ESTIMATION OF CARRYING CAPACITY FOR HUMAN POPULATIONS IN A PART OF THE TRANSAMAZON HIGHWAY COLONIZATION AREA OF BRASIL

Volume II

by
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APPENDICES

APPENDIX A

INITIAL SOIL QUALITY ON THE TRANSAMAZON HIGHWAY

Fig. A-1. -- Soil sampling procedure. Samples are composites of cores taken to a depth of 20 cms at a minim of 15 locations in a field. Over 1000 samples were taken. Profiles were also taken to 1 meter depth. Photograph sh author taking sample in area newly cleared for pasture.

TABLE A-1.

TRANSITION PROBABILITIES FOR VIRGIN SOIL pH

BEGINNING pH CLASS	ENDING pH CLASS							SAMPLE SIZE
	≤3.9	4.0-4.4	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	≥6.5	
move of 100 meters(1)								
≤3.9	0.00	0.33	0.00	0.33	0.33	0.00	0.00	3
4.0-4.4	0.09	0.73	0.09	0.00	0.00	0.00	0.09	11
4.5-4.9	0.00	0.17	0.33	0.00	0.50	0.00	0.90	6
5.0-5.4	0.09	0.00	0.00	0.36	0.36	0.18	0.00	11
5.5-5.9	0.11	0.00	0.33	0.44	0.00	0.11	0.00	9
6.0-6.4	0.00	0.00	0.00	0.40	0.20	0.40	0.00	5
≥6.5	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1
move of 500 meters(2)								
≤3.9	0.40	0.43	0.09	0.06	0.00	0.30	0.03	35
4.0-4.4	0.25	0.43	0.15	0.08	0.00	0.02	0.00	61
4.5-4.9	0.12	0.36	0.24	0.08	0.12	0.08	0.00	25
5.0-5.4	0.12	0.29	0.12	0.24	0.24	0.00	0.00	17
5.5-5.9	0.00	0.25	0.15	0.20	0.30	0.10	0.30	20
6.0-6.4	0.00	0.20	0.40	0.00	0.40	0.00	0.00	5
≥6.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1

(1) calculated from samples which are 100 meters from each reference sample ± 100 meters.

(2) calculated from samples which are 500 meters from each reference sample ± 100 meters.

Fig. A-2. -- Map of pH in virgin soil of intensive s
area. Levels are assigned to 20 hectare quadrats from
nearest sample for which data are available.

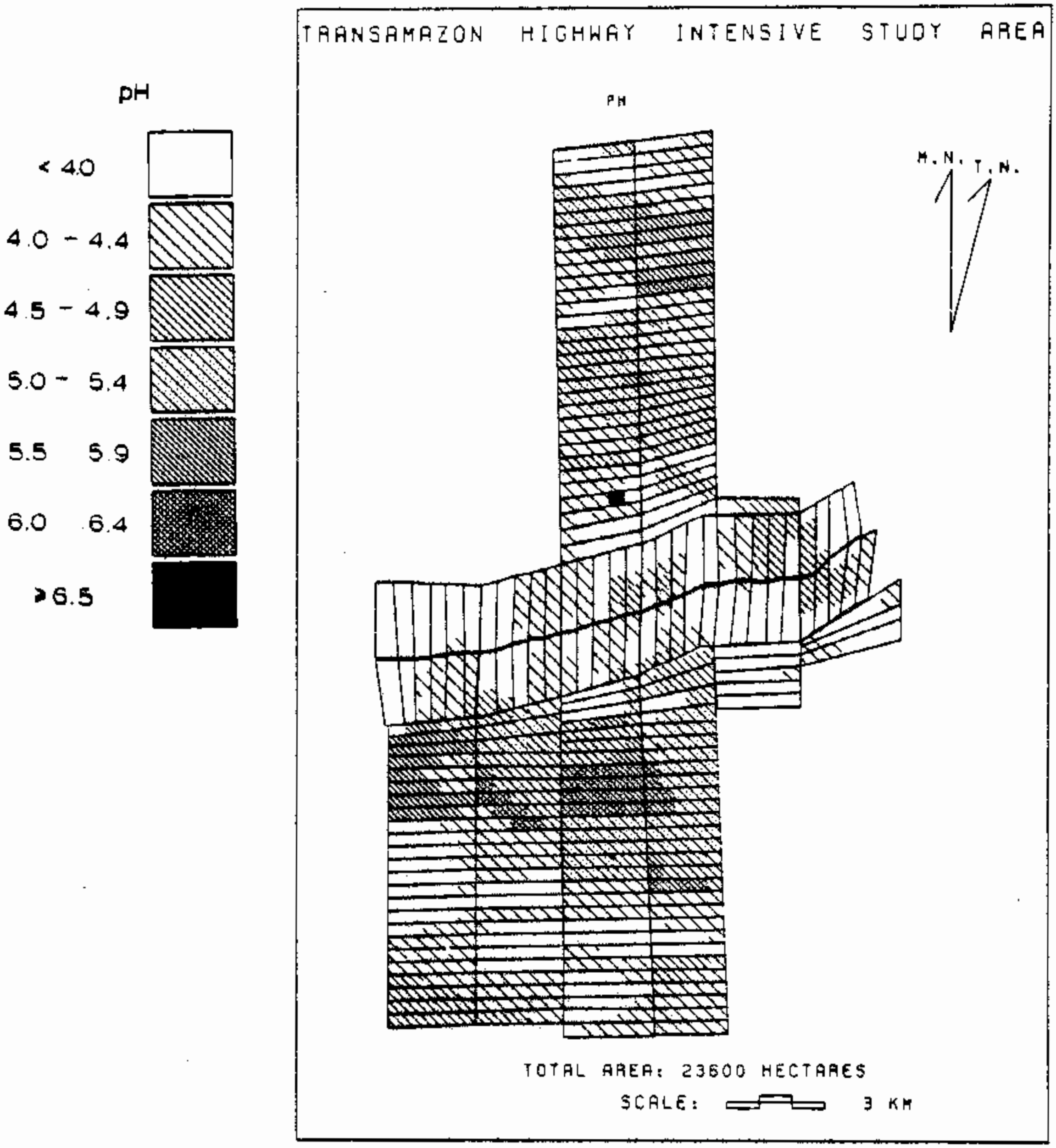

pH
< 4.0
4.0 - 4.4
4.5 - 4.9
5.0 - 5.4
5.5 5.9
6.0 6.4
>6.5
TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
PH
M.N. T.N.
TOTAL AREA: 23600 HECTARES
SCALE: 3 KM

Fig. A-3. -- Map of phosphorus in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.

PHOSPHORUS IN VIRGIN FOREST SOIL

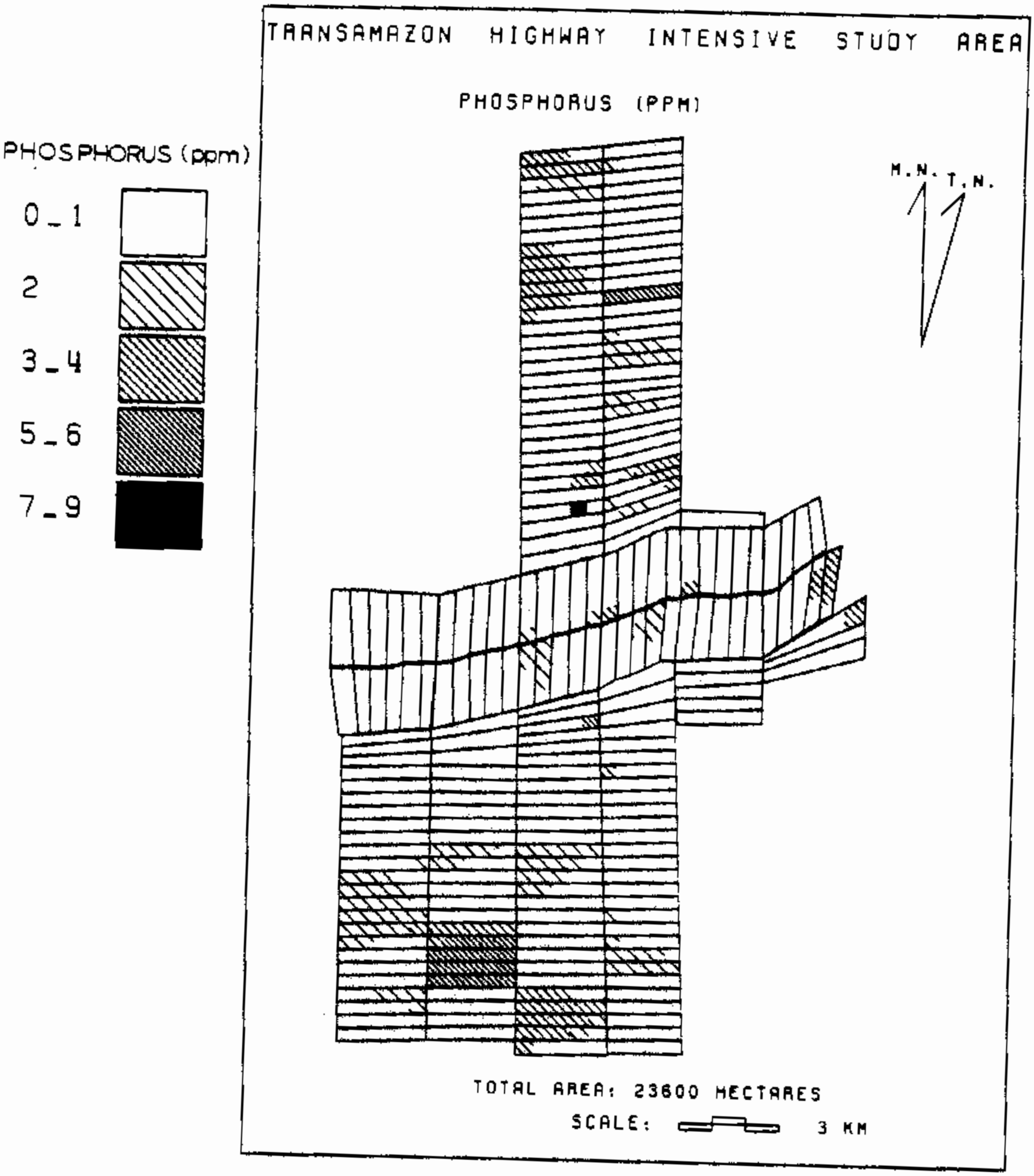


Fig. A-4. -- Map of aluminum in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.

ALUMINUM IN VIRGIN FOREST SOIL

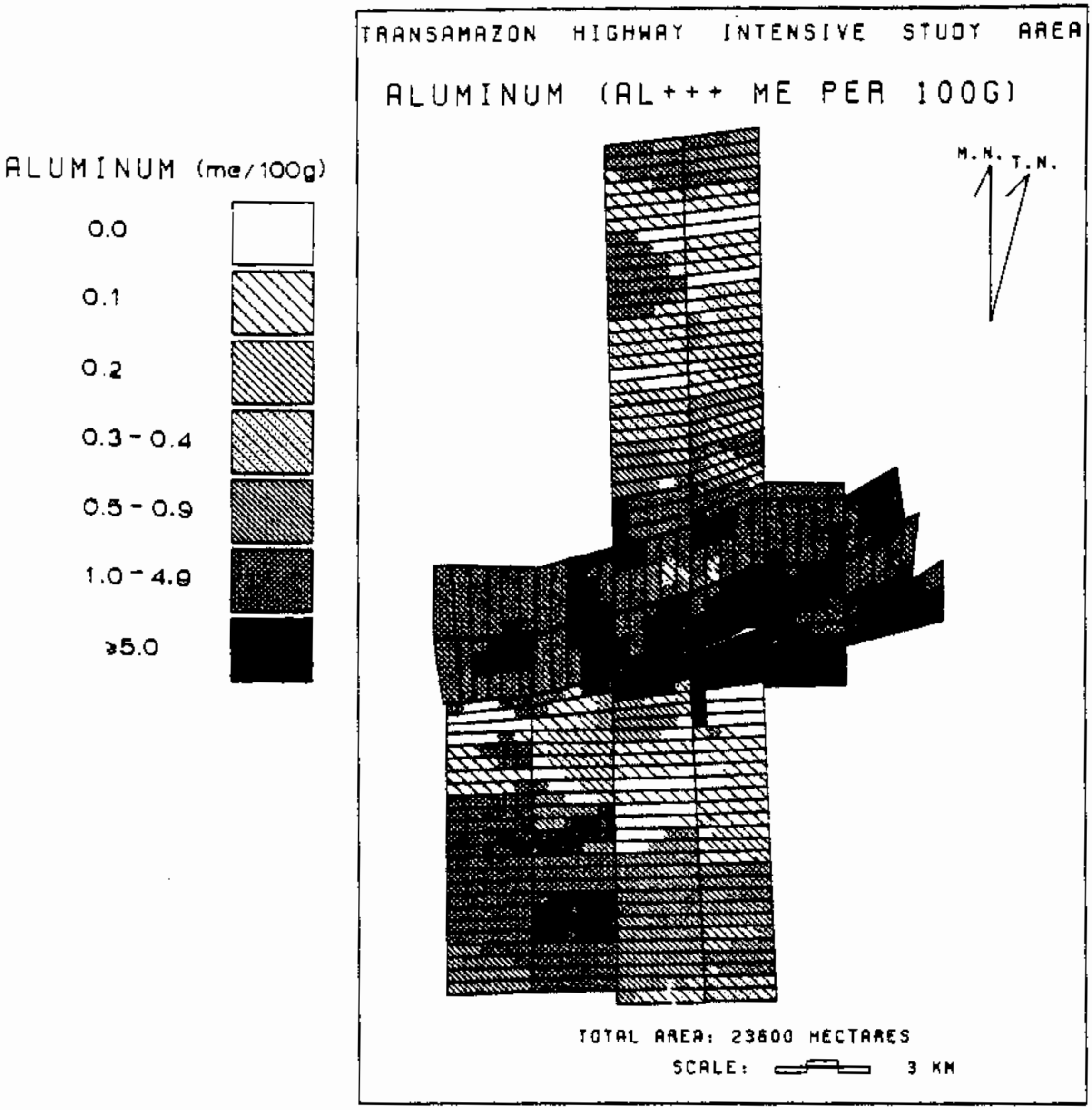


Fig. A-5. -- Map of calcium and magnesium in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.

CALCIUM AND MAGNESIUM IN VIRGIN FOREST SOIL

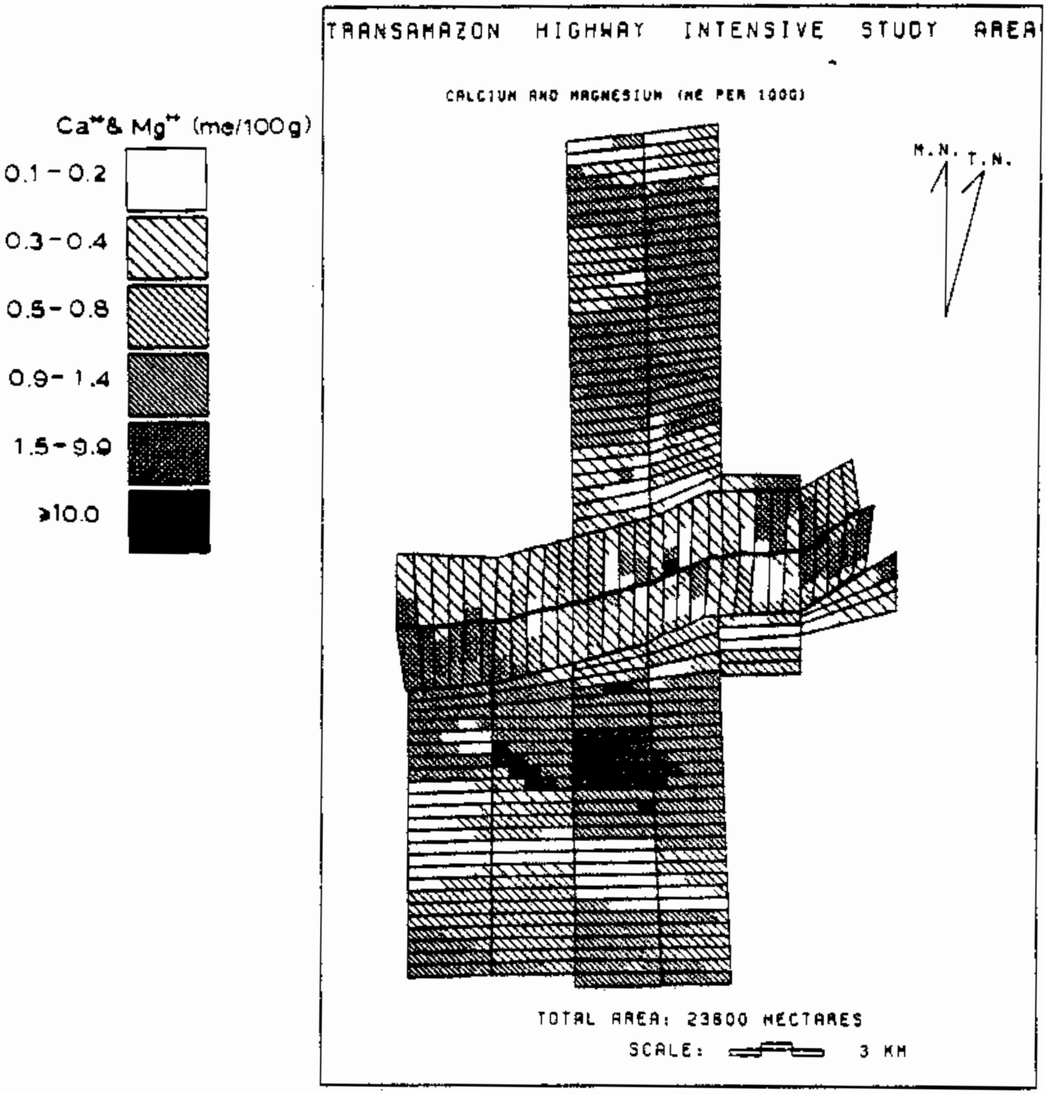


Fig. A-6. -- Map of potassium in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.

POTASSIUM IN VIRGIN FOREST SOIL

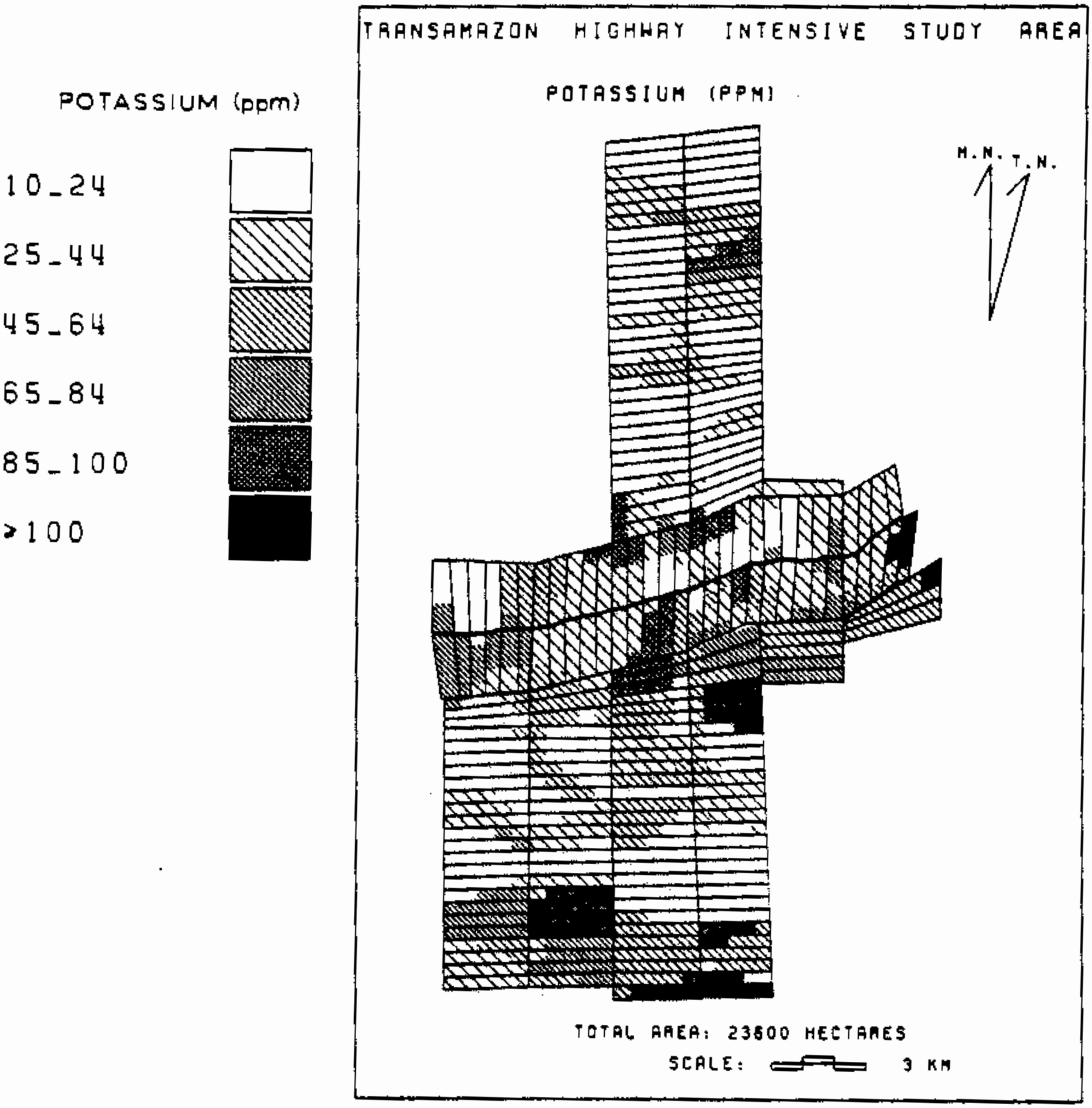


Fig. A-7. -- Locations of samples for basic fertility maps of virgin soils of the intensive study area. "Basic fertility" refers to pH, Al^{+++}, Ca^{++} and Mg^{++}, K, and P.

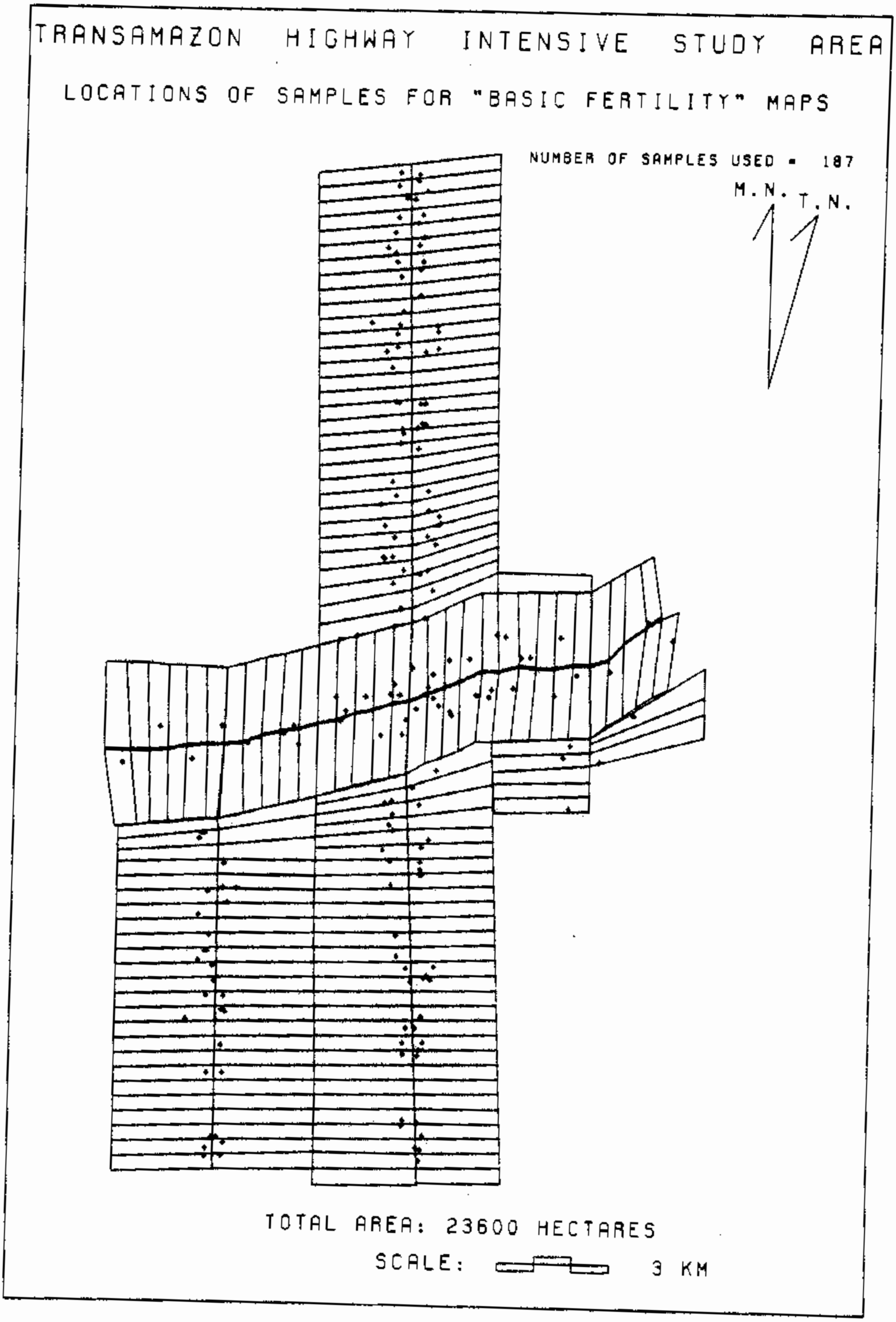

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
LOCATIONS OF SAMPLES FOR "BASIC FERTILITY" MAPS
NUMBER OF SAMPLES USED = 187
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-8. -- Map of nitrogen in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.

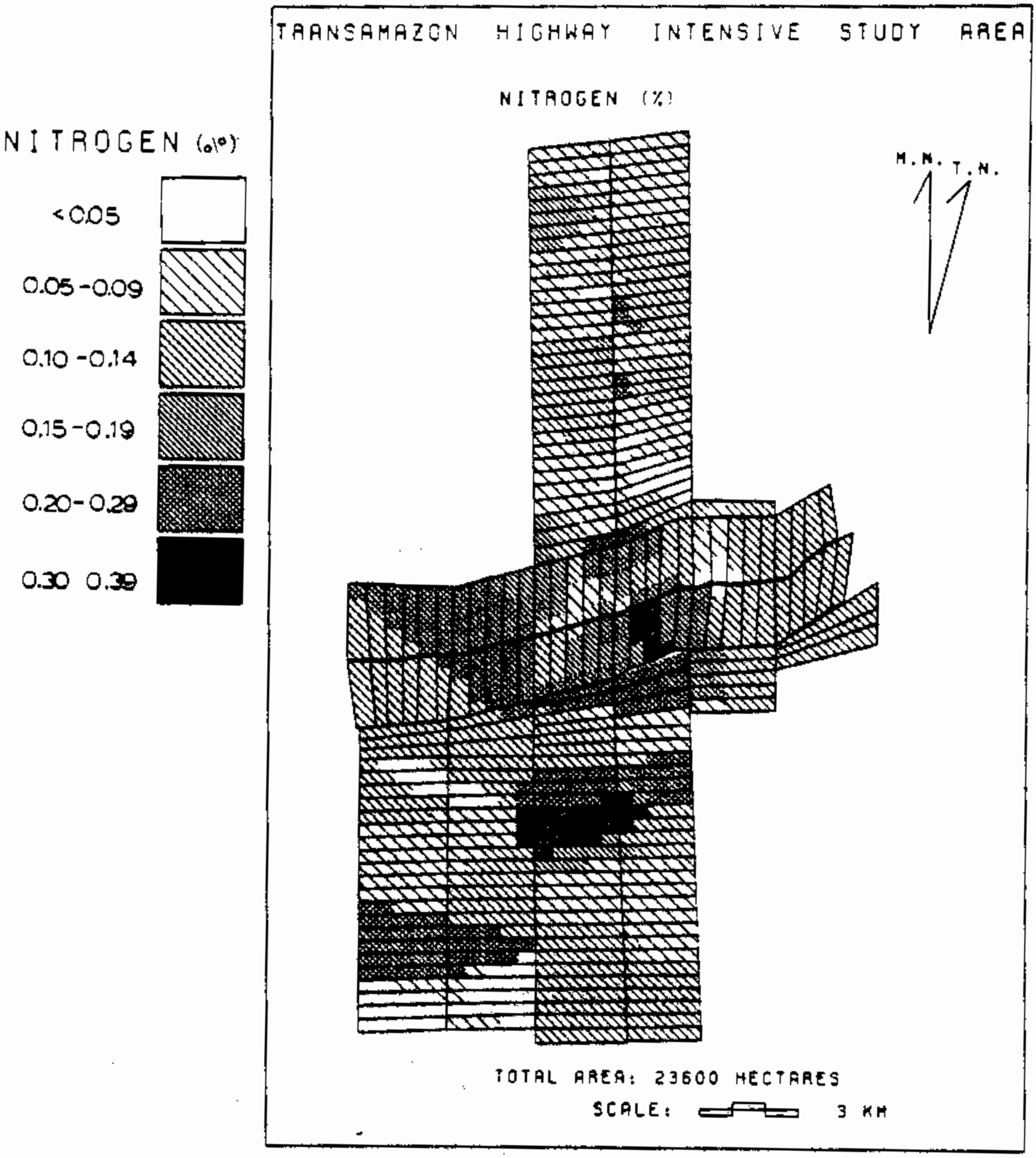

NITROGEN (o/o)
<0.05
0.05-0.09
0.10-0.14
0.15-0.19
0.20-0.29
0.30 0.39
TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
NITROGEN (%)
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-9. -- Locations of samples for nitrogen map of virgin soils of the intensive study area.

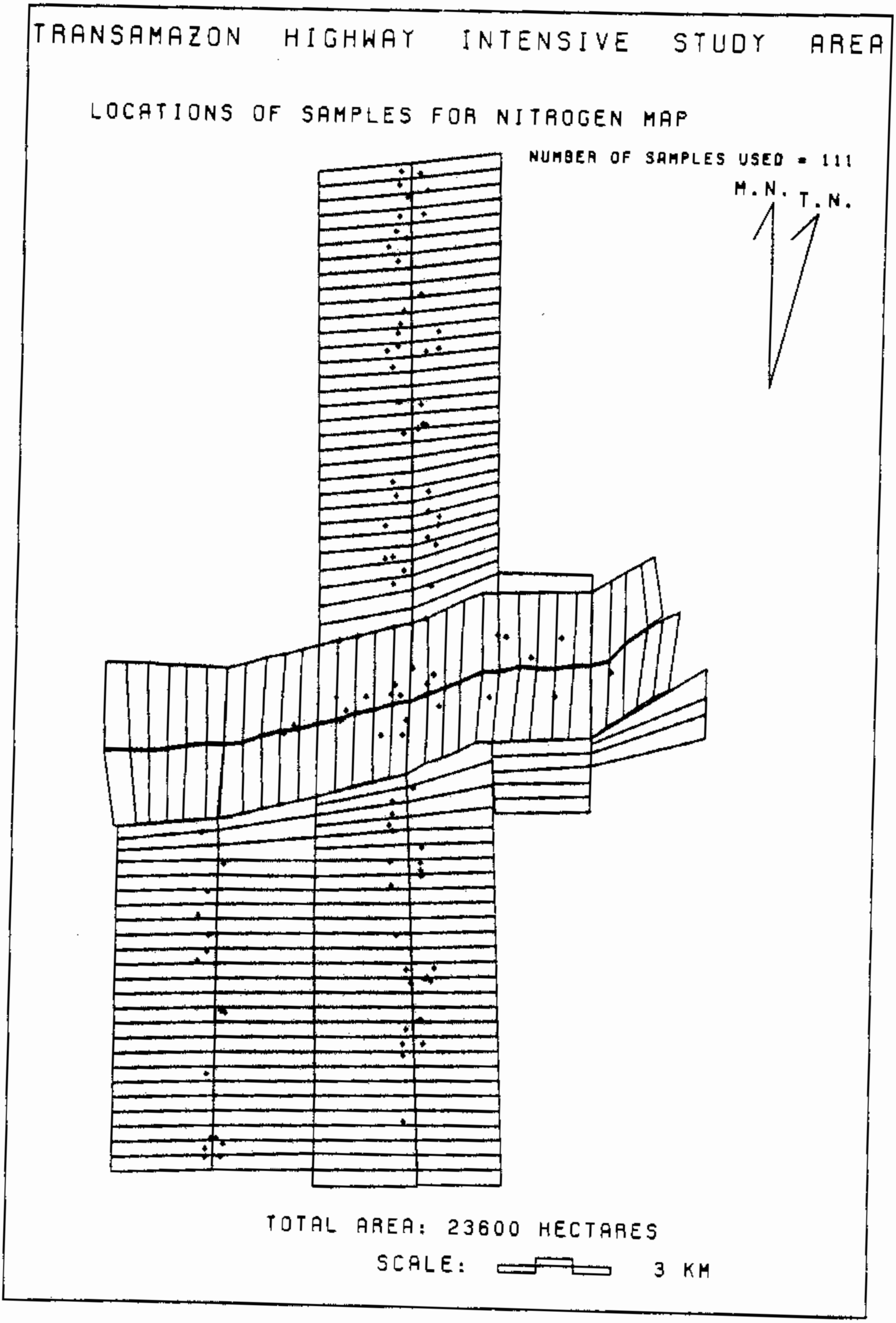

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
LOCATIONS OF SAMPLES FOR NITROGEN MAP
NUMBER OF SAMPLES USED = 111
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-10. -- Map of carbon in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.

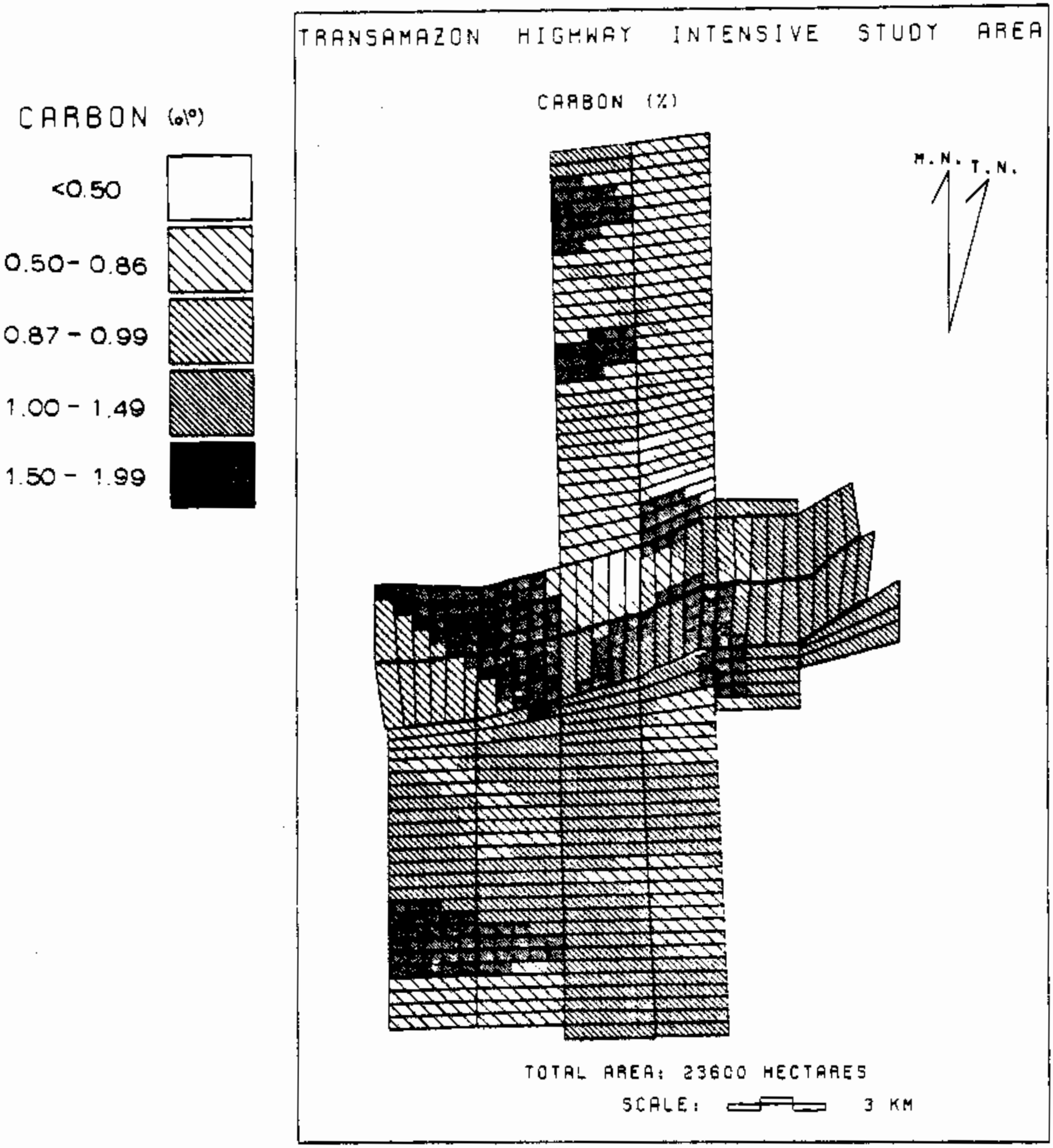

CARBON (%)
<0.50
0.50 - 0.86
0.87 - 0.99
1.00 - 1.49
1.50 - 1.99
TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
CARBON (%)
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-11. -- Locations of samples for carbon map of virgin soils of the intensive study area. Virgin soils of the intensive study area.

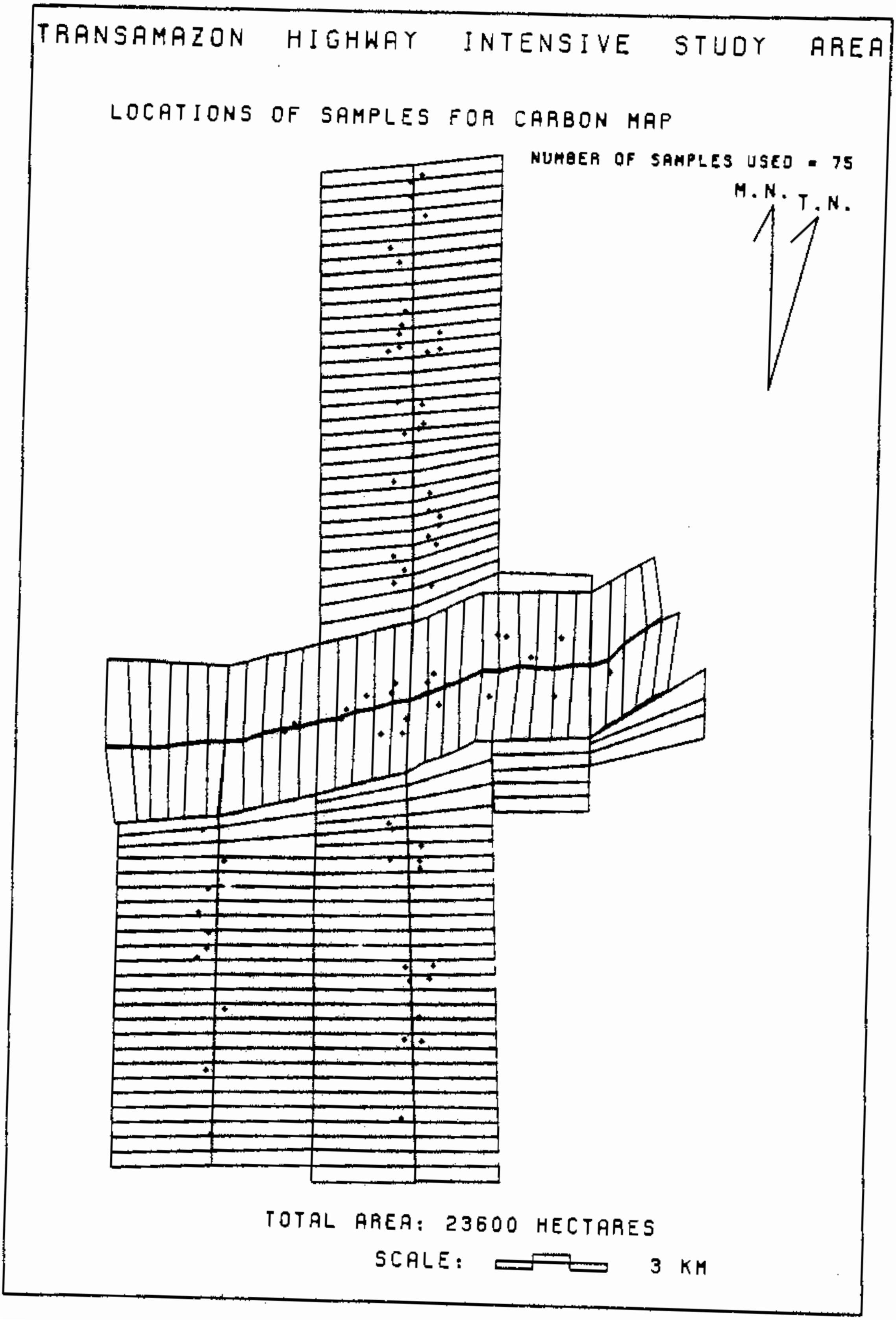

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
LOCATIONS OF SAMPLES FOR CARBON MAP
NUMBER OF SAMPLES USED = 75
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-12. -- Map of total clay in intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available. All samples, both virgin and non-virgin, are used.

