AN EVALUATION OF THE WOOD CLASSIFICATION

AN EVALUATION OF SELECTED BASIC ASSUMPTIONS OF THE H. A. WOOD LAND USE CLASSIFICATION

By

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SCOPE AND CONTENTS:

Two basic assumptions of the H. A. Wood Land Use Classification for the American Tropics are examined.

First, the nature of the relationship between the level of technology, climatic characteristics, economic output, and labour requirements is examined for individual crops using data acquired from the Ecuadorian government.

Second, the author examines the extent to which it is possible to separate, and accurately identify, the Wood Land Use Systems on aerial photographs. Photographs were interpreted from both the Sierra and coastal regions of Ecuador and later field checked by the author with the aid of the Ministerio de Agricultura.

Through analysis, certain assumptions of the classification have been verified, and some modifications have been suggested.

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I wish to express my sincere thanks and indebtedness to Dr. H. A. Wood for his assistance and guidance during the course of my research work and preparation of this thesis.

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M. Susanne Wobschall

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CHAPTER I

INTRODUCTION

Purpose:

The purpose of this study is to evaluate selected basic assumptions of H. A. Wood's Land Use Classification for the American Tropics.[1]

The Wood Classification:

The unit of analysis of the Wood Classification is the Land Use System. The Land Use System is characterized by a distinct combination of crops, livestock and/or forest exploitation, at a level of productivity determined by a set of physical and/or human conditions. The classification takes into consideration the following six components in its definition of individual Land Use Systems:

1. The Land Use Order: the proportion of the area developed, and the reasons for non-development of certain sections.
2. The Land Use Group: the general land use emphasis.
3. The Land Use Series: the seasonality of production.

[1]The Wood Classification was based on data collected in 1965 from Colombia, Costa Rica, Guatamala, Mexico and the Dominican Republic. The objective of the classification was to provide an adequate link between natural resource inventory, economic and social planning.

4. The Land Use Type: the item(s) or groups of items produced.
5. The Land Use Level: the level of technology used in production.
6. The Land Use Phase: the influence of certain specific conditions (if applicable.)

Ninety-six specific Land Use Systems were isolated by Wood from the grouping of single-farm data collected. Each system is considered to be homogeneous in terms of Disposable Income[1] and Labour Index.[2]

Wood considered his classification to be useful for rational land planning programs, and to facilitate the taking of land use inventories and the recording of data from such inventories. In the latter case, he assumes that it is possible to determine and measure the six Land Use Components largely from aerial photographs.

[1]Disposable Income is defined as the average net value in United States dollars of the total production per annum per hectare for any given form of land exploitation after all production costs have been paid, except those of labour and land.

[2]Labour Index is defined as the number of man days worked per hectare per year.

Assumptions To Be Examined:

The first assumption to be examined is that the classification must include the elements of production techniques and the length of the production period in order to give a true indication of the output of economic goods and the level of employment which any form of land use can maintain, or effectiveness with which the natural resources of any area are being exploited.[1]

In this study, the only Land Use Type considered in the above relationship is crop cultivation. Livestock raising and forest exploitation have not been examined in part because of a lack of available data in these areas, and also because of the limitations of time. Therefore, the first part of this study deals with the nature of the relationship which exists between the level of technology, the length of the productive period, and the Disposable Income and Labour Index for areas of crop cultivation.

The second assumption to be examined is that much of the information required to determine existing Land Use Systems can be obtained from aerial photographs. All six Land Use Components are examined individually. No limitations on Land Use Types exist in this part of the study since it is based on interpretation of actual photographs and subsequent field work.

[1]H. A. Wood, A Land Use of Classification For The American Tropics, A Report Prepared for the Natural Resources Unit, Pan American Union, Washington, D.C., page 2.

Assumptions Not Examined:

It was not within the scope of the data available to examine the assumption that land use combinations can satisfactorily be related to, and change with, the physical environment and socio-economic conditions. While certain aspects of climate have been related to crop production to determine the nature of subsequent variations in Disposable Income and Labour Index, attention to soil variations is obviously lacking. The author acknowledges the importance of soil type as a variable but due to the complexity of the factors already included, the influence of soil characteristics has been omitted.

The second basic assumption not considered in this paper is the value of the Wood Classification for use in regional planning.

Therefore, in conclusion, those assumptions examined in this paper were partially determined by the data available.

Sources of Data:

Ecuador was selected as the study area because of the ready co-operation of its government for research projects organized through H. A. Wood. A variety of departments and services were made available for obtaining agricultural data. This study is primarily based on three agricultural reports, supplemented by observations made in the field by the author:

1. Costos De Produccion Agropecuarios En La Zona De Cayambe. Programa Ecuador. Organizacion De Los Estados Americanos. Febrero 1969. Instituto Ecuatoriano De Reforma Agraria Y Colonizacion. This report was a census taken on production costs in the Cayambe area[1] and is hereafter referred to as the Cayambe Report.

2. Primer Curso Nacional Sobre Programacion Regional: Enero II - Febrero 20, 1971. Programa De Desarrollo "Area Mojanda", Ministerio De La Produccion, Instituto Interamericano De Ciencias Agriculas.
   This report was produced as part of a research project designed as a training exercise in procedures to be used in the development of an agricultural plan. It is henceforth referred to as the Mojanda Report and it should be noted at this time that the area studied partially overlaps the area covered in the Cayambe Report.

3. Datos Agroeconomicos Del Ing. Cesar Hamburgo Calles, Instituto Ecuatoriano De Reforma Agraria Y Colonization. The Calles data incorporates average yeilds for individual crops in a variety of climatic areas throughtout Ecuador. For each crop, in each climatic area, detailed farm operations are given.

These three sources of data are used in all or part of each of the subsequent study sections.

[1]The Cayambe area is 45 Km. from Quito and has an elevation of approximately 2500-3000 meters above sea level.

Study Organization:

The methodology used in evaluating the basic assumptions changes with the variable which has been isolated. For this reason, a detailed description of the method of approach appears at the beginning of each chapter.

In the analysis of the first basic assumption the four components, the level of technology, the length of the productive period, the Disposable Income and Labour Index have been separated to better determine the effect of one upon the other. Chapter II is an attempt to show the effect of the level of technology on the Disposable Income and Labour Index which any form of land use can maintain within an area of limited climatic variation.

Chapter III is an examination of the effect of the climate on the Disposable Income and Labour Index when the technological level varies within a limited range.

Chapter IV is an attempt to group different crop types according to their response to climatic and technological variations. This response is measured in terms of the Disposable Income and Labour Index.

Chapter V is an evaluation of the second basic assumption which is the extent to which it is possible to determine and measure the six Land Use Components, which determine individual Land Use Systems, from aerial photographs. The Land Use Systems found from aerial photograph interpretation have been checked through field study.

Chapter VI is the summary and final conclusions concerning the two basic assumptions examined in this paper.

For the sake of clarity, the first assumption regarding the relationship between the level of technology, climate and Labour Index and Disposable Income is handled in three separate chapters. Each of these chapters has its own emphasis but relates to the first assumption. While Chapter V, which deals with the interpretation of aerial photographs, appears in contrast to the preceeding chapters, the reader must keep in mind that it is the analysis of the second assumption of the study.

CHAPTER II

TECHNOLOGY

Purpose:

The purpose of this chapter is to examine the nature of the relationship between the level of technology and the Disposable Income and Labour Index.

Methodology:

To analyze the relationship between the level of technology, the Disposable Income and Labour Index, one climatic area is used with a variety of crop types. This approach was necessitated by the data available. The principal source of data which contains sufficient detail concerning technological levels with respect to the production of individual crops is the Mojanda Report.

The part of this area covered in the Cayambe Report is described as having an annual average temperature range from 12.92°C. to 13.48°C. and a total annual rainfall of 913.67 mm. The area covered by the Mojanda Report is described as having an annual average temperature of 13.4°C. and a total annual rainfall range from 808 mm. to 1070 mm.

In this area, a variety of temperate crops are grown and much of the area is devoted to livestock raising.

The remainder of this chapter consists of four basic sections:

1. An examination and re-classification of the different technological levels found in the data.

2. An examination of the implications of technology in terms of yield, value, and costs, to determine its relationship to Disposable Income.
3. An examination of the relationship between the level of technology and labour requirements.
4. A suggested revision of the technological categories and an evaluation of these new categories based on a variety of crops from all data sources.

The Technological Levels Found In The Data:

Differences in operational procedures and the use of implements are recognized in all sources of data. By combining the levels from all sources, there emerges a total of seven distinct technological levels. Each of these levels was found by the author in the course of field work with one exception.[1] The following chart gives a brief description of the technological levels and the source(s) of data where it is either described or used.

[1]No interview was held on a farm where rented machinery was being used along with recommended application of agricultural chemicals.

CHART 1

COMBINED LEVELS OF TECHNOLOGY FROM ALL DATA SOURCES

Level	Description	Level Subdivision	Source(s) In Which Level Is Found
I	Hand Labour Only	A - No Chemicals	Calles Author
		B - Use of Chemicals	Calles Author
II	Animal And Hand Labour	A - No Chemicals	Mojanda Report's Actual Level 1 Calles Author
		B - Use of Chemicals	Mojanda Report's Suggestion 1* Calles Author Cayambe Level I
III	Rented Machinery	A - Less Than Recommended* Operation Both Machinery And Chemicals	Mojanda Report's Actual Level II Author Cayambe Level II
		B - Recommended Operation With Both Machinery And Chemicals	Mojanda Report's Suggestion II Cayambe Level III
IV	Owned Machinery	Both Machinery And Chemicals	Mojanda Report's Suggestion III Cayambe Level IV Author

*"Suggestion" or "Recommended" are terms which indicate the ideal farm operations for the production of any crop, as determined by research agriculturalists for the Mojanda Report.

At Level I no animal traction is used. All land preparation, crop care and harvesting is done by hand. The level has been subdivided because in some cases no agricultural chemicals are used, while in other examples some use was being made of fertilizers and/or pesticides. While it is natural that some crops might require only hand labour, this level of technology also exists in cases where mechanization would greatly improve the yield and efficiency of crop production.

Level II uses both animal traction and hand labour. The animal traction is found in the preparation of the land but most other operations are carried on by hand. There is the occasional use at this level of a rented threshing machine for harvesting the crop. Again, this level is subdivided into two because of the complete lack of agricultural chemicals in some cases. Quite often this lack of chemicals coincides with the use of rented animals while those farming systems which are using chemicals of some sort own the animals used.

Level III uses rented machinery for one of, or both, the land preparation operation and the harvesting of the crop. This level has been subdivided because insufficient use can be made of chemicals or there can be an efficient operation. Often, when chemicals are used fully, the only rented machinery being employed is for harvesting because a tractor is owned for preparing the land.

At Level IV owned machinery is used and agricultural chemicals are always applied. It should be noted that when the machinery is owned, more thorough land preparation is the rule. This preparation would not only include ploughing and harrowing, but they would generally be repeated operations.

The Mojanda Report presents information regarding technology in three ways. The detailed information for individual crops, which is used in the analysis of the relationship between the level of technology and Disposable Income and Labour Index, is given for both actual and recommended levels of technology for farms under 20 hectares and farms over 20 hectares. Level I on Chart 1 deals with farms under 20 hectares for actual and recommended ("Suggestion 1") procedures. Levels II and III indicate both actual and recommended ("Suggestions II and III") procedures for farms over 20 hectares.

The Mojanda Report considers farm size an indication of technological level and at the beginning of the report presents valuable information regarding productivity first using a six-fold division of farms and then a four-fold division of farm size.

The Six-fold Division:

Group S_1: farms of 0.1 to 4.9 hectares.

Group S_2: farms of 5.0 to 9.9 hectares.

Group T: farms of 10.0 to 19.9 hectares.

Farms in Groups S_1, S_2, and T normally use seed for planting which was produced on the farm itself, use organic manure, and make little or no use of pesticides.

Group U_1: farms of 20.0 to 49.9 hectares.

Group U_2: farms of 50.0 to 99.9 hectares.

Group V: farms of 100 hectares or more.

Farms in Groups U_1, U_2, and V normally buy the required fertilizer, pesticides and seeds from commercial outlets, and represent

a higher technological level than the first grouping. This evidence of a higher technological level is reinforced by differences in livestock raising practices, since farms in the former category almost never engage in livestock fattening, and seldom make use of veternarian services. Farms of over 20 hectares do both. Throughout the study, farms of under 20 hectares are found to operate without the use of machinery, while those over 20 hectares generally own or rent machinery for most farm operations.

Further on in the Mojanda Report only four farm size categories are used:

Group S: farms of 0.0 to 9.9 hectares.

Group T: farms of 10.0 to 19.9 hectares.

Group U: farms of 20.0 to 99.9 hectares.

Group V: farms of 100 hectares or greater.

Using this subdivision, the farm of 20 hectares again emerges as the point at which machinery becomes general. The farms of over 20 hectares are described as employing permanent workers and generally owning tractors, mowers, harrows and ploughs. Milking machines and irrigation equipment may also be found in this group. Farms of over 100 hectares are described only as having more developed mechanization.

The six and four-fold division of farms by size correspond to the over-all division of technological levels (Chart 1) in a general way. Groups S and T would belong to technological levels I and II while Groups U and V would belong to technological levels III and IV. The four-fold subdivision of farms can be used to show the over-all

effect of technology on economic output and labour index.

The Relationship Between The Level Of Technology And Disposable Income:

In the following analysis, Level I is not examined because no detailed information on this level was available, even though it was found to exist in the field by the author, as well as, in the Calles data. Calles usually deals with each crop at the same technological level and, therefore, information for comparisons cannot be found.

