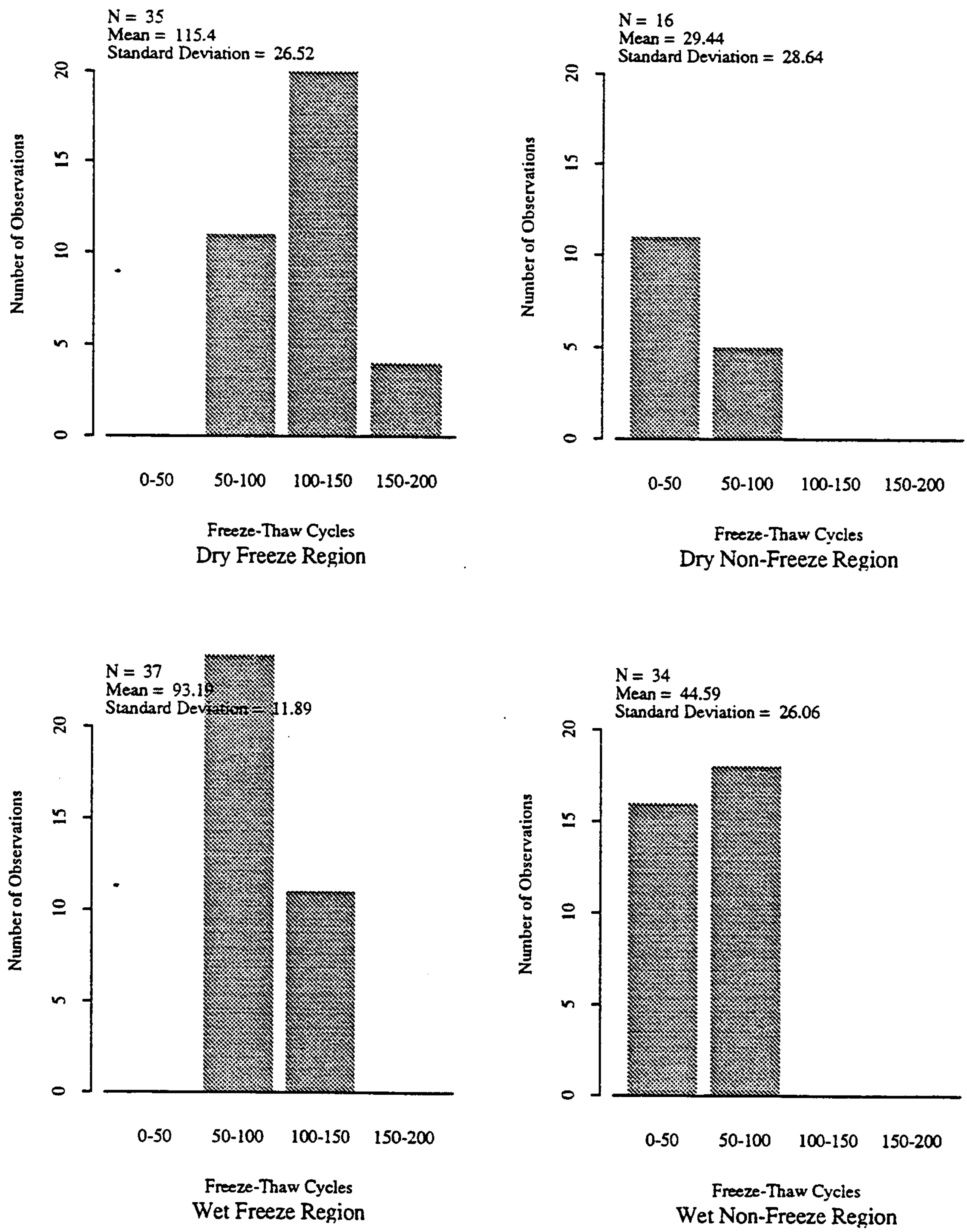


Figure 4.29 Distribution of Freeze-Thaw Cycles by Environmental Regions for GPS-3 Sections, Number

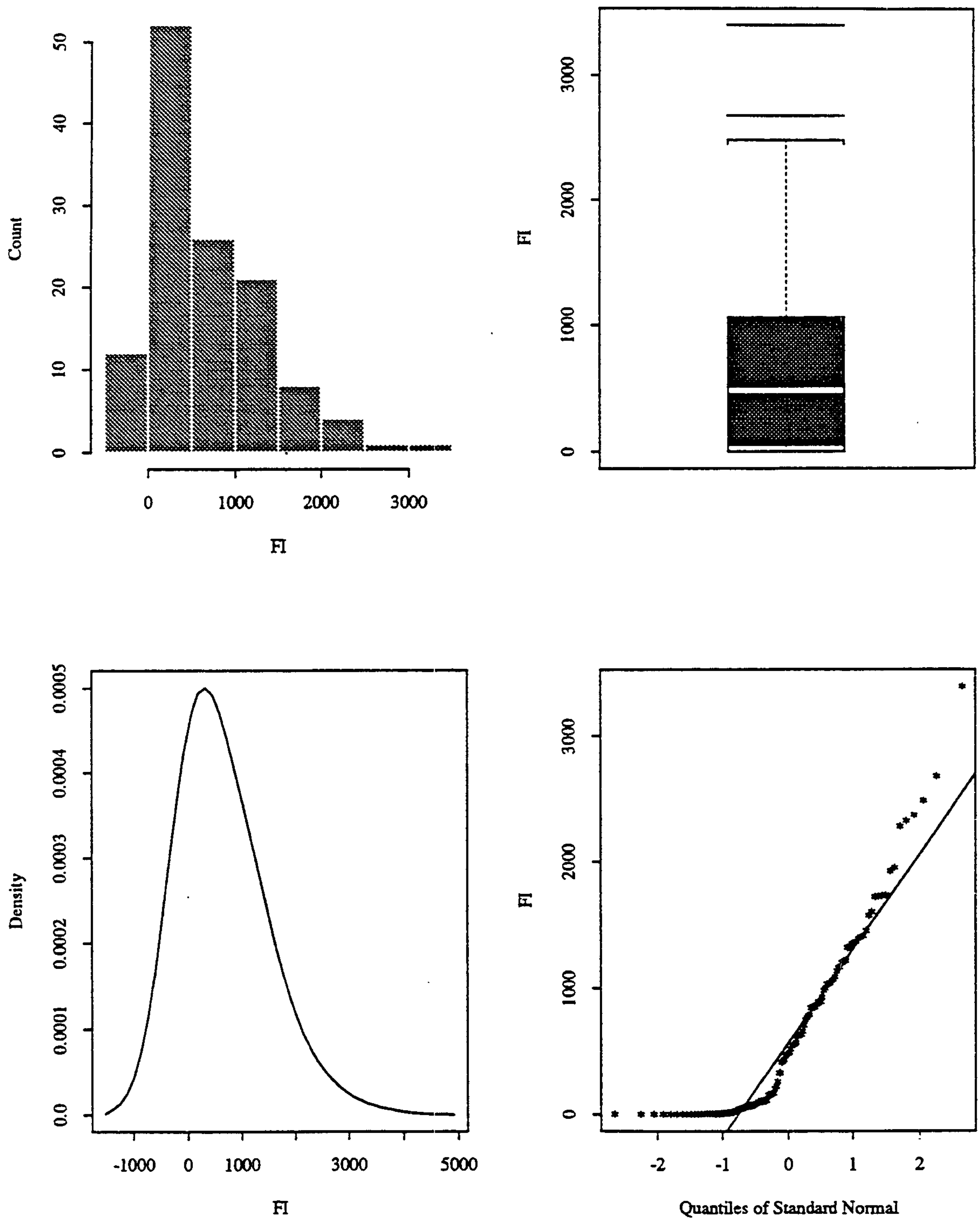


Figure 4.30 Statistical Distribution of Freezing Index for GPS-3 Sections

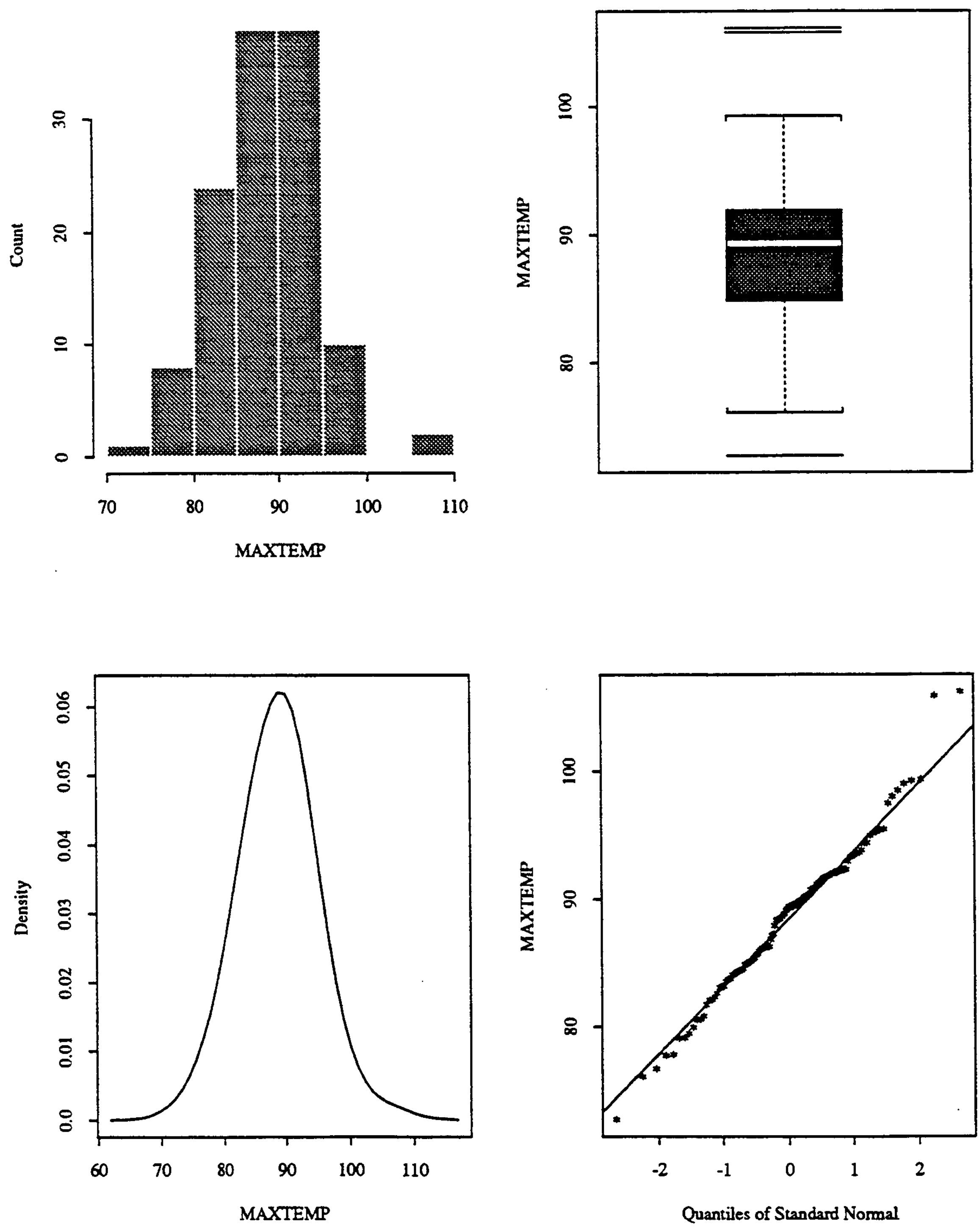


Figure 4.31 Statistical Distribution of Average Monthly Maximum Temperature for GPS-3 Sections, °F

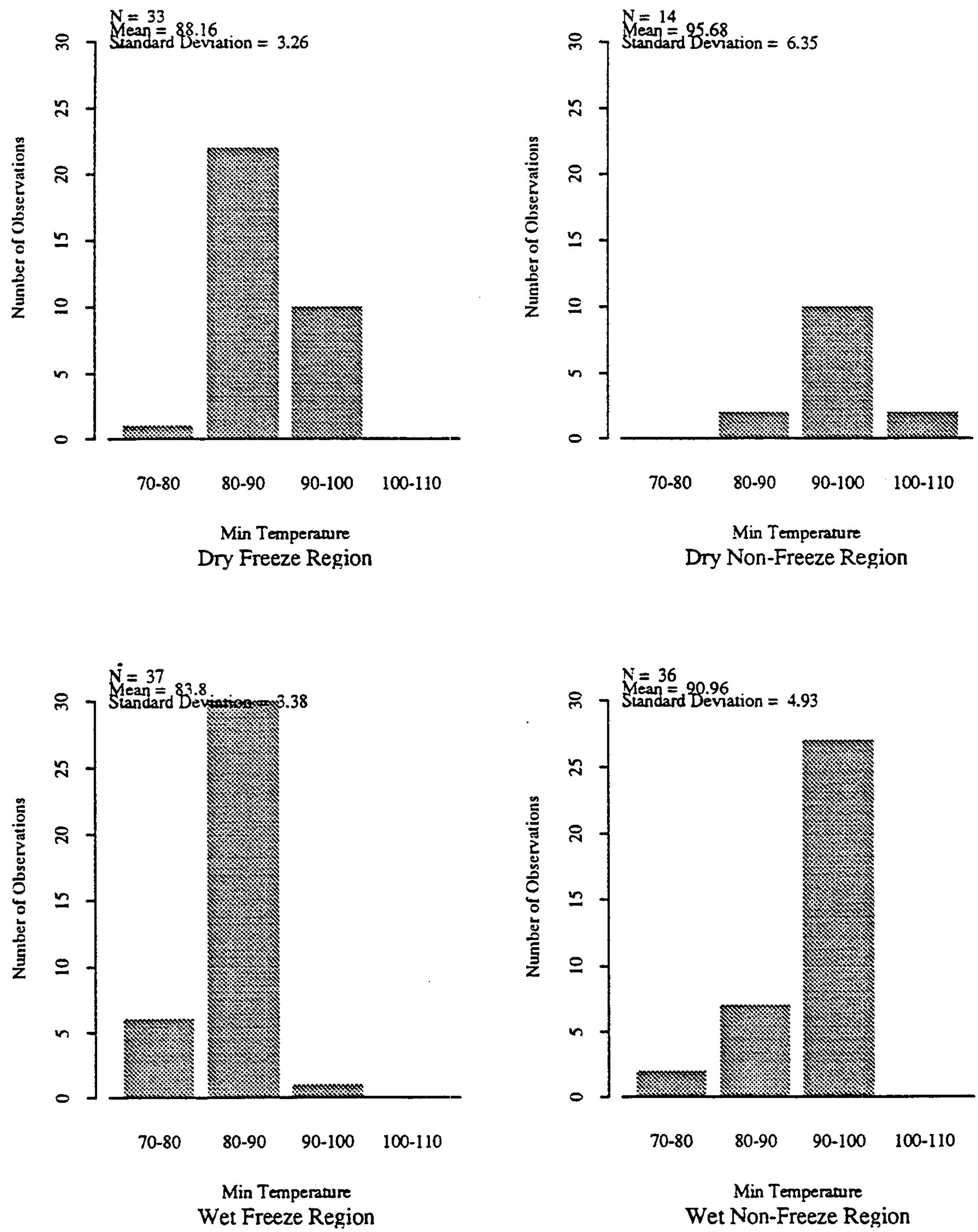


Figure 4.32 Distribution of Max. Temperature by Environmental Regions for GPS-3 Sections, °F

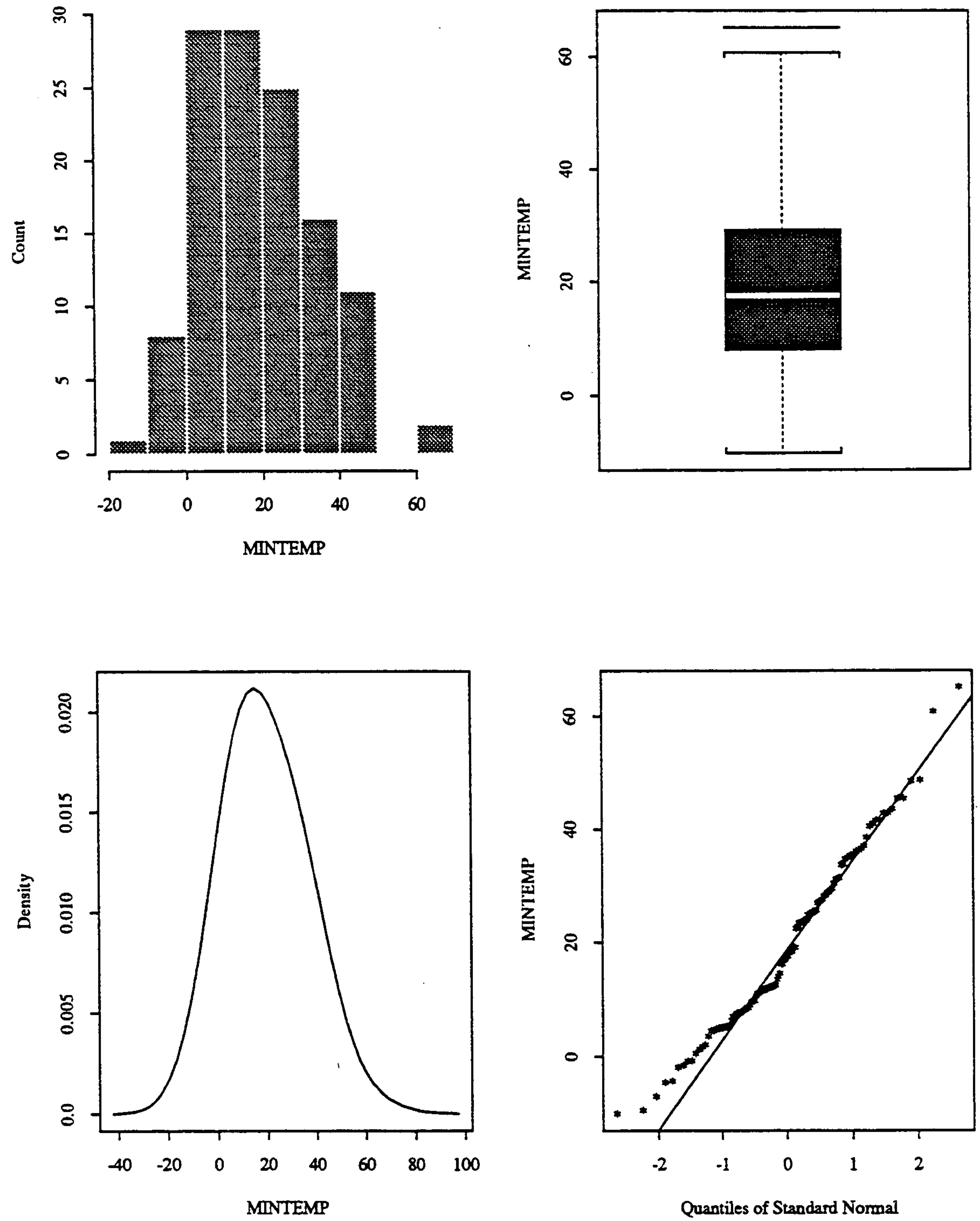


Figure 4.33 Statistical Distribution of Average Monthly Minimum Temperature for GPS-3, Sections, °F

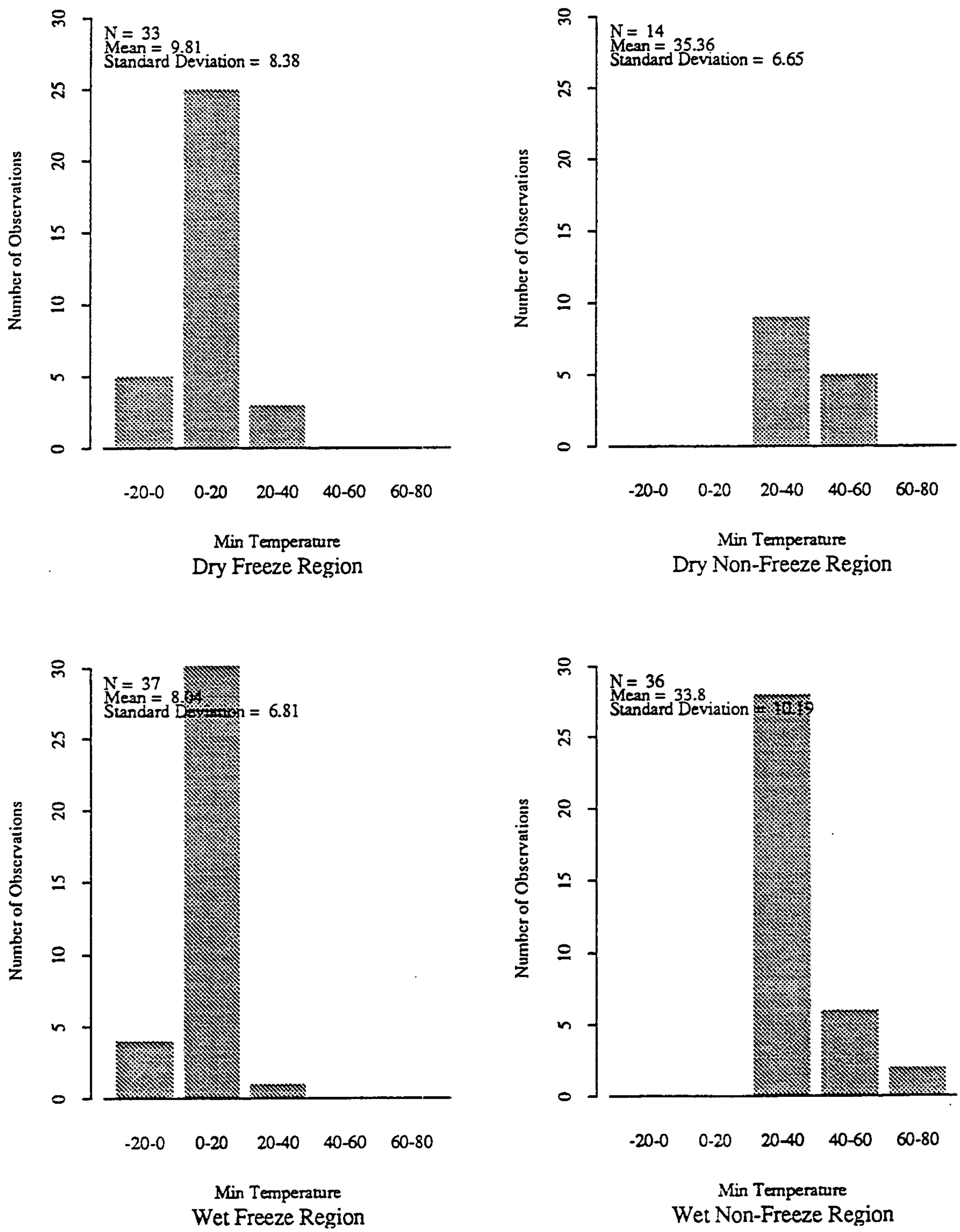


Figure 4.34 Distribution of Min. Temperature by Environmental Regions for GPS-3 Sections, °F

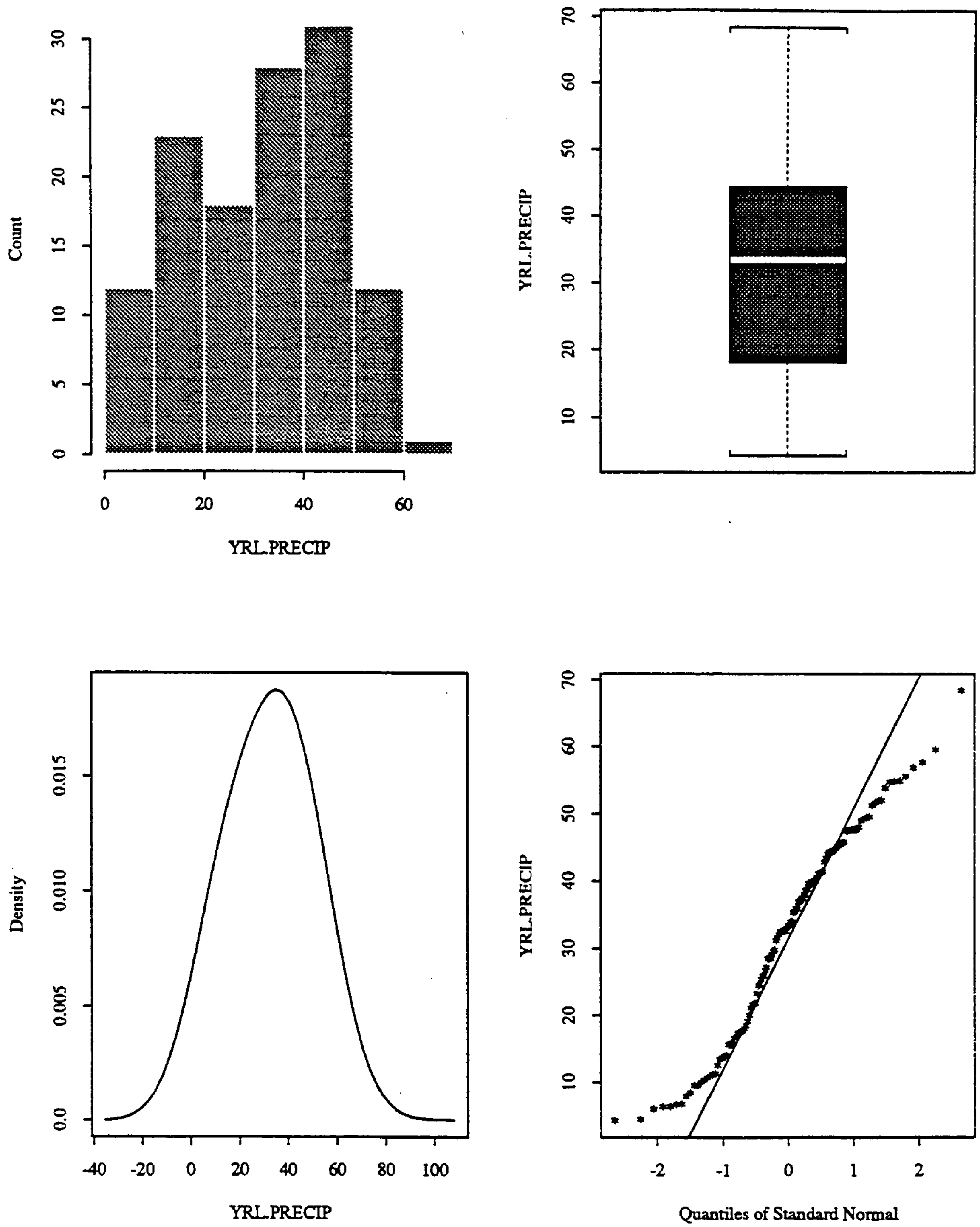


Figure 4.35 Statistical Distribution of Average Yearly Precipitation for GPS-3 Sections, In.

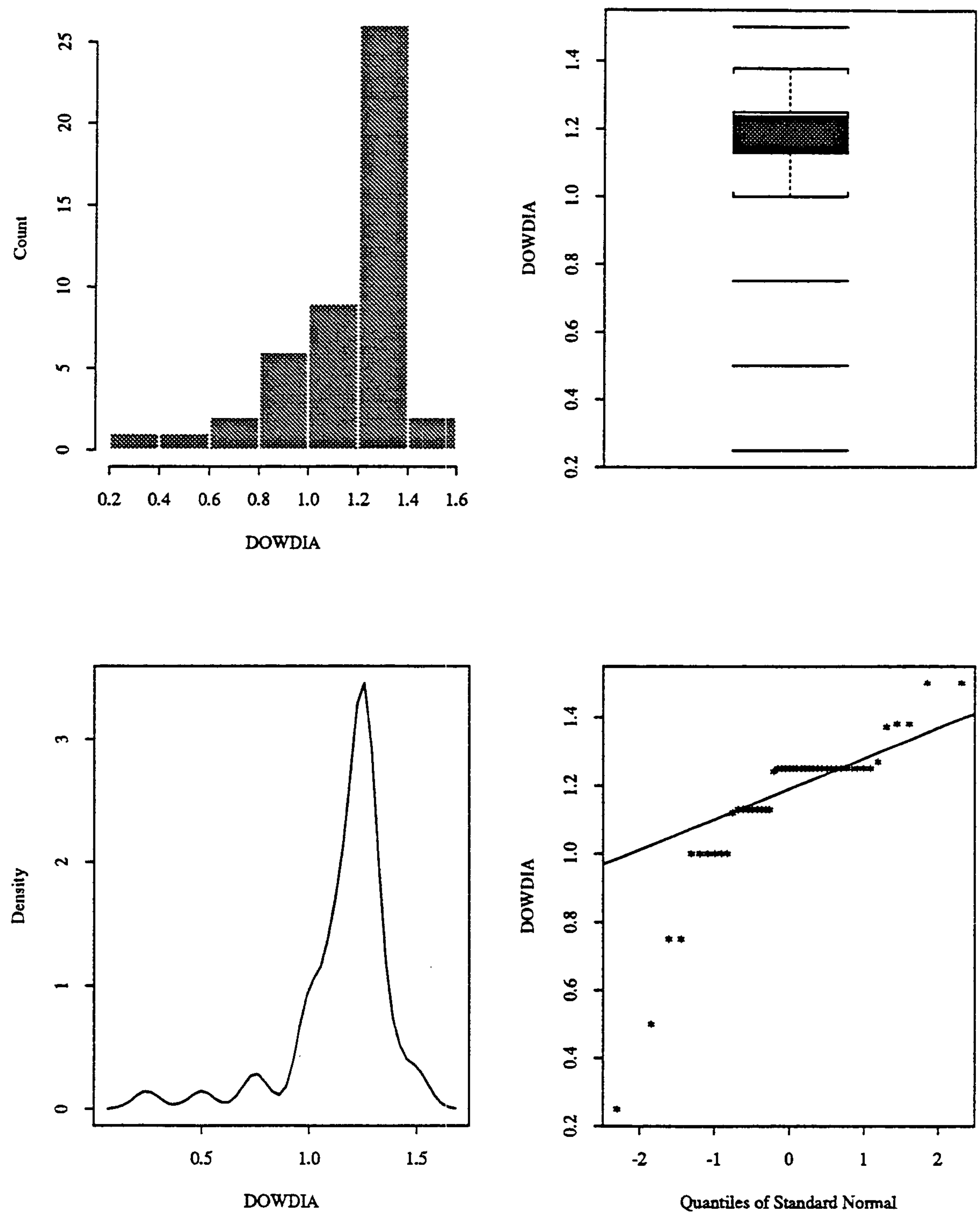


Figure 4.36 Statistical Distribution of Dowel Diameter for GPS-3 Sections

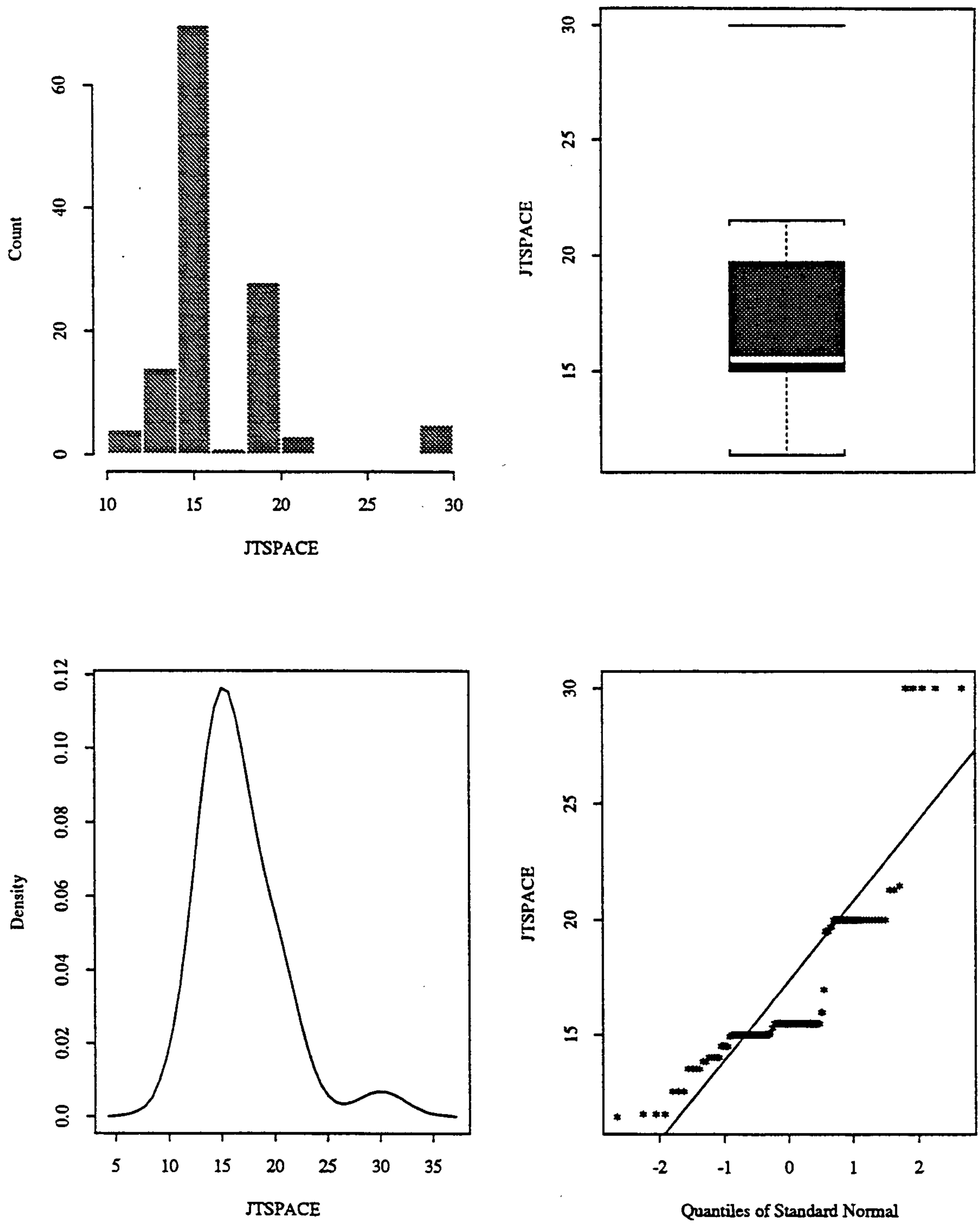


Figure 4.37 Statistical Distribution of Joint Spacing for GPS-3 Sections

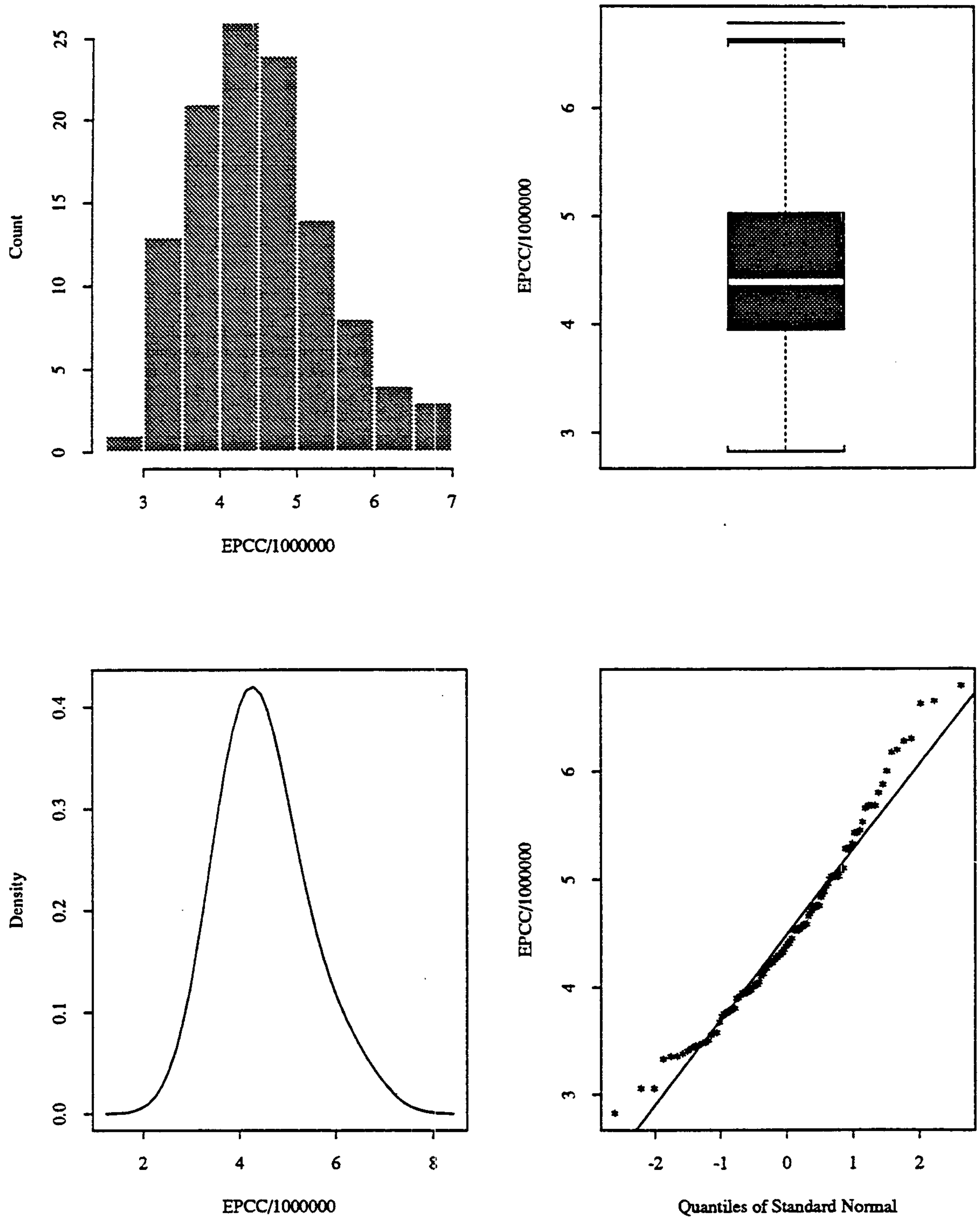


Figure 4.38 Statistical Distribution of PCC Elastic Modulus for GPS-3 Sections

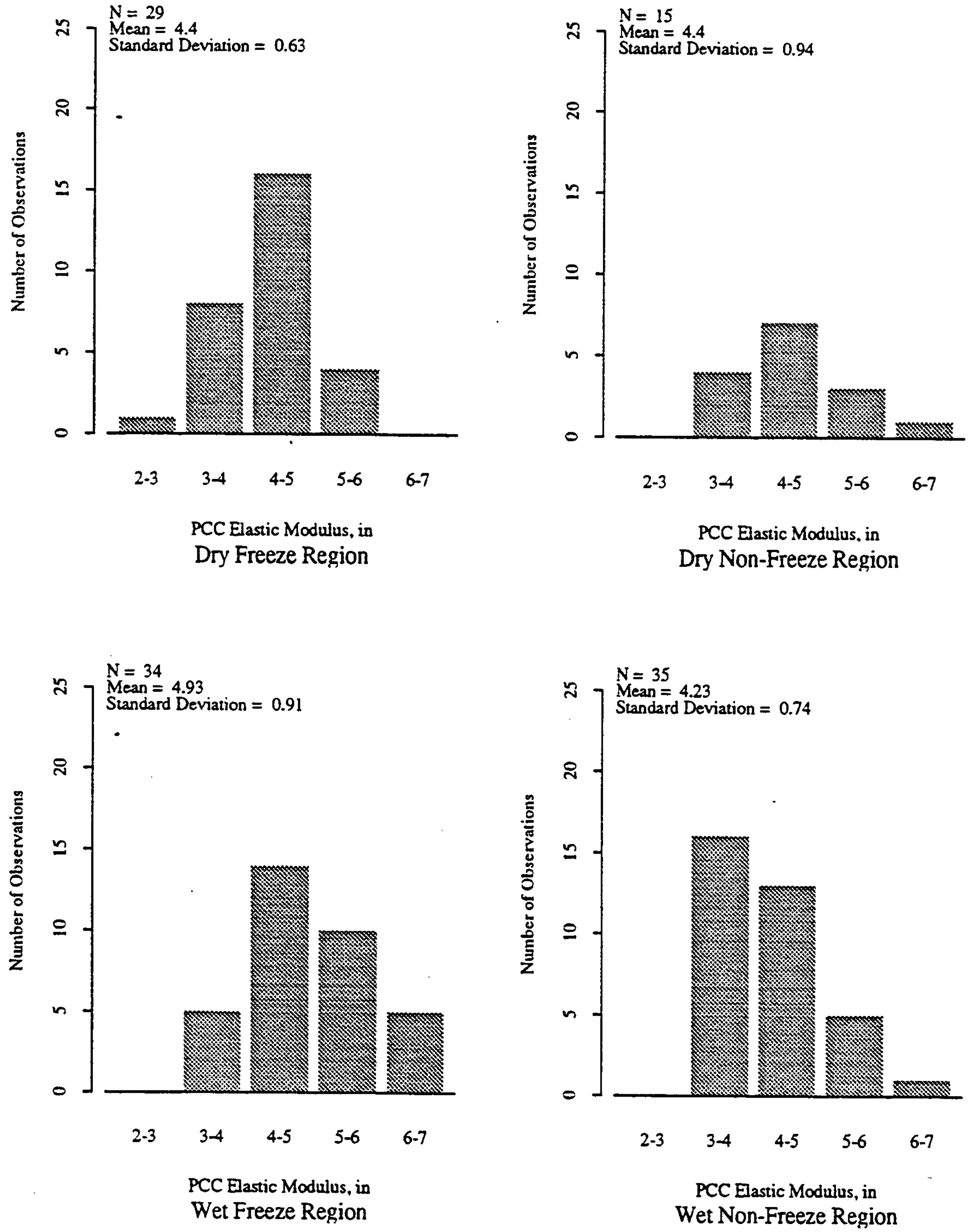


Figure 4.39 Distribution of PCC Elastic Modulus by Environmental Regions for GPS-3 Sections, Million psi