GRANULOMETRIC ANALYSIS SOIL MAP FROM ALL SAMPLES

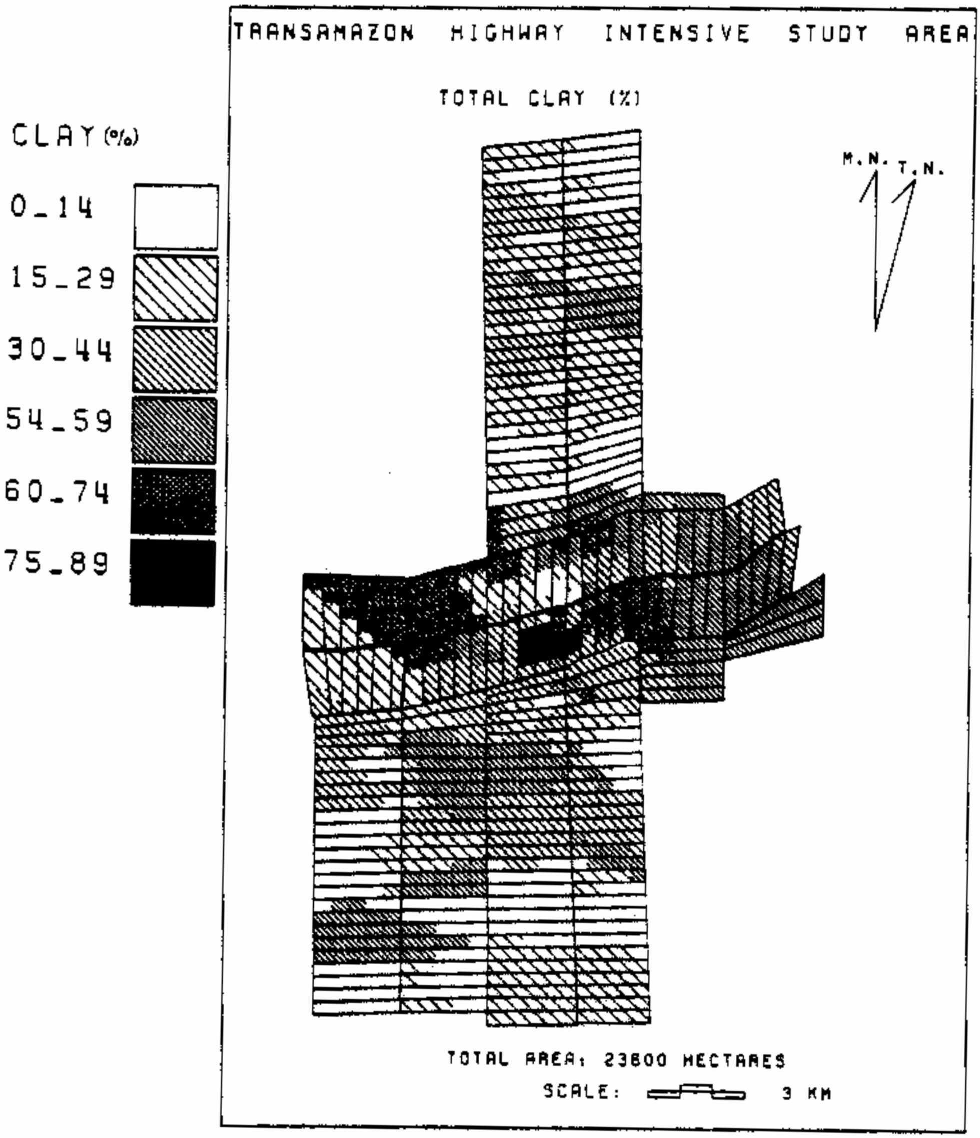


Fig. A-13. -- Map of silt in intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available. All samples, both virgin and non-virgin, are used.

GRANULOMETRIC ANALYSIS SOIL MAP FROM ALL SAMPLES

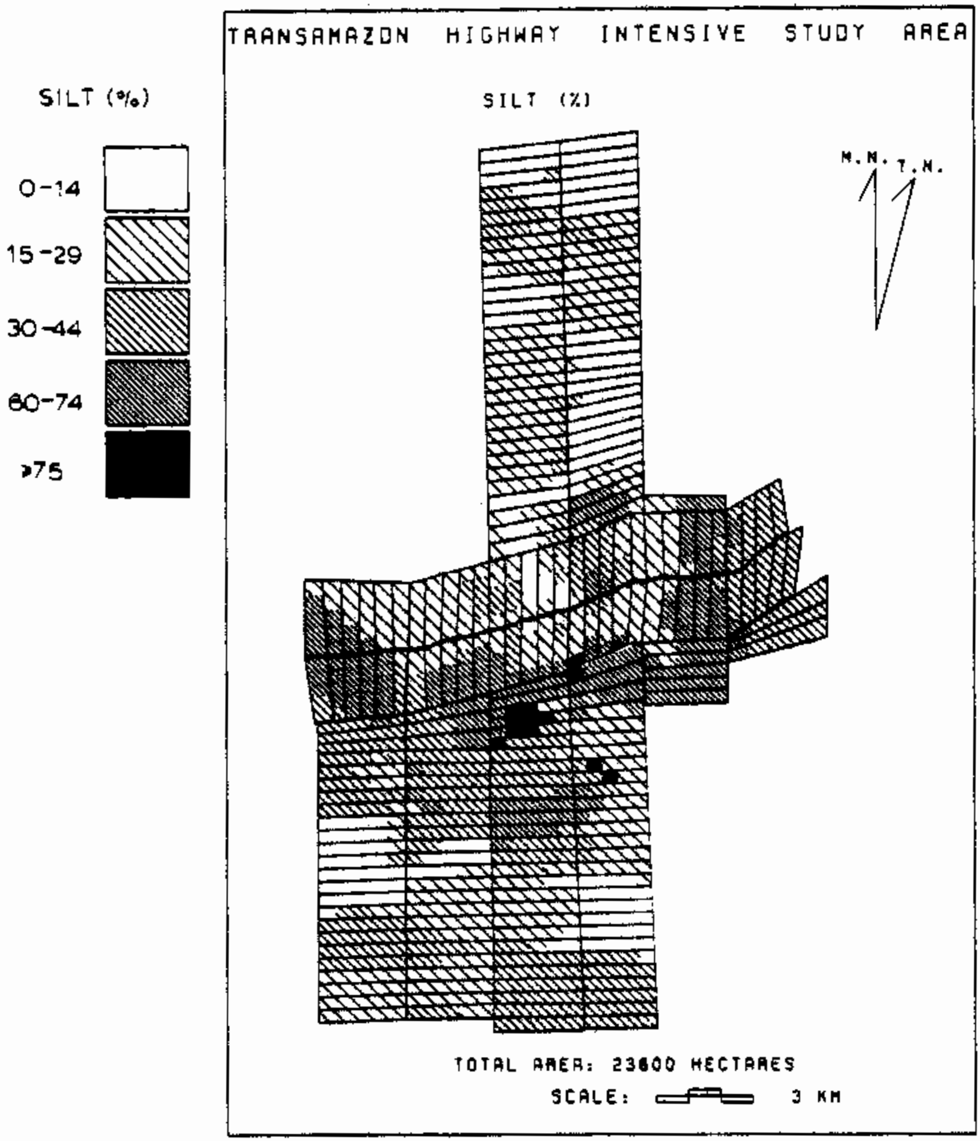


Fig. A-14. -- Map of fine sand in intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available. All samples, both virgin and non-virgin, are used.

GRANULOMETRIC ANALYSIS SOIL MAP FROM ALL SAMPLES

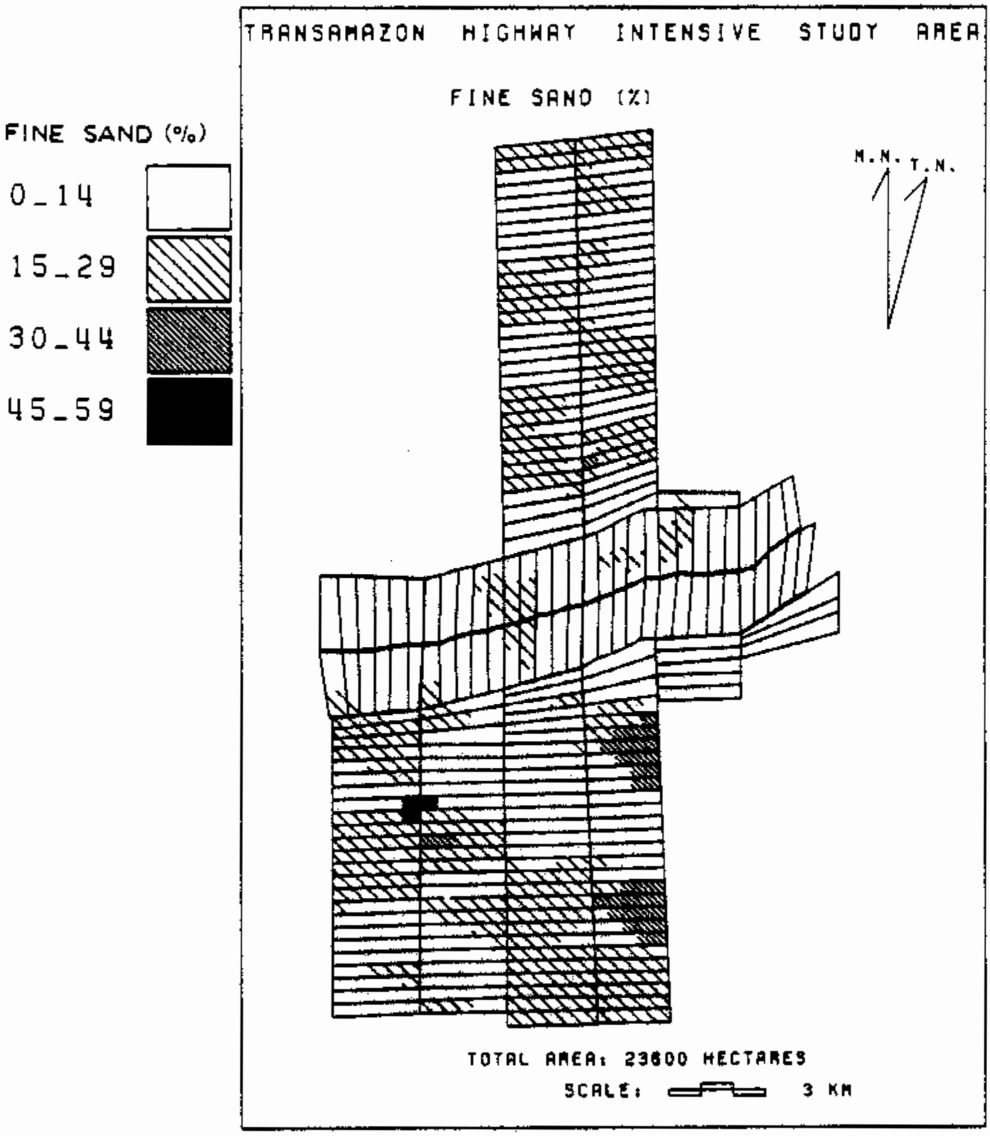


Fig. A-15. -- Map of coarse sand in intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available. All samples, both virgin and non-virgin, are used.

GRANULOMETRIC ANALYSIS SOIL MAP FROM ALL SAMPLES

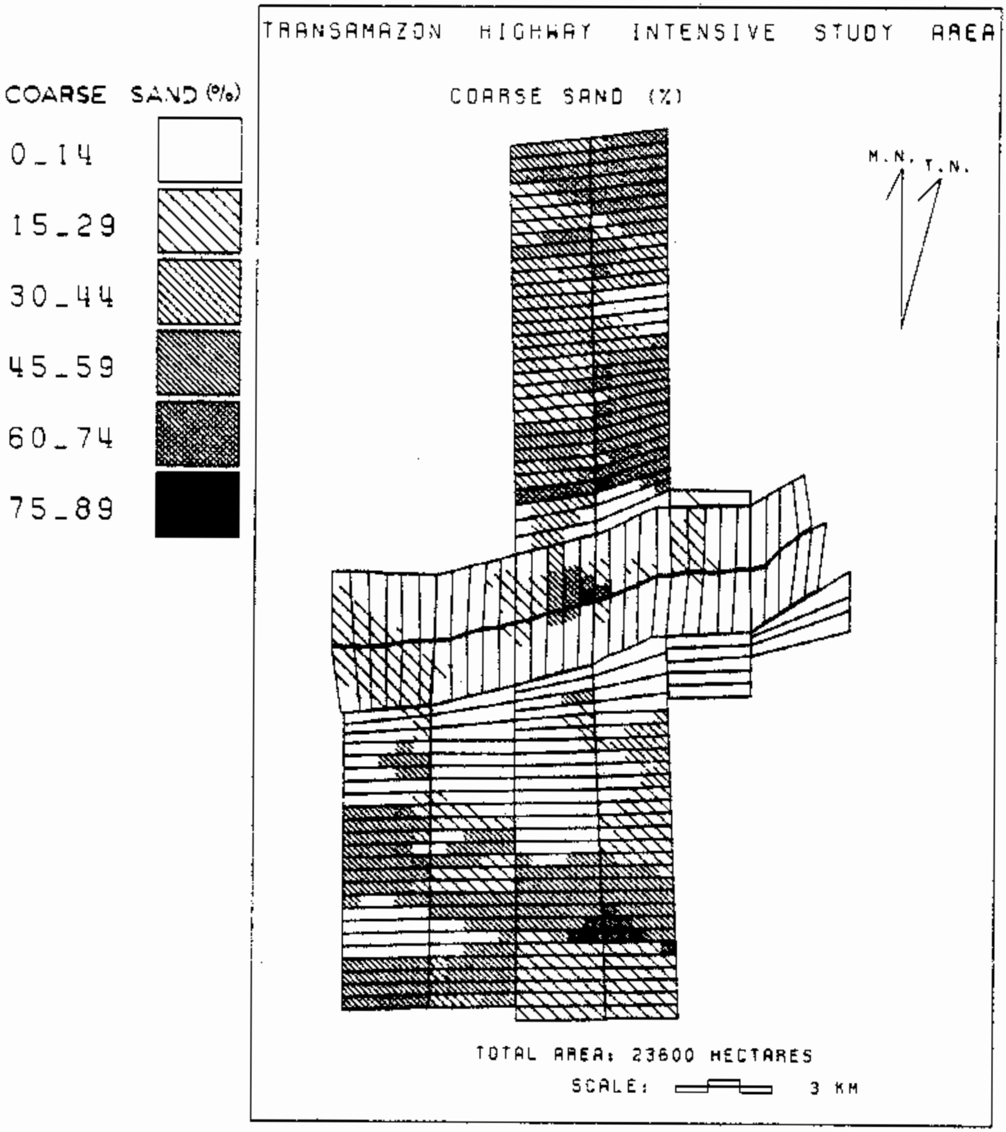


Fig. A-16. -- Locations of samples for granulometric maps of the intensive study area. Granulometric measures are total clay, silt, fine sand, and coarse sand.

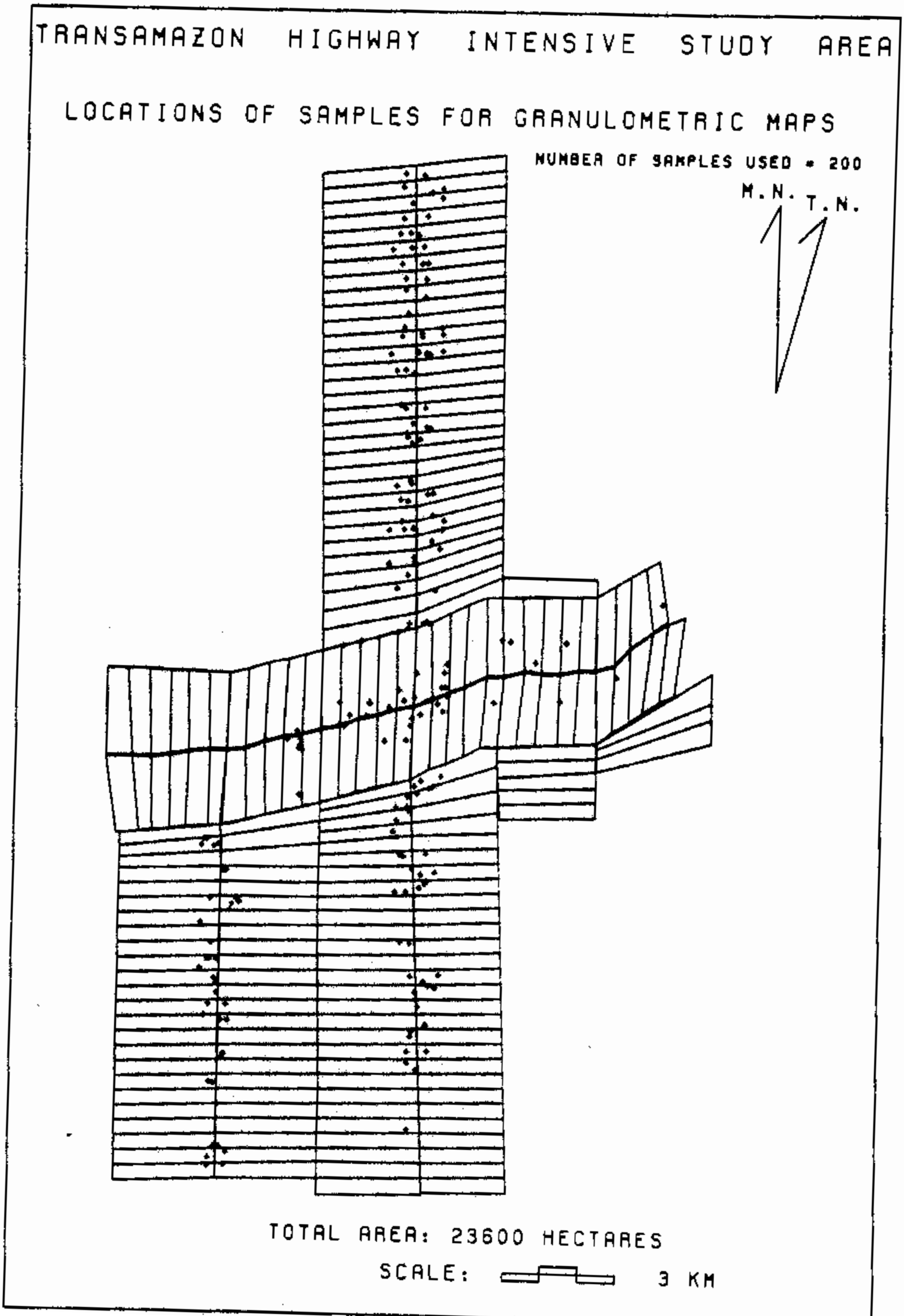

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
LOCATIONS OF SAMPLES FOR GRANULOMETRIC MAPS
NUMBER OF SAMPLES USED = 200
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-17. -- Map of slope in intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available. Slopes of all sample locations are used, virgin or non-virgin. Slopes are measured over distances on the order of 10 - 30 meters.

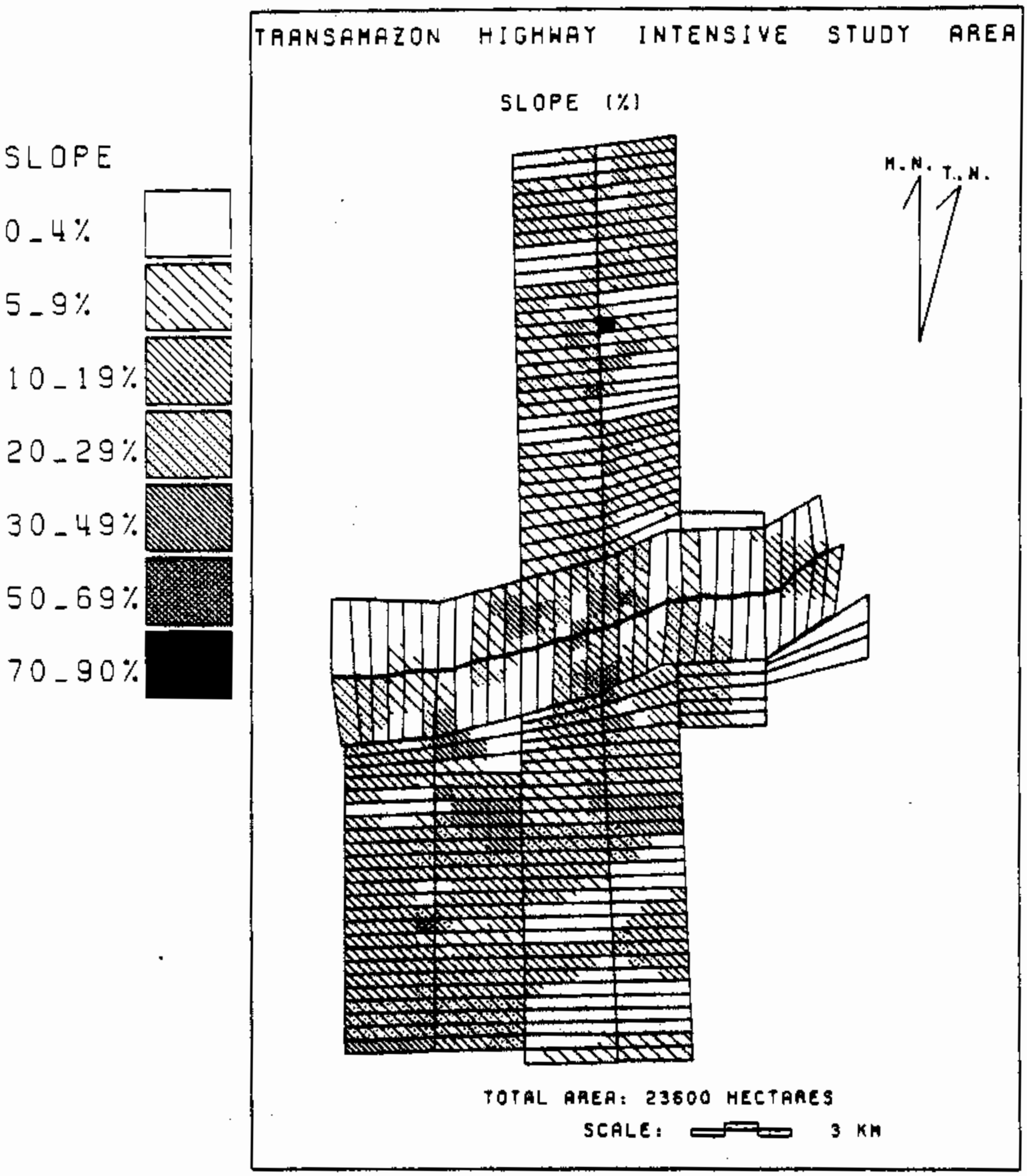

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
SLOPE (%)
SLOPE
0_4%
5_9%
10_19%
20_29%
30_49%
50_69%
70_90%
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

Fig. A-18. -- Locations of measurements for slope map of the intensive study area.

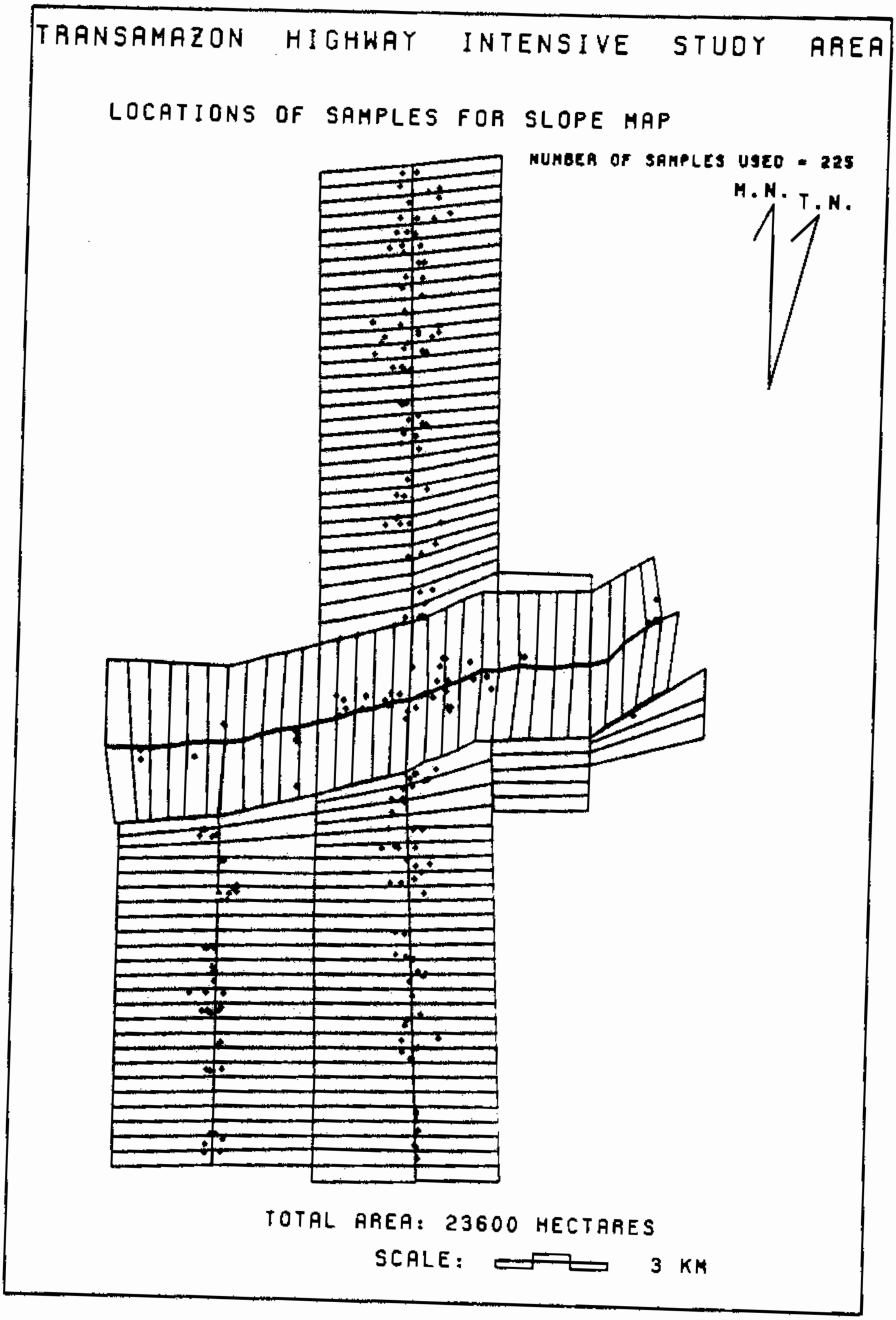

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA
LOCATIONS OF SAMPLES FOR SLOPE MAP
NUMBER OF SAMPLES USED = 225
M.N.
T.N.
TOTAL AREA: 23600 HECTARES
SCALE:
3 KM

TABLE A-2.

MULTIPLE REGRESSION FOR ALUMINUM IN VIRGIN SOIL

Regression	Y =	11.429 -	7.677 a +	0.0627 b
Standard Errors		1.391	0.907	0.0079
t statistics		8.216	-8.467	7.913
Significance		<0.001	<0.001	<0.001
Partial Correlations			-0.620	0.594
	R-Squared =	0.54	F stat. =	67.38
	Std. error of est. =	1.559	Multiple R =	0.73
	P <	0.001	N =	110

Abbreviations: Y = Al^{+++} (ME/100g)

a = natural log of pH

b = total clay (%)

Fig. A-19. -- Aluminum ions in virgin soil observed vs predicted values from regression on natural log of pH and total clay.

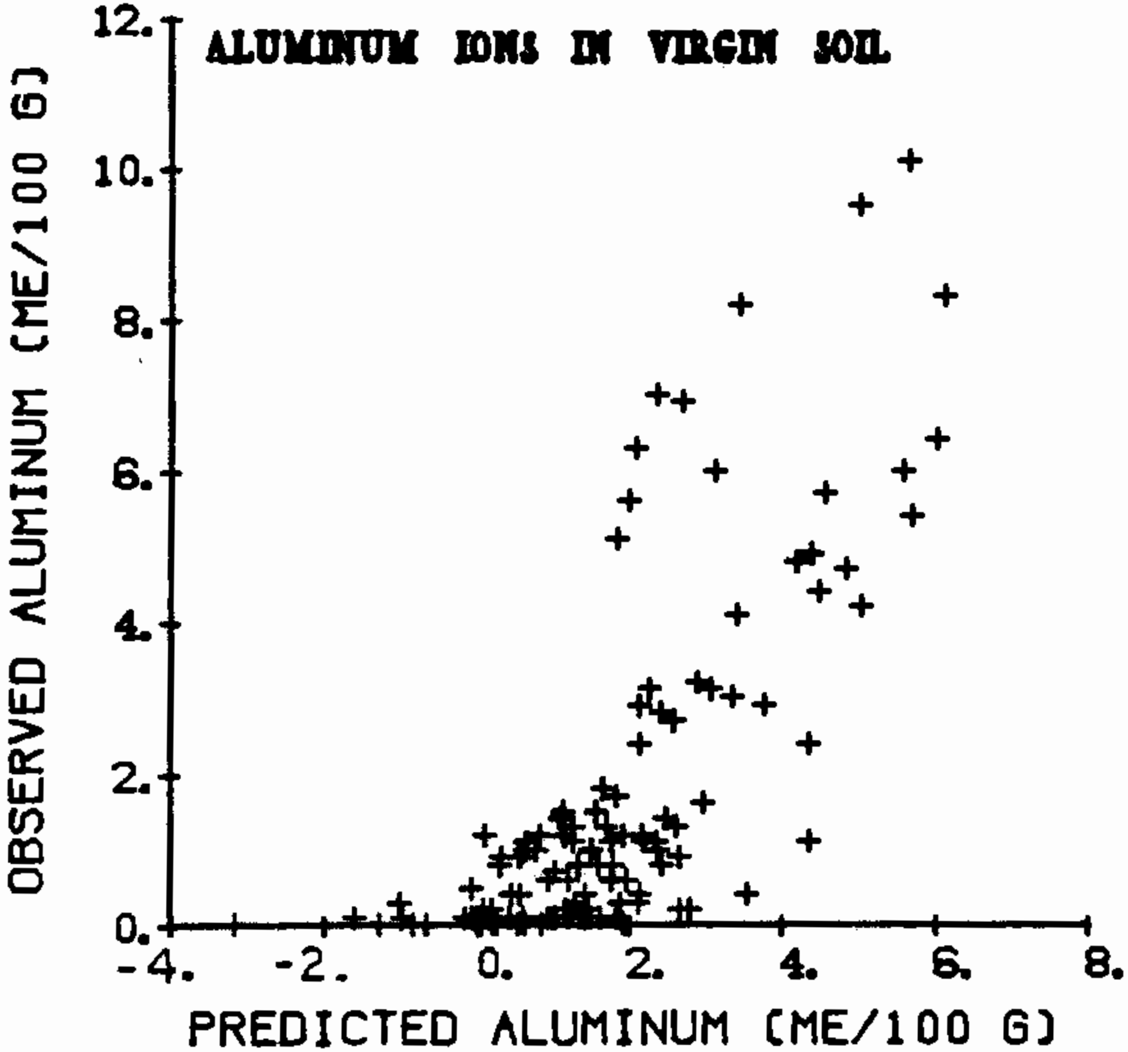

ALUMINUM IONS IN VIRGIN SOIL
OBSERVED ALUMINUM (ME/100 G)
PREDICTED ALUMINUM (ME/100 G)
12.
10.
8.
6.
4.
2.
0.
-4.
-2.
0.
2.
4.
6.
8.

TABLE A-3.

MULTIPLE REGRESSION FOR NITROGEN IN VIRGIN SOIL

Regression	Y =	-11.986 +	0.132 a +	0.0220 b
Standard errors		0.0333	0.0115	0.0067
t statistics		-3.599	11.489	3.267
Significance		0.0007	<0.001	0.0020
Partial correlations			0.852	0.419
	R-squared =	0.73	F stat. =	68.05
	Std. error of est. =	0.0304	Multiple R =	0.73
	P <	0.001	N =	53

Abbreviations: Y = Nitrogen (% dry weight)

D = pH

FIG. A-20. -- Nitrogen in virgin soil observed vs predicted values from regression on carbon and pH

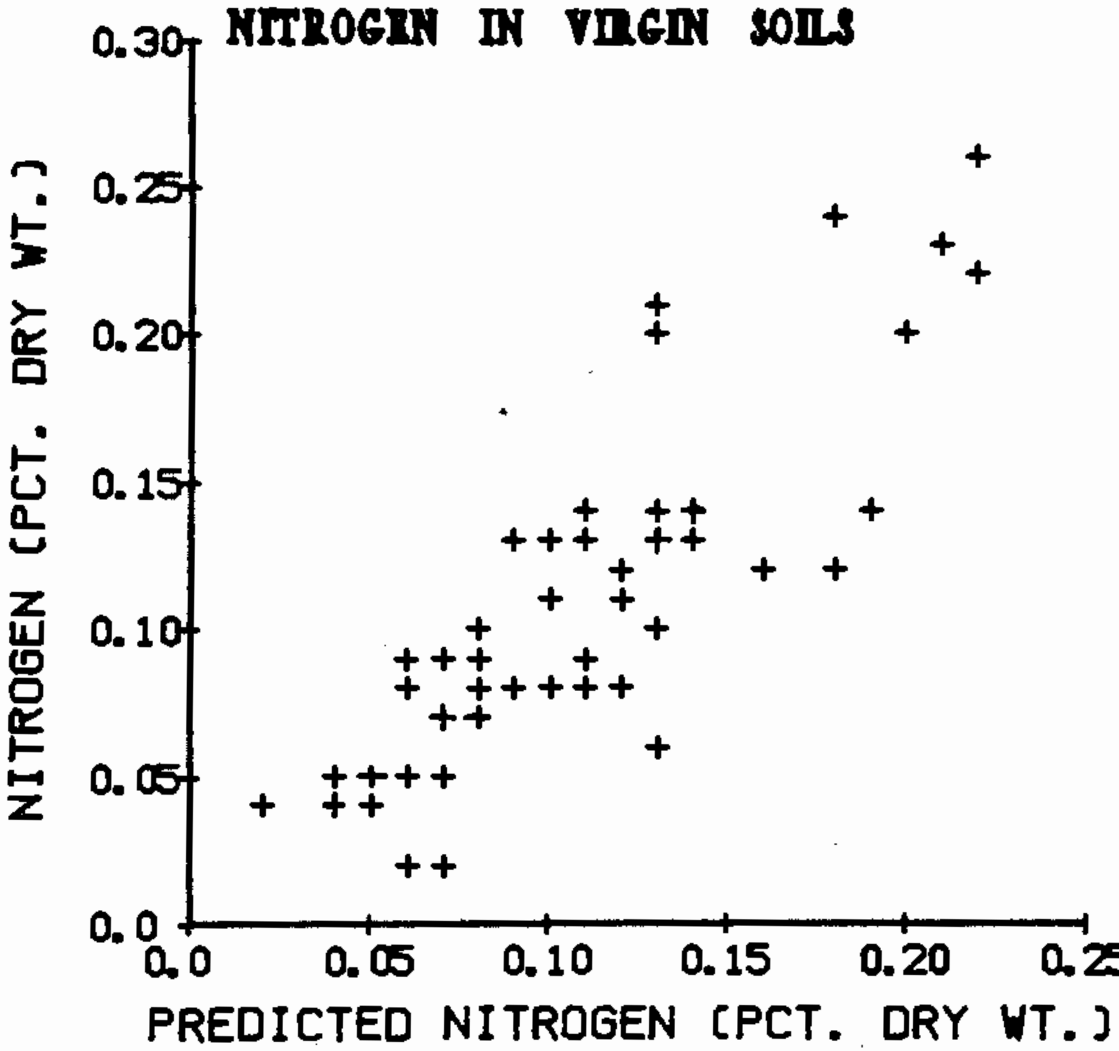

NITROGEN IN VIRGIN SOILS
NITROGEN (PCT. DRY WT.)
0.0
0.05
0.10
0.15
0.20
0.25
0.30
PREDICTED NITROGEN (PCT. DRY WT.)
0.0
0.05
0.10
0.15
0.20
0.25

TABLE A-4.

REGRESSION OF CALCIUM AND MAGNESIUM IN VIRGIN SOIL

Regression	Y =	-10.610	+	2.041 a
Standard Errors		0.942		0.209
t statistics		-11.268		13.570
Significance		<0.001		<0.001
Partial Correlation				0.706
	R-Squared =	0.50	F stat. =	184.15
	Std. error of est. =	2.08	Multiple R =	0.71
	P <	0.001	N =	187

Abbreviations: $Y = Ca^{++}$ and Mg^{++} (ME/100g)

a = pH

Fig. A-21. -- Calcium and magnesium vs pH in virgin soil.

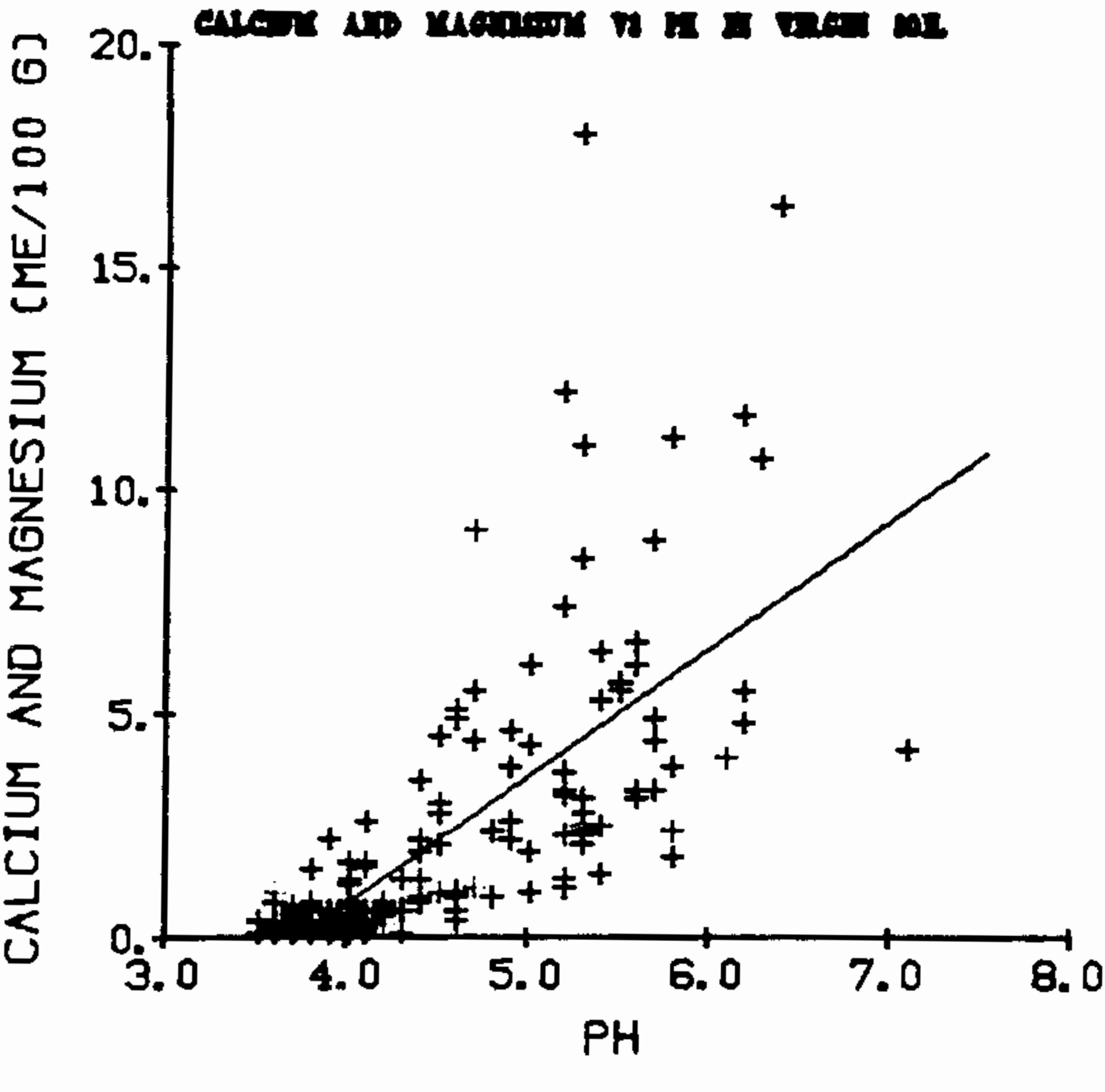

CALCIUM AND MAGNESIUM (ME/100 G)
20.
15.
10.
5.
0.
3.0
4.0
5.0
6.0
7.0
8.0
PH

Fig. B-1. -- Mean monthly rainfalls for Altamira from 1931 through 1976. All months for which complete data for month available used. Means have been calculated from raw data from Weather Department. Numbers of complete cases range from 18 to 29 per month.

