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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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
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APPENDICES
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 minimum of 15 locations in a field. Over 1000 samples were taken. Profiles were also taken to 1 meter depth. Photograph shows author taking sample in area newly cleared for pasture.
<table>
<thead>
<tr>
<th>Beginning pH Class</th>
<th>≤3.9</th>
<th>3.9-4.4</th>
<th>4.5-5.0</th>
<th>5.0-5.5</th>
<th>5.5-6.0</th>
<th>6.0-6.5</th>
<th>≥6.5</th>
<th>SAMPLE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤3.9</td>
<td>0.00</td>
<td>0.31</td>
<td>0.00</td>
<td>0.25</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>4.0-4.4</td>
<td>0.09</td>
<td>0.21</td>
<td>0.04</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>11</td>
</tr>
<tr>
<td>4.5-5.0</td>
<td>0.06</td>
<td>0.11</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>6</td>
</tr>
<tr>
<td>5.0-5.5</td>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>17</td>
</tr>
<tr>
<td>5.5-6.0</td>
<td>0.11</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>9</td>
</tr>
<tr>
<td>6.0-6.5</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>5</td>
</tr>
</tbody>
</table>

For calculation for samples in which are 500 meters from each reference sample, 15 meters.}

46) calculated from samples which are 500 meters from each reference sample 100 meters.
Fig. A-2. — Map of pH in virgin soil of intensive study area. Levels are assigned to 20 hectare quadrats from nearest sample for which data are available.
TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

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

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

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

PHOSPHORUS (PPM)

TOTAL AREA: 23600 HECTARES

SCALE: \[\frac{\text{1 cm}}{3 \text{ km}}\]
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

TRANSAazon HIGHWAY INTENSIVE STUDY AREA

ALUMINUM (AL+++ ME PER 100G)

ALUMINUM (mg/100g)

0.0
0.1
0.2
0.3-0.4
0.5-0.9
1.0-4.0
>5.0

TOTAL AREA: 23,600 HECTARES

SCALE: 3 KM
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

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

TOTAL AREA: 23600 HECTARES
SCALE:  3 KM

Ca²⁺ & Mg²⁺ (me/100g)

0.1 - 0.2
0.3 - 0.4
0.5 - 0.8
0.9 - 1.4
1.5 - 9.0
>10.0
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

TRANSAazon HIGHWAY INTENSIVE STUDY AREA

TOTAL AREA: 23500 HECTARES

SCALE: \[ \begin{array}{c}
10 - 24 \\
25 - 44 \\
45 - 64 \\
65 - 84 \\
85 - 100 \\
> 100 \\
\end{array} \]

\[ \begin{array}{c}
\text{M.N.Y.T.H.} \\
\end{array} \]
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

H.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.
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

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 - 0.66
0.67 - 0.99
1.00 - 1.49
1.50 - 1.99

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

TOTAL AREA: 23600 HECTARES
SCALE: ——— 3 KM
Fig. A-11. -- Locations of samples for carbon map of virgin soils of the intensive study area.
TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

LOCATIONS OF SAMPLES FOR CARBON MAP

NUMBER OF SAMPLES USED = 75

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

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

TOTAL CLAY (%)

CLAY (%)

0-14
15-29
30-44
54-59
60-74
75-89

TOTAL AREA: 23600 HECTARES
SCALE: ——— 3 KM
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

TRANSAAZON HIGHWAY INTENSIVE STUDY AREA

SILT (%)

0-14
15-29
30-44
60-74
>75

TOTAL AREA: 23600 HECTARES
SCALE: ----- 3 KM
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

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

FINE SAND (%)

- 0 - 14
- 15 - 29
- 30 - 44
- 45 - 59

TOTAL AREA: 23800 HECTARES
SCALE: — 3 KM
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

TRANSAMAZON HIGHWAY INTENSIVE STUDY AREA

COARSE SAND (%)

0-14
15-29
30-44
45-59
60-74
75-89

TOTAL AREA: 22600 HECTARES
SCALE: 3 KM
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.
TRANSAazon 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.
SLOPE

0-4%
5-9%
10-19%
20-29%
30-49%
50-69%
70-90%

TOTAL AREA: 23600 HECTARES
SCALE: 3 KM
Fig. A-18. — Locations of measurements for slope map of the intensive study area.
LOCATIONS OF SAMPLES FOR SLOPE MAP

NUMBER OF SAMPLES USED = 225

TOTAL AREA: 23600 HECTARES

SCALE: — 3 KM
**TABLE A-2.**

**MULTIPLE REGRESSION FOR ALUMINUM IN VIRGIN SOIL**

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y =</th>
<th>11.429 -</th>
<th>7.677 a +</th>
<th>0.0627 b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>1.391</td>
<td>0.907</td>
<td>0.0079</td>
</tr>
<tr>
<td>t statistics</td>
<td></td>
<td>8.216</td>
<td>-8.467</td>
<td>7.913</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td></td>
<td>-0.620</td>
<td>0.594</td>
<td></td>
</tr>
</tbody>
</table>

R-Squared = 0.54  F stat. = 67.38
Std. error of est. = 1.559  Multiple R = 0.73
P < 0.001  N = 116

Abbreviations:  Y = Al^{+++}(mg/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)
### Table A-3.

**Multiple Regression for Nitrogen in Virgin Soil**

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = -11.986 + 0.132a + 0.0220b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard errors</td>
<td>0.0333 0.0115 0.0067</td>
</tr>
<tr>
<td>$t$ statistics</td>
<td>-3.99 11.49 3.267</td>
</tr>
<tr>
<td>Significance</td>
<td>0.0007 $&lt;0.001$ 0.0020</td>
</tr>
<tr>
<td>Partial correlations</td>
<td>0.852 0.419</td>
</tr>
<tr>
<td>$R$-squared</td>
<td>0.73 $F$ stat. = 68.05</td>
</tr>
<tr>
<td>Std. error of est.</td>
<td>0.0304 Multiple $R = 0.73$</td>
</tr>
<tr>
<td>$p &lt;$</td>
<td>0.001 $N = 53$</td>
</tr>
</tbody>
</table>

**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
**TABLE A-4.**

**REGRESSION OF CALCIUM AND MAGNESIUM IN VIRGIN SOIL**

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = $</th>
<th>-10.610</th>
<th>$+ $</th>
<th>2.041 $a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>0.942</td>
<td>0.209</td>
<td></td>
</tr>
<tr>
<td>$t$ statistics</td>
<td></td>
<td>-11.268</td>
<td>13.570</td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>$&lt;0.001$</td>
<td>$&lt;0.001$</td>
<td></td>
</tr>
<tr>
<td>Partial Correlation</td>
<td></td>
<td></td>
<td>0.706</td>
<td></td>
</tr>
</tbody>
</table>