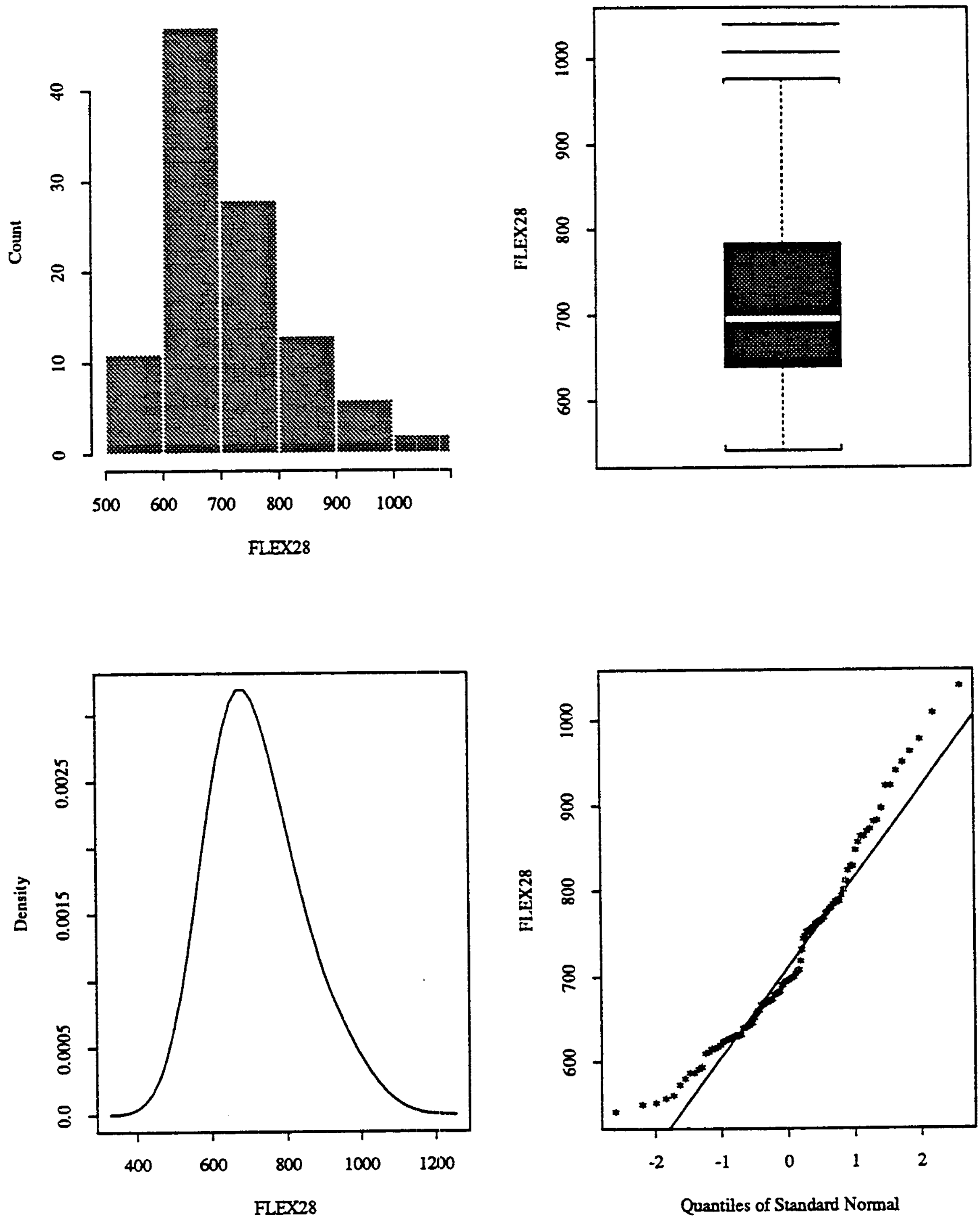


Figure 4.40 Statistical Distribution of 28-Day Flexural Strength for GPS-3 Sections, psi

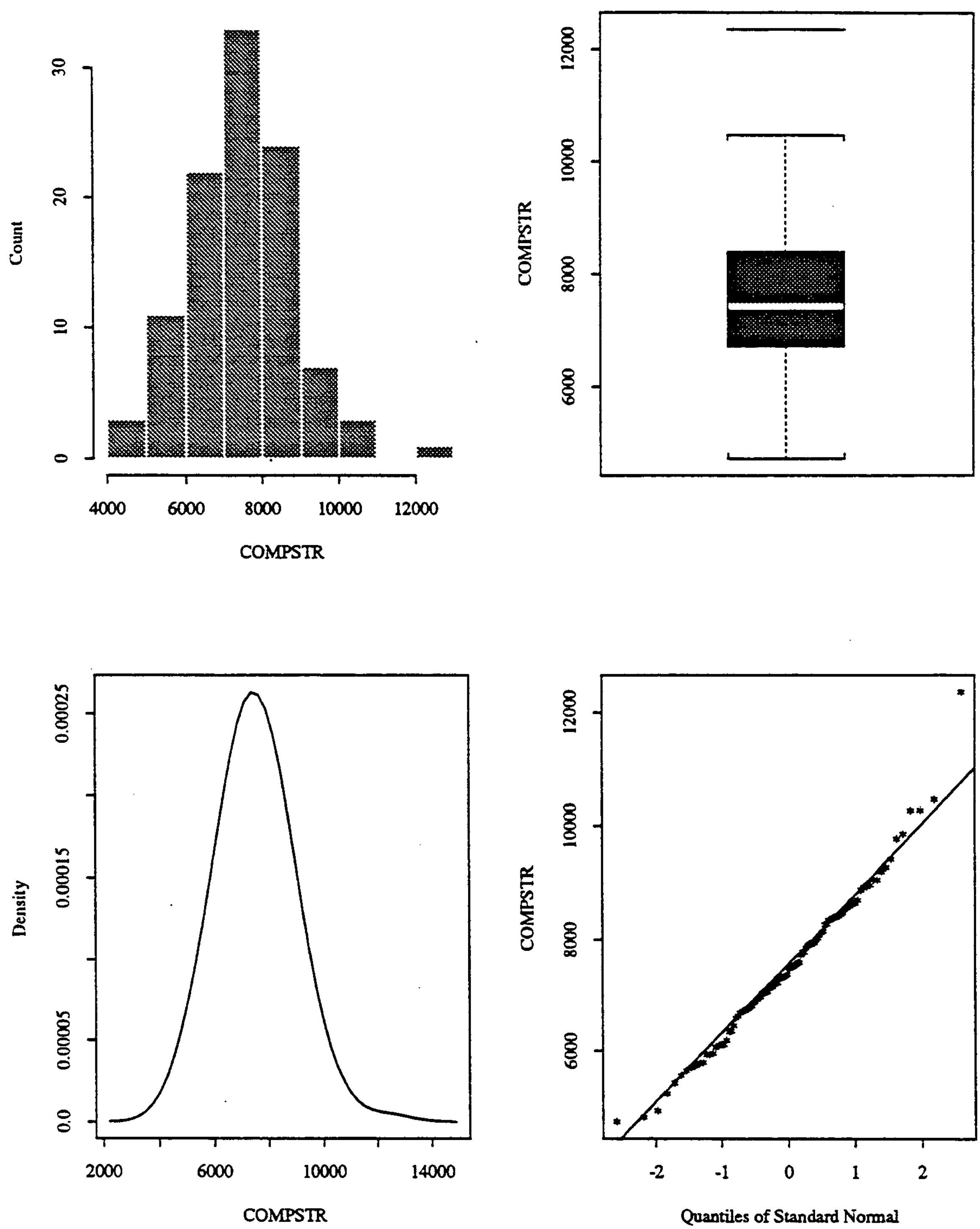


Figure 4.41 Statistical Distribution of Compressive Strength for GPS-3 Sections, psi

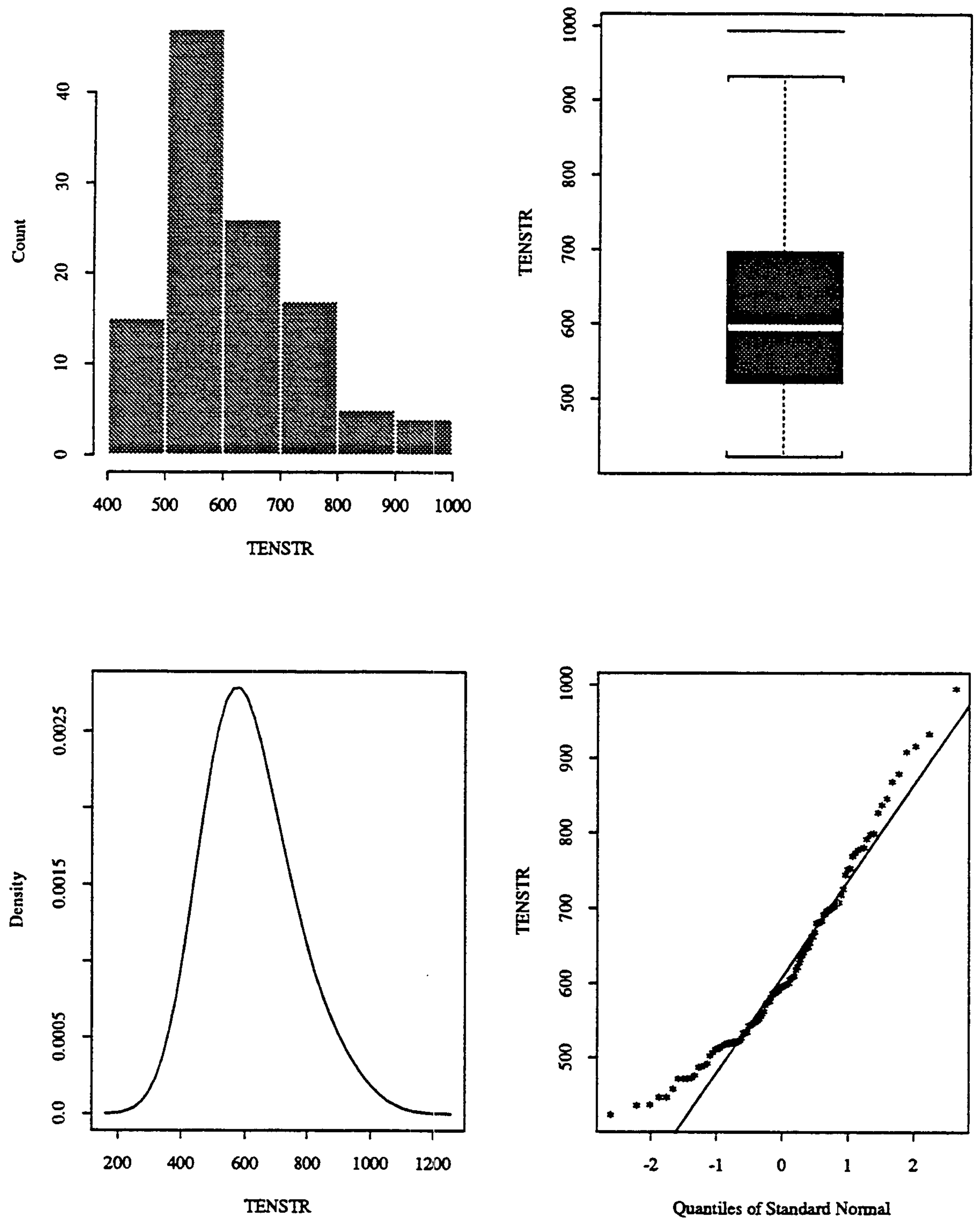


Figure 4.42 Statistical Distribution of Split Tensile Strength for GPS-3 Sections, psi

5

Statistical Data for GPS-4 Test Sections

Statistical information on the 71 GPS 4 concrete pavement test sections for which data was available is provided in this chapter. The information includes statistical information on the key distress/roughness variables, and the significant variables of interest for the GPS-4 pavement sections. Specifically, they include tables that give information on the number of sections for each variable for which data was available, the mean, standard deviation, the minimum value, the median value, the maximum value, and range of the variable. A table that shows the correlations between the various significant variables, distresses, and roughness is also provided.

In addition, a number of plots are also provided that show the distribution of the various variables, distresses, and roughness. For each significant variable or distress/roughness a histogram, boxplot, probability density plot, and normal quantile-quantile plot are provided. For some of these variables or distresses/roughness, histograms that show their distribution by the four SHRP climatic regions, and scatter plots that show the relationship between the variable or distress/roughness and other selected variables or distresses/roughness, are also provided. For brevity, this latter information is not provided for all the variables or distresses/roughness.

Table 5.1 shows the number of test sections in each cell of the sampling template for the GPS-4 experiment. Environmental factors are defined in Figure 2.2 of Chapter 2. Other factors are summarized as follows:

Traffic Rate:	L - Less than 200 KESAL/Yr. H - Greater than or equal to 200 KESAL/Yr.
Joint Spacing:	L - Less than or equal to 40 ft. (12 m) H - Greater than 40 ft. (12 m)
PCC Thickness;	L - Less than 9.5 inches (240 mm) H - Greater than or equal to 9.5 inches (240 mm)

Table 5.4 relates the variable names used in the correlation table and statistical plots to variable descriptions.

Table 5.1 Number of Test Sections in Each Cell of the GPS-4 Sampling Template

Moisture		Wet								Dry							
Temperature		Freeze				No Freeze				Freeze				No Freeze			
Subgrade Type		F		C		F		C		F		C		F		C	
Traffic Rate		L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
PCC Thickness	Joint Spacing	Number of JRCP Sections in the Data Set															
L	L	2	3	3	3					1		1	1	-	-	-	-
	H	2	63	2	2	3	2		2	1	2			-	-	-	-
H	L		2	3	2	2	1				2			-	-	-	-
	H	2	3	1	1	2	3		1					-	-	-	-

Table 5.2 Statistical Values for Distress/Roughness Variables in the GPS-4 Data Set.

Variable	Units	Sections With distress	Mean	Standard Deviation	Low Value	Median Value	High Value	Range
Faulting	Inches	32	0.039	0.052	-0.01	0.02	0.18	0.19
Spalling: Low Severity:	No. Spalls	42	4.4	4.8	0	3	25	25
	Lin. Ft.	63	9.98	19.32	0.00	3.12	119.60	119.60
Moderate Severity:	No. Spalls	42	0.7	1.6	0	0	8	8
	Lin. Ft.	63	3.88	18.21	0.00	0.00	139.90	139.90
High Severity:	No. Spalls	42	0.1	0.5	0	0	2	2
	Lin. Ft.	63	1.29	6.41	0.00	0.00	47.67	47.67
Transverse Cracking: Low Severity:	No. Cracks	39	6.5	9.8	0	2	42	42
	Lin. Ft.	54	42.53	98.59	0.00	0.00	571.30	571.30
Medium Severity:	No. Cracks	39	2.3	3.9	0	1	16	16
	Lin. Ft.	54	17.37	36.64	0.00	0.00	163.30	163.30
High Severity:	No. Cracks	39	1.1	3.0	0	0	15	15
	Lin. Ft.	54	9.15	32.54	0.00	0.00	187.00	187.00
Roughness(IRI)	Inches/Mile	70	111.90	28.48	48.61	108.10	198.40	149.79

Table 5.3. Statistical Values of Interest for Significant Variables in the GPS-4 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
PCC Thickness	Inches	56	9.39	0.83	7.38	9.43	11.35	3.97
Base Thickness	Inches	70	5.45	3.00	0.00	5.10	18.00	18.00
Subbase Thickness	Inches	70	1.84	3.35	0.00	0.00	12.00	12.00
KESALs per Year	No.	64	348.1	311.5	34.2	229.3	1326.0	1291.8
Pavement Age	Years	52	12.53	5.72	1.93	12.89	24.76	22.83
Air Freeze-Thaw Cycles	No.	71	80.1	24.2	12	88	140	128
Freezing Index	Degree Days	71	733.5	696.49	8	562	3483	3475
No. of Days Temp. > 90°F	No.	71	29.97	24.16	1	23	88	87
No. of Days Temp. < 32°F	No.	71	106.30	42.72	10	111	193	183
Average Min. Temp. by Month	°F	70	15.76	11.19	-13.11	15.84	38.61	51.72
Average Max. Temp. by Month	°F	70	88.08	4.34	79.22	88.50	95.26	18.04
Average Monthly Precipitation	Inches	71	3.40	0.82	1.42	3.30	5.66	4.24
Average Yearly Precipitation	Inches	71	40.78	9.88	17.10	39.50	67.90	50.80
Wet Days in Year	No.	71	129.8	24.9	71	129	199	128

Continued on Page 193

Table 5.3. Statistical Values of Interest for Significant Variables in the GPS-4 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
Dowel Diameter	Inches	68	1.15	0.20	0.25	1.25	1.50	1.25
Dowel Length	Inches	66	18.44	2.46	14	18	30	16
Dowel Spacing	Inches	54	6.46	1.98	0.6	6.0	12.0	11.4
Joint Spacing	Feet	71	48.8	17.2	0.0	45.6	100.0	100.0
Subgrade Soil Passing #200	Percent	62	55.43	30.83	1.4	57.2	97.6	96.2
Backcalculated Static k-value	pci	54	127.10	81.85	47.68	99.52	458.50	410.82
PCC Elastic Modulus	x 10^6, psi	57	4.76	0.78	3.50	4.73	6.35	2.85
PCC 28-day Flexural Strength	psi	56	751.6	104.6	569	743	1081	512
PCC Compressive Strength	psi	57	7762	1304	3960	7745	11450	7490
PCC Indirect Tensile Strength	psi	57	664.5	119.5	462	652	1050	588

Table 5.4 Nomenclature Used for Correlation Table and Statistical Plots

Variable	Description of Variable
FAULT	Faulting, inches
TSPALLNO	Total number of spalled joints (all severities)
SPALL.H.NO	Number of high severity spalled joints
SPALL.M.NO	Number of low severity spalled joints
SPALL.L.NO	Number of low severity spalled joints
TSPALLFT	Total measured joint spalling (all severities) in linear feet
SPALL.H.FT	Measured high severity spalling in linear feet
SPALL.M.FT	Measured medium severity spalling in linear feet
SPALL.L.FT	Measured low severity spalling in linear feet
TCRACKNO	Total number of transverse cracks (all severities)
TCRACK.H.NO	Number of high severity transverse cracks
TCRACK.M.NO	Number of medium severity transverse cracks
TCRACK.L.NO	Number of low severity transverse cracks
TCRACKFT	Total measured transverse cracking (all severities) in linear feet
TCRACK.H.FT	Measured high severity transverse cracking in linear feet
TCRACK.M.FT	Measured medium severity transverse cracking in linear feet
TCRACK.L.FT	Measured low severity transverse cracking in linear feet
AVE.IRI or IRI	Measured average IRI value, inches/mile
AVE.SV	Measured average slope variance
THICK	Measured PCC layer thickness, inches
BASETHK	Measured base thickness, inches
SBASETHK	Measured subbase thickness, inches
YRL.KESAL or YRKESAL	Cumulative 18-kip ESALs per year, thousands
AGE	Pavement age, years

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Table 5.4 Nomenclature Used for Correlation Table and Statistical Plots

Variable	Description of Variable
FT	Average number of air freeze-thaw cycles
FI	Freezing index, degree days
DAYS90	Number of days with temperature greater than 90°F
DAYS32	Number of days with temperature lower than 32°F
MAXTEMP	Average monthly maximum temperature, °F
MINTEMP	Average monthly minimum temperature, °F
YRL.PRECIP or YRPRECIP	Average precipitation by year, inches
PRECIP	Average precipitation by month, inches
DAYSWET	Average number of wet days
DOWDIA	Dowel diameter, inches
JTSPACE	Joint Spacing, feet
PM200	Subgrade soil passing the #200 sieve, percent by weight
KSTATIC	Backcalculated modulus of subgrade reaction, psi/inch
EPCC	Measured PCC layer elastic modulus, psi
FLEX28	PCC layer 28-day flexural strength, psi
COMPSTR	PCC layer compressive strength, psi
TENSTR	PCC layer indirect (split) tensile strength, psi

Table 5.5 Correlation Matrix for Significant Variables in the GPS-4 Data Set

	FAULT	TSPALLNO	TSPALLFT	TCRACKNO	TCRACKFT	IRI	THICK	BASETHK	SBASETHK	KSTATIC	YRKESAL	FT
FAULT	1.000	-0.248	-0.192	0.818	0.798	0.598	0.363	0.350	0.522	-0.501	0.345	-0.306
TSPALLNO	-0.248	1.000	0.990	-0.136	-0.139	0.220	0.277	-0.487	0.029	0.222	-0.289	-0.496
TSPALLFT	-0.192	0.990	1.000	-0.061	-0.058	0.323	0.327	-0.461	0.089	0.182	-0.325	-0.486
TCRACKNO	0.818	-0.136	-0.061	1.000	0.997	0.860	0.482	0.416	0.616	-0.749	0.381	-0.316
TCRACKFT	0.798	-0.139	-0.058	0.997	1.000	0.873	0.470	0.392	0.608	-0.762	0.345	-0.267
IRI	0.598	0.220	0.323	0.860	0.873	1.000	0.528	0.159	0.532	-0.628	0.177	-0.327
THICK	0.363	0.277	0.327	0.482	0.470	0.528	1.000	0.276	0.911	0.102	0.200	-0.676
BASETHK	0.350	-0.487	-0.461	0.416	0.392	0.159	0.276	1.000	0.532	-0.026	0.090	-0.389
SBASETHK	0.522	0.029	0.089	0.616	0.608	0.532	0.911	0.532	1.000	0.011	0.114	-0.600
KSTATIC	-0.501	0.222	0.182	-0.749	-0.762	-0.628	0.102	-0.026	0.011	1.000	-0.454	-0.196
YRKESAL	0.345	-0.289	-0.325	0.381	0.345	0.177	0.200	0.090	0.114	-0.454	1.000	-0.132
FT	-0.306	-0.496	-0.486	-0.316	-0.267	-0.327	-0.676	-0.389	-0.600	-0.196	-0.132	1.000
FI	-0.437	-0.242	-0.293	-0.392	-0.362	-0.501	-0.684	-0.501	-0.683	-0.188	-0.099	0.781
MAXTEMP	0.509	0.278	0.277	0.382	0.336	0.340	0.807	0.230	0.704	0.145	0.449	-0.817
MINTEMP	0.406	0.382	0.405	0.377	0.335	0.435	0.709	0.481	0.676	0.204	0.110	-0.942
DAYS90	0.425	0.369	0.348	0.324	0.269	0.262	0.726	0.296	0.625	0.185	0.362	-0.935
DAYS32	-0.395	-0.402	-0.421	-0.377	-0.334	-0.430	-0.723	-0.464	-0.678	-0.199	-0.130	0.957
YRPRECIP	0.669	0.238	0.293	0.515	0.488	0.505	0.633	0.475	0.716	0.101	-0.118	-0.774
PRECIP	0.669	0.239	0.293	0.515	0.488	0.505	0.633	0.475	0.716	0.101	-0.115	-0.776
DOWDIA	-0.630	0.161	0.164	-0.179	-0.143	0.050	0.053	-0.300	-0.100	-0.081	0.125	0.311
JTSPACE	0.476	0.282	0.293	0.283	0.253	0.411	0.260	-0.286	0.074	-0.204	0.549	-0.328
PM200	-0.177	0.366	0.350	-0.272	-0.293	0.039	-0.102	-0.350	-0.354	0.141	0.281	-0.140
EPCC	0.391	0.125	0.114	0.446	0.420	0.247	0.775	0.365	0.845	0.045	0.288	-0.637
DAYSWET	0.189	0.344	0.445	0.381	0.427	0.621	0.067	-0.084	0.157	-0.310	-0.612	0.045

Table 5.5 Correlation Matrix for Significant Variables in the GPS-4 Data Set

	FI	MAXTEMP	MINTEMP	DAYS90	DAYS32	YRPRECIP	PRECIP	DOWDIA	JTSPACE	PM200	EPCC	DAYSWET
FAULT	-0.437	0.509	0.406	0.425	-0.395	0.669	0.669	-0.630	0.476	-0.177	0.391	0.189
TSPALLNO	-0.242	0.278	0.382	0.369	-0.402	0.238	0.239	0.161	0.282	0.366	0.125	0.344
TSPALLFT	-0.293	0.277	0.405	0.348	-0.421	0.293	0.293	0.164	0.293	0.350	0.114	0.445
TCRACKNO	-0.392	0.382	0.377	0.324	-0.377	0.515	0.515	-0.179	0.283	-0.272	0.446	0.381
TCRACKFT	-0.362	0.336	0.335	0.269	-0.334	0.488	0.488	-0.143	0.253	-0.293	0.420	0.427
IRI	-0.501	0.340	0.435	0.262	-0.430	0.505	0.505	0.050	0.411	0.039	0.247	0.621
THICK	-0.684	0.807	0.709	0.726	-0.723	0.633	0.633	0.053	0.260	-0.102	0.775	0.067
BASETHK	-0.501	0.230	0.481	0.296	-0.464	0.475	0.475	-0.300	-0.286	-0.350	0.365	-0.084
SBASETHK	-0.683	0.704	0.676	0.625	-0.678	0.716	0.716	-0.100	0.074	-0.354	0.845	0.157
KSTATIC	-0.188	0.145	0.204	0.185	-0.199	0.101	0.101	-0.081	-0.204	0.141	0.045	-0.310
YRKESAL	-0.099	0.449	0.110	0.362	-0.130	-0.118	-0.115	0.125	0.549	0.281	0.288	-0.612
FT	0.781	-0.817	-0.942	-0.935	0.957	-0.774	-0.776	0.311	-0.328	-0.140	-0.637	0.045
FI	1.000	-0.769	-0.944	-0.744	0.929	-0.842	-0.842	0.264	-0.464	-0.318	-0.476	-0.093
MAXTEMP	-0.769	1.000	0.834	0.953	-0.847	0.705	0.707	-0.273	0.617	0.220	0.748	-0.261
MINTEMP	-0.944	0.834	1.000	0.886	-0.999	0.867	0.868	-0.329	0.415	0.235	0.582	0.033
DAYS90	-0.744	0.953	0.886	1.000	-0.904	0.727	0.729	-0.350	0.503	0.182	0.720	-0.260
DAYS32	0.929	-0.847	-0.999	-0.904	1.000	-0.855	-0.856	0.313	-0.415	-0.227	-0.604	-0.015
YRPRECIP	-0.842	0.705	0.867	0.727	-0.855	1.000	1.000	-0.622	0.324	-0.054	0.528	0.308
PRECIP	-0.842	0.707	0.868	0.729	-0.856	1.000	1.000	-0.622	0.326	-0.053	0.529	0.306
DOWDIA	0.264	-0.273	-0.329	-0.350	0.313	-0.622	-0.622	1.000	-0.186	0.151	-0.070	-0.013
JTSPACE	-0.464	0.617	0.415	0.503	-0.415	0.324	0.326	-0.186	1.000	0.719	0.085	-0.130
PM200	-0.318	0.220	0.235	0.182	-0.227	-0.054	-0.053	0.151	0.719	1.000	-0.348	-0.229
EPCC	-0.476	0.748	0.582	0.720	-0.604	0.528	0.529	-0.070	0.085	-0.348	1.000	-0.143
DAYSWET	-0.093	-0.261	0.033	-0.260	-0.015	0.308	0.306	-0.013	-0.130	-0.229	-0.143	1.000