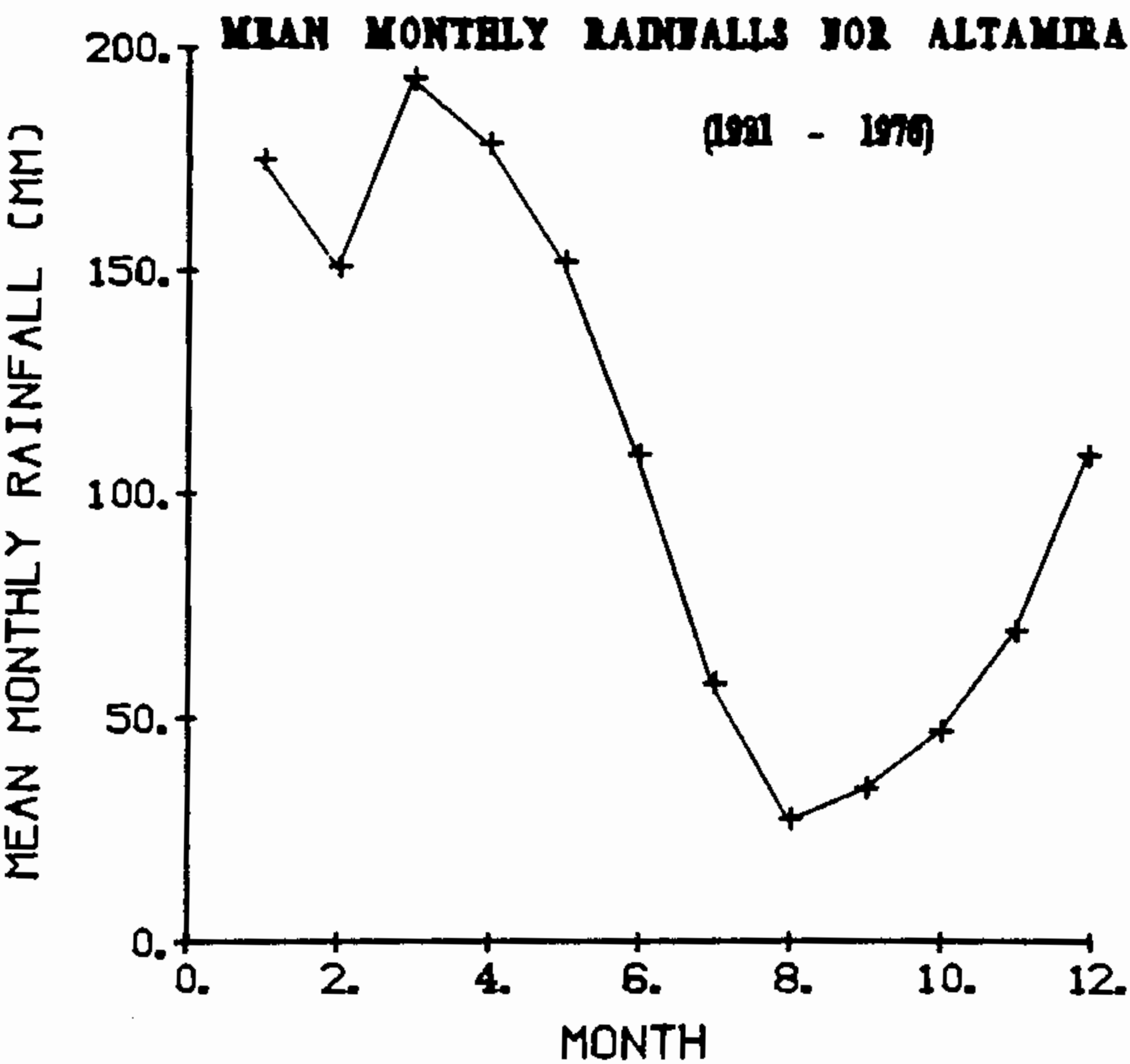

MEAN MONTHLY RAINFALLS FOR ALTAMIRA
(1931 - 1976)
MEAN MONTHLY RAINFALL (MM)
0.
50.
100.
150.
200.
0.
2.
4.
6.
8.
10.
12.
MONTH

TABLE B-1.

ALTAMIRA MONTHLY RAINFALLS AS PROPORTION OF YEARLY TOTALS

ITEM	Total Rain (mm)	Percent of yearly total — month: Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
complete years (N = 8) (monthly rainfalls as percents)													
Mean	1942.3	16.2	15.0	20.2	13.9	13.4	6.3	4.4	1.9	2.3	2.9	2.3	6.7
Std.Dev.	489.6	8.8	2.3	7.8	3.5	3.9	1.8	3.1	1.1	1.0	2.2	2.2	3.4
all years (rainfalls in mm)													
Mean	1295.7(1)	174.7	150.7	192.9	178.3	151.3	102.9	57.4	27.2	33.9	46.6	68.9	110.5.
Std.Dev.	--	118.9	157.3	190.8	128.5	106.8	67.9	49.5	22.0	23.3	31.5	57.2	65.0
N	--	21	22	21	20	19	18	30	29	29	21	26	23

(1) "mean" is sum of monthly means

TABLE B-2.

VARIABILITY IN DAILY WEATHER AS PROPORTION OF MONTHLY TOTALS(1)

MONTH	RAIN		EVAPORATION		INSOLATION	
	S.D.	N	S.D.	N	S.D	N
1	0.0485	142	0.0219	123	0.0243	123
2	0.0490	113	0.0178	113	0.0307	85
3	0.0412	155	0.0123	153	0.0261	123
4	0.0478	150	0.0270	150	0.0289	120
5	0.0696	155	0.0258	155	0.0667	124
6	0.0640	150	0.0302	150	0.0313	120
7	0.0843	155	0.0342	154	0.0162	124
8	0.1096	147	0.0267	146	0.0108	124
9	0.0969	120	0.0289	120	0.0136	120
10	0.1013	119	0.0250	119	0.0231	59
11	0.1346	120	0.0150	120	0.0263	120
12	0.0677	124	0.0302	124	0.0336	124

(1) means used are monthly totals divided by number of days in month

TABLE B-3.

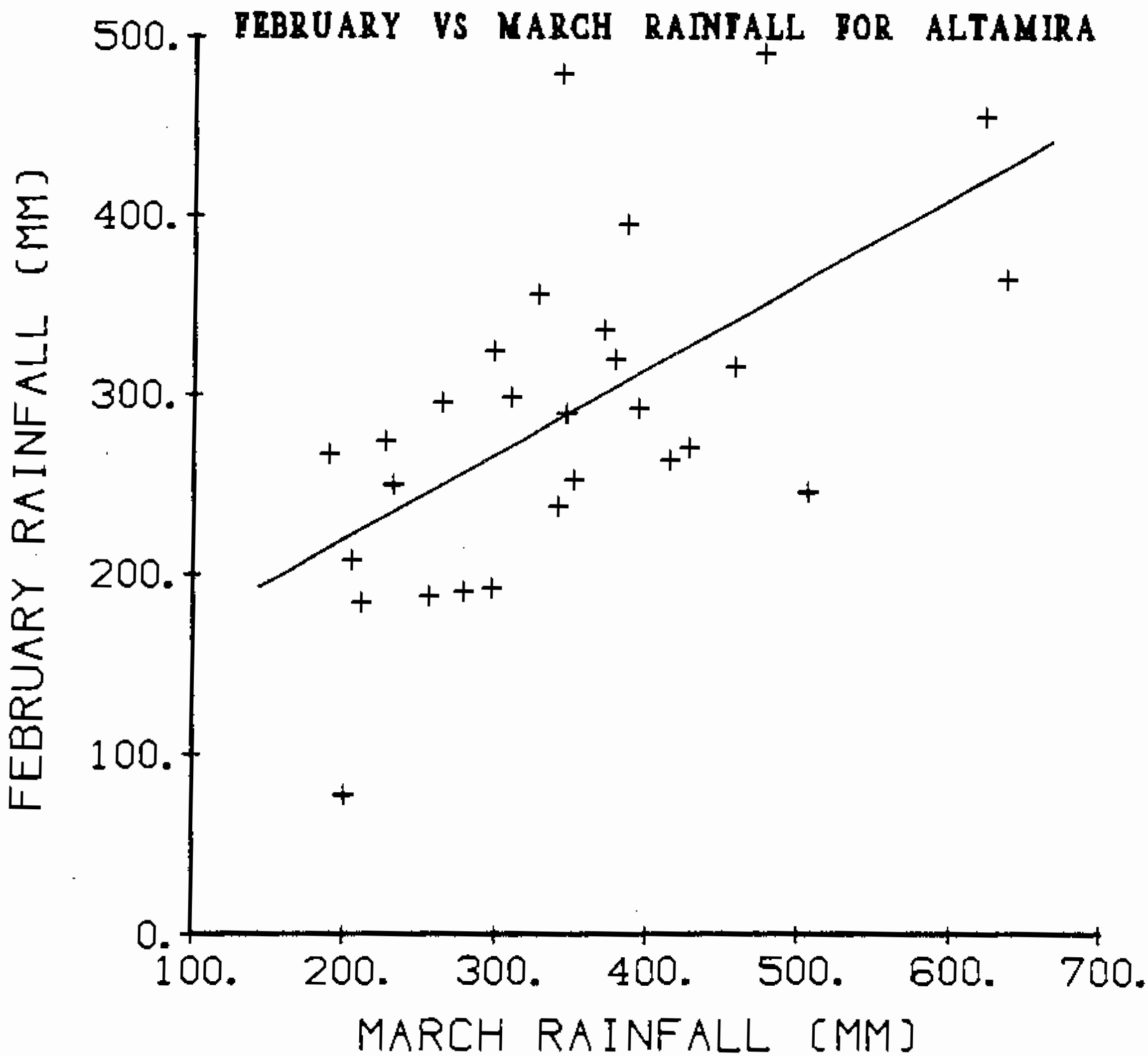
REGRESSION OF FEBRUARY RAIN ON MARCH RAIN FOR ALTAMIRA

Regression	Y =	124.32	+	0.474 a
Standard Errors		45.13		0.123
t statistics		2.755		3.838
Significance		0.011		<0.001
Partial Correlation				0.601
	R-Squared =	0.36	F stat. =	14.73
	Std. error of est. =	75.40	Multiple R =	0.60
	p <	0.001	N =	28

Abbreviations: Y = February rain (mm)

a = March rain (mm)

Fig. B-2. -- February rainfall vs March rainfall for Altamira



FEBRUARY VS MARCH RAINFALL FOR ALTAMIRA
FEBRUARY RAINFALL (MM)
500.
400.
300.
200.
100.
0.
100.
200.
300.
400.
500.
600.
700.
MARCH RAINFALL (MM)

TABLE B-4.

REGRESSION OF MARCH RAIN ON APRIL RAIN FOR ALTAMIRA

Regression	Y =	135.03	+	0.763 a
Standard Errors		64.51		0.211
t statistics		2.093		3.613
Significance		0.047		0.001
Partial Correlation				0.586
	R-Squared =	0.34	F stat. =	13.06
	Std. error of est. =	97.54	Multiple R =	0.59
	P =	0.001	N =	27

Abbreviations: Y = March rain (mm)

a = April rain (mm)

Fig. B-3. -- March rainfall vs April rainfall for Altamira

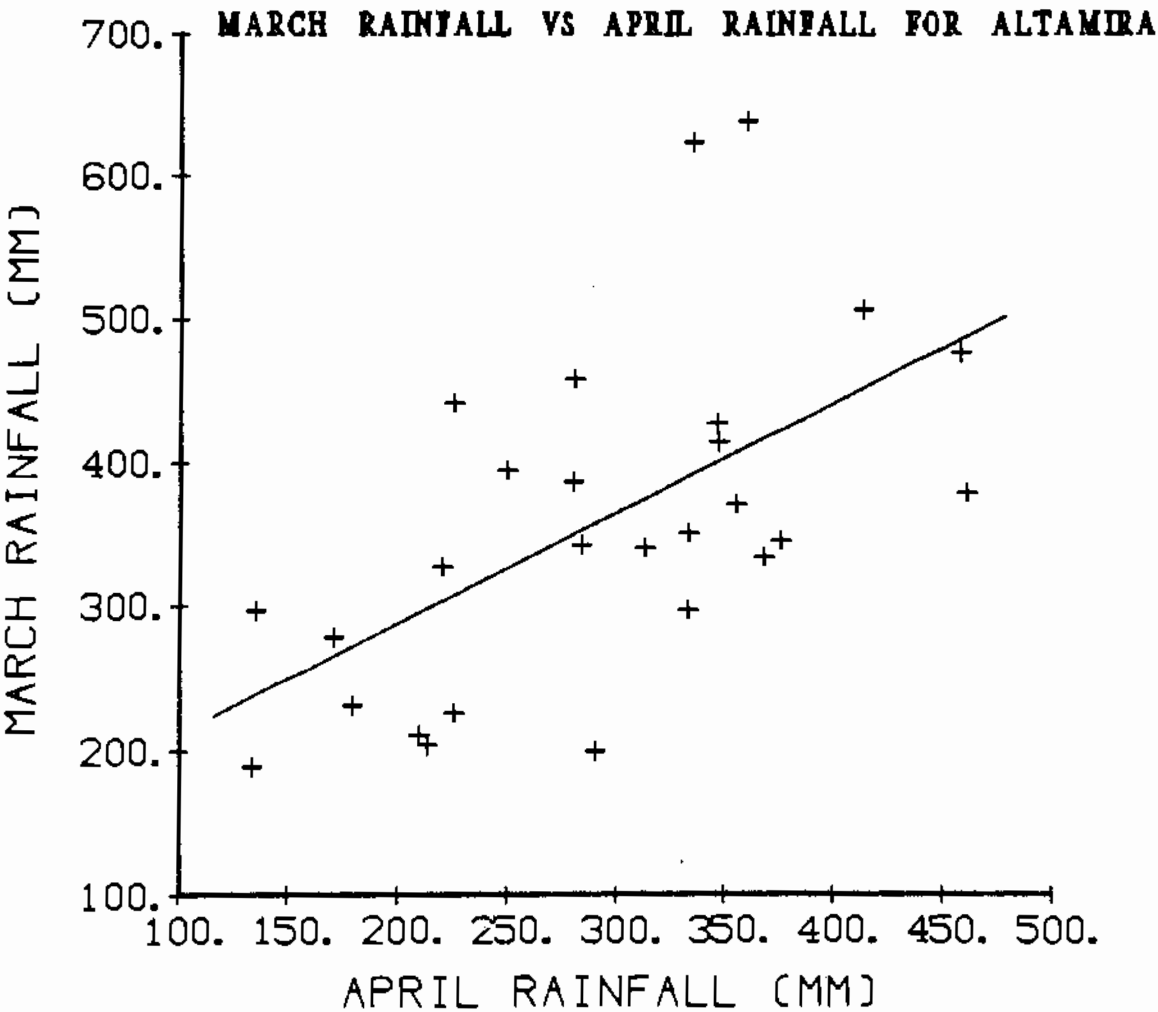

MARCH RAINFALL VS APRIL RAINFALL FOR ALTAMIRA
700.
600.
500.
400.
300.
200.
100.
MARCH RAINFALL (MM)
100.
150.
200.
250.
300.
350.
400.
450.
500.
APRIL RAINFALL (MM)

TABLE D-5.

MONTHLY RAINFALLS AS PROPORTIONS OF PERIOD TOTALS

MONTH	N	MEAN	STANDARD DEVIATION
proportions of rainy period (Jan. - May) totals			
Jan.	21	0.1778	0.0588
Feb.	21	0.2141	0.0380
Mar.	21	0.2631	0.0502
Apr.	21	0.2136	0.0505
May	21	0.1312	0.0522
rainfalls in mm for months not included in periods			
Jun.	30	77.58	48.18
Jul.	28	58.82	50.74
Aug.	27	28.07	22.39
proportions of burning period (Sept. - Dec.) totals			
Sep.	12	0.1862	0.1095
Oct.	12	0.1995	0.1075
Nov.	12	0.1850	0.1377
Dec.	12	0.4293	0.1026

TABLE B-6.

REGRESSION OF MONTHLY INSOLATION ON MONTHLY RAINFALL

Regression	Y =	156.68	-	0.180 a
Standard Errors		11.015		0.045
t statistics		14.224		-3.999
Significance		<0.0001		0.0002
Partial Correlation				-0.521
	R-Squared =	0.27	F stat. =	15.99
	Std. error of est. =	44.05	Multiple R =	0.52
	P =	0.0002	N =	45

Abbreviations: Y = Monthly insolation (hours)

a = Monthly rainfall (mm)

Fig. B-4. -- Monthly insolation vs monthly rainfall for Altamira

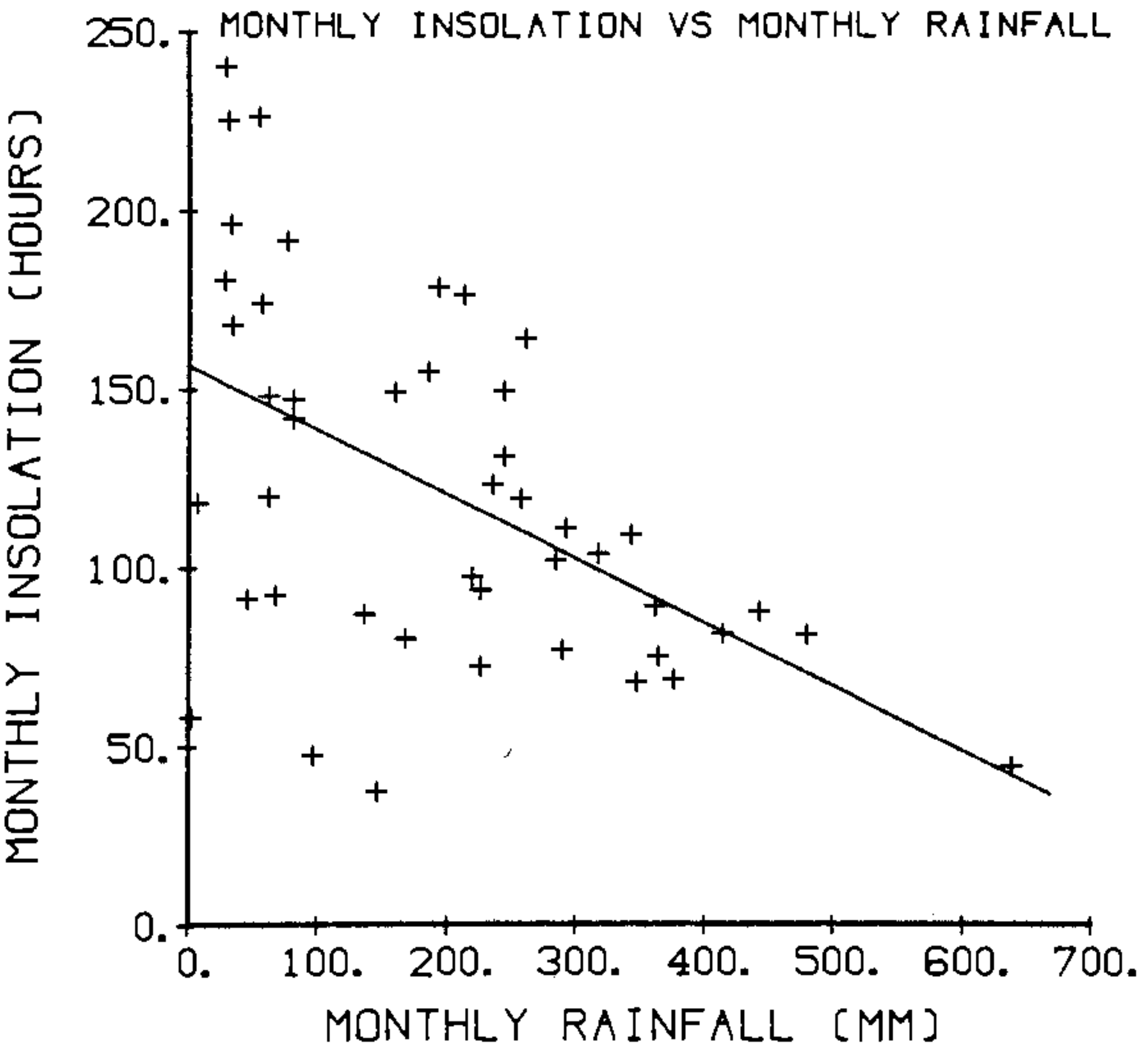

MONTHLY INSOLATION VS MONTHLY RAINFALL
MONTHLY INSOLATION (HOURS)
250.
200.
150.
100.
50.
0.
0.
100.
200.
300.
400.
500.
600.
700.
MONTHLY RAINFALL (MM)

TABLE B-7.

REGRESSION OF MONTHLY EVAPORATION ON MONTHLY RAINFALL

Regression	Y =	102.04	-	0.150 a
Standard Errors		0.018		0.033
t statistics		12.727		-4.572
Significance		<0.0001		<0.0001
Partial Correlation				-0.572
	R-Squared =	0.33	F stat. =	20.90
	Std. error of est. =	32.06	Multiple R =	0.57
	P <	0.0001	N =	45

Abbreviations: Y = Monthly evaporation (mm)

a = Monthly rainfall (mm)

Fig. 8-5. -- Monthly evaporation vs monthly rainfall for Altamira

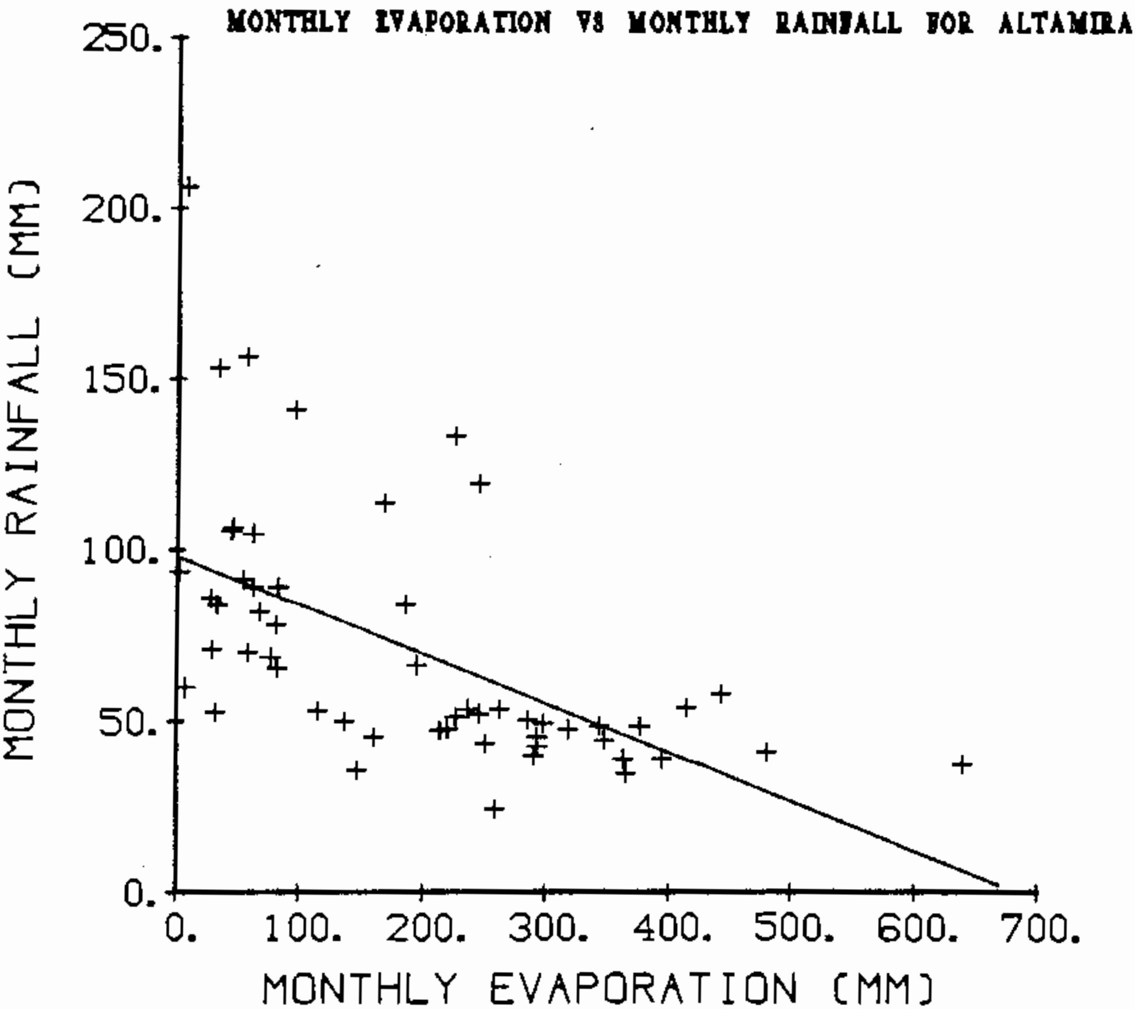

MONTHLY EVAPORATION VS MONTHLY RAINFALL FOR ALTAMIRA
MONTHLY RAINFALL (MM)
250.
200.
150.
100.
50.
0.
0.
100.
200.
300.
400.
500.
600.
700.
MONTHLY EVAPORATION (MM)

TABLE B-8.

BURN QUALITY CLASSIFICATION FOR VIRGIN BURNS

BURN QUALITY	DEFINITION
none	No burn was attempted (therefore no date for burning).
0	Burn attempted (therefore with burning date) but did not burn. There may be some blackened bark and burned leaves, but the ground remains "raw". Usually the colonist cannot plant. "Não queimou".
1	Bad burn. Only leaves and small twigs burned. Only maize can be planted without a great deal of coivara (piling up unburned material to clear land for planting) "Queimou ruim", "Só pecou as folhas."
2	Patchy burn. A mixture of class 1 and 3 patches where fire burned with varying intensity. Can be planted with coivara. "Mais ou menos quemou." "Quemou variado."
3	Good burn. Burned wood as well as twigs and leaves, although larger logs are invariably only partly burned. Can be planted with rice with no or very little coivara. "Quemou bém."
4	Overburned. Large logs burned completely to ashes. This "burns the earth" and results in stunted crops. "Quemou até que quemou a terra."

Fig. B-6. -- Poor burns are a major agricultural problem. Burn quality can be predicted from clearing and burning dates and weather information. This is a class one virgin burn.

TABLE B-9.

VIRGIN BURN QUALITY PREDICTION DISCRIMINANT ANALYSIS

VARIABLE	COEFFICIENTS	
	Bad burn	Good burn
Constant:	-6.1617	-7.5752
rain between felling and burning (mm)	0.0032459	0.0012662
evaporation between felling and burning (mm)	-0.0035933	-0.000052735
insolation between felling and burning (hours)	0.0034928	0.0025793
rain in 15 days previous to burn (mm)	0.076949	0.088626
evaporation in 15 days previous to burn (mm)	0.15809	0.01027
insolation in 15 days previous to burn (mm)	0.038381	0.031593
general variances	2.43×10^{22}	2.26×10^{20}
sample sizes	76	171

Equality of covariances: df=21, 83234 F=22.47 Signif. < 0.0001

Mahalanobis distance: $D^2 = 0.686$

F statistic = 5.89

Significance < 0.0001

TABLE B-10.

OBSERVED AND PREDICTED VIRGIN BURN QUALITIES

PREDICTED BURN QUALITY	OBSERVED BURN QUALITY		total
	bad(1)	good(2)	
bad(1)	15 (83.3%)	3 (16.7%)	18 (100%)
good(2)	61 (26.6%)	168 (73.4%)	229 (100%)
TOTALS	76	171	247

Number correctly predicted is 183 of 247 cases or 74%

(1) "bad" burns are lumped class D and 1 virgin burns.

(2) "good" burns are lumped class 2 and 3 virgin burns.

TABLE B-11.

SECOND GROWTH CUTTING AND BURNING MONTH DISTRIBUTIONS

ITEM	MONTH								TOTAL
	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	
				cutting					
number	1	8	8	39	24	20	10	1	111
percent	0.9	7.2	7.2	35.1	21.6	18.0	9.0	0.9	100
				burning					
number	0	0	4	10	50	37	13	5	119
percent	0	0	3.4	8.4	42.0	31.1	10.9	4.2	100

mean days between cutting and burning = 52.6 (S.D.=96.1 N = 79)

TABLE B-12.

SECOND GROWTH BURN QUALITY PREDICTION DISCRIMINANT ANALYSIS

VARIABLE	COEFFICIENTS	
	Bad burn	Good burn
Constant:	-0.32692	-1.0033
rain between cutting and burning (mm)	0.00048378	-0.0033761
evaporation between cutting and burning (mm)	-0.013939	-0.020641
insolation between cutting and burning (hours)	0.0029030	0.00060930
general variances	8.92×10^{11}	1.29×10^{13}
sample sizes	31	23
Equality of covariances: df=6, 15499 F=5.78 Signif. < 0.0001		
Mahalanobis distance: $D^2 = 0.566$		
F statistic = 2.39		
Significance = 0.0793		

TABLE D-13.

OBSERVED AND PREDICTED SECOND GROWTH BURN QUALITIES

PREDICTED BURN QUALITY	OBSERVED BURN QUALITY		total
	bad(1)	good(2)	
bad(1)	26 (65.0%)	14 (35.0%)	40 (100%)
good(2)	5 (35.7%)	9 (64.3%)	14 (100%)
TOTALS	31	23	54

Number correctly predicted is 35 of 54 cases or 65%

(1) "bad" burns are lumped class 0 and 1 second growth burns.

(2) "good" burns are lumped class 2 and 3 second growth burns.

APPENDIX C

BURN EFFECTS ON SOIL FERTILITY

TABLE C-1.

MULTIPLE REGRESSION FOR pH CHANGES WITH VIRGIN BURNS WITH INITIAL pH LESS THAN 4.0

Regression	Y =	1.538 -	0.266 a -	0.230 b
Standard Errors		0.111	0.0714	0.0290
t statistics		13.802	-3.720	-7.035
Significance		<0.0001	0.0004	<0.0001
Partial Correlations			-0.376	-0.655
	R-Squared =	0.48	F stat. =	38.07
	Std. error of est. =	0.609	Multiple R =	0.69
	P <	0.0001	N =	87

Abbreviations: Y = pH change

a = virgin burn quality dummy variable (+1 if bad; -1 if good)

b = initial Al^{+++} (ME/100g)

Fig. C-1. -- Virgin burn pH change regression observed vs predicted values for initial pH less than 4.0.

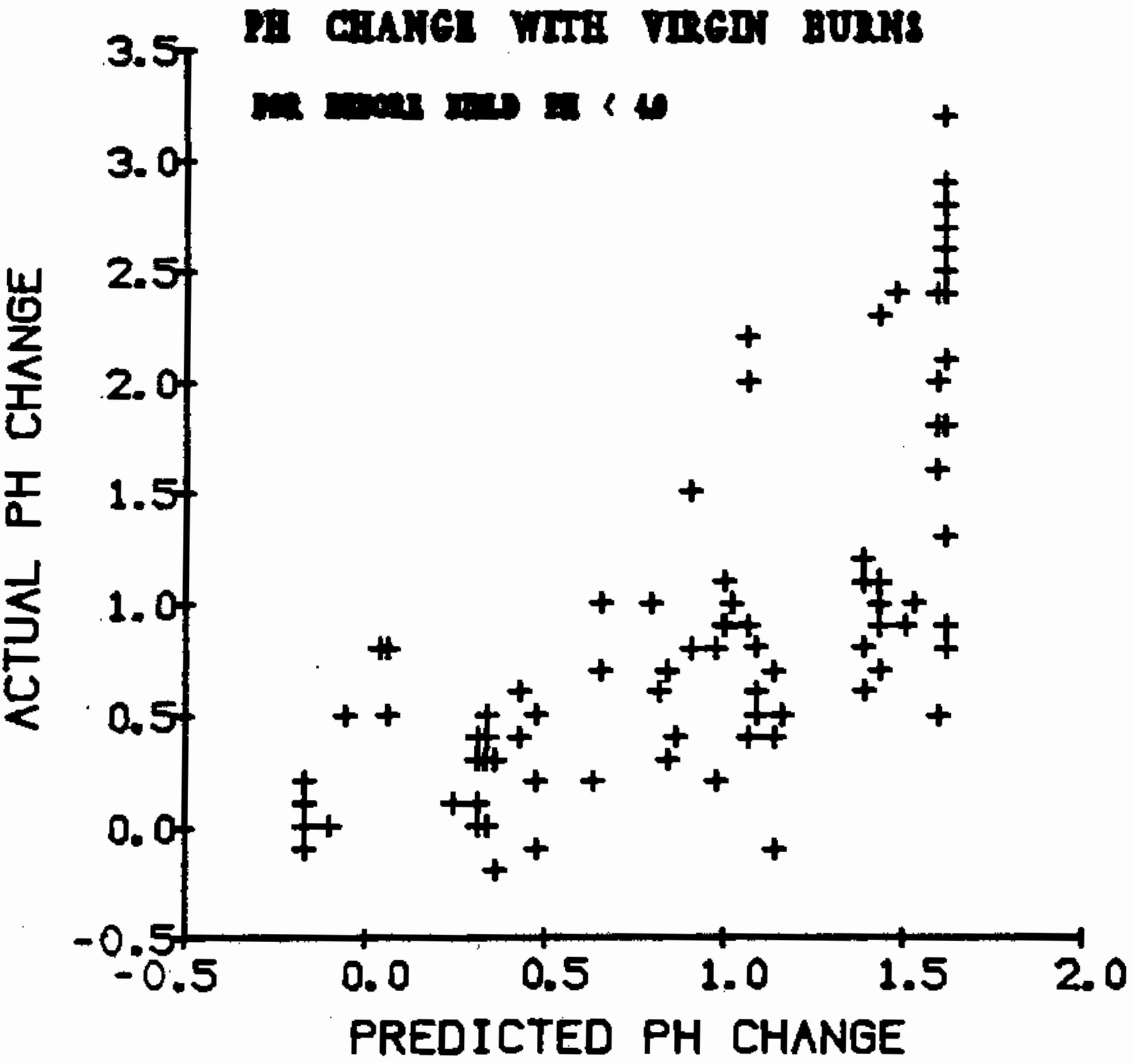

PH CHANGE WITH VIRGIN BURNS
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
ACTUAL PH CHANGE
-0.5
0.0
0.5
1.0
1.5
2.0
PREDICTED PH CHANGE

TABLE C-2.

MULTIPLE REGRESSION FOR pH CHANGES WITH VIRGIN BURNS WITH INITIAL pH FROM 4.0 TO 5.0

Regression	Y =	1.888 -	0.0311 a -	0.0668 b
Standard Errors		0.264	0.00627	0.0367
t statistics		7.154	-4.965	-1.818
Significance		<0.0001	<0.0001	0.0737
Partial Correlations			-0.527	-0.222
	R-Squared =	0.29	F stat. =	12.95
	Std. error of est. =	0.714	Multiple R =	0.54
	P <	0.0001	N =	67

Abbreviations: Y = pH change

a = initial total clay (%)

b = predicted erosion per year (mm) (see Fearnside 1978i for erosion prediction equations)

479

Fig. C-2. -- Virgin burn pH change regression observed vs predicted values for initial pH from 4.0 to 5.0.

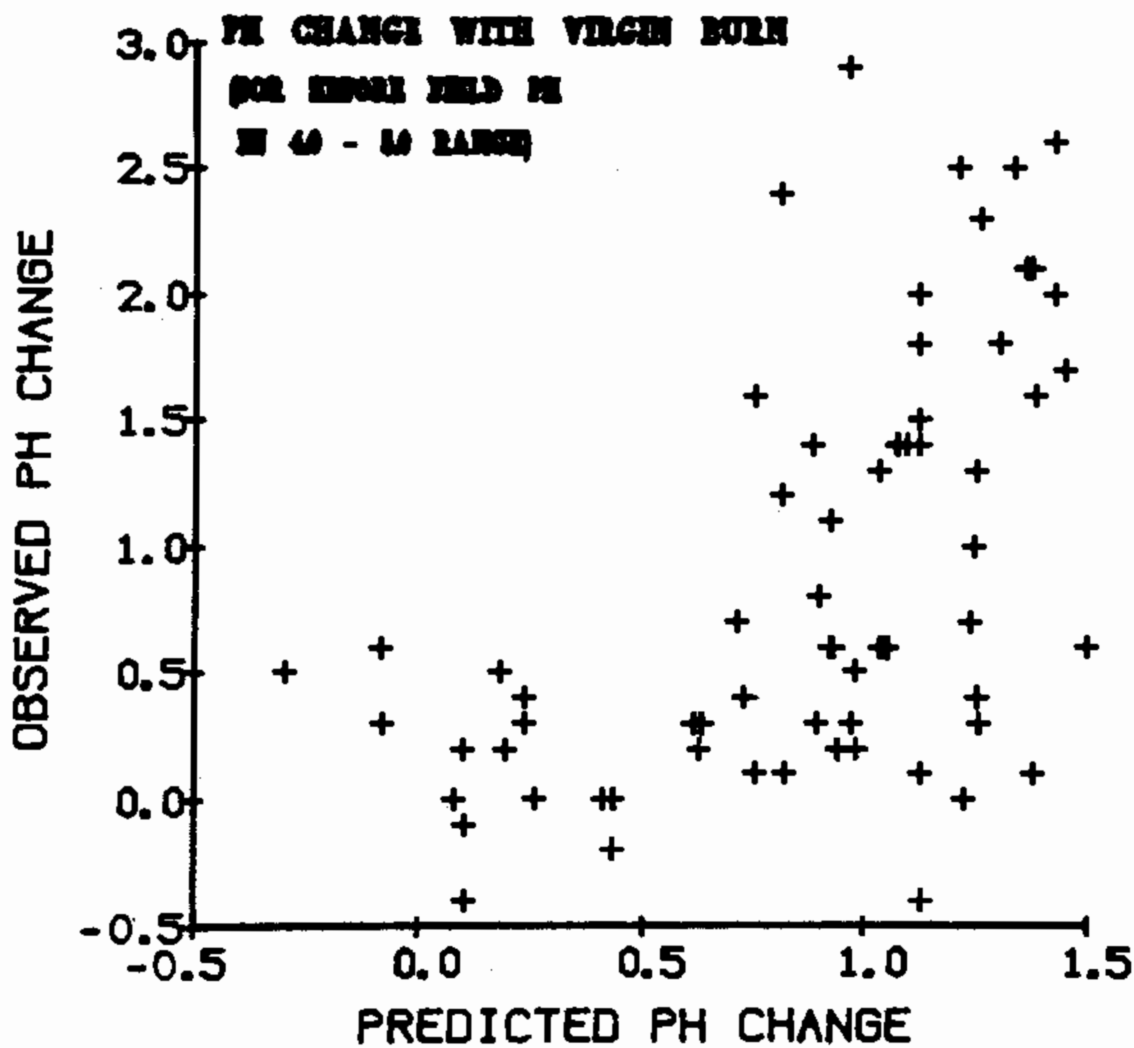

PH CHANGE WITH VIRGIN BURN
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
OBSERVED PH CHANGE
-0.5
0.0
0.5
1.0
1.5
PREDICTED PH CHANGE

TABLE C-3.