- **$R^2$-squared** = 0.50
- **$F$ stat.** = 184.15
- **Std. error of est.** = 2.08
- **Multiple $R$** = 0.71
- $P <$ 0.001
- $N =$ 107

**Abbreviations:**

- $Y =$ Ca$^{++}$ and Mg$^{++}$ (Mg/100g)
- $a =$ pH
Fig. A-21. -- Calcium and magnesium vs pH in virgin soil.
CALCIUM AND MAGNESIUM VS pH IN VINEGAR MILK

CALCIUM AND MAGNESIUM (mg/100 g)
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 - 1970)
<table>
<thead>
<tr>
<th>ITEM</th>
<th>Total Rain (mm)</th>
<th>Percent of yearly total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1942.3</td>
<td>16.2</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>489.6</td>
<td>8.8</td>
</tr>
</tbody>
</table>

### Complete years (N = 8) (monthly rainfalls as percentages)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Total Rain (mm)</th>
<th>Percent of yearly total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1295.7(1)</td>
<td>174.7</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>--</td>
<td>118.9</td>
</tr>
<tr>
<td>N</td>
<td>--</td>
<td>21</td>
</tr>
</tbody>
</table>

(1) "mean" is sum of monthly means
TABLE 3-2.

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

<table>
<thead>
<tr>
<th>MONTH</th>
<th>RAIN</th>
<th>EVAPORATION</th>
<th>INSOLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S.D.</td>
<td>N</td>
<td>S.D.</td>
</tr>
<tr>
<td>1</td>
<td>0.0485</td>
<td>142</td>
<td>0.0219</td>
</tr>
<tr>
<td>2</td>
<td>0.0490</td>
<td>113</td>
<td>0.0176</td>
</tr>
<tr>
<td>3</td>
<td>0.0412</td>
<td>155</td>
<td>0.0123</td>
</tr>
<tr>
<td>4</td>
<td>0.0478</td>
<td>150</td>
<td>0.0270</td>
</tr>
<tr>
<td>5</td>
<td>0.0696</td>
<td>155</td>
<td>0.0258</td>
</tr>
<tr>
<td>6</td>
<td>0.0640</td>
<td>150</td>
<td>0.0302</td>
</tr>
<tr>
<td>7</td>
<td>0.0840</td>
<td>155</td>
<td>0.0342</td>
</tr>
<tr>
<td>8</td>
<td>0.1096</td>
<td>147</td>
<td>0.0267</td>
</tr>
<tr>
<td>9</td>
<td>0.0969</td>
<td>120</td>
<td>0.0289</td>
</tr>
<tr>
<td>10</td>
<td>0.1013</td>
<td>119</td>
<td>0.0250</td>
</tr>
<tr>
<td>11</td>
<td>0.1340</td>
<td>120</td>
<td>0.0150</td>
</tr>
<tr>
<td>12</td>
<td>0.0677</td>
<td>124</td>
<td>0.0302</td>
</tr>
</tbody>
</table>

(1) means used are monthly totals divided by number of days in month
<table>
<thead>
<tr>
<th>Regression</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Y = 124.32 + 0.471a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Errors</td>
<td>45.13</td>
<td>0.123</td>
<td></td>
</tr>
<tr>
<td>t statistics</td>
<td>2.755</td>
<td>3.038</td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>0.011</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Partial Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Squared = 0.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F stat. = 14.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std. error of est. = 75.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R = 0.60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P &lt; 0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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)

MARCH RAINFALL (MM)
### TABLE B-4.

**REGRESSION OF MARCH RAIN ON APRIL RAIN FOR ALTAMIRA**

<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = )</th>
<th>135.03</th>
<th>( \beta )</th>
<th>0.763 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>64.51</td>
<td>0.211</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t statistics</td>
<td>2.093</td>
<td>3.613</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>0.047</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Correlation</td>
<td>0.586</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Squared =</td>
<td>0.34</td>
<td>P stat. = 13.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std. error of est. =</td>
<td>97.54</td>
<td>Multiple R = 0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( P = )</td>
<td>0.001</td>
<td>( N = ) 27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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
<table>
<thead>
<tr>
<th>MONTH</th>
<th>N</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>21</td>
<td>0.1170</td>
<td>0.0583</td>
</tr>
<tr>
<td>Feb.</td>
<td>21</td>
<td>0.2144</td>
<td>0.0360</td>
</tr>
<tr>
<td>Mar.</td>
<td>21</td>
<td>0.2831</td>
<td>0.0502</td>
</tr>
<tr>
<td>Apr.</td>
<td>21</td>
<td>0.2136</td>
<td>0.0505</td>
</tr>
<tr>
<td>May</td>
<td>21</td>
<td>0.1312</td>
<td>0.0522</td>
</tr>
<tr>
<td>Jun.</td>
<td>30</td>
<td>77.58</td>
<td>48.18</td>
</tr>
<tr>
<td>Jul.</td>
<td>28</td>
<td>58.62</td>
<td>50.74</td>
</tr>
<tr>
<td>Aug.</td>
<td>27</td>
<td>28.07</td>
<td>22.39</td>
</tr>
<tr>
<td>Sep.</td>
<td>12</td>
<td>0.1862</td>
<td>0.1095</td>
</tr>
<tr>
<td>Oct.</td>
<td>12</td>
<td>0.1995</td>
<td>0.1075</td>
</tr>
<tr>
<td>Nov.</td>
<td>12</td>
<td>0.1850</td>
<td>0.1377</td>
</tr>
<tr>
<td>Dec.</td>
<td>12</td>
<td>0.4293</td>
<td>0.1326</td>
</tr>
</tbody>
</table>
### TABLE B-6.

**REGRESSION OF MONTHLY INSOLATION ON MONTHLY RAINFALL**

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y =</th>
<th>156.68</th>
<th>-</th>
<th>0.180 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>11.015</td>
<td></td>
<td>0.045</td>
</tr>
<tr>
<td>t statistics</td>
<td></td>
<td>14.224</td>
<td></td>
<td>-3.999</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>&lt;0.0001</td>
<td></td>
<td>0.0002</td>
</tr>
<tr>
<td>Partial Correlation</td>
<td></td>
<td></td>
<td></td>
<td>-0.521</td>
</tr>
</tbody>
</table>

- 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
### Table 9-7.