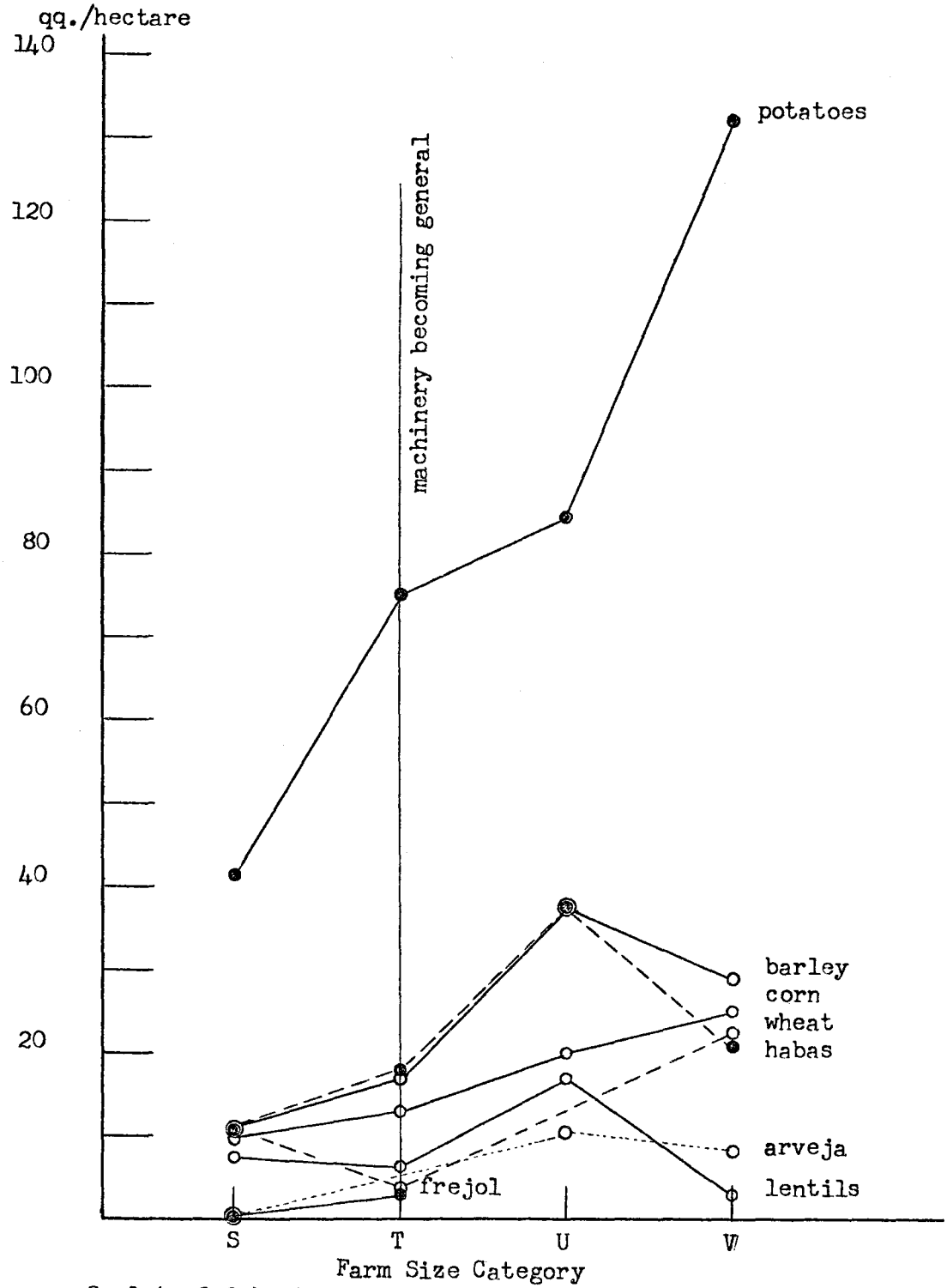
The General Effect Of Mechanization And Agricultural Chemicals:

Figures 1, 2, and 3 have been included because they represent actual information collected for the Mojanda Report, and indicate the variations in crop yield and value for the technological descriptions previously given. The actual analysis of this chapter is based on the averages of those farms under 20 hectares and those over 20 hectares. The figures clearly indicate the real variations that take place within each of these major groups, and also show the effect of mechanization on crop yield and value in a general way.

Figure 1 shows individual crop yields by farm size. It can be observed that with an increase in the level of technology, there is an increase in the economic output for most crops. The exception to this trend is found in those farms of greater than 100 hectares where three of the seven crops show a sharp decline. Extensive farming probably accounts for the lower figures. Even though there is a general drop in yield from Group U to Group V, no crop except lentils shows lower yields than in Group S which is characterized by animal traction and

Figure 1

The Relationship Between Yield and Technology by Crop



S 1 to 9.9 hectares
T 10 to 49.9 hectares
U 50 to 99.9 hectares
V 100 hectares or more

Figure 2

Technological Level and Value of Production

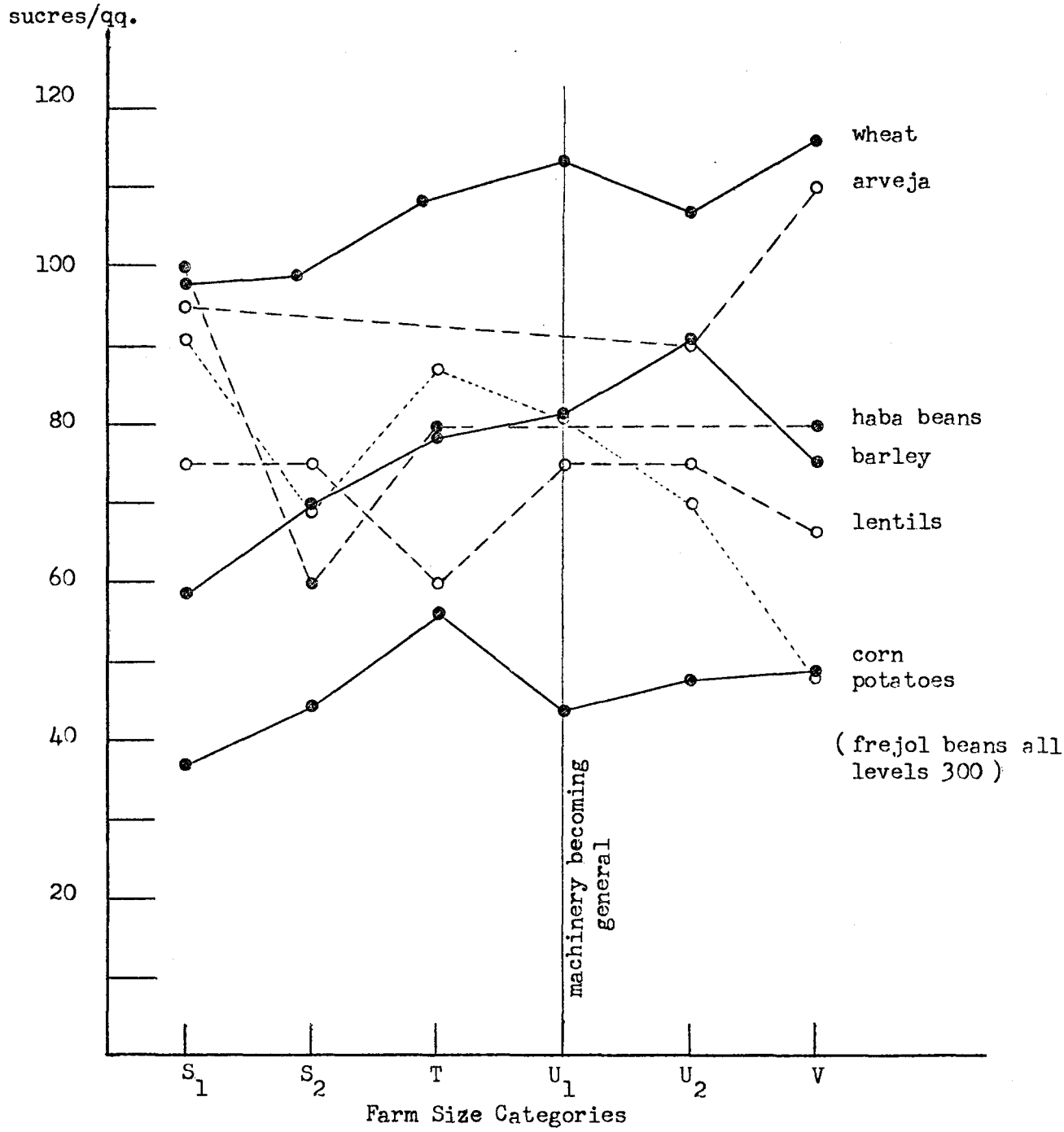
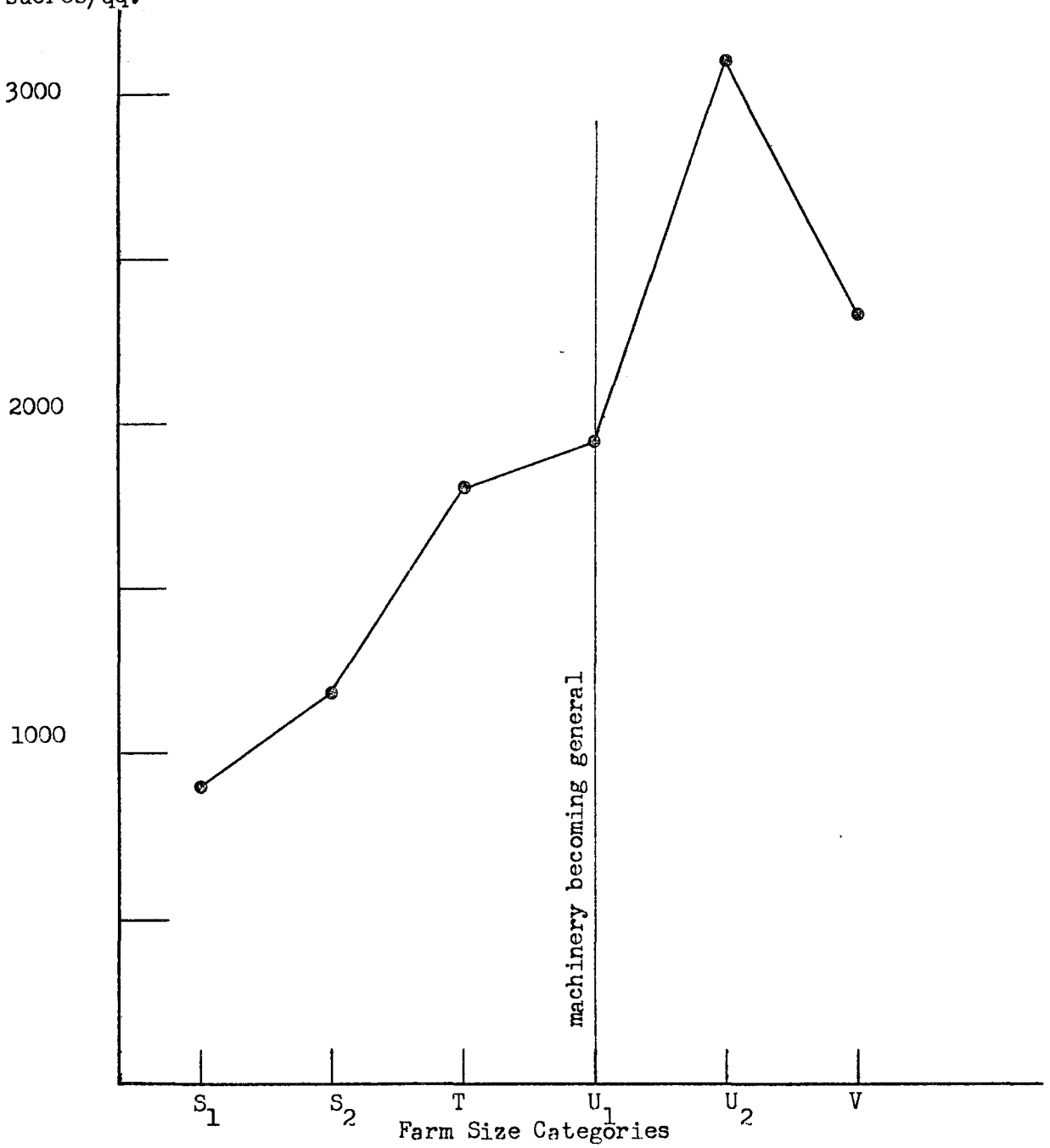


Figure 3

Value of Agricultural Production Per Hectare by Levels
(crop value only)
sucres/qq.



little or no use of agricultural chemicals.

Figure 2 shows the variations in crop value produced on farms in each category. Although no single pattern exists here, in Figure 3 where the value of goods produced has been averaged, there is a general increase in crop value with farm size. There is a slight drop in value on farms over 100 acres, but it is clearly evident that with increased use of machinery and chemicals, there is an increase in the value of the commodity. The combination of increased value, and increased yield would lead to the expectation of an increase in the Disposable Income with advances in technological level. The following section is a look at this relationship for individual crops at specific levels of technology using both the actual and recommended information given in the report.

Technology And Disposable Income:

In order to obtain the necessary detail required to find differences between the technological levels it was necessary to use the theoretical, or recommended, information given on the individual crop sheets of the Mojanda Report, as well as the actual information for mechanized and non-mechanized farms. This information has been fitted into the author's subdivision of technological levels found on Chart 1. The remainder of this chapter presents the data according to the format of Chart 1.

Figure 4 shows crop yields for five technological levels according to Chart 1. It can be observed that for all crops there is

Figure 4

Technology and Yield

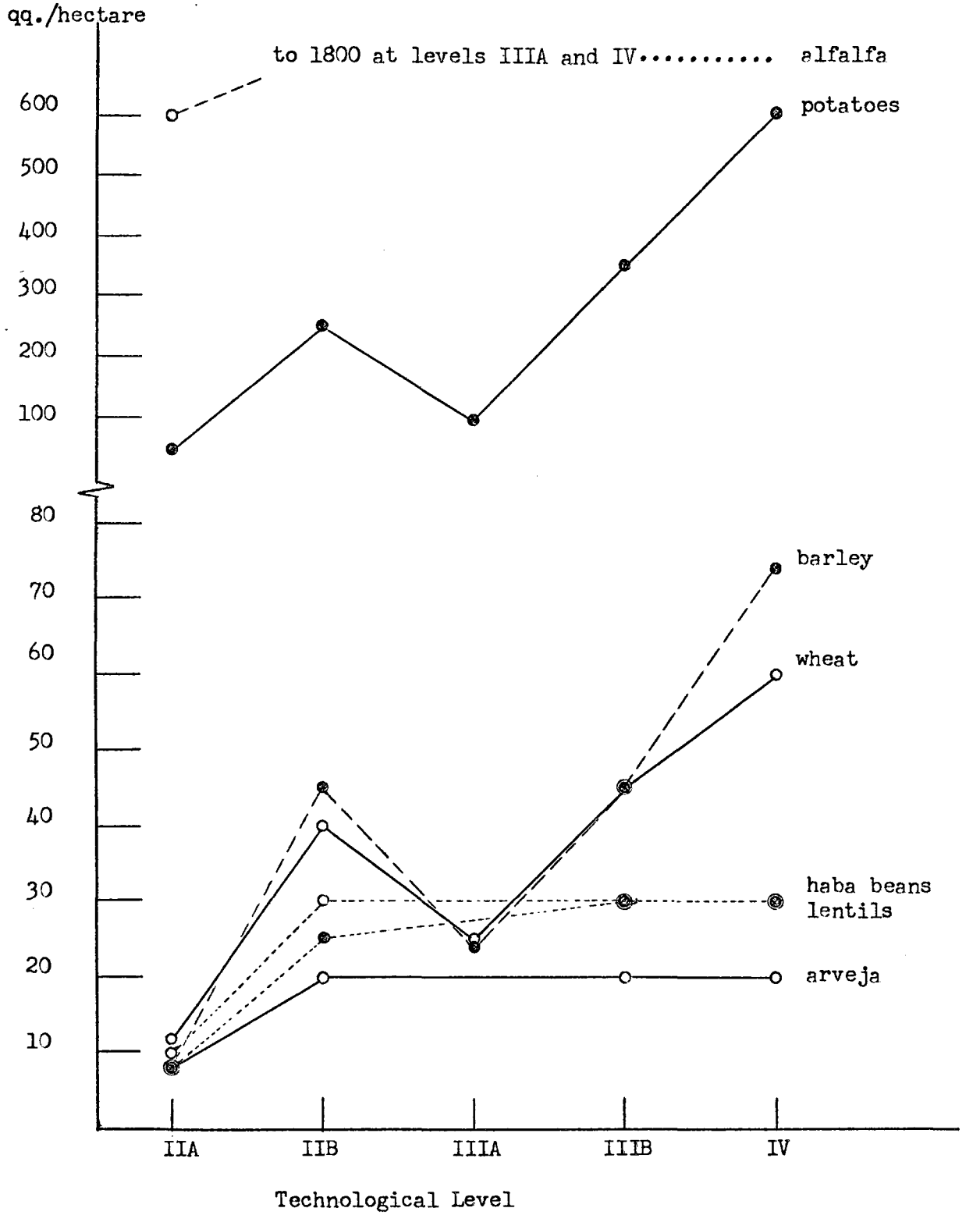


CHART 2

COST OF ACTUAL PRODUCTION AND ALTERNATIVES

(IN SUCRES)