MULTIPLE REGRESSION FOR pH CHANGES WITH VIRGIN BURNS FOR INITIAL pH GREATER THAN 5.0

Regression	Y =	5.207 -	0.180 A	- 0.814 B	- 0.000609 C
Standard Errors		0.606	0.0537	0.1065	0.000175
t statistics		8.584	-3.345	-7.640	-3.474
Significance		<0.0001	0.001	<0.0001	<0.001
Partial Correlations			-0.245	-0.499	-0.253
	R-Squared =	0.31	F stat. = 26.91		
	N =	180	Multiple R = 0.56		
	P <	0.0001	Std. error = 0.717		

Abbreviations: Y = pH change

A = virgin burn quality dummy variable
(+1 for bad burns; -1 for good burns)

B = initial pH

C = days in annual crops

Fig. C-3. -- pH change regression observed vs predicted with virgin burns for initial pH greater than 5.0 Values

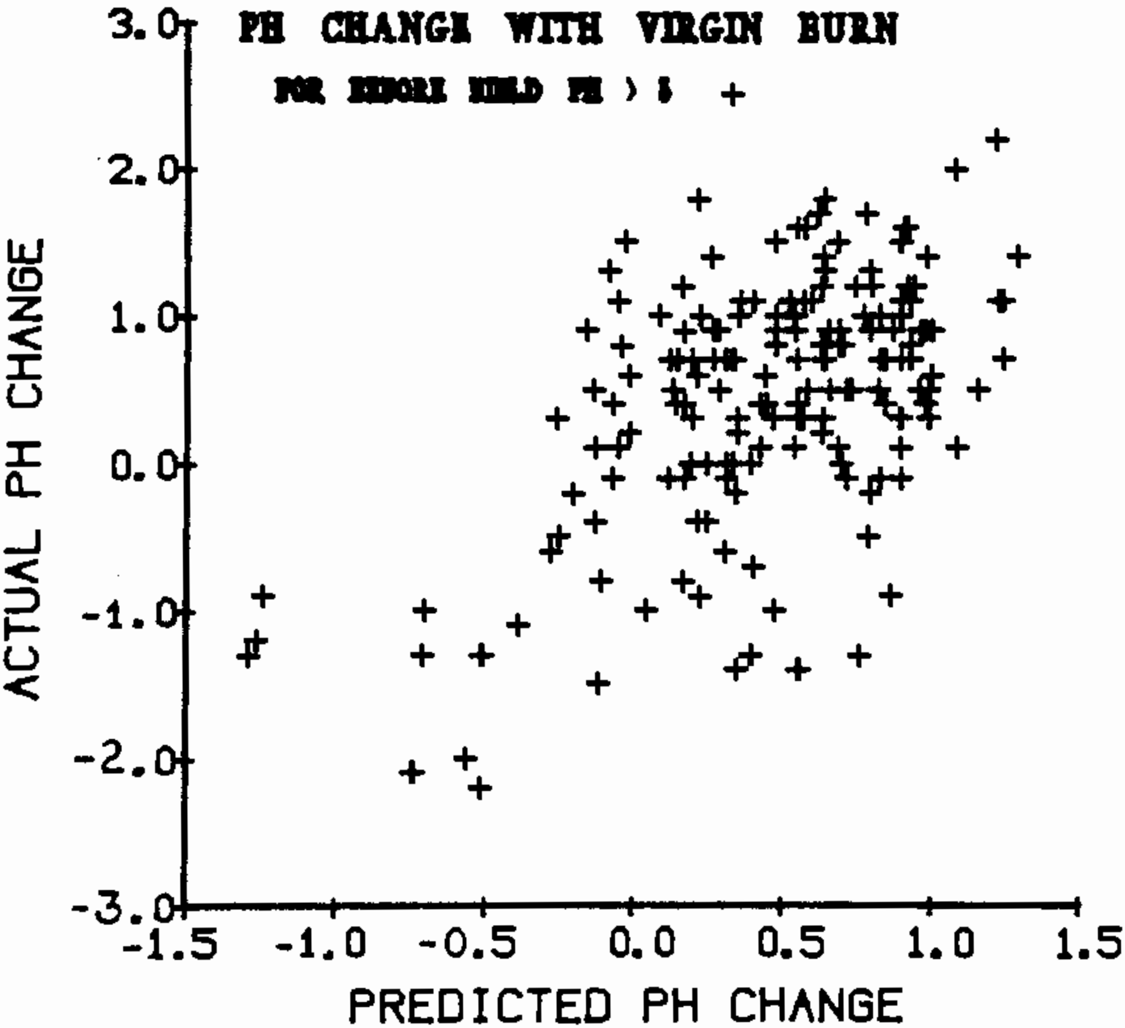

PH CHANGE WITH VIRGIN BURN
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
ACTUAL PH CHANGE
PREDICTED PH CHANGE

TABLE C-4.

MULTIPLE REGRESSION FOR ALUMINUM CHANGES WITH VIRGIN BURNS

Regression	Y =	0.295 -	0.222 a -	0.224 b
Standard Errors		0.129	0.0376	0.0907
t statistics		2.297	-5.897	2.472
Significance		0.022	<0.0001	0.014
Partial Correlations			-0.324	0.142
	R-Squared =	0.13	F stat. =	22.93
	Std. error of est. =	1.489	Multiple R =	0.37
	P <	0.0001	N =	299

Abbreviations: Y = Aluminum change (ME/100g)

a = initial Al^{+++} (ME/100g)

b = virgin burn quality dummy variable (+1 if bad; -1 if good)

Fig. C-4. -- Virgin burn aluminum change regression observed vs predicted

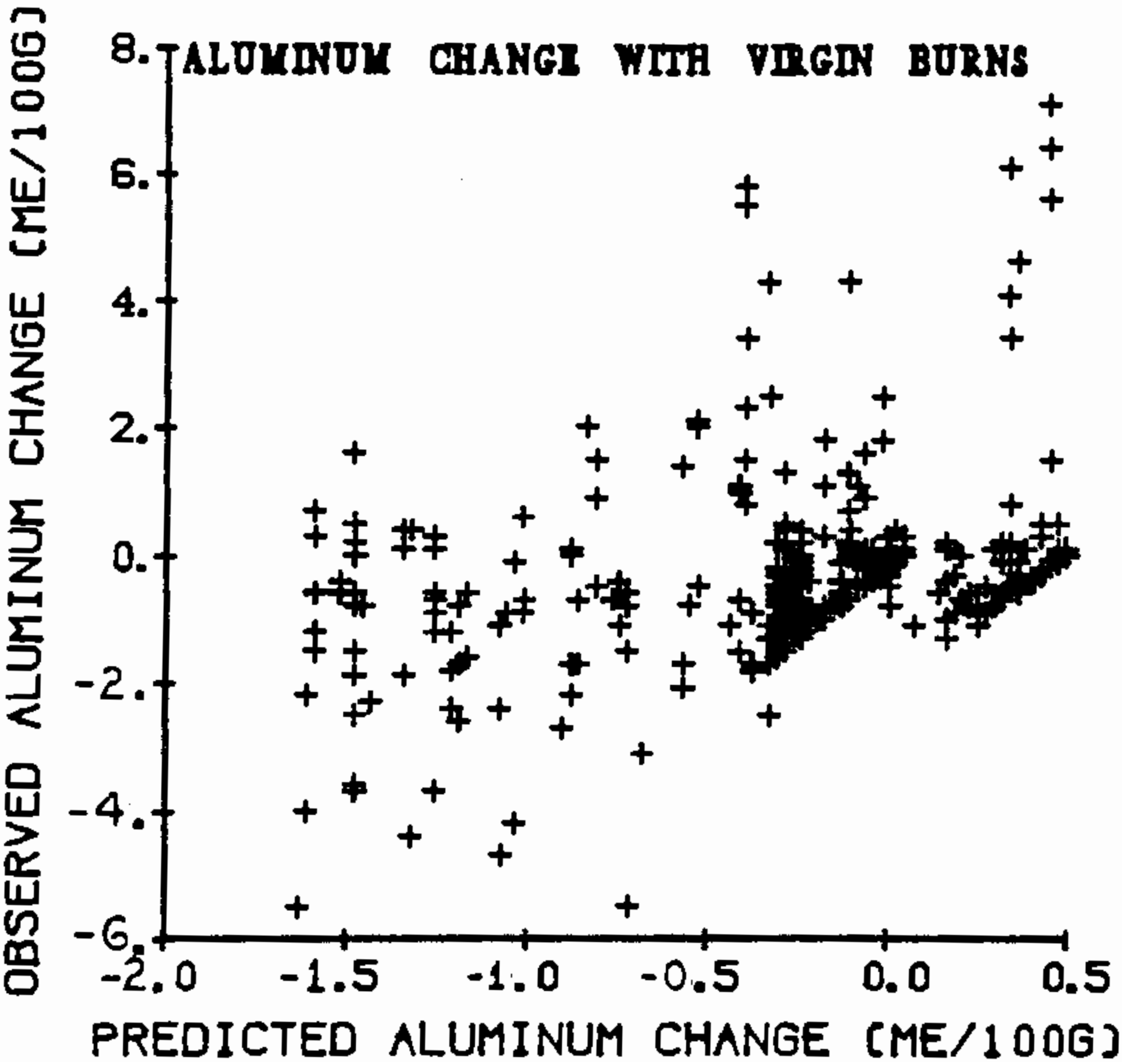

ALUMINUM CHANGE WITH VIRGIN BURNS
OBSERVED ALUMINUM CHANGE (ME/100G)
8.
6.
4.
2.
0.
-2.
-4.
-6
-2.0
-1.5
-1.0
-0.5
0.0
0.5
PREDICTED ALUMINUM CHANGE (ME/100G)

TABLE C-5.

MULTIPLE REGRESSION FOR PHOSPHORUS CHANGES WITH VIRGIN BURNS

Regression	Y =	-0.778 +	0.677 a -	0.357 b
Standard Errors		0.288	0.0613	0.1514
t statistics		-2.702	11.034	-2.358
Significance		0.007	<0.0001	0.019
Partial Correlations			0.454	-0.108
	R-Squared =	0.21	F stat. =	63.48
	Std. error of est. =	3.255	Multiple R =	0.46
	P <	0.0001	N =	473

Abbreviations: Y = phosphorus change (ppm)

a = predicted phosphorus change from unburned regression (see Fearnside 1978j)

b = virgin burn quality dummy variable (+1 if bad; -1 if good)

Fig. C-5. -- Virgin burn phosphorus Change Regression Observed vs Predicted Values

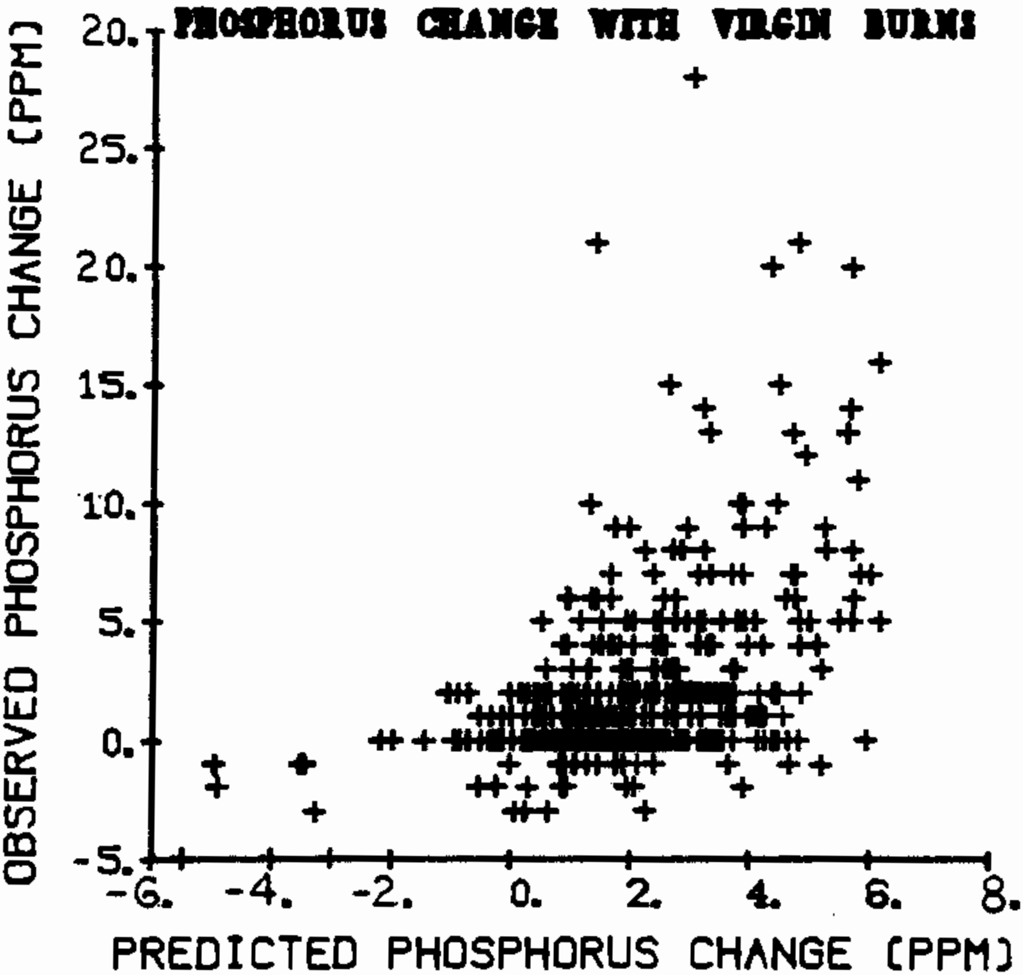

PHOSPHORUS CHANGE WITH VIRGIN BURNS
OBSERVED PHOSPHORUS CHANGE (PPM)
PREDICTED PHOSPHORUS CHANGE (PPM)
20.
25.
20.
15.
10.
5.
0.
-5.
-6.
-4.
-2.
0.
2.
4.
6.
8.

TABLE C-6.

MULTIPLE REGRESSION OF NITROGEN CHANGE WITH VIRGIN BURNS

Regression	Y =	-0.0583 -	0.654 A	+	0.0489 B + 0.0263 C
Standard Errors		0.0653	0.2111	0.0335	0.0128
t statistics		-0.889	-3.098	1.458	2.048
Significance		0.378	0.003	0.152	0.046
Partial Correlations			-0.408	0.206	0.283
	R-Squared =	0.21	F stat. =	4.32	
	N =	52	Multiple R =	0.46	
	P <	0.01	Std. error =	0.0588	

Abbreviations: Y = Nitrogen change (% dry weight)

A = initial nitrogen (% dry weight)

B = initial carbon (% dry weight)

C = initial pH

Fig. C-6. -- Nitrogen change with virgin burns regressio
observed vs predicted values.

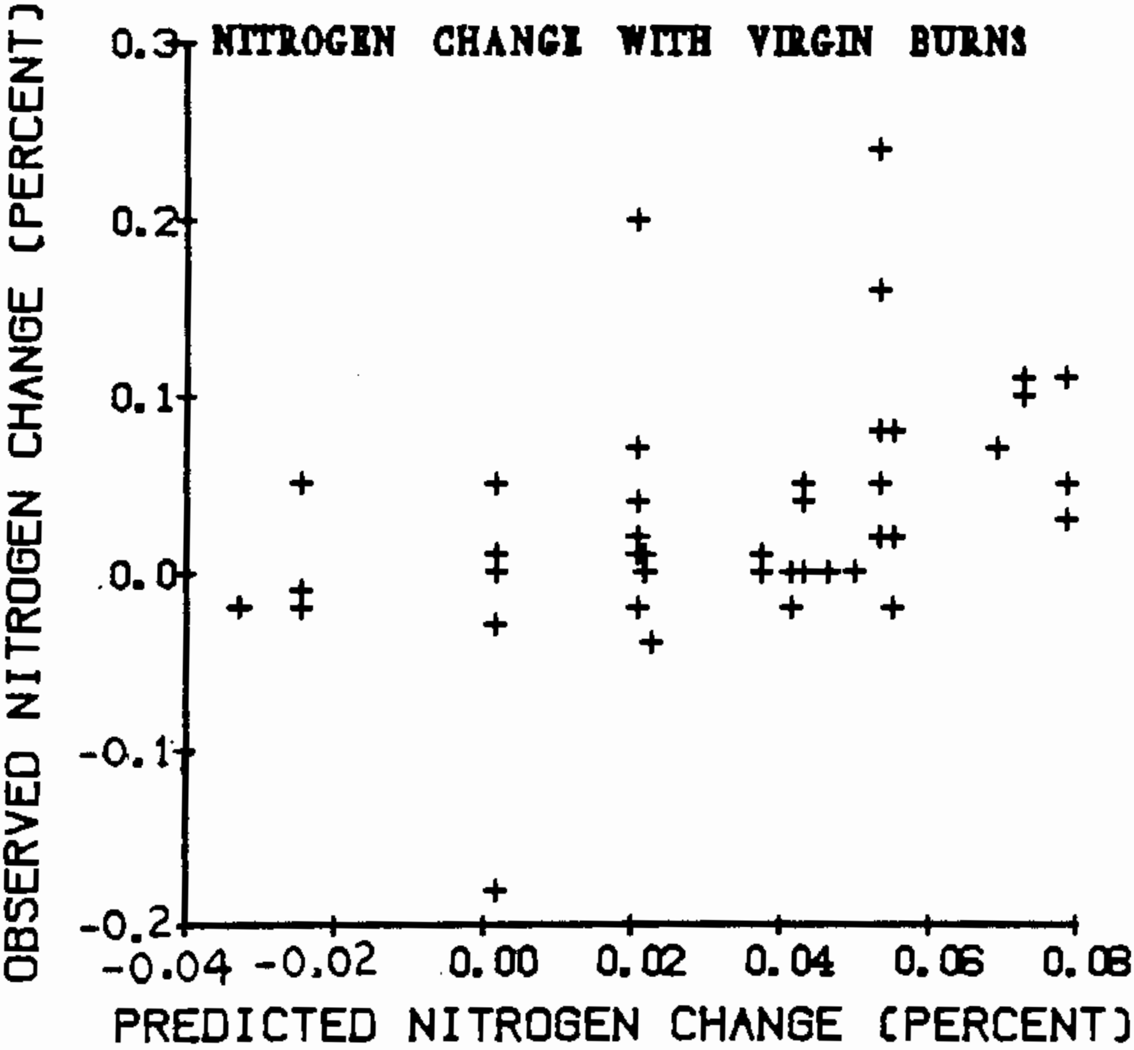

NITROGEN CHANGE WITH VIRGIN BURNS
OBSERVED NITROGEN CHANGE (PERCENT)
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.04
-0.02
0.00
0.02
0.04
0.06
0.08
PREDICTED NITROGEN CHANGE (PERCENT)

TABLE C-7.

MULTIPLE REGRESSION OF pH CHANGE WITH SECOND GROWTH BURNS

Regression	Y =	3.4817	-	0.22603 A		-	0.23129 B	- 0.51750 C	- 0.00033683 D
Standard Errors		0.555		0.0464			0.0660	0.1030	0.000132
t statistics		6.293		-4.874			-3.506	-5.024	-2.557
Significance		<0.0001		<0.0001			<0.001	<0.0001	0.012
Partial Correlations				-0.465			-0.354	-0.476	-0.266
	R-Squared =	0.34		F stat. =	11.29				
	N =	91		Multiple R =	0.59				
	P <	0.0001		Std. error =	0.686				

Abbreviations: Y = pH change

A = initial Al^{+++} (ME/100g)

B = aluminum change (ME/100g)

C = initial pH

D = days in annual crops

Fig. C-7. -- pH change with second growth burns regres
observed vs predicted values.

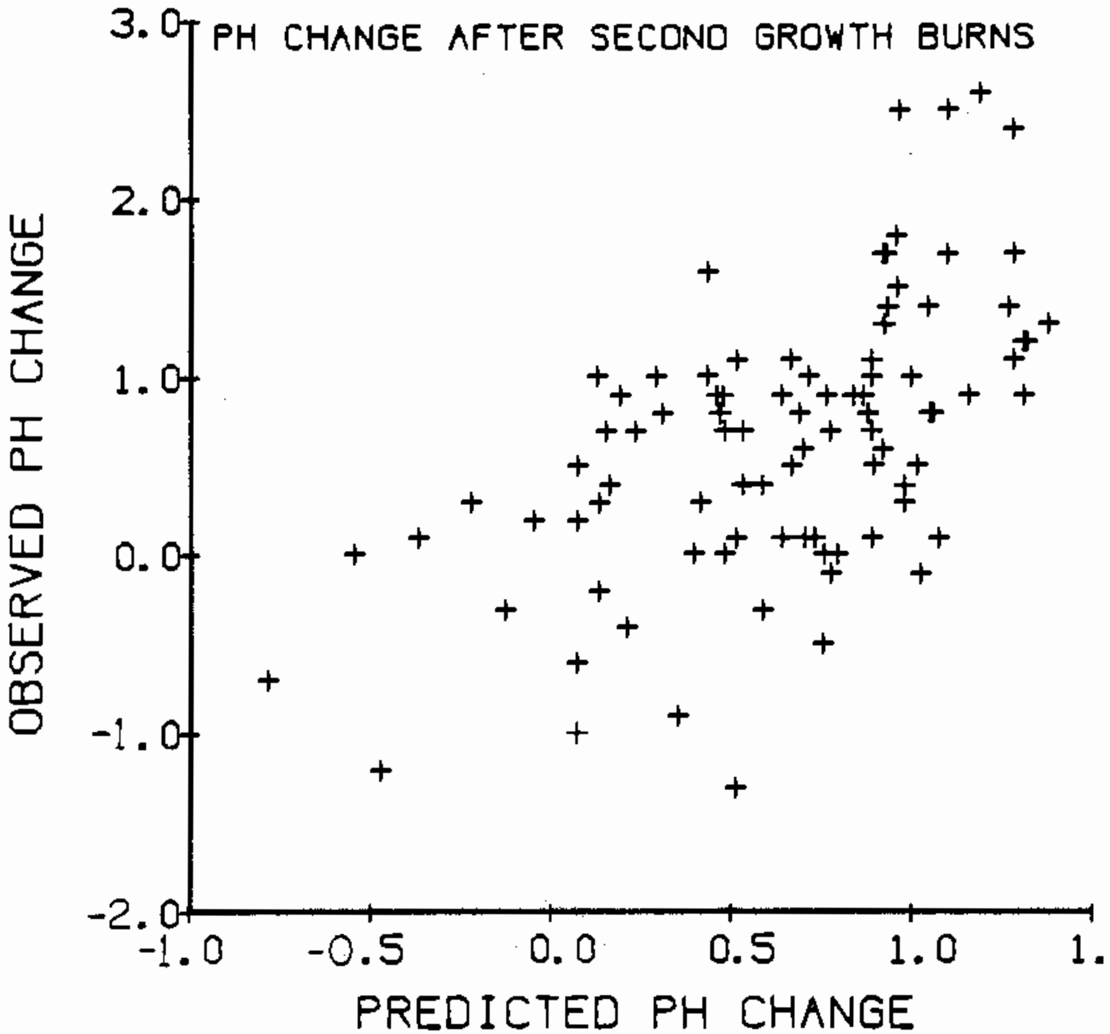

PH CHANGE AFTER SECOND GROWTH BURNS
OBSERVED PH CHANGE
PREDICTED PH CHANGE
3.0
2.0
1.0
0.0
-1.0
-2.0
-1.0
-0.5
0.0
0.5
1.0
1.

TABLE C-8.

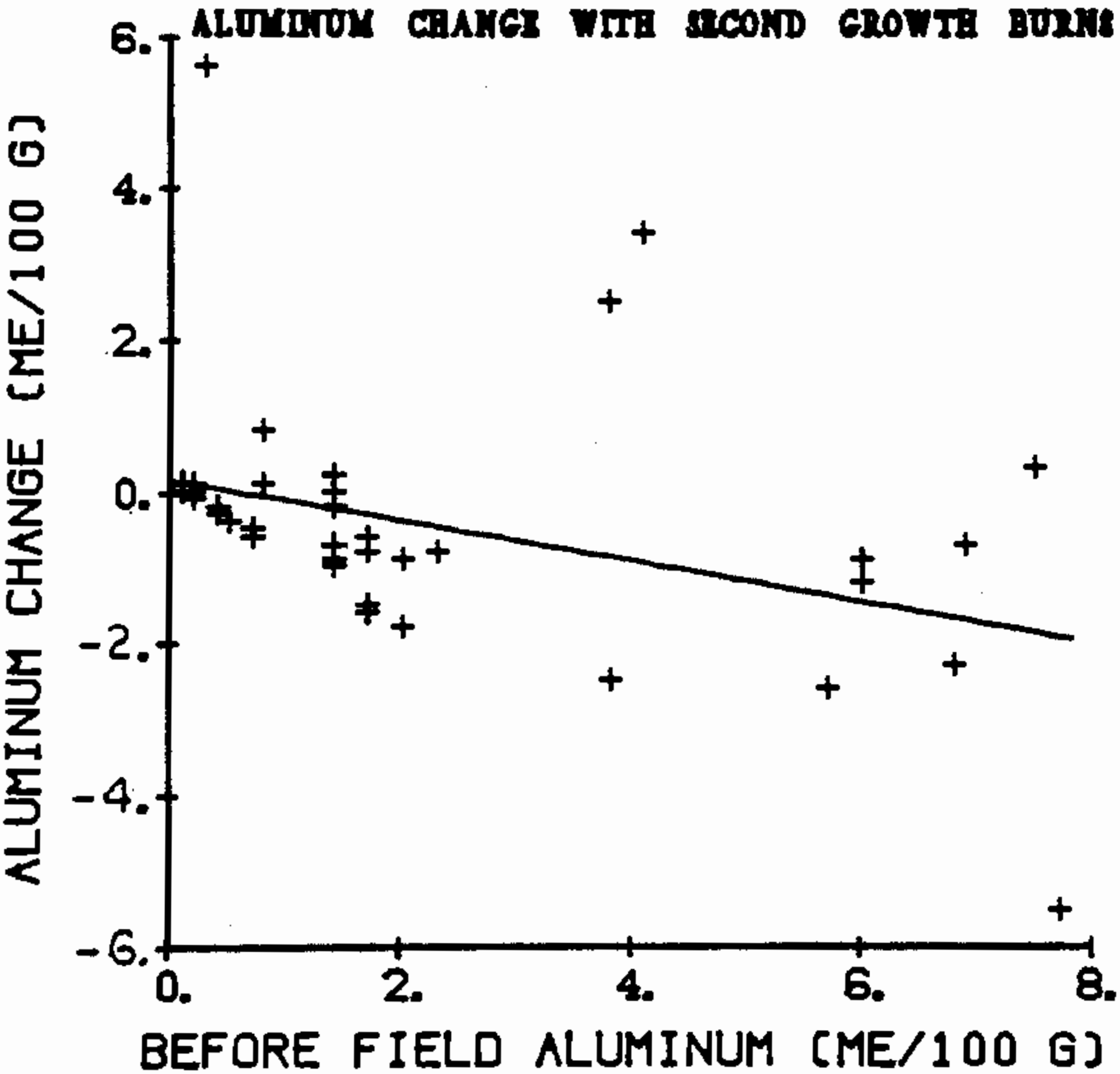
REGRESSION OF ALUMINUM CHANGE WITH SECOND GROWTH BURNS

Regression	Y =	0.16551	-	0.26687 a	
Standard Errors		0.324		0.104	
t statistics		0.511		-2.555	
Significance		0.612		0.015	
Partial Correlation				-0.375	
	R-Squared =	0.14	F stat. =	6.53	
	Std. error of est. =	1.53	Multiple R =	0.37	
	P =	0.015	N =	42	

Abbreviations: Y = aluminum change (ME/100g)

a = initial Al^{+++} (ME/100g)

Fig. C-8. -- Aluminum Change with Second Growth Bur
Before field Aluminum



ALUMINUM CHANGE WITH SECOND GROWTH BURNS
ALUMINUM CHANGE (ME/100 G)
6.
4.
2.
0.
-2.
-4.
-6.
0.
2.
4.
6.
8.
BEFORE FIELD ALUMINUM (ME/100 G)

TABLE C-9.

MULTIPLE REGRESSION FOR PHOSPHORUS CHANGES WITH SECOND GROWTH BURNS

Regression	Y =	-1.5170 +	0.74065 a -	0.83055 b
Standard Errors		0.637	0.135	0.317
t statistics		-2.382	5.484	-2.623
Significance		0.012	<0.0001	0.011
Partial Correlations			0.535	-0.290
	R-Squared =	0.31	F stat. =	17.07
	Std. error of est. =	2.620	Multiple R =	0.56
	P <	0.0001	N =	78

Abbreviations: Y = phosphorus change (ppm)

a = predicted phosphorus change from unburned regression (see Fearnside 1978j)

b = second growth burn quality dummy variable (+1 if bad; -1 if good)

Fig. C-9. -- Second growth burn phosphorus change regression observed vs predicted values

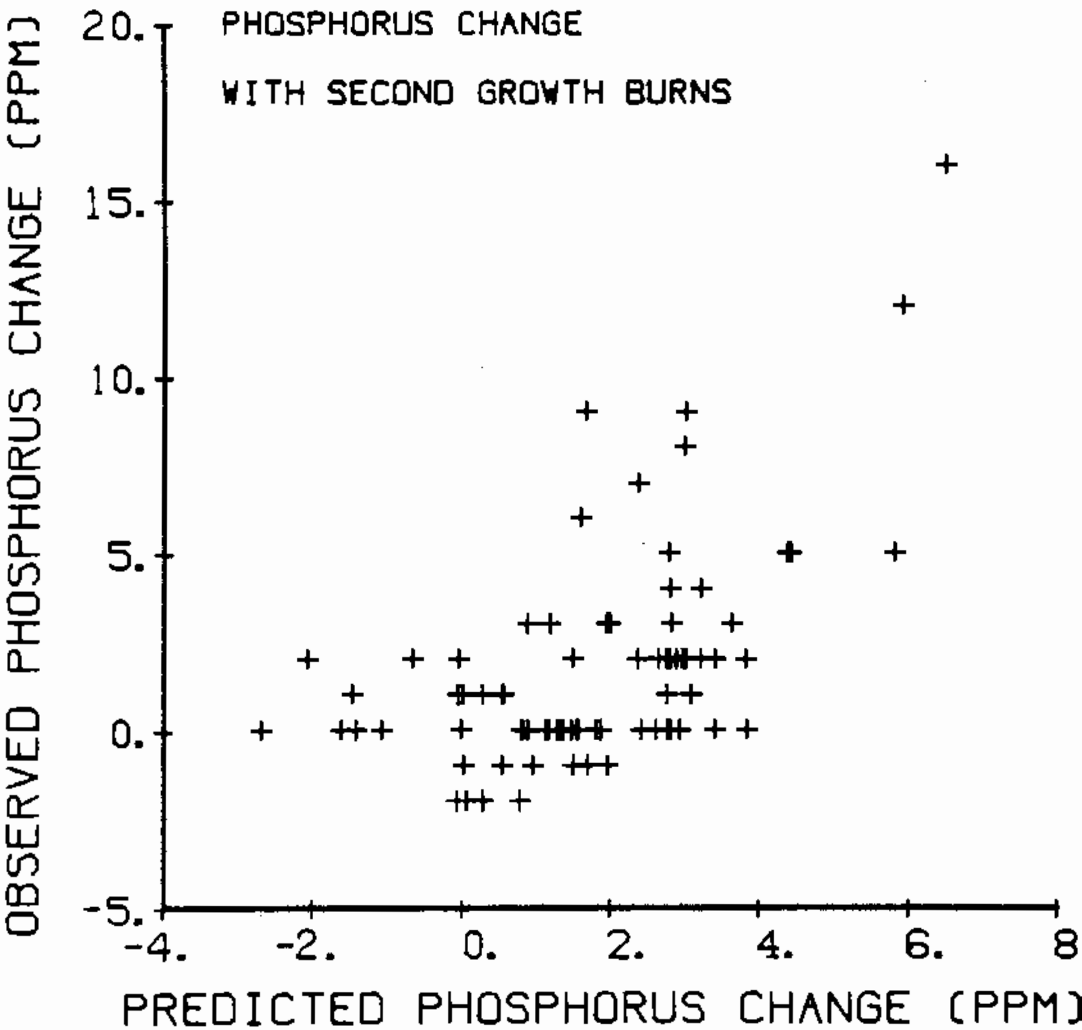

PHOSPHORUS CHANGE
WITH SECOND GROWTH BURNS
OBSERVED PHOSPHORUS CHANGE (PPM)
20.
15.
10.
5.
0.
-5.
-4.
-2.
0.
2.
4.
6.
8
PREDICTED PHOSPHORUS CHANGE (PPM)

TABLE C-10.

MULTIPLE REGRESSION FOR pH CHANGES WITH WEED BURNS

Regression	Y =	2.9749 -	0.16504 a -	0.51659 b
Standard Errors		0.6939	0.0717	0.1161
t statistics		4.287	-2.303	-4.449
Significance		0.0001	0.025	<0.0001
Partial Correlations			-0.287	-0.501
	R-Squared =	0.26	F stat. =	10.11
	Std. error of est. =	0.74525	Multiple R =	0.51
	P =	0.0002	N =	62

Abbreviations: Y = pH change

a = initial pH

b = initial Al^{+++} (ME/100g)

Fig. C-10. -- Weed burn pH change regression observed vs predicted values

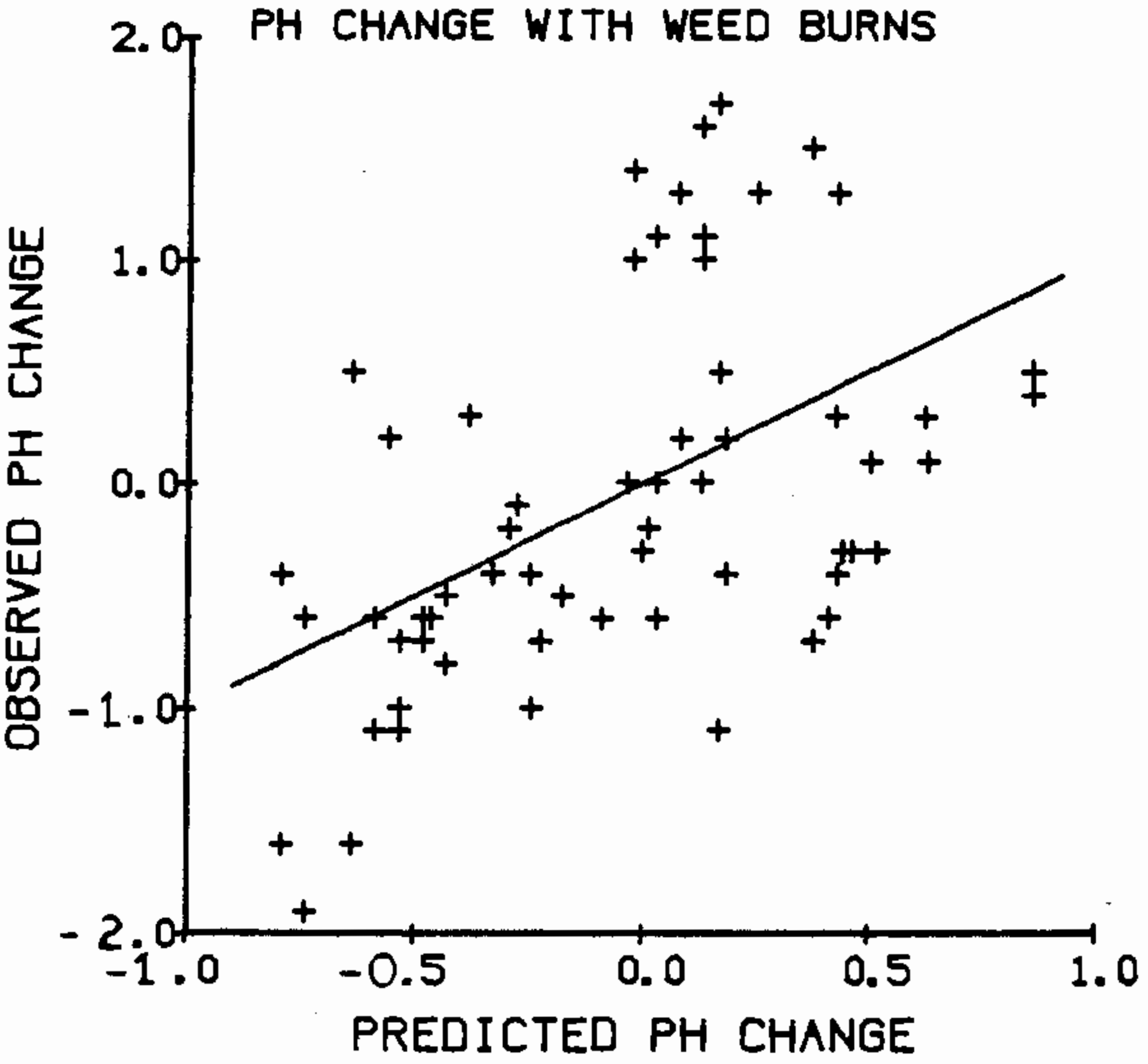

PH CHANGE WITH WEED BURNS
2.0
1.0
0.0
-1.0
-2.0
-1.0
-0.5
0.0
0.5
1.0
OBSERVED PH CHANGE
PREDICTED PH CHANGE

TABLE C-11.

REGRESSION OF ALUMINUM CHANGE WITH WEED BURNS

Regression	Y =	0.55043	-	0.39232 a
Standard Errors		0.509		0.163
t statistics		1.081		-2.403
Significance		0.290		0.024
Partial Correlation				-0.426
	R-Squared =	0.18	F stat. =	5.78
	Std. error of est. =	1.8503	Multiple R =	0.43
	P =	0.024	N =	28

Abbreviations: Y = aluminum change (ME/100g)

a = aluminum of before field (ME/100g)

Fig. C-11. -- Aluminum change vs before field aluminum with weed burns.

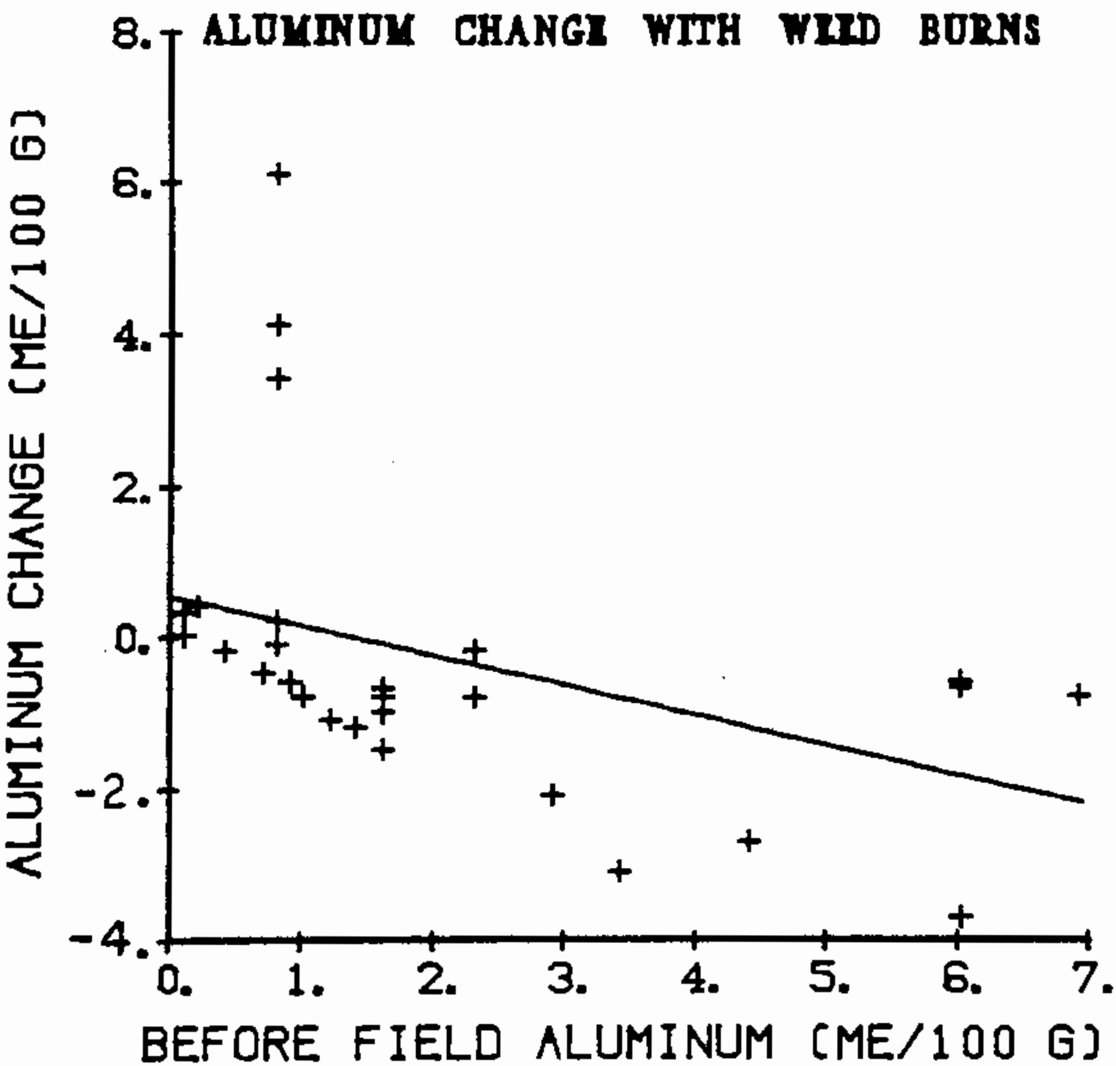

ALUMINUM CHANGE WITH WEED BURNS
ALUMINUM CHANGE (ME/100 G)
8.
6.
4.
2.
0.
-2.
-4.
0.
1.
2.
3.
4.
5.
6.
7.
BEFORE FIELD ALUMINUM (ME/100 G)

TABLE C-12.