**Regressive of Monthly Evaporation on Monthly Rainfall**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regression</strong></td>
<td>$Y = $</td>
<td>102.34</td>
<td>0.150 a</td>
</tr>
<tr>
<td><strong>Standard Errors</strong></td>
<td></td>
<td>0.016</td>
<td>0.033</td>
</tr>
<tr>
<td><strong>t statistics</strong></td>
<td></td>
<td>12.727</td>
<td>-4.572</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td></td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Partial Correlation</strong></td>
<td></td>
<td></td>
<td>-0.572</td>
</tr>
<tr>
<td><strong>R-Squared</strong></td>
<td></td>
<td>0.33</td>
<td>20.90</td>
</tr>
<tr>
<td><strong>Std. error of est.</strong></td>
<td></td>
<td>32.06</td>
<td>0.57</td>
</tr>
<tr>
<td><strong>P &lt;</strong></td>
<td></td>
<td>0.0001</td>
<td>45</td>
</tr>
</tbody>
</table>

**Abbreviations:**
- $Y =$ Monthly evaporation (mm)
- $a =$ Monthly rainfall (mm)
Fig. B-5. -- Monthly evaporation vs monthly rainfall for Altamira
MONTHLY EVAPORATION VS MONTHLY RAINFALL FOR ALTAMIRA
### TABLE 3-8.
**BURN QUALITY CLASSIFICATION FOR VIRGIN BURNS**

<table>
<thead>
<tr>
<th>BURN QUALITY</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>none</strong></td>
<td>No burn was attempted (therefore no date for burning).</td>
</tr>
<tr>
<td><strong>0</strong></td>
<td>Burn attempted (therefore with burning date) but did not burn. There may be some blackened bark and burned leaves, but the ground remains &quot;raw&quot;. Usually the colonist cannot plant. &quot;Não queimou&quot;.</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>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) &quot;Queimou ruim&quot;, &quot;Só pecou as folhas&quot;.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Patchy burn. A mixture of class 1 and 3 patches where fire burned with varying intensity. Can be planted with coivara. &quot;Mais ou menos quemou.&quot; &quot;Queimou variado.&quot;</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>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. &quot;Queimou bem.&quot;</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Overburned. Large logs burned completely to ashes. This &quot;burns the earth&quot; and results in stunted crops. &quot;Queimou até que quemou a terra.&quot;</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>COEFFICIENTS</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bad burn</td>
<td>Good burn</td>
<td></td>
</tr>
<tr>
<td>Constant:</td>
<td>-6.1617</td>
<td>-7.5752</td>
<td></td>
</tr>
<tr>
<td>rain between felling and burning (mm)</td>
<td>0.0032459</td>
<td>0.0012662</td>
<td></td>
</tr>
<tr>
<td>evaporation between felling and burning (mm)</td>
<td>-0.0035933</td>
<td>-0.00052735</td>
<td></td>
</tr>
<tr>
<td>insolation between felling and burning (hours)</td>
<td>0.0034926</td>
<td>0.0025793</td>
<td></td>
</tr>
<tr>
<td>rain in 15 days previous to burn (mm)</td>
<td>0.076949</td>
<td>0.088626</td>
<td></td>
</tr>
<tr>
<td>evaporation in 15 days previous to burn (mm)</td>
<td>0.15809</td>
<td>0.01027</td>
<td></td>
</tr>
<tr>
<td>insolation in 15 days previous to burn (mm)</td>
<td>0.038381</td>
<td>0.031593</td>
<td></td>
</tr>
<tr>
<td>general variances</td>
<td>2.43 X 10^-7</td>
<td>2.26 X 10^-6</td>
<td></td>
</tr>
<tr>
<td>sample sizes</td>
<td>76</td>
<td>171</td>
<td></td>
</tr>
</tbody>
</table>

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

Mahalanobis distance: D² = 0.686

F statistic = 5.89
Significance < 0.0001
### Table B-10.

**Observed and Predicted Virgin Burn Qualities**

<table>
<thead>
<tr>
<th>Predicted Burn Quality</th>
<th>Observed Burn Quality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bad(^{(1)})</td>
<td>good(^{(2)})</td>
</tr>
<tr>
<td>bad(^{(1)})</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(83.3%)</td>
<td>(16.7%)</td>
</tr>
<tr>
<td>good(^{(2)})</td>
<td>61</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td>(26.6%)</td>
<td>(73.4%)</td>
</tr>
<tr>
<td>Totals</td>
<td>76</td>
<td>171</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>ITEM</th>
<th>Month</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>cutting number</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>percent</td>
<td>0.9</td>
<td>7.2</td>
</tr>
<tr>
<td>burning number</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>percent</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean days between cutting and burning = 52.6 (S.D. = 96.1  N = 79)
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>COEFFICIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bad burn</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.32692</td>
</tr>
<tr>
<td>rain between cutting and burning (mm)</td>
<td>0.00048378</td>
</tr>
<tr>
<td>evaporation between cutting and burning (mm)</td>
<td>-0.013939</td>
</tr>
<tr>
<td>insolation between cutting and burning (hours)</td>
<td>0.0029030</td>
</tr>
<tr>
<td>general variances</td>
<td>8.92 X 10^11</td>
</tr>
<tr>
<td>sample sizes</td>
<td>31</td>
</tr>
</tbody>
</table>

Equalit of covariances: df=6, 15499 F=5.78 Signif. < 0.001

Mahalanobis distance: D^2 = 0.566

F statistic = 2.39

Significance = 0.0793
### Table D-13.

**Observed and Predicted Second Growth Burn Qualities**

<table>
<thead>
<tr>
<th>Predicted Burn Quality</th>
<th>Observed Burn Quality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bad (1)</td>
<td>good (2)</td>
</tr>
<tr>
<td>bad (1)</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>(65.0%)</td>
<td>(35.0%)</td>
</tr>
<tr>
<td>good (2)</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>(35.7%)</td>
<td>(64.3%)</td>
</tr>
<tr>
<td>Totals</td>
<td>31</td>
<td>23</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = 1.538 - 0.266a - 0.230b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>$0.111$  $0.0714$  $0.0290$</td>
</tr>
<tr>
<td>t statistics</td>
<td>$13.802$  $-3.720$  $-7.035$</td>
</tr>
<tr>
<td>Significance</td>
<td>$&lt;0.0001$  $0.0004$  $&lt;0.0001$</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td></td>
</tr>
</tbody>
</table>

- **R-Squared** = 0.48
- **F stat.** = 30.07
- **Std. error of est.** = 0.609
- **Multiple $R$** = 0.69
- **$p <$** 0.0001

**Abbreviations:**
- $Y$ = pH change
- $a$ = virgin burn quality dummy variable
  (+1 if bad; -1 if good)
- $b$ = initial Al$^{+++}$ ($mg/100g$)
Fig. C-1. -- Virgin burn pH change regression observed vs predicted values for initial pH less than 4.0.
PH CHANGE WITH VIRGIN BURNS
FOR BURNS HEALED IN < 40