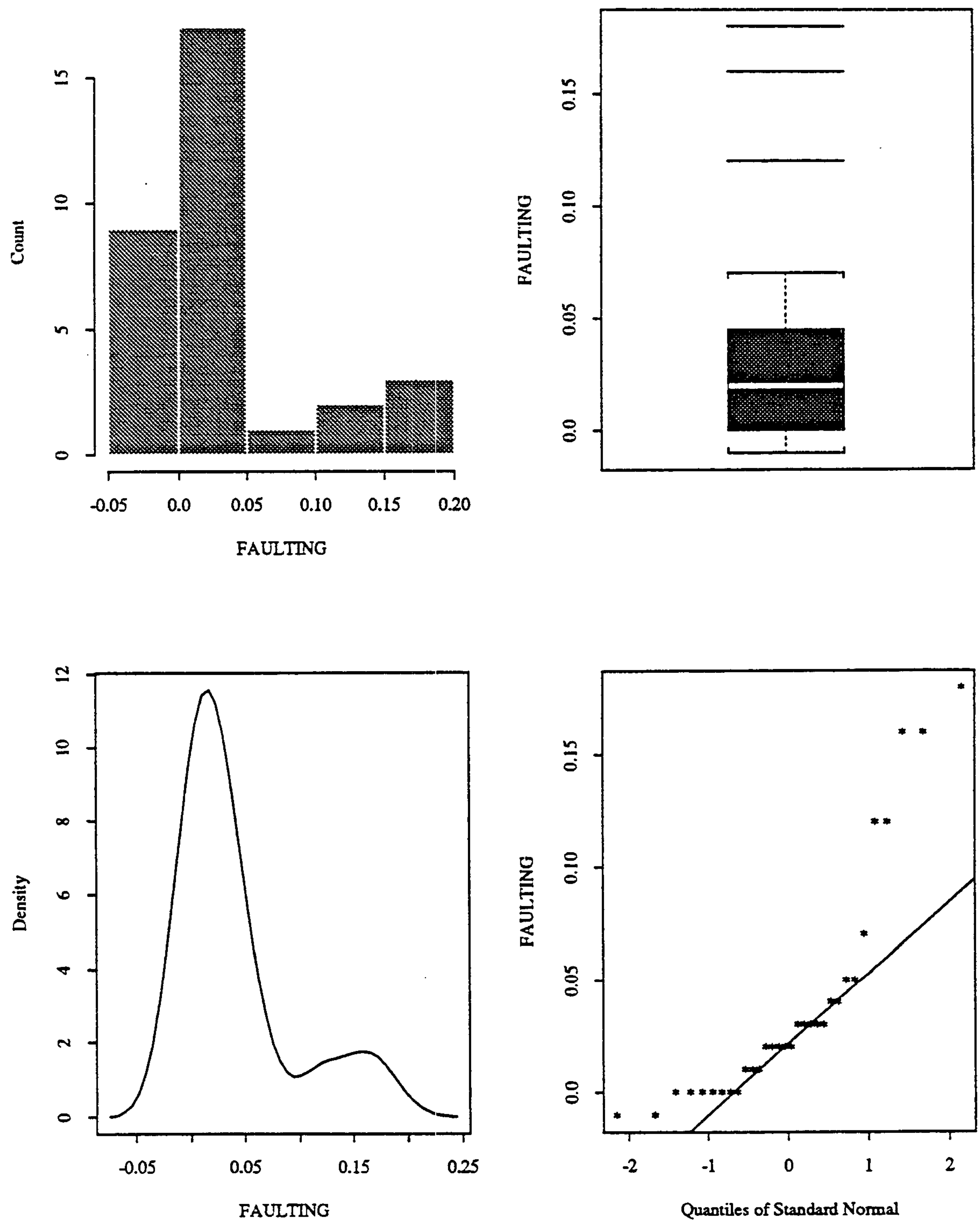


Figure 5.1 Statistical Distribution of Faulting for GPS-4 Sections

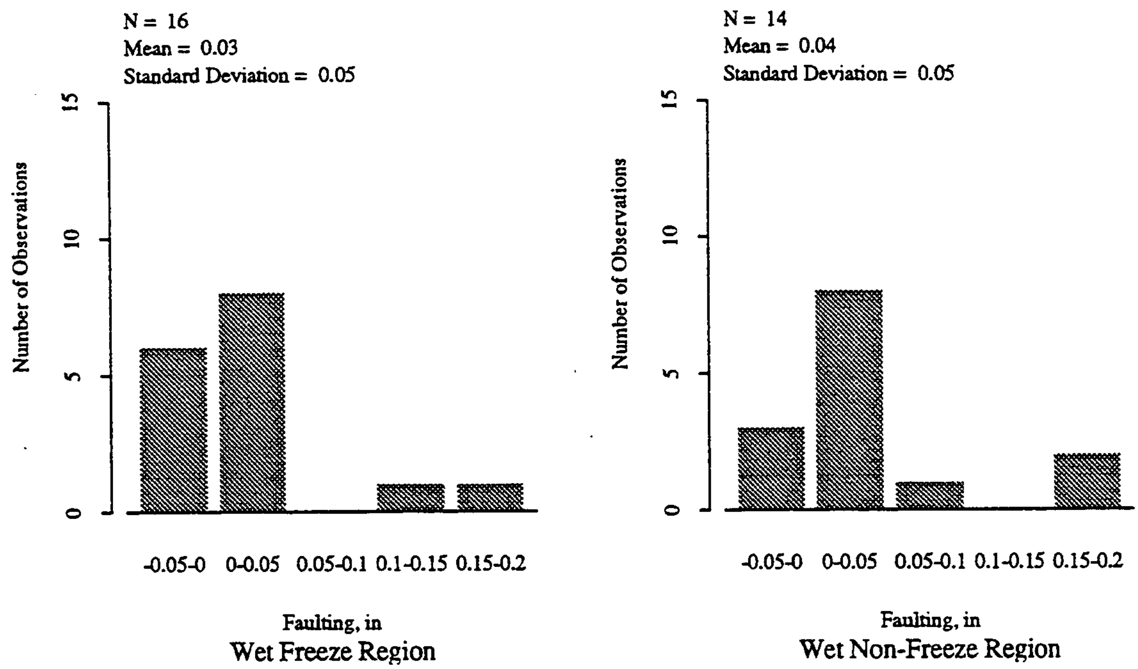


Figure 5.2 Distribution of Faulting by Environmental Regions for GPS-4 Sections

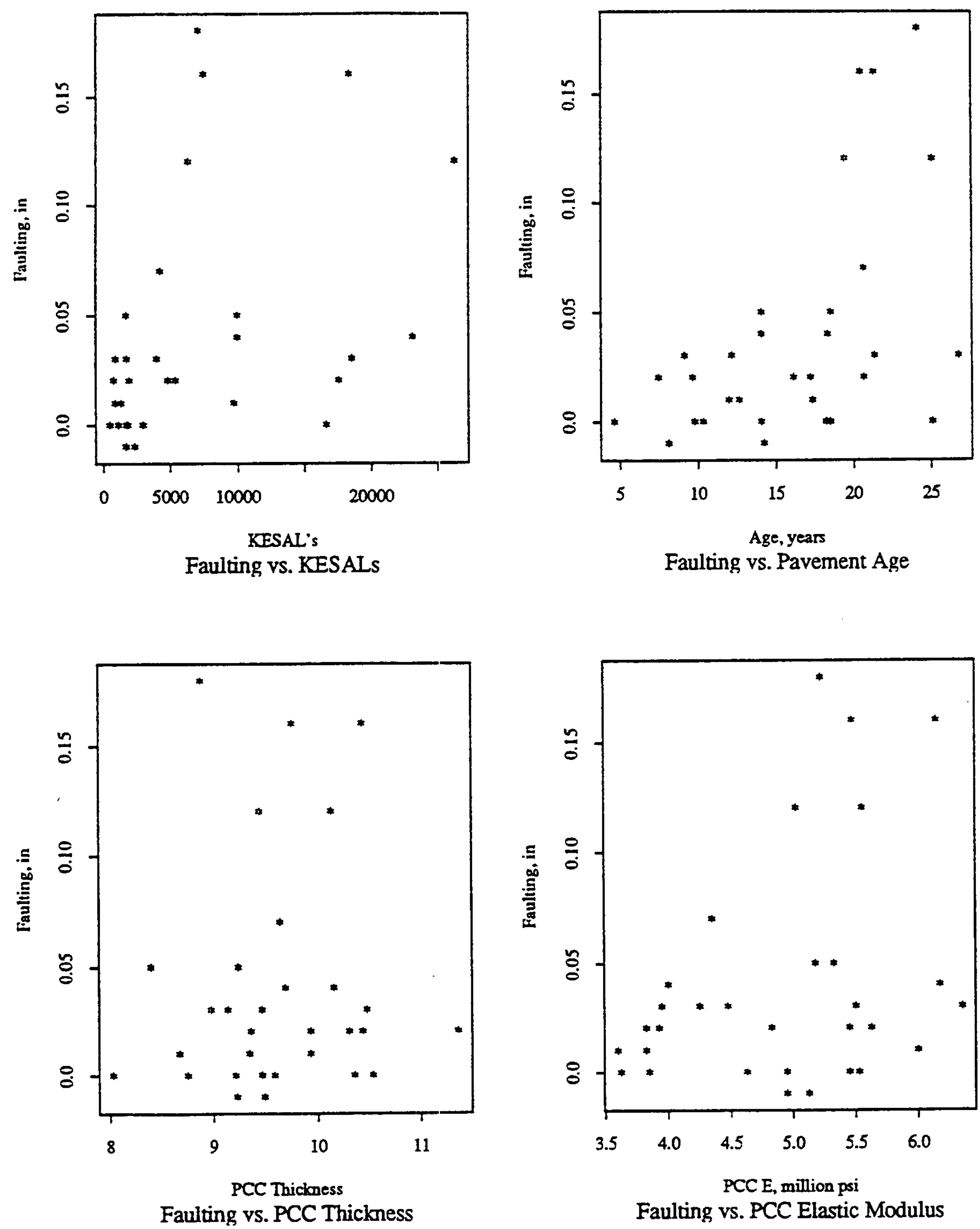


Figure 5.3 Faulting Scatter Plots for GPS-4 Sections

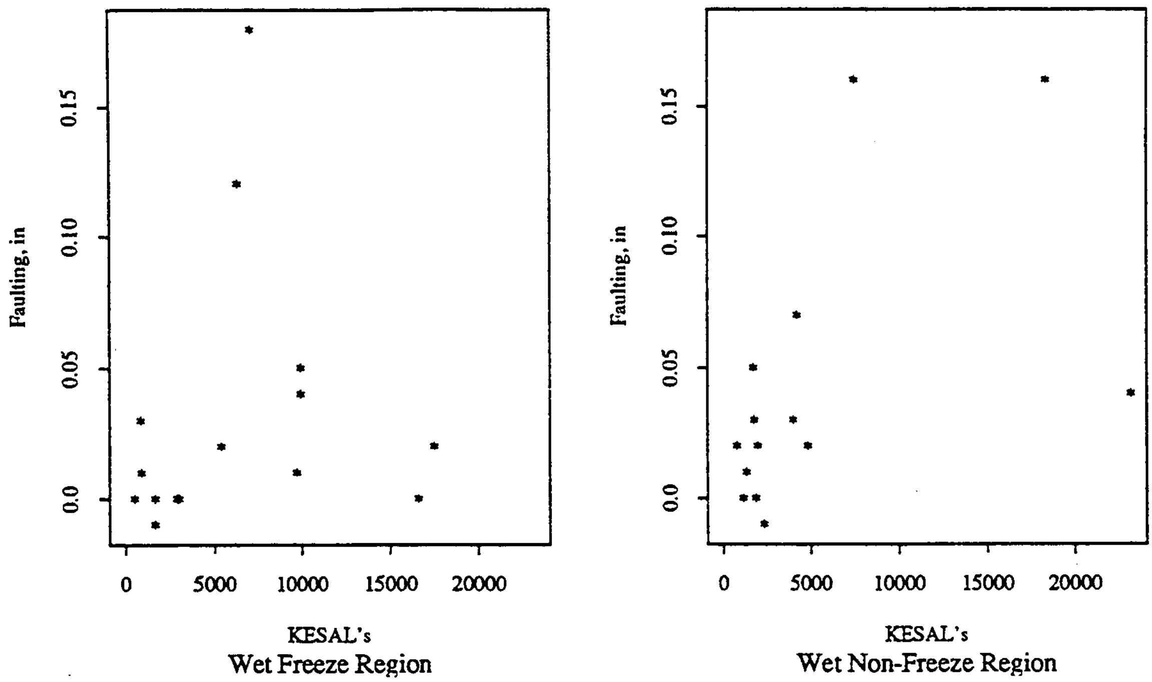


Figure 5.4 Faulting vs. KESALs Scatter Plots for GPS-4 Sections

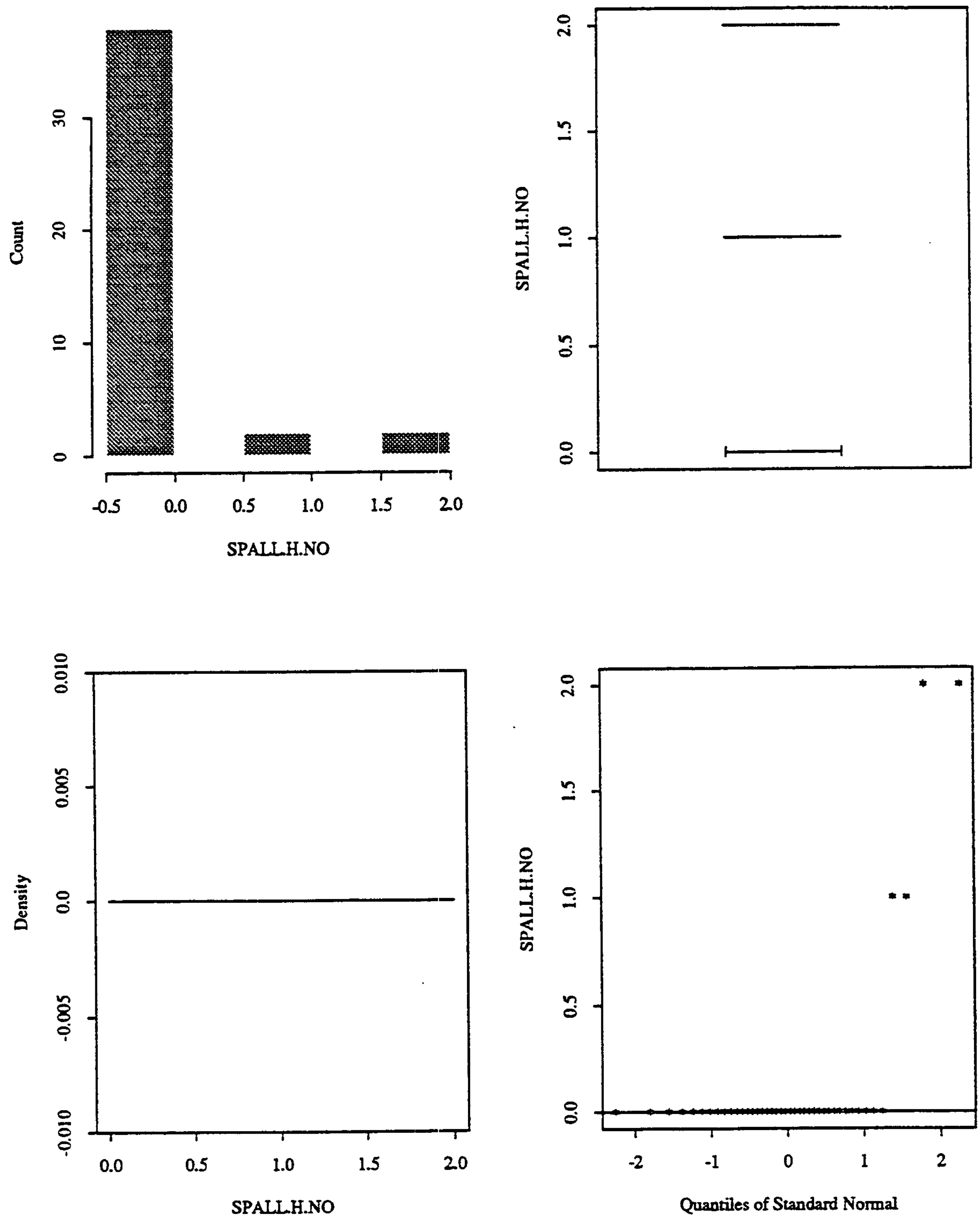


Figure 5.5 Statistical Distribution of High Severity Spalling for GPS-4 Sections, Number

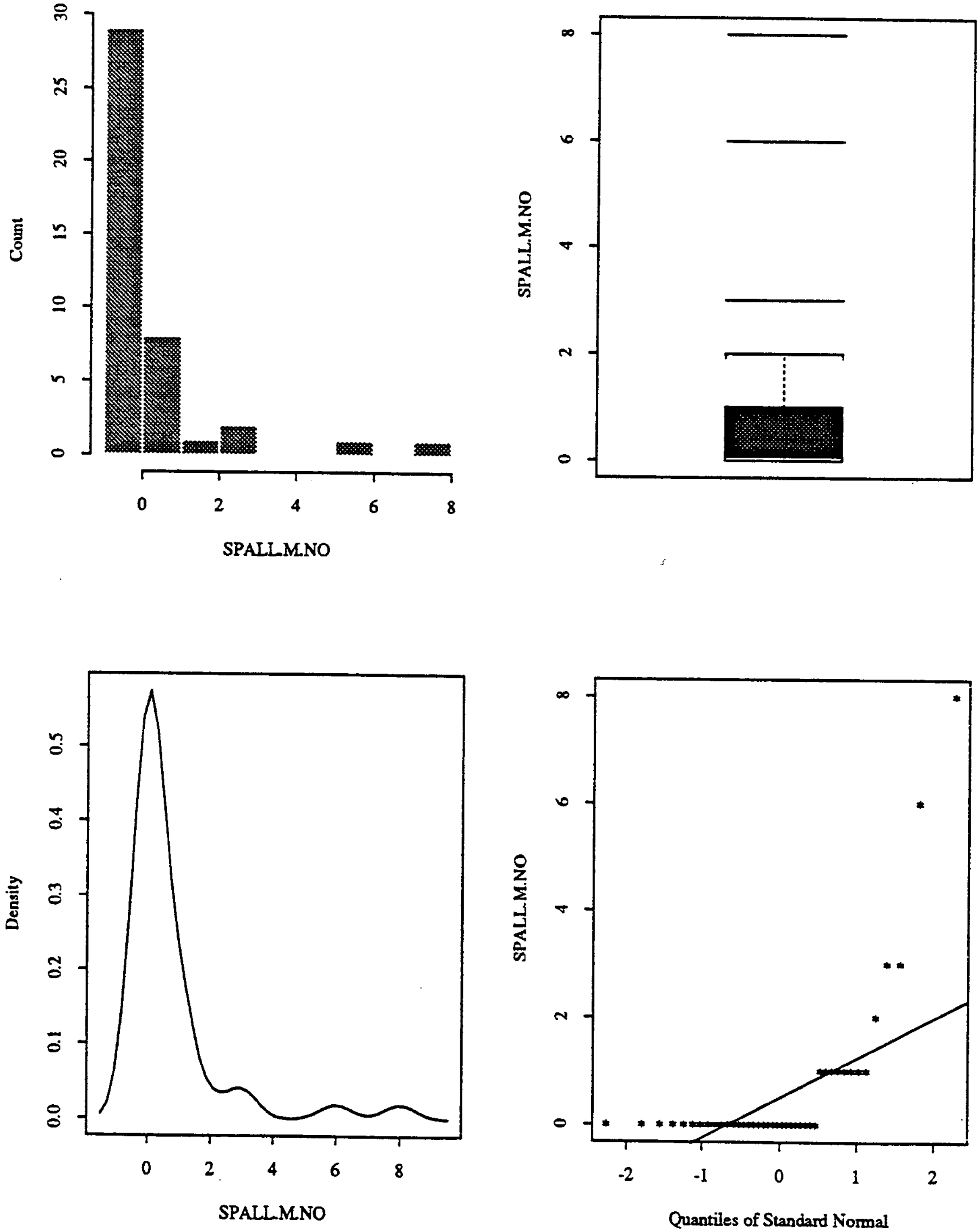


Figure 5.6 Statistical Distribution of Medium Severity Spalling for GPS-4 Sections, Number

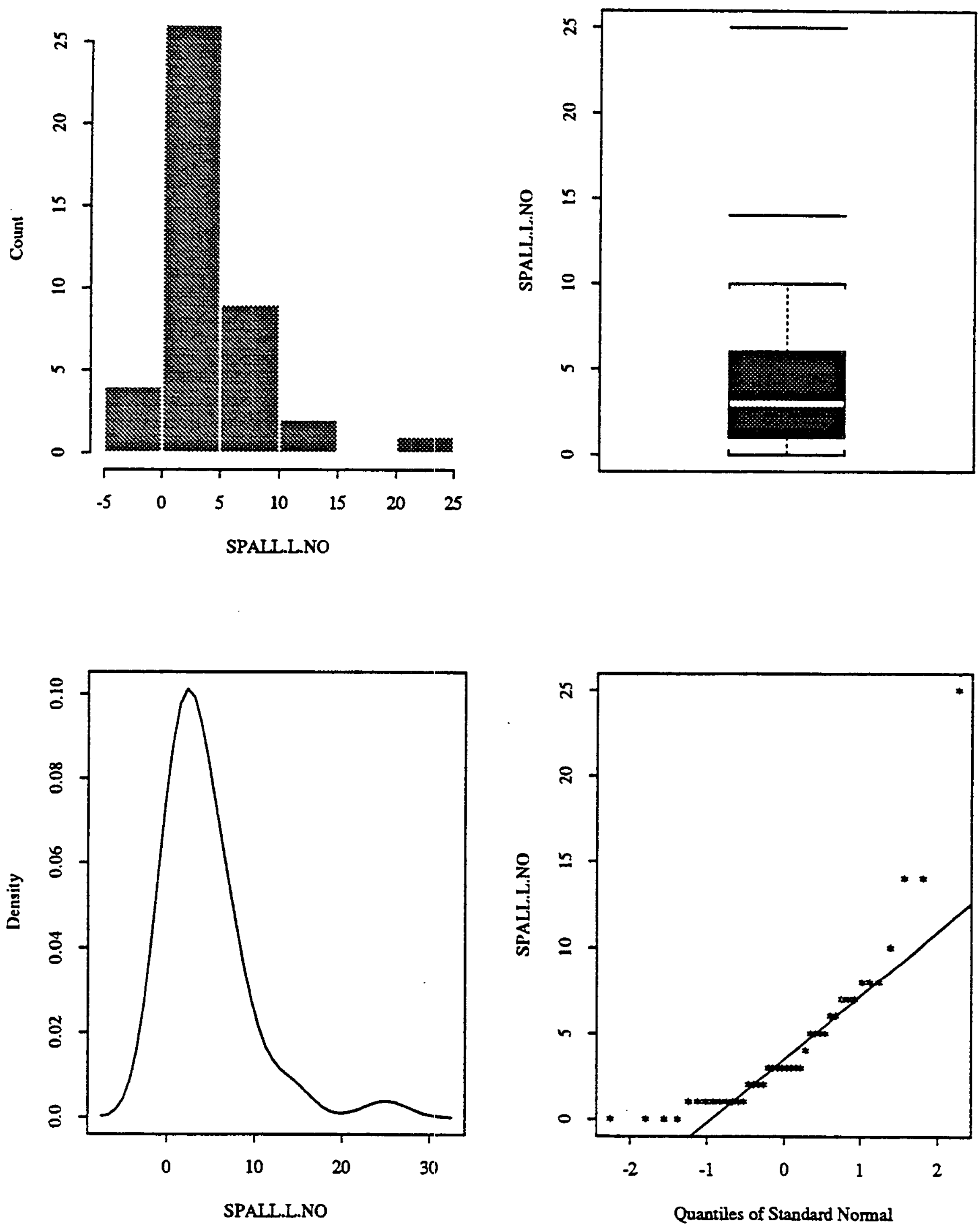
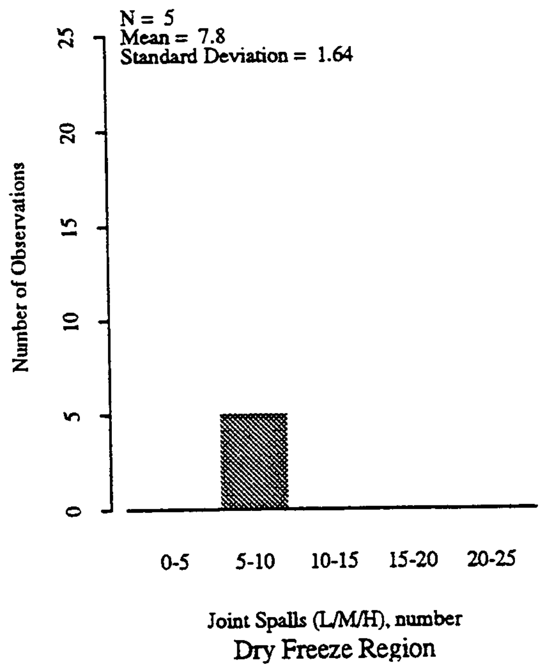
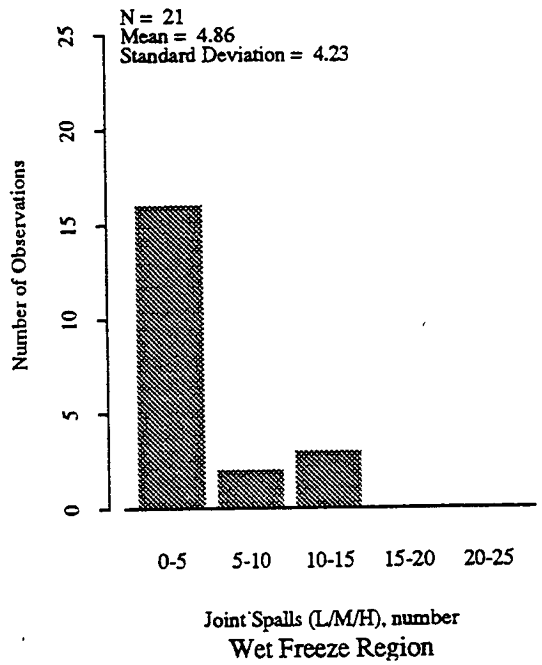


Figure 5.7 Statistical Distribution of Low Severity Spalling for GPS-4 Sections, Number





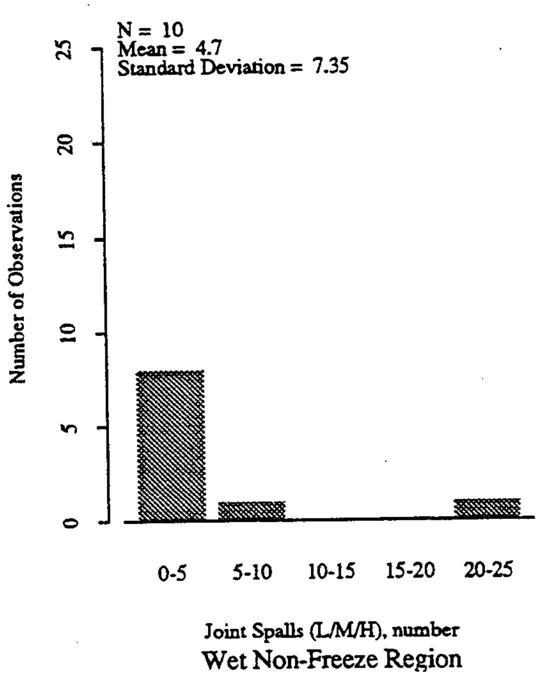


Figure 5.8 Distribution of Joint Spalling by Environmental Regions for GPS-4 Sections

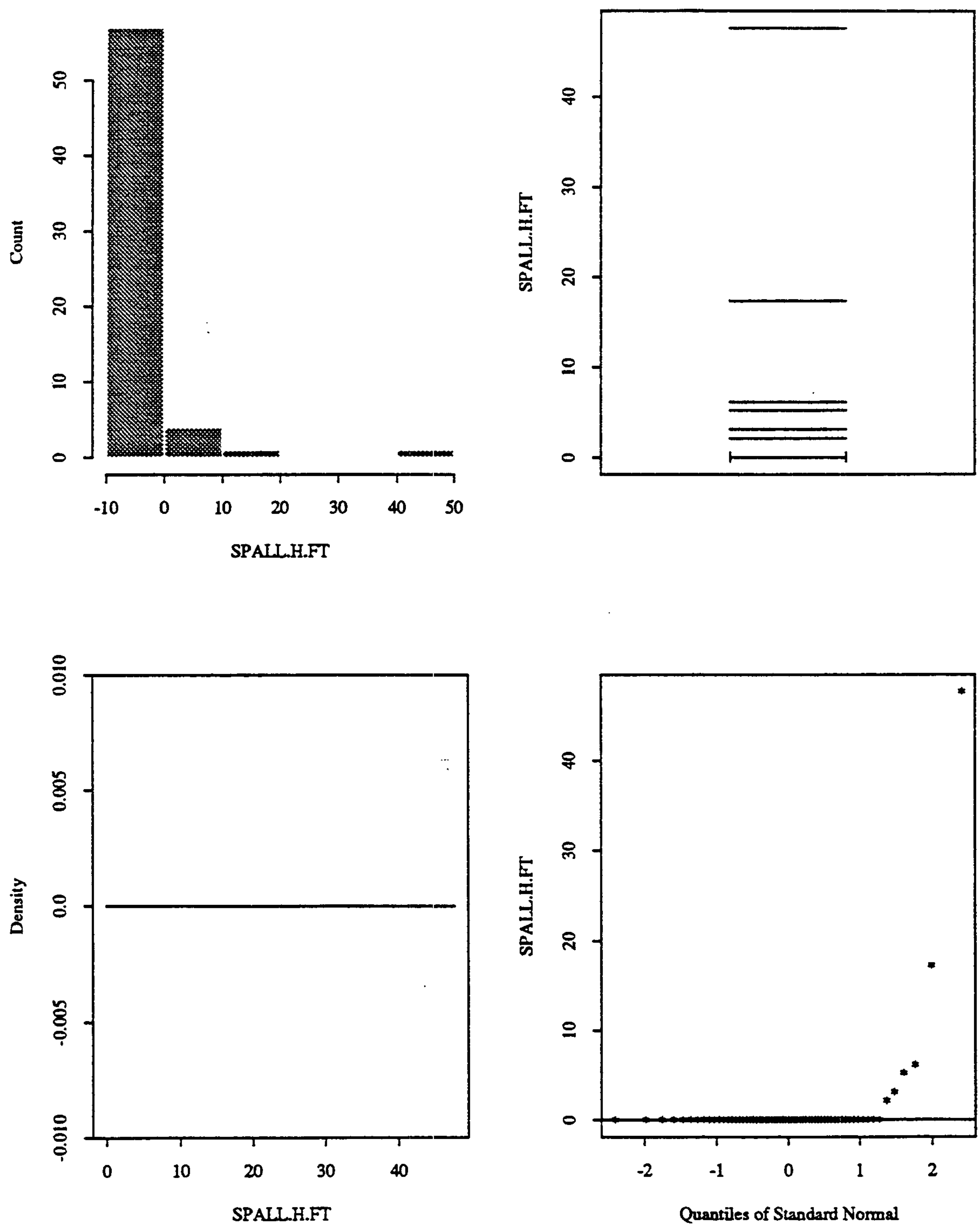


Figure 5.9 Statistical Distribution of High Severity Spalling for GPS-4 Sections, Ft.

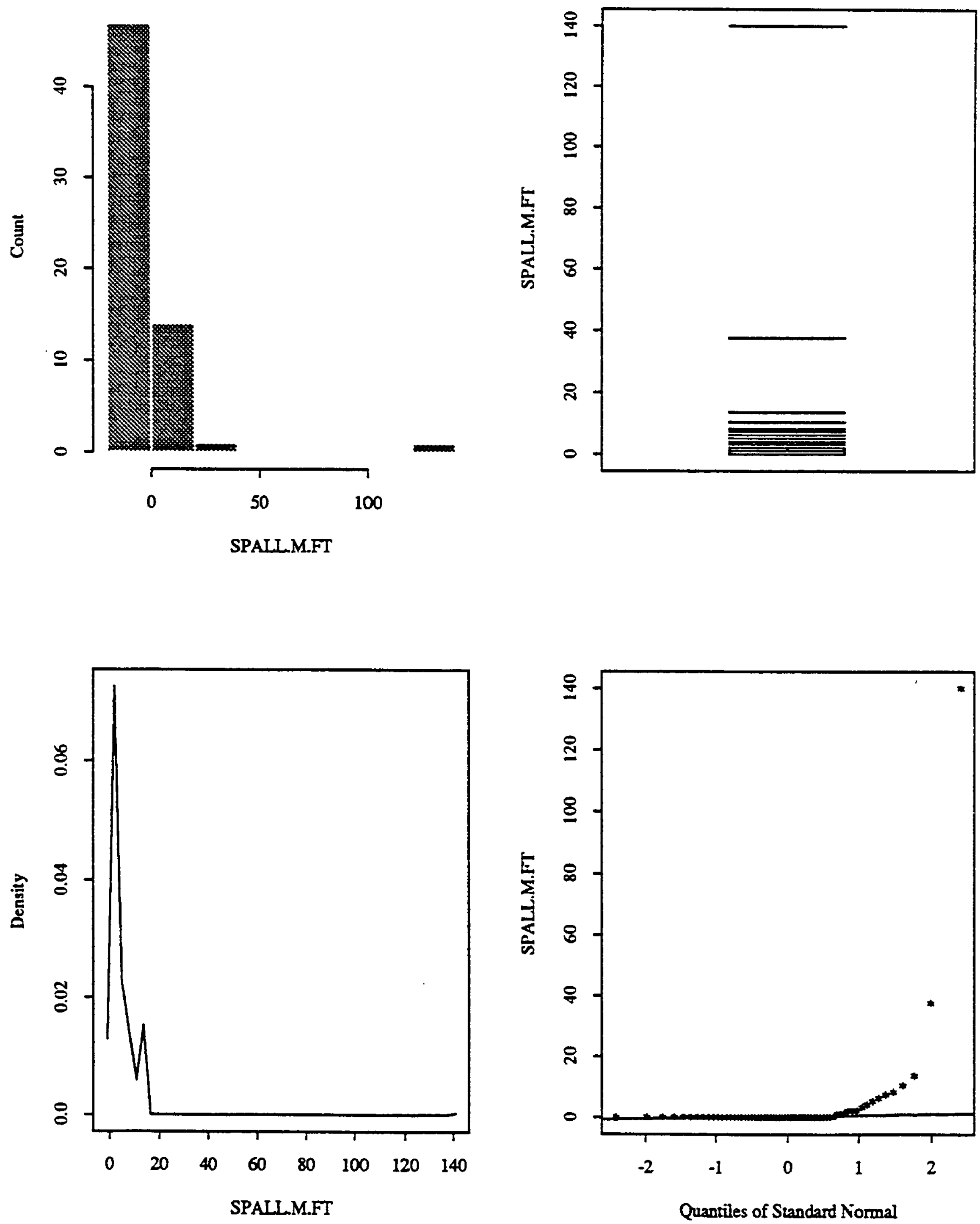


Figure 5.10 Statistical Distribution of Medium Severity Spalling for GPS-4 Sections, Ft.

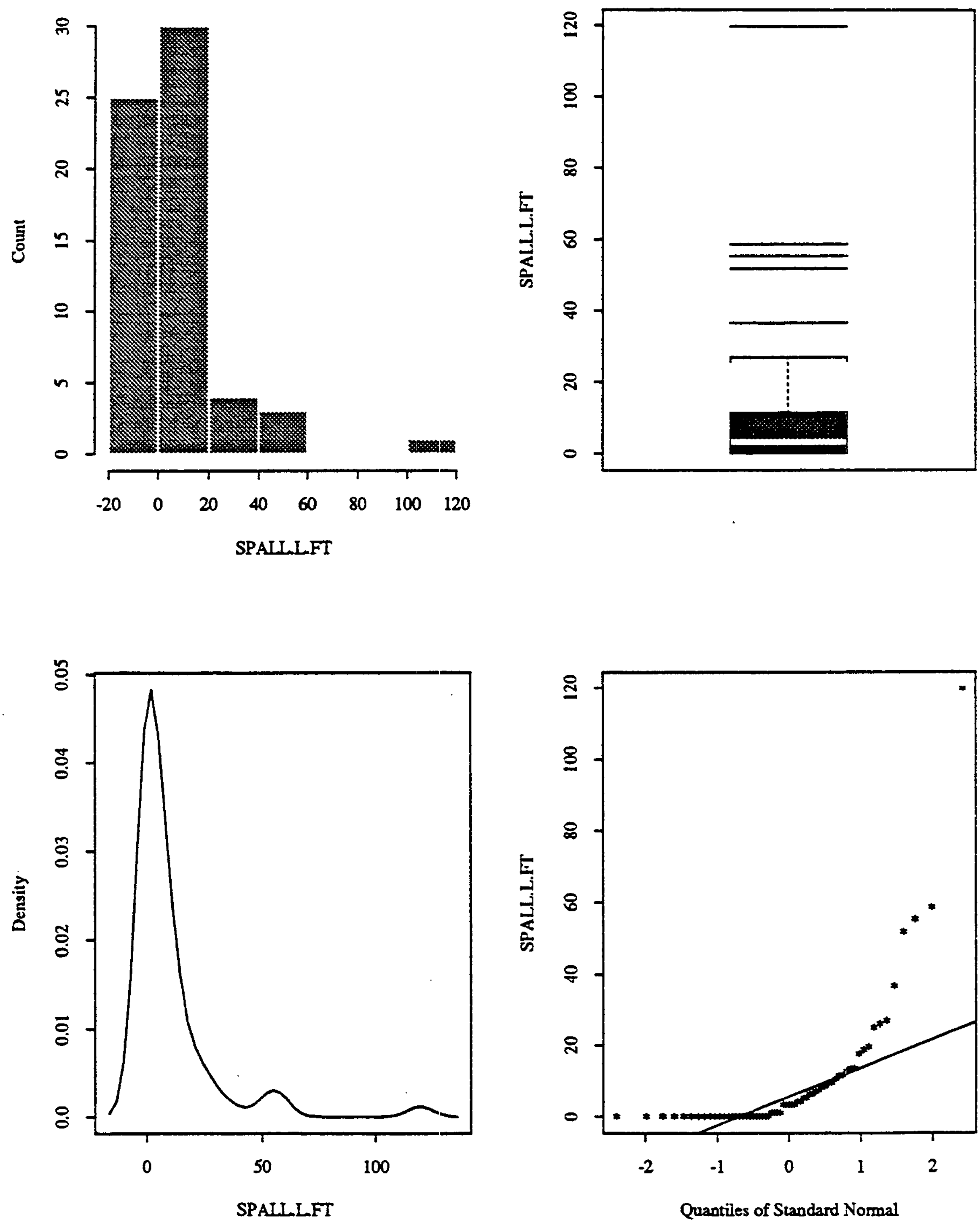


Figure 5.11 Statistical Distribution of Low Severity Spalling for GPS-4 Sections, Ft.