	Actual				Recommended For Farms Under 20 Hectares Alternative 1			
Crop	Cost Per Hect.	Yield qq.	Cost/ qq.	Net Profit/ Hect.	Cost Per Hect.	Yield qq.	Cost/ qq.	Net Profit Per Hect.
Wheat								
*With Oxen	1296.0	12	108.0	-226.0	2395	40	59.88	1475
**With Tractor	2173.0	25	86.92	312.0				
Barley								
*With Oxen	1075	9	119.44	535.0	2276	45	50.57	744
**With Tractor	1826	24	76.88	-14.60				
Potatoes								
*With Oxen	2422	45	53.82	-622	6913	250	27.65	2465
** With Tractor	4600	92	50.00	-920				
Beans Habas								
*With Oxen	1113	10	113.0	-113	1606	30	55.53	1394
** With Tractor								
Beans Fréjol								
*With Oxen					2836	30	94.53	3164
**With Tractor								
Lentils								
*With Oxen	787	8	98.38	-187	1715	25	68.60	160
**With Tractor								
Arveja								
*With Oxen	996	8	124.50	604	2017	20	100.85	1983
**With Tractor								
Corn and Fréjol	1364	14		236				
Installation Of Alfalfa								
*With Oxen	2465	300	8.22	-965				
**With Tractor								
Alfalfa- Maint./Year	2239	600	0.75	732				
Other Pastures Installation								
Maintenance					2812	2112	1.60	360

*Farms under 20 hectares, without machinery

**Farms over 20 hectares, with machinery

CHART 2 - Continued

COST OF ACTUAL PRODUCTION AND ALTERNATIVES

Recommended For Farms Over 20 Hectares

Crop	Alternative 2 Rented Machinery: Cost Per Hect.	Yield qq.	Cost qq.	Net Profit/ Hect.	Alternative 3 Owned Machinery: Cost Per Hect.	Yield qq.	Cost/ qq.	Net Profit/ Hect.
Wheat								
*With Oxen								
**With Tractor	310.8	45	69.01	1692	3019	60	50.32	3206
Barley								
*With Oxen								
**With Tractor	2653	45	58.96	947	2773	74	37.47	2907
Potatoes								
*With Oxen								
**With Tractor	7919	350	22.63	6081	12703	600	21.17	11297
Beans Habas								
*With Oxen								
**With Tractor	1814	30	60.46	1186	1615	30	53.83	1385
Beans Fréjol								
*With Oxen								
**With Tractor	3045	30	101.5	2955	2843	30	94.77	3157
Lentils								
*With Oxen								
**With Tractor	1966	30	65.53	284	1750	30	58.33	500
Arveja								
*With Oxen								
**With Tractor	2225	20	111.25	1775	2023	20	101.15	1977
Corn and Fréjol								
Installation of Alfalfa								
*With Oxen								
**With Tractor	4484	528	8.49	-1844	4168	528	7.88	-1528
Alfalfa- Maint/Year	3899	1800	0.43	5101	3664	1800	0.41	5336
Other Pastures Installation	3037				2803			

*Farms under 20 hectares, without machinery

**Farms over 20 hectares, with machinery

(Mojanda Report, Table 22, Page 35.)

a marked increase between IIA and IIB. This is a measure of the beneficial effects of the use of agricultural chemicals, and improved methods of cultivation because animal traction is being used at both levels. Category IIIA always represents higher yields than IIA where animal traction is used, but it does not represent an improvement over IIB where chemicals are fully used with animal traction. For wheat, barley, potatoes and alfalfa, the two highest levels of technology represent the highest yields. For these crops, machinery can be used for almost all operations. The lack of a marked increase for arveja, haba and fréjol beans, and lentils may be due to the intensive hand labour which is always required. Machinery would make little difference if chemicals and fertilizer are being used at each level beyond IIA.

Figure 5 illustrates the cost per hectare for production of selected crops (Chart 3). These costs were calculated from the individual crop sheets of the Mojanda Report, since the costs given on Chart 2 include interest, labour and others not included in the calculation of Disposable Income. There is a general increase in costs per hectare, with advances in the technological level. For seven of the ten crops, there is a slight decrease in cost when the machinery is owned. Except for pasture installation, all mechanized operations exhibit higher costs than a hand labour operation. The marked increase from level IIA to IIB is due to the use of chemicals. Generally in comparing costs and yields it can be noted that while category IIIA has significantly lower yields in most cases than IIB, the costs do not exhibit the same pattern.

Figure 5

Calculated Costs per Hectare for Selected Crops

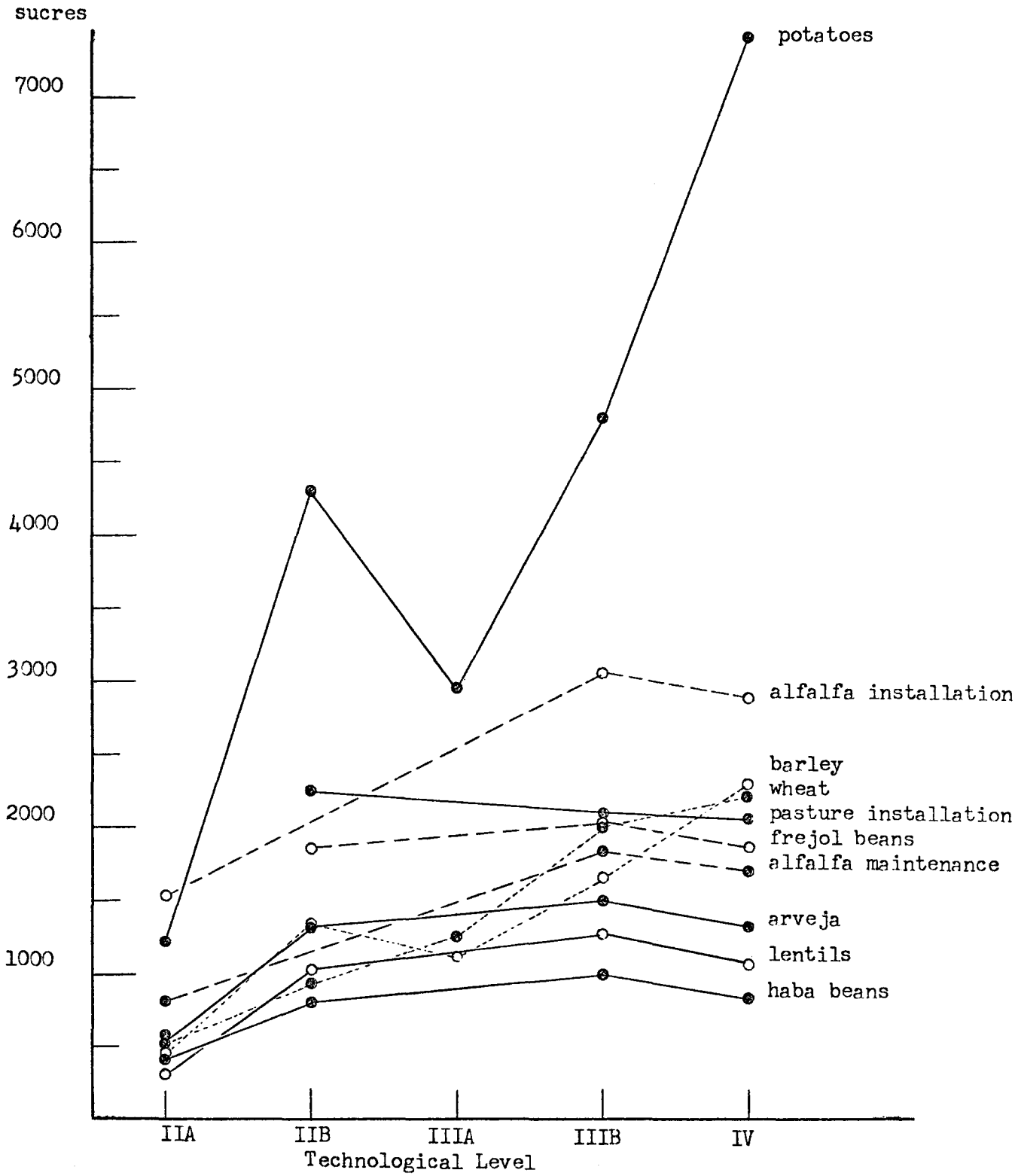


CHART 3

DISPOSABLE INCOME, LABOUR INDEX AND PRODUCTIVITY RATIO FOR INDIVIDUAL CROPS IN THE MOJANDA REPORT

Crop	Item	Actual Level IIA	Recommended Level IIB	Actual Level IIIA	Recommended Level IIIB	Recommended Level IV
Wheat	Disposable Income	468	2932	1588	2786	4110
	Labour Index	27 7Y.	33 9Y.	7 4R.T.	6M.D. 5R.T.	7M.D. 10.5M.H.
	Productivity Ratio	17.3	88.8	226.6	464.3	587.2
	Cost per Hectare	602	938	1257	2014	2115
Barley	Disposable Income	90	1709	454	1833	3286
	Labour Index	26 7Y.	35 11Y.	7 3R.T. 1 Yoke	4M.D. 5R.T.	5M.D. 9.5M.H.
	Productivity Ratio	3.5	48.8	64.9	458.3	657.2
	Cost per Hectare	450	1341	1126	1647	2314
Potatoes	Disposable Income	579	5695	725	9185	16589
	Labour Index	64 16Y.	129 22Y.	66 4R.T. 10Y.	142M.D. 5R.T. 12Yoke	187M.D. 7M.H. 12Yoke
	Productivity Ratio	9.1	44.2	11.0	64.7	88.7
	Cost per Hectare	1221	4305	2955	4815	7411

CHART 3 - Continued

DISPOSABLE INCOME, LABOUR INDEX AND PRODUCTIVITY

RATIO FOR INDIVIDUAL CROPS IN THE MOJANDA REPORT

Crop	Item	Actual Level IIA	Recommended Level IIB	Actual Level IIIA	Recommended Level IIIB	Recommended Level IV
Beans Habas	Disposable Income	579	2183		2003	2177
	Labour Index	32 10Y.	36 12Y.		28M.D. 3R.T. 4Yoke	28M.D. 5M.H. 4Yoke
	Productivity Ratio	18.1	60.6		71.5	77.7
	Cost per Hectare	421	817		997	823
Beans Fréjol	Disposable Income		4144		3964	4138
	Labour Index		41 13Y.		35M.D. 3R.T. 5Y.	35M.D. 5M.H. 5Y.
	Productivity Ratio		101.1		113.3	118.2
	Cost per Hectare		1856		2036	1862
Lentils	Disposable Income	290	838		983	1189
	Labour Index	19 7Y.	26 9Y.		17 4R.T.	17 6M.H.
	Productivity Ratio	15.3	32.2		57.8	69.9
	Cost per Hectare	310	1037		1267	1061

CHART 3 - Continued

DISPOSABLE INCOME, LABOUR INDEX AND PRODUCTIVITY

RATIO FOR INDIVIDUAL CROPS IN THE MOJANDA REPORT

Crop	Item	Actual Level IIA	Recommended Level IIB	Actual Level IIIA	Recommended Level IIIB	Recommended Level IV
Arveja	Disposable Income	1070	2678		2498	2672
	Labour Index	16 7Y.	20 11Y.		20M.D. 5R.T. 1 Yoke	20M.D. 7M.H. 1 Yoke
	Productivity Ratio	66.9	133.9		124.9	133.6
	Cost Per Hectare	530	1322		1502	1328
Corn and Fréjol Beans	Disposable Income					
	Labour Index					
	Productivity Ratio					
	Cost per Hectare					
Installation of Alfalfa	Disposable Income	-45			-425	0
	Labour Index	38 8Y.			45M.D. 5R.T.	40M.D. 21½M.H.
	Productivity Ratio	-1.4			-9.4	0
	Cost per Hectare	1545			3065	2882

CHART 3 - Continued

DISPOSABLE INCOME, LABOUR INDEX AND PRODUCTIVITY

RATIO FOR INDIVIDUAL CROPS IN THE MOJANDA REPORT

Crop	Item	Actual Level IIA	Recommended Level IIB	Actual Level IIIA	Recommended Level IIIB	Recommended Level IV
Alfalfa Maintenance	Disposable Income	2190			7161	7305
	Labour Index	54			68M.D.	68M.D. 24M.H.
	Productivity Ratio	40.6			105.3	107.4
	Cost Per Hectare	810			1839	1695
Other Pasture	Disposable Income					
	Labour Index		7 6M.H.		7 4R.T.	4 8M.H.
	Productivity Ratio		321.7		302.4	516.0
	Cost per Hectare		2252		2117	2064

Note:

1. The Productivity Ratio, Disposable Income, and Costs are in sucres.
2. Harvesting costs have not been included because in many cases it includes hand labour.
3. Transportation and materials have been included in the costs.
4. Y. yoke of oxen M.H. machine hours