REGRESSION OF PHOSPHORUS CHANGE WITH WEED BURNS[1]

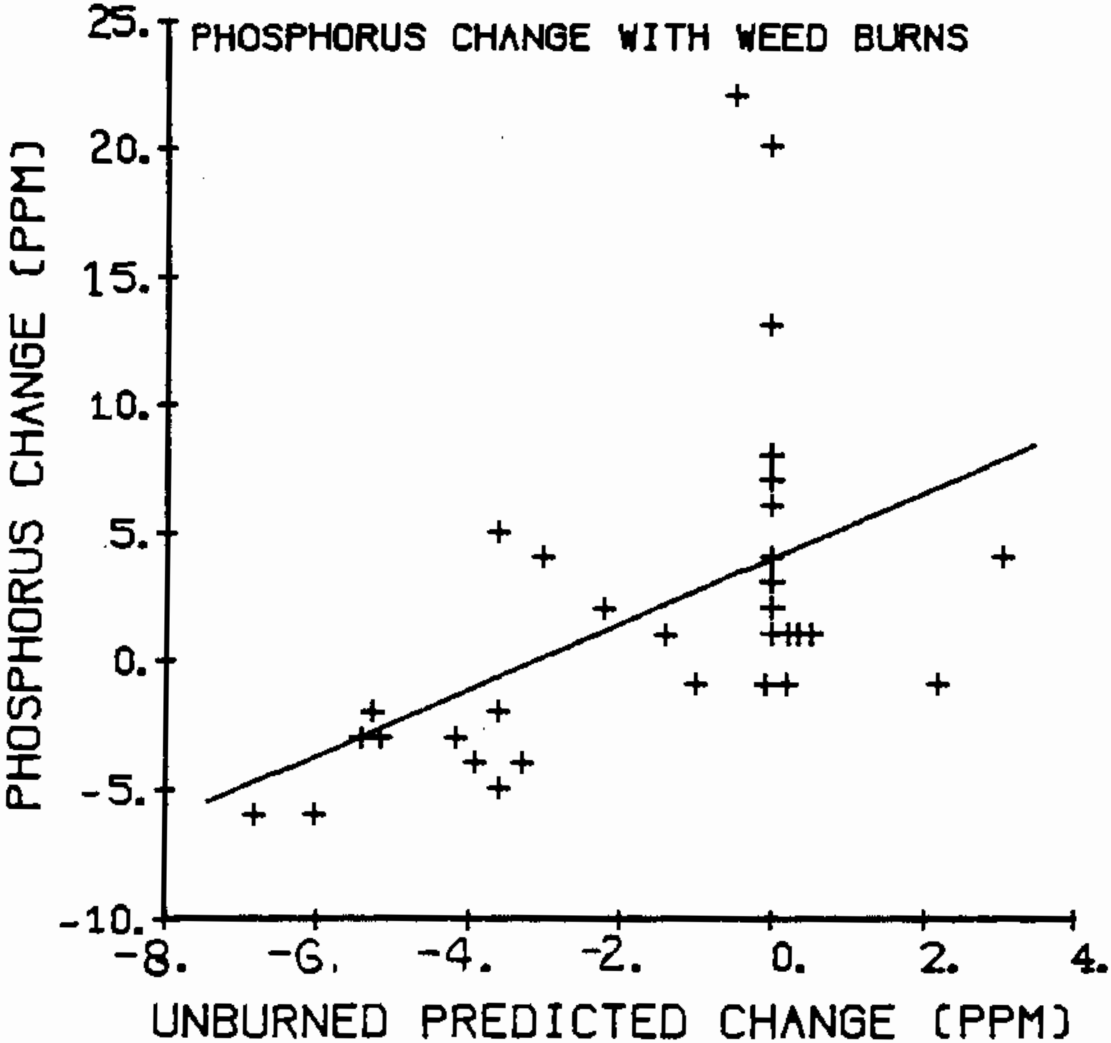
Regression	Y =	3.9375	+	1.2668 a
Standard Errors		0.844		0.335
t statistics		4.666		3.778
Significance		<0.0001		<0.001
Partial Correlation				0.499
	R-Squared =	0.25	F stat. =	14.27
	Std. error of est. =	5.0023	Multiple R =	0.50
	P <	0.001	N =	45

Abbreviations: Y = phosphorus change (ppm)

a = predicted phosphorus change per year from unburned regression (ppm) (see Fearnside 1978j)

[1] for non-zero phosphorus changes only. Probability of zero change is 0.262 (N = 61).

Fig. C-12. -- Phosphorus change with weed burns Pasture


PHOSPHORUS CHANGE WITH WEED BURNS
PHOSPHORUS CHANGE (PPM)
UNBURNED PREDICTED CHANGE (PPM)
25.
20.
15.
10.
5.
0.
-5.
-10.
-8.
-6.
-4.
-2.
0.
2.
4.

APPENDIX D

SOIL EROSION PREDICTION

Fig. D-1. Erosion measurement stake showing typical drop in soil surface level on the order of one centimeter per year under annual crops. Stakes were arranged in 47 plots of 15 stakes each for erosion prediction with different land uses and slopes.

Fig. D-2. -- Erosion in fields bare or in annual crops on the day of maximum rainfall observed vs predicted values.

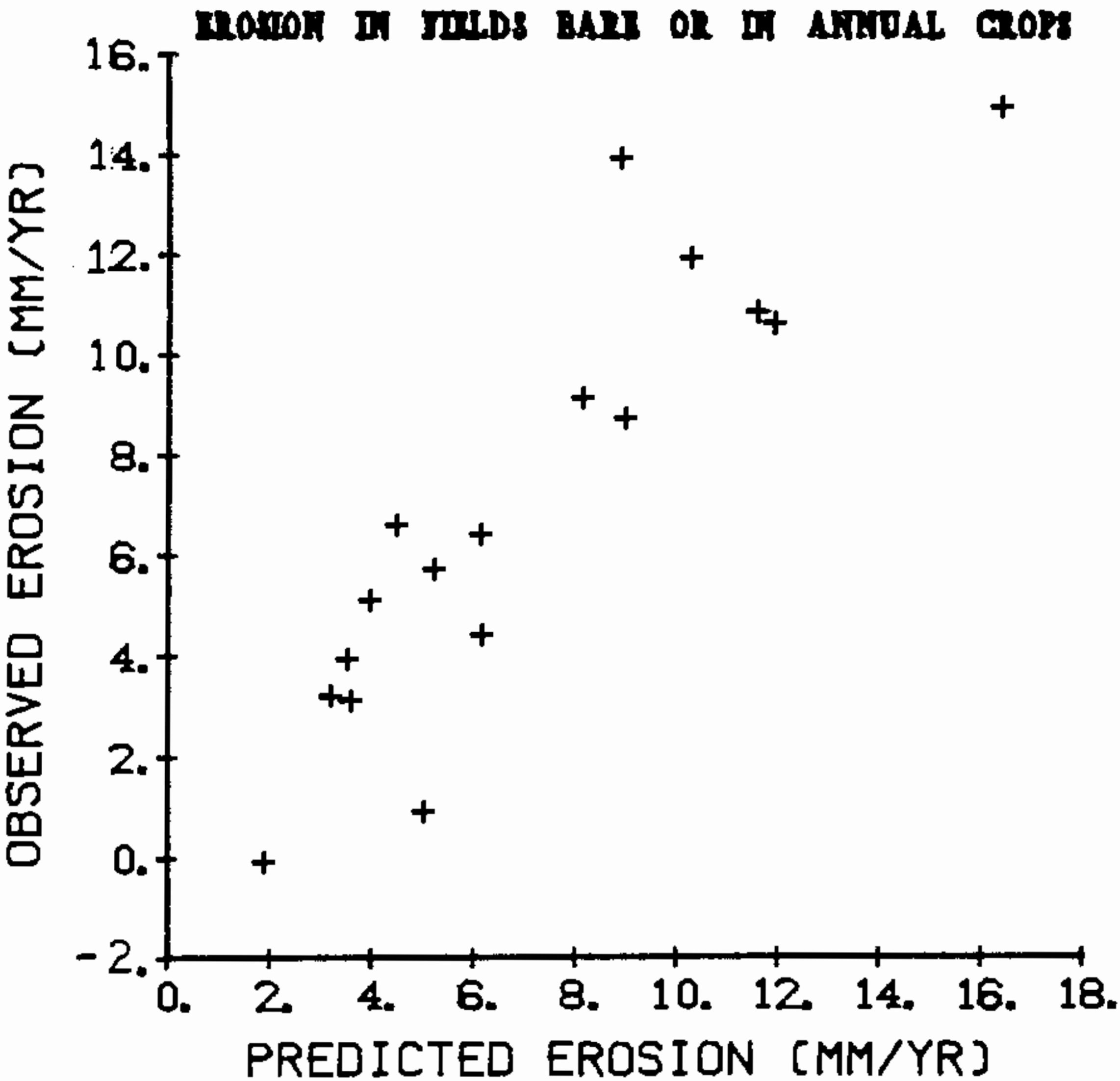
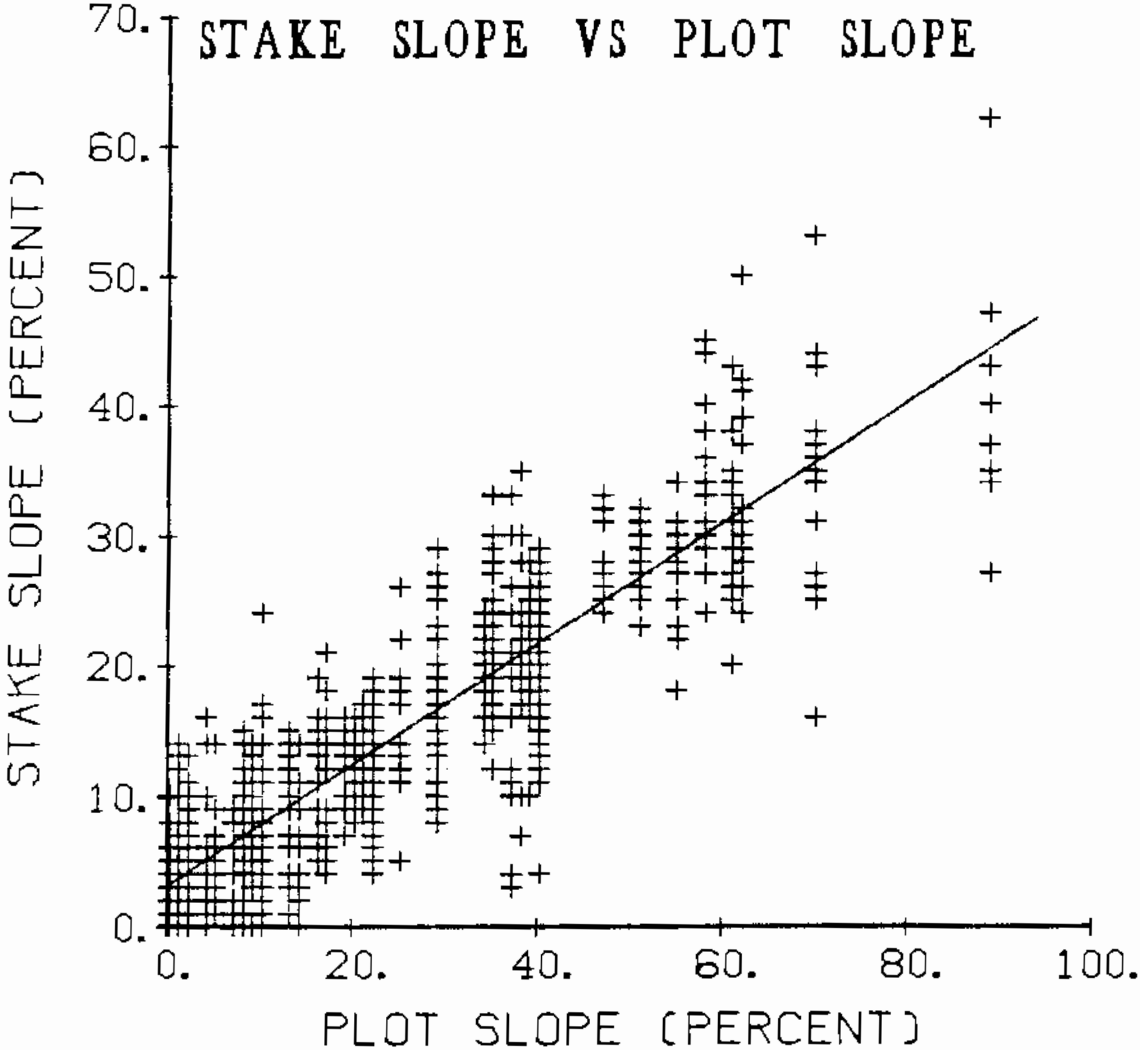
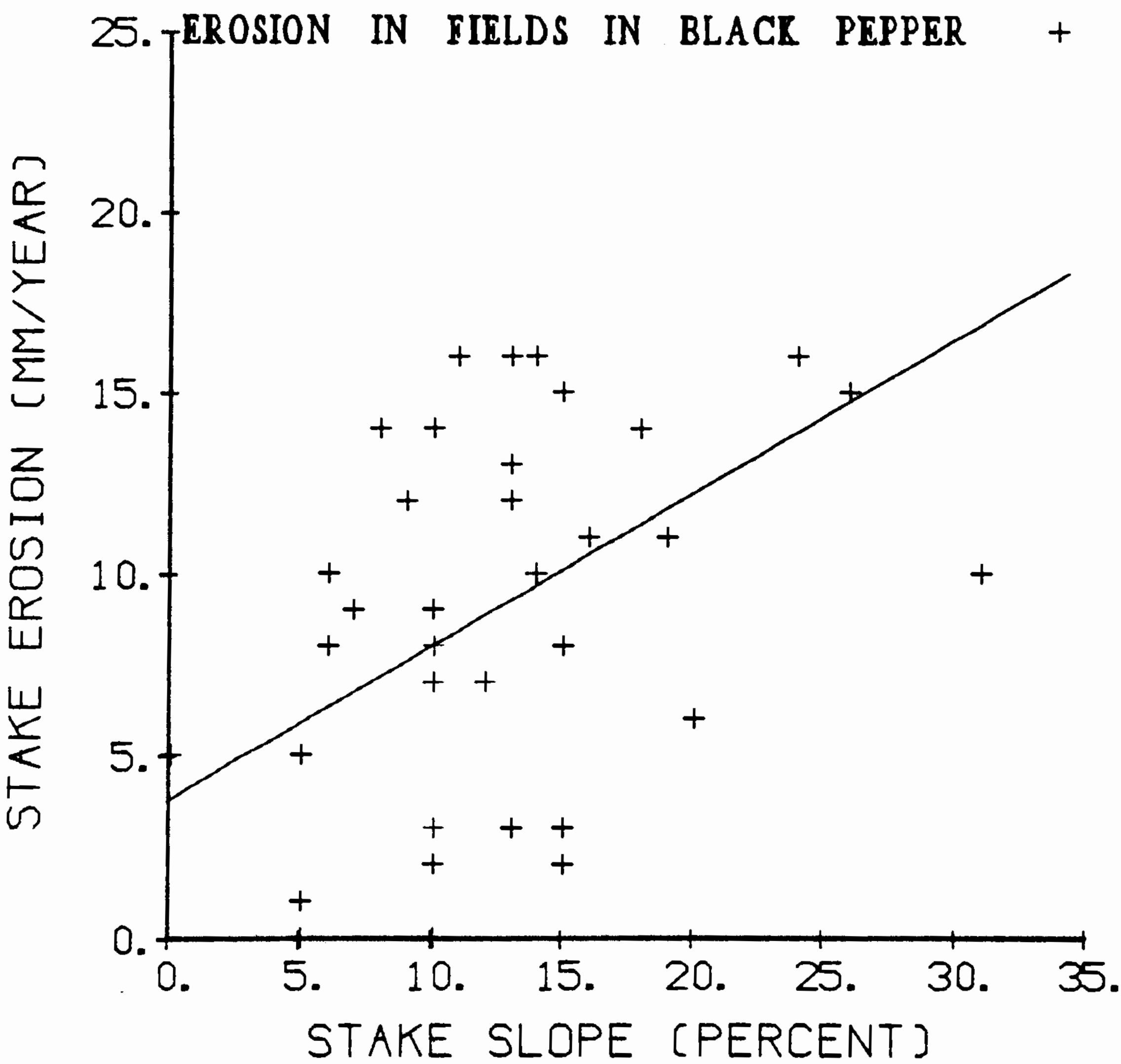

EROSION IN FIELDS BARE OR IN ANNUAL CROPS
OBSERVED EROSION (MM/YR)
PREDICTED EROSION (MM/YR)
16.
14.
12.
10.
8.
6.
4.
2.
0.
-2.
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.

Fig. D-3. -- Stake slope vs plot slope for erosion stakes.



STAKE SLOPE VS PLOT SLOPE
STAKE SLOPE (PERCENT)
PLOT SLOPE (PERCENT)
0.
10.
20.
30.
40.
50.
60.
70.
0.
20.
40.
60.
80.
100.

Fig. D-4. -- Stake erosion in fields in black pepper vs stake slope.


EROSION IN FIELDS IN BLACK PEPPER
STAKE EROSION (MM/YEAR)
STAKE SLOPE (PERCENT)
0.
5.
10.
15.
20.
25.
30.
35.

APPENDIX E

SOIL CHANGE PREDICTION UNDER VARIOUS CROPPING AND FALLOWING TREATMENTS

TABLE E-1.

REGRESSION OF pH CHANGE IN UNBURNED FIELDS VS BEFORE FIELD pH[1]

Regression	Y =	1.8594	-	0.41866 a
Standard Errors		0.265		0.0472
t statistics		7.022		-8.871
Significance		<0.0001		<0.0001
Partial Correlation				-0.476
	R-Squared =	0.23	F stat. =	78.70
	Std. error of est. =	0.84175	Multiple R =	0.48
	P <	0.0001	N =	270

Abbreviations: Y = pH change

a = pH of before field

(1) excluding pasture

Fig. E-1. -- pH change in unburned fields vs before field pH.

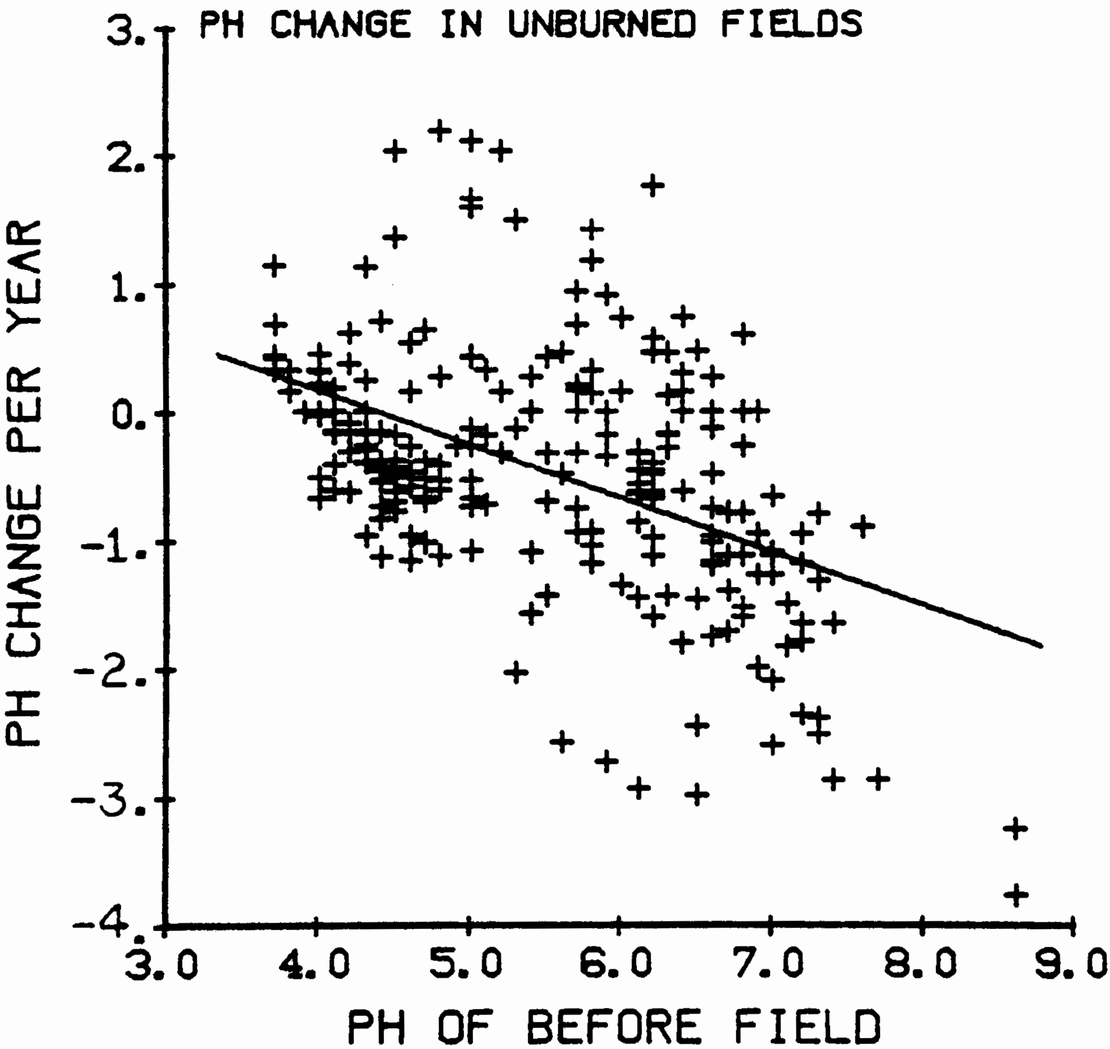

PH CHANGE IN UNBURNED FIELDS
3.
2.
1.
0.
-1.
-2.
-3.
-4.
PH CHANGE PER YEAR
3.0
4.0
5.0
6.0
7.0
8.0
9.0
PH OF BEFORE FIELD

TABLE E-2.

MULTIPLE REGRESSION FOR ALUMINUM CHANGES IN UNBURNED FIELDS(1)

Regression	Y =	0.0000048516	- 0.000015033 a	- 0.000151317 b
Standard Errors		0.0000226	0.00000656	0.0000299
t statistics		0.215	-2.290	-5.121
Significance		0.831	0.024	<0.0001
Partial Correlations			-0.230	-0.467
	R-Squared =	0.28	F stat. =	18.31
	Std. error of est. =	0.00014465	Multiple R =	0.53
	P <	0.0001	N =	97

Abbreviations: Y = Al^{+++} change (ME/100g)

a = Al^{+++} of before field (ME/100g)

b = pH change

(1) excuding fields with either before or after aluminum equal to zero and excluding pasture.

Fig. E-2. -- Aluminum change in unburned fields regression observed vs predicted values

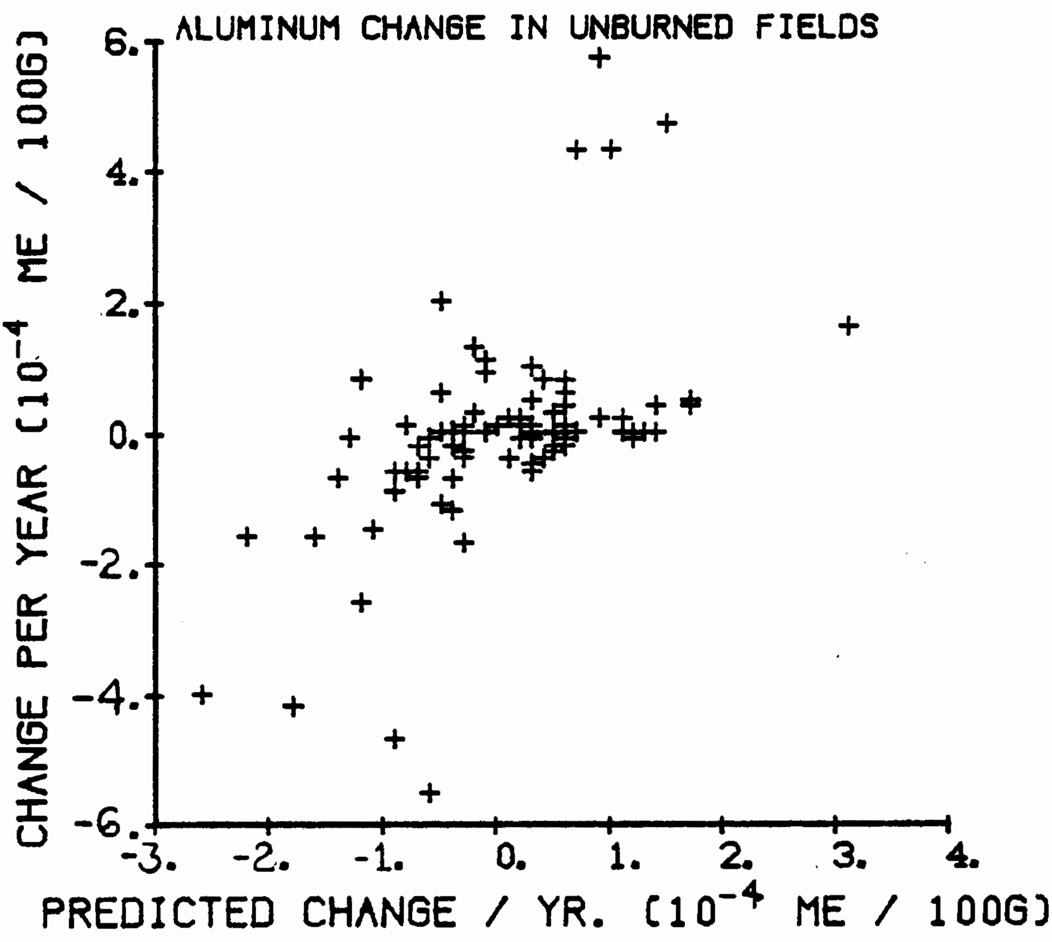

ALUMINUM CHANGE IN UNBURNED FIELDS
6.
4.
2.
0.
-2.
-4.
-6.
-3.
-2.
-1.
0.
1.
2.
3.
4.
CHANGE PER YEAR (10^-4 ME / 100G)
PREDICTED CHANGE / YR. (10^-4 ME / 100G)

TABLE E-3.

REGRESSION OF PHOSPHORUS UNBURNED CHANGE PER YEAR ON BEFORE FIELD pH FOR BEFORE FIELD PHOSPHORUS OF ONE PPM.

Regression	Y =	-3.4733	+	1.4143 a
Standard Errors		1.864		0.354
t statistics		-1.864		3.991
Significance		0.072		0.0004
Partial Correlation				0.576
	R-Squared =	0.33	F stat. =	15.93
	Std. error of est. =	1.9841	Multiple R =	0.58
	P =	0.0004	N =	34

Abbreviations: Y = Phosphorus change per year (ppm)

a = Before field pH [1] Excluding pasture. Probability of zero change = 0.648 (N = 108)

Fig. E-3. -- Phosphorus change per year in unburned fields vs before field pH for fields with before field phosphorus equal to one ppm. Excluding pasture and zero changes.

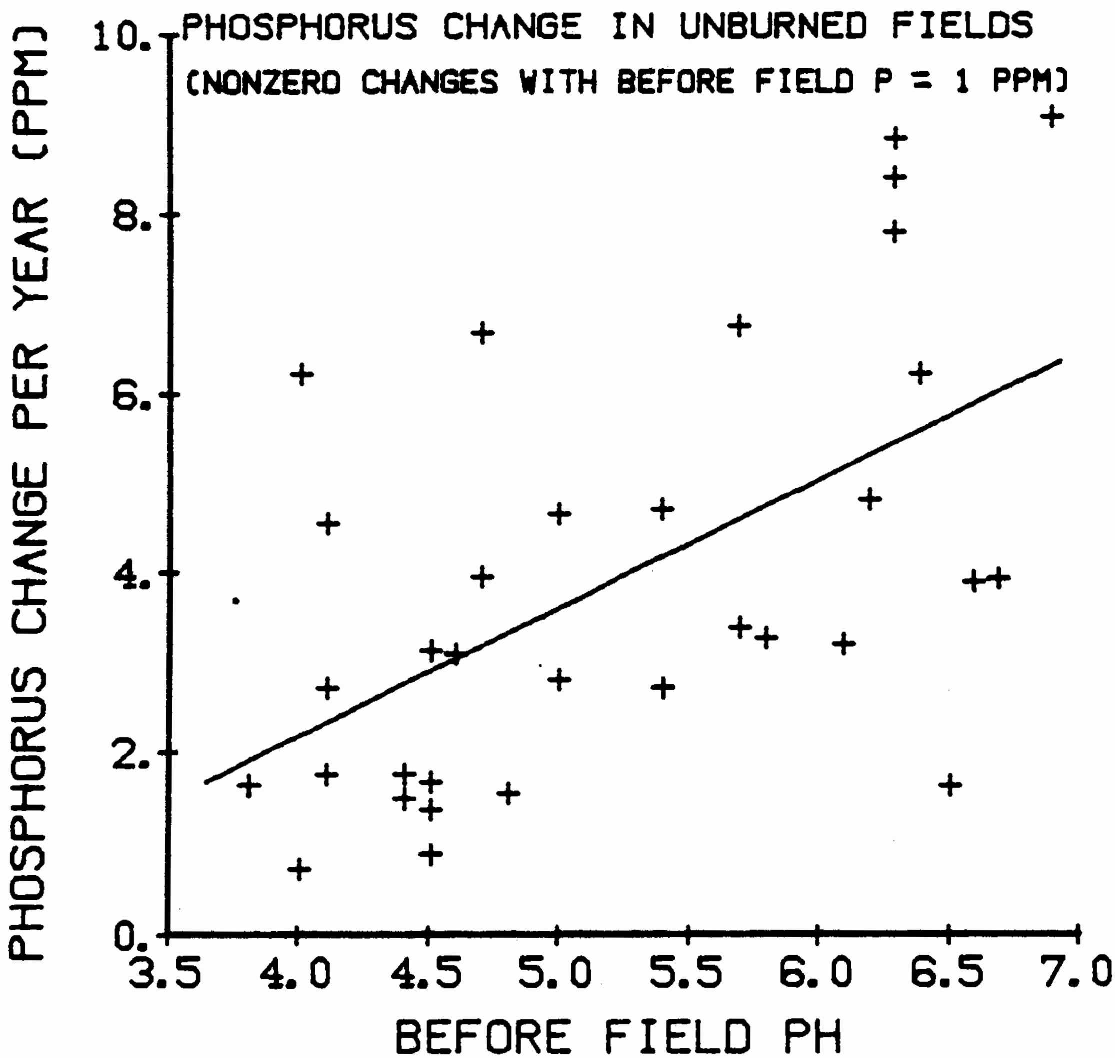

PHOSPHORUS CHANGE IN UNBURNED FIELDS
(NONZERO CHANGES WITH BEFORE FIELD P = 1 PPM)
PHOSPHORUS CHANGE PER YEAR (PPM)
0.
2.
4.
6.
8.
10.
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
BEFORE FIELD PH

TABLE E-4.

MULTIPLE REGRESSION OF PHOSPHORUS CHANGE PER YEAR IN UNBURNED FIELDS WITH BEFORE FIELD PHOSPHORUS IN 2 - 9 PPM RANGE[1]

Regression	Y = 2.1671 +	0.97151 A -	1.0405 B +	0.022395 C
Standard Errors	0.496	0.235	0.114	0.00480
t statistics	4.371	4.134	-9.117	4.666
Significance	<0.0001	0.0001	<0.0001	<0.0001
Partial Correlations		0.335	-0.617	0.373

R-Squared =	0.48	F stat. =	41.29
N =	139	Multiple R =	0.69
P <	0.0001	Std. error =	2.5049

Abbreviations: Y = Phosphorus change per year (ppm)

A = pH change per year

B = Phosphorus of before field (ppm)

C = Proportion of time field bare or in annual crops

(1) Excluding pasture.

Fig. E-4. -- Phosphorus change per year in unburned fields regression observed vs predicted values for before field phosphorus in 2 - 9 ppm range. Pasture is excluded.

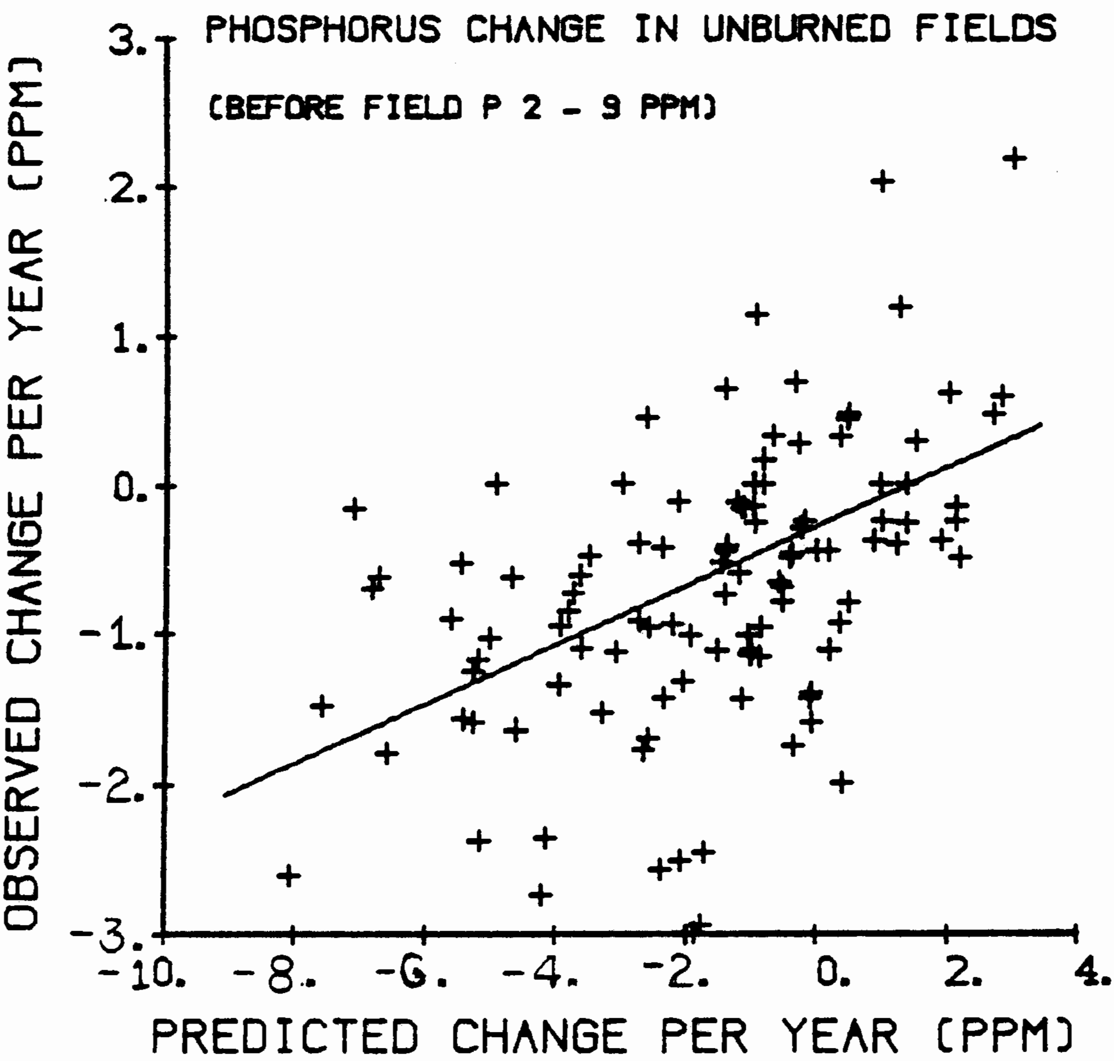

PHOSPHORUS CHANGE IN UNBURNED FIELDS
(BEFORE FIELD P 2 - 9 PPM)
OBSERVED CHANGE PER YEAR (PPM)
3.
2.
1.
0.
-1.
-2.
-3.
-10.
-8.
-6.
-4.
-2.
0.
2.
4.
PREDICTED CHANGE PER YEAR (PPM)

TABLE E-5.

REGRESSION OF PHOSPHORUS CHANGE PER YEAR IN UNBURNED FIELDS VS BEFORE FIELD PHOSPHORUS FOR BEFORE FIELD PHOSPHORUS OF F 10 PPM OR OVER[1]

Regression	Y =	6.8086	-	1.4363 a
Standard Errors		4.157		0.254
t statistics		1.638		-5,651
Significance		0.130		0.0001
Partial Correlation				-0.862
	R-Squared =	0.74	F stat. =	31.93
	Std. error of est. =	6.5830	Multiple R =	0.86
	P =	0.0001	N =	13

Abbreviations: Y = Phosphorus change per year (ppm)

a = Before field phosphorus (ppm)

[1] Excluding pasture.

Fig. E-5. -- Phosphorus change per year in unburned fields vs before field phosphorus for before field phosphorus of 10 ppm or over. Pasture is excluded.

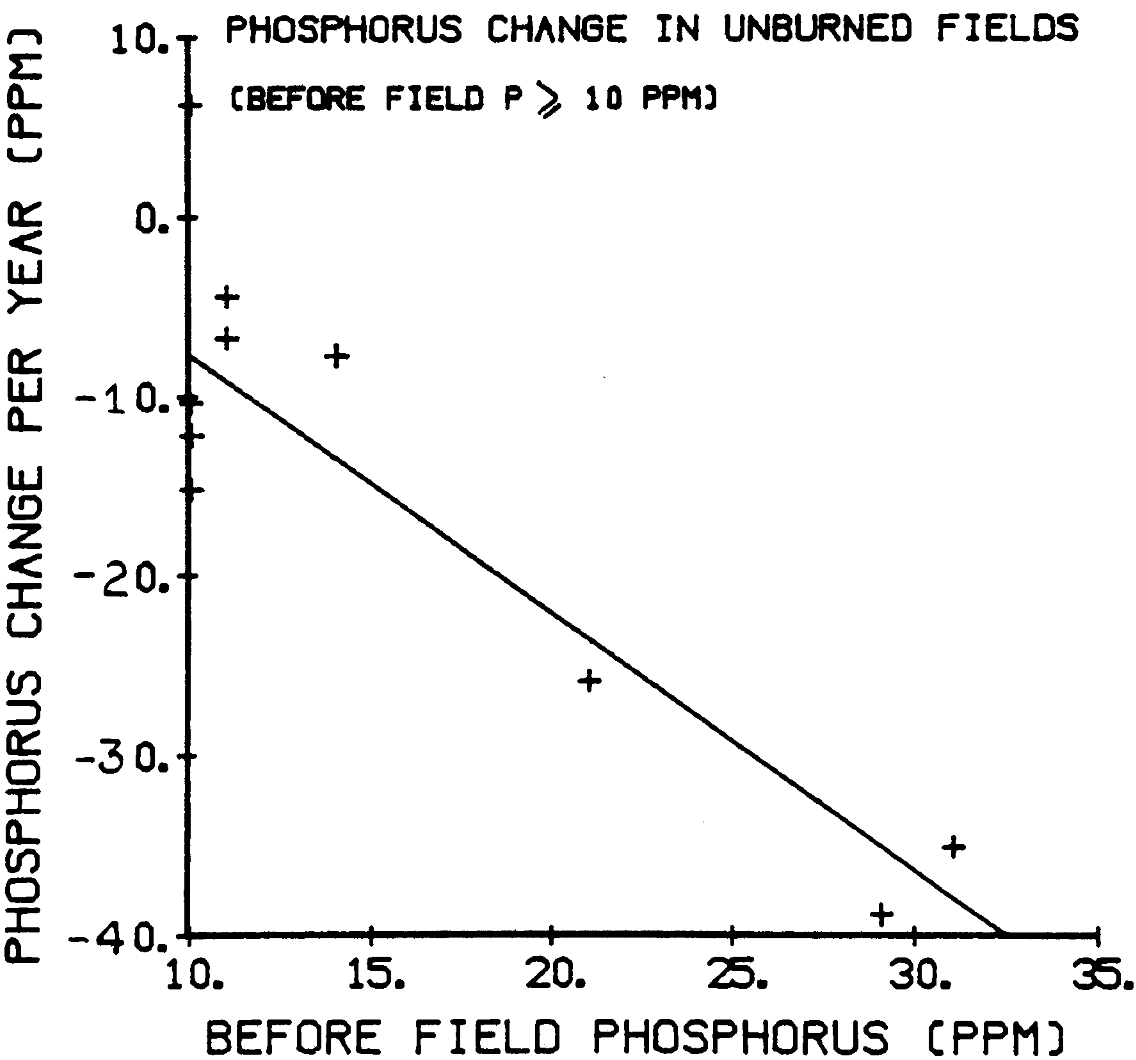

PHOSPHORUS CHANGE IN UNBURNED FIELDS
(BEFORE FIELD P ≥ 10 PPM)
PHOSPHORUS CHANGE PER YEAR (PPM)
10.
0.
-10.
-20.
-30.
-40.
10.
15.
20.
25.
30.
35.
BEFORE FIELD PHOSPHORUS (PPM)

TABLE E-6.