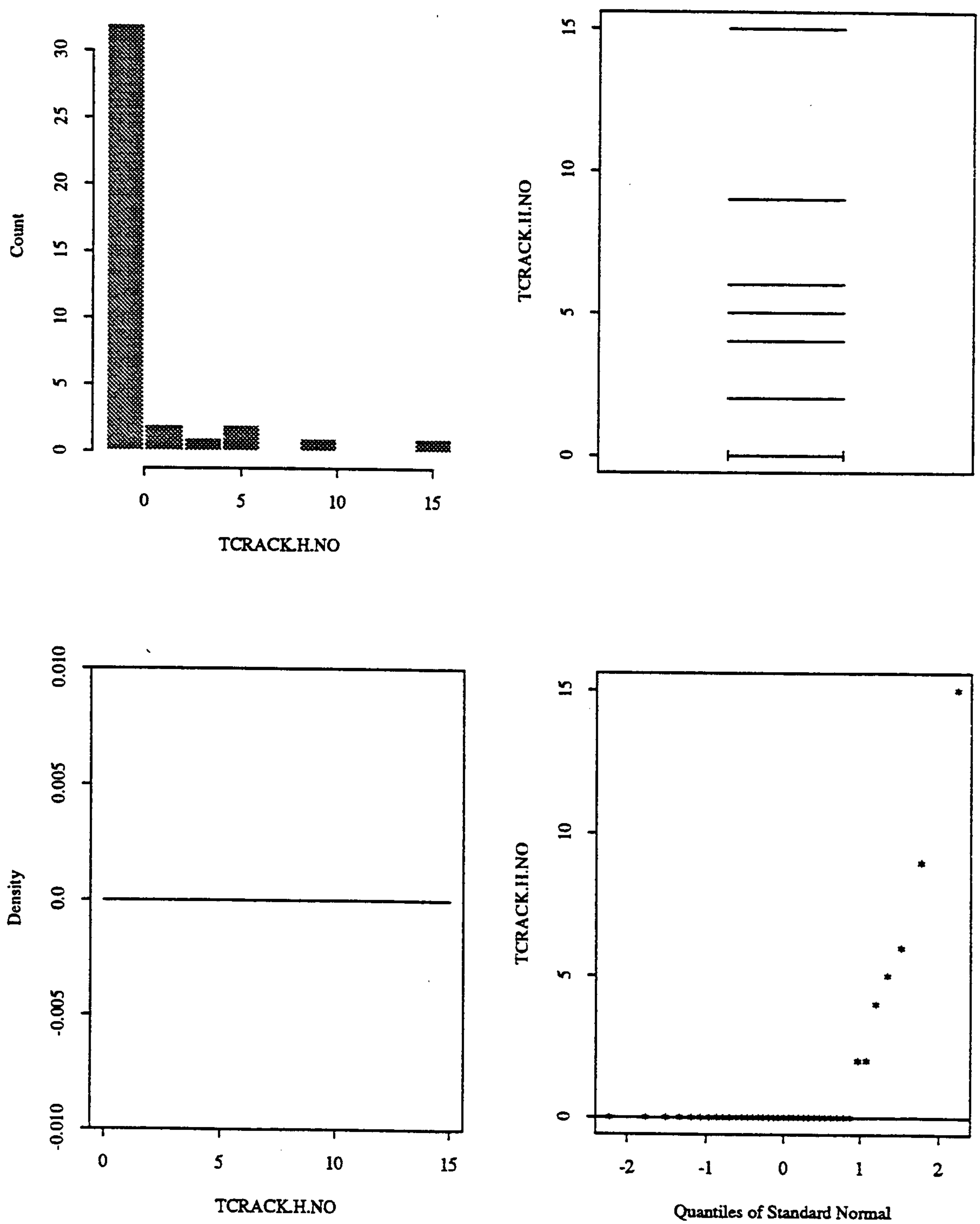


Figure 5.12 Statistical Distribution of High Severity Transverse Cracking for GPS-4 Sections, Number

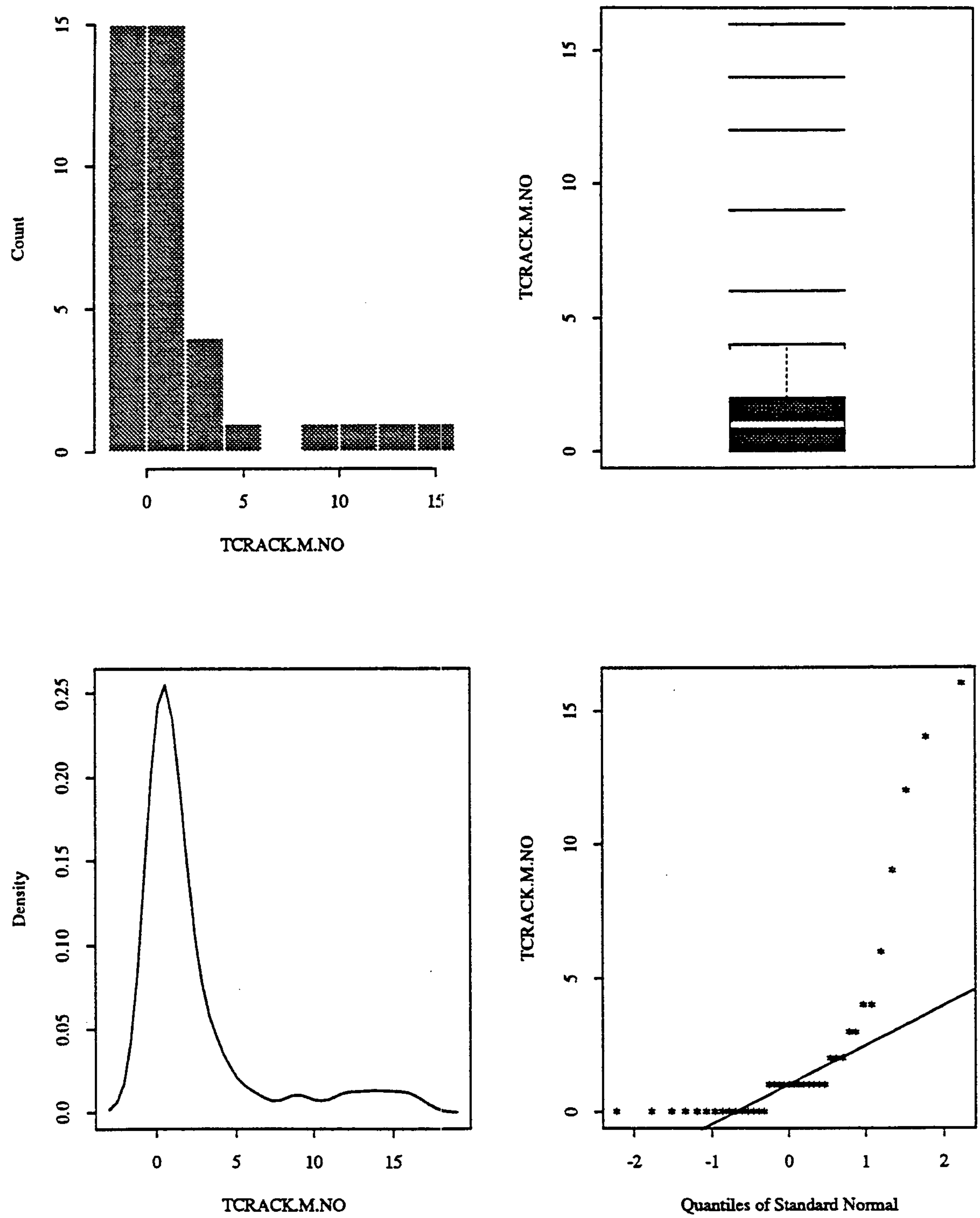


Figure 5.13 Statistical Distribution of Medium Severity Transverse Cracking for GPS-4 Sections, Number

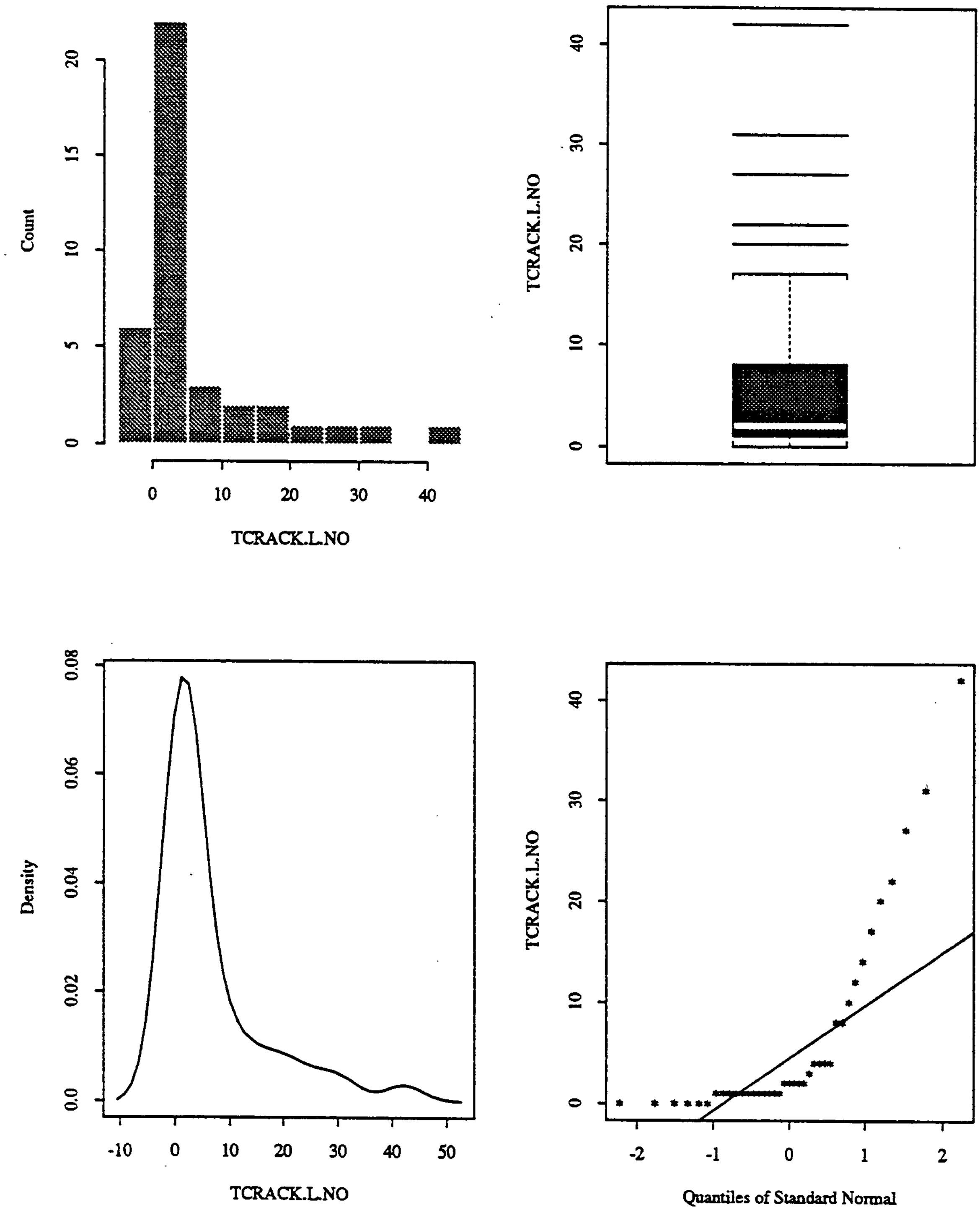
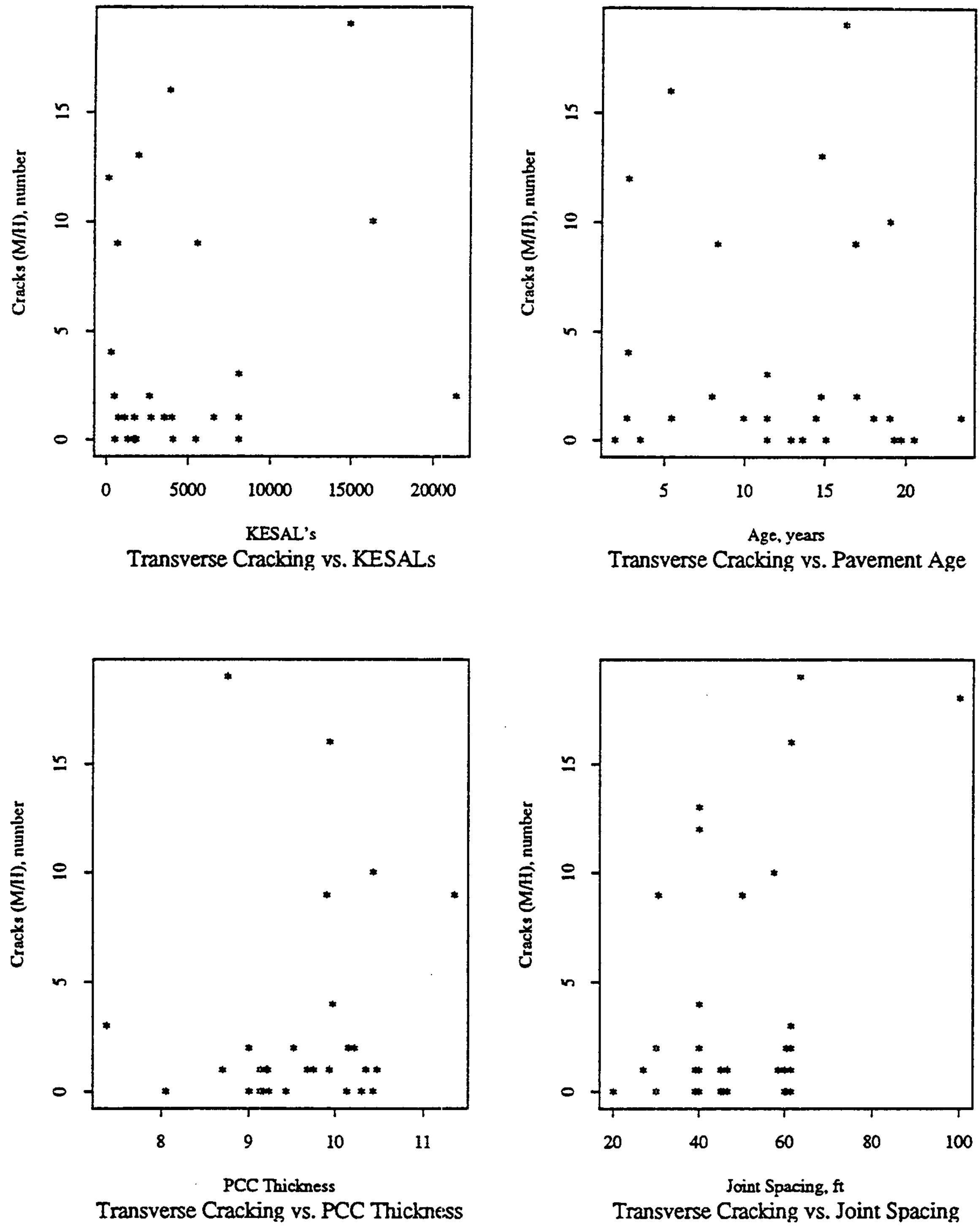


Figure 5.14 Statistical Distribution of Low Severity Transverse Cracking for GPS-4 Sections, Number



Transverse Cracking vs. KESALs

Transverse Cracking vs. Pavement Age

Transverse Cracking vs. PCC Thickness

Transverse Cracking vs. Joint Spacing

Figure 5.15 Transverse Cracking Scatter Plots for GPS-4 Sections

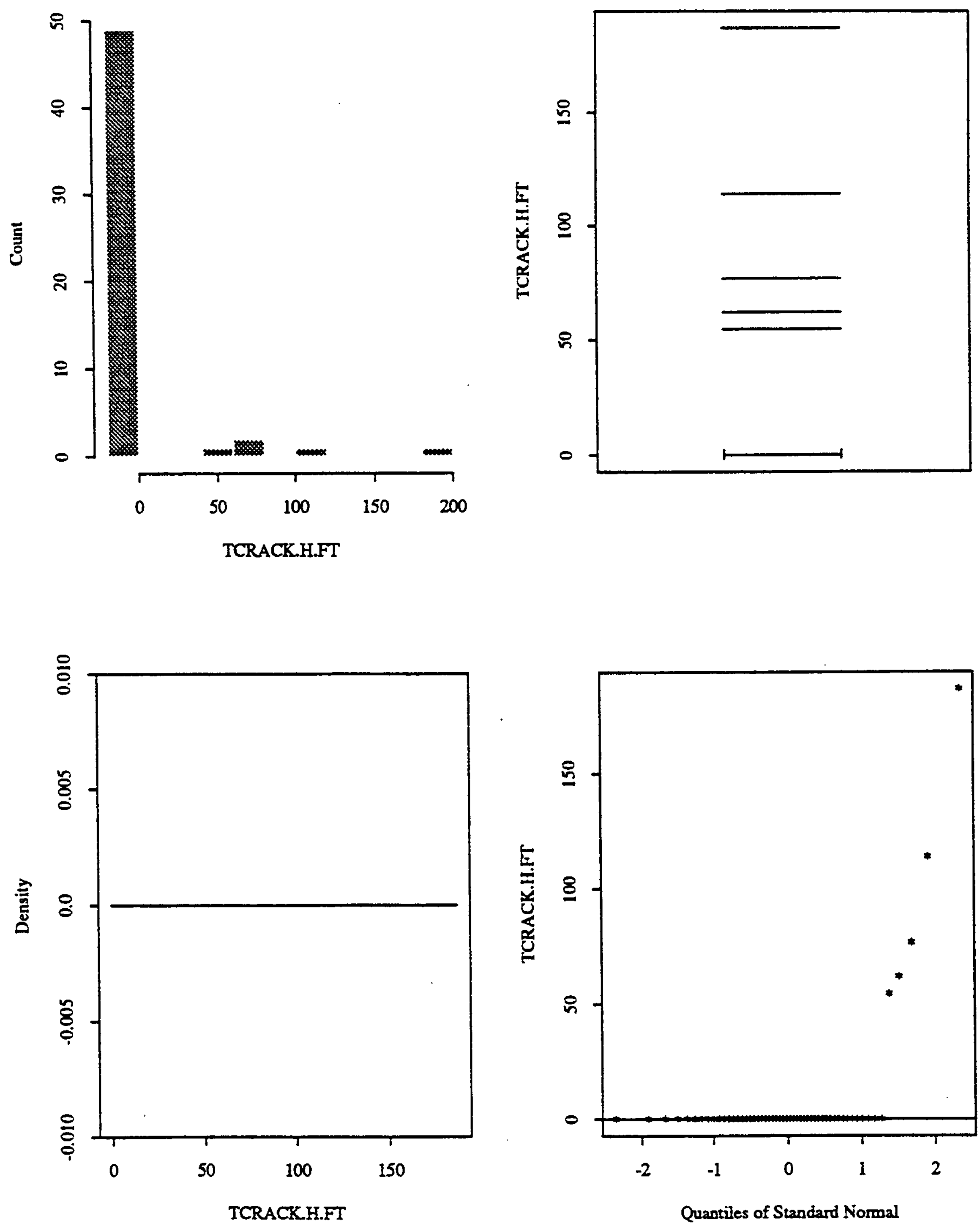


Figure 5.16 Statistical Distribution of High Severity Transverse Cracking for GPS-4 Sections, Ft.

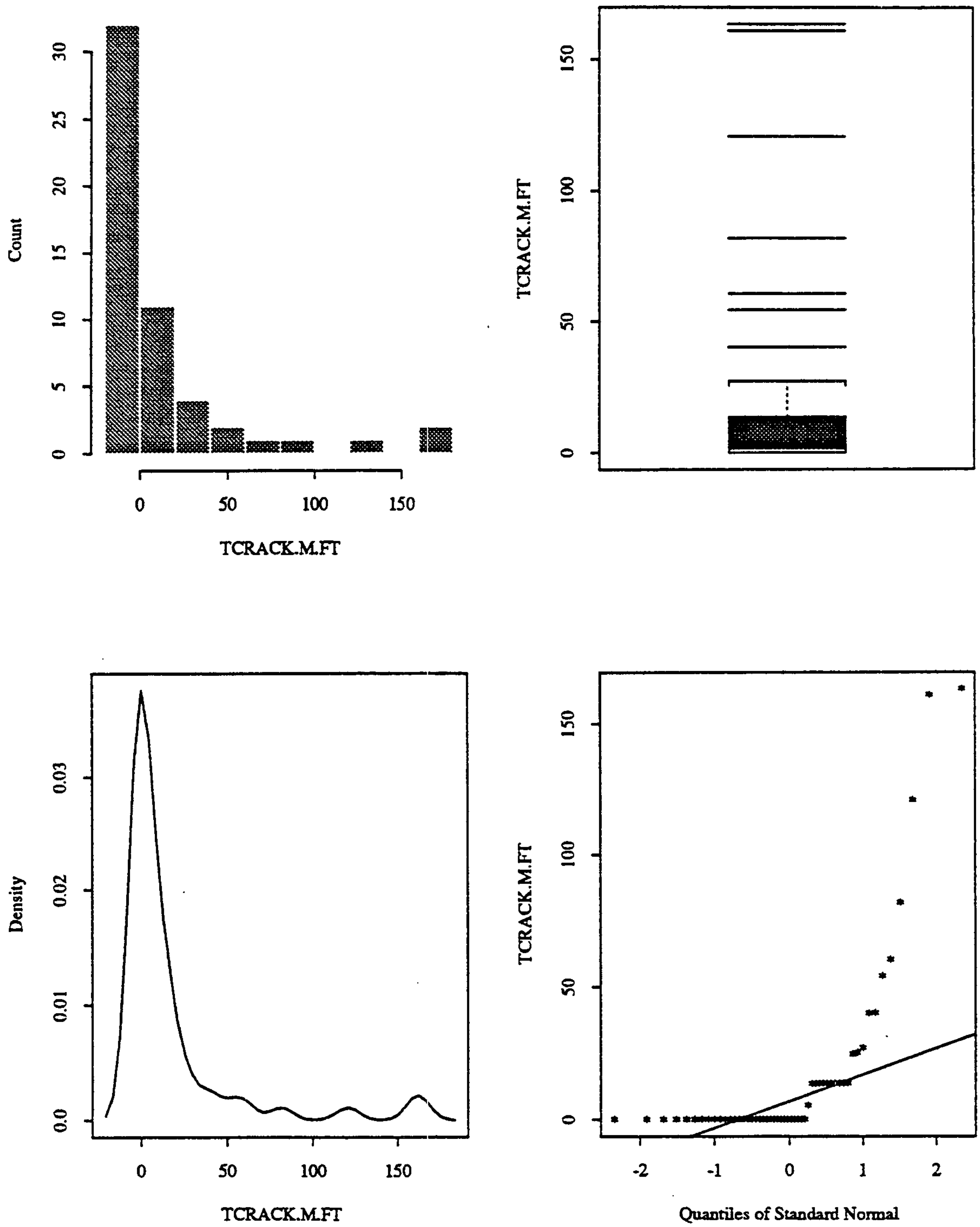


Figure 5.17 Statistical Distribution of Medium Severity Transverse Cracking for GPS-4 Sections, Ft.

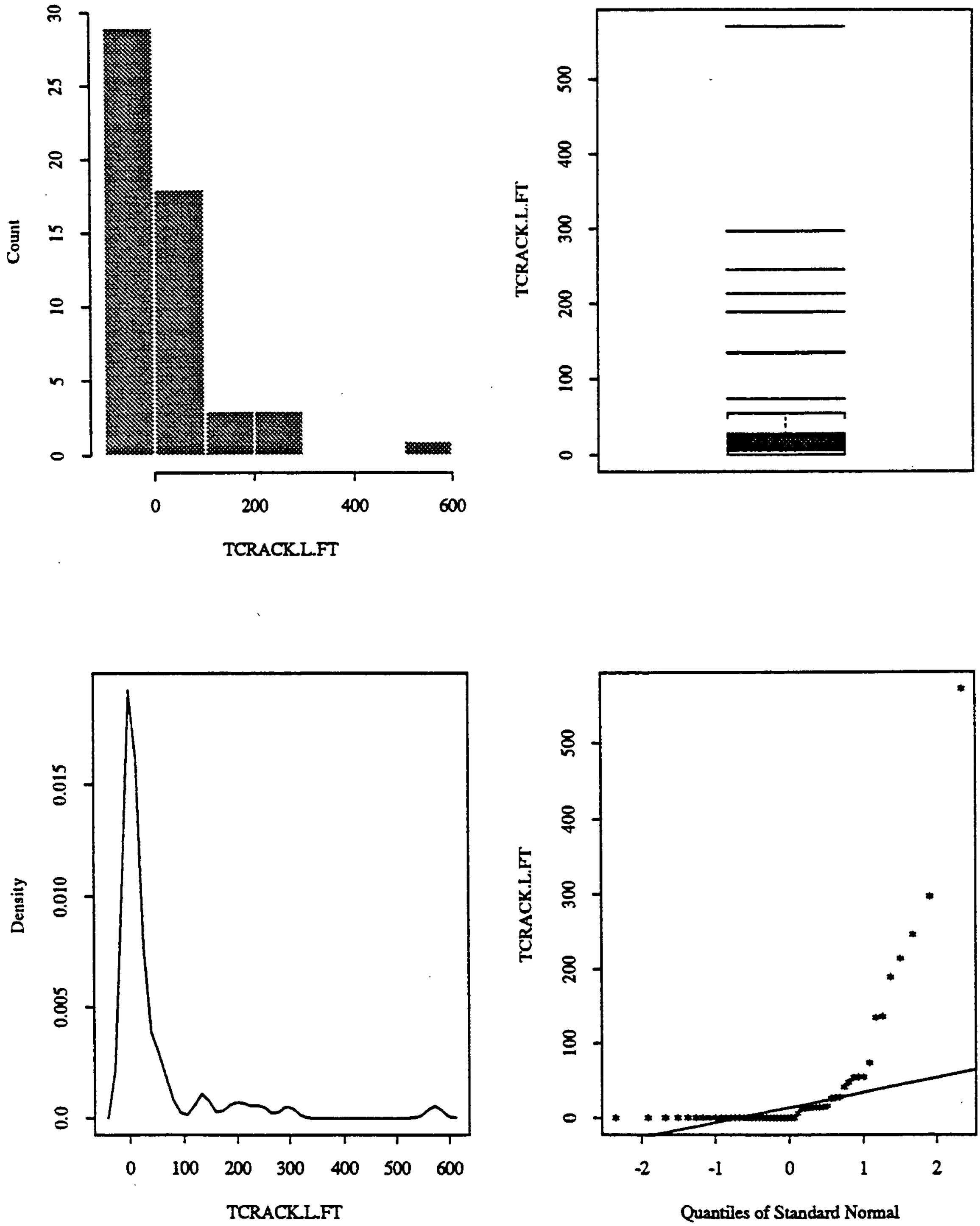


Figure 5.18 Statistical Distribution of Low Severity Transverse Cracking for GPS-4 Sections, Ft.

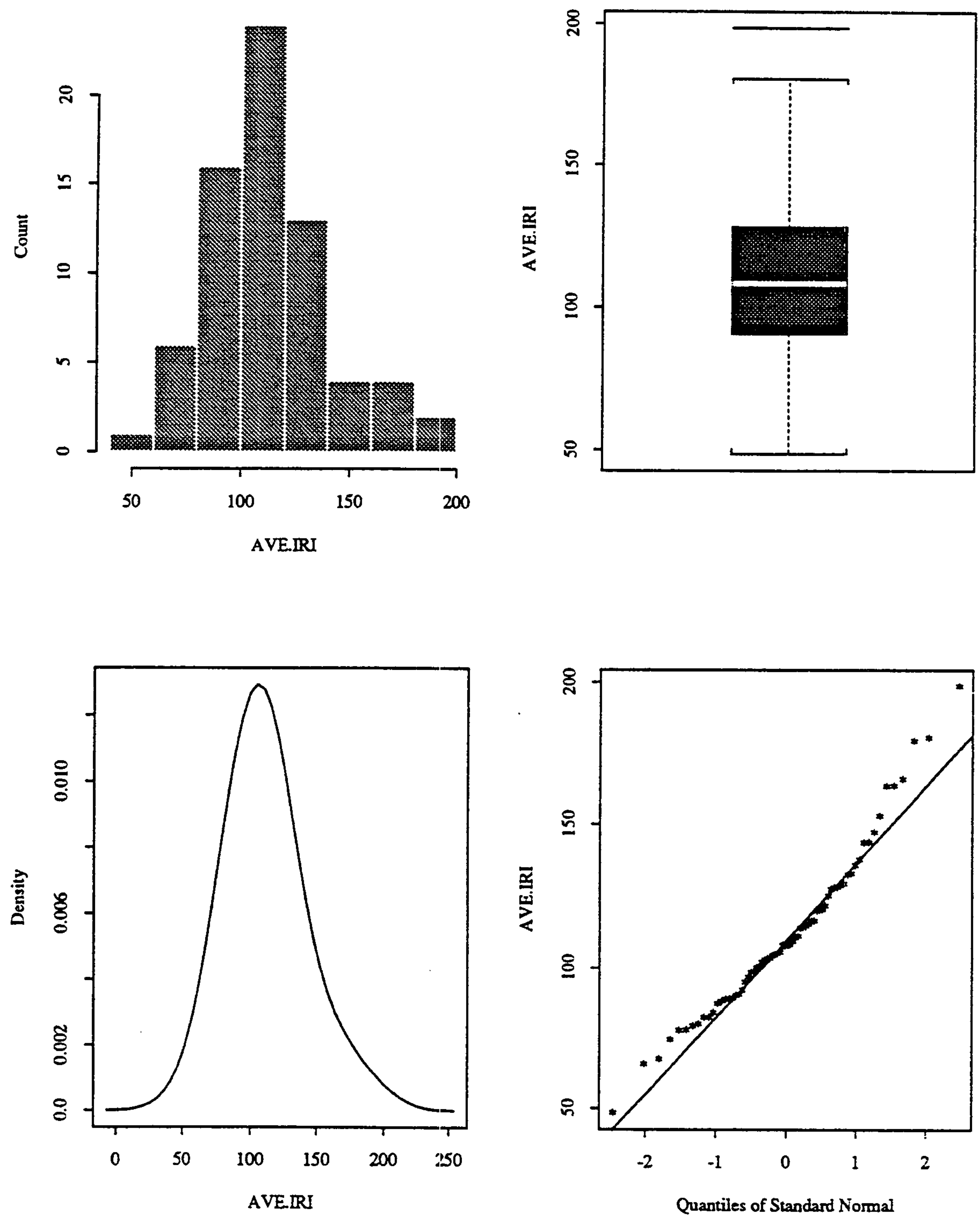


Figure 5.19 Statistical Distribution of Average IRI for GPS-4 Sections, In./Mile

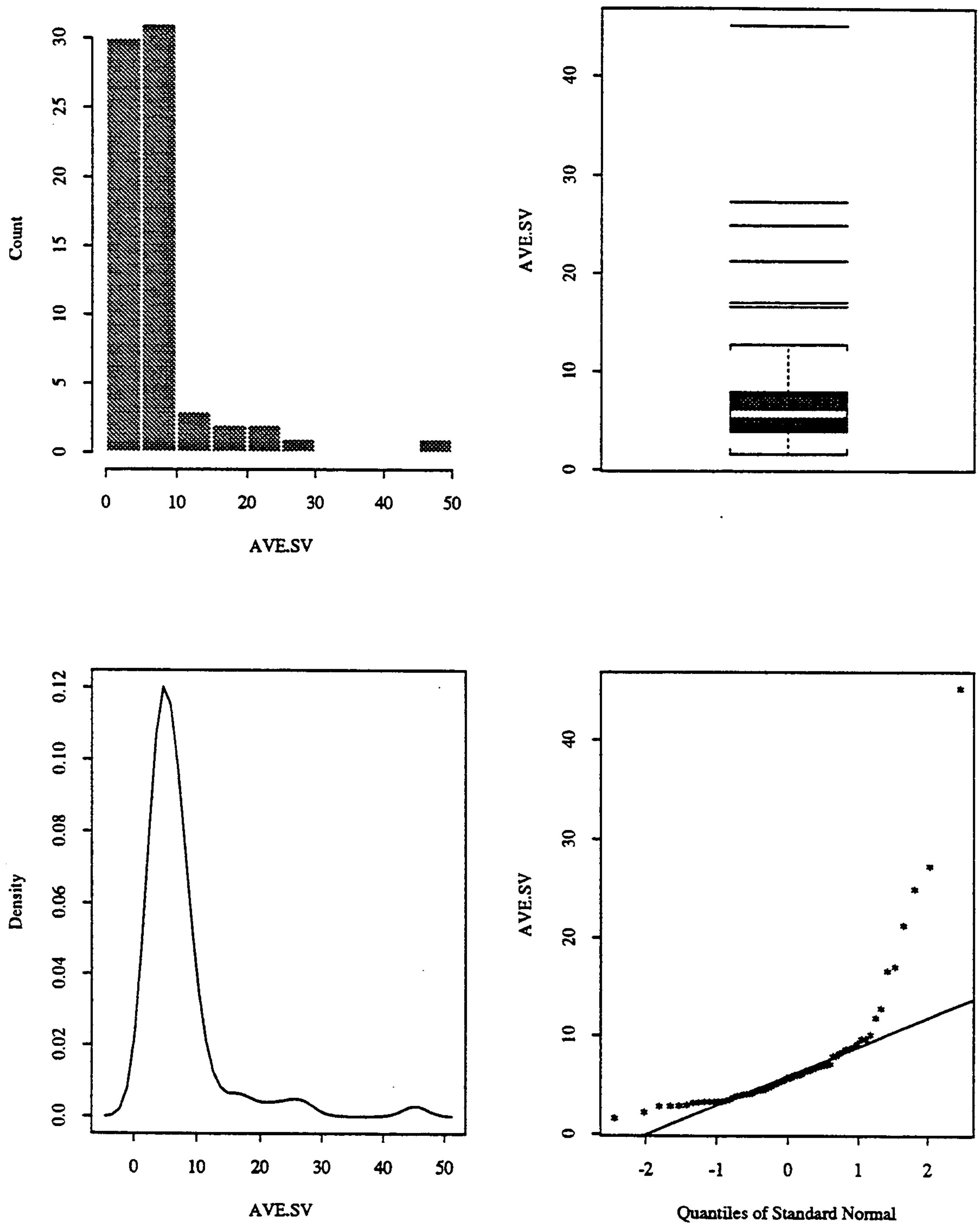


Figure 5.20 Statistical Distribution of Average Slope Variance for GPS-4 Sections

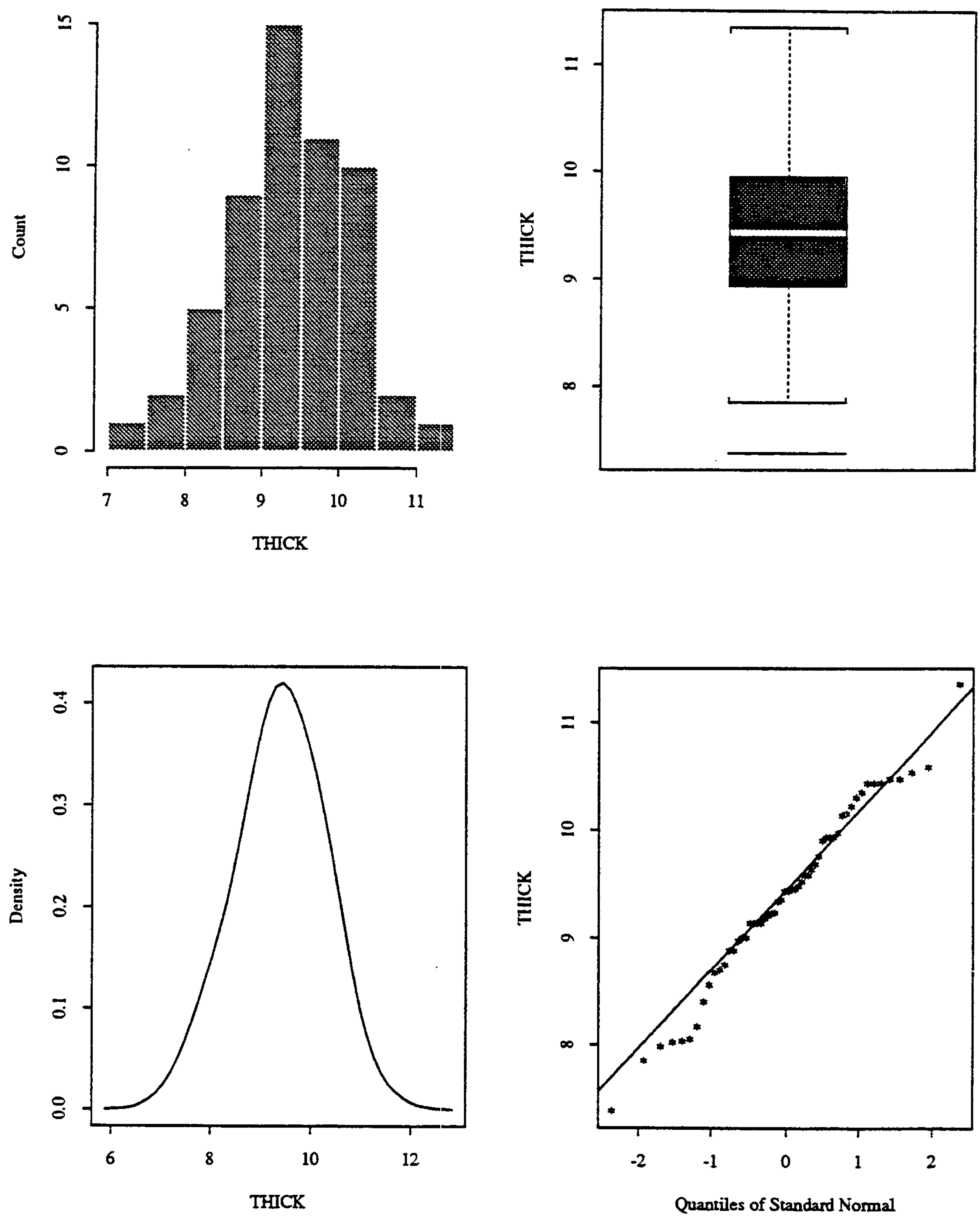


Figure 5.21 Statistical Distribution of PCC Thickness for GPS-4 Sections

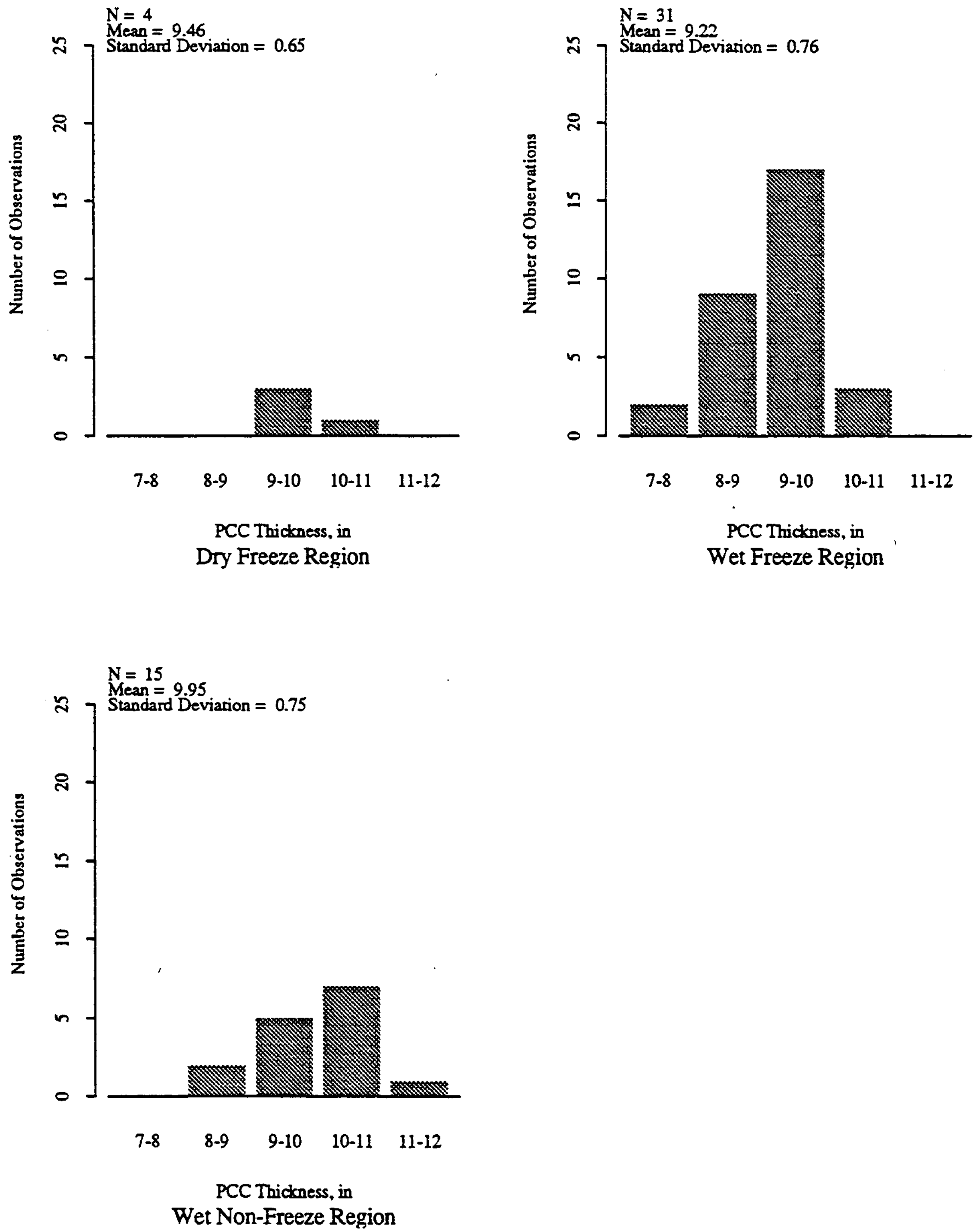


Figure 5.22 Distribution of PCC Thickness by Environmental Regions for GPS-4 Sections