   R.T. rented tractor

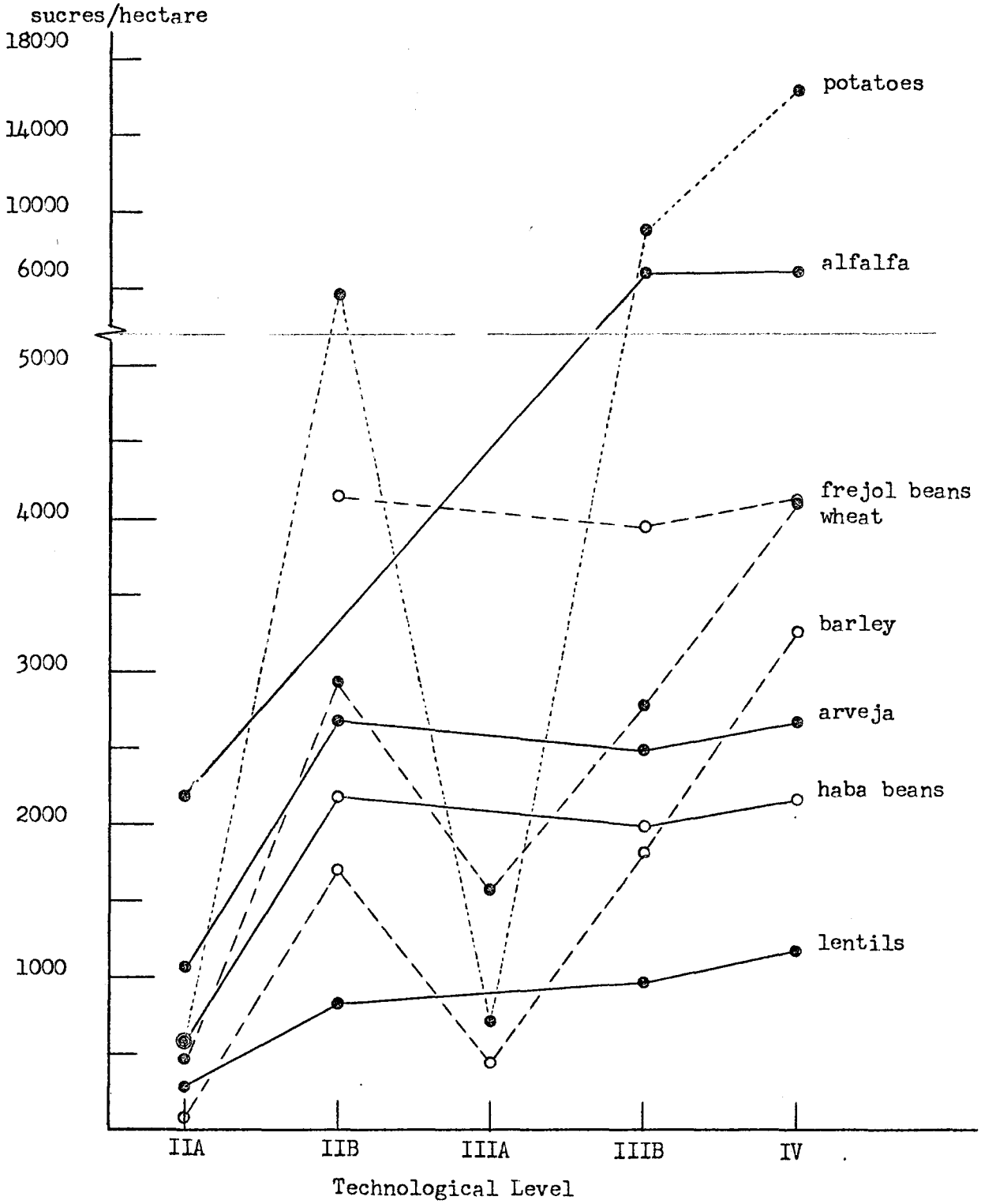
For potatoes costs and yields show a parallel pattern of increase with advances in technological level. Wheat and barley show similar responses which differ from those of lentils, haba and fréjol beans, and arveja because costs increase and yields drop from Level IIB to IIIA. Hence, when machinery and chemicals are being used in less than recommended proportions, the Disposable Income would be expected to be lower than on those farms with a more rudimentary form of traction but full use of agricultural chemcials.

Figure 6 shows the Disposable Income for the technological levels of the Mojanda Report as calculated from costs on individual data sheets, and profits on Chart 2. A similar pattern emerges here as with the costs of production and crop yields.

All crops show a marked increase in the Disposable Income when agricultural chemicals are used with animal traction. For all crops which are being grown with less than recommended operations and rented machinery, the Disposable Income represents a lower level of income than at a recommended level with animal traction. In all cases, the Disposable Income is higher when the machinery is owned than when it is rented.

In general, there is an increase in the Disposable Income with advances in technological level with one exception: when a mechanized operation is carried on in a less than recommended manner, the Disposable Income is lower than one where animal traction is used with recommended agricultural chemicals. It should also be noted that not all crops show a marked response to mechanization. Beans, arveja and lentils can be grown profitably using animal traction since they

Figure 6
Calculated Disposable Income for Selected Crops



require a great deal of hand labour at all levels. It is the use of agricultural chemicals which causes a marked increase in the Disposable Income of these crops.

The Relation Between Technology And Labour Requirements:

In this section, an attempt is made to determine the nature of the relationship between the level of technology and the labour requirements in the production of different crops. The labour requirements for specific crops, at different technological levels is always expressed in terms of Wood's Labour Index.

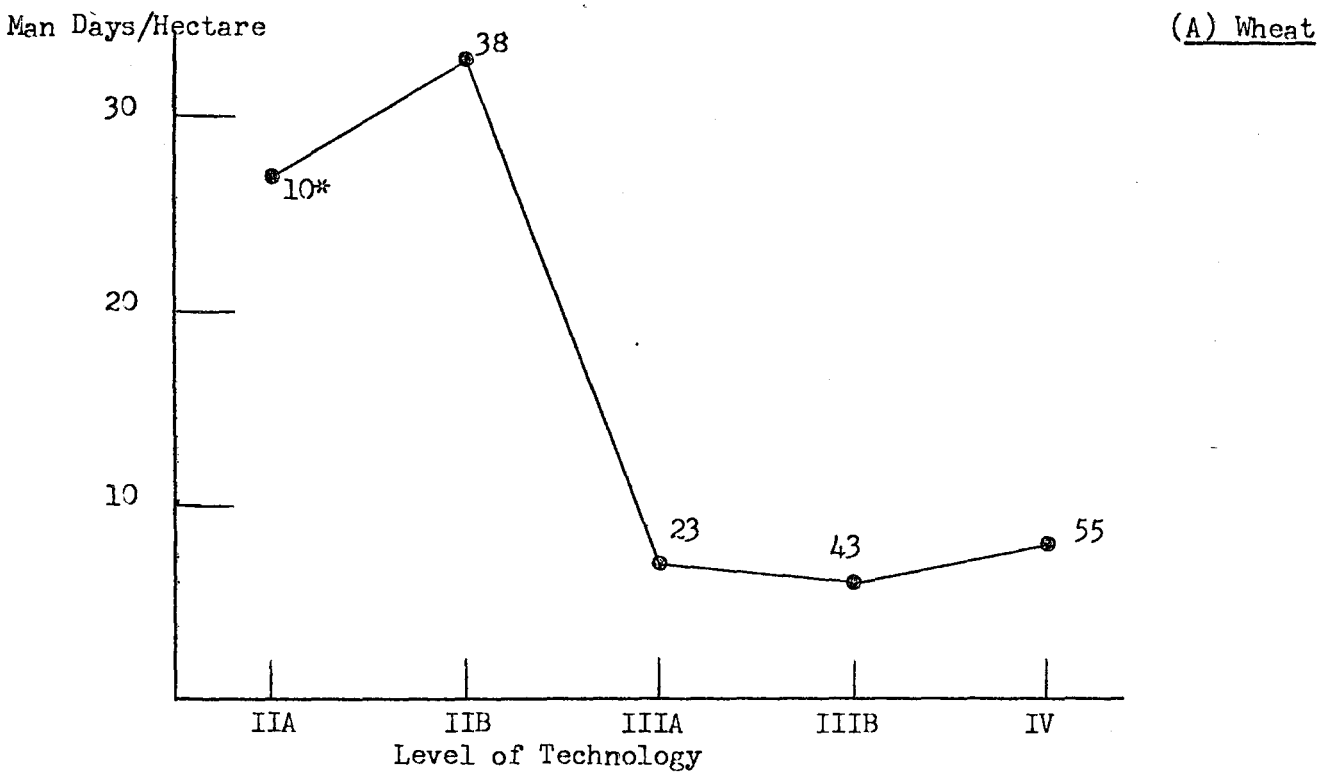
Figures 7A to 7I are based on Chart 4[1] and show the differences in labour requirements for specific crops in the Mojanda-Cayambe area. Secondly, these figures illustrate the corresponding differences in yields for each crop's labour input.

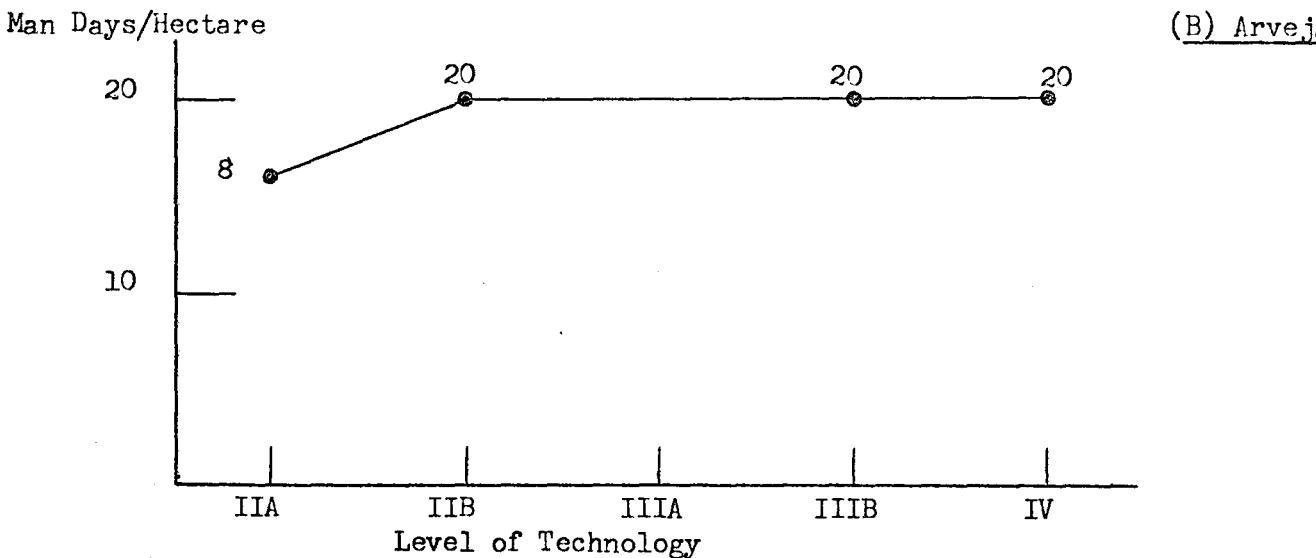
Observation of Figures 7A to 7I will show a consistent increase in labour requirements in the animal-traction category, when chemicals are used. This increase in labour input corresponds to an increase in yield.

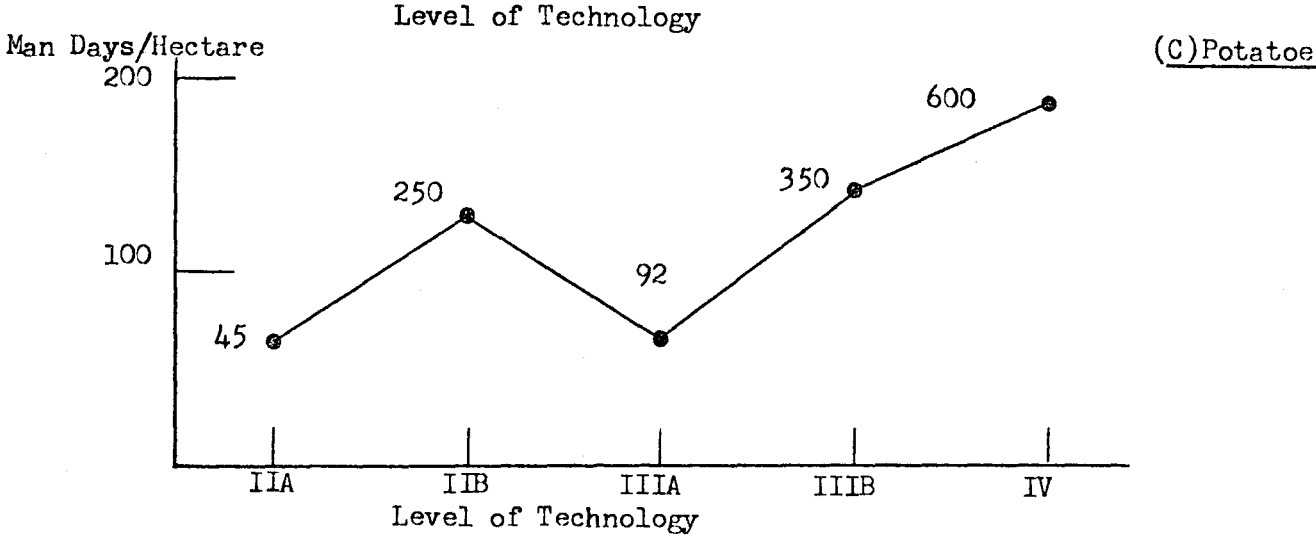
For seven of the nine crops where data is available for operations without the use of machinery, as well as with the use of machinery, the labour input shows a very sharp decline with progression from level IIB to level III. In other words, the use of machinery appreciably reduces labour input for all crops but arveja and alfalfa.

[1]Chart 5 is included for comparison purposes.