MULTIPLE REGRESSION OF NITROGEN CHANGE IN UNBURNED FIELDS[1]

Regression	Y =	-0.070371 -	0.77136 A	+	0.091648 B -	0.000033756 C -	0.012951 D 0.000041763 E
Std. Errors		0.0240	0.0685		0.0128	0.0000286	0.00344 / 0.0000255
t stats.		-2.937;	-11.253		7.177	-1.284	3.769 / 1.640
Significance		0.004	<0.0001		<0.0001	0.202	0.0003 / 0.104
Partial Corr.			-0.735		0.568	-0.123	0.341 / 0.156

R-Squared =	0.59	F stat. =	31.15
N =	114	Multiple R =	0.77
P <	0.0001	Std. error =	0.036064

Abbreviations: Y = Nitrogen change (% dry weight)

A = Initial nitrogen (% dry weight)

B = Initial carbon (% dry weight)

C = Days in annual crops

D = Initial pH

E = Days fallow

(1) Excluding pasture and fallow periods of 3 or more years.

Fig. E-6. -- Nitrogen change in unburned fields regressi observed vs predicted values. Both days in annual crops an days fallow are significant (<0.05) when included separately; the depletion of nitrogen through cropping and regeneration through fallowing are regarded as fundamental processes in the agroecosystem. Pasture and fallow periods of three or more years are excluded.

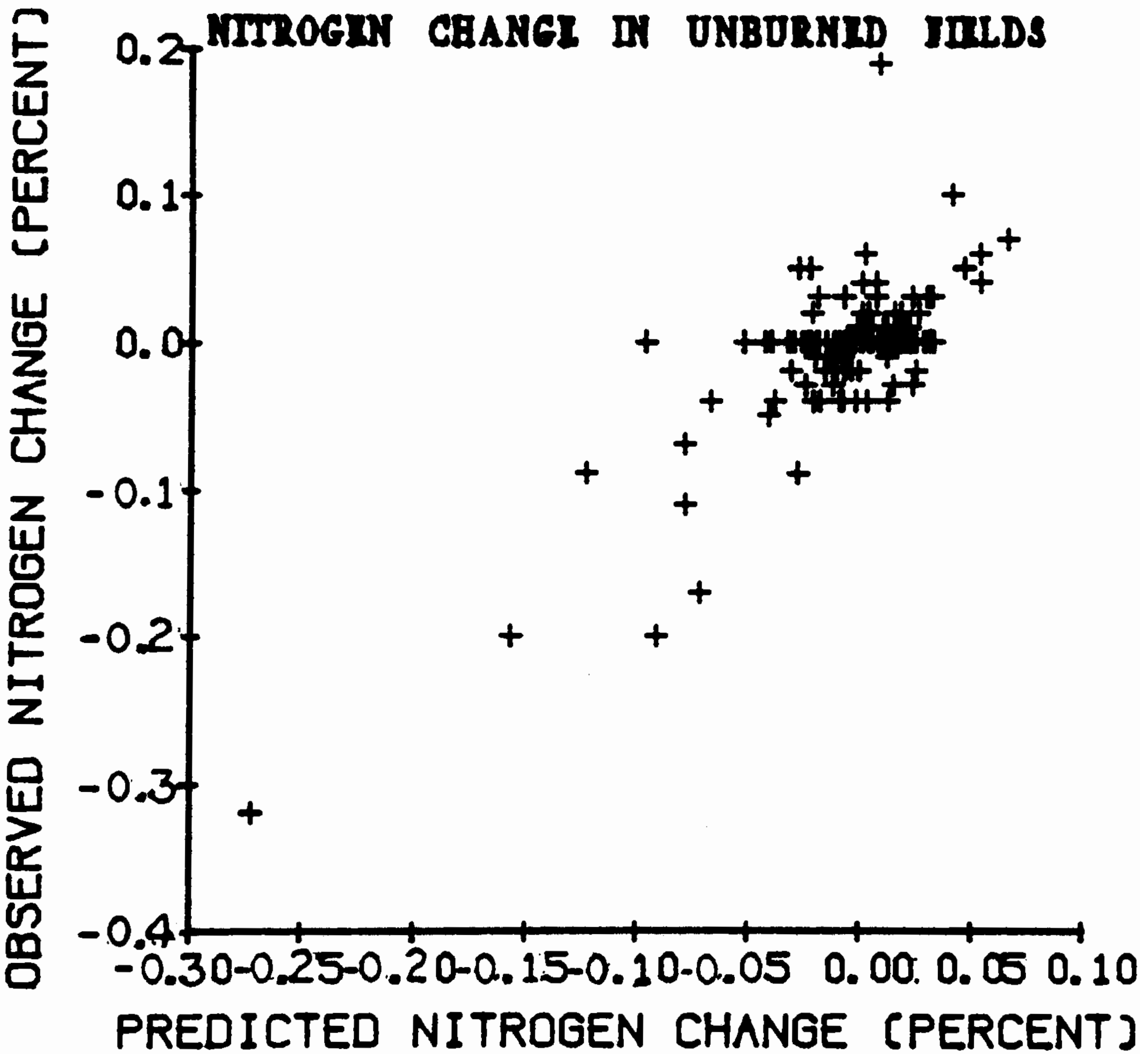

NITROGEN CHANGE IN UNBURNED FIELDS
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10
PREDICTED NITROGEN CHANGE (PERCENT)
OBSERVED NITROGEN CHANGE (PERCENT)

TABLE E-7.

MULTIPLE REGRESSION FOR CARBON CHANGE IN BURNED OR UNBURNED FIELDS[1]

Regression	Y =	0.11566 +	4.3151 a -	0.52549 b	3.8721 c
Standard Errors		0.433	0.346	0.639	0.413
t statistics		2.671	12.483	-8.218	9.566
Significance		0.009	<0.0001	<0.0001	<0.0001
Partial Correlations			0.672	-0.513	0.563
	R-Squared =	0.47	F stat. =	56.46	
	Std. error of est. =	0.21106	Multiple R =	0.69	
	P <	0.0001	N =	193	

Abbreviations: Y = Carbon change (%dry weight)

a = Nitrogen change (% dry weight)

b = Initial carbon (% dry weight)

c = Initial nitrogen (% dry weight) [1] Pasture more than 25% of comparison interval excluded.

Fig. E-7. -- Carbon change regression observed vs predicted values for both burned and unburned fields.

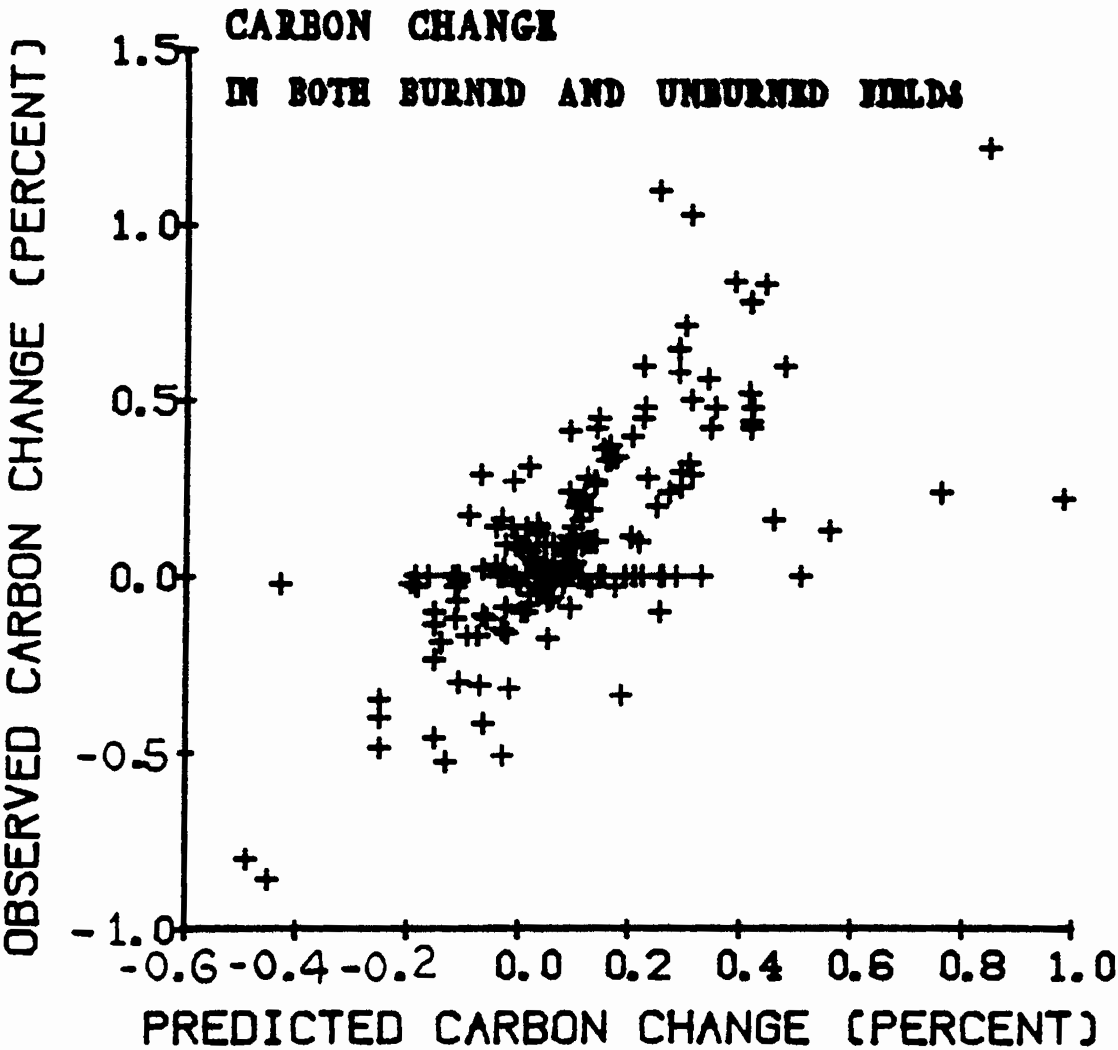

CARBON CHANGE
IN BOTH BURNED AND UNBURNED FIELDS
OBSERVED CARBON CHANGE (PERCENT)
1.5
1.0
0.5
0.0
-0.5
-1.0
-0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
PREDICTED CARBON CHANGE (PERCENT)

TABLE E-8.

PRICES OF FERTILIZERS AND LIME IN ALTAMIRA

ITEM	DATE	PRICE AT DATE	Cr75$/kg[3]	ACTIVE INGREDIENT	PERCENT ACTIVE INGREDIENT	Cr75$/kg ACTIVE INGREDIENT
Superphosphate (triple)	Apr.10,1976	4.70[1]	2.72	P_2O_5	46%[4]	5.90
Urea		4.60[1]	2.66	N	45%[4]	5.91
Potassium Chloride		2.70[1]	1.56	K	60%[4]	2.60
Dolomitic Lime		0.75[1]	0.43	Dolomitic Lime	100%	0.43
Organic fertilizer (rice bran and spoiled beans)	Jul.17,1974	0.25[2]	0.31	Cow manure equiv.	50%[5]	0.61

(1) Prices of Brasil Norte Ltda., Altamira (where financed colonists purchase supplies)

(2) Average of Cr$0.30/kg for rice bran and Cr$0.20/kg for spoiled beans paid by Japanese colonist who was using 2222 kg/ha of each of these on black pepper.

(3) Cruzeiro values corrected to Jan. 1, 1975 using an inflation rate of 35%/year.

Coelho and Varlengia (1973, p.181).

(5) Estimated (for purposes of cost) from the fact that the dose for the rice bran and spoiled bean combination being used by the Japanese colonist mentioned was double the recommended manure dose for pepper.

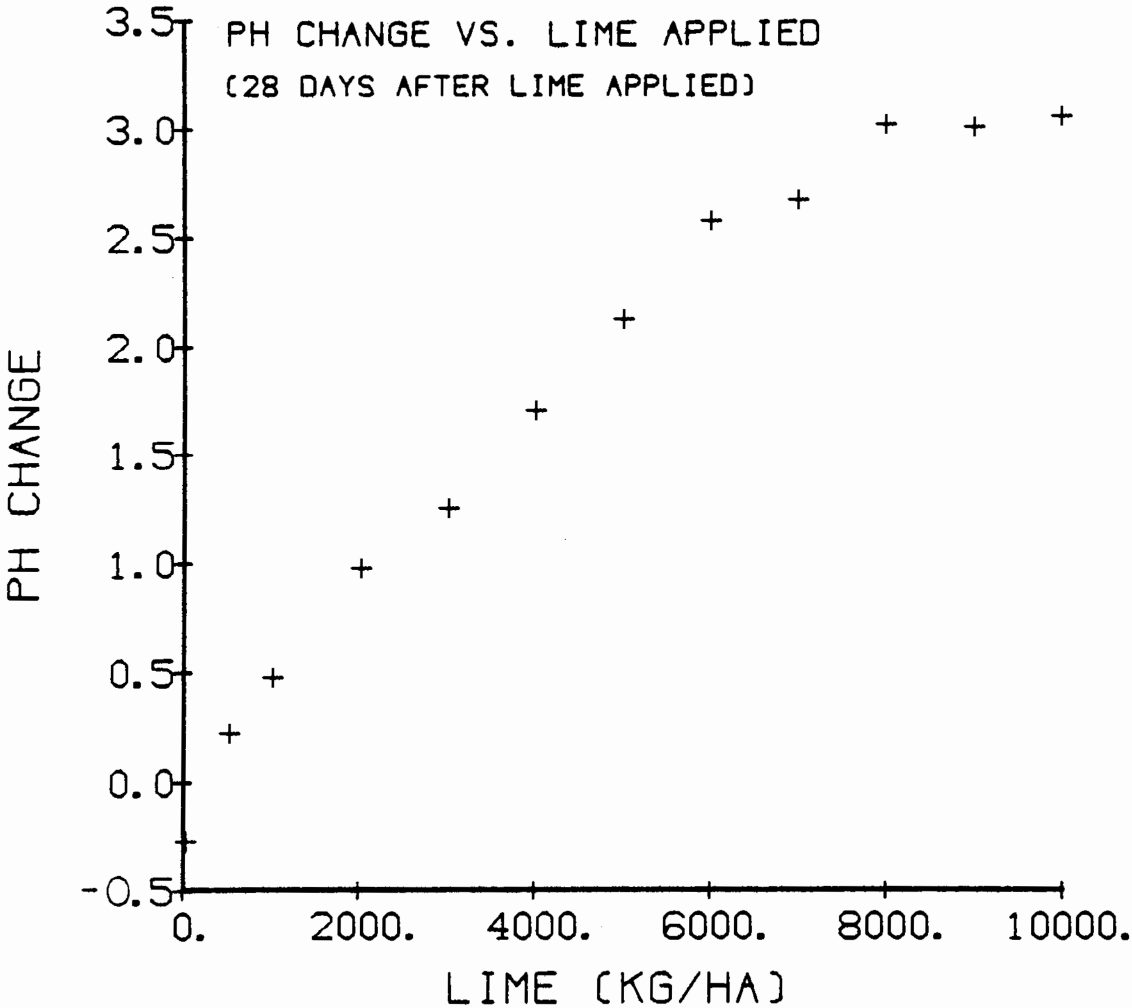
Effects of Fertilizers on Soils

Effect of Liming

An equation usable for obtaining quantitative estimates of the pH changes which would result from the liming applications recommended for cacao (Fearnside 1978q) and black pepper (Fearnside 1978r) is needed for use in modeling soil changes as a part of the carrying capacity models. No data which would be usable for this exists for the Transamazon Highway, but a liming trial carried out in the Zona Bragantina near Belém does contain usable data. The liming trials (Struchtemeyer et al. 1971) were carried out on three different soil types, one of which is the yellow latosol (Utisol) which is common over much of the Transamazon Highway. The raw data which is presented in the report of the liming experiments (Struchtemeyer et al. 1971, p.22) was used to obtain a regression equation of kgs/hectare of dolomitic lime on change in pH. The pH changes as of the twenty-eighth day were used, since this appeared to represent the high-point of pH effect form most lime doses. The data are plotted in figure E-8. It is apparent that that a dose of 8000 kgs lime/ha represents the limit above which no further increase in pH above the starting pH of 3.9 is possible. The regression analysis therefore only includes lime doses less than or equal to 8000 kg/ha.

The Zona Bragantina liming trials include weekly

Fig. E-8. -- pH change vs kgs per hectare lime applied in Zona Bragantina liming experiment. Soil is yellow latosol (Utisol), with initial pH of 3.9. pH changes are 28 days after application. Only lime doses up to 8000 kg/ha used for regression ($R^2 = 0.98$, $P < 0.0001$). Data source: Struchtemeyer et al. 1971, p.22).


PH CHANGE VS. LIME APPLIED
(28 DAYS AFTER LIME APPLIED)
PH CHANGE
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0.
2000.
4000.
6000.
8000.
10000.
LIME (KG/HA)

observations for an additional three weeds beyond the peak at 28 days. these data were analyzed in an attempt to obtain an estimate of the rate at which pH declines subsequent to the attainment of its highest value. Although the mean pH change for the 33 additional measurements would indicate a slight drop in pH, the change is not significantly different from zero. Therefore no special relation for the declines in pH subsequent to attainment of the peak pH from liming were included in the simulation. In the years following the year of liming, however, other equations governing pH changes under different cropping treatments make appropriate pH adjustments during the course of a simulation.

The data on changes in aluminum is not included in the report of the Zona Bragantina liming trials, although a hand-sketched curve of the trend in aluminum (Struchtemeyer et al. 1971, graph 5) indicates that a relation with pH holds which is very similar to the relation found between aluminum and pH in virgin soil on the Transamazon Highway (Fearnside 1978f). The virgin soil relation was therefore used in the modeling to calculate aluminum values from pH and clay subsequent to liming (Fearnside 1978b).

Effects of Phosphate Fertilization

No appropriate data exists for obtaining a usable quantitative relationship between phosphate fertilization rates and soil phosphorus levels for experiments in Pará, so the search for appropriate data had to go farther afield. Data were found which is usable for this purpose in the report of two phosphate fertilization experiments carried out in the cerrado zone of Brasil. Both trials include soil phosphorus measurements taken three months after the application of different amounts of P205 in the form of simple superphosphate (North Carolina State University Soil Science Department 1974, pp.89 and 101). In the case of one data point where no three month measurement was reported the mean of the zero and six month measurements which were reported were used. Phosphorus changes were expressed as differences from the 2.3 ppm (North Carolina extractant) level in the unfertilized control plot. A simple linear regression analysis was run on the fourteen data points which was able to explain 97% of the variance in soil phosphorus changes ($P < 0.0001$). The data are plotted in figure E-9 and the regression equation is summarized in table E-9. This equation has been incorporated into the simulation models to make appropriate adjustments in soil phosphorus values when fertilizers are used.

In addition to the principal effect on phosphorus levels, phosphate fertilization is known to have a variable amount of "liming" effect in raising pH and lowering aluminum levels. The amount of the effect depends on the type of phosphate fertilizer used (North Carolina State University Soil Science Department 1974, p.94). Simple superphosphate has relatively little liming effect when compared with several other phosphate sources. It was decided not to include the liming effect of phosphates in the simulation models in view of the variability in effects, the lack of data, and the fact that nitrogen fertilization is always carried out with phosphate fertilization. Nitrogen fertilization generally has the opposite effect on pH.

Effect of Nitrogen Fertilization

An attempt was made to locate a data set which would be usable for deriving a regression equation for soil nitrogen changes following nitrogen fertilization similar to the equations derived for pH changes from lime and phosphorus changes from phosphate dressings. Data were used from a nitrogen fertilization experiment done on bulldozed and burned plots at Yurimaguas in the amazonian portion of Peru (North Carolina State University Soil Science Department 1974, p.21). The results were inconsistent: the soil nitrogen level in the top 50 cms after four months depended on whether the plot had been burned or bulldozed. In the case of the bulldozed plots, the nitrogen levels after four months were lower with nitrogen fertilization than without. The mean changes for the six measurements reported lumping both types of plots is not significantly different from zero: the nitrogen from the fertilizer applied had been taken up by the crops planted or lost to leaching, etc. If the soil nitrogen additions from fertilization at all dosages disappears within four months,

TABLE E-9.

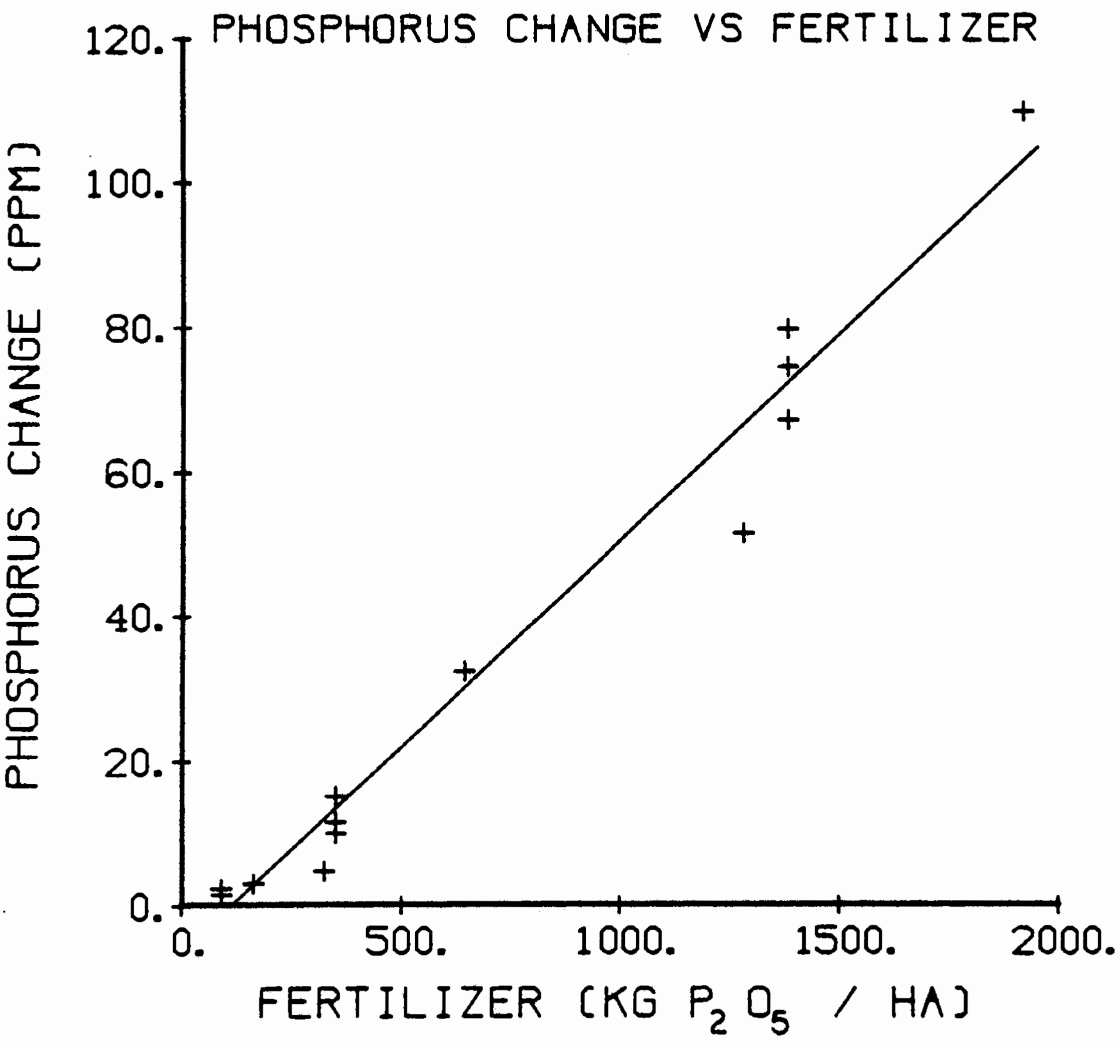
REGRESSION OF SOIL PHOSPHORUS CHANGE ON PHOSPHATE FERTILIZER APPLIED

Regression	Y =	-6.4136	+	0.056751 a
Standard Errors		2.5583		0.00277
t statistics		-2.507		20.499
Significance		0.028		<0.0001
Partial Correlation				0.986
	R-Squared =	0.97	F stat. =	420.20
	Std. error of est. =	6.2891	Multiple R =	0.99
	P <	0.0001	N =	14

Abbreviations: Y = pH change

a = kg/ha P205

Fig. E-9. -- Phosphorus change vs kg/ha P_2O_5 applied. Data are from experiments in the cerrado zone of Brasil (North Carolina State University Soil Science Department 1974, pp.89 and 101).


PHOSPHORUS CHANGE VS FERTILIZER
PHOSPHORUS CHANGE (PPM)
120.
100.
80.
60.
40.
20.
0.
0.
500.
1000.
1500.
2000.
FERTILIZER (KG P_2O_5 / HA)

one can safely assume that soil nitrogen will not build up as a result of accumulation through fertilization from one year to the next.

Since nitrogen does not enter directly in either of the two yield equations for crops fertilized -- cacao (Fearnside 1978q) and pepper (Fearnside 1978r) -- the level of nitrogen in the soil can be ignored during the year that the fertilizer is applied. Since there is no carry-over of fertilize-supplied nitrogen from year to year, one can simply consider the change in nitrogen resulting from fertilization to be zero for the purposes of modeling soil changes.

Nitrogen fertilization is known to have an effect on soil pH, varying with the nitrogen source used. Ammonium sulfate, ammonium nitrate, and urea all cause decreases in pH, while pH goes up slightly with sodium nitrate (Sanchez 1973, p.105). Acidity resulting from ammonium sulfate fertilization has become a severe problem in many parts of East Africa (Phillips 1972, p.554). Russell (1972, p.570) estimates that it takes 110-120 kg of calcium carbonate to neutralize the effect of 100 kg of ammonium sulfate. It was decided that the optimistic assumption that nitrogen fertilization would not increase acidity would be the best for the simulation models, given the variable effects of different sources, and the opposite "liming" effect of the phosphate fertilizer which is always administered at the same time as the nitrogen if government recommendations are followed.

Effect of Manuring

The effect of manuring on soil carbon levels must be considered for use with the pepper yield regression equation (Fearnside 1978r) for which manuring is recommended in government fertilizer schedules and for which carbon levels had a significant effect on yields. Fortunately, the lack of data available for accuracy of yield predictions for unfertilized pepper or the soil carbon levels for the years after fertilization has ceased. Soil organic matter has a very high rate of breakdown in exposed soil such as the soil under pepper (Cunningham 1963). Soil carbon levels following fertilization probably follow the same pattern as soil nitrogen levels, since the relative constancy of C/N ratios is a common denominator for most carbon-nitrogen relations. One can therefore probably be safe in ignoring any carry-over of soil carbon from one year to the next, and simply use the pepper critical level of 2.0% carbon (Fearnside 1978r) in making yield calculations for fertilized pepper. In modeling this the 2.0% value for carbon is used in the pepper yield subroutine, but no adjustment is made in the carbon value stored for the patch in the soil nutrient change subroutine (Fearnside 1978b).

Fig. E-10. -- Average pH in fields bare or in annual crops in a typical stochastic run of AGRISIM. pH is high after initial virgin burn, but falls to low values soon afterwards.

RUN NUMBER 7

PH: AVERAGE IN FIELDS BARE OR IN ANNUAL CROPS

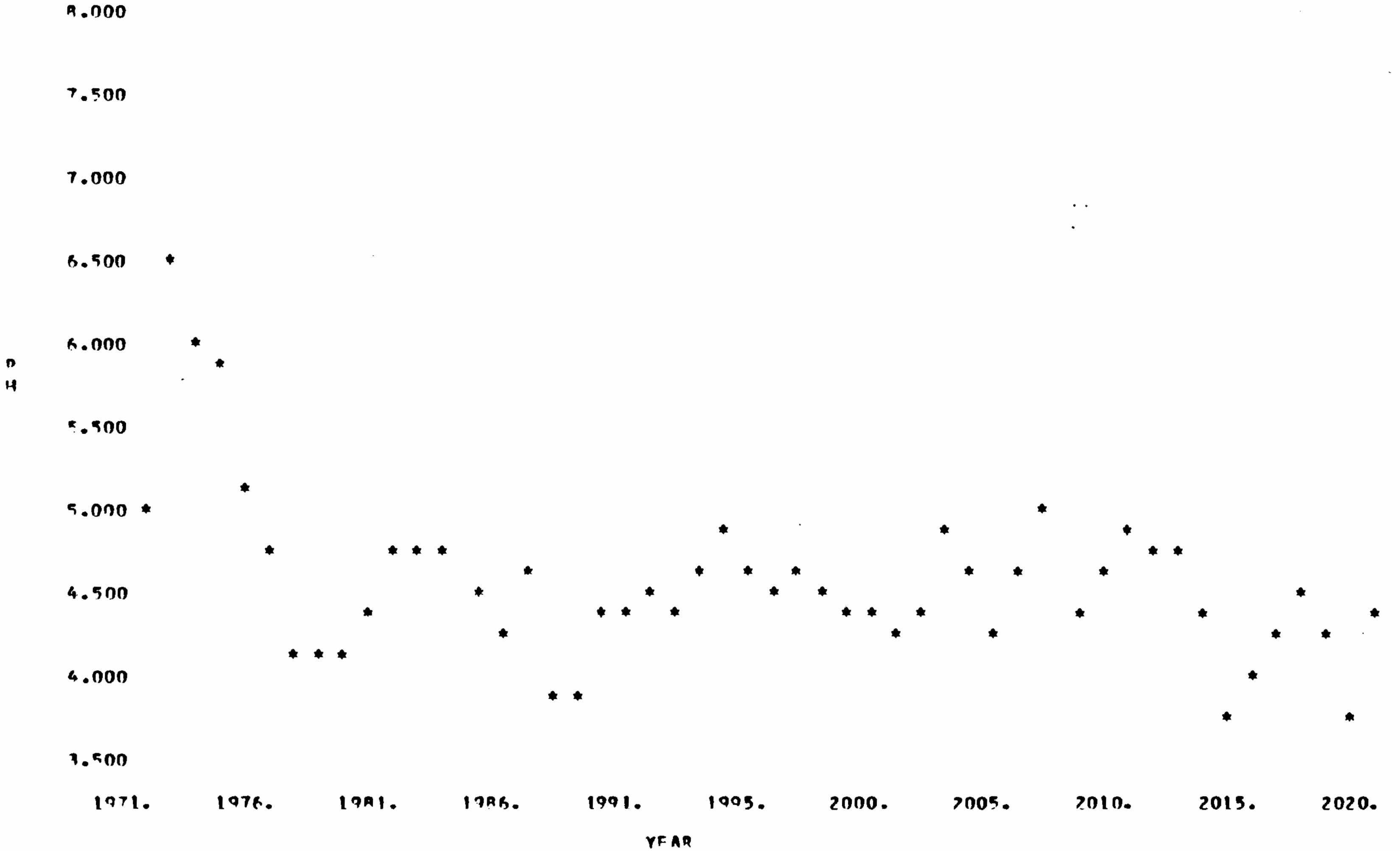
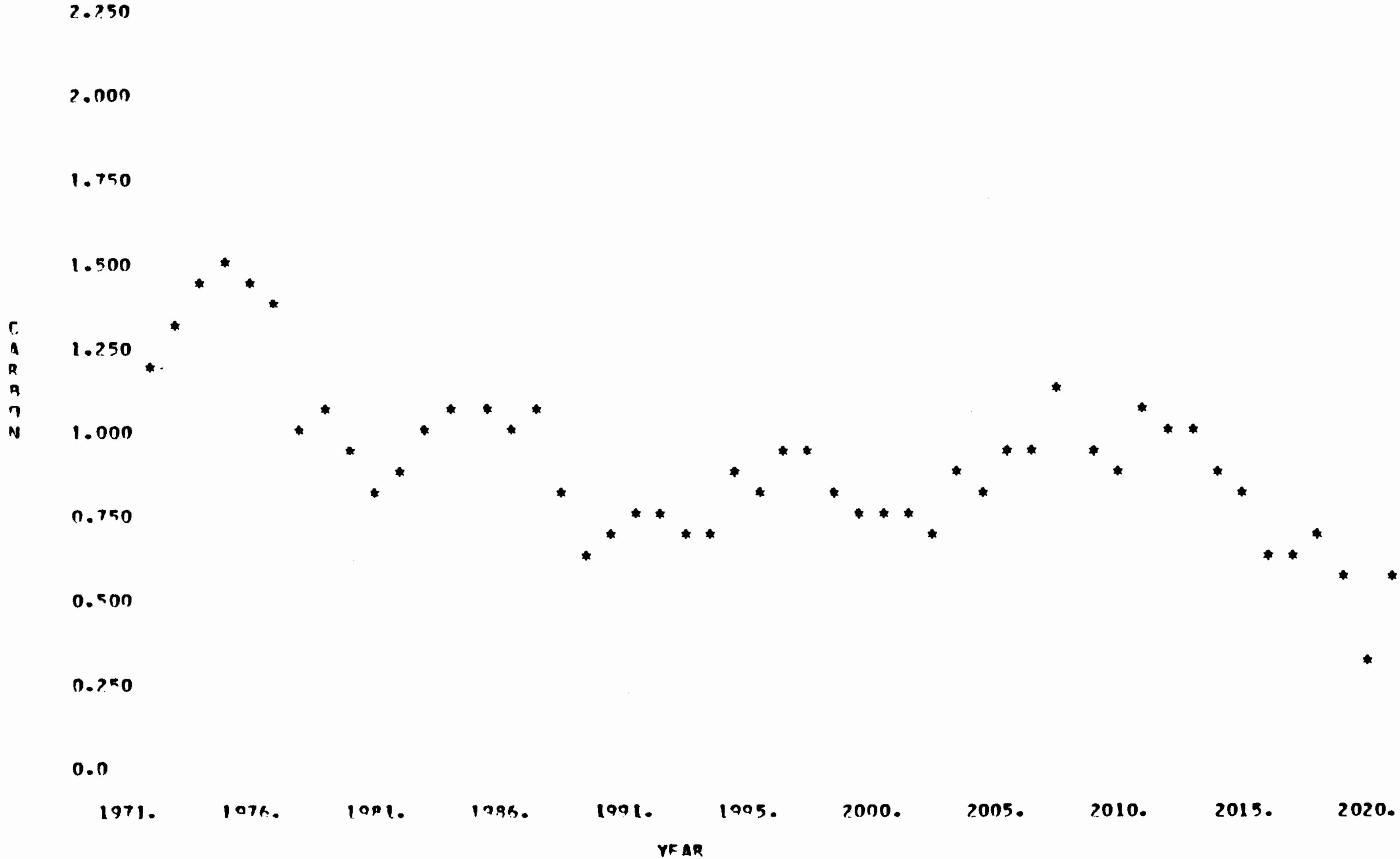


Fig. E-11. -- Average carbon in fields bare or in annual crops in a typical stochastic run of AGRISIM. Carbon levels fall to low levels after several years of cropping.

RUN NUMBER 7

CARBON: AVERAGE FOR FIELDS BARE OR IN ANNUAL CROPS (% DRY WT.)



APPENDIX F

YIELD PREDICTION FOR ANNUAL CROPS

Fig. F-1. -- Typical rice fields in newly cleared land. Rice is planted alone on the left and interplanted with maize on the right. Rice is the principal cash crop in the Transamazon Highway Colonization Area.

TABLE F-1.

MULTIPLE REGRESSION FOR RICE YIELD PREDICTION

Regression	Y = -0.0060286	+ 0.59699 A	- 0.000015236 B	+ 0.016996 C	- 0.094706 D
Standard Errors	0.178	0.160	0.0000163	0.0170	0.0398
t statistics	-0.0339	3.722	-0.935	1.002	-2.379
Significance	0.974	0.003	0.368	0.336	0.035
Partial Correlations		0.732	-0.261	0.278	-0.566

R-Squared =	0.61	F stat. =	4.69
N =	17	Multiple R =	0.78
P =	0.017	Std. error =	0.20288

Abbreviations: Y = Rice yield (proportion of experiment station yield for variety)

A = Carbon (% dry weight) adjusted to 2.0

B = Interplanted maize density (plants/ha)

C = Phosphorus (ppm)

D = Al^{+++} (ME/100g)

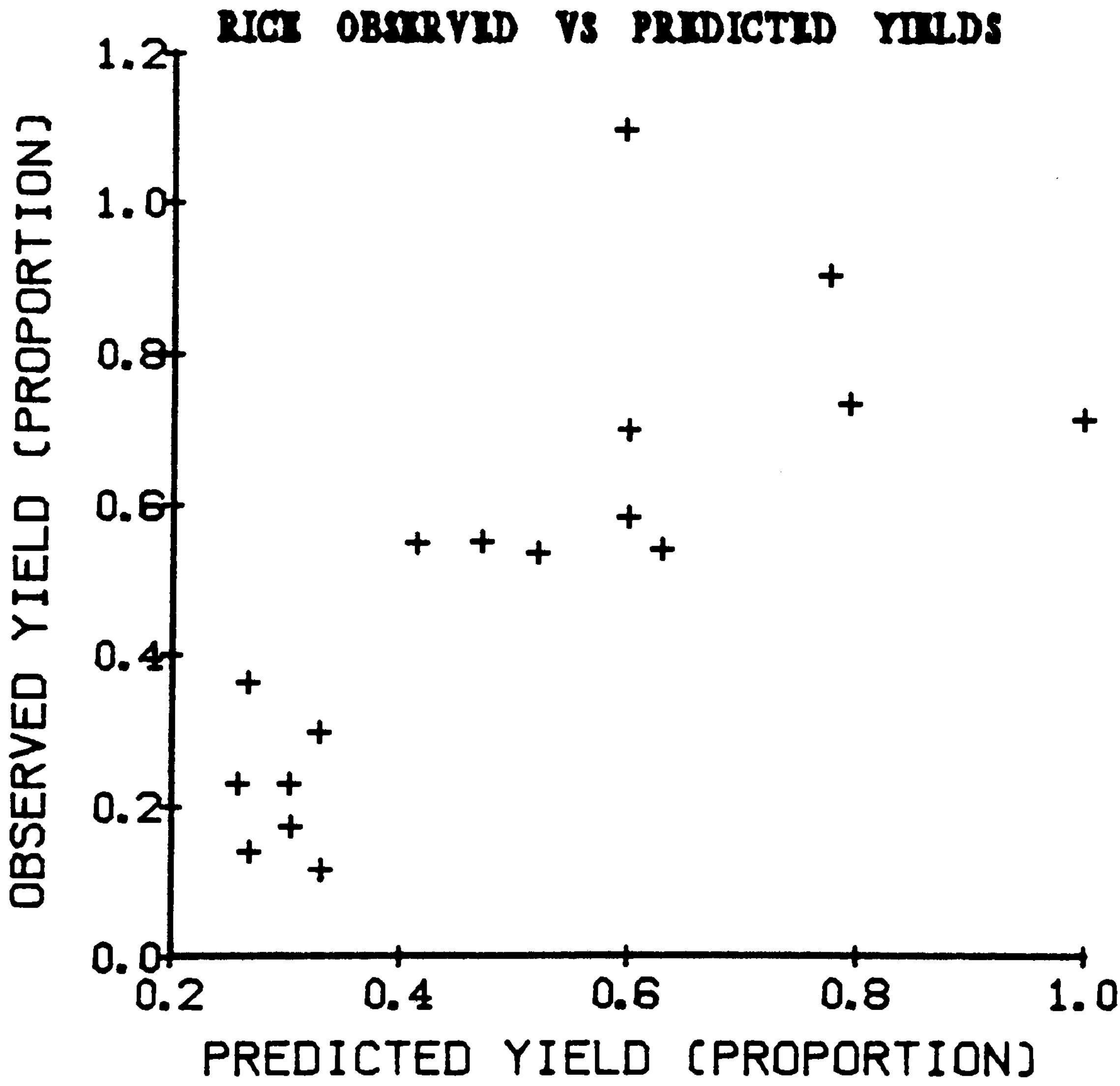

RICE OBSERVED VS PREDICTED YIELDS
OBSERVED YIELD (PROPORTION)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
PREDICTED YIELD (PROPORTION)

TABLE F-2.