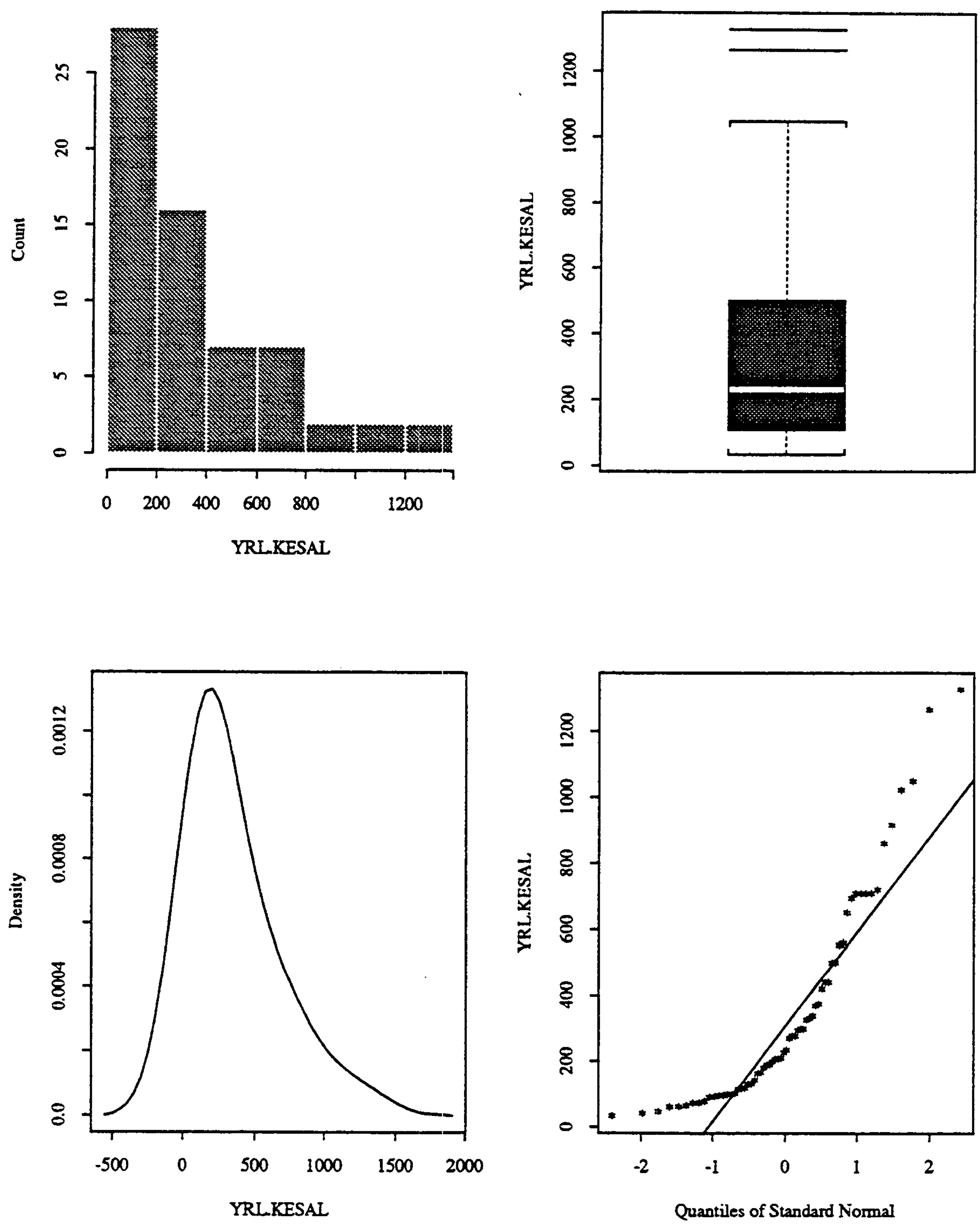


Figure 5.23 Statistical Distribution of KESALs/Year for GPS-4 Sections

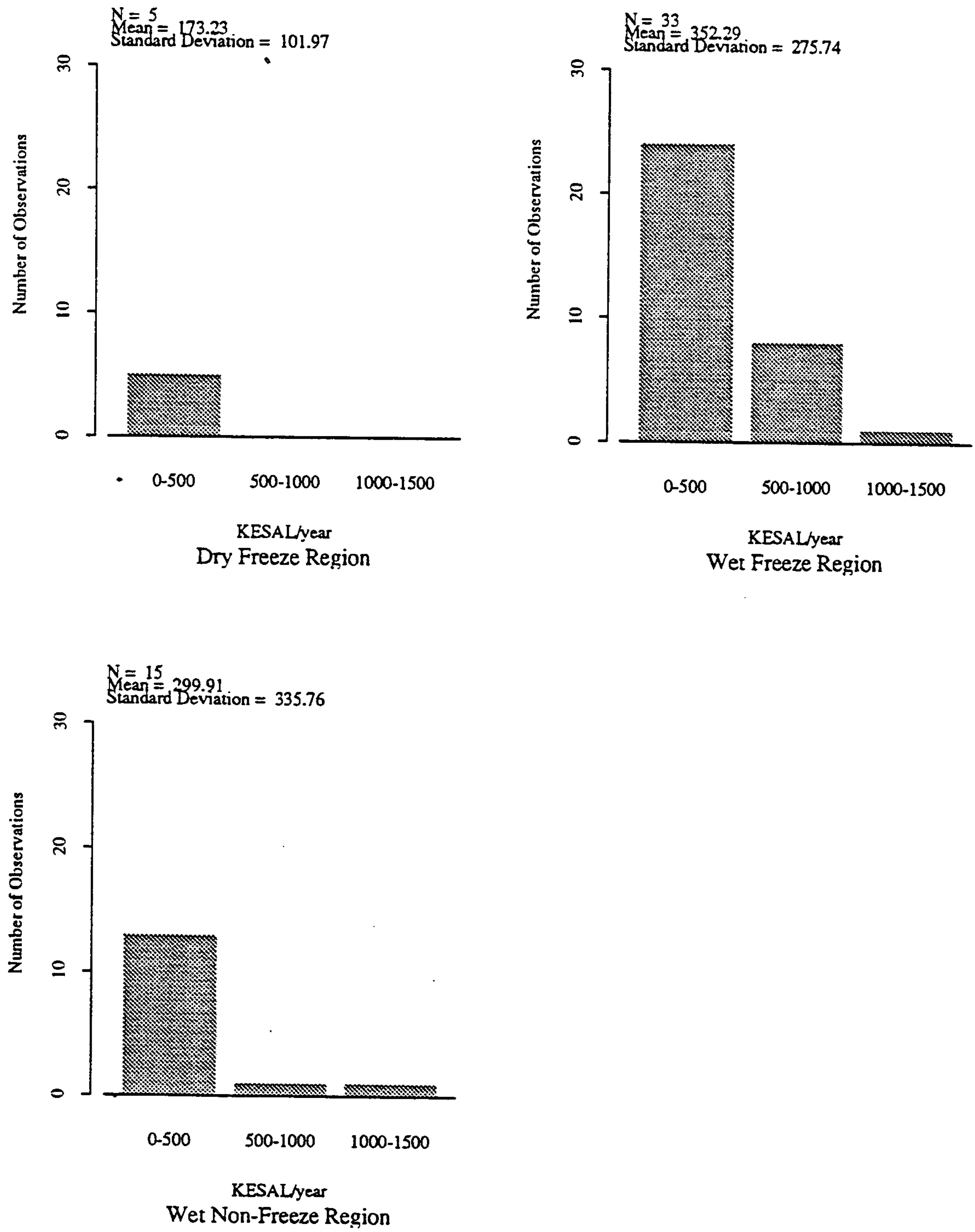


Figure 5.24 Distribution of KESALs/Year by Environmental Regions for GPS-4 Sections

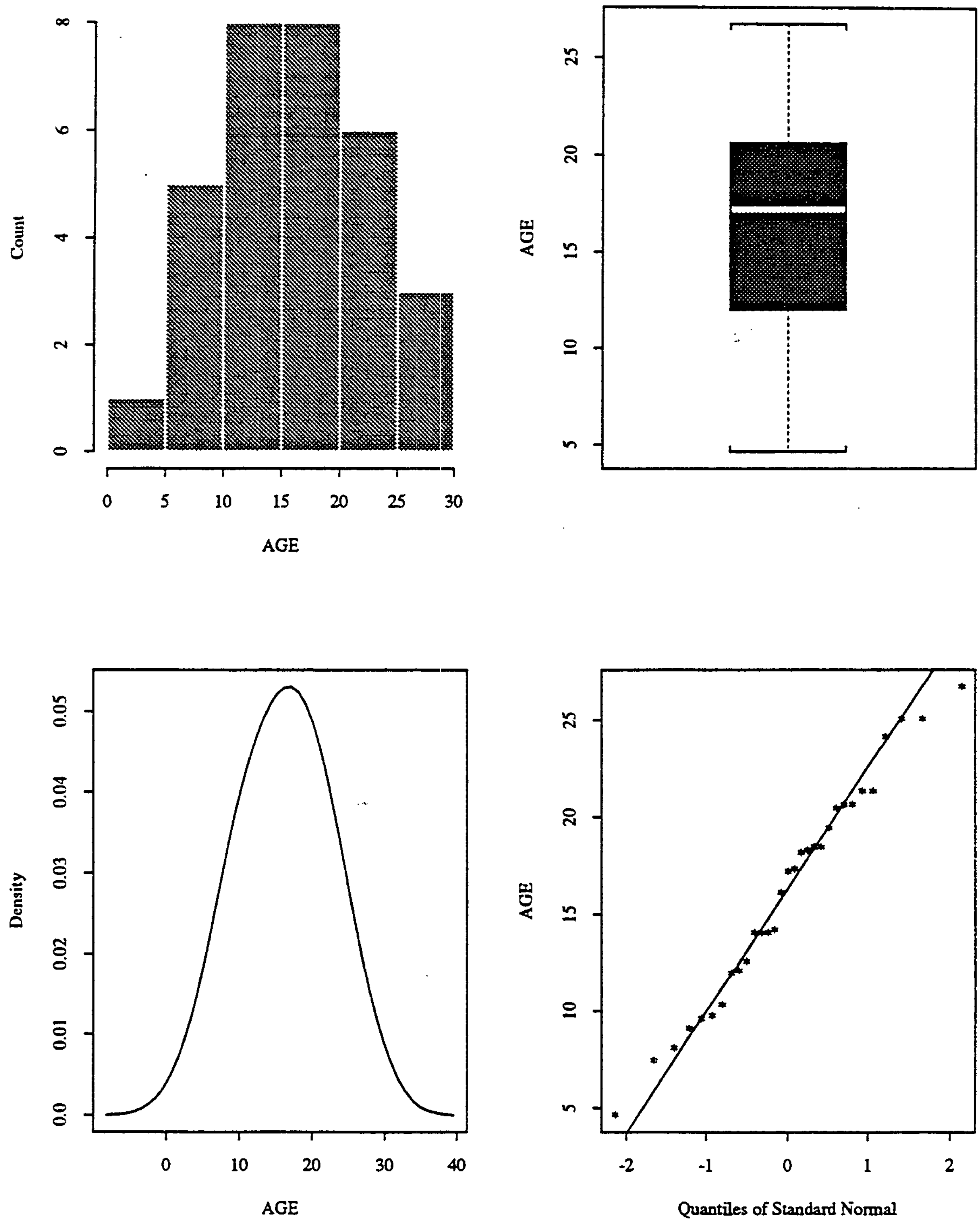


Figure 5.25 Statistical Distribution of Pavement Age for GPS-4 Sections

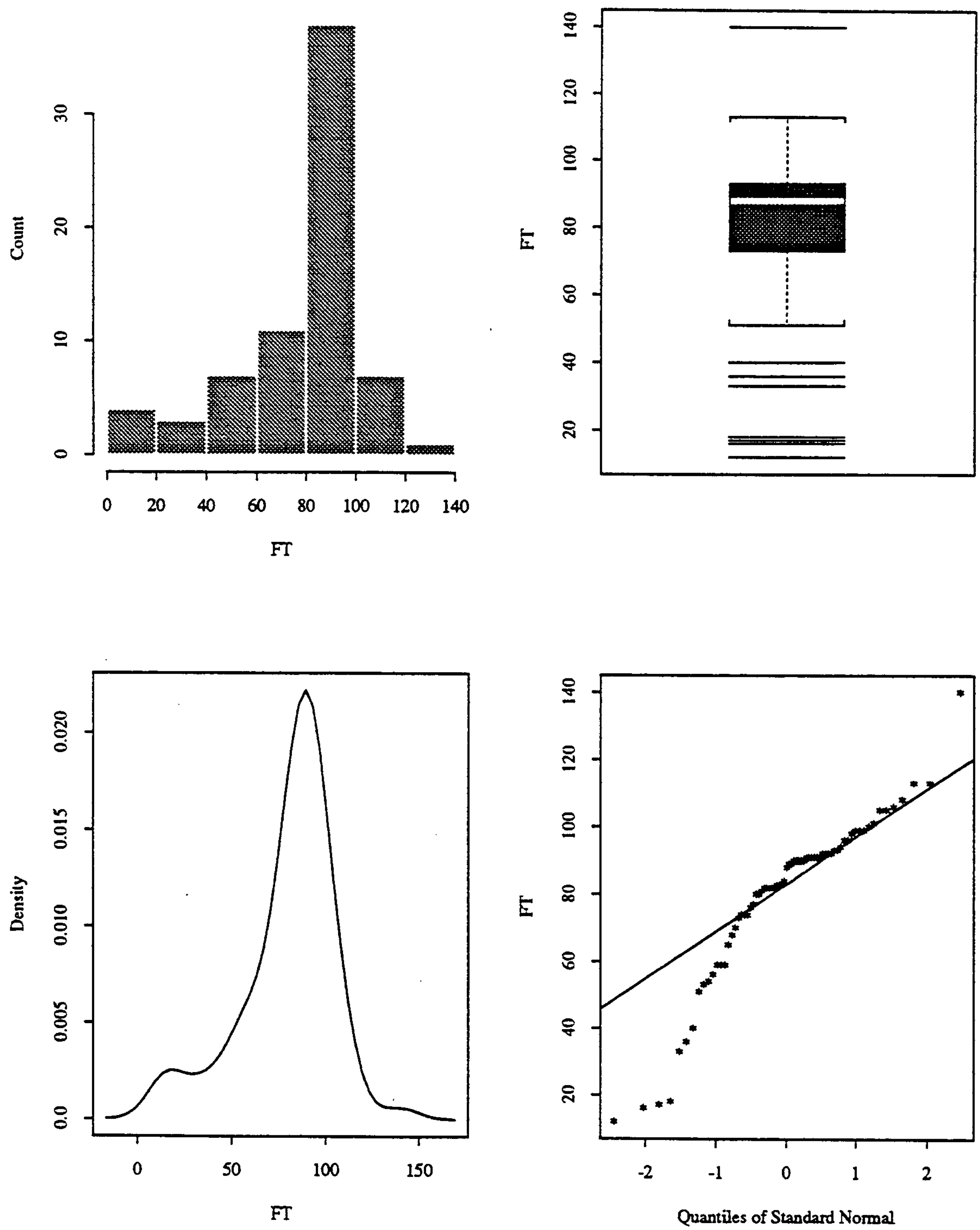
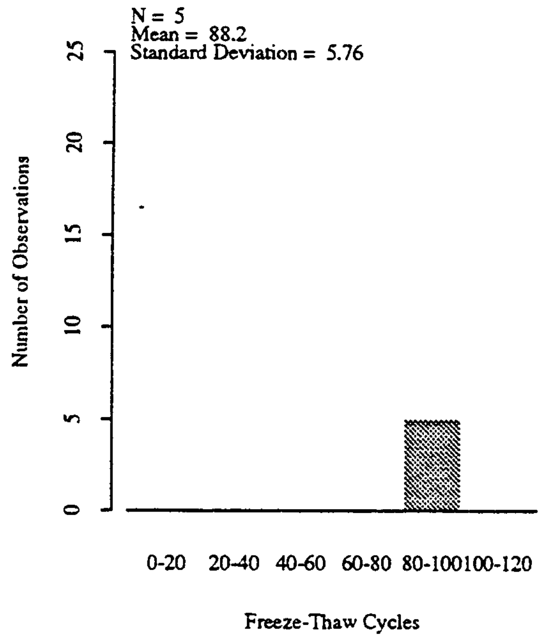
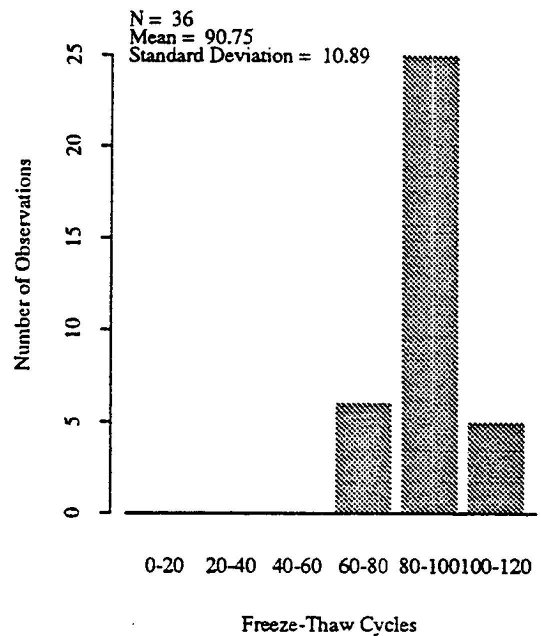


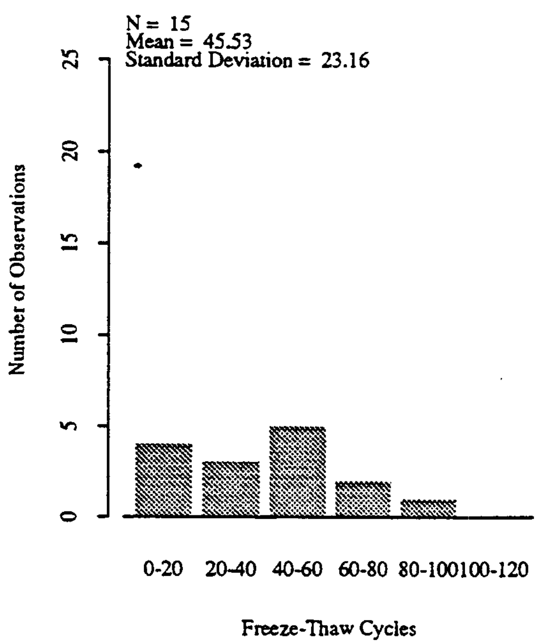
Figure 5.26 Statistical Distribution of Freeze-Thaw Cycles for GPS-4 Sections



Dry Freeze Region



Wet Freeze Region



Wet Non-Freeze Region

Figure 5.27 Distribution of Freeze-Thaw Cycles by Environmental Regions for GPS-4 Sections

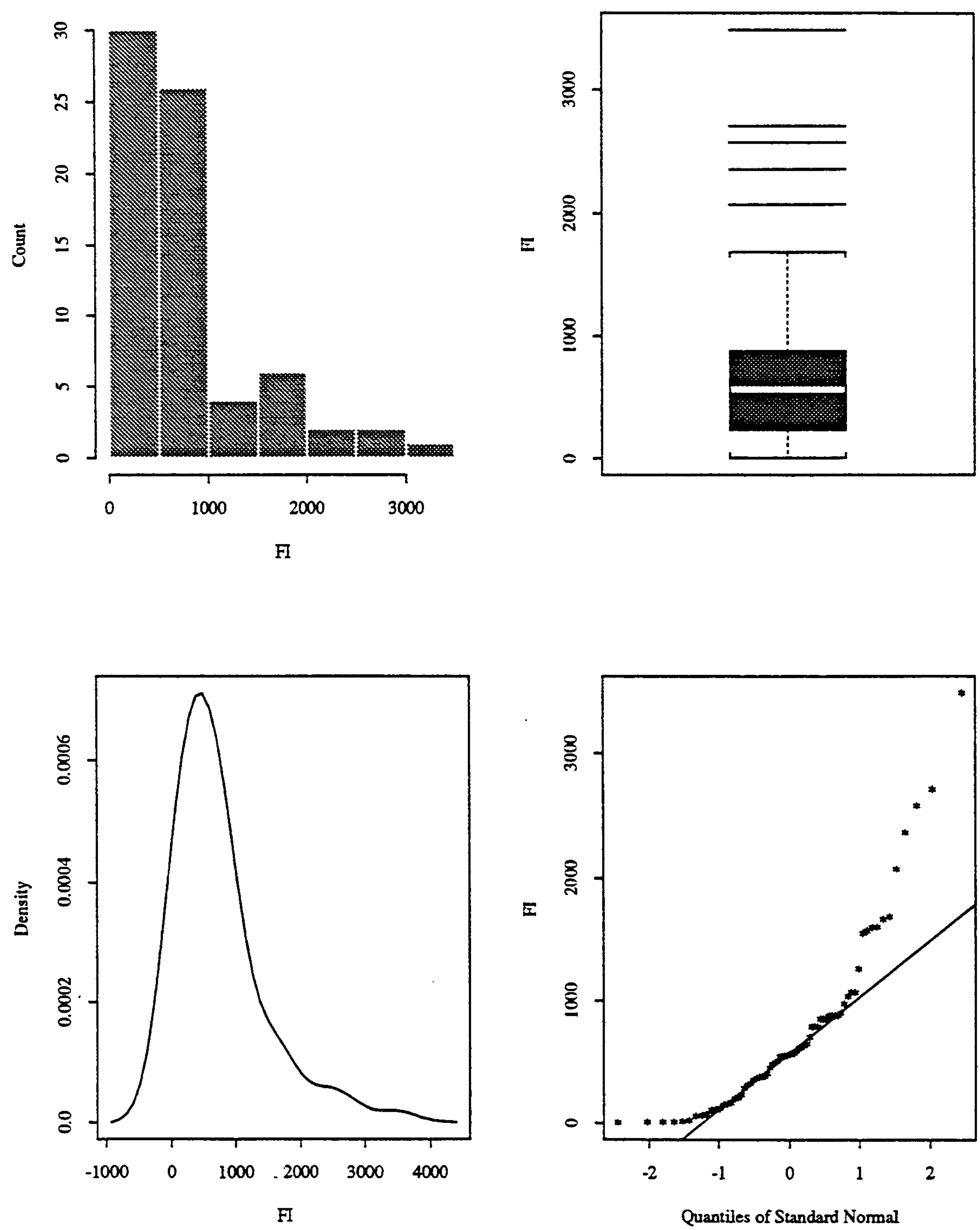


Figure 5.28 Statistical Distribution of Freezing Index for GPS-4 Sections

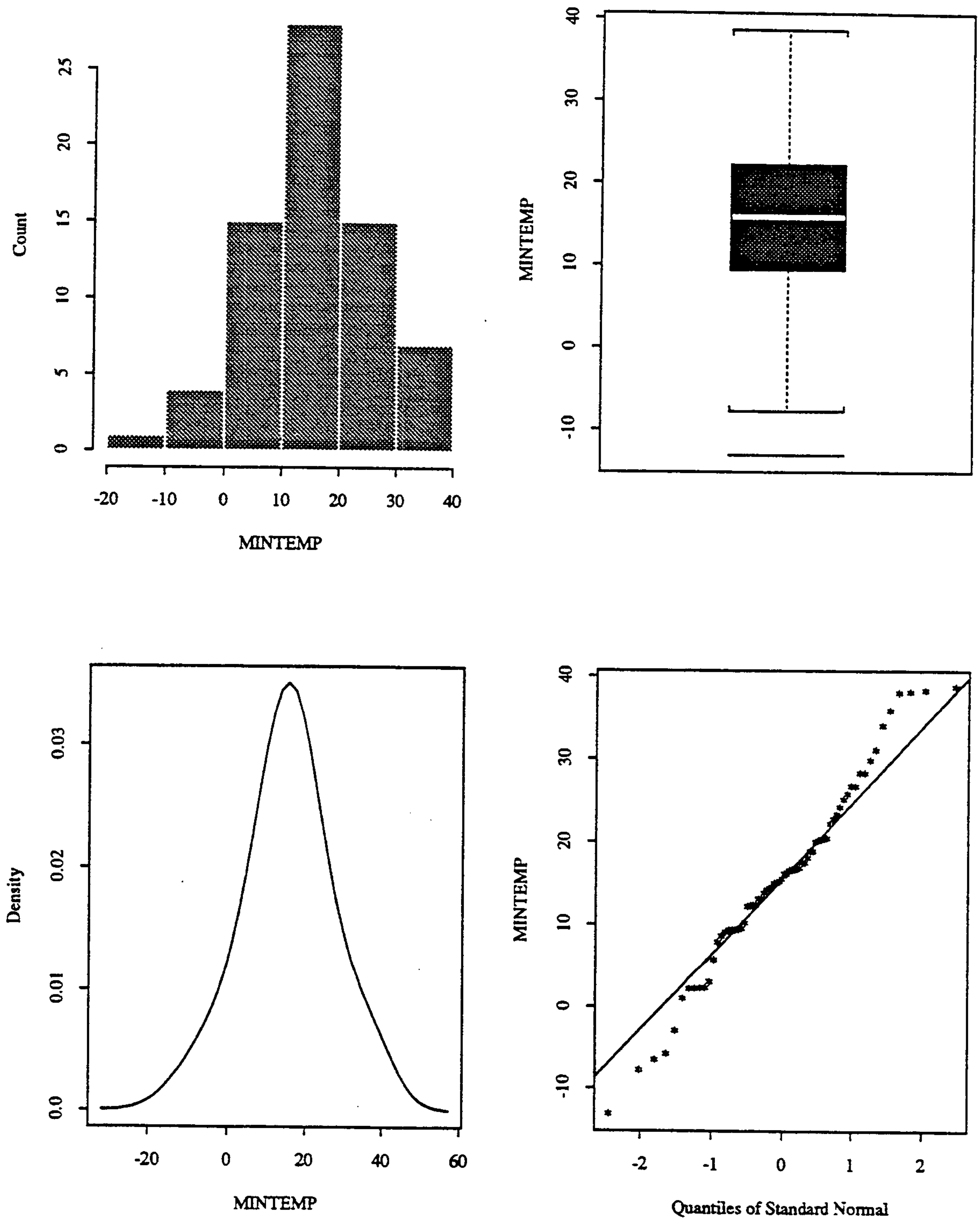


Figure 5.29 Statistical Distribution of Average Monthly Minimum Temperature for GPS-4 Sections, °F

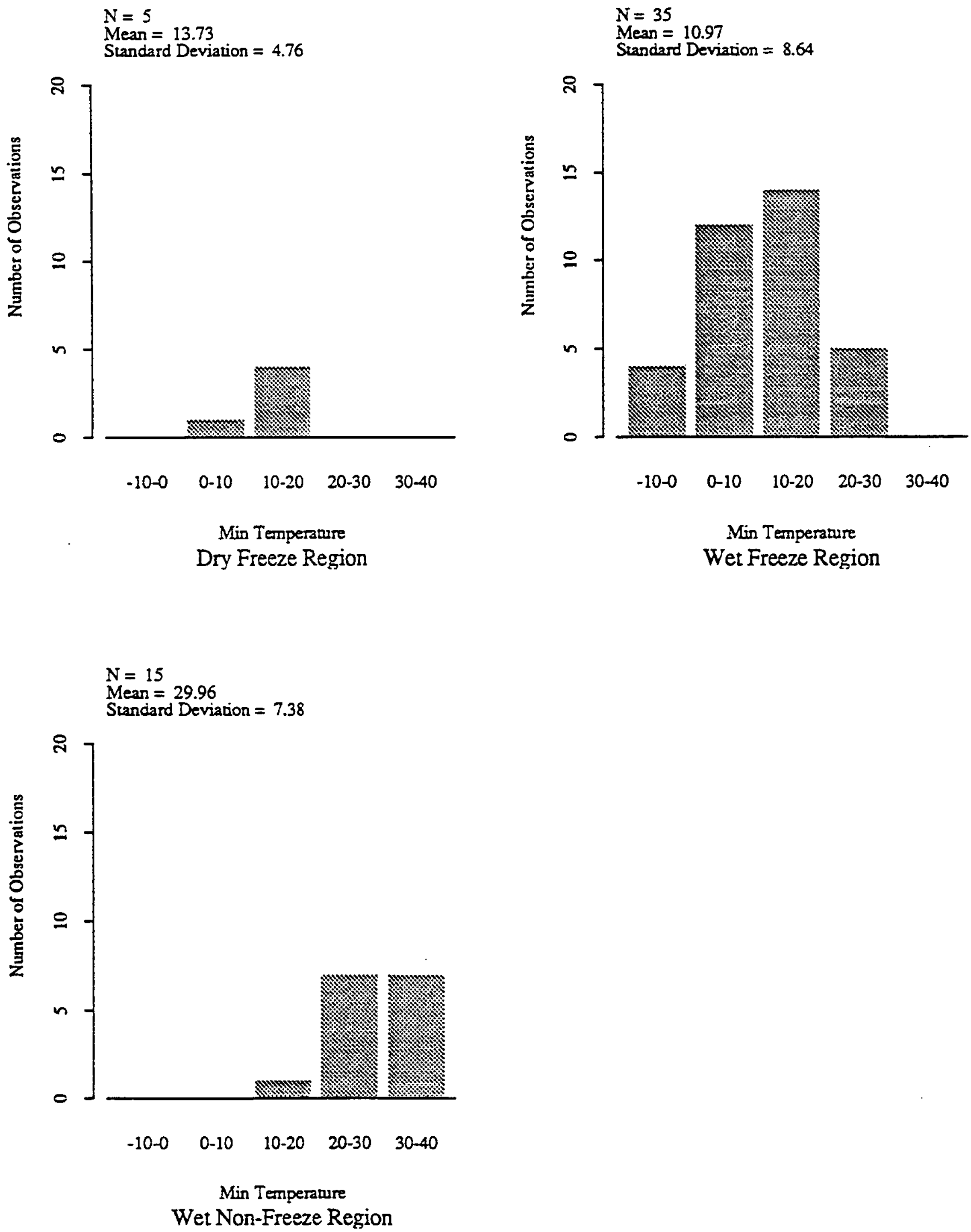


Figure 5.30 Distribution of Minimum Temperature by Environmental Regions for GPS-4 Sections, °F

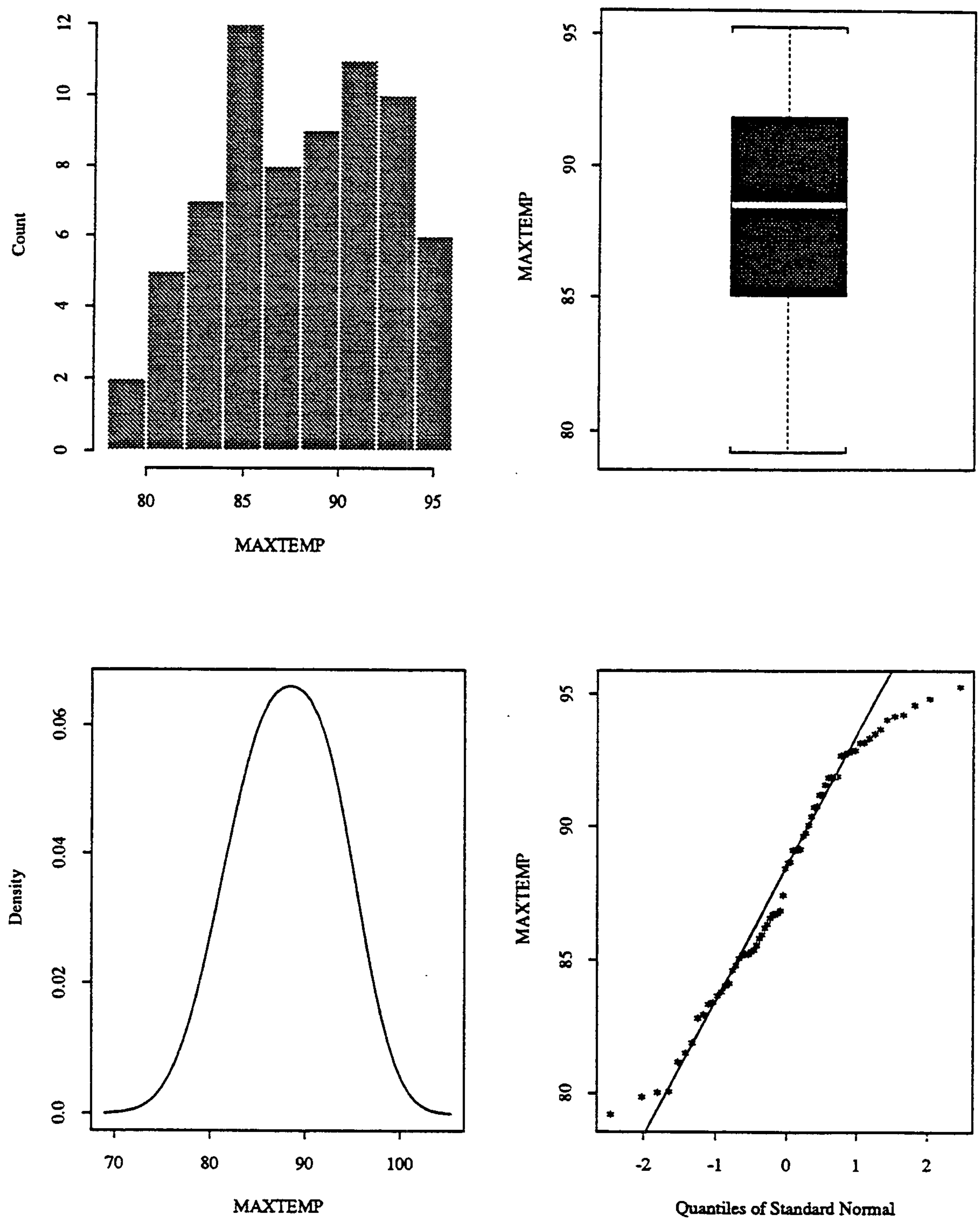


Figure 5.31 Statistical Distribution of Average Monthly Maximum Temperature for GPS-4 Sections, °F

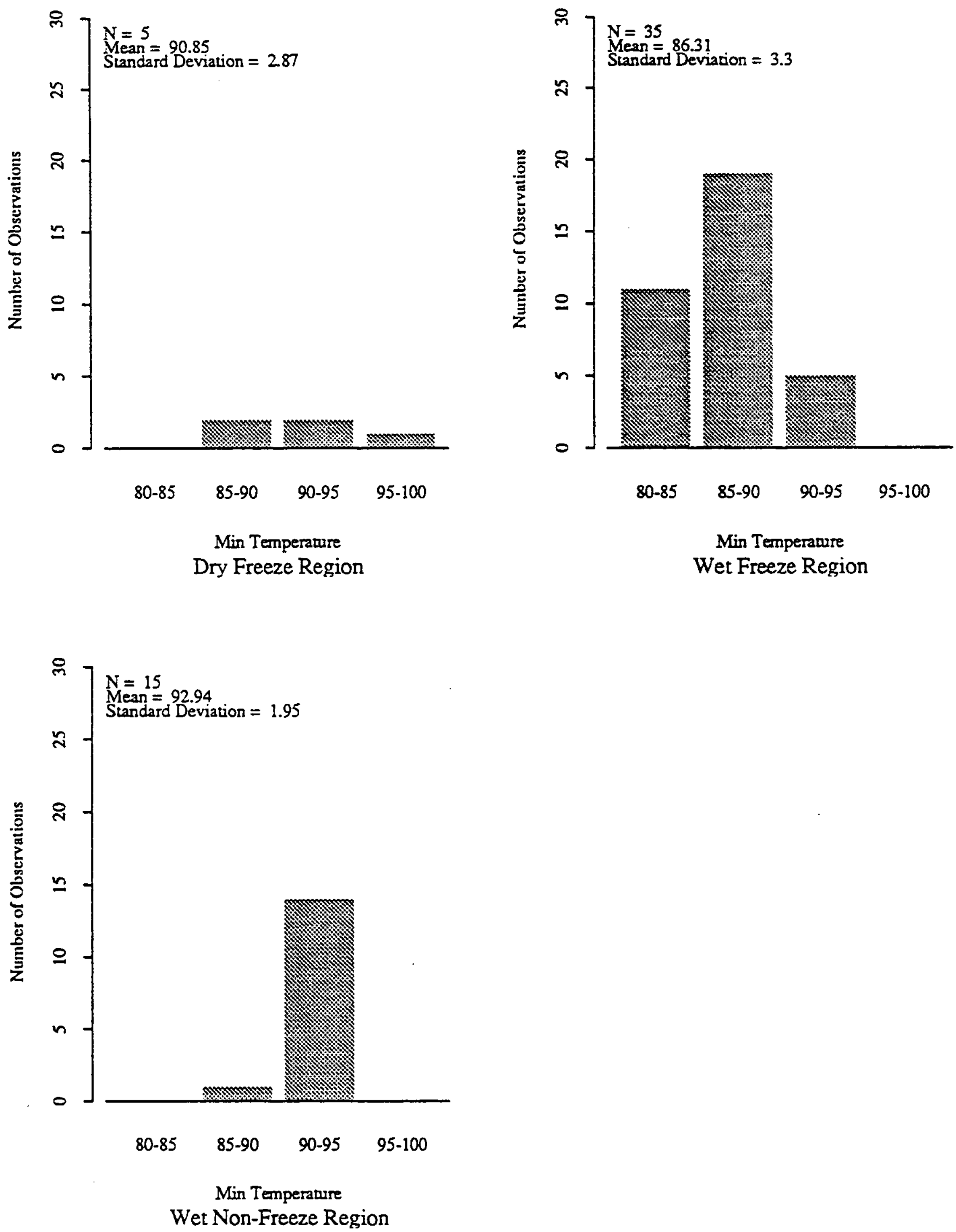


Figure 5.32 Distribution of Maximum Temperature by Environmental Regions for GPS-4 Sections, °F

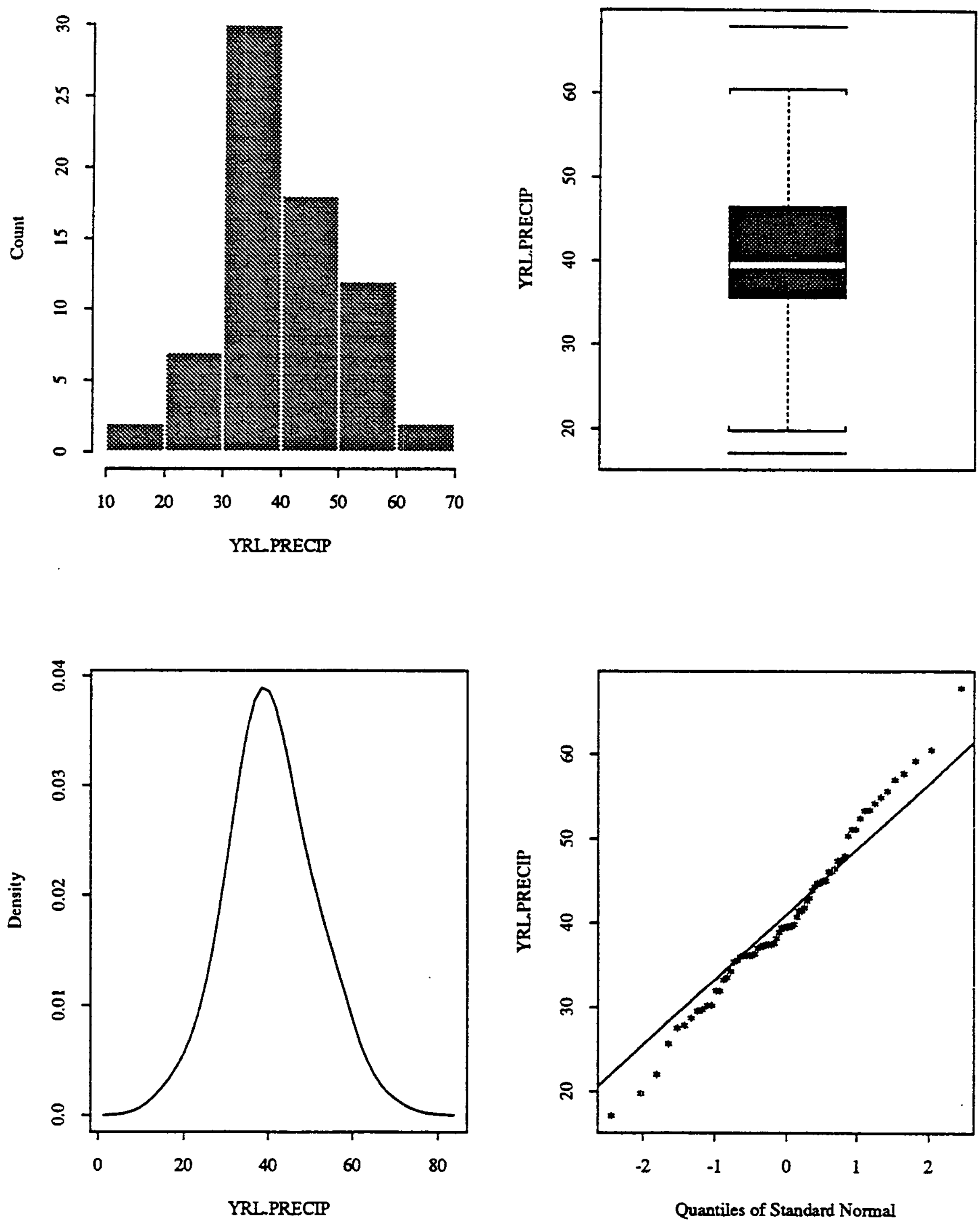


Figure 5.33 Statistical Distribution of Average Yearly Precipitation for GPS-4 Section, In.