ACTUAL PH CHANGE

PREDICTED PH CHANGE
**Table C-2.**

**Multiple Regression for pH Changes with Virgin Burns with Initial pH from 4.0 to 5.0**

<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = )</th>
<th>1.888 - 0.0311 a - 0.0668 b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.264 0.00627 0.0367</td>
<td></td>
</tr>
<tr>
<td>t statistics</td>
<td>7.154 -4.965 -1.818</td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>&lt;0.0001 &lt;0.0001 0.0737</td>
<td></td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>-0.527 -0.222</td>
<td></td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.29 F stat. = 12.95</td>
<td></td>
</tr>
<tr>
<td>Std. error of est.</td>
<td>0.714 Multiple ( R = ) 0.54</td>
<td></td>
</tr>
<tr>
<td>( P ) &lt;</td>
<td>0.0001 ( N = ) 67</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:**  
\( Y \) = pH change  
\( a \) = initial total clay (%)  
\( b \) = predicted erosion per year (mm)  
(see Fearnside 1978i for erosion prediction equations)
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
FOR SEDILEX FIELD IN
60 - 65 RANGE

OBSERVED PH CHANGE

PREDICTED PH CHANGE
**TABLE C-3.**

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

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y = 5.207 - 0.180 A - 0.814 B - 0.000609 C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.646 0.0537 0.1065 0.000175</td>
</tr>
<tr>
<td>t statistics</td>
<td>8.584 -3.345 -7.640 -3.474</td>
</tr>
<tr>
<td>Significance</td>
<td>&lt;0.0001 0.001 &lt;0.0001 &lt;0.001</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>-0.245 -0.499 -0.253</td>
</tr>
</tbody>
</table>

\[
\text{R-Squared} = 0.31 \quad \text{F stat.} = 26.91
\]

N = 180 \quad \text{Multiple R} = 0.56

\[
p < 0.0001 \quad \text{Std. error} = 0.717
\]

**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 FOR FRESH KILD PH > 8
### TABLE C-4.

**MULTIPLE REGRESSION FOR ALUMINUM CHANGES WITH VIRGIN BURNS**

<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = )</th>
<th>( 0.295 )</th>
<th>( 0.222 )</th>
<th>( 0.224 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>( 0.129 )</td>
<td>( 0.0376 )</td>
<td>( 0.0907 )</td>
</tr>
<tr>
<td>t statistics</td>
<td></td>
<td>( 2.297 )</td>
<td>( -5.897 )</td>
<td>( 2.472 )</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>( 0.022 )</td>
<td>(&lt;0.0001)</td>
<td>( 0.014 )</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td></td>
<td></td>
<td>( -0.324 )</td>
<td>( 0.142 )</td>
</tr>
</tbody>
</table>

- **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)

PREDICTED ALUMINUM CHANGE (ME/100G)
### TABLE C-5.

**MULTIPLE REGRESSION FOR PHOSPHORUS CHANGES WITH VIRGIN BURNS**

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y =</th>
<th>-0.770 + 0.677 a - 0.357 b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>0.288 0.0613 0.1514</td>
</tr>
<tr>
<td>t statistics</td>
<td></td>
<td>-2.702 11.034 -2.358</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>0.007 &lt;0.0001 0.019</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td></td>
<td>0.454 -0.108</td>
</tr>
<tr>
<td>R-Squared</td>
<td></td>
<td>0.21</td>
</tr>
<tr>
<td>Std. error of est.</td>
<td></td>
<td>3.255</td>
</tr>
<tr>
<td>Multiple R</td>
<td></td>
<td>0.46</td>
</tr>
<tr>
<td>P &lt;</td>
<td></td>
<td>0.0001</td>
</tr>
<tr>
<td>N =</td>
<td></td>
<td>473</td>
</tr>
</tbody>
</table>

**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)
### TABLE C-6.

**MULTIPLE REGRESSION OF NITROGEN CHANGE WITH VIRGIN BURNS**

<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = -0.0583 - 0.654A + 0.0489B + 0.0263C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.0653 0.2111 0.0315 0.0123</td>
</tr>
<tr>
<td>t statistics</td>
<td>-0.889 -3.098 1.458 2.048</td>
</tr>
<tr>
<td>Significance</td>
<td>0.370 0.003 0.152 0.046</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>-0.408 0.206 0.283</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.21</td>
</tr>
<tr>
<td>F stat.</td>
<td>4.32</td>
</tr>
<tr>
<td>N</td>
<td>52</td>
</tr>
<tr>
<td>Multiple R</td>
<td>0.46</td>
</tr>
<tr>
<td>( p &lt; )</td>
<td>0.01</td>
</tr>
<tr>
<td>Std. error</td>
<td>0.0588</td>
</tr>
</tbody>
</table>

**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 regression observed vs predicted values.
NITROGEN CHANGE WITH VIRGIN BURNS

OBSERVED NITROGEN CHANGE (PERCENT)

PREDICTED NITROGEN CHANGE (PERCENT)
<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = 3.4017 - 0.22601 A - 0.13129 B - 0.51750 C - 0.000126483 D )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.555 0.266 0.0660 0.1030 0.000112</td>
</tr>
<tr>
<td>t statistics</td>
<td>6.293 -4.874 -3.306 -5.024 -2.557</td>
</tr>
<tr>
<td>Significance</td>
<td>&lt;0.0001 &lt;0.0001 &lt;0.001 &lt;0.0001 &lt;0.012</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>-0.265 -0.139 -0.276 -0.266</td>
</tr>
</tbody>
</table>

- Squared: 0.74  Total: 11.29
- \( n = 91 \)  Multiple \( R = 0.59 \)
- \( p < 0.0001 \)  Std. Error = 0.046

**Abbreviations:**  
- \( Y \) = pH change  
- \( A \) = Initial \( \text{Al}^{3+} \) (ME/100g)  
- \( B \) = Aluminum change (ME/100g)  
- \( C \) = Initial pH  
- \( D \) = Days in annual crops
Fig. C-7. -- pH change with second growth burns regression observed vs predicted values.
PH CHANGE AFTER SECOND GROWTH BURNS

OBSERVED PH CHANGE

PREDICTED PH CHANGE

-2.0  -1.0   0.0   0.5   1.0   1.

0.0   0.5   1.0   1.5   2.0   2.5   3.0
### Table C-8.

**Regression of Aluminum Change with Second Growth Burns**

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

**Abbreviations:**

- Y = aluminum change (ME/100g)
- a = initial Al+++ (ME/100g)
Fig. C-8. -- Aluminum Change with Second Growth Bar
Before field Aluminum
### TABLE C-9.

MULTIPLE REGRESSION FOR PHOSPHORUS CHANGES WITH SECOND GROWTH BURNS

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y = -1.5170 + 0.74065 a - 0.03055 b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.637 0.135 0.317</td>
</tr>
<tr>
<td>t statistics</td>
<td>-2.382 5.484 -2.623</td>
</tr>
<tr>
<td>Significance</td>
<td>0.012 &lt;0.0001 0.011</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>0.535 -0.290</td>
</tr>
<tr>
<td>R-Squared =</td>
<td>0.31</td>
</tr>
<tr>
<td>F stat. = 17.07</td>
<td></td>
</tr>
<tr>
<td>Std. error of est. = 2.620</td>
<td></td>
</tr>
<tr>
<td>Multiple R = 0.56</td>
<td></td>
</tr>
<tr>
<td>P &lt; 0.0001</td>
<td></td>
</tr>
<tr>
<td>N = 78</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:**

- Y = phosphorus change (ppm)
- a = predicted phosphorus change from unburned regression (see Pearson 1978)
- 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)

PREDICTED PHOSPHORUS CHANGE (PPM)
### Table C-10.