Figure 7A, 7B, and 7C
Technological Level and Labour Requirements

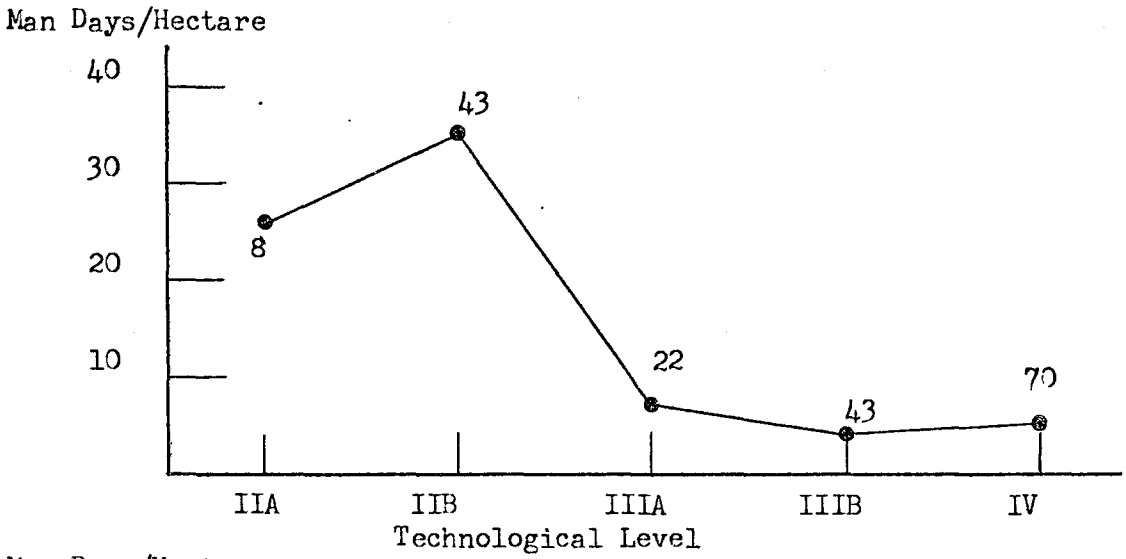


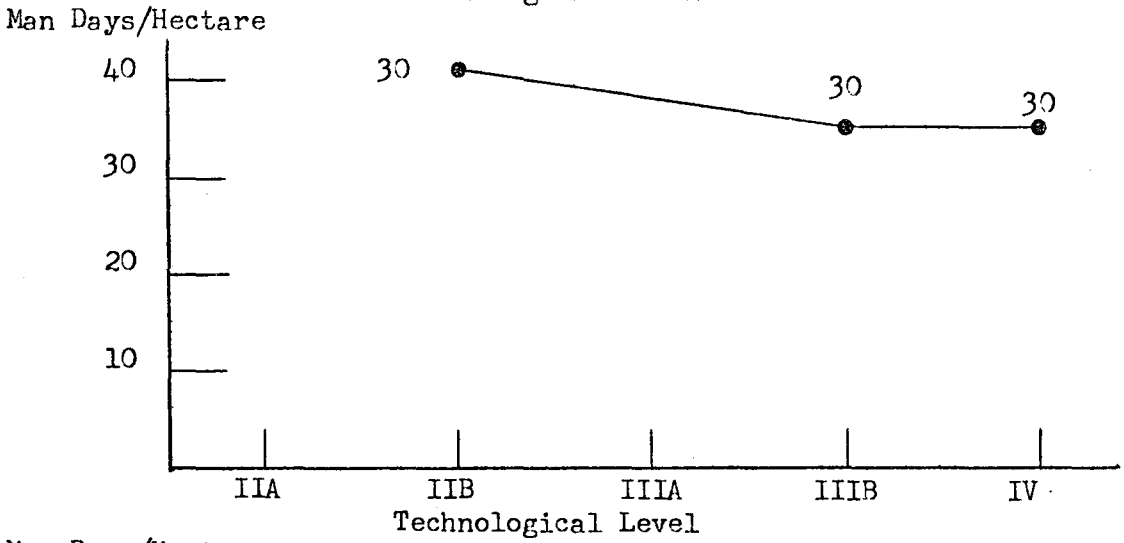




* numbers indicate crop yield per hectare

Figure 7D, 7E, and 7F
Technological Level and Labour Requirements





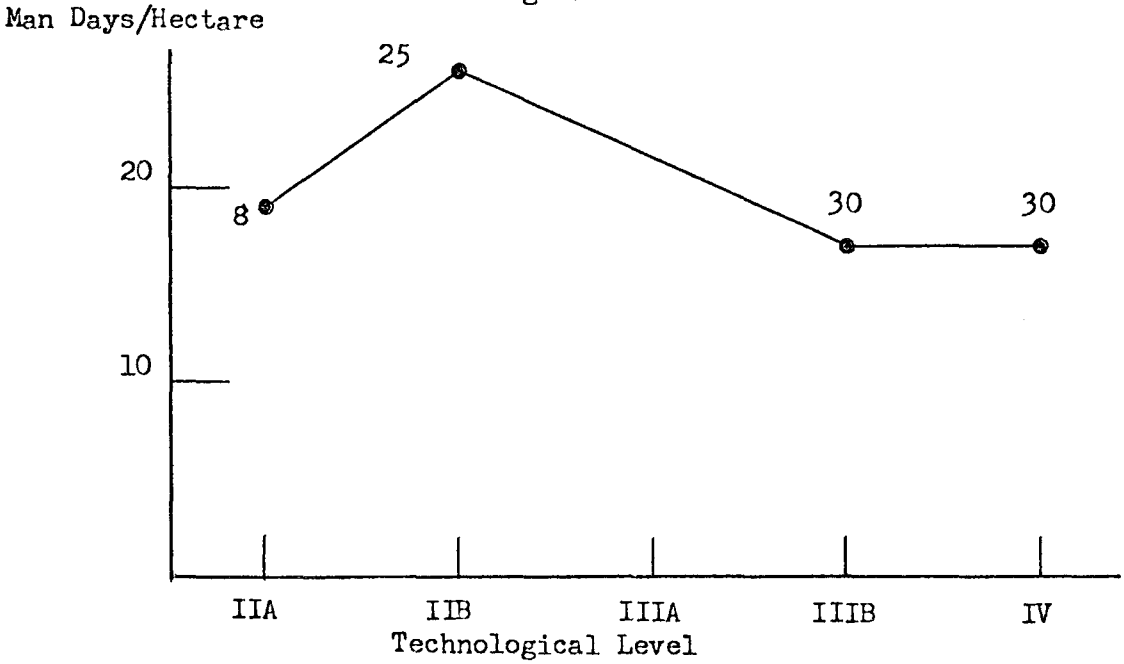
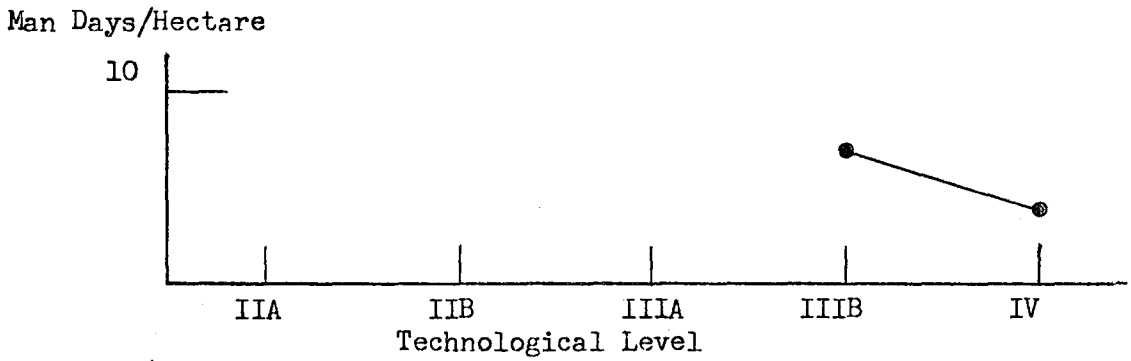
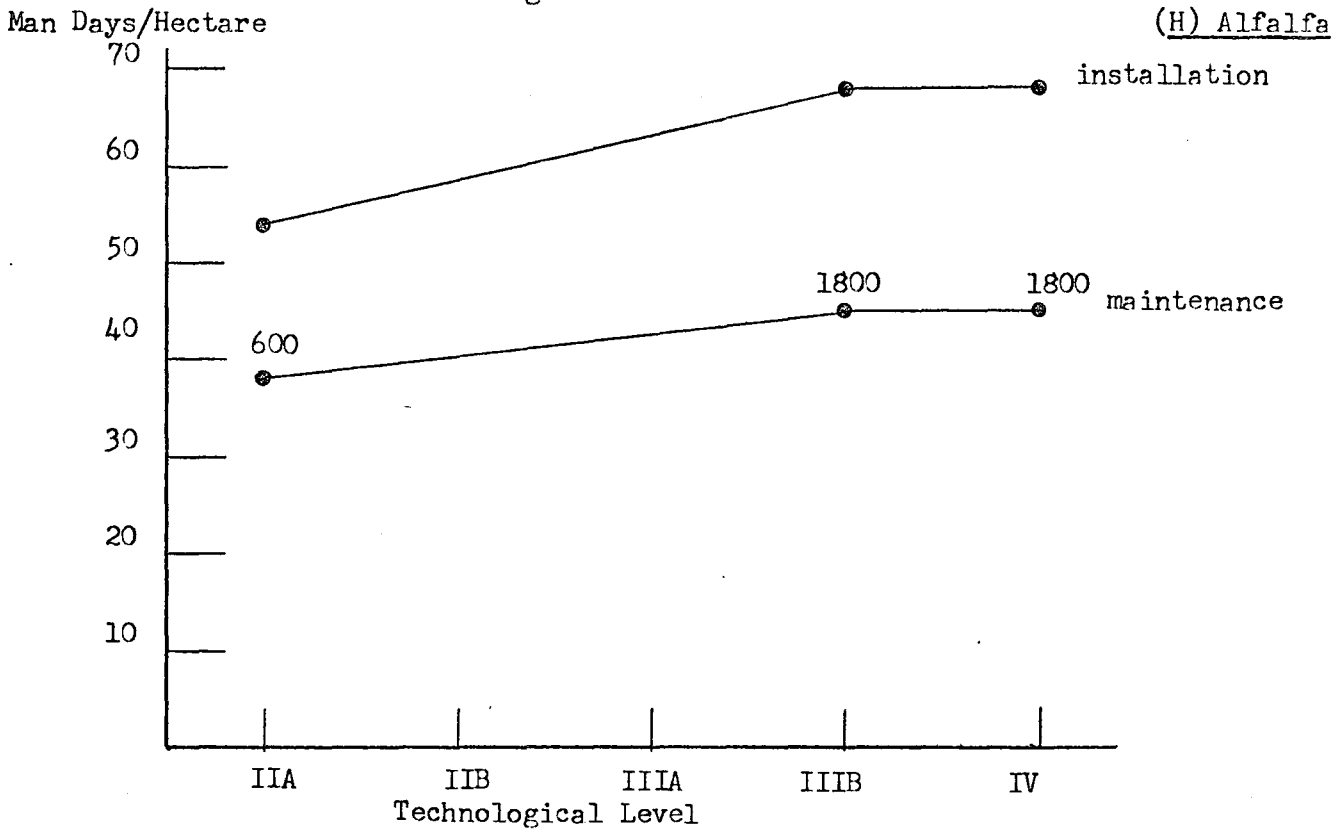


Figure 7G, 7H, and 7I
Technological Level and Labour Requirements





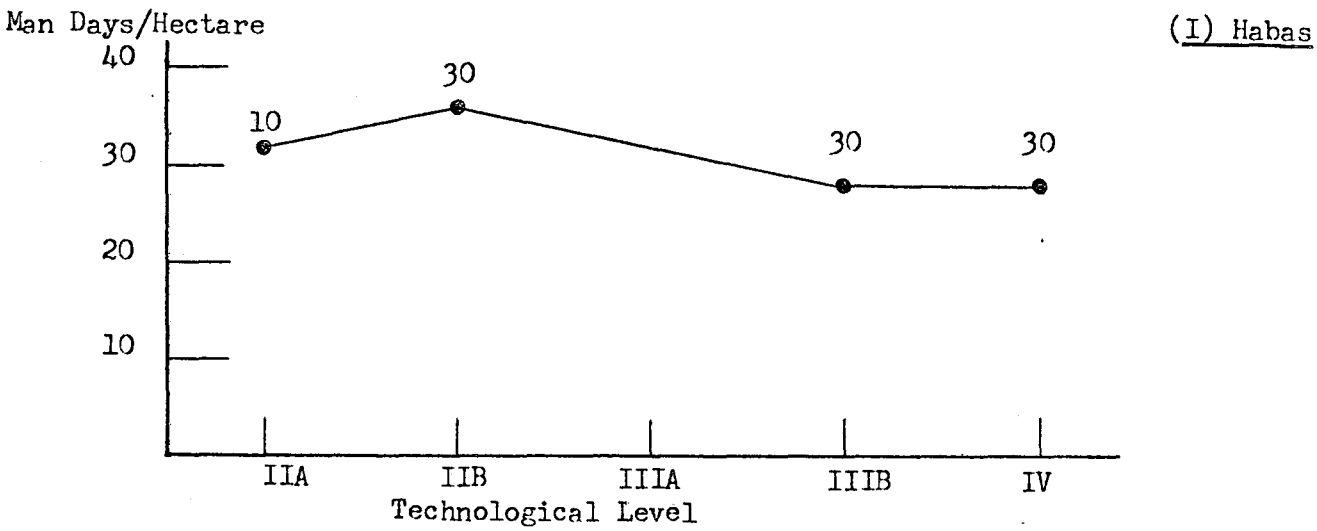


CHART 4

LABOUR REQUIREMENTS PER HECTARE PER CROP

FROM THE MOJANDA REPORT (IN DAYS)

Crop	Actual Under 20H. Level IIA	Recommended Under 20H. Level IIB	Actual Over 20H. Level IIIA	Recommended Over 20H. Level IIIB	Recommended Over 20H. Level IV
1. Wheat	27 7Y.	33 9Y.	7 4R.T.	6 5R.T.	7 10½M.H.
Yield:	10qq.	38qq.	23qq.	43qq.	55qq.
2. Arveja	16 7Y.	20 11Y.		20 5R.T. 1Y.	20 7M.H. 1Y.
Yield:	8qq.	20qq.		20qq.	20qq.
3. Potatoes	64 16Y.	129 22Y.	66 4R.T. 10Y.	142 5R.T. 12Y.	187 7M.H. 12Y.
Yield:	45qq.	250qq.	92qq.	350qq.	600qq.
4. Barley	26 7Y.	35 11Y.	7 3R.T. 1Y.	4 5R.T.	5 9½M.H.
Yield:	8qq.	43qq.	22qq.	43qq.	70qq.
5. Frejol De Mata		41 13Y.		35 3R.T. 5Y.	35 5M.H. 5Y.
Yield:		30qq.		30qq.	30qq.
6. Lentils	19 7Y.	26 9Y.		17 4R.T.	17 6M.H.
Yield:	8qq.	25qq.		30qq.	30qq.
7. Habas	32 10Y.	36 12Y.		28 3R.T. 4Y.	28 5M.H. 4Y.
Yield	10qq.	30qq.		30qq.	30qq.
8. Alfalfa (install-ation)	38 8Y.			45 5R.T.	40 21½M.H.
Yield:	300qq.			528qq.	528qq.
9. Alfalfa (maintain)	54M.D.			68	68 24M.H.
Yield:	600qq.			1800qq.	1800qq.
10. Pasture				7 4R.T.	4 8M.H.

Note:

Y. Yoke of oxen
R.T. Rented tractor
M.H. Machine hours
M.D. Man Days
qq. Quintal

CHART 5

LABOUR REQUIREMENTS PER HECTARE PER CROP

FROM THE CAYAMBE REPORT (IN DAYS)

Crop	With owned Machinery	With rented Machinery	Machinery & Animals	Hand Labour Only
1. Wheat	10M.D. 8.5M.H.	10M.D. 12.5M.H.		
Yield:	38qq.	38qq.		
2. Barley	10M.D. 8.5M.H.	10M.D. 12.5M.H.		
Yield:	40qq.	40qq.		
3. Potatoes	138M.D. 10.0M.H.		138M.D. 8M.H.(10M.H.) 4 Yoke	
Yield:	350qq.		350qq.	
4. Habas	21M.D. 4.0M.H.		4M.H. 2 Yoke 21M.D.	
Yield:	20qq.		20qq.	
5. Fréjol	30M.D.			30M.D.11 Yoke
Yield:	14qq.			14qq.
6. Arveja	16M.D.		25M.D. 10 Yoke	
Yield:	20qq.		20qq.	
7. Corn:	11M.D.			16M.D. 6 Yoke
Yield:	25qq.			25qq.
8.*Alfalfa	25M.D. 14.5M.H.		8.5M.H. 34M.D.	
Yield:	528qq.		528qq.	
9.** Alfalfa	31M.D. 12.0M.H.		49M.D.	
Yield:	1032qq.		1032qq.	
10. * Pyreth-rum	62M.D.	62M.D. 13.5M.H. 2 Yoke		
Yield:	8qq.	8qq.		
11.** Pyreth-rum	282M.D. 13.5M.H.	282M.D. only		
Yield:	225qq.	225qq.		