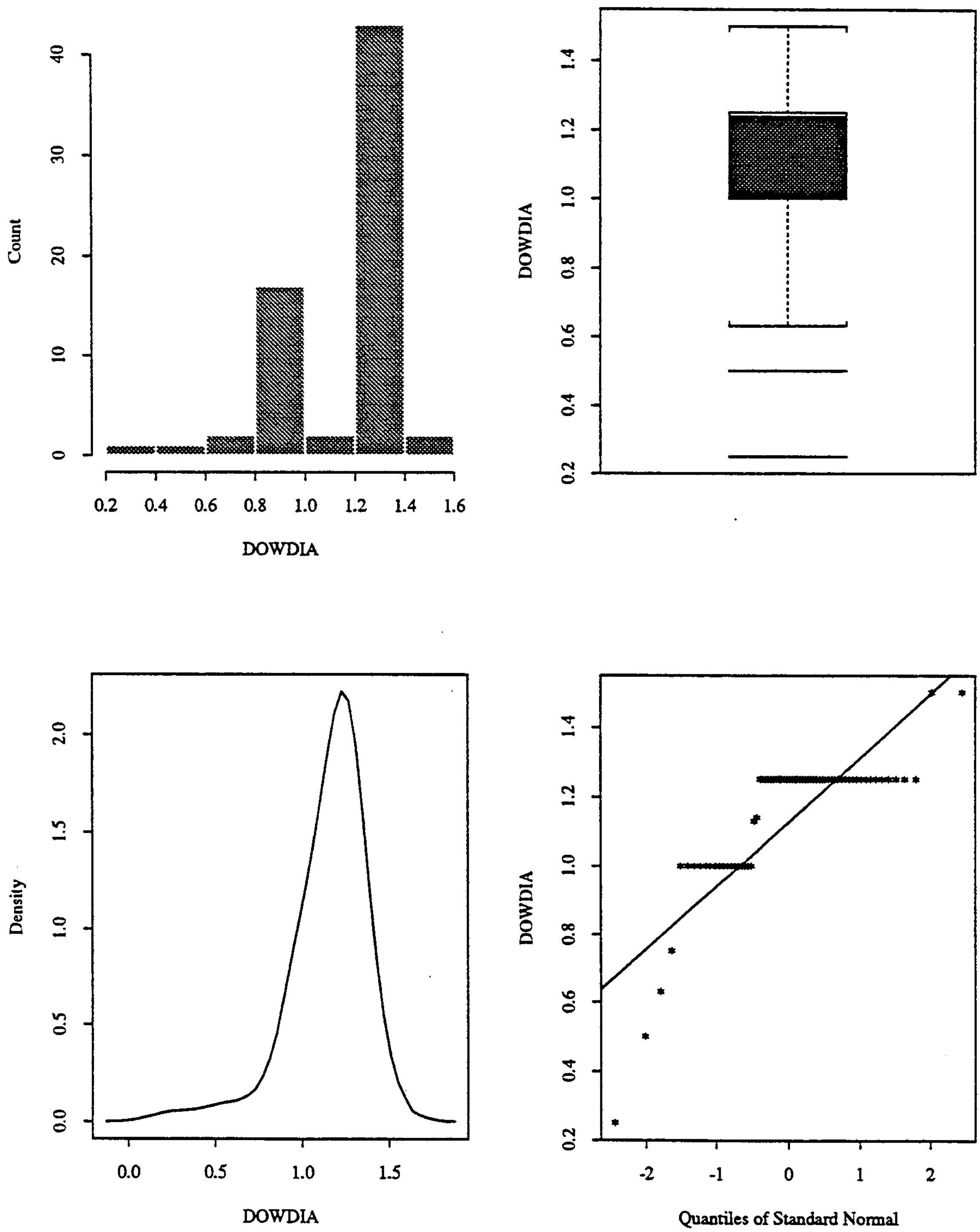


Figure 5.34 Statistical Distribution of Dowel Diameter for GPS-4 Sections

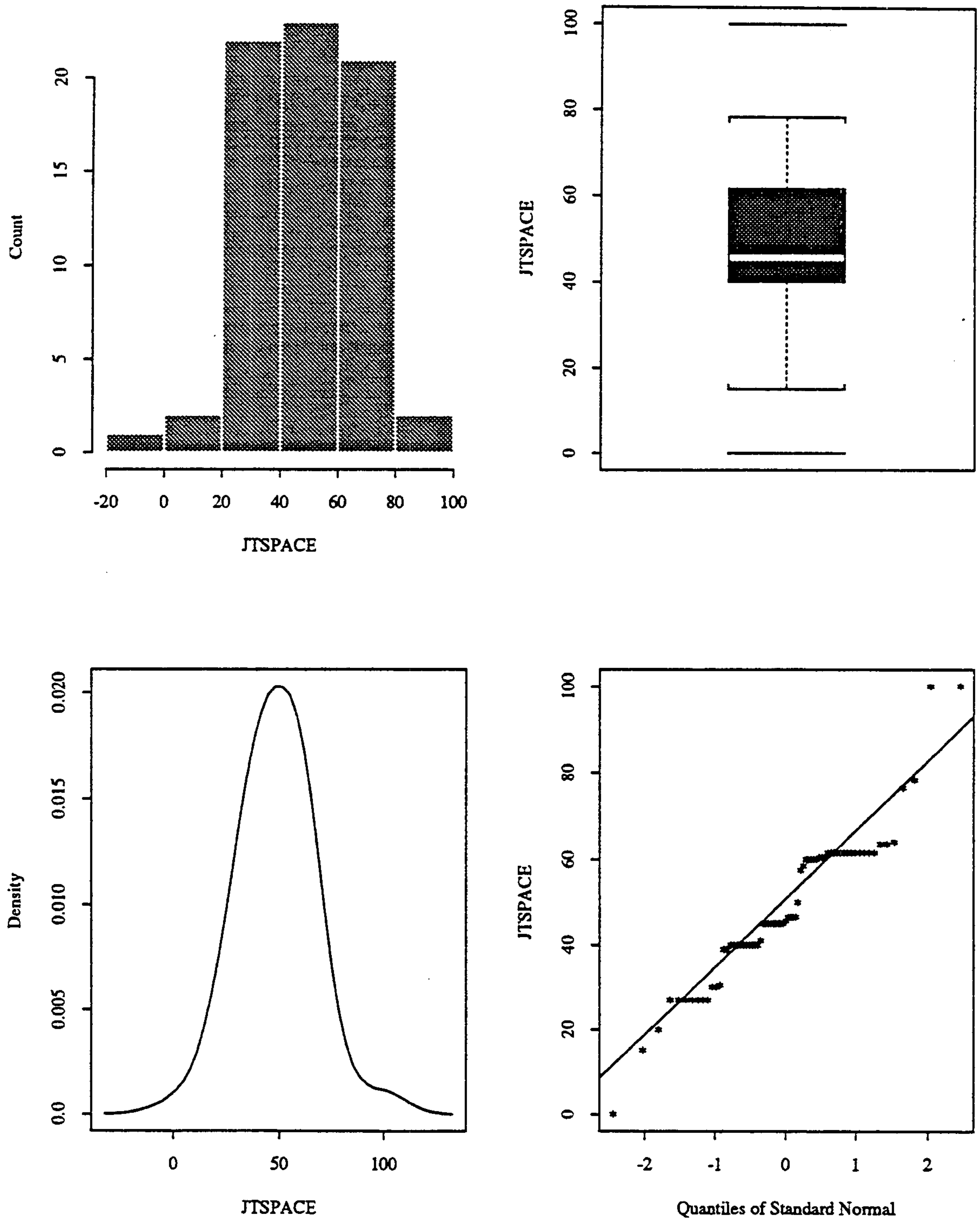


Figure 5.35 Statistical Distribution of Joint Spacing for GPS-4 Sections

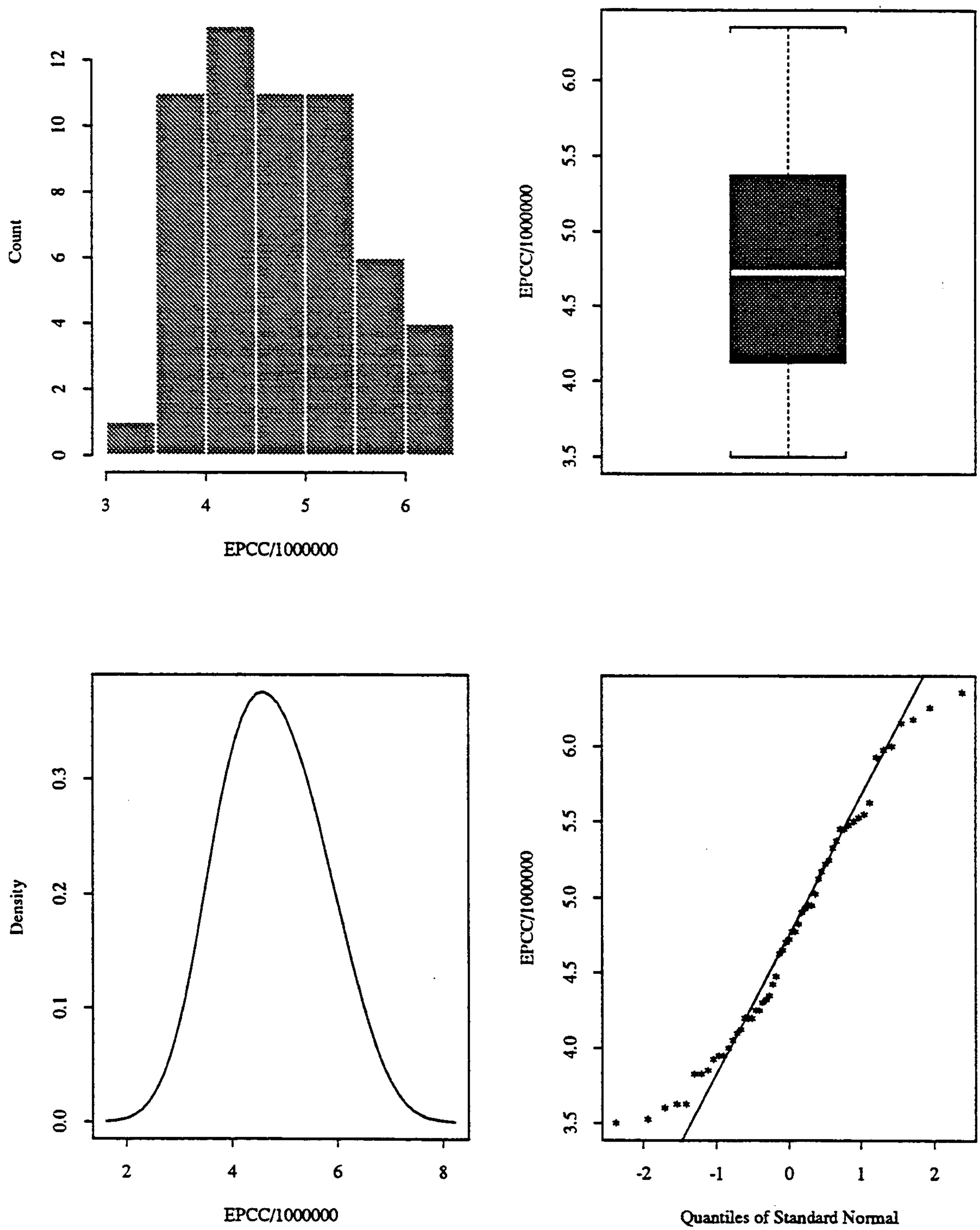


Figure 5.36 Statistical Distribution of PCC Elastic Modulus for GPS-4 Sections

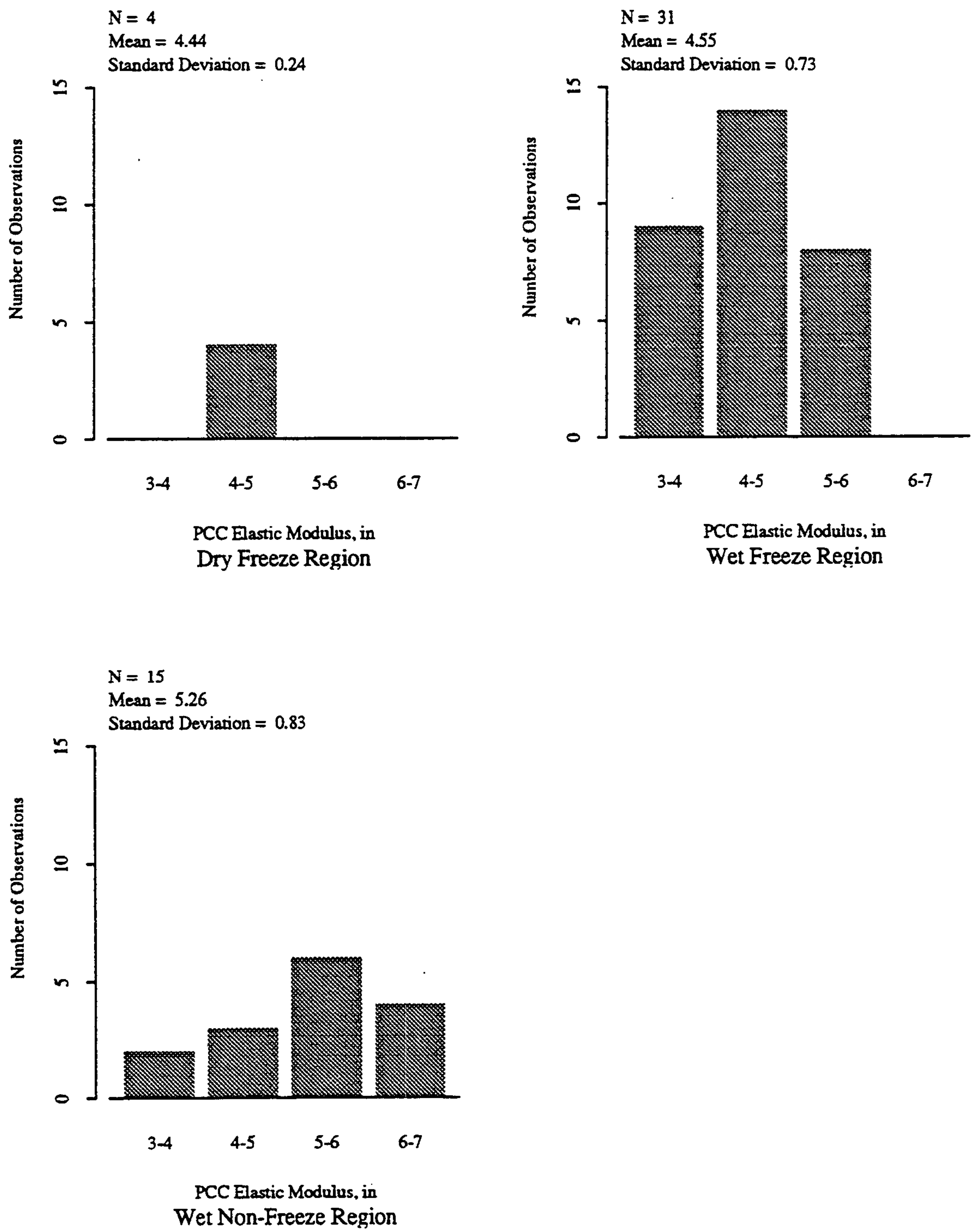


Figure 5.37 Distribution of PCC Elastic Modulus by Environmental Regions for GPS-4 Sections

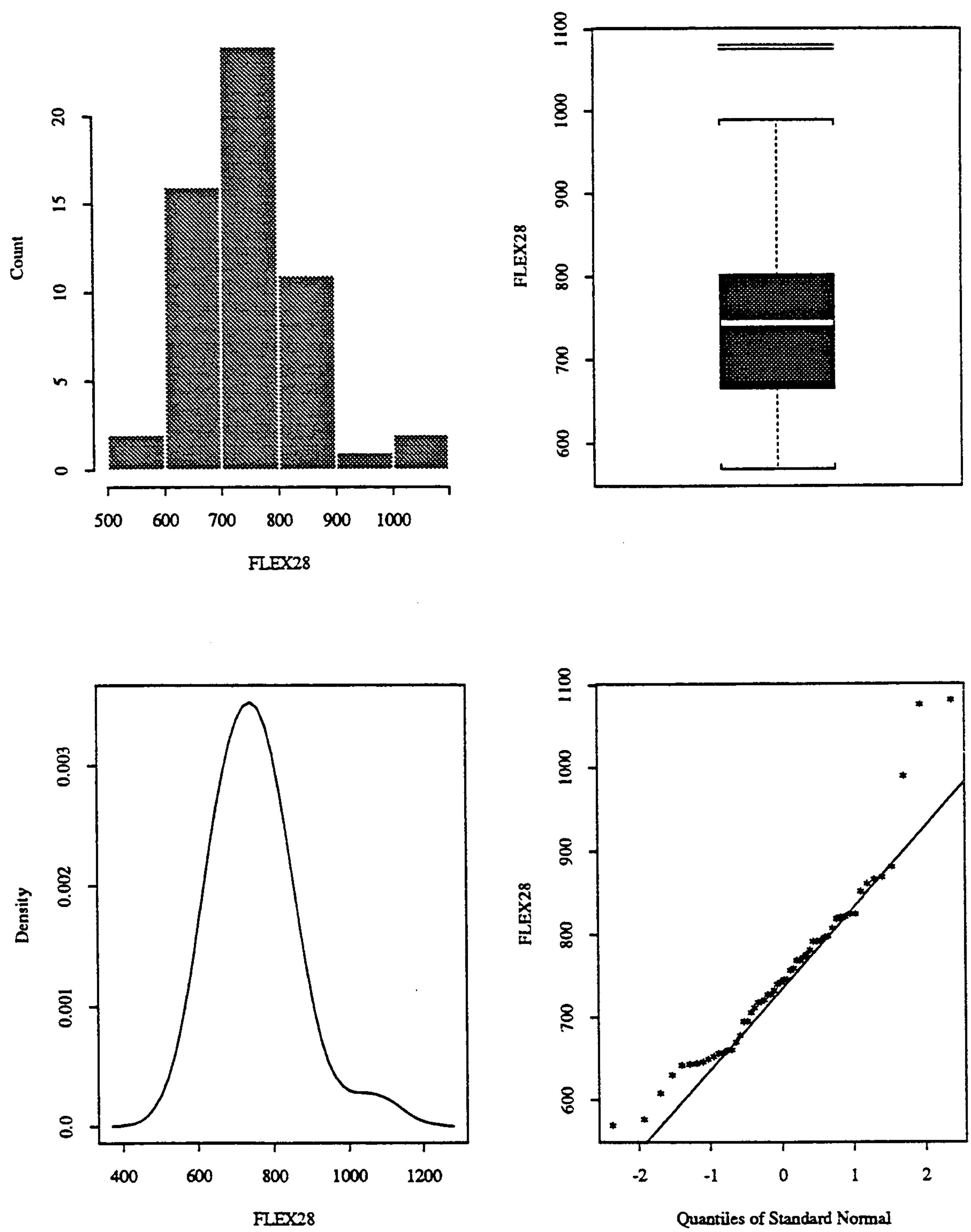


Figure 5.38 Statistical Distribution of 28-Day Flexural Strength for GPS-4 Sections, psi

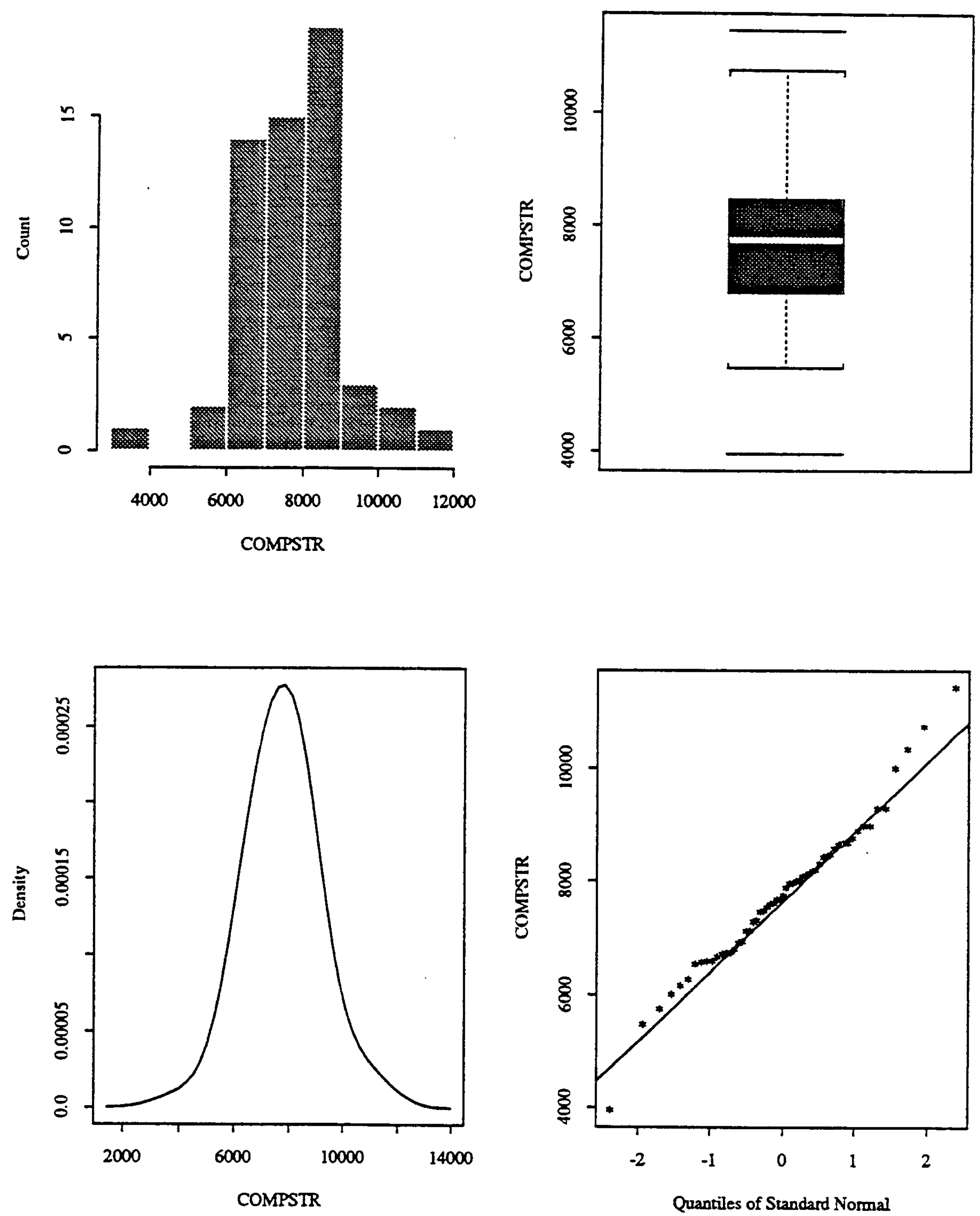


Figure 5.39 Statistical Distribution of Compressive Strength for GPS-4 Section, psi

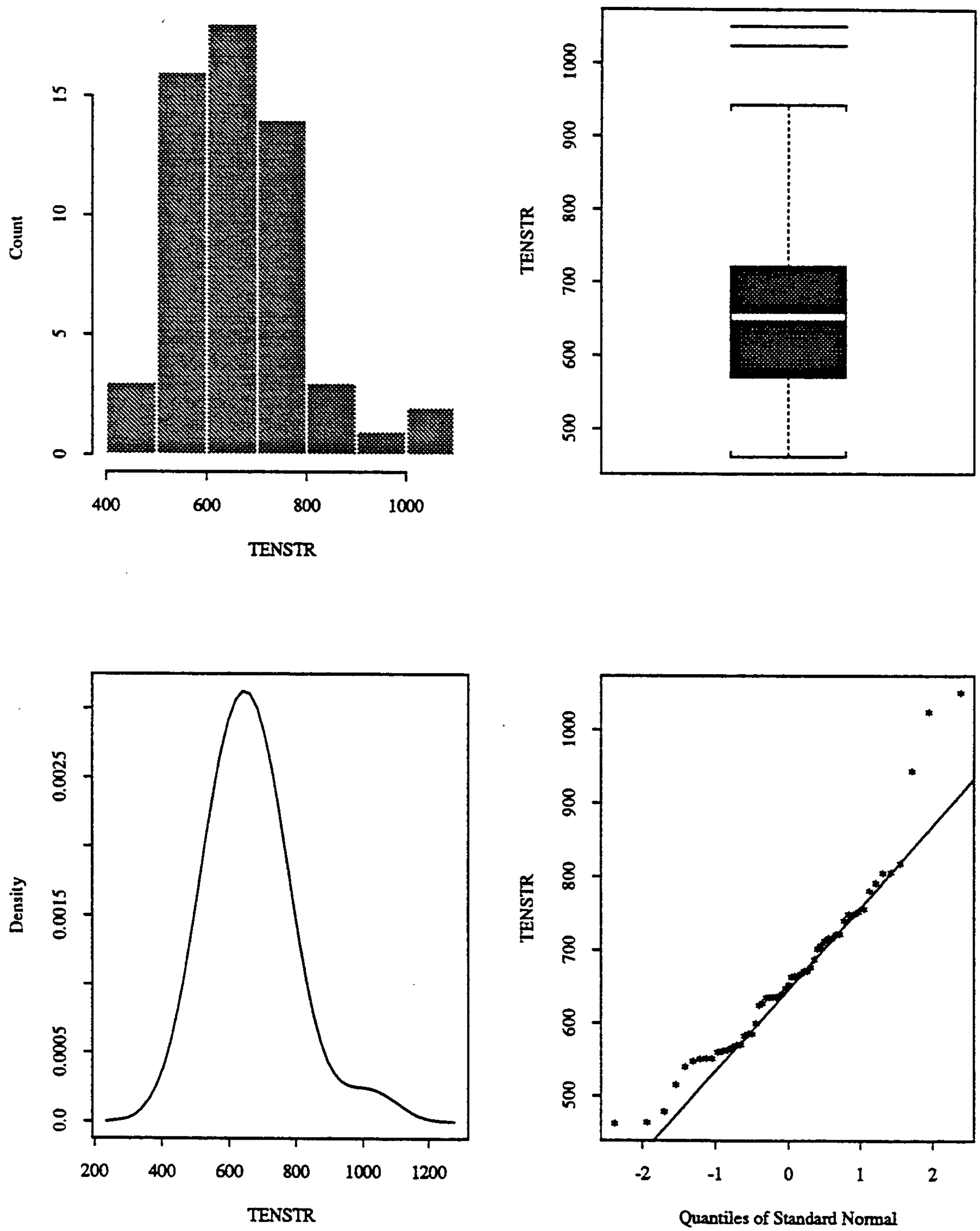


Figure 5.40 Statistical Distribution of Split Tensile Strength for GPS-4 Section, psi

6

Statistical Data for GPS-5 Test Sections

Statistical information on the 86 GPS 5 concrete pavement test sections for which data was available is provided in this chapter. The information includes statistical information on the key distress/roughness variables, and the significant variables of interest for the GPS-5 pavement sections. Specifically, they include tables that give information on the number of sections for each variable for which data was available, the mean, standard deviation, the minimum value, the median value, the maximum value, and range of the variable. A table that shows the correlations between the various significant variables, distresses, and roughness is also provided.

In addition, a number of plots are also provided that show the distribution of the various variables, distresses, and roughness. For each significant variable or distress/roughness a histogram, boxplot, probability density plot, and normal quantile-quantile plot are provided. For some of these variables or distresses/roughness, histograms that show their distribution by the four SHRP climatic regions, and scatter plots that show the relationship between the variable or distress/roughness and other selected variables or distresses/roughness, are also provided. For brevity, this latter information is not provided for all the variables or distresses/roughness.

Table 6.1 shows the number of test sections in each cell of the sampling template for the GPS-5 experiment. Environmental fractors are defined in Figure 2.2 of Chapter 2. Other factors are summarized as follows:

Traffic Rate:	L - Less than 300 KESAL/Yr. H - Greater than or equal to 300 KESAL/Yr.
Percent Reinforcing:	L - Less than or equal to 0.61% H - Greater than 0.61%
PCC Thickness:	L - Less than 8.5 inches (210 mm) H - Greater than or equal to 8.5 inches (210 mm)

Table 6.4 relates the variable names used in the correlation table and statistical plots to variable descriptions.

Table 6.1 Number of Test Sections in Each Cell of the GPS-5 Sampling Template

Moisture		Wet								Dry							
Temperature		Freeze				No Freeze				Freeze				No Freeze			
Subgrade Type		F		C		F		C		F		C		F		C	
Traffic Rate		L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
PCC Thickness	% Reinforcement	Number of CRCP Sections in the Data Set															
L	L	3	2	2	2	2	3	2	3	2	1	1		2	3	2	1
	H	2	2	2	1	2	2	2		2	1		1				
H	L	2	2	1	2	2	2		1					2	3	2	1
	H	2	2	1	1		2	2	2				1				

Table 6.2 Statistical Values for Roughness Variables in the GPS-5 Data Set.