**Multiple Regression for pH Changes with Weed Burn**

<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = )</th>
<th>2.9749 - 0.16504 ( a ) - 0.51659 ( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.6939 - 0.0717 - 0.1161</td>
<td></td>
</tr>
<tr>
<td>( t ) statistics</td>
<td>4.287 -2.303 -4.449</td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>0.0001 0.025 &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>-0.287 -0.501</td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = 0.26 \quad F \text{ stat.} = 10.11 \]
\[ \text{Std. error of est.} = 0.74525 \quad \text{Multiple } R = 0.51 \]
\[ P = 0.0002 \quad n = 62 \]

**Abbreviations:**
- \( Y = \) pH change
- \( a = \) initial pH
- \( b = \) initial Al\(^{+++}\) (mg/100g)
Fig. C-10. -- Weed burn pH change regression observed vs predicted values
PH CHANGE WITH WEED BURNS

OBSERVED PH CHANGE

PREDICTED PH CHANGE
<table>
<thead>
<tr>
<th>Regression</th>
<th>Y = 0.55043</th>
<th>-</th>
<th>0.39232 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.509</td>
<td>0.163</td>
<td></td>
</tr>
<tr>
<td>t statistics</td>
<td>1.081</td>
<td>-2.403</td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>0.299</td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td>Partial Correlation</td>
<td>-0.426</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Squared = 0.48  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 WHEED BURNS

ALUMINUM CHANGE (ME/100 G)

BEFORE FIELD ALUMINUM (ME/100 G)
### Table C-12.

Regression of phosphorus change with weed burn (1)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>$Y = 3.9375 + 1.2660 a$</td>
</tr>
<tr>
<td>Standard Errors</td>
<td>0.335</td>
</tr>
<tr>
<td>t statistics</td>
<td>3.778</td>
</tr>
<tr>
<td>Significance</td>
<td>$&lt;0.0001$</td>
</tr>
<tr>
<td>Partial Correlation</td>
<td>0.499</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.25</td>
</tr>
<tr>
<td>F stat.</td>
<td>14.27</td>
</tr>
<tr>
<td>Std. error of est.</td>
<td>5.0023</td>
</tr>
<tr>
<td>Multiple R</td>
<td>0.50</td>
</tr>
<tr>
<td>P &lt;</td>
<td>0.001</td>
</tr>
<tr>
<td>N</td>
<td>45</td>
</tr>
</tbody>
</table>

**Abbreviations:**
- $Y =$ phosphorus change (ppm)
- $a =$ predicted phosphorus change per year from unburned regression (ppm) (see Pearnside 1978)

(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)
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.
Fig. D-3. -- Stake slope vs plot slope for erosion stakes.
Fig. D-4. -- Stake erosion in fields in black pepper vs stake slope.
EROSION IN FIELDS IN BLACK PEPPER
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

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = $</th>
<th>1.8594</th>
<th>-</th>
<th>0.41866 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.265</td>
<td>0.0472</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t$ statistics</td>
<td>7.022</td>
<td>-8.071</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>$&lt;0.0001$</td>
<td>$&lt;0.0001$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Correlation</td>
<td>-0.476</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F stat.</td>
<td>78.70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std. error of est.</td>
<td>0.84175</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p &lt;$</td>
<td>0.0001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$N =$</td>
<td>270</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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

PH CHANGE PER YEAR

PH OF BEFORE FIELD
**TABLE E-2.**

MULTIPLE REGRESSION FOR ALUMINUM CHANGES IN UNEARMD FIELDS\(^{(1)}\)

<table>
<thead>
<tr>
<th>Regression</th>
<th>( Y = 0.0000048516 - 0.000015033 \ a - 0.000151317 \ b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.00000226  0.00000656  0.0000299</td>
</tr>
<tr>
<td>( t ) statistics</td>
<td>0.215  -2.290  -5.121</td>
</tr>
<tr>
<td>Significance</td>
<td>0.831  0.024  &lt;0.0001</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>-0.230  -0.467</td>
</tr>
</tbody>
</table>

\( R \)-Squared = 0.28 \( F \) stat. = 18.31

Std. error of est. = 0.00014465 \( P \) < 0.0001 \( N \) = 97

**Abbreviations:**

\( Y \) = Al+++ change \( (\text{ME}/100\text{g}) \)

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

\( b \) = pH change

\((1)\) excluding 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

PREDICTED CHANGE / YR. \(10^{-4} \text{ ME} / 100G\)

CHANGE PER YEAR \(10^{-4} \text{ ME} / 100G\)
**TABLE E-3.**

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

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y = -3.4733 + 1.4143 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>1.864 0.354</td>
</tr>
<tr>
<td>t statistics</td>
<td>-1.064 3.991</td>
</tr>
<tr>
<td>Significance</td>
<td>0.072 0.0004</td>
</tr>
<tr>
<td>Partial Correlation</td>
<td>0.576</td>
</tr>
</tbody>
</table>

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)
<table>
<thead>
<tr>
<th>Regression</th>
<th>Y =</th>
<th>2.1671 + 0.97151 A - 1.0405 B + 0.022395 C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>0.496 0.235 0.114 0.00480</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>&lt;0.0001 0.0001 &lt;0.0001 &lt;0.0001</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td></td>
<td>0.335 -0.617 0.373</td>
</tr>
</tbody>
</table>

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)
### TABLE E-5.

**Regression of Phosphorus Change per Year in Unburned Fields vs Before Field Phosphorus for Before Field Phosphorus of 10 PPM or Over**

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y = 6.8086</th>
<th>-</th>
<th>1.4363a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>4.157</td>
<td>0.254</td>
<td></td>
</tr>
<tr>
<td>t statistics</td>
<td>1.638</td>
<td>-5.651</td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>0.130</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Partial Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.74</td>
<td>F stat. = 31.93</td>
<td></td>
</tr>
<tr>
<td>Std. error of est.</td>
<td>6.5030</td>
<td>Multiple R = 0.86</td>
<td></td>
</tr>
<tr>
<td>P =</td>
<td>0.0001</td>
<td>N = 13</td>
<td></td>
</tr>
</tbody>
</table>