CHART 5 - Continued

LABOUR REQUIREMENTS PER HECTARE PER CROP

FROM THE CAYAMBE REPORT (IN DAYS)

Crop	With owned Machinery	With rented Machinery	Machinery & Animals	Hand Labour Only
12. Onions*				*1 Yoke 127M.D.
Yield:				60qq.
**				**1 Yoke 95 M.D.
Yield:				240qq.
13. Garden Veg.				5 Yokes 214M.D.
Yield:				50,000qq.
14. Pasture*	12M.D.	12*M.D. & 9M.H.		
	9.0M.H.	10**M.D. only		
**	10M.D.			

* year 1

** years 2 - 5

The only crop which shows an increase in labour input, with the use of machinery at the higher technological levels, is potatoes. This increase in labour is also associated with a marked increase in yield which could be expected. Potatoes require a great deal of hand labour at all levels and an increase in yield would be accompanied by an increase in labour input, since planting and harvesting operations account for the additional labour.

For those crops which can almost entirely be handled by machine (wheat and other cereal crops) a marked decrease in labour input corresponds with the increased use of machinery. The use of labour and the nature of farm operations changes with a progression in technological levels. These changes are largely responsible for the increased yields, and hence the Disposable Income.

Changes In Labour Use And Farm Operations With Advances Of The Technological Level:

This section attempts to show the changes in the use of labour and different tasks for each the technological levels found in the Mojanda Report. For this purpose an analysis follows of the farm operations for one crop, wheat. The pattern of operations is characteristic of those crops where mechanization is possible.

CHART 6

* COST OF PRODUCTION PER HECTARE OF WHEAT

SOURCE: TABLE 21 OF MOJANDA REPORT

	Actual Costs For Farms Under 20 Hectares Without Machinery				Recommended Costs Of Farms Under 20 Hectares Without Machinery				Actual Costs For Farms Over 20 Hectares With Rented Machinery			
	Unit	Quan.	Price	Total Value	Unit	Quan.	Price	Total Value	Unit	Quan.	Price	Total Value
Income Wheat	qq.	10	100	1000	qq.	38	100	3800	qq.	23	105	2415
Straw	qq.	2	35	70	qq.	2	35	70	qq.	2	35	70
Total		12		1070		40		3870		25		2485
Costs												
break land	yoke	4	30	120	yoke	4	3	120	tract.	1	180	180
cross plough	yoke	2	30	60	yoke	2	30	60	tract.	1	120	120
harrow					yoke	1	30	30	tract.	1	120	120
harrow					yoke	1	30	30				
harrow												
seeding by machine												
seeding by hand	M.D.	2	15	30	M.D.	2	15	30	M.D.	2	15	30
seed	qq.	3	120	360	qq.	2.5	160	400	qq.	2.5	120	300
fertilizer					qq.	4.0	143	572	qq.	2	143	286
cover	yoke	1	30	30	yoke	1	30	30	tract.	1	120	120
herbicides					litre	2	35	70	litre	2	35	70
application					M.D.	2	15	30	M.D.	2	15	30
fertilizer												
application												
cut	M.D.	10	15	150	M.D.	12	15	180				
thresh	M.D.	6	15	90	M.D.	6	15	90				
hired threshing machine	qq.	12	3	36	qq.	40	3	120				
machine harvesting									qq.	25	10	250

*in sucres

CHART 6 CONTINUED

COST OF PRODUCTION PER HECTARE OF WHEAT

SOURCE: TABLE 21 OF MOJANDA REPORT

	Actual Costs For Farms Under 20 Hectares Without Machinery				Recommended Costs Of Farms Under 20 Hectares Without Machinery				Actual Costs For Farms Over 20 Hectares With Rented Machinery			
	Unit	Quan.	Price	Total Value	Unit	Quan.	Price	Total Value	Unit	Quan.	Price	Total Value
Income Wheat	qq.	10	100	1000	qq.	38	100	3800	qq.	23	105	2415
Straw	qq.	2	35	70	qq.	2	35	70	qq.	2	35	70
Total		12		1070		40		3870		25		2485
materials (sacks)	sacks	15	0.5	8	sacks	40	0.5	20	sacks	25	0.5	13
condition grain	M.D.	2	15	30	M.D.	2	15	30	M.D.	3	15	45
transport.	qq.	12	2	24	qq.	38	2	76	qq.	22	2	44
interest on operating capital	(12%)			75				151				130
Miscell. 2%				21				42				36
Total Direct Costs				1034				2081				1174
General Costs (5%)				52				104				89
Interest on original Capital				210				210				210
				262				314				399
Total Costs				1296				2395				2173
Profit Or Losses Per Hectare In Sucres				-226				1475				312
No. of M.D. Per Hectare		27				33				7		
Cost Per Produced qq.		S/108.00				S/59.88				S/86.92		

CHART 6 CONTINUED

COST OF PRODUCTION PER HECTARE OF WHEAT

SOURCE: TABLE 21 OF MOJANDA REPORT

	Recommended For Farms Over 20 Hectares With Rented Machinery				Recommended For Farms Over 20 Hectares With Owned Machinery			
	Unit	Quan.	Price	Total Value	Unit	Quan.	Price	Total Value
Income Wheat	qq.	43	110	4730	qq.	55	110	6050
Straw	qq.	2	35	70	qq.	5	35	175
Total		45		4800		60		6225
Costs								
break land	tract	1	180	180	hour	2	51	102
cross plough	tract	1	120	120	hour	1½	48	72
harrow	tract	1	120	120	hour	1½	48	72
harrow	tract	1	120	120	hour	1½	48	72
harrow					hour	1½	48	72
seeding by machine	tract	1	80	80	hour	1½	48	72
seeding by hand								
seed	qq.	2.2	160	352	qq.	2.2	160	352
fertilizer	qq.	5.0	143	715	qq.	6.0	143	858
cover								
herbicides	litre	2	35	70	litre	2	35	70
application	M.D.	2	15	30	M.D.	2	15	30
fertilizer	area	1	105	105	qq.	2	105	210
application	M.D.	1	15	15	M.D.	1	15	15
cut								
thresh								
hired threshing machine								
machine harvesting	qq.	45	10	450	hour	1	230	230

CHART 6 CONTINUED

COST OF PRODUCTION PER HECTARE OF WHEAT

SOURCE: TABLE 21 OF MOJANDA REPORT

	Recommended For Farms Over 20 Hectares With Rented Machinery				Recommended For Farms Over 20 Hectares With Owned Machinery			
	Unit	Quan.	Price	Total Value	Unit	Quan.	Price	Total Value
Income Wheat	qq.	43	110	4730	qq.	55	110	6050
Straw	qq.	2	35	70	qq.	5	35	175
Total		45		4800		60		6225
materials (sacks)	sacks	45	0.5	23	sacks	60	0.5	30
condition grain	M.D.	3	15	45	M.D.	4	15	60
transport.	qq.	42	2	84	qq.	55	2	110
interest on operating capital				201				194
Miscell. 2%				50				54
Total Direct Costs				2760				2675
General Costs (5%)				138				134
Interest on original Capital				210				210
				348				344
Total Costs				3108				3019
Profit or Losses Per Hectare In Sucres				1692				3206
No. of M.D. Per Hectare		6						
Cost Per Produced qq.		S/69.01				S/50.32		

Land Preparation Operations[1]:

Level	IIA	IIB	IIIA	IIIB	IV
Operations					
Plough	1	1	1	1	1
Furrow	1	1	1	1	1
Harrow		2	1	2	3
Total Labour Input	6 Yoke and 6 M.D.	8 Yoke and M.D.	3 Rented Tractors With Driver	4 Rented Tractors With Driver	8 Machine Hours

The recommended situation for an animal-traction operation requires 2 more man days devoted to land preparation. The eight days required in this category for land preparation becomes 3 tractor with driver days in IIIA, 4 tractor with driver days in IIIB, and 8 machine hours or 1 man day for a highly mechanized operation. Therefore, in the case of land preparation, the higher the level of technology, the greater the number of farm operations carried out but the smaller the labour input if machines are used.

[1]The tables are summarized from the accompanying Chart 6 taken from the Mojanda Report.

Planting Operations:

Level	IIA	IIB	IIIA	IIIB	IV
Operation					
Planting Covering Seed	2 M.D. 1 M.D. and Yoke	2 M.D. 1 M.D. and Yoke	2 M.D. 1 Rented With Driver	1 Rented Tractor With Driver	$1\frac{1}{2}$ Machine Hours
Labour Input	3 M.D.	3 M.D.	3 M.D.	1 M.D.	$1\frac{1}{2}$ Hours

For the planting operation, 3 man days becomes $1\frac{1}{2}$ hours when machinery (tractor with seeder) replaces manual labour.

Chemical Treatment:

Level	IIA	IIB	IIIA	IIIB	IV
Operation					
Fertilizer Herbicides Chemical fertilizer		2 M.D.	2 M.D.	2 M.D. 1 M.D.	2 M.D. 1 M.D.
Total	0	2 M.D.	2 M.D.	3 M.D.	3 M.D.

Additional fertilizer is being applied at levels IIA through IV but the labour involved in its application has not been listed separately. The application of chemicals accounts for 2 extra days at levels IIB and IIIA, but 3 days with levels IIIB and IV which are applying the recommended amount.

Harvesting Operation:

Level	IIA	IIB	IIIA	IIIB	IV
Operation					
Cut	10 M.D.	12 M.D.			
Thresh	6 M.D.	6 M.D.			
Mechanical Harvesting			Less than 1 hour per/qq.	Less than 1 hour per/qq.	1 Hour
Grade Grain	2 M.D.	2 M.D.	3 M.D.	3 M.D.	4 M.D.
Labour Input	18 M.D.	20 M.D.	3 M.D. 1 Hour	3 M.D. 1 Hour	4 M.D.

For Level II, harvesting is done by hand and combined with the grading of the grain, the labour requirements are 18 to 20 M.D. In Level III, a combine is rented and is paid for by the quintal of harvested grain. Costs would then be higher for IIIB than IIIA, but the time required in both cases would be less than one hour.

It is the grading of the grain which requires the labour at higher technological levels since 16 to 18 man days of harvesting have been replaced by less than one machine hour. The following chart summarizes the labour equivalents:

Summary Of Labour

Ploughing:	4 M.D.	oxen	1 Rented Tractor	2 Machine Hours
To Furrow:	2 M.D.	oxen	1 Rented Tractor	1½ Machine Hours
To Harrow:	1 M.D.	oxen	1 Rented Tractor	1½ Machine Hours
Seed And To Cover	3 M.D.	oxen	1 Rented Tractor	1½ Machine Hours
To Cut And Thresh	16 M.D. - 18 M.D. = 1 Machine Hour			

While less time is spent on the foregoing operations at higher technological levels, more time is spent applying fertilizers and herbicides.

In general, therefore, the higher the technological level, the fewer the labour days required in land preparation, planting and harvesting but the greater the time allotted to the application of agricultural chemicals. These agricultural chemicals and more thorough land preparations are responsible for the increase in crop yields. The yield directly affects the Disposable Income of any Land Use System and therefore the Productivity Ratio. The Productivity Ratio is the Disposable Income divided by the Labour Index and is a measure of the income per work day.

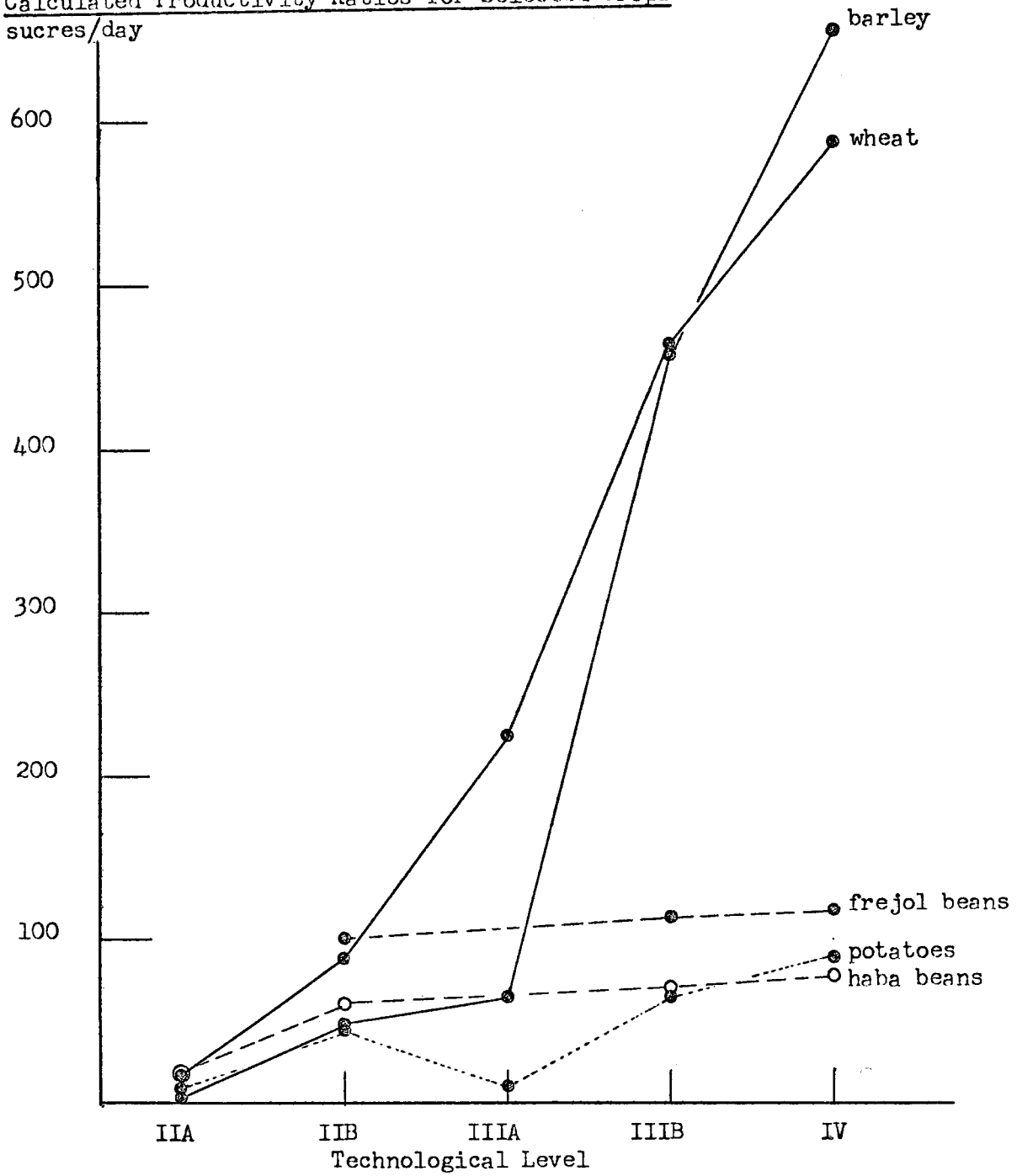
The Relationship Between Productivity Ratio and Level of Technology:

Figures 8A and 8B show the Productivity Ratio for selected crops for different levels of technology from the Mojanda Report (Chart 3). Those crops which can be most completely mechanized (barley, wheat and alfalfa) show the greatest increase in Productivity Ratio for mechanized levels of technology. Those crops which require a great deal of hand labour (beans, potatoes, arveja) at all levels, show only gradual increases in Productivity Ratios with advances in technological level. In all cases a definite increase occurs between IIA and IIB where agricultural chemicals are added in an animal-traction operation.