RICE INTERPLANTING FREQUENCIES BY YEAR

YEAR	PERCENT INTERPLANTED	NUMBER INTERPLANTED	NUMBER ALONE
1972	27.8	10	26
1973	42.2	27	37
1974	58.2	39	28
1975	62.7	64	38
1976	38.7	7	11(1)

Year effects $P < 0.01$ ($X^2=17.84$; df=4 N=287)

(1) biased toward rice alone by selection of large fields

Fig. F-3. -- Rice showing toppling in government-distributed variety (IAC-1246) in the foreground and resistance to toppling in traditional variety (canela de ferro) in the background.

TABLE F-3.

SEVERE RICE TOPPLING BY VARIETY

VARIETY	NUMBER NOT TOPPLED	NUMBER TOPPLED	PERCENT TOPPLED
hybrid (IAC-1246 or IAC-101)	183	28	13.3
traditional (canela de ferro)	25	0	0.0
other	14	0	0.0

variety difference $P < 0.01$ (Max. likelihood statistic = 10.13 df=2 N=250)

TABLE F-5.

RICE YIELD REGRESSION EXCLUDED CATEGORY SUMMARY

CONDITION	FREQUENCY (percent)		RICE DENSITY (1000 hills/ha)			EFFECT ON YIELD (proportion of predicted)		
	MEAN	N	MEAN	STD.DEV.	N	MEAN	STD.DEV.	N
Manioc interplanted	10.1	306	93.50	44.59	28	1.08		
Pasture interplanted	2.9	306	83.73	33.99	7	0.814		
Other interplanted crop	1.6	306	73.22	14.68	5	0.815		
Poor germination	4.7	306			0.793			
Disease								
Hybrid(IAC-1246,IAC-101)	1.9	211						
Tradit.(canela de ferro)	12.0	25						
Other (non-barbalha)	14.3	5						
lumped non-barbalha effect						0.806		
Toppling								
Hybrid(IAC-1246,IAC-101)	13.3	211				0.760	0.559	7
Others(non-barbalha)	0.0	39						
Varieties planted								
Hybrid(IAC-1246,IAC-101)	84.4	183						
Tradit.(canela de ferro)	10.0	183						
Other(non-barbalha)	0.823	183						
Planting date out of season (Nov.,Mar.,Apr.)	3.4	290				0.168	0.226	2

Fig. F-4. -- A.) Maize with stunted growth in poor soil. Ruler in photograph is 15 cm long. B.) Maize ears with beetle damage showing greater damage in government-distributed hybrid maize than the traditional variety. Note that the hybrid ears are larger, partly compensating for increased levels of beetle attack. C.) Maize ears eaten by rats in the field. Rats damage maize when green, dry, or i storage.

TABLE F-6.

MULTIPLE REGRESSION FOR MAIZE YIELD PREDICTION

Regression	Y =	-330.00 +	125.46 A	- 0.029183 B	- 0.022234 C	- 0.00081571 D
Standard Errors		251.180	46.235	99.228	14.091	430.66
t statistics		-1.311	2.714	-2.941	-1.578	-1.894
Significance		0.203	0.012	0.007	0.128	0.071
Partial Correlations			0.492	-0.523	-0.313	-0.367

R-Squared =	0.42	F stat. =	4.18
N =	28	Multiple R =	0.65
P =	0.011	Std. error =	150.69

Abbreviations: Y = Maize yield (kg/1000 plants)

A = pH (adjusted to 6.0)

B = Maize planting density (plants/ha)

C = Interplanted manioc density (plants/ha)

D = Interplanted rice density (plants/ha)

Fig. F-5. -- Maize yield regression observed vs predicted values

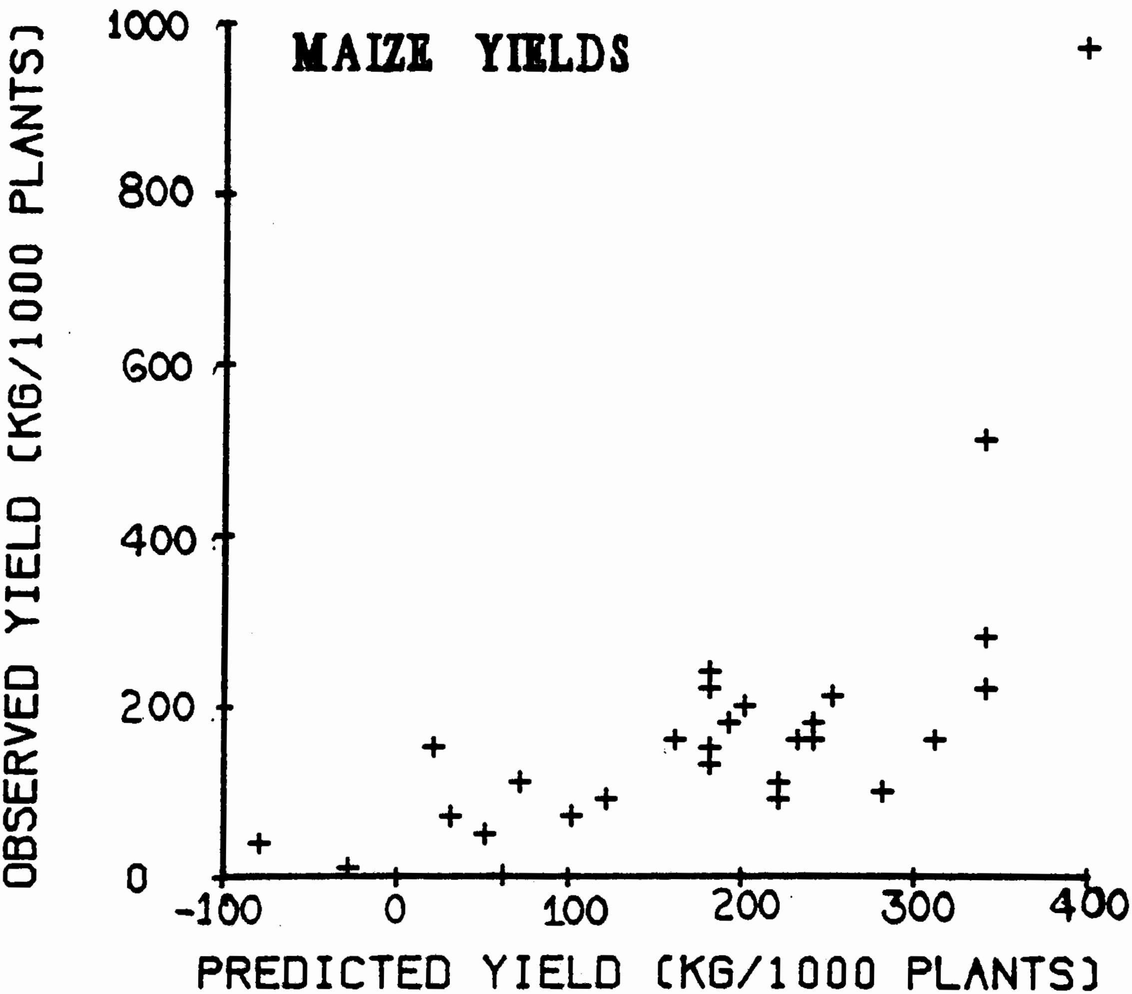

MAIZE YIELDS
OBSERVED YIELD (KG/1000 PLANTS)
1000
800
600
400
200
0
-100
0
100
200
300
400
PREDICTED YIELD (KG/1000 PLANTS)

TABLE F-7.

MAIZE YIELD REGRESSION VARIABLES SUMMARY

CONDITION	FREQUENCY (percent)		MAIZE DENSITY (plants/ha)			INTERPLANTED CROP DENSITY (plants/ha)		
	MEAN	N	MEAN	STD.DEV.	N	MEAN	STD.DEV.	N
Maize alone	33.9	224	6274.8	4343.7	68	0		224
Rice interplanted	51.8	224	3507.0	3444.1	126	126100	118280	41
Manioc interplanted	13.4	224	5119.0	3530.3	21	5328.7	2647.0	18
Other interplanted crops	9.4	224	5623.9	2794.3	18			

TABLE F-8.

MAIZE YIELD REGRESSION EXCLUDED CATEGORY SUMMARY

CONDITION	FREQUENCY (percent)		EFFECT ON YIELD (proportion of predicted)		
	MEAN	N	MEAN	STD.DEV.	N
Poor germination	7.1	224	0.966		
Rats intensity 2 or 3	38.8	224	0.563	0.469	17
Disease	1.8	220	0.396		

TABLE F-9.

MULTIPLE REGRESSION FOR *PHASEOLUS* BEAN YIELD PREDICTION

Regression	Y =	267.64 -	69.765 A	+ 13.777 B	- 0.001509 C
Standard Errors		134.53	20.233	15.283	0.00232
t statistics		1.989	-3.448	0.901	-0.649
Significance		0.078	0.007	0.391	0.532
Partial Correlations			-0.754	0.288	-0.212
	R-Squared =	0.62	F stat. = 4.98		
	N =	13	Multiple R = 0.79		
	P =	0.026	Std. error = 29.802		

Abbreviations: Y = Phaseolus yield (kg/kg seed sown)

A = Common log of planting density in plants/ha

B = pH adjusted to 5.7

C = Interplanted maize density (plants/ha)

Fig. F-6. -- Phaseolus bean yield regression observed vs predicted values.

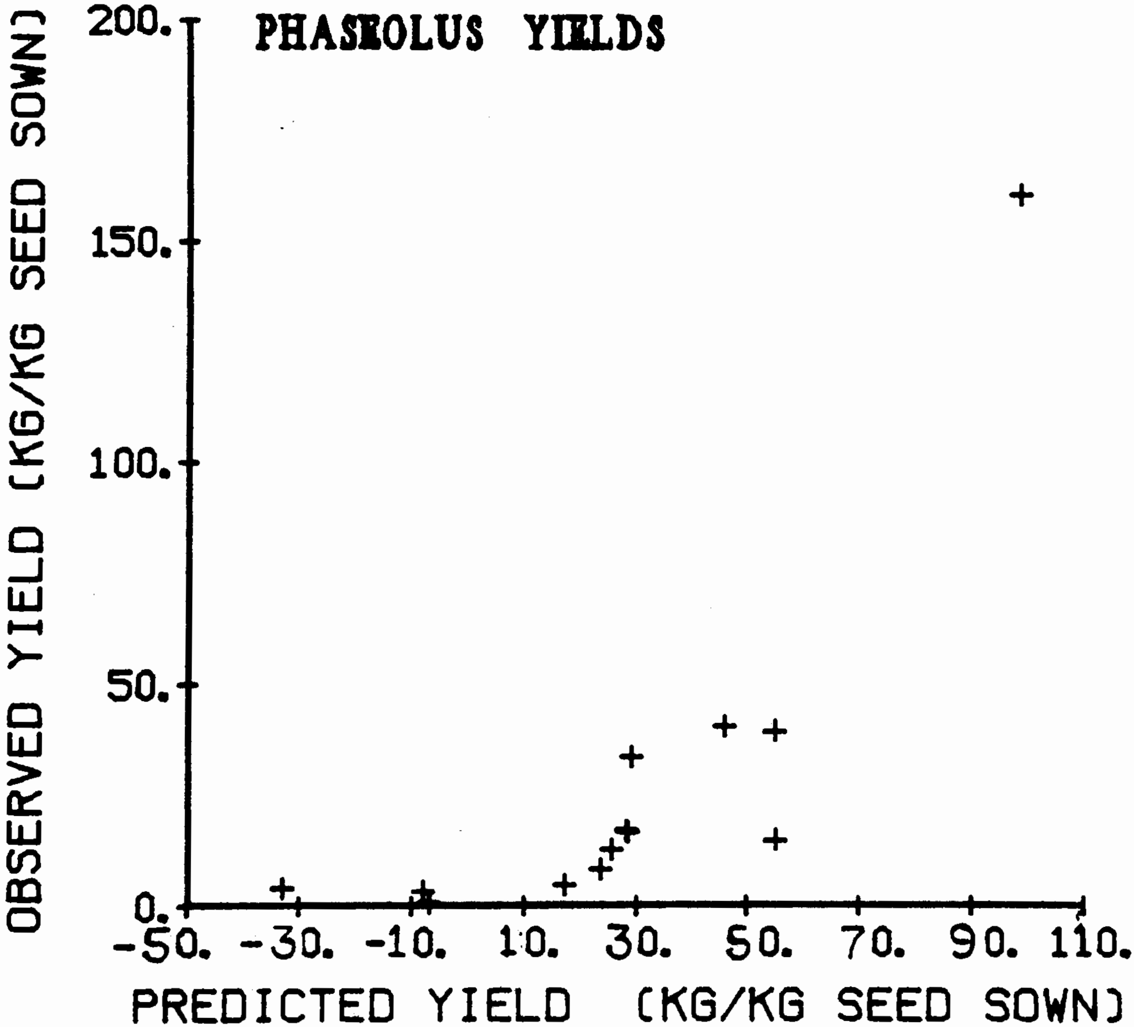

PHASEOLUS YIELDS
200.
150.
100.
50.
0.
-50. -30. -10. 10. 30. 50. 70. 90. 110.
OBSERVED YIELD (KG/KG SEED SOWN)
PREDICTED YIELD (KG/KG SEED SOWN)

Fig. F-7. -- A.) Phaseolus beans attacked by the fungus Rhizoctonia. Phaseolus seed is distributed by the government. When healthy, yields are higher than Vigna cow-peas, but frequent disease attack causes mean yields to be lower. B.) Vigna cow-peas show resistance to Rhizoctonia fungal attack. Vigna is typically planted in small fields with dry maize stalks. Vigna is not financed and Vigna seed is not distributed by the government. C.) Vigna cow-peas showing severe damage from rabbits. Vertebrate pests attack both Phaseolus and Vigna. Both disease attack and vertebrate pest attack probabilities are included in the KPROG2 and AGRISIM simulations.

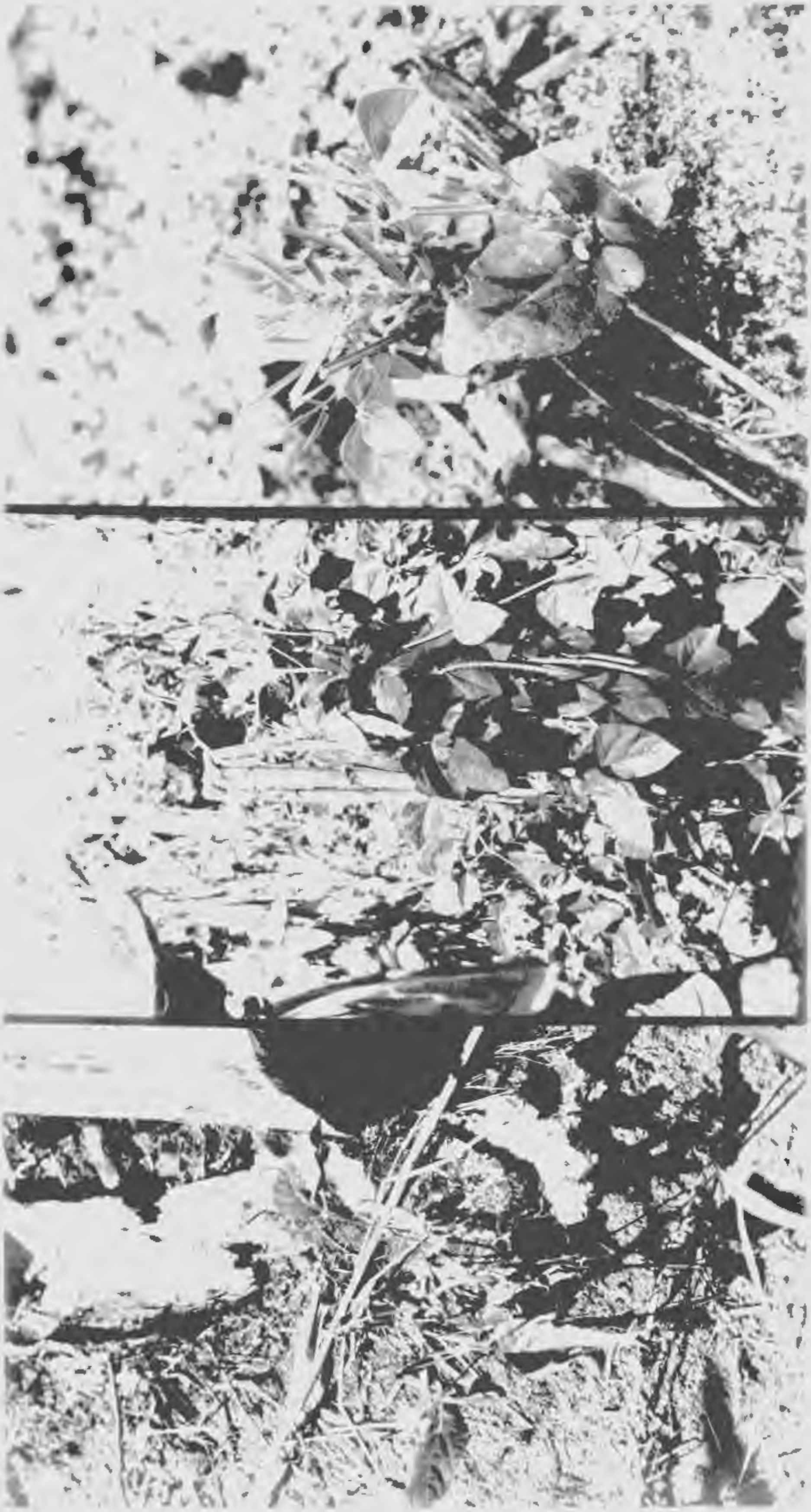


TABLE F-10.

PHASEOLUS YIELDS AND DISEASE INTENSITY

Disease intensity	0	1	2	3
Phaseolus yield (kg/ha)	308	186	151	58
Sample size	11	10	24	11

TABLE F-11.

PHASEOLUS **BEAN YIELD REGRESSION VARIABLES SUMMARY**

ITEM	MEAN	STANDARD DEVIATION	N
kgs seeds planted/ha	29.18	26.15	112
Planting density (plants/ha)	52666	49036	114
Interplanted maize:			
Frequency	11.7%		120
maize density (plants/ha)	1698.4	3688.2	13
Frequency of planting in previously planted soil when virgin soil available	9.1%		

TABLE F-12.

PHASEOLUS BEAN YIELD REGRESSION EXCLUDED CONDITION SUMMARY

ITEM	MEAN	STANDARD DEVIATION	N
Poor germination:			
frequency	5.8%		120
effect on yield(1)	1.002		1
Disease:			
frequency:			
overall	67%		115
virgin soil	78%		50
previously planted	100%		5
Effect on yield	0.3496	0.5728	32

(1) an *a priori* decision was made to exclude poor germination from all crop yield regressions.

TABLE F-13.

REGRESSION OF *VIGNA* COW-PEA YIELDS ON pH

Regression	Y =	-84.403	+	20.810 a
Standard Errors		36.981		6.726
t statistics		-2.282		3.094
Significance		0.1067		0.0535
Partial Correlation				0.873
	R-Squared =	0.76	F stat. =	9.57
	Std. error of est. =	36.98	Multiple R =	0.87
	P =	0.0535	N =	5

Abbreviations: Y = *Vigna* yield (kg/kg seed sown)

a = pH

590

Fig. F-8. -- *Vigna* cow-pea yields (kg/kg seed sown) vs soil pH

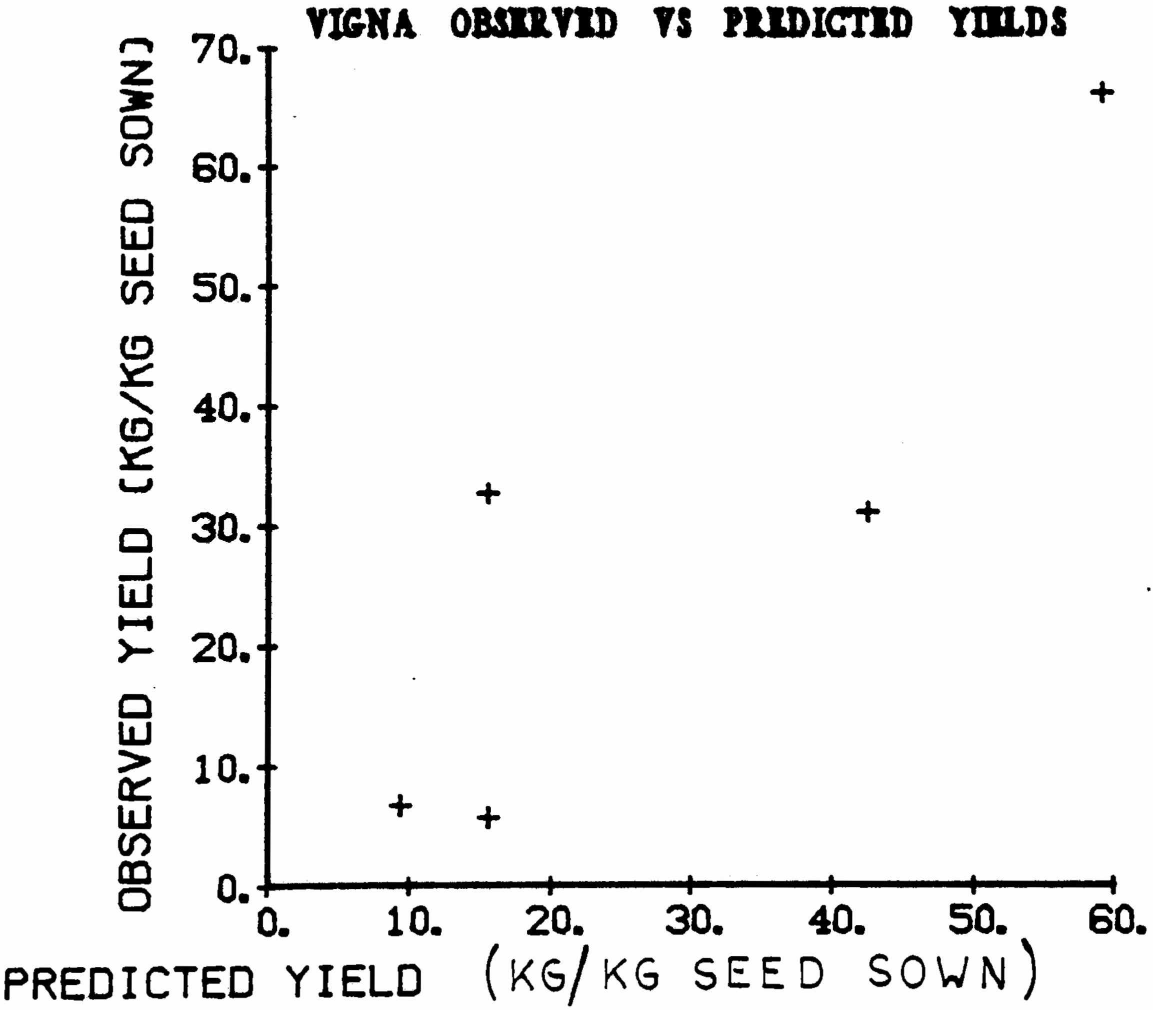

VIGNA OBSERVED VS PREDICTED YIELDS
OBSERVED YIELD (KG/KG SEED SOWN)
70.
60.
50.
40.
30.
20.
10.
0.
0.
10.
20.
30.
40.
50.
60.
PREDICTED YIELD (KG/KG SEED SOWN)

TABLE F-14.

VIGNA COW-PEA YIELD REGRESSION VARIABLES AND EXCLUDED CONDITIONS SUMMARY

ITEM	MEAN	STANDARD DEVIATION	N
	variables		
kgs seeds planted/ha	8.10	7.82	30
	excluded conditions		
Disease:			
frequency	14.3%		28
effect on yield	0.0896		1
Rabbits (intensity 3 or 4)			
frequency	17.65		34
effect on yield	0.677		1
Poor germination			
frequency	0%		
effect on yield	?		

TABLE F-15.

REGRESSION OF BITTER MANIOC YIELDS ON pH

Regression	Y =	-17369.	+	4124.4 a
Standard Errors		4503.6		945.33
t statistics		-3.857		4.363
Significance		0.031		0.022
Partial Correlation				0.929
	R-Squared =	0.86	F stat. =	19.04
	Std. error of est. =	414.22	Multiple R =	0.93
	P =	0.022	N =	5

Abbreviations: Y = Bitter manioc yield (kgs flour/12 months growth)

a = soil pH

Fig. F-9. -- Bitter manioc yields vs soil pH. Yields are kgs flour/ha/12 months growth for fields with areas of at least 0.5 ha and growth periods of 1 - 2 years. Note that upper limit of regression is a pH of 5.0; yields could not be expected to increase substantially at pH levels above this (see text).

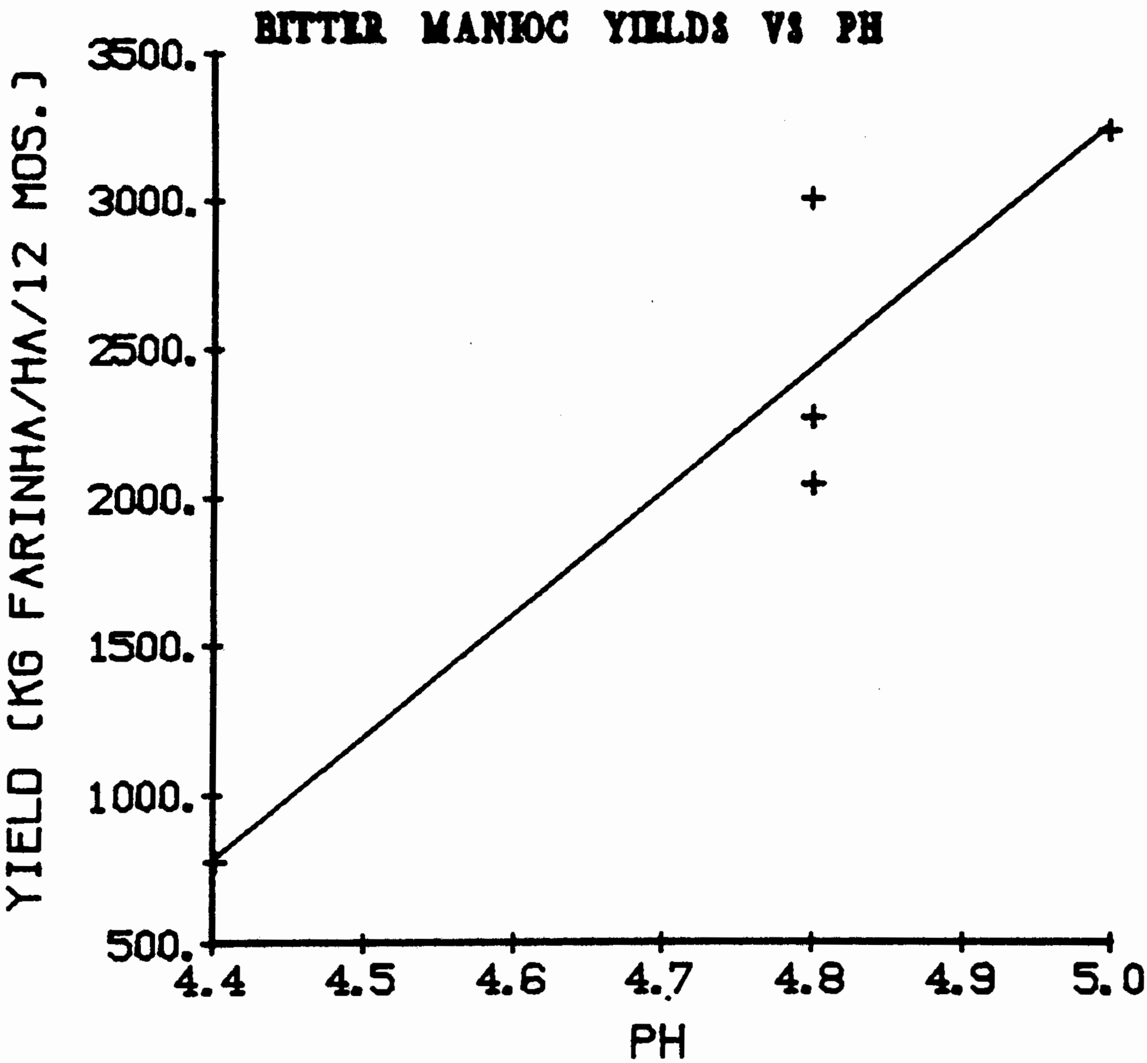

BITTER MANIOC YIELDS VS PH
YIELD (KG FARINHA/HA/12 MOS.)
3500.
3000.
2500.
2000.
1500.
1000.
500.
4.4
4.5
4.6
4.7
4.8
4.9
5.0
PH

TABLE F-16.

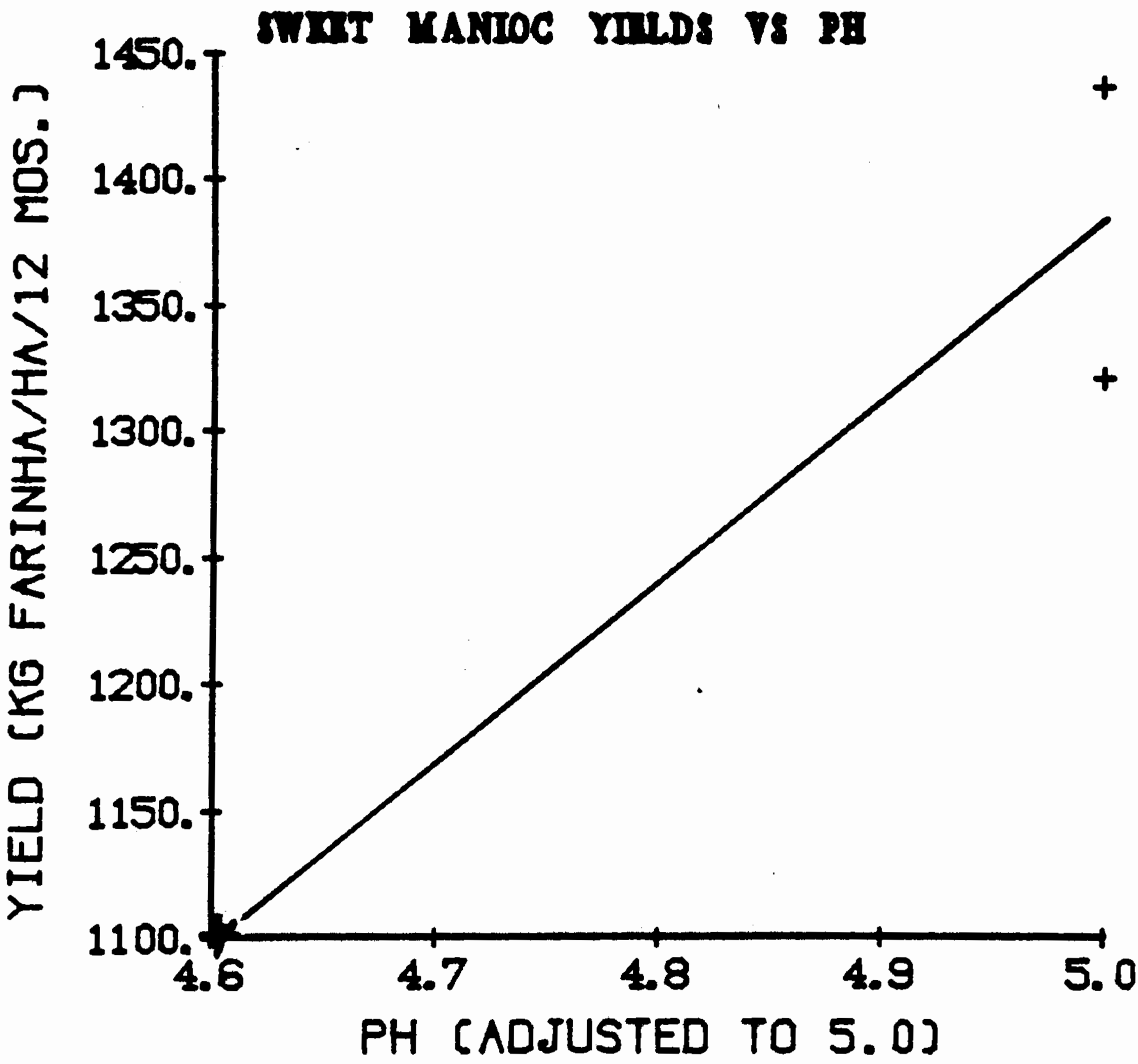
REGRESSION OF SWEET MANIOC YIELDS ON pH

Regression	Y =	-1559.2	+	587.53 a
Standard Errors		1215.4		249.55
t statistics		-1.283		2.354
Significance		0.422		0.256
Partial Correlation				0.920
	R-Squared =	0.85	F stat. =	5.54
	Std. error of est. =	81.504	Multiple R =	0.92
	P =	0.256	N =	3

Abbreviations: Y = Sweet manioc yield (kgs flour/12 months growth)

a = soil pH (adjusted to 5.0)

Fig. F-10. -- Sweet manioc yields vs soil pH. Yields are kgs flour/ha/12 months growth for fields with areas of at least 1.0 ha and growth periods of 1 - 2 years. pH is adjusted to 5.0. The parallel with bitter manioc adds some credence to the general nature of the sweet manioc regression. Very few colonists harvest large areas of sweet manioc for flour at one time.


SWEET MANIOC YIELDS VS PH
YIELD (KG FARINHA/HA/12 MOS.)
1450.
1400.
1350.
1300.
1250.
1200.
1150.
1100.
4.6
4.7
4.8
4.9
5.0
PH (ADJUSTED TO 5.0)

APPENDIX G

POPULATION: DEMOGRAPHY, HEALTH, AND LABOR SUPPLY

TABLE G-1.

AGE DISTRIBUTION IN COLONIZATION AREA AND RURAL BRASIL

ALTAMIRA COLONIZATION AREA(1)		CENSUS DATA FOR RURAL BRAZILIAN POPULATION(2)	
age group	percent	age group	percent
0-5	24	0-4	17.2
6-10	18	5-9	15.5
11-15	14	10-14	12.9
16-20	9.5	15-19	10.8
>20	54.5	20-24	8.7
		25-29	6.7
		30-34	5.5
		35-39	4.9
		40-44	4.3
		45-49	3.5
		50-54	3.0
		55-59	2.3
		60-69	3.0
		≥70	1.6
		unknown	0.2

(1) SOURCE: Brasil, Ministério de Agricultura, INCRA 1972)

(2) SOURCE: Brasil, FIBGE/IBI. 1970 (data presented in da Mata et al. 1973, p.119).

TABLE G-2.

LABOR EQUIVALENTS IN AGRICULTURAL WORK

SOURCE 1[1]			SOURCE 2[2]		
age group	man	woman	age group	man	woman
9 - 10	0.30	0.30	7 - 8	0.20	0.15
11 - 13	0.50	0.30	9 - 13	0.25	0.20
14 - 17	1.00	0.50	14 - 17	0.50	0.40
≥18	1.00	0.75	≥18	1.00	0.75

(1) source 1 data presented in Tavares et al. (1972, p.148).

(2) source 2 data from Brasil,Ministério de Agricultura, INCRA (1972, p.202).

TABLE G-3.

FREQUENCY DISTRIBUTION OF FAMILY LABOR FORCE

Labor force (man-equivalents)	Percent occurrence
1.0 - 1.5	9
1.6 - 2.0	24
2.1 - 2.5	16
2.6 - 3.0	8
3.0 - 3.5	9
3.6 - 4.0	9
4.1 - 4.5	9
4.6 - 5.0	3
5.1 - 5.5	8
5.6 - 6.0	3
> 6.0	2

SOURCE: Brasil, Ministério de Agricultura, INCRA 1972

TABLE G-4.

AGE-SPECIFIC FECUNDITIES FOR RURAL BRAZILIAN POPULATION

Age class	Total No. Women	Total live births in previous year	Probability of live birth for age class
15-19	2,188,350	132,029	0.060
20-24	1,772,913	414,291	0.234
25-29	1,334,934	362,629	0.272
30-34	1,087,643	274,239	0.252
35-39	987,395	198,659	0.201
40-44	837,890	91,988	0.110

SOURCE: 1970 census figures presented in da Mata et al. (1973, p.175).

Fig. G-1. -- Malaria yearly probabilities for males by a class. Age classes are: 1=0-4 yrs, 2=5-9. yrs, 3=10-14 yrs, 4=15-19 yrs, 5=20-24 yrs, 6=25-29 yrs, 7=30-34 yrs, 8=35-39 yrs, 9=40-44 yrs, 10=45-49 yrs, 11=50-54 yrs, 12=55-59 yrs, 13=≥60 yrs. Disease probabilities are used calculate family labor availability for agricultural operations in KPROG2. Probabilities are calculated from numbers of hospital admittances in SESP hospital in Altamira by given sex and age class for 1973. Data used are from Smith (1976, pp.217,235,239, and 247). Proportions o individuals in the entire area by sex and age were estimat from the survey of 101 families done by Moran (1975) as modified by Smith (1976, p.216) to include Smith's estimat of individuals in each category in the (mostly migrant labor) population not under INCRA auspices (Smith 1976, p.216). The estimate of the total population of the area used is the 34,000 figure given by Smith (1976, p.212). (note: Smith also gives a figure of 24,000 (Smith 1976, p.205).

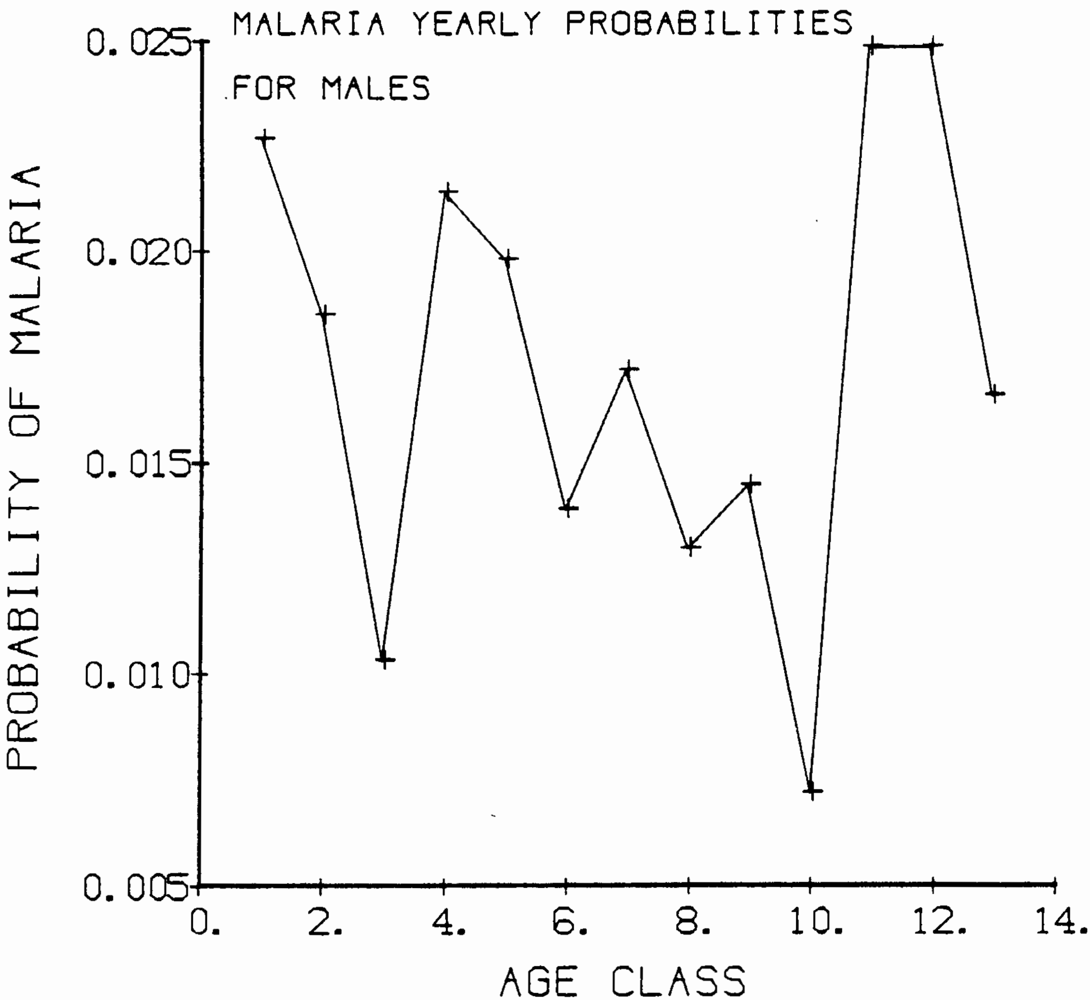

MALARIA YEARLY PROBABILITIES
FOR MALES
PROBABILITY OF MALARIA
0.025
0.020
0.015
0.010
0.005
0.
2.
4.
6.
8.
10.
12.
14.
AGE CLASS

Fig. G-2. -- Malaria yearly probabilities for females by age class. Age classes are: 1=0-4 yrs, 2=5-9.yrs, 3=10-14 yrs, 4=15-19 yrs, 5=20-24 yrs, 6=25-29 yrs, 7=30-34 yrs, 8=35-39 yrs, 9=40-44 yrs, 10=45-49 yrs, 11=50-54 yrs, 12=55-59 yrs, 13=≥60 yrs. Disease probabilities are used to calculate family labor availability for agricultural operations in KPROG2. Probabilities are calculated from numbers of hospital admittances in SESP hospital in Altamira by given sex and age class for 1973. Data used are from Smith (1976, pp.217,235,239, and 247). Proportions of individuals in the entire area by sex and age were estimated from the survey of 101 families done by Moran (1975) as modified by Smith (1976, p.216) to include Smith's estimates of individuals in each category in the (mostly migrant labor) population not under INCRA auspices (Smith 1976, p.216). The estimate of the total population of the area used is the 34,000 figure given by Smith (1976, p.212). (note: Smith also gives a figure of 24,000 (Smith 1976, p.205).