**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)
### Table E-6.

**Multiple Regression of Nitrogen Change in Unburned Fields**

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y = -0.070371 - 0.77136 A + 0.091698 B - 0.000013756 C - 0.012951 D 0.000041763 E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. Errors</td>
<td>0.0240 0.0685 0.0128 0.000286 0.00348 0.0000255</td>
</tr>
<tr>
<td>t stats.</td>
<td>-2.937; -11.252; 7.177; -1.284; 3.769; 1.640</td>
</tr>
<tr>
<td>Significance</td>
<td>0.004 &lt;0.0001 &lt;0.0001 0.202 0.0003 0.104</td>
</tr>
<tr>
<td>Partial Corr.</td>
<td>-0.735 0.568 -0.124 0.341 0.156</td>
</tr>
</tbody>
</table>

$R^2$-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 regression observed vs predicted values. Both days in annual crops and 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 YIELDS

OBSERVED NITROGEN CHANGE (PERCENT)

PREDICTED NITROGEN CHANGE (PERCENT)
<table>
<thead>
<tr>
<th>Regression</th>
<th>Y =</th>
<th>0.11566 + 4.3151 a - 0.52549 b 3.8721 c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>0.433 0.346 0.639 0.413</td>
</tr>
<tr>
<td>t statistics</td>
<td></td>
<td>2.671 12.483 -8.218 9.566</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>0.009 &lt;0.0001 &lt;0.0001 &lt;0.0001</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td></td>
<td>0.672 -0.513 0.563</td>
</tr>
<tr>
<td>R-Squared =</td>
<td></td>
<td>0.47 F stat. = 56.46</td>
</tr>
<tr>
<td>Std. error of est. =</td>
<td></td>
<td>0.21106 Multiple R = 0.69</td>
</tr>
<tr>
<td>P &lt;</td>
<td></td>
<td>0.0001 N = 193</td>
</tr>
</tbody>
</table>

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 YIELDS
<table>
<thead>
<tr>
<th>ITEM</th>
<th>DATE</th>
<th>PRICE AT DATE Cr$75/kg(^{(3)})</th>
<th>ACTIVE INGREDIENT</th>
<th>PERCENT ACTIVE INGREDIENT</th>
<th>Cr$75/kg ACTIVE INGREDIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superphosphate (Triple)</td>
<td>Apr. 10, 1976</td>
<td>4.70(^{(1)})</td>
<td>P(<em>{2})O(</em>{5})</td>
<td>66(^{(4)})</td>
<td>5.90</td>
</tr>
<tr>
<td>Urea</td>
<td></td>
<td>4.60(^{(1)})</td>
<td>N</td>
<td>65(^{(4)})</td>
<td>5.91</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td></td>
<td>2.70(^{(1)})</td>
<td>N</td>
<td>60(^{(4)})</td>
<td>2.60</td>
</tr>
<tr>
<td>Dolomitic Lime</td>
<td></td>
<td>0.75(^{(1)})</td>
<td>Dolomitic Lime</td>
<td>100(^{(2)})</td>
<td>0.43</td>
</tr>
<tr>
<td>Organic fertilizer (rice bran and</td>
<td>Jul. 17, 1978</td>
<td>0.25(^{(2)})</td>
<td>Cow manure equiv.</td>
<td>50(^{(2)})</td>
<td>0.61</td>
</tr>
<tr>
<td>spoiled beans)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

\(^{(2)}\) Average of Cr\$0.19/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% per year.


\(^{(4)}\) 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 (Utsisol) 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 from 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)
observations for an additional three weeks 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 \( \text{P}_2\text{O}_5 \) 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 cm 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*

<table>
<thead>
<tr>
<th>Regression</th>
<th>Y =</th>
<th>-6.4136</th>
<th>+</th>
<th>0.056751 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td></td>
<td>2.5583</td>
<td></td>
<td>0.00277</td>
</tr>
<tr>
<td>t statistics</td>
<td></td>
<td>-2.507</td>
<td></td>
<td>20.499</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>0.028</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Partial Correlation</td>
<td></td>
<td></td>
<td></td>
<td>0.986</td>
</tr>
<tr>
<td>R-Squared</td>
<td></td>
<td>0.97</td>
<td></td>
<td>420.20</td>
</tr>
<tr>
<td>Std. error of est.</td>
<td></td>
<td>6.2891</td>
<td></td>
<td>0.99</td>
</tr>
<tr>
<td>P &lt;</td>
<td></td>
<td>0.0001</td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

Abbreviations:  
Y = pH change  
a = kg/ha P205
Fig. E-9. — Phosphorus change vs kg/ha P$_4$O$_5$ 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)

FERTILIZER (KG P₂O₅ / 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 1978) 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 1978) 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.
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.
CROP: AVERAGE FOR FIELDS RARE OR IN ANNUAL CROPS (X DRY WT.)

YEAR

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**

<table>
<thead>
<tr>
<th>Regression</th>
<th>[ Y = -0.0060206 + 0.59699 A - 0.000015236 B + 0.016996 C - 0.094706 D ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>0.170 0.160 0.000163 0.0170 0.0398</td>
</tr>
<tr>
<td>t statistics</td>
<td>-0.0339 3.722 -0.935 1.002 -2.379</td>
</tr>
<tr>
<td>Significance</td>
<td>0.974 0.003 0.360 0.336 0.035</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>0.732 -0.261 0.278 -0.566</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.61</td>
</tr>
<tr>
<td>F stat.</td>
<td>4.69</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
</tr>
<tr>
<td>Multiple R</td>
<td>0.70</td>
</tr>
<tr>
<td>F</td>
<td>0.017</td>
</tr>
<tr>
<td>Std. error</td>
<td>0.20288</td>
</tr>
</tbody>
</table>

**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)
TABLE F-2.
RICE INTERPLANTING FREQUENCIES BY YEAR

<table>
<thead>
<tr>
<th>YEAR</th>
<th>PERCENT INTERPLANTED</th>
<th>NUMBER INTERPLANTED</th>
<th>NUMBER ALONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>27.8</td>
<td>10</td>
<td>26</td>
</tr>
<tr>
<td>1973</td>
<td>42.2</td>
<td>27</td>
<td>37</td>
</tr>
<tr>
<td>1974</td>
<td>58.2</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>1975</td>
<td>62.7</td>
<td>64</td>
<td>38</td>
</tr>
<tr>
<td>1976</td>
<td>38.7</td>
<td>7</td>
<td>11(1)</td>
</tr>
</tbody>
</table>

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

(1) biased toward rice alone by selection of large fields
Fig. P-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