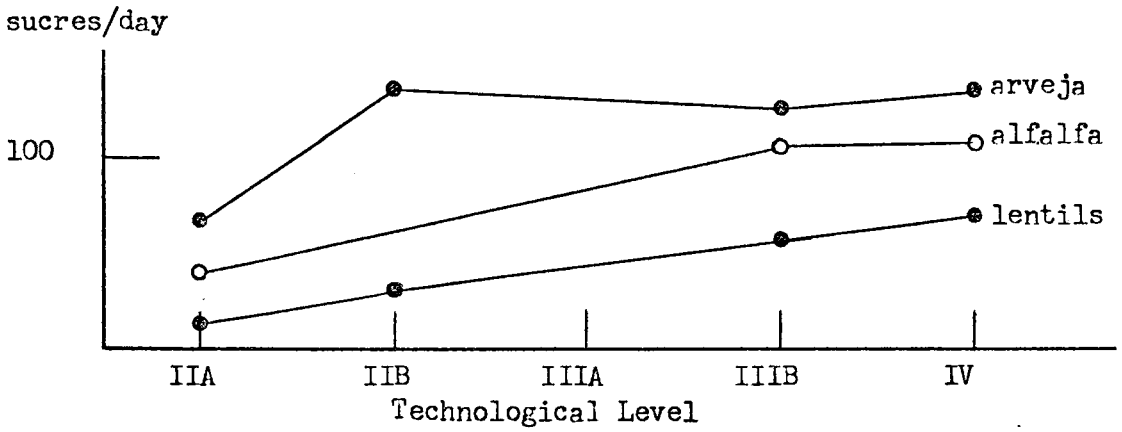
From the preceding examination of data the following general statements can be made:

Figure 8A and 8B
Calculated Productivity Ratios for Selected Crops

(A)



(B)



An increase in the technological level of farm operations is closely associated with

a. an increase in crop yield except for a drop at Level IIIA.

b. an increase in crop value.

c. an increase in costs per hectare.

d. an increase in Disposable Income except for a decline at Level IIIA.

e. a decrease in the Labour Index for crops which can be mechanized.

f. an increase in Productivity Ratio.

These statements are most valid for crops which can be completely mechanized. The one exception to the general trend in each case is a marked decline with movement from a recommended animal-traction operation, to a substandard mechanized operation.

In view of the differences between each of the categories, found in the foregoing analysis, the adequacy of Wood's classification of technological levels must now be examined.

Wood's Classification Of Technological Levels:

Wood has presented a four-fold division of technology which is as follows:

The Rudimentary Level:

At this level, "little or no use is made of agricultural chemicals and all work is by hand or, especially in drier or more level areas, with the use of animal traction." For livestock raising

at this level, "one finds at best a single fence enclosing the property and a barrier to prevent the animals entering any patches of cropland. Otherwise, they wander where they will, except where they are under the care of a herder. The pasture grasses are of unimproved types and pasture management is generally restricted to occasional burnings."

The Subtechnified Level:

The subtechnified category "includes both those operations which are mechanically and those which are chemically assisted...A useful clarification is afforded by noting the general relief of the area in which the operation occurs. Tractors are almost never used on slopes of over 12%, while the practical limit for ploughing with oxen is about 30%. On most sloping land, therefore, and especially on slopes with thin soils, a sub-technified designation refers almost invariably to the use of agricultural chemicals. On level land one may expect to find some agricultural chemicals as well as a limited use of tractors for land preparation, and perhaps for seeding, particularly in specialized and semi-specialized farms. Very few sub-technified farms without specialization have their own machinery. Unless a tractor is available for rent and unless credit is easily obtainable to cover the rental cost, they tend to use simple equipment."

"A sub-technified level of livestock raising calls for the subdivision of the grazing area into a number of separate pastures. Grasses will normally be of improved strains, while some use may be

made of mowing machines and herbicides."

The Technified Level:

Wood defines a technified level as having a "regular use of a wide range of chemical and mechanical aids to production, provided that such aids are clearly useful." In terms of livestock raising, the technified level "differs from the sub-technified chiefly through its more scientific approach to forage production."

The Highly Technified Level:

Wood has reserved the category of "highly technified" "for the very few operations which both (chemical and mechanical aids to production) lend themselves readily to "technification" and which the process has been advanced close to the limits of present technology." "A highly technified operation (for livestock raising) would be making adequate use of machinery for feed handling and milking."[1]

Revision Of The Categories:

There would appear to be sufficient evidence for a subdivision of the Wood Rudimentary technological level.

The Mojanda Report recognizes the use of hand labour which may be supplemented by animal traction without the use of any type of agricultural chemicals. The report also recognizes the same

[1]H.A. Wood, A Land Use Classification For The American Tropics, pages 10-12.

labour characteristics as the above, but with the use of agricultural chemicals. This second category exists as well in the Cayambe Report (Level "B") and most of the data collected by Cesar Hamburgo Calles. Both of these subdivisions were found by the author in the course of field work. Wood had considered both hand labour and animal traction as one level, and also included little or no use of agricultural chemicals.

The use of agricultural chemicals will almost always increase the yield, and will most certainly increase the labour requirements. The use of animal traction will probably result in better land preparation and better yields.

The Mojanda Report recognizes three additional levels:

(1) The use of rented machinery and agricultural chemicals, but with a less than recommended program of land preparation or chemical treatment.

(2) The use of rented machinery with a recommended application of chemicals and all necessary farm operations.

(3) The use of owned machinery and a recommended application of chemicals and number of farm operations.

These last two categories are also found in the Cayambe Report, and all three were found in the course of field work by the author.

The author suggests that the Wood classification be redefined in terms of the crop cultivation aspects. This paper has not taken into consideration the livestock raising aspects of farming; therefore,

no attempt is being made to alter this aspect of the definition originally given.

Redefined Categories:

The author puts forth the following definitions of technological levels:

Rudimentary I:

For this level, no use is being made of fertilizer, agricultural chemicals, or bought seed. The labour on these farms is largely by hand with the occasional use of rented oxen, especially for land preparation. Land preparation is usually limited to one ploughing with an absence of harrowing. Generally, in livestock raising, there would be no use made of veternarian services, no overfeeding for fattening purposes and it would be subsistence oriented.

Rudimentary II:

The difference between this level, and that represented by Rudimentary I, is that use is being made of fertilizer and/or agricultural chemicals. Again, labour is largely by hand but in this case the oxen used in land preparation may be owned. No differences are likely to exist in farming operations or in the handling of livestock.

In keeping with the Mojanda Report, farm size can be considered a valid indicator of these levels. The farms would generally be small, under 10 hectares, with no farm buildings and no visible storage areas.

Sub-Technified:

For a sub-technified farm operation, land preparation is almost always mechanized, but the machinery being used is rented. Animal traction and/or hand labour is involved in most other farm operations. At this level, use is made of any combination, or all of, the following, although it is not consistent: agricultural chemicals, fertilizer and bought seed. If the farm were located in an arid area, the farm crops would usually be irrigated.

Generally, these farms are also small, but would not be under 10 hectares as in the Rudimentary levels.

Technified:

The technified level of operation involves mechanization of all possible farm operations. Most of the machinery at this level is owned, but some specialized equipment may be rented, such as seeders and combines. Consistent use is made of appropriate agricultural chemicals, fertilizers and commercial seed. Other recommended farm operations are also employed such as crop rotation and repeated land preparation operations.

These farms can be recognized by the availability of storage areas for both machinery and animals, large area, and the number of farm buildings which would include accommodation for permanent farm labourers.

Highly Technified:

A highly technified level of technology would closely resemble a technified level, in that all possible operations would be mechanized. The basic difference between these two levels would be that in a highly technified operation all machinery is owned. More complete land preparation is made possible by the ownership of the machinery but most other methods would resemble the technified operation.

The Validity Of The Revised Technological Levels:

The following section of this chapter is an attempt to show the validity of the new definitions of the technological levels. If the foregoing redefinition is realistic, marked differences should appear between levels for both Disposable Income and Labour Index.

Charts 7A to 7I list the Disposable Income and Labour Index for individual crops, from all sources of data where these figures could be calculated. It can be noted here that examples of individual crop production were not available, in all cases, for all technological levels. What is important is that sufficient examples were collected to reveal a pattern which supports the redefinition of the categories.

The range within each technological level was examined for both Labour Index and Disposable Income:

Technological Level	Range as a percentage of average value for Labour Index	Range as a percentage of average value for Disposable Income
Rudimentary I	56%	100%
Rudimentary II	40%	64%
Sub-Technified	-	-
Technified	40%	53%
Highly Technified	37%	64%

These percentages show that within each category there is a fairly wide range of values; however, Disposable Incomes show the greatest variations.

If the examples had been classified according to H.A. Wood, then the Rudimentary II and Sub-Technified levels would have been combined. The resulting range as a percentage of the average value would then be

CHART 7A

LABOUR INDEX AND DISPOSABLE INCOME

FOR WHEAT

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report	27	22.
Rudimentary II	Mojanda Report Calles - IIB	33 40	140. 61.
Sub-Technified	Mojanda Report	7	76.
Technified	Cayambe Report Mojanda Report	10 6	91. 133.
Highly Technified	Cayambe Report Mojanda Report	10 7	111. 196.

CHART 7B

LABOUR INDEX AND DISPOSABLE INCOME

FOR BARLEY

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report	26	4.
Rudimentary II	Mojanda Report Calles - IIB	35 34	81. 36.
Sub-Technified	Mojanda Report	7	22.
Technified	Mojanda Report Cayambe Report	4 10	87. 48.
Highly Technified	Mojanda Report Cayambe Report	5 10	156. 70.

CHART 7C

LABOUR INDEX AND DISPOSABLE INCOME

FOR HABAS

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report Calles - IIB Calles - IIC	32 33 33	28. 64. 66.
Rudimentary II	Mojanda Report	36	104.
Technified	Mojanda Report Cayambe Report	28 21	95. 49.
Highly Technified	Mojanda Report Cayambe Report	28 21	104. 55.

CHART 7D

LABOUR INDEX AND DISPOSABLE INCOME

FOR FREJOL

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary II	Mojanda Report Cayambe Report Calles - IIB	41 30 53	197. 98. 93.
Technified	Mojanda Report	35	189.
Highly Technified	Mojanda Report Cayambe Report	35 30	197. 100.

CHART 7E

LABOUR INDEX AND DISPOSABLE INCOME

FOR LENTILS

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report	19	14.
	Calles IIB	53	143.
	Calles IIC	53	143.
Rudimentary II	Mojanda Report	26	40.
Technified	Mojanda Report	17	47.
Highly Technified	Mojanda Report	17	57.

CHART 7F

LABOUR INDEX AND DISPOSABLE INCOME

FOR POTATOES

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report	64	28.
Rudimentary II	Mojanda Report	129	271.
	Calles IIB	119	251.
	Calles IIC	113	246.
Sub-Technified	Mojanda Report	66	35.
Technified	Mojanda Report	142	437.
	Cayambe Report	138	270.
Highly Technified	Mojanda Report	187	790.
	Cayambe Report	138	287.

CHART 7G

LABOUR INDEX AND DISPOSABLE INCOME

FOR ARVEJA

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report	16	51.
Rudimentary II	Mojanda Report	20	128.
	Calles - IIB	49	68.
	Calles - IIC	53	76.
Technified	Mojanda Report	20	119.
	Cayambe Report	25	84.
Highly Technified	Mojanda Report	20	127.
	Cayambe Report	16	85.

CHART 7H

LABOUR INDEX AND DISPOSABLE INCOME

FOR ALFALFA INSTALLATION AND MAINTENANCE

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Mojanda Report	38 I	x
		54 M	104.
Technified	Mojanda Report	45 I	x
		68 M	341.
	Cayambe Report	34 I	x
		40 M	188.
Highly Technified	Mojanda Report	40 I	x
		68 M	348.
	Cayambe Report	25 I	6.
		31 M	193.

CHART 7I

LABOUR INDEX AND DISPOSABLE INCOME

FOR CORN

Technological Level	Source	Labour Index (In Man Days)	Disposable Income (In U.S. Dollars)
Rudimentary I	Calles IIB	49	51.
Rudimentary II	Cayambe Report	16	33.
Highly Technified	Cayambe Report	11	31.

98 per cent for the Labour Index and 110 per cent for the Disposable Income. It is obvious, therefore, that the greatest shortcoming of the Wood classification of technological levels is in this area and that a subdivision of his Rudimentary level represents an improvement.

Conclusion:

The foregoing analysis outlines two areas of improvement within the Wood Classification's definition of technological levels:

(1) Each level should be more clearly defined, as outlined previously in this chapter, in terms of the number and nature of farm operations, as well as, in terms of the ownership of the type of traction used.

(2) The Rudimentary level should be subdivided since marked differences occur in Labour Index and Disposable Income when agricultural chemicals are used in an animal traction, with hand labour, operation.

Throughout the chapter, significant differences have been shown to exist in the Disposable Income and Labour Index between different technological levels. These variations would justify the inclusion of technological level in the definition of a Land Use System.

CHAPTER III

CLIMATE

Purpose:

The purpose of this chapter is to examine the nature of the relationship between climate and Disposable Income and Labour Index. It was not possible to examine the seasonality of production because the available data dealt with individual crop production in a variety of climatic areas which were classified according to Holdridge.

Methodology:

This chapter is based on data collected by Cesar Hamburgo Calles who examined farm operations and productivity for selected crops in different climatic areas. Each crop in the original data is at the same general technological level which in most cases is Rudimentary I or II. Some crops are presented for a mechanized operation.

The Labour Index and Disposable Income were calculated for each crop for each climatic area. No information was available to define any more adequately where double and triple cropping begin and end; therefore, all calculations are for one crop a year.

The above index figures were used to examine three implicit assumptions of Wood concerning climate:

(1) Wood assumes that temperature is not an important factor in

differentiating Land Use Systems.

(2) Wood assumes that actual variations in total rainfall within any one of his four moisture categories can be ignored.

(3) Wood assumes a balance of labour input for any one crop, between wet and irrigated dry areas in the extra labour required for each.

For purposes of simplification, the Holdridge Climatic classification has been reduced to the following code which is used throughout Chapters III and IV:

Rainfall Categories:	A. 250 - 500 mm.
	B. 500 - 1000 mm.
	C. 1000 - 2000 mm.
	D. 2000 - 4000 mm.
	E. 4000 - 5000 mm.
Temperature Categories:	I. 6 - 12°C.
	II. 12 - 16°C.
	III. 16 - 24°C.
	IV. 24°C. or more

The different climatic regions are designated by the use of this code, as it is presented in Chart 8.