Variable	Units	Sections With distress	Mean	Standard Deviation	Low Value	Median Value	High Value	Range
IRI: Left Wheelpath:	Inches/mile	82	97.85	27.73	46.63	96.72	159.90	113.27
Right Wheelpath:	Inches/mile	82	97.28	30.10	52.94	91.67	178.40	125.46
Average IRI:	Inches/mile	82	97.56	27.95	49.79	92.98	160.40	110.61
Slope Variance: Left Wheelpath:		82	5.04	2.59	1.70	4.43	12.76	11.06
Right Wheelpath:		82	4.77	2.80	1.44	4.44	19.62	18.18
Average Slope Variance:		82	4.90	2.37	1.73	4.34	12.07	10.34

Table 6.3 Statistical Values of Interest for Significant Variables in the GPS-5 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
PCC Thickness	Inches	69	8.74	1.19	6.25	8.30	12.78	6.53
Base Thickness	Inches	85	4.80	2.57	0.00	4.00	20.00	20.00
Subbase Thickness	Inches	85	3.92	5.09	0.00	4.00	24.00	24.00
KESALs Per Year	No.	76	492.7	588.2	0	368	3506	3506
Pavement Age	Years	80	14.3	6.6	0.6	15.8	28.1	27.5
Air Freeze-Thaw Cycles	No.	86	70.6	29.3	8	75	155	147
Freezing Index	Degree Days	86	433.0	519.4	0	198	2339	2339
No. of Days Temp. > 90°F	No.	86	42.9	32.9	4	32	182	178
No. of Days Temp. < 32°F	No.	86	84.3	45.2	6	81	181	175
Average Min. Temp. by Month	°F	86	21.54	10.49	-3.81	22.62	41.03	44.84
Average Max. Temp. by Month	°F	86	90.11	4.81	81.15	89.54	107.20	26.05
Average Monthly Precipitation	Inches	86	3.15	1.07	0.58	3.19	5.53	4.95
Average Yearly Precipitation	Inches	86	37.78	12.89	7.0	38.4	66.4	59.4
Wet Days in Year	No.	86	118.6	29.0	42	120	171	129
Backcalculated Static k-value	pci	69	172.1	113.1	70.38	145.10	838.40	768.02
PCC Elastic Modulus	x 10^6 psi	69	4.58	0.87	2.70	4.55	6.72	4.02
PCC 28-day Flexural Strength	psi	67	767.6	92.5	589	762	1005	416

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Table 6.3. Statistical Values of Interest for Significant Variables in the GPS-5 Data Set

Variable	Units	No. of Values	Mean Value	Standard Deviation	Low Value	Median Value	High Value	Range
PCC Compressive Strength	psi	68	7621	1261	4860	7615	11310	6450
PCC Indirect Tensile Strength	psi	70	680.8	97.9	489	672	926	437
Steel Yield Strength	ksi	70	60.49	5.66	40.0	60.0	76.9	36.9
Depth to Steel	Inches	80	3.77	0.72	2.3	3.8	5.5	3.2

Table 6.4 Nomenclature Used for Correlation Table and Statistical Plots

Variable	Description of Variable
AVE.IRI or IRI	Measured average IRI value, inches/mile
AVE.SV or SLPVAR	Measured average slope variance
THICK	Measured PCC layer thickness, inches
BASETHK	Measured base thickness, inches
SBASETHK	Measured subbase thickness, inches
YRL.KESAL or YRKESAL	Cumulative 18-kip ESALs per year, thousands
AGE	Pavement age, years
FT	Average number of air freeze-thaw cycles
FI	Freezing index, degree days
DAYS90	Number of days with temperature greater than 90°F
DAYS32	Number of days with temperature lower than 32°F
MAXTEMP	Average monthly maximum temperature, °F
MINTEMP	Average monthly minimum temperature, °F
YRL.PRECIP or YRPRECIP	Average precipitation by year, inches
PRECIP	Average precipitation by month, inches
DAYSWET	Average number of wet days
KSTATIC	Backcalculated modulus of subgrade reaction, psi/inch
EPCC	Measured PCC layer elastic modulus, psi
FLEX28	PCC layer 28-day flexural strength, psi
COMPSTR	PCC layer compressive strength, psi
TENSTR	PCC layer indirect (split) tensile strength, psi
YLDSTR	Steel yield strength, psi
STLDEPTH	Depth to steel reinforcement, inches

Table 6.5 Correlation Matrix for Significant Variables in the GPS-5 Data Set

	IRI	SLPVAR	THICK	BASETHK	SBASETHK	YRKESAL	FT	FI	DAYS90	DAYS32	MAXTEMP	MINTEMP	PRECIP
IRI	1.000	0.725	0.111	-0.219	0.186	-0.156	-0.188	-0.057	0.402	-0.131	0.359	0.122	-0.035
SLPVAR	0.725	1.000	0.239	-0.064	0.432	-0.073	-0.057	-0.054	0.331	-0.050	0.296	0.031	-0.152
THICK	0.111	0.239	1.000	0.375	-0.014	0.499	-0.199	-0.179	-0.061	-0.227	-0.178	0.194	0.084
BASETHK	-0.219	-0.064	0.375	1.000	-0.216	0.630	0.025	-0.117	-0.407	-0.054	-0.485	0.084	0.214
SBASETHK	0.186	0.432	-0.014	-0.216	1.000	-0.184	-0.313	-0.158	0.484	-0.268	0.465	0.226	-0.117
YRKESAL	-0.156	-0.073	0.499	0.630	-0.184	1.000	-0.016	-0.172	-0.357	-0.111	-0.455	0.153	0.078
FT	-0.188	-0.057	-0.199	0.025	-0.313	-0.016	1.000	0.675	-0.628	0.950	-0.514	-0.875	-0.497
FI	-0.057	-0.054	-0.179	-0.117	-0.158	-0.172	0.675	1.000	-0.566	0.866	-0.516	-0.920	-0.357
DAYS90	0.402	0.331	-0.061	-0.407	0.484	-0.357	-0.628	-0.566	1.000	-0.645	0.966	0.608	-0.034
DAYS32	-0.131	-0.050	-0.227	-0.054	-0.268	-0.111	0.950	0.866	-0.645	1.000	-0.544	-0.972	-0.477
MAXTEMP	0.359	0.296	-0.178	-0.485	0.465	-0.455	-0.514	-0.516	0.966	-0.544	1.000	0.514	-0.086
MINTEMP	0.122	0.031	0.194	0.084	0.226	0.153	-0.875	-0.920	0.608	-0.972	0.514	1.000	0.447
PRECIP	-0.035	-0.152	0.084	0.214	-0.117	0.078	-0.497	-0.357	-0.034	-0.477	-0.086	0.447	1.000
YRPRECIP	-0.036	-0.152	0.084	0.213	-0.117	0.078	-0.497	-0.357	-0.033	-0.478	-0.085	0.448	1.000
DAYSWET	-0.105	-0.183	0.269	0.482	-0.300	0.483	-0.133	-0.067	-0.497	-0.129	-0.560	0.131	0.651
KSTATIC	0.003	-0.072	-0.163	-0.045	0.133	-0.061	-0.162	-0.160	0.355	-0.176	0.336	0.145	-0.085
EPCC	0.289	0.253	0.009	-0.173	0.403	-0.040	-0.229	-0.031	0.307	-0.160	0.252	0.165	0.106
COMPSTR	0.057	0.156	0.092	0.080	0.112	0.090	-0.035	0.105	-0.041	0.009	-0.083	0.007	0.152
YLDSTR	0.114	0.041	-0.060	-0.106	-0.076	-0.220	0.247	0.352	-0.154	0.310	-0.078	-0.365	-0.276
STLDEPTH	0.333	0.274	0.534	-0.119	0.248	0.091	-0.436	-0.462	0.381	-0.468	0.303	0.456	0.084

Table 6.5 Correlation Matrix for Significant Variables in the GPS-5 Data Set

	YRPRECIP	DAYSWET	KSTATIC	EPCC	COMPSTR	YLDSTR	STLDEPTH
IRI	-0.036	-0.105	0.003	0.289	0.057	0.114	0.333
SLPVAR	-0.152	-0.183	-0.072	0.253	0.156	0.041	0.274
THICK	0.084	0.269	-0.163	0.009	0.092	-0.060	0.534
BASETHK	0.213	0.482	-0.045	-0.173	0.080	-0.106	-0.119
SBASETHK	-0.117	-0.300	0.133	0.403	0.112	-0.076	0.248
YRKESAL	0.078	0.483	-0.061	-0.040	0.090	-0.220	0.091
FT	-0.497	-0.133	-0.162	-0.229	-0.035	0.247	-0.436
FI	-0.357	-0.067	-0.160	-0.031	0.105	0.352	-0.462
DAYS90	-0.033	-0.497	0.355	0.307	-0.041	-0.154	0.381
DAYS32	-0.478	-0.129	-0.176	-0.160	0.009	0.310	-0.468
MAXTEMP	-0.085	-0.560	0.336	0.252	-0.083	-0.078	0.303
MINTEMP	0.448	0.131	0.145	0.165	0.007	-0.365	0.456
PRECIP	1.000	0.651	-0.085	0.106	0.152	-0.276	0.084
YRPRECIP	1.000	0.651	-0.084	0.106	0.152	-0.275	0.085
DAYSWET	0.651	1.000	-0.227	-0.065	0.063	-0.181	-0.007
KSTATIC	-0.084	-0.227	1.000	-0.058	-0.214	0.029	0.016
EPCC	0.106	-0.065	-0.058	1.000	0.549	-0.251	0.168
COMPSTR	0.152	0.063	-0.214	0.549	1.000	-0.108	-0.048
YLDSTR	-0.275	-0.181	0.029	-0.251	-0.108	1.000	-0.152
STLDEPTH	0.085	-0.007	0.016	0.168	-0.048	-0.152	1.000

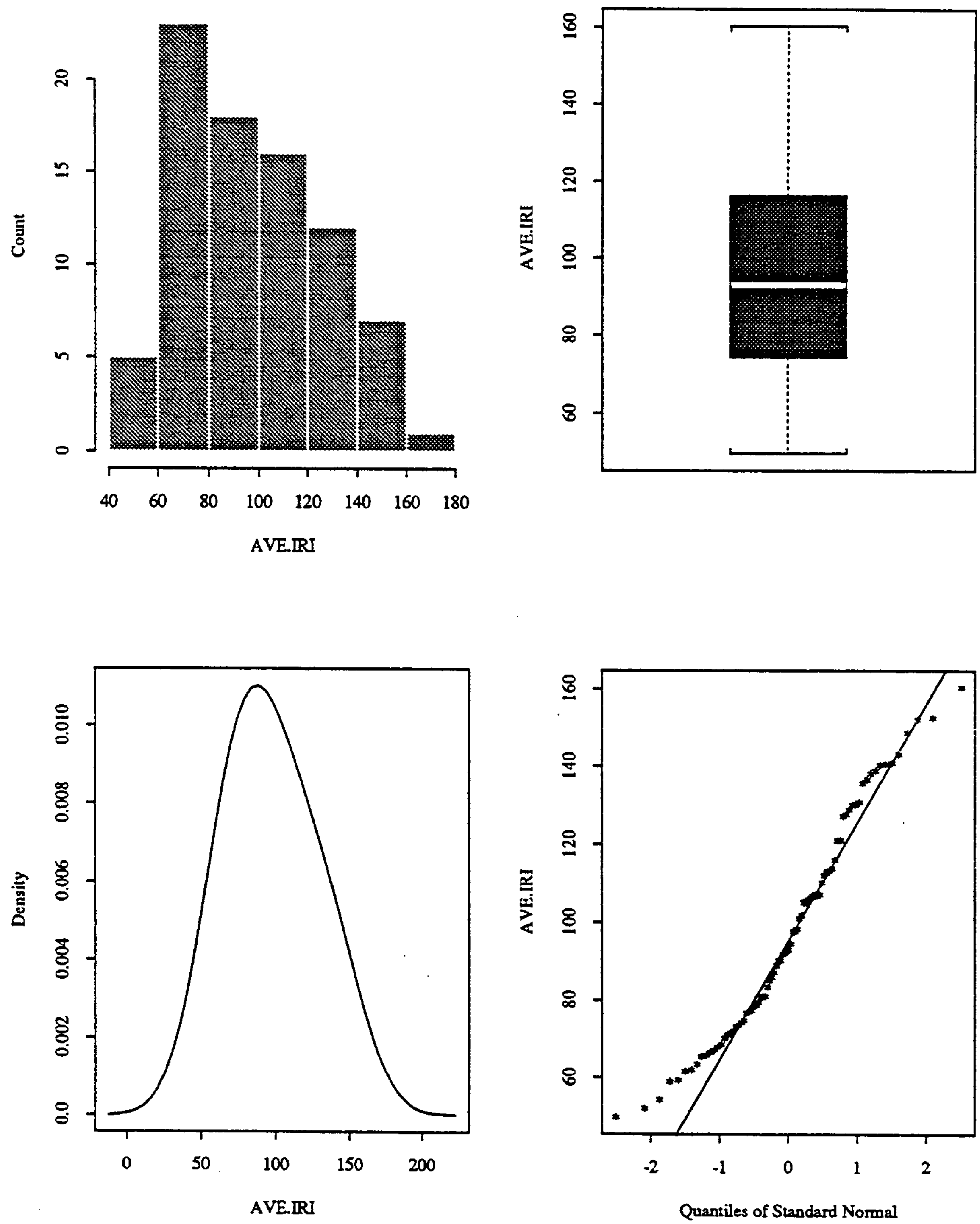

Figure 6.1 Statistical Distribution of Average IRI for GPS-5 Sections, In./Mile

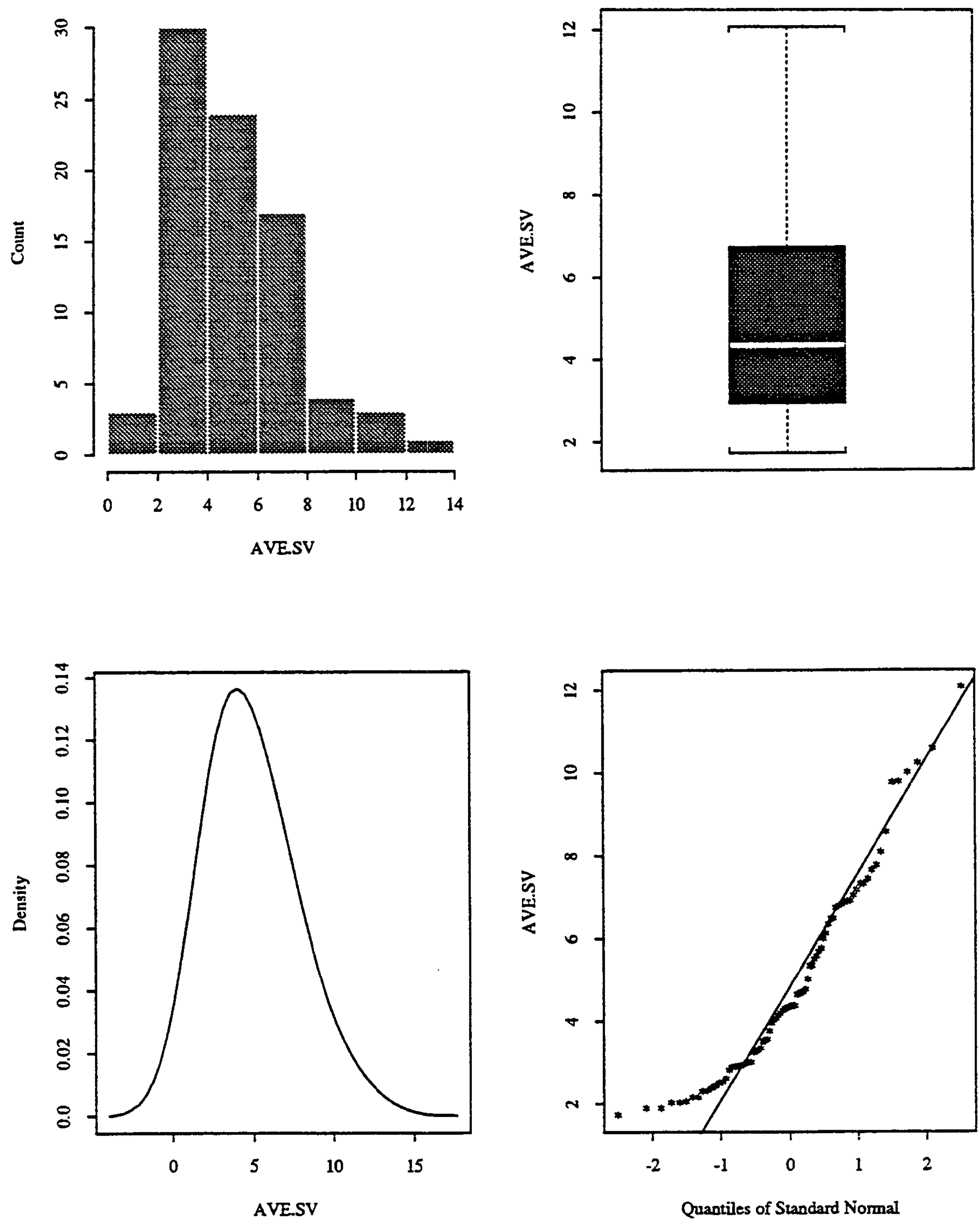

Figure 6.2 Statistical Distribution of Average Slope Variance for GPS-5 Sections

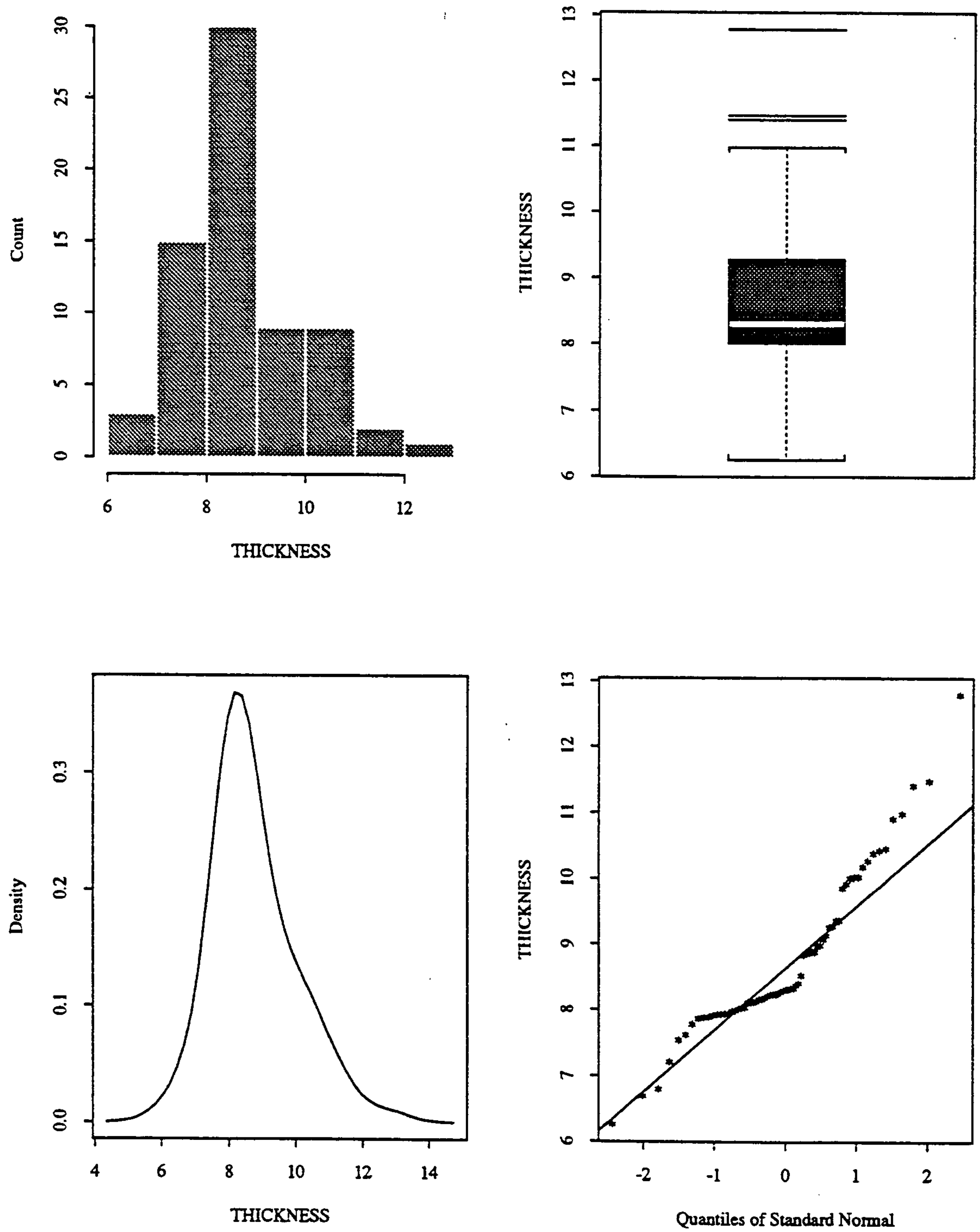

Figure 6.3 Statistical Distribution of PCC Thickness for GPS-5 Sections, In.

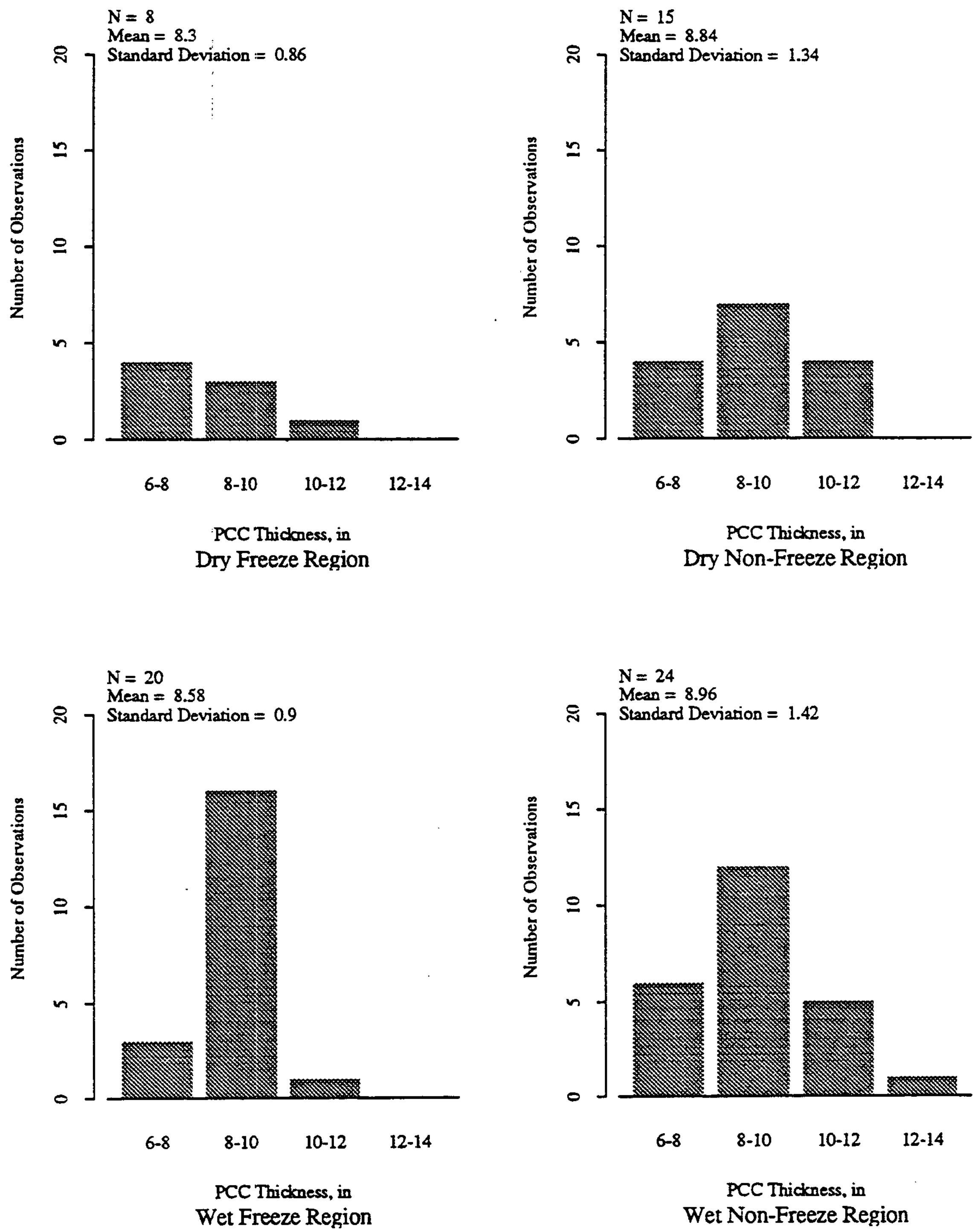

Figure 6.4 Distribution of PCC Thickness by Environmental Regions for GPS-5 Sections

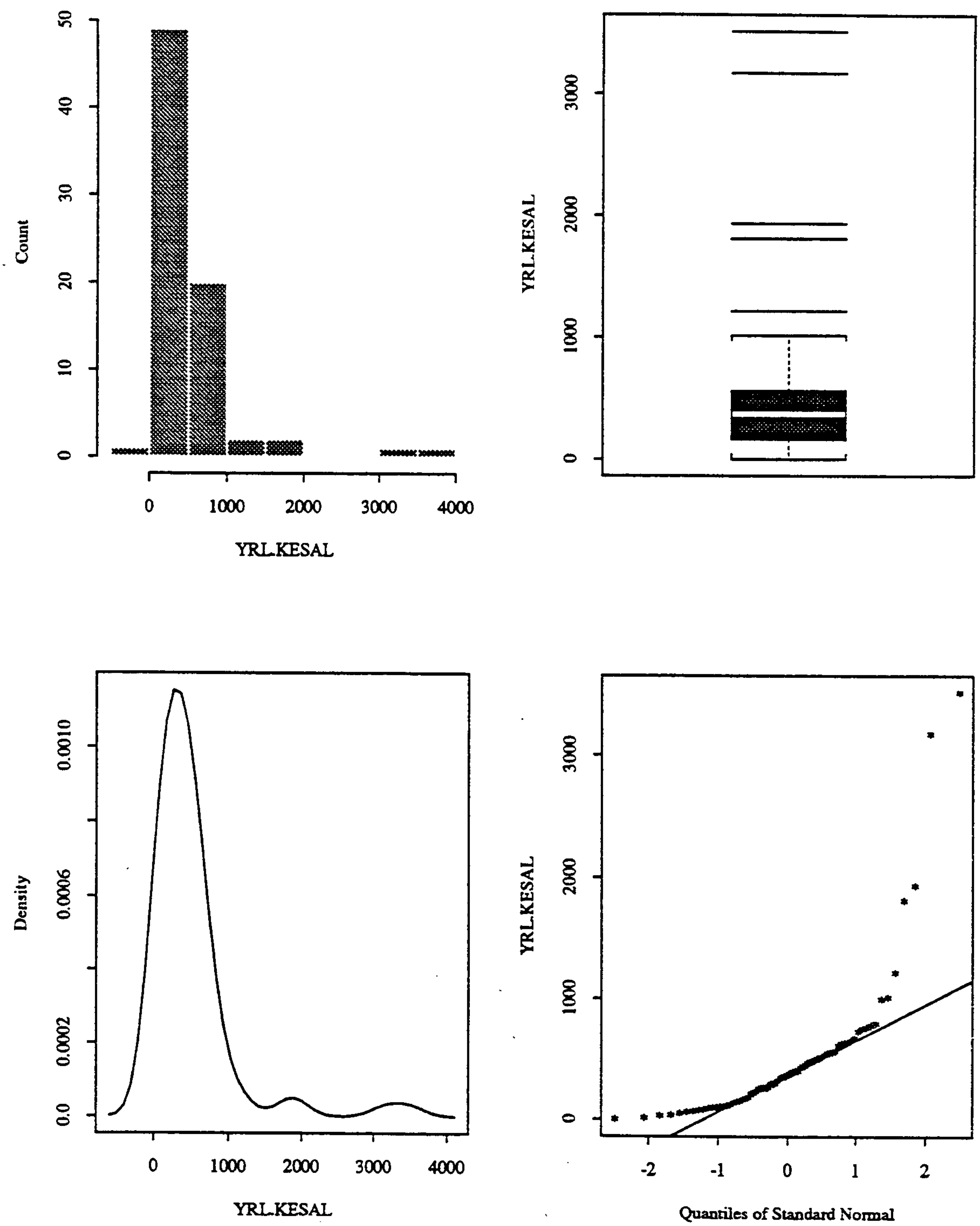

Figure 6.5 Statistical Distribution of KESALs/Year for GPS-5 Sections

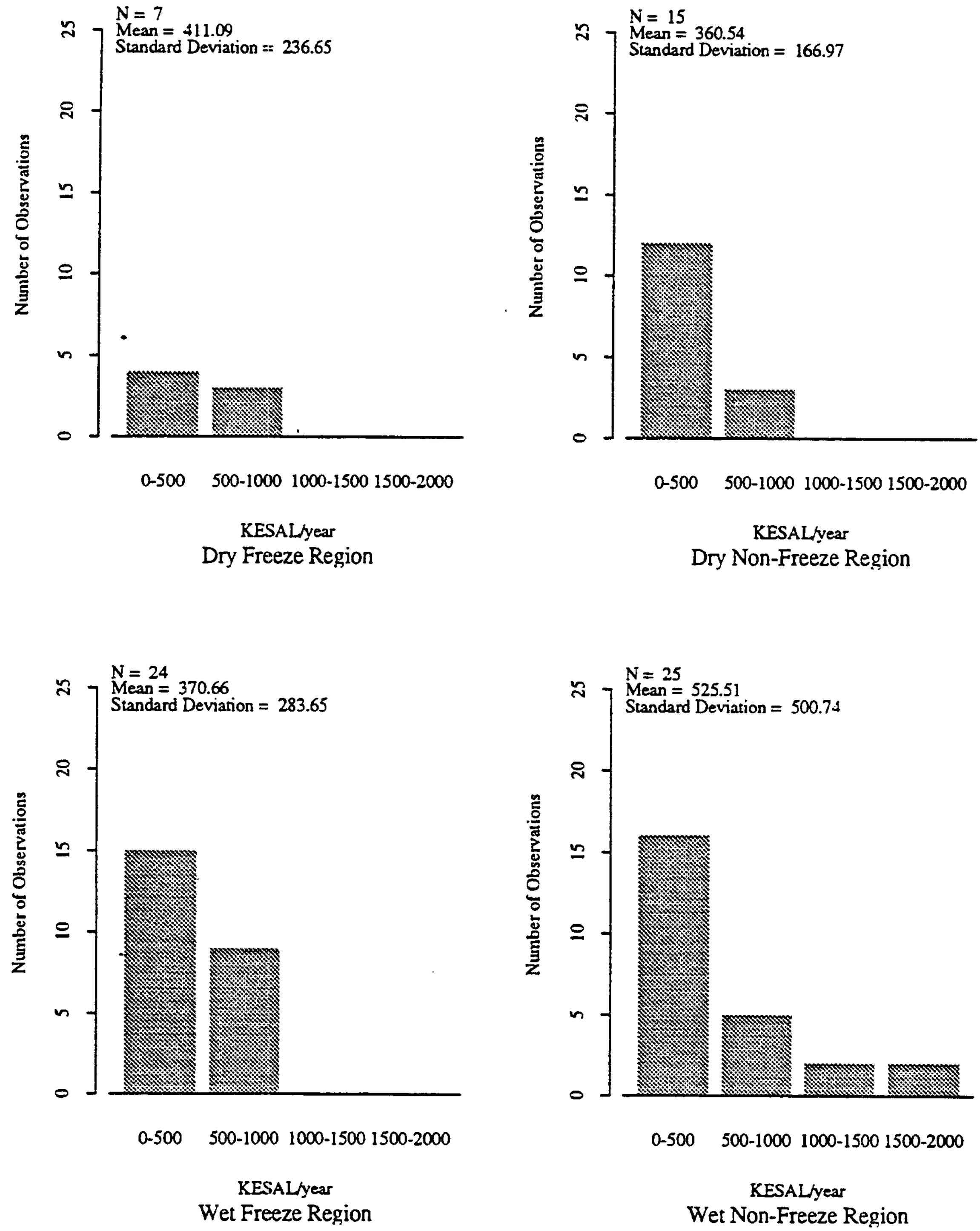

Figure 6.6 Distribution of KESALs/Year by Environmental Regions for GPS-5 Sections

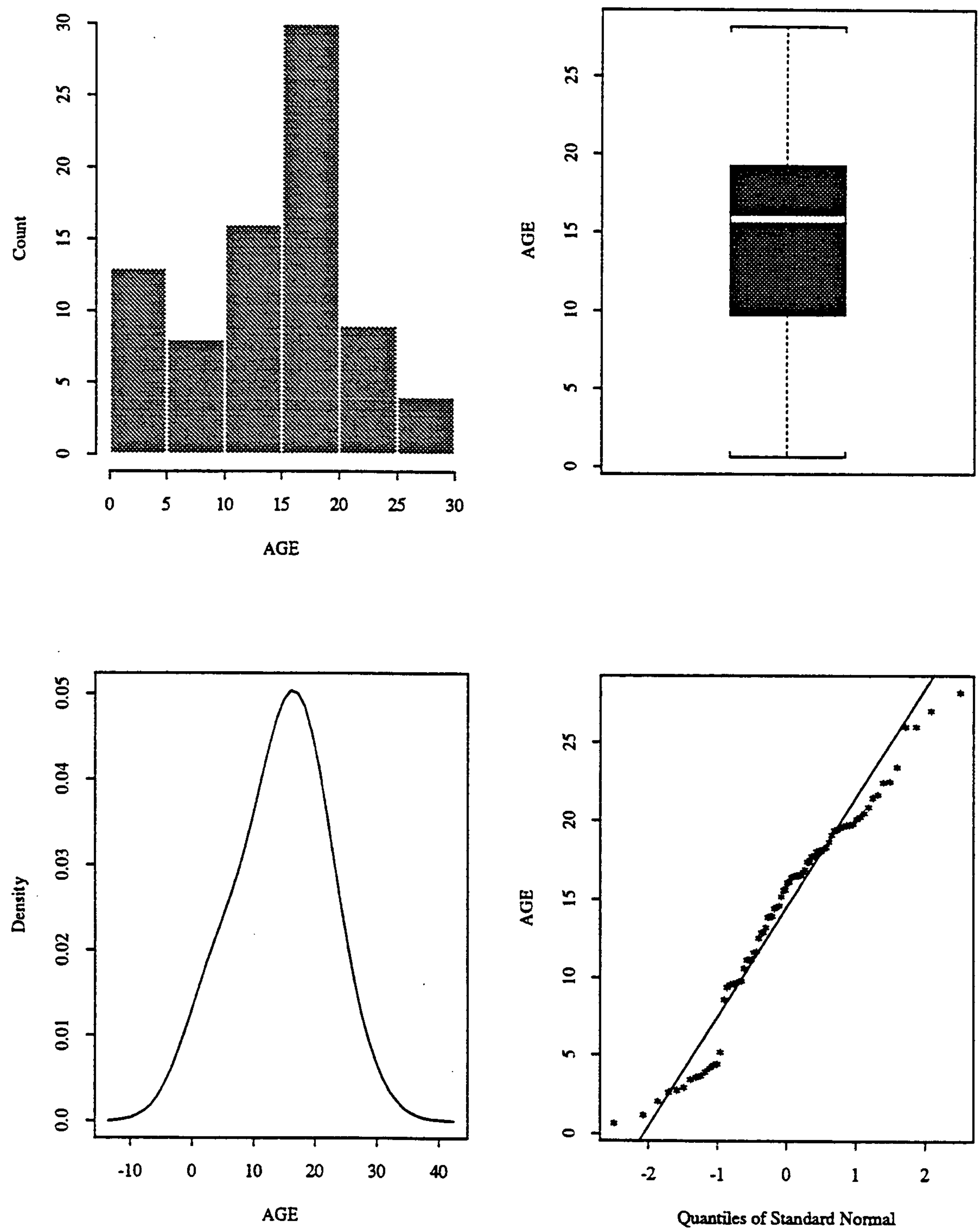

Figure 6.7 Statistical Distribution of Pavement Age for GPS-5 Sections, Years

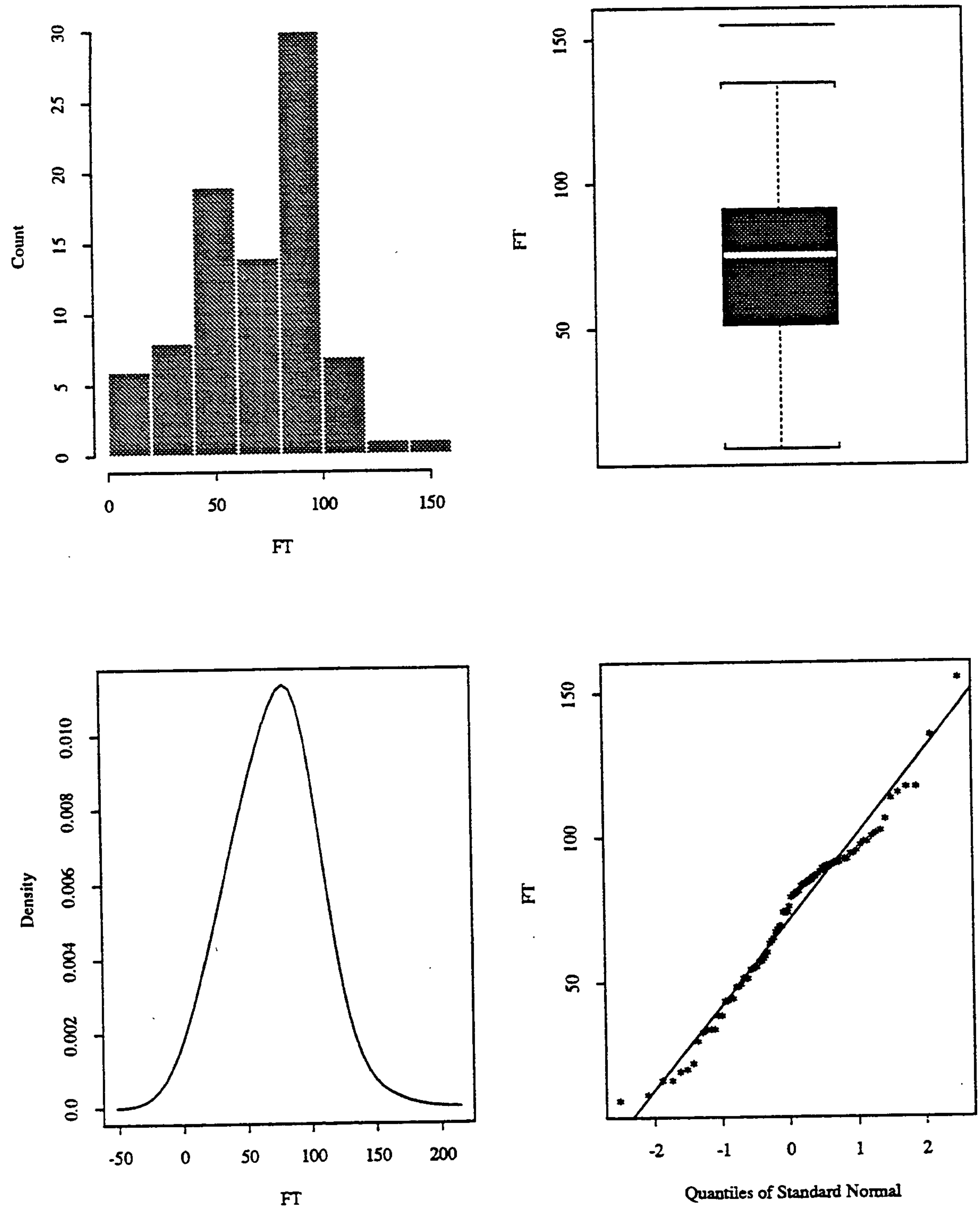

Figure 6.8 Statistical Distribution of Freeze-Thaw Cycles for GPS-5 Sections

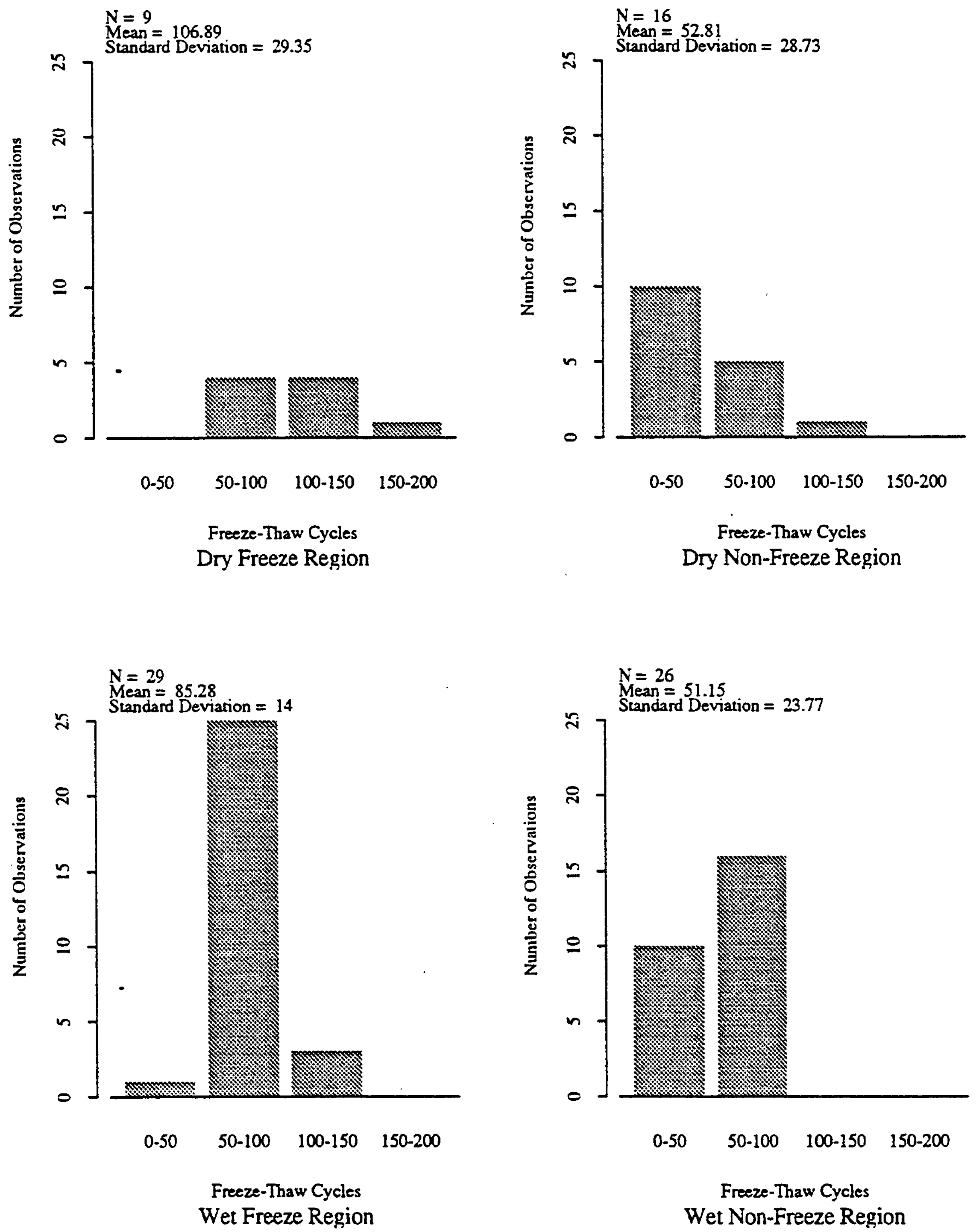

Figure 6.9 Distribution of Freeze-Thaw Cycles by Environmental Regions for GPS-5 Sections