<table>
<thead>
<tr>
<th>VARIETY</th>
<th>NUMBER NOT TOPPLED</th>
<th>NUMBER TOPPLED</th>
<th>PERCENT TOPPLED</th>
</tr>
</thead>
<tbody>
<tr>
<td>hybrid (IAC-1246 or IAC-101)</td>
<td>183</td>
<td>28</td>
<td>13.3</td>
</tr>
<tr>
<td>traditional (canela de ferro)</td>
<td>25</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>other</td>
<td>14</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Variety difference $P < 0.01$ (Max. likelihood statistic = 10.13 df=2 N=250)
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>FREQUENCY (percent)</th>
<th>RICE DENSITY (1000 hills/ha)</th>
<th>EFFECT ON YIELD (proportion of predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEAN</td>
<td>N</td>
<td>MEAN</td>
</tr>
<tr>
<td>Manioc interplanted</td>
<td>10.1</td>
<td>306</td>
<td>93.50</td>
</tr>
<tr>
<td>Pasture interplanted</td>
<td>2.9</td>
<td>306</td>
<td>83.73</td>
</tr>
<tr>
<td>Other interplanted crop</td>
<td>1.6</td>
<td>306</td>
<td>73.22</td>
</tr>
<tr>
<td>Poor germination</td>
<td>4.7</td>
<td>306</td>
<td>0.793</td>
</tr>
<tr>
<td>Disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid (IAC-1246, IAC-101)</td>
<td>1.9</td>
<td>211</td>
<td></td>
</tr>
<tr>
<td>Tradit. (canela de ferro)</td>
<td>12.0</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Other (non-barbalha)</td>
<td>14.3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>lumped non-barbalha effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toppling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid (IAC-1246, IAC-101)</td>
<td>13.3</td>
<td>211</td>
<td></td>
</tr>
<tr>
<td>Others (non-barbalha)</td>
<td>0.0</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Varieties planted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid (IAC-1246, IAC-101)</td>
<td>84.4</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>Tradit. (canela de ferro)</td>
<td>10.0</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>Other (non-barbalha)</td>
<td>0.82</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>Planting date out of season</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Nov., Mar., Apr.)</td>
<td>3.4</td>
<td>290</td>
<td></td>
</tr>
</tbody>
</table>

TABLE F-5.
RICE YIELD REGRESSION EXCLUDED CATEGORY SUMMARY
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 in storage.
### Table F-6.

**Multiple Regression for Maize Yield Prediction**

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = -339.00 + 125.46 A - 0.029183 B - 0.022334 C - 0.00081571 D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>251.180 46.235 99.228 14.091 430.66</td>
</tr>
<tr>
<td>$t$ Statistics</td>
<td>-1.311 2.714 -2.941 -1.578 -1.094</td>
</tr>
<tr>
<td>Significance</td>
<td>0.203 0.012 9.007 0.128 0.071</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>0.492 -0.523 -0.313 -0.367</td>
</tr>
</tbody>
</table>

- $R^2 = 0.42$  
- $F$ stat. $= 4.18$  
- $N = 28$  
- Multiple $R = 0.65$  
- $F = 0.017$  
- Std. error $= 15.69$

**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)

PREDICTED YIELD (KG/1000 PLANTS)
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>FREQUENCY (percent)</th>
<th>MAIZE DENSITY (plants/ha)</th>
<th>INTERPLANTED CROP DENSITY (plants/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEAN N</td>
<td>MEAN STD.DEV. N</td>
<td>MEAN STD.DEV. N</td>
</tr>
<tr>
<td>Maize alone</td>
<td>33.9 224</td>
<td>16724.8</td>
<td>4343.7</td>
</tr>
<tr>
<td>Rice interplanted</td>
<td>51.8 224</td>
<td>3507.0</td>
<td>3444.1</td>
</tr>
<tr>
<td>Manioc interplanted</td>
<td>13.4 224</td>
<td>5119.0</td>
<td>3530.3</td>
</tr>
<tr>
<td>Other interplanted crops</td>
<td>9.4 224</td>
<td>5623.9</td>
<td>2794.3</td>
</tr>
<tr>
<td>CONDITION</td>
<td>FREQUENCY (percent)</td>
<td>EFFECT ON YIELD (proportion of predicted)</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------</td>
<td>------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MEAN</td>
<td>N</td>
<td>MEAN</td>
</tr>
<tr>
<td>Poor germination</td>
<td>7.1</td>
<td>224</td>
<td>0.966</td>
</tr>
<tr>
<td>Rats intensity 2 or 3</td>
<td>38.8</td>
<td>224</td>
<td>0.563</td>
</tr>
<tr>
<td>Disease</td>
<td>1.8</td>
<td>220</td>
<td>0.396</td>
</tr>
</tbody>
</table>
### TABLE F-9.
**MULTIPLE REGRESSION FOR PHASEOLUS BEAN YIELD PREDICTION**

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = 267.64 - 69.765 A + 13.777 B - 0.001509 C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>$134.53$ $20.213$ $15.283$ $0.00232$</td>
</tr>
<tr>
<td>$t$ statistics</td>
<td>$1.989$ $-3.4118$ $0.901$ $-0.649$</td>
</tr>
<tr>
<td>Significance</td>
<td>$0.078$ $0.007$ $0.391$ $0.532$</td>
</tr>
<tr>
<td>Partial Correlations</td>
<td>$-0.7511$ $0.288$ $-0.212$</td>
</tr>
<tr>
<td>$R^2$-squared</td>
<td>$0.62$</td>
</tr>
<tr>
<td>$F$ stat.</td>
<td>$4.90$</td>
</tr>
<tr>
<td>$N$</td>
<td>$13$</td>
</tr>
<tr>
<td>Multiple $R$</td>
<td>$0.79$</td>
</tr>
<tr>
<td>$P$</td>
<td>$0.026$</td>
</tr>
<tr>
<td>Std. error</td>
<td>$29.802$</td>
</tr>
</tbody>
</table>

**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.
584

PHASEOLUS YIELDS

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>
<thead>
<tr>
<th>Disease intensity</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phaseolus yield (kg/ha)</td>
<td>308</td>
<td>186</td>
<td>151</td>
<td>58</td>
</tr>
<tr>
<td>Sample size</td>
<td>11</td>
<td>10</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>ITEM</td>
<td>MEAN</td>
<td>STANDARD DEVIATION</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------</td>
<td>--------------------</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>kgs seeds planted/ha</td>
<td>29.18</td>
<td>26.15</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Planting density (plants/ha)</td>
<td>52666</td>
<td>49036</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>Interplanted maize:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>11.7%</td>
<td></td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>maize density (plants/ha)</td>
<td>1698.4</td>
<td>3688.2</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Frequency of planting in previously planted soil when virgin soil available</td>
<td>9.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE P-12.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor germination:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency</td>
<td>5.8%</td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>effect on yield(^{(1)})</td>
<td>1.002</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Disease:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>overall</td>
<td>67%</td>
<td></td>
<td>115</td>
</tr>
<tr>
<td>virgin soil</td>
<td>78%</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>previously planted</td>
<td>100%</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Effect on yield</td>
<td>0.3496</td>
<td>0.5728</td>
<td>32</td>
</tr>
</tbody>
</table>

\(^{(1)}\) 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 | | -2.202 | | 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
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)

PREDICTED YIELD (KG/KG SEED SOWN)
<table>
<thead>
<tr>
<th>ITEM</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kgs seeds planted/ha</td>
<td>8.10</td>
<td>7.82</td>
<td>30</td>
</tr>
<tr>
<td><strong>excluded conditions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency</td>
<td>14.3%</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>effect on yield</td>
<td>0.0896</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Rabbits (intensity 3 or 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency</td>
<td>17.65</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>effect on yield</td>
<td>0.677</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Poor germination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency</td>
<td>0%</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>effect on yield</td>
<td>?</td>
<td></td>
<td>?</td>
</tr>
</tbody>
</table>
### Table F-15.