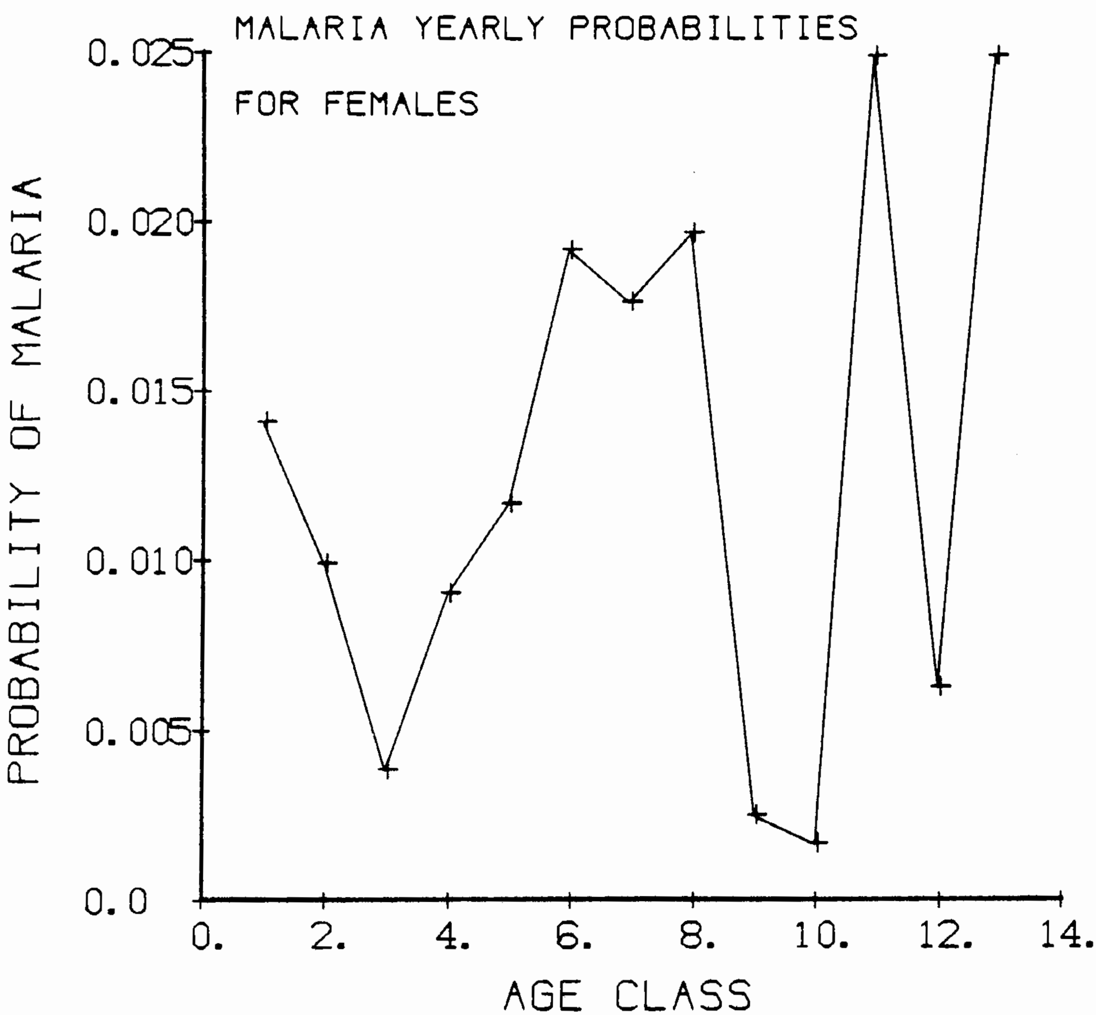

MALARIA YEARLY PROBABILITIES
FOR FEMALES
PROBABILITY OF MALARIA
0.025
0.020
0.015
0.010
0.005
0.0
0.
2.
4.
6.
8.
10.
12.
14.
AGE CLASS

Fig. G-3. -- Trauma yearly probabilities for males by age class. Age classes are: 1=0-4 yrs, 2=5-9.yrs, 3=10-14 yrs, 4=15-19 yrs, 5=20-24 yrs, 6=25-29 yrs, 7=30-34 yrs, 8=35-39 yrs, 9=40-44 yrs, 10=45-49 yrs, 11=50-54 yrs, 12=55-59 yrs, 13=≥60 yrs. Disease probabilities are used to calculate family labor availability for agricultural operations in KPROG2. Probabilities are calculated from numbers of hospital admittances in SESP hospital in Altamira by given sex and age class for 1973. Data used are from Smith (1976, pp.217,235,239, and 247). Proportions of individuals in the entire area by sex and age were estimated from the survey of 101 families done by Moran (1975) as modified by Smith (1976, p.216) to include Smith's estimates of individuals in each category in the (mostly migrant labor) population not under INCRA auspices (Smith 1976, p.216). The estimate of the total population of the area used is the 34,000 figure given by Smith (1976, p.212). (note: Smith also gives a figure of 24,000 (Smith 1976, p.205).

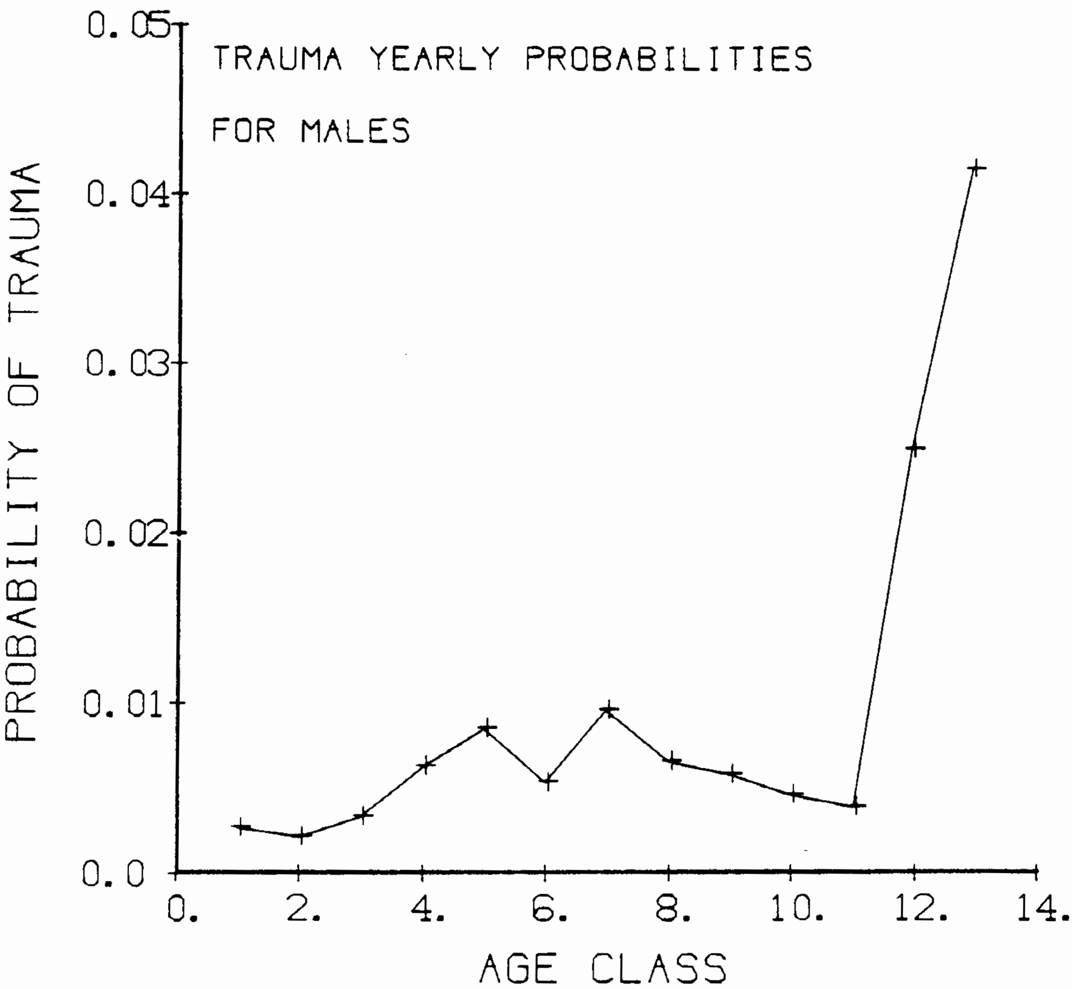

TRAUMA YEARLY PROBABILITIES
FOR MALES
PROBABILITY OF TRAUMA
0.05
0.04
0.03
0.02
0.01
0.0
0.
2.
4.
6.
8.
10.
12.
14.
AGE CLASS

Fig. G-4. -- Trauma yearly probabilities for females by age class. Age classes are: 1=0-4 yrs, 2=5-9.yrs, 3=10-14 yrs, 4=15-19 yrs, 5=20-24 yrs, 6=25-29 yrs, 7=30-34 yrs, 8=35-39 yrs, 9=40-44 yrs, 10=45-49 yrs, 11=50-54 yrs, 12=55-59 yrs, 13=≥60 yrs. Disease probabilities are used to calculate family labor availability for agricultural operations in KPROG2. Probabilities are calculated from numbers of hospital admittances in SESP hospital in Altamira by given sex and age class for 1973. Data used are from Smith (1976, pp.217,235,239, and 247). Proportions of individuals in the entire area by sex and age were estimated from the survey of 101 families done by Moran (1975) as modified by Smith (1976, p.216) to include Smith's estimates of individuals in each category in the (mostly migrant labor) population not under INCRA auspices (Smith 1976, p.216). The estimate of the total population of the area used is the 34,000 figure given by Smith (1976, p.212). (note: Smith also gives a figure of 24,000 (Smith 1976, p.205).

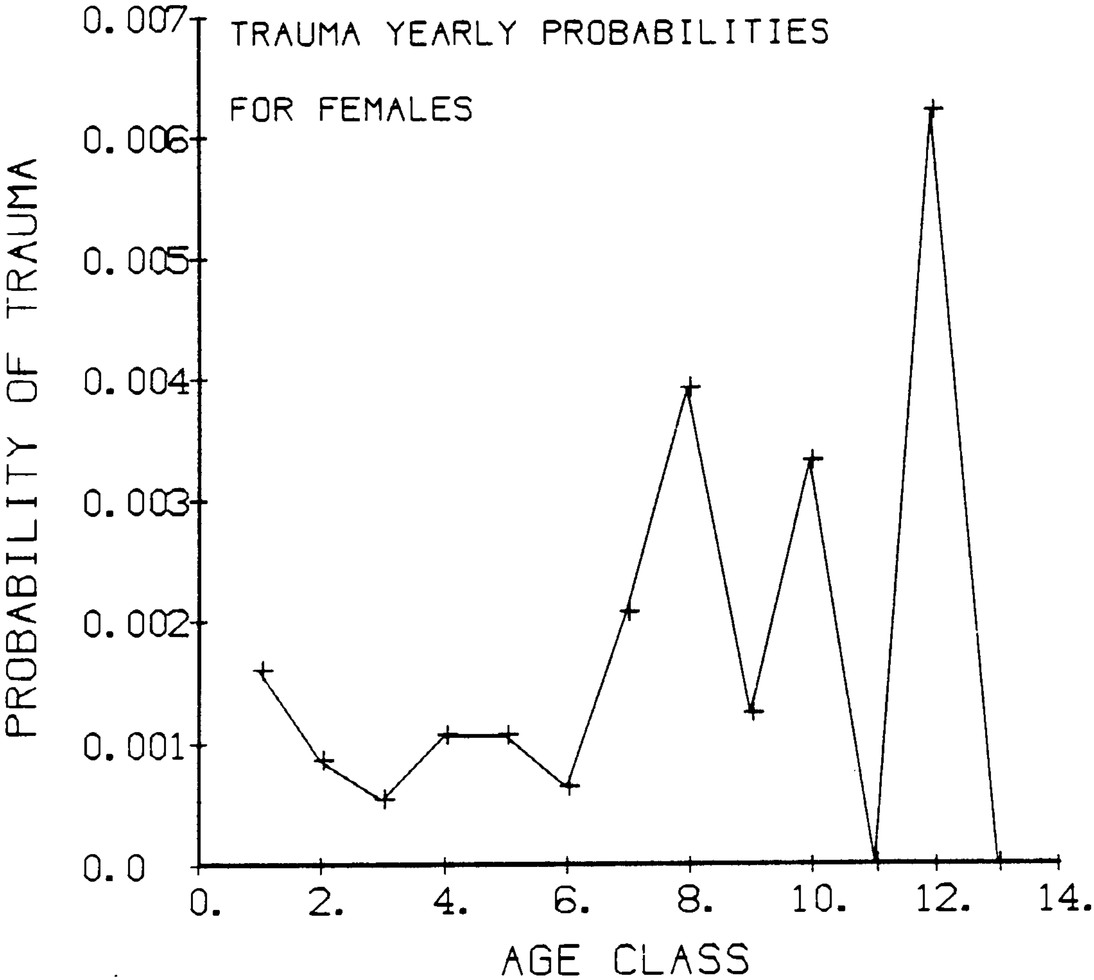

TRAUMA YEARLY PROBABILITIES
FOR FEMALES
PROBABILITY OF TRAUMA
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.0
0.
2.
4.
6.
8.
10.
12.
14.
AGE CLASS

Fig. G-5. -- Other disease yearly probabilities for males by age class. Age classes are: 1=0-4 yrs, 2=5-9.yrs, 3=10-14 yrs, 4=15-19 yrs, 5=20-24 yrs, 6=25-29 yrs, 7=30-34 yrs, 8=35-39 yrs, 9=40-44 yrs, 10=45-49 yrs, 11=50-54 yrs, 12=55-59 yrs, 13=≥60 yrs. Disease probabilities are used to calculate family labor availability for agricultural operations in KPROG2. Probabilities are calculated from numbers of hospital admittances in SESP hospital in Altamira by given sex and age class for 1973. Data used are from Smith (1976, pp.217,235,239, and 247). Proportions of individuals in the entire area by sex and age were estimated from the survey of 101 families done by Moran (1975) as modified by Smith (1976, p.216) to include Smith's estimates of individuals in each category in the (mostly migrant labor) population not under INCRA auspices (Smith 1976, p.216). The estimate of the total population of the area used is the 34,000 figure given by Smith (1976, p.212). (note: Smith also gives a figure of 24,000 (Smith 1976, p.205).

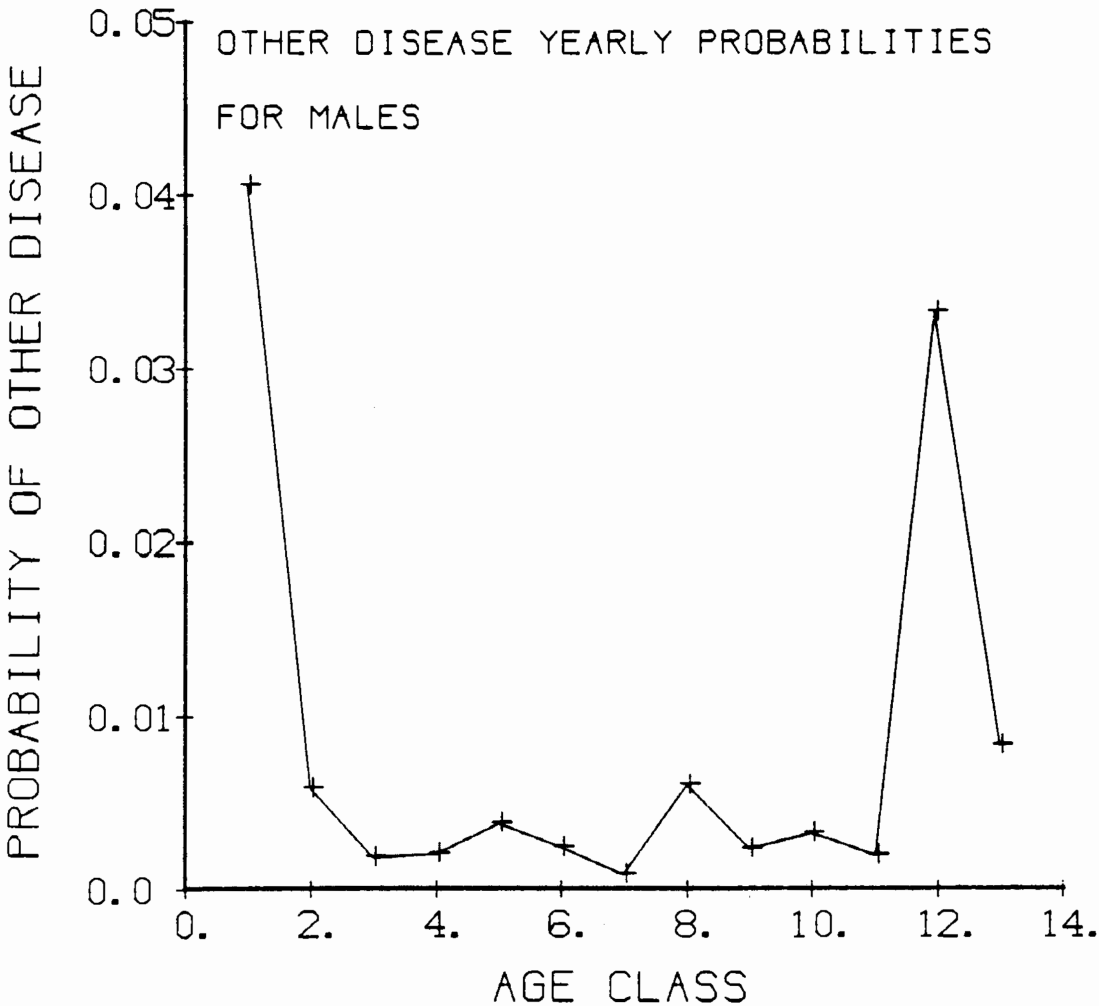
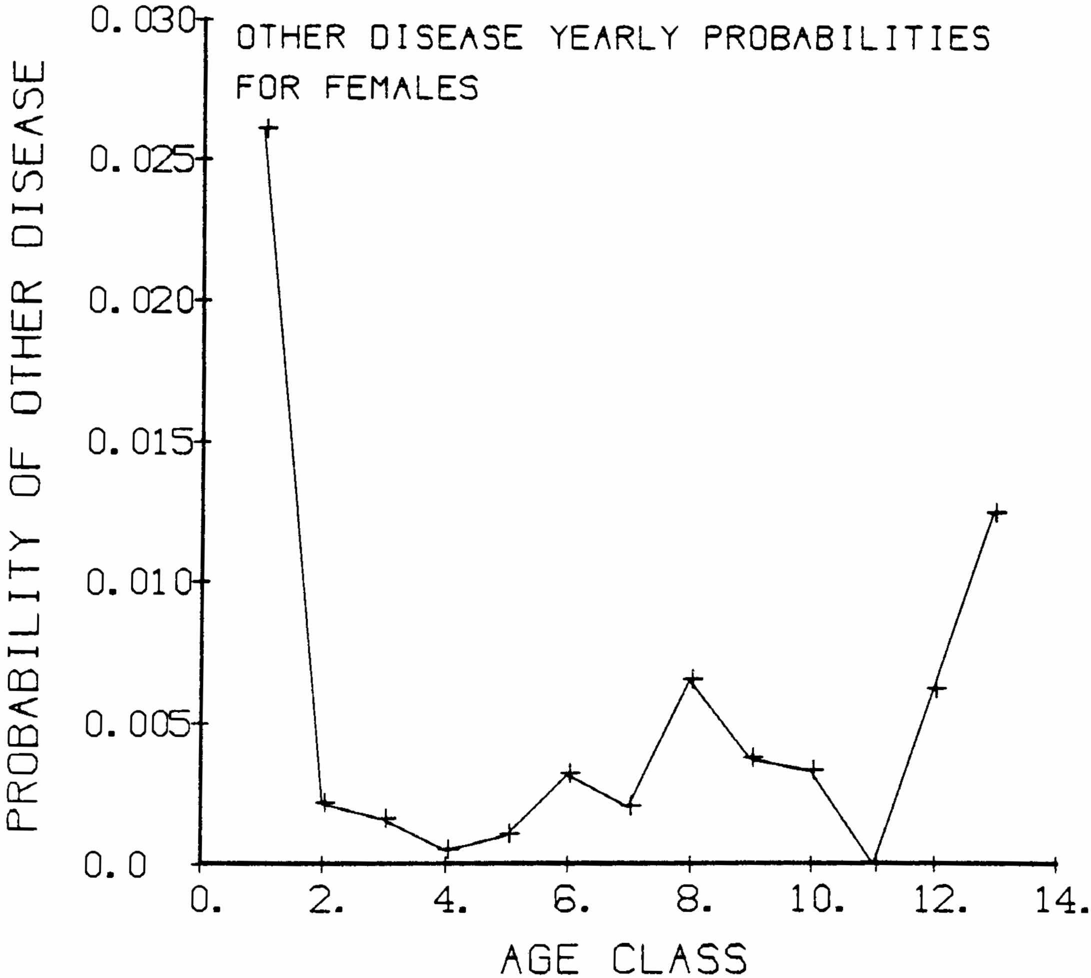

OTHER DISEASE YEARLY PROBABILITIES
FOR MALES
PROBABILITY OF OTHER DISEASE
0.05
0.04
0.03
0.02
0.01
0.0
0.
2.
4.
6.
8.
10.
12.
14.
AGE CLASS

Fig. G-6. -- Other disease yearly probabilities for females by age class. Age classes are: 1=0-4 yrs, 2=5-9.yrs, 3=10-14 yrs, 4=15-19 yrs, 5=20-24 yrs, 6=25-29 yrs, 7=30-34 yrs, 8=35-39 yrs, 9=40-44 yrs, 10=45-49 yrs, 11=50-54 yrs, 12=55-59 yrs, 13=$\geq$60 yrs. Disease probabilities are used to calculate family labor availability for agricultural operations in KPROG2. Probabilities are calculated from numbers of hospital admittances in SESP hospital in Altamira by given sex and age class for 1973. Data used are from Smith (1976, pp.217,235,239, and 247). Proportions of individuals in the entire area by sex and age were estimated from the survey of 101 families done by Moran (1975) as modified by Smith (1976, p.216) to include Smith's estimates of individuals in each category in the (mostly migrant labor) population not under INCRA auspices (Smith 1976, p.216). The estimate of the total population of the area used is the 34,000 figure given by Smith (1976, p.212). (note: Smith also gives a figure of 24,000 (Smith 1976, p.205).



OTHER DISEASE YEARLY PROBABILITIES FOR FEMALES
PROBABILITY OF OTHER DISEASE
0.030
0.025
0.020
0.015
0.010
0.005
0.0
0.
2.
4.
6.
8.
10.
12.
14.
AGE CLASS

Fig. G-7. -- Malaria monthly probabilities. Calculations are made by month since the probabilities of illness are far greater during the key agricultural seasons. Malaria monthly probabilities are calculated from SUCAM data for the Altamira area on numbers of positive slides found for malaria in blood samples from patients with suspected malaria who had been referred to this agency. Data used to calculate the probabilities is taken from Smith (1976, p.212).

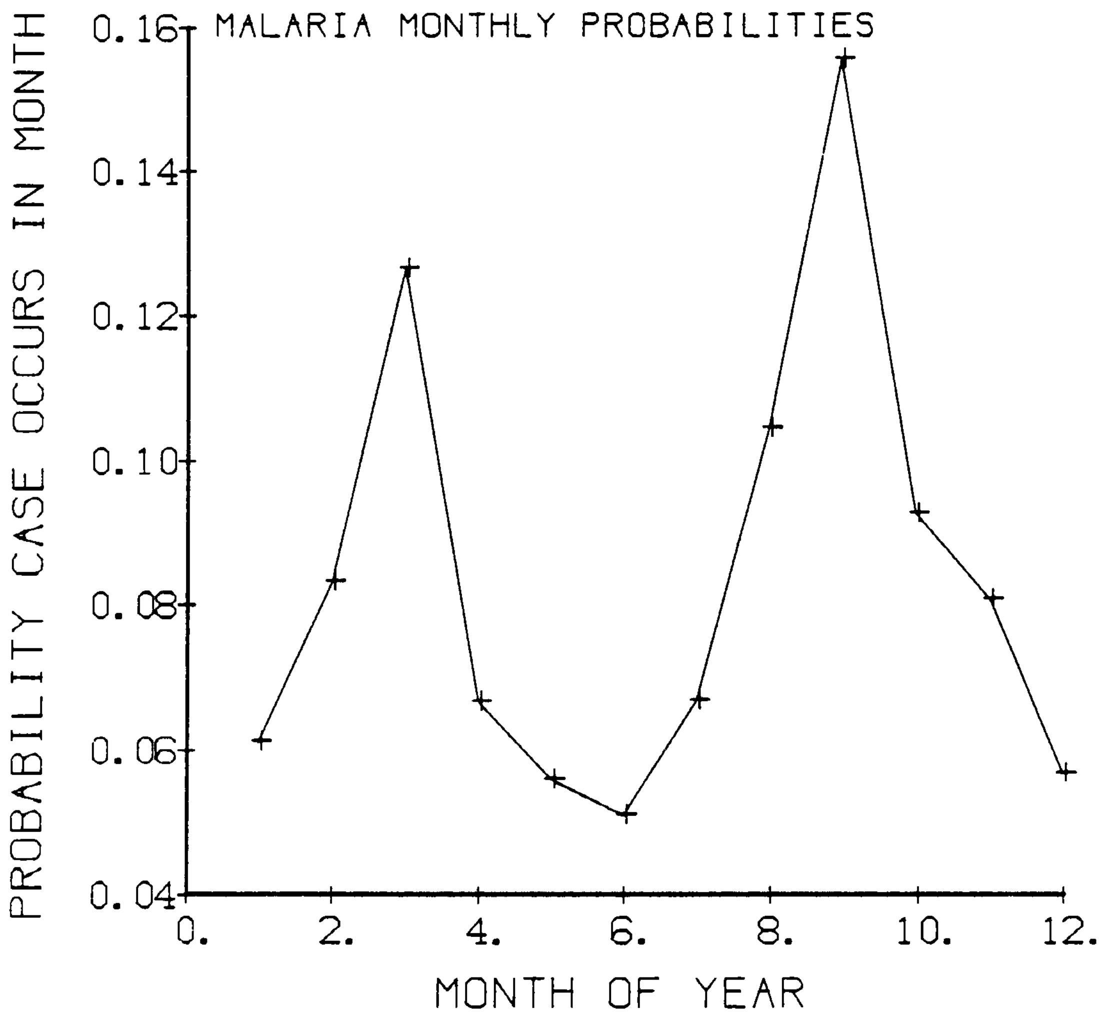
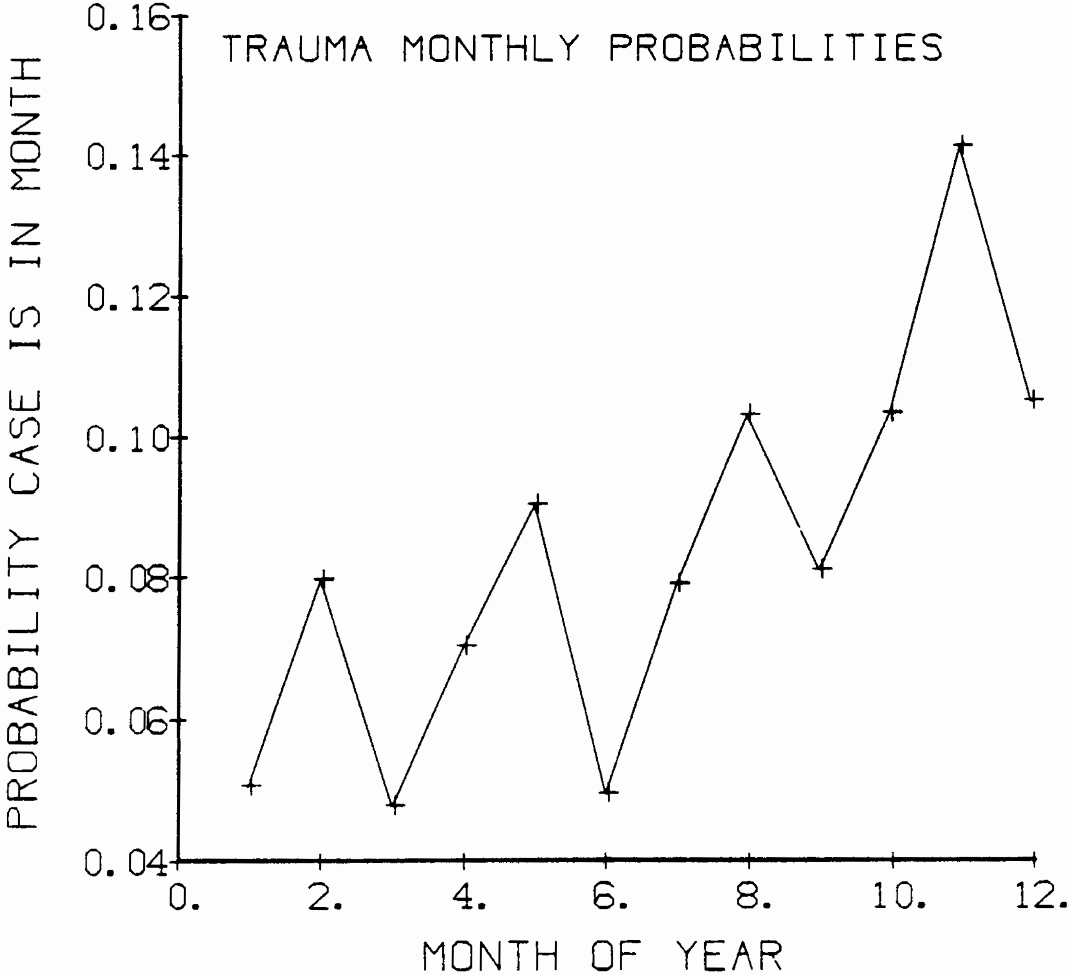

MALARIA MONTHLY PROBABILITIES
PROBABILITY CASE OCCURS IN MONTH
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.
2.
4.
6.
8.
10.
12.
MONTH OF YEAR

Fig. G-8. -- Trauma monthly probabilities. Trauma probabilities are calculated from numbers of hospital admittances in SESP hospital, Altamira, for 1971, 1972, and 1973. Data for complete census of hospital records done by Smith was taken from Moran (1976, p. 121).



TRAUMA MONTHLY PROBABILITIES
PROBABILITY CASE IS IN MONTH
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.
2.
4.
6.
8.
10.
12.
MONTH OF YEAR

Fig. G-9. -- Proportion of original colonists remaining by year in a stochastic run of KPROG2 with the dynamic population sector option enabled. The rate of turnover in the colonist population (based on data from the intensive study area) is somewhat higher than that in the actual population. Even at lower rates the turnover would be quite rapid: INCRA's report for 1974 states that 17% of the original colonist population had left by the end of that year (Brasil, Ministério de Agricultura, INCRA, Coordenaria Regional do Norte CR-01. 1974), which would correspond to a half-life of approximately 11 years. Colonist turnover influences land use and resource allocation patterns.

RUN NUMBER 47
PROPORTION OF ORIGINAL COLONISTS REMAINING

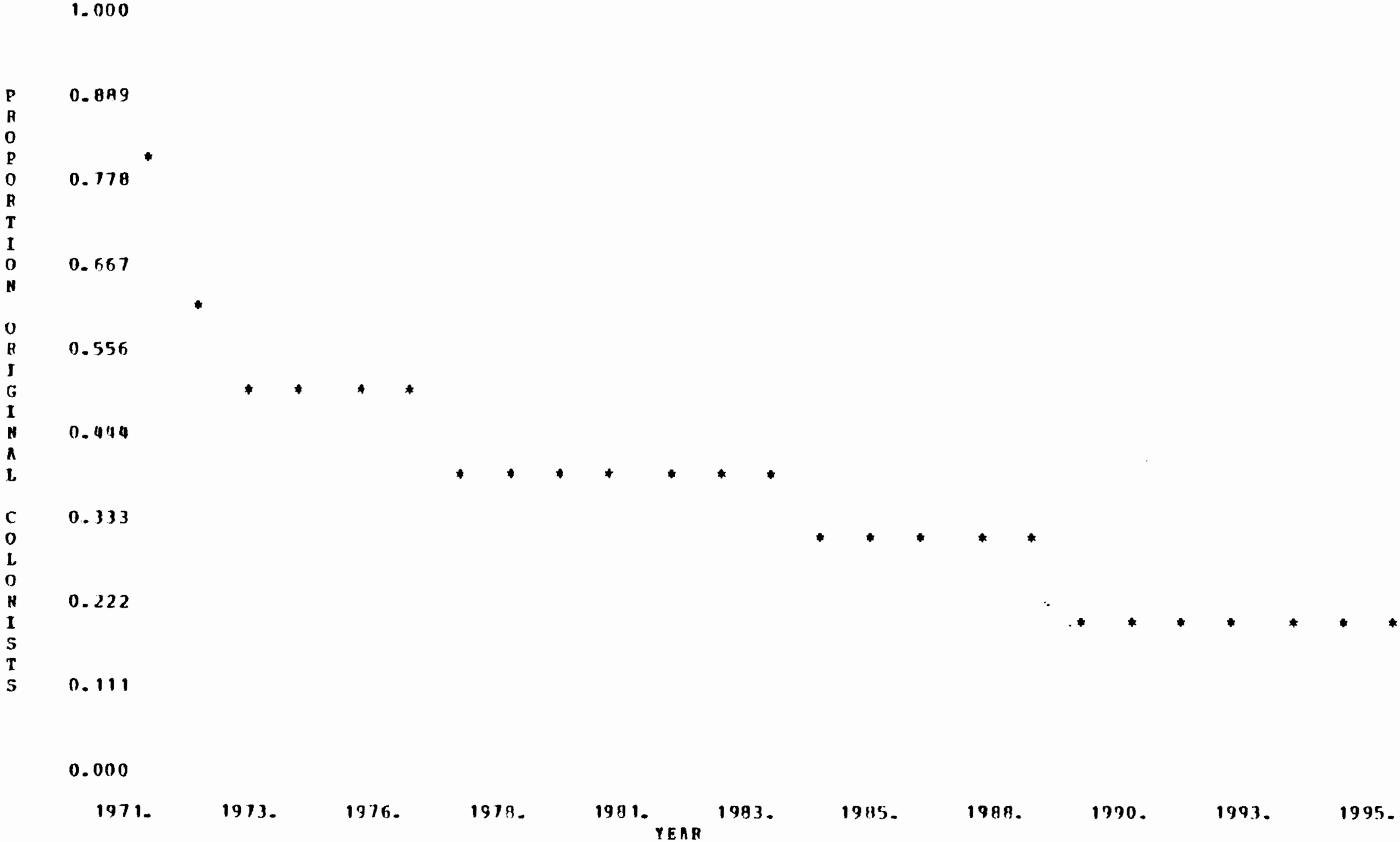
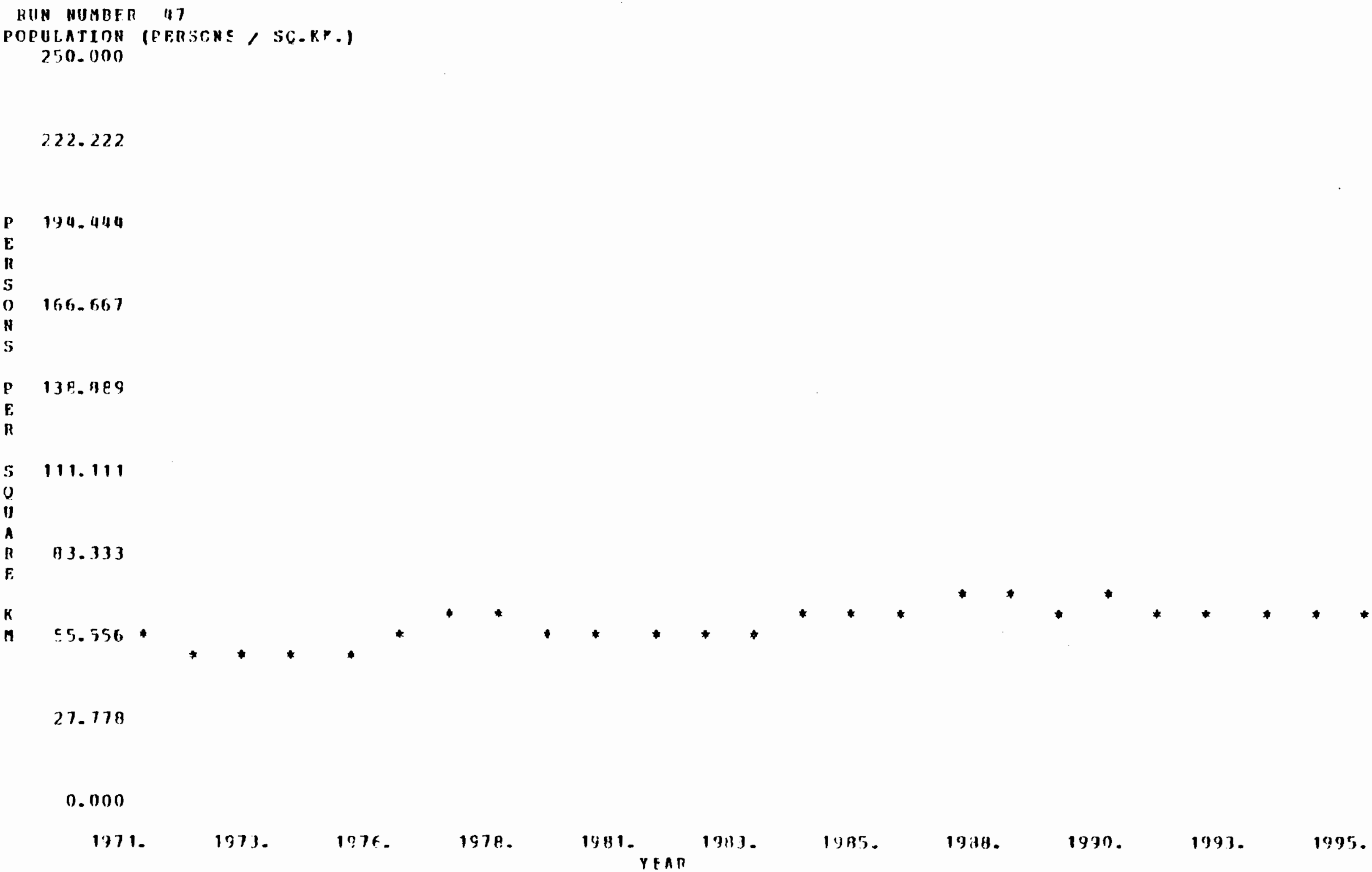


Fig. G-10. -- Simulated colonist population in stochastic run of KPROG2 with dynamic population sector enabled. Population growth is quite slow due to rapid turnover in colonist population with newcomers entering with relatively small family sizes. The maintenance of this pattern is dependent on the continued presence of attractive alternatives for emigrating colonists. The model does not imply that such alternatives would exist indefinitely.


RUN NUMBER 47
POPULATION (PERSONS / SQ.KM.)
250.000
222.222
194.444
166.667
138.889
111.111
83.333
55.556
27.778
0.000
PERSONS PER SQUARE KM
1971.
1973.
1976.
1978.
1981.
1983.
1985.
1988.
1990.
1993.
1995.
YEAR