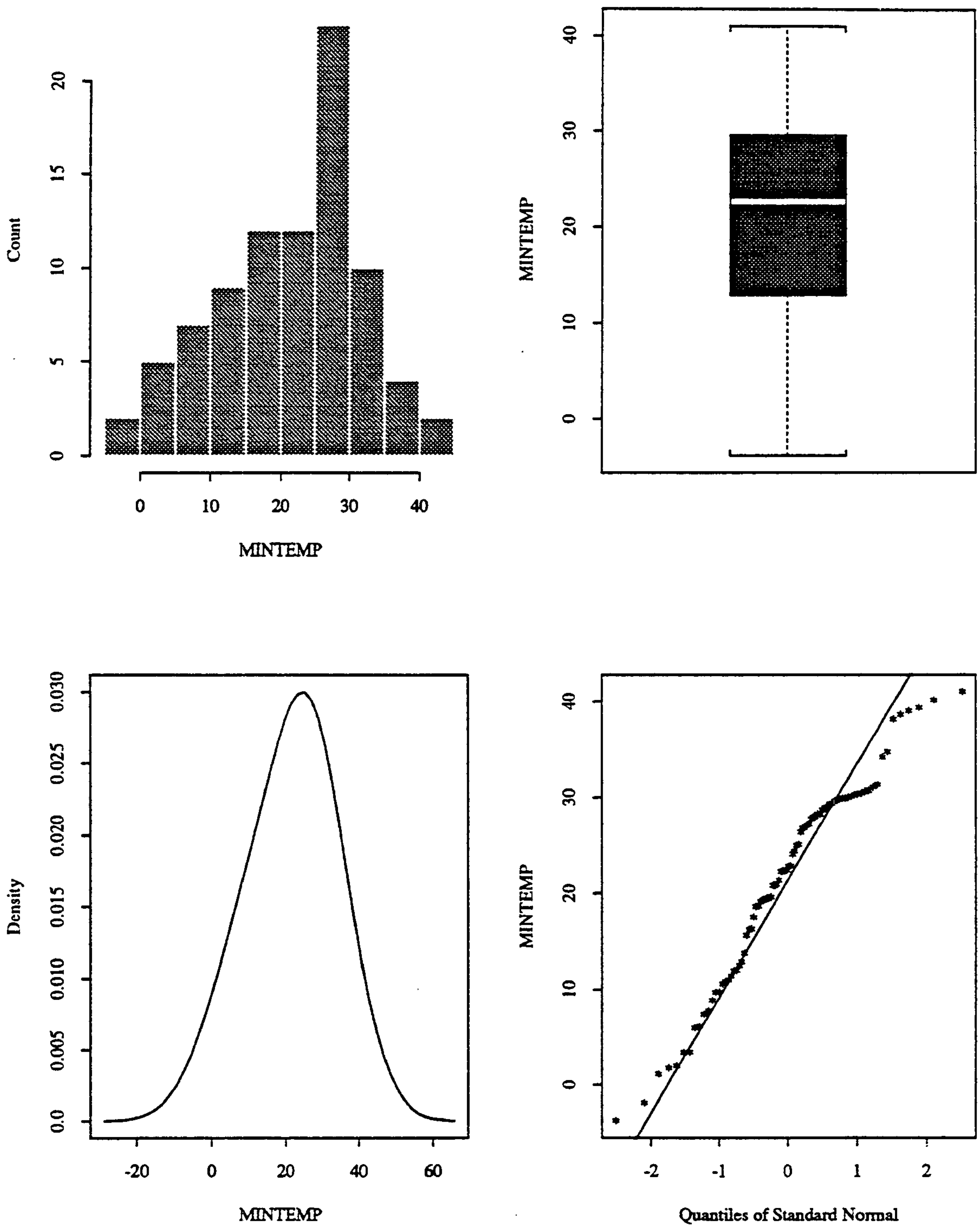

Figure 6.10 Statistical Distribution of Average Monthly Minimum Temperature for GPS-5 Sections, °F

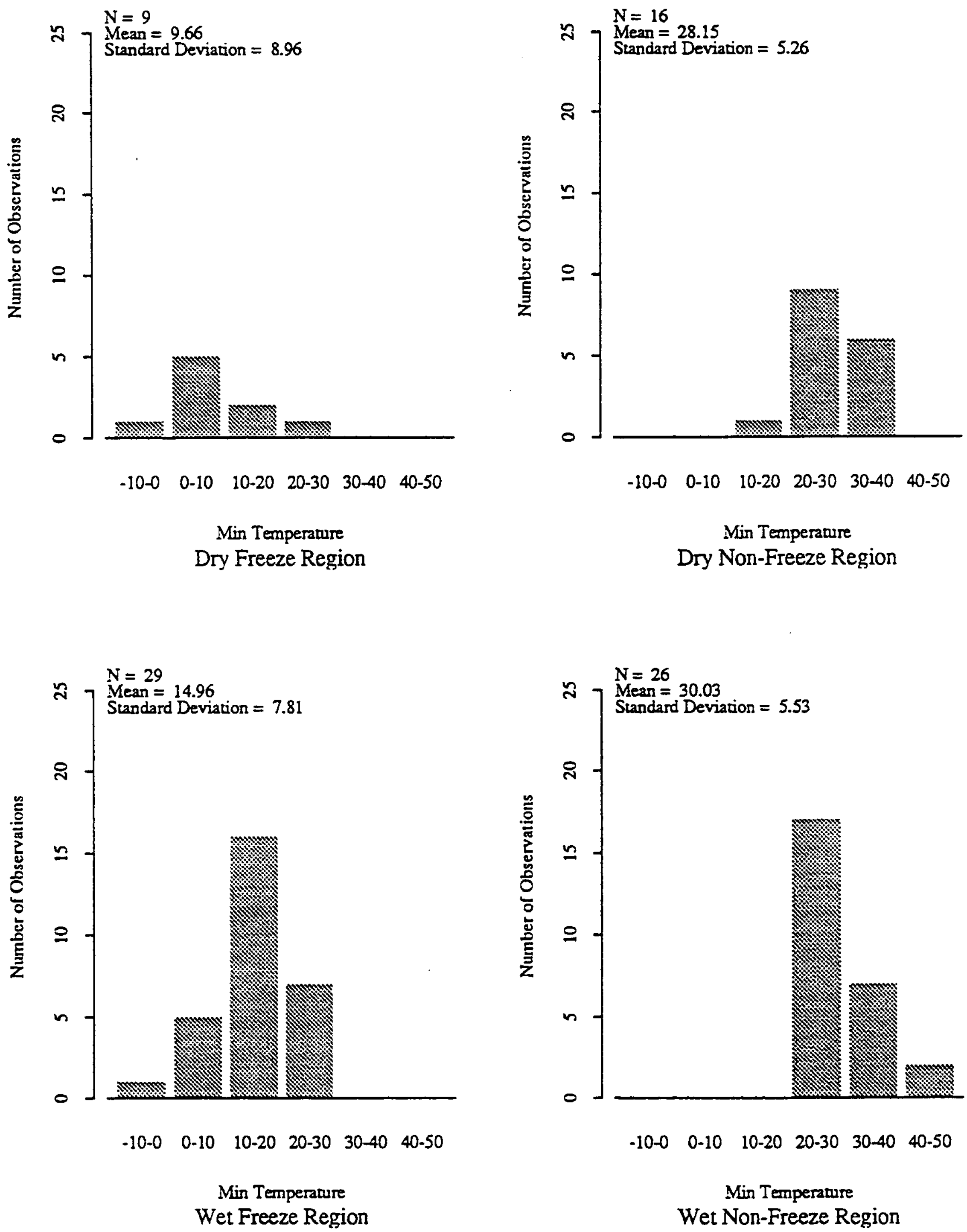

Figure 6.11 Distribution of Minimum Temperature by Environmental Regions for GPS-5 Sections, •F

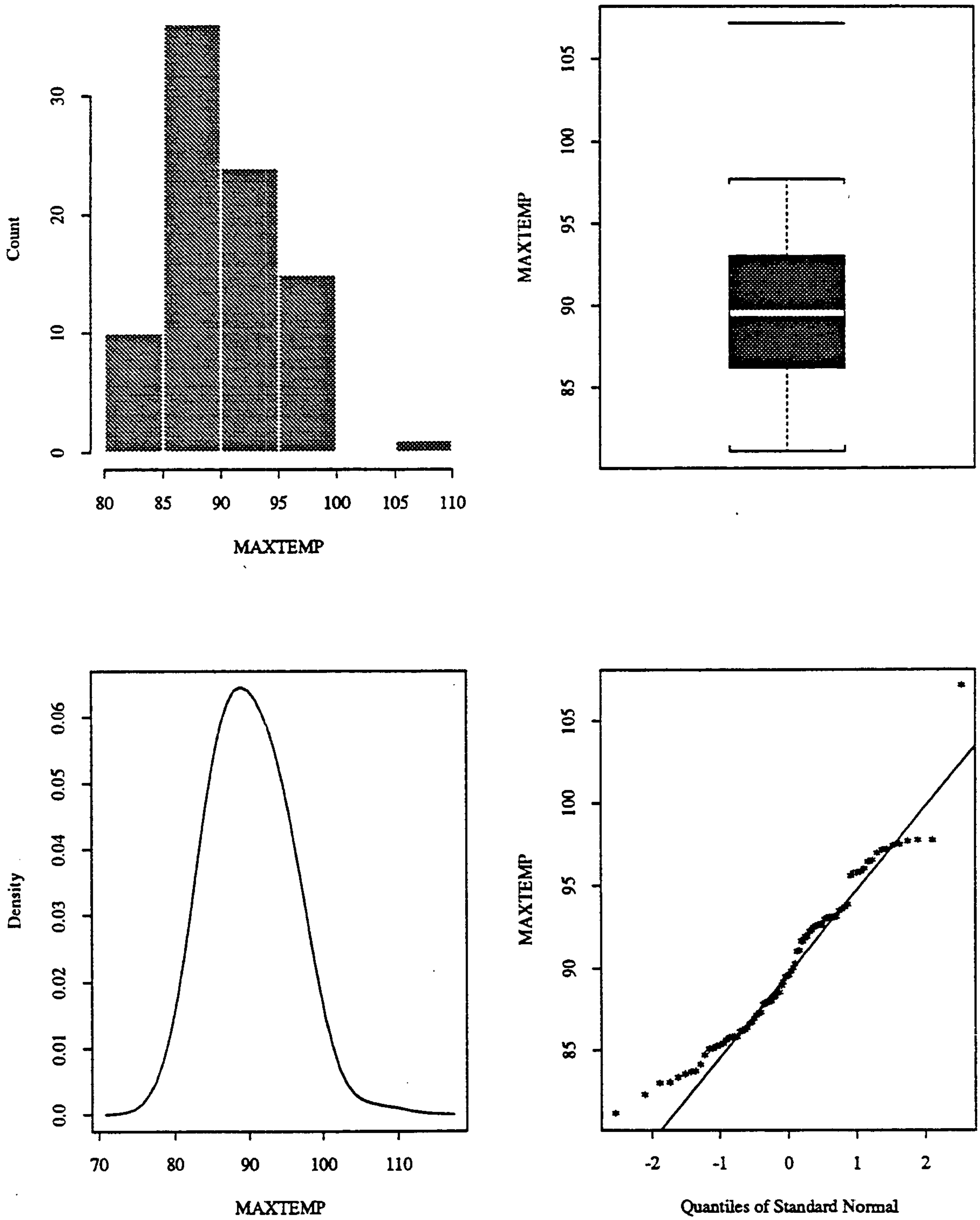

Figure 6.12 Statistical Distribution of Average Monthly Maximum Temperature for GPS-5 Sections, °F

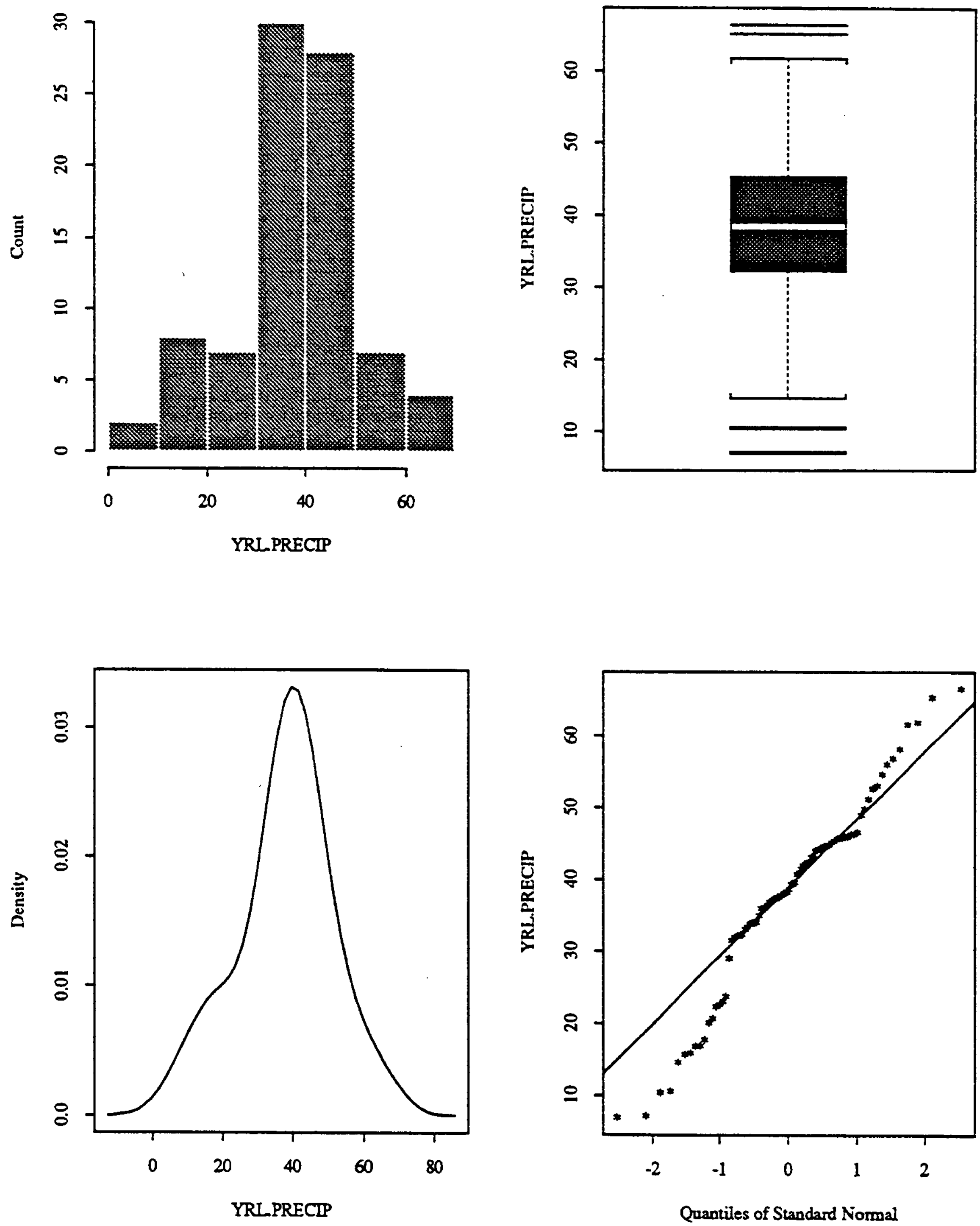

Figure 6.13 Statistical Distribution of Average Yearly Precipitation for GPS-5 Sections, Inches

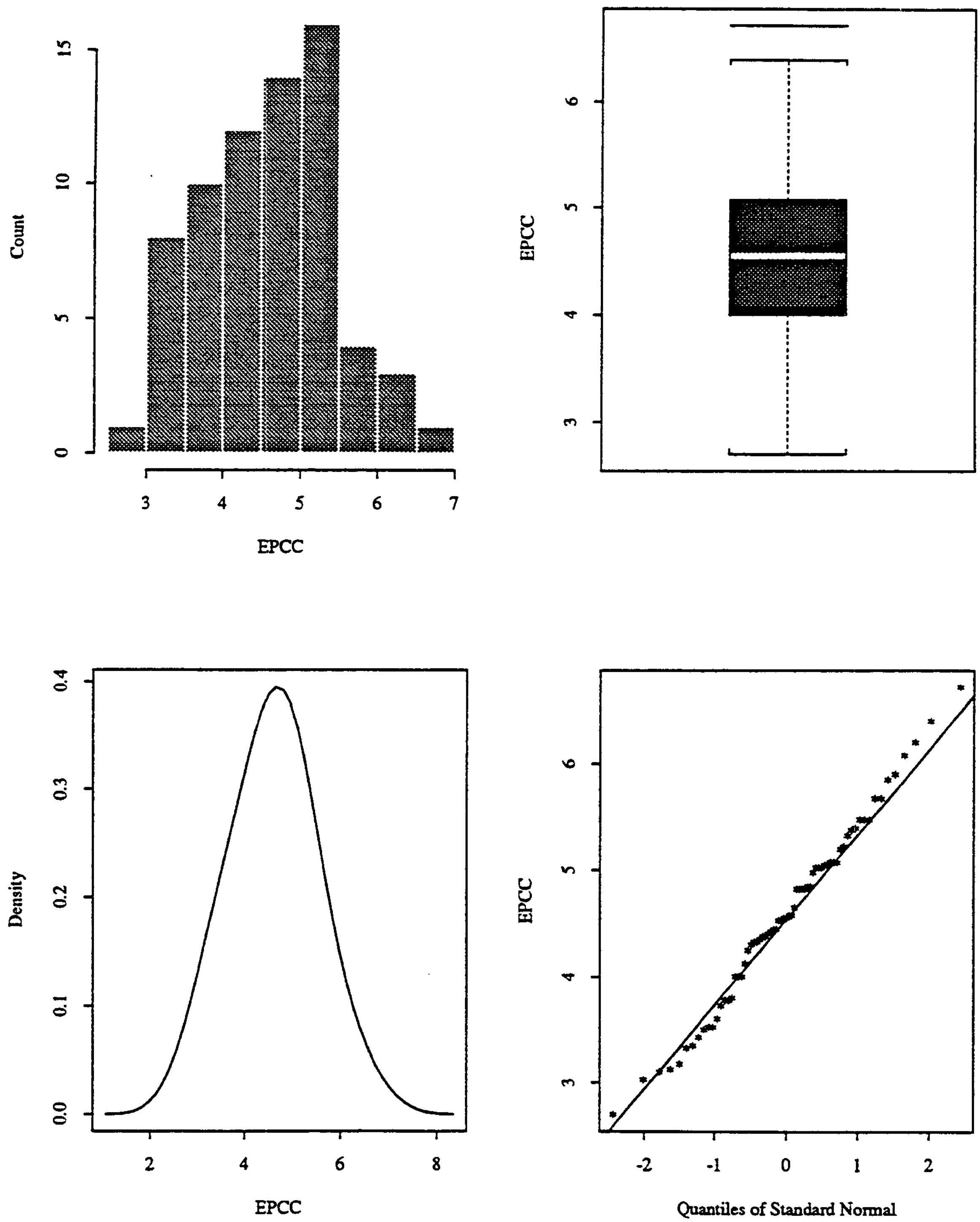

Figure 6.14 Statistical Distribution of PCC Elastic Modulus for GPS-5 Sections, Million, psi

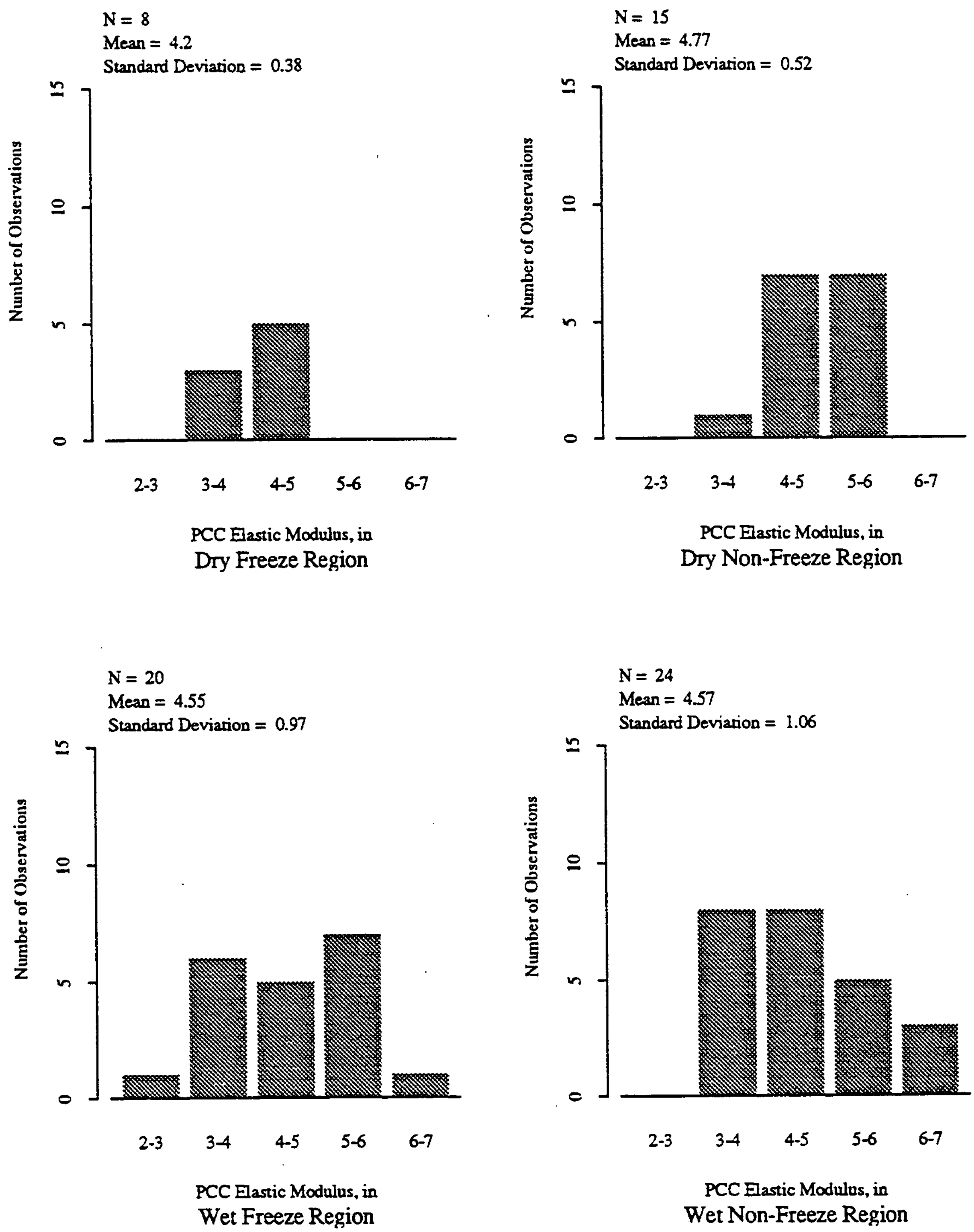

Figure 6.15 Distribution of PCC Elastic Modulus by Environmental Regions for GPS-5 Sections

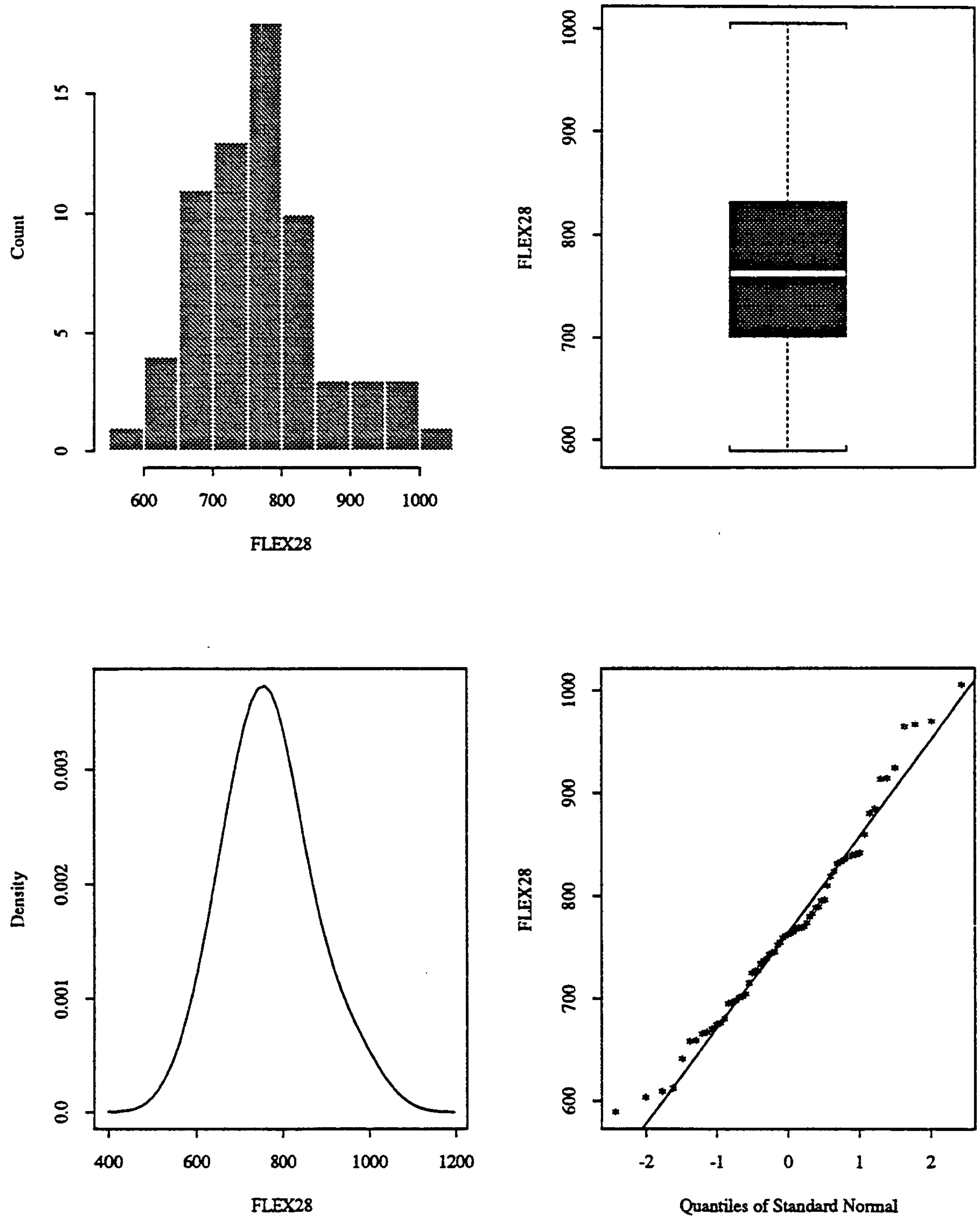

Figure 6.16 Statistical Distribution of 28-Day Flexural Strength for GPS-5 Sections, psi

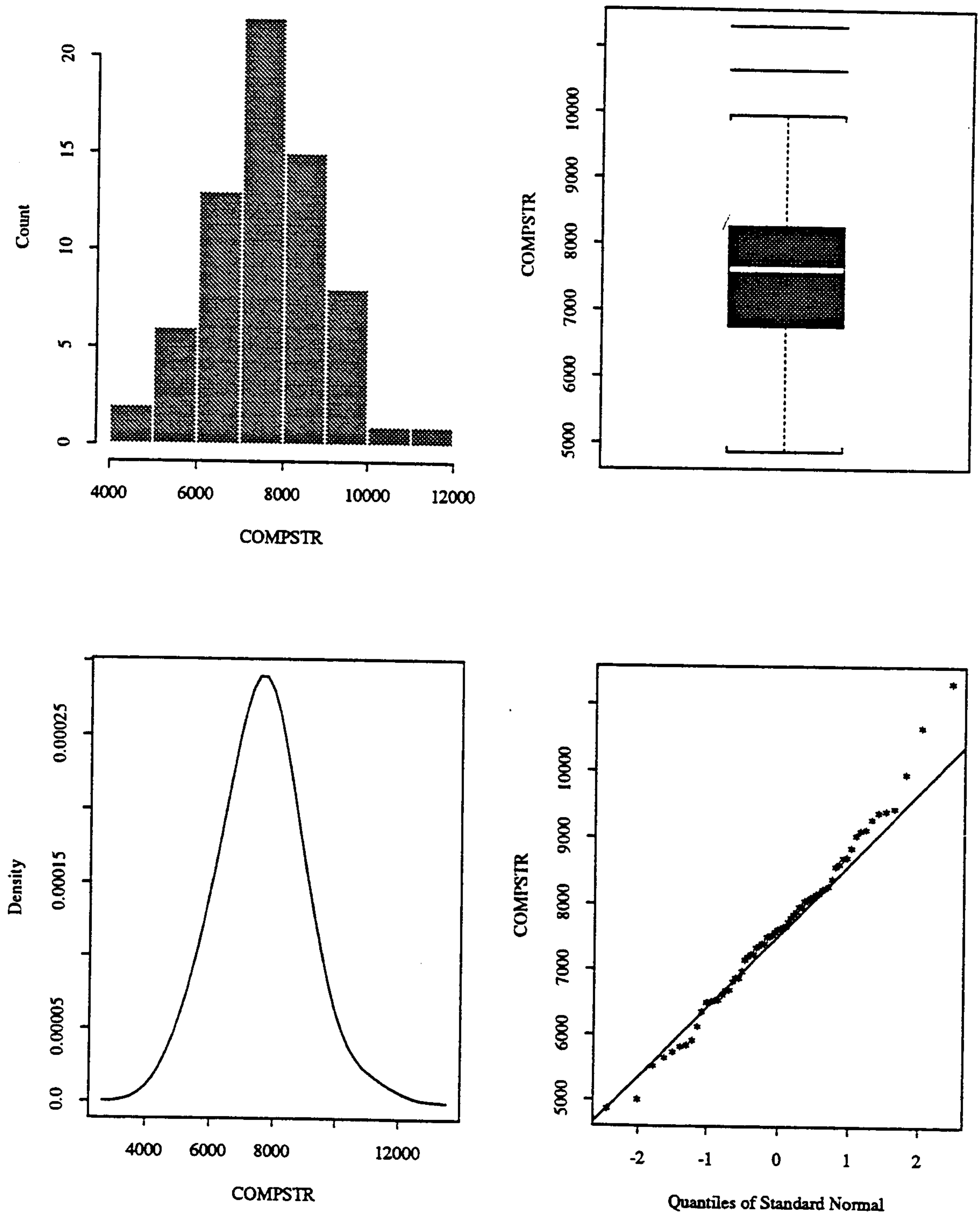

Figure 6.17 Statistical Distribution of Compressive Strength for GPS-5 Sections, psi

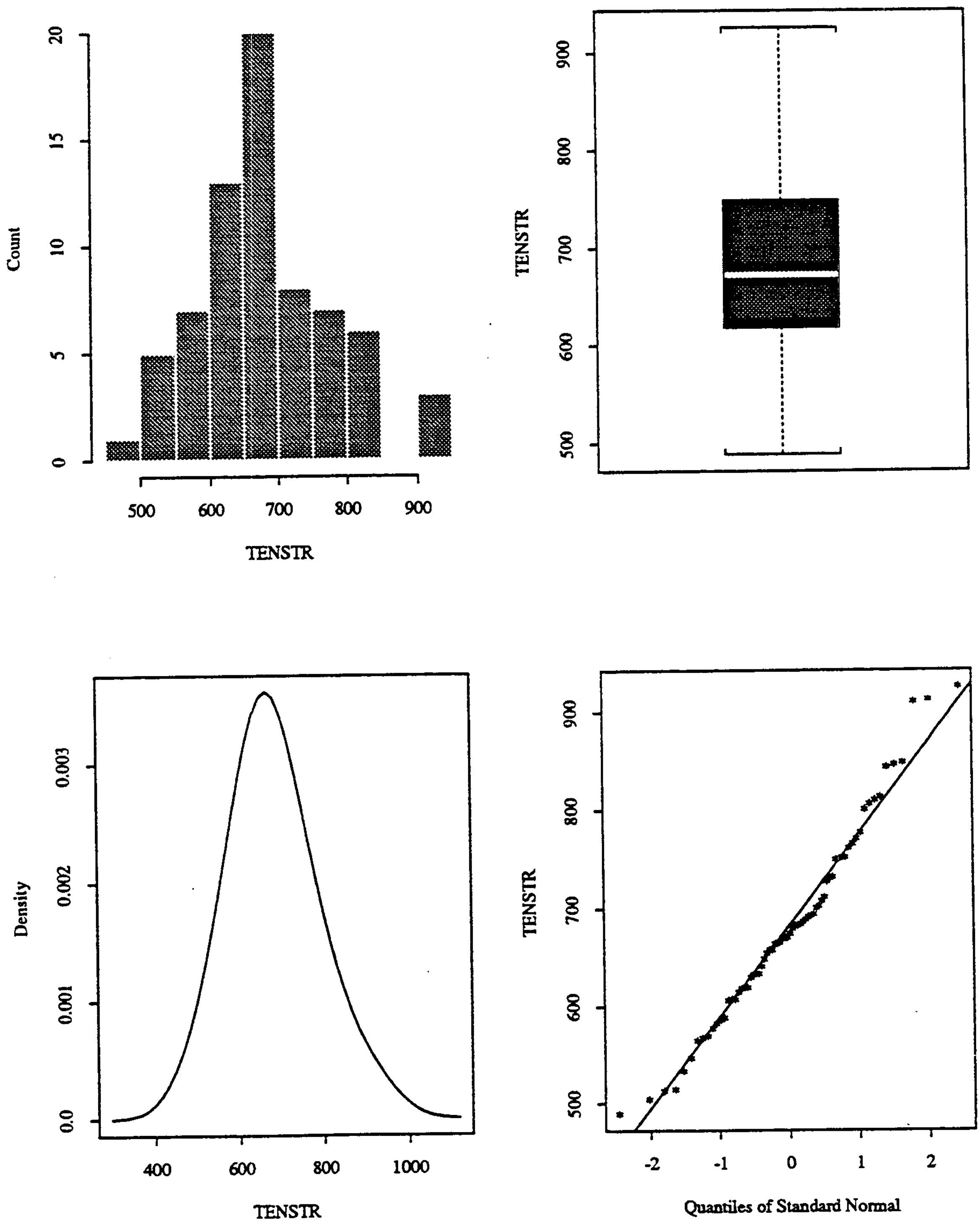

Figure 6.18 Statistical Distribution of Split Tensile Strength for GPS-5 Sections, psi