**Regression of Bitter Manioc Yields on pH**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regression</strong></td>
<td>$Y = -$17369$ + $4124.4 a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Standard Errors</strong></td>
<td>4503.6</td>
<td></td>
<td>945.33</td>
</tr>
<tr>
<td><strong>t statistics</strong></td>
<td>-3.857</td>
<td></td>
<td>4.363</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td>0.031</td>
<td></td>
<td>0.022</td>
</tr>
<tr>
<td><strong>Partial Correlation</strong></td>
<td></td>
<td></td>
<td>0.929</td>
</tr>
<tr>
<td><strong>R-Squared</strong></td>
<td>0.96</td>
<td></td>
<td>19.04</td>
</tr>
<tr>
<td><strong>std. error of est.</strong></td>
<td>414.22</td>
<td></td>
<td>Multiple R = 0.93</td>
</tr>
<tr>
<td><strong>F =</strong></td>
<td>0.022</td>
<td></td>
<td>N = 5</td>
</tr>
</tbody>
</table>

**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.)

PH

4.4 4.5 4.6 4.7 4.8 4.9 5.0
### TABLE F-16.

**REGRESSION OF SWEET MANIOC YIELDS ON pH**

<table>
<thead>
<tr>
<th>Regression</th>
<th>$Y = \text{-}1559.2 + 587.53a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Errors</td>
<td>1215.4, 249.55</td>
</tr>
<tr>
<td>$t$ statistics</td>
<td>-1.283, 2.354</td>
</tr>
<tr>
<td>Significance</td>
<td>0.422, 0.256</td>
</tr>
<tr>
<td>Partial Correlation</td>
<td>0.920</td>
</tr>
</tbody>
</table>

**Abbreviations:**
- $Y = \text{Sweet manioc yield (kgs flour/12 months growth)}$
- $a = \text{soil pH (adjusted to 5.0)}$
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.]

PH (ADJUSTED TO 5.0)
APPENDIX G

POPULATION: DEMOGRAPHY, HEALTH, AND LABOR SUPPLY
### Table G-1

**Age Distribution in Colonization Area and Rural Brazil**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>ALTAMIRA Colonization Area(1)</th>
<th>CENSUS Data for Rural Brazilian Population(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>0-5</td>
<td>24</td>
<td>0-4</td>
</tr>
<tr>
<td>6-10</td>
<td>18</td>
<td>5-9</td>
</tr>
<tr>
<td>11-15</td>
<td>14</td>
<td>10-14</td>
</tr>
<tr>
<td>16-20</td>
<td>9.5</td>
<td>15-19</td>
</tr>
<tr>
<td>&gt;20</td>
<td>54.5</td>
<td>20-24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35-39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40-44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45-49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50-54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55-59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60-69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>270</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unknown</td>
</tr>
</tbody>
</table>

---

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

TABLE G-2.

LABOR EQUIVALENTS IN AGRICULTURAL WORK

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Source (1)</th>
<th></th>
<th>Source (2)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Man</td>
<td>Woman</td>
<td>Man</td>
<td>Woman</td>
<td></td>
</tr>
<tr>
<td>9 - 10</td>
<td>0.30</td>
<td>0.30</td>
<td>7 - 8</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>11 - 13</td>
<td>0.50</td>
<td>0.30</td>
<td>9 - 13</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>14 - 17</td>
<td>1.00</td>
<td>0.50</td>
<td>14 - 17</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>≥18</td>
<td>1.00</td>
<td>0.75</td>
<td>≥18</td>
<td>1.00</td>
<td>0.75</td>
</tr>
</tbody>
</table>

(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**

<table>
<thead>
<tr>
<th>Labor force (man-equivalents)</th>
<th>Percent occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - 1.5</td>
<td>9</td>
</tr>
<tr>
<td>1.6 - 2.0</td>
<td>24</td>
</tr>
<tr>
<td>2.1 - 2.5</td>
<td>16</td>
</tr>
<tr>
<td>2.6 - 3.0</td>
<td>8</td>
</tr>
<tr>
<td>3.0 - 3.5</td>
<td>9</td>
</tr>
<tr>
<td>3.6 - 4.0</td>
<td>9</td>
</tr>
<tr>
<td>4.1 - 4.5</td>
<td>9</td>
</tr>
<tr>
<td>4.6 - 5.0</td>
<td>3</td>
</tr>
<tr>
<td>5.1 - 5.5</td>
<td>8</td>
</tr>
<tr>
<td>5.6 - 6.0</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 6.0</td>
<td>2</td>
</tr>
</tbody>
</table>

**SOURCE:** Brasil, Ministério de Agricultura, INCRA 1972
<table>
<thead>
<tr>
<th>Age class</th>
<th>Total No. Women</th>
<th>Total live births in previous year</th>
<th>Probability of live birth for age class</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>2,188,350</td>
<td>132,029</td>
<td>0.060</td>
</tr>
<tr>
<td>20-24</td>
<td>1,772,913</td>
<td>414,291</td>
<td>0.234</td>
</tr>
<tr>
<td>25-29</td>
<td>1,334,934</td>
<td>362,629</td>
<td>0.272</td>
</tr>
<tr>
<td>30-34</td>
<td>1,087,643</td>
<td>274,239</td>
<td>0.252</td>
</tr>
<tr>
<td>35-39</td>
<td>987,395</td>
<td>198,659</td>
<td>0.201</td>
</tr>
<tr>
<td>40-44</td>
<td>837,890</td>
<td>91,938</td>
<td>0.110</td>
</tr>
</tbody>
</table>

Fig. G-1. -- Malaria 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 estimate 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

0.000

0. 2. 4. 6. 8. 10. 12. 14.

AGE CLASS

606
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 SBSP 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

AGE CLASS

PROBABILITY OF MALARIA
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 SEESP 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

AGE CLASS

0.0 0.1 0.2 0.3 0.4 0.5

0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0
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
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

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=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

AGE CLASS

0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.0
0. 2. 4. 6. 8. 10. 12. 14.
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

MONTH OF YEAR

PROBABILITY CASE OCCURS IN MONTH

0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
0.  2.  4.  6.  8.  10.  12.
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

MONTH OF YEAR

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.
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.
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.