CHART 8

CODE FOR HOLDRIDGE CLIMATIC AREAS

Name of Zone	Temperature (°C)	Rainfall (mm.)	Code
Montane: Steppe	6 - 12	250-500	IA
Montane: Moist Forest	6 - 12	500-1000	IB
Montane: Wet Forest	6 - 12	1000-2000	IC
Lower Montane: Thorn Steppe	12 - 16	250-500	IIA
Lower Montane: Dry Forest	12 - 16	500-1000	IIB
Lower Montane: Moist Forest	12 - 16	1000-2000	IIC
Subtropical: Thorn Woodland	16 - 24	250-500	IIIA
Subtropical: Dry Forest	16 - 24	500-1000	IIIB
Subtropical: Moist Forest	16 - 24	1000-2000	IIIC
Subtropical: Wet Forest	16 - 24	2000-4000	IIID
Subtropical: Rain Forest	16 - 24	4000-8000	IIIE
Tropical: Thorn Woodland	24	250-500	IVA
Tropical: Very Dry Forest	24	500-1000	IVB
Tropical: Dry Forest	24	1000-2000	IVC
Tropical: Moist Forest	24	2000-4000	IVD

The Relationship Between Temperature And Disposable Income:

The Wood Classification ignores temperature as a factor influencing the Land Use System. Chart 9 shows the climatic areas and associated Labour Index and Disposable Income for individual crops. The climatic areas have been arranged according to the Disposable Incomes, from the highest to the lowest. For fifteen of the twenty-two crops available, it was possible to relate Disposable Income and temperature ranges.

Of these fifteen crops, overlap is indicated for seven, which rules out any relationship between Disposable Income and temperature for these cases.

For the remaining eight crops, the range between temperature categories was found and expressed as a percentage of the average figure. The following summarizes these findings:

Crop	Range as a percentage of average figure	Average Disposable Income for each temperature range
1. arveja	6	71.87 and 67.75
2. cabuya	82	537.00 and 225.00
3. lentils	12	143.25 and 126.75
4. peanuts	39	197.25 and 133.00
5. potatoes	33	268.25 and 191.65
6. soya	29	136.10 and 101.50
7. wheat	20	71.17 and 58.50
8. winter rice	41	170.28 and 111.80

Average range - 33 percent

In all of the analysis done for this paper, Disposable Incomes were found to vary a great deal for most crops. (This statement is further substantiated in Chapter IV.) While cabuya could be isolated

CHART 9

DISPOSABLE INCOME AND LABOUR INDEX

BY CLIMATIC AREA

Crop	Climatic Area	Labour Index (In Man Days)	Disposable Income (U.S.Dollars)
1. Arveja	IIC	53	75.50
	IIB	49	68.25
	IB	49	67.75
2. Barley	IB	34	44.75
	IIC	38	44.00
	IIB	34	35.50
	IA	28	34.20
	IIA	30	26.75
	IC	39	24.75
3. Cabuya	IVB	144	575.00
	IVA	110	500.00
	IIIA	90	330.00
	IIA	60	225.00
4. Corn	IIC	64	77.40
	IIIB	55	68.00
	IVB	40	68.00
	IIID	36	58.25
	IIIC	49	51.00
	IIIC	32	50.00
	IA	50	50.00
	IIA	55	49.30
5. Corn & Beans (Fréjol)	IIID	53	88.00
	IIB	63	61.85
6. Cotton	IVC	72	260.50
	IVD	72	260.00
	IIIA	81	238.00
	IVA	82	219.50
	IVB	64	212.00
7. Fréjol Beans	IIIC	52	122.00
	IIA	50	121.75
	IIC	50	121.75
	IIIB	55	119.50
	IVB	54	119.00
	IIB	53	93.35
	IB	52	91.35
	IIID	43	88.75

CHART 9 - Continued

DISPOSABLE INCOME AND LABOUR INDEX

BY CLIMATIC AREA

Crop	Climatic Area	Labour Index (In Man Days)	Disposable Income (U.S. Dollars)
8. Garden Vegetables	IVC	156	375.00
	IIA	150	338.25
	IIC	144	338.25
	IIB	150	338.25
	IB	150	336.50
	IIIA	187	328.00
9. Haba Beans	IB	33	66.50
	IIC	33	66.25
	IIB	33	63.50
	IC	50	59.50
	IIA	37	54.50
	IA	42	43.00
10. Lentils	IIB	53	143.25
	IIC	53	143.25
	IB	52	126.75
11. Melons	IVB	87	462.40
	IVC	83	460.00
12. Peanuts	IVA	87	211.00
	IVB	82	183.50
	IIIB	80	145.50
	IIIA	81	132.00
	IIIC	77	121.50
13. Potatoes	IIC	121	306.00
	IIA	102	270.50
	IIB	119	251.00
	IIC	113	245.50
	IB	105	234.75
	IA	102	182.05
	IA	87	180.50
	IC	68	169.35
14. Rye	IA	48	43.50
	IIA	27	39.00

CHART 9 - Continued

DISPOSABLE INCOME AND LABOUR INDEX

BY CLIMATIC AREA

Crop	Climatic Area	Labour Index (In Man Days)	Disposable Income (U.S. Dollars)
15. Sesame	IVC	77	180.40
	IVB	52	169.25
	IVA	76	165.40
16. Soya	IVC	58	147.50
	IVB	42	147.50
	IVA	70	113.30
	IIIA	55	101.50
17. Tobacco	IVA	126	186.00
	IIIA	108	158.50
18. Tobacco (Criollo)	IVB	100	229.00
	IVC	101	229.00
19. Watermelon	IVB	91	457.60
	IVC	82	411.50
20. Wheat	IB	36	72.25
	IA	33	71.00
	IC	34	70.25
	IIA	28	61.25
	IIB	40	61.25
	IIC	37	53.00
21. Winter Rice	IVD	68	172.30
	IVB	68	168.25
	IVC	65	111.80
22. Yuca	IIIE	99	148.50
	IIIC	80	123.00
	IVD	60	113.50
	IIIB	65	112.50
	IVB	62	111.00
	IIID	84	107.50
	IIIA	84	100.00

as the exception, the author does not feel that these ranges are sufficiently large to state that there is a relationship between Disposable Income and temperature range. In other words, temperature as a factor in determining the economic output of a Land Use System can be ignored in the classification.

The Relationship Between Total Rainfall, Labour Index And Disposable Income:

Wood assumes that variations in total rainfall within any one of his moisture categories can be ignored, and that it is only necessary to examine the number and distribution of the wet and dry months. The Holdridge and Wood moisture divisions are not compatible, but for Tropical[1] areas (Temperature ranges III and IV) the following outlines the general relationship between the two:

Holdridge Rainfall Range	Wood Crop Production Area
A. 250 - 500 mm.	no crop
B. 500 - 1,000 mm. C. 1,000 - 2,000 mm.[2]	single crop area
D. 2,000 - 4,000 mm. E. 4,000 - 8,000 mm.	double crop area

[1]Temperate areas (Temperature ranges I and II) are not examined because what constitutes a wet or dry month in these areas is very uncertain.

[2]In Tropical Ecuador, areas of less than 2,000 mm. of rainfall have fewer than 6 months of wet weather and, therefore, belong to Wood's single crop group.

Since the climatic aspect of the paper deals with single crop production, the data is now examined for differences in Labour Index and Disposable Income for areas of 500 to 1,000 mm., and 1,000 to 2,000 mm. of rainfall.

Of the twenty-two crops listed on Chart 9, ten include information for either IIIB and IIIC areas, or IVB and IVC areas. The Labour Index and Disposable Income figures were compared within the temperature range to determine if figures for either rainfall range B or rainfall range C were consistently higher. For rainfall range B, the Disposable Income was higher in four of the ten cases than in rainfall range C; Labour Index was higher in five of the ten cases. For rainfall range C, the Disposable Income was higher in four of the ten cases than rainfall range B; Labour Index was higher in five of the ten cases.

In summary, the variation in rainfall total within the single-crop moisture category of the Wood Classification does not significantly affect either the Labour Index or the Disposable Income. The implicit assumption of the classification that this aspect of climate can be ignored is valid.

The Relationship Between Climate And Labour Index:

Differences between climatic areas do result in different labour demands for several crops. These variations in labour requirements are usually the result of either irrigation, weeding or an increase in harvest. Wood assumes that the additional labour required for irrigation in dry areas can be ignored due to economies in other tasks which would be required in a wet area.

CHART 10

LABOUR REQUIREMENTS AND CLIMATIC AREA

Crop	Area	Weeding	Harvesting	Total Labour Input	Range as a percentage of the average	
					Weeding	Harvesting
Corn	IIIB	20 (clean & hill)	18 (harvest & remove kernels)	55	67%	
	IIIC	10	15 (harvest & remove kernels)	32		18%
Cotton	IVB	20	15	64	0%	
	IVC	20	30	72		67%
Fréjol Beans	IIIB	20	16	55	0%	
	IIIC	20	16	54		0%
Melons	IVB	36	10	87	18%	
	IVC	30	10	83		0%
Peanuts	IIIB	20	27 (pull & strip)	80	0%	
	IIIC	20	24	77		12%
Sesame	IVB	21	15 (cut & tie)	52	49%	
	IVC	20	12 (cut & tie)	77		22%
Soya	IVB	-	20(harvest & thresh)	42	-	
	IVC	20	20(harvest & thresh)	58		0%
Tobacco	IVB	20	15 (remove leaves & harvest)	100	22%	
	IVC	25	15 (remove leaves & harvest)	101		0%

CHART 10 - continued

LABOUR REQUIREMENTS AND CLIMATIC AREA

Crop	Area	Weeding	Harvesting	Total Labour Input	Range as a percentage of the average	
					Weeding	Harvesting
Water-melon	IVB	36	10	91	18%	
	IVC	30	10	82		0%
Yuca	IIIB	18	15	65	11%	
	IIIC	20	20	80		29%
				Average Range	21%	15%

The foregoing section of this chapter included an examination of the difference in total labour input, in Tropical areas, for rainfall range B and C. The fact that no difference was found would substantiate the assumption of Wood that a balance of labour input occurs between wet and dry areas.

The labour requirements for weeding and harvesting were examined for rainfall ranges B and C on Chart 10. The final column gives the range expressed as a percentage of the average figure first for the weeding labour and then for the harvesting labour of that crop. The average of the ranges for weeding is 21 per cent and for harvesting is 15 per cent. These figures are considered to be too small to be significant, therefore, the influence of total rainfall within Wood's single-crop moisture category can be ignored as a factor influencing the nature of labour requirements.

A limited number of crops were found to have data concerning irrigation. The following is a summary of this information:

Crop	Climatic Area	Labour Index	M.D. for Irrigation
Garden Vegetables	IB	150	8
	IIB	150	15
	IVB	150	20
	IIA	150	15
	IIIA	171	20
Cotton	IIIA	80	10
	IVA	82	18
	IVB	74	8
Potatoes	IIC	113	-
	IIC Irrig.	121	8

Summary - Continued

Crop	Climatic Area	Labour Index	M.D. for Irrigation
Peanuts	IIIC	77	16
	IVA	87	15
Sesame	IVA	76	15
	IVB	52	-

All garden vegetables in Calles' data are irrigated; however, it can be observed the higher the temperature range within the same rainfall range, the more labour that is required for irrigation because it is that much more dry.

For cotton, the same pattern holds true because the hotter and drier the area, the greater the labour for irrigation.

Potatoes is the only crop where irrigated and unirrigated operations are given for the same climatic area. Here, irrigation accounts for an additional 8 M.D. per hectare.

The figures for sesame show the difference in labour within one temperature range with the irrigation.

In general, irrigation can account for 8 to 20 additional man-days per hectare with the hottest and driest areas requiring the most for any one crop.

The author does not feel that sufficient data was available concerning irrigation to merit the recommendation that a symbol be added to the Land Use System. It would appear that irrigation can result in additional labour which is not compensated for by reduced labour in weeding. The author suggests a further examination of

irrigated areas should take place and if a general increase in labour is always required, the classification should be modified to include an indication of an irrigated operation.

Summary:

The assumption that temperature is not an important factor in differentiating Land Use Systems is valid. For eight of the fifteen crops where temperature showed some relationship to Disposable Income, the average range as a percentage of the average figure was 33 per cent. This range was not considered large enough to further complicate the classification with a component for temperature.

The actual variations in total rainfall within a single-crop moisture category can also be ignored, since no pattern emerged for either Disposable Income or Labour Index indicating consistent differences with higher rainfall totals.

The nature of farm operations (especially weeding and harvesting) does not show a significant change with higher rainfall totals within a single-crop moisture category . The author suspects that the assumed additional labour in humid areas does not balance with additional labour required for irrigation in dry areas. Further investigation into irrigation is required to merit any change to the classification in this area.

Generally, the author believes that variations in climate within a single-crop moisture category do not affect the resulting Land Use System.

CHAPTER IV

CROP GROUPS

Purpose:

The purpose of this chapter is to determine a valid grouping of different crop types in terms of Disposable Income and Labour Index.

Methodology:

The first part of this chapter is an examination of the existing crop subdivision found in the Wood Classification. This section is followed by an examination of the response of individual crops within each group. Contained within each of the four studies will be any suggestions for change to the Wood Classification.

All data used in this chapter is from Cesar Hamburgs Calles' individual crop data from which Disposable Income, Labour Index and Productivity Ratios were calculated.

The Wood Subdivision of Crop Types:

In the Wood Classification, Land Use Type is divided into four parts which are as follows:

Set A: crop groups found in areas of mixed or general farming.

Set B: specific livestock emphasis for Land Use Systems specializing in livestock or a general farming system.

Set C: involves the specific crop grown in a specialized or semi-specialized system.

Set D: designates the use made of areas of natural vegetation. It is only with Set A that this chapter is concerned since livestock and forest exploitation are not part of this study. Specific crop designation, as indicated in Set C, is straightforward and requires no analysis.

In the general or mixed farming systems, Wood has made the following grouping:

(1) General Tropical Crops: emphasis on grains and other annuals.

(2) General Tropical Crops: emphasis on roots and tree fruits.

(3) Horticultural crop emphasis.

(4) Temperate crop emphasis.

If each of these four indicate a distinct Land Use System, the Labour Index, Disposable Income and Productivity Ratios will not show significant variations for each of the crops within the group.

The General Tropical Crop Group:

According to the Wood Classification, General Tropical crops are divided into two groups:

1. Grains and other annuals
2. Tree fruits and roots

Initially, the Labour Index and Disposable Income were examined separately on graphs for those examples found in climatic areas with a temperature range of III, and those climatic areas with a temperature range of IV.

In Figures 9A and 9B[1] the labour requirements for annuals and grains are shown separately for climates of temperature range III and IV respectively. The resulting pattern shows very little difference between the groups.

In Figures 10A and 10B the labour requirements for tree fruits and root crops are shown separately for climates of temperature ranges III and IV respectively. A greater measure of separation between the groups appears in temperature range III, than in range IV.

Figures 11A and 11B use a similar method of presentation for Disposable Income for grains and annuals. In both cases, annuals show much higher Disposable Incomes than do grains.

In Figure 12A, root crops show higher Disposable Incomes than do tree fruits, while in Figure 12B the Disposable Incomes are fairly similar. Figure 12C shows the Disposable Income plotted against the Labour Index for all Tropical crops. The grouping of these crops is not as distinct as that found for Temperate crops, however, further separation of the Wood divisions does represent an improvement.

The average of the ranges expressed as a percentage of the average figure was calculated for each group:

Group	Labour Index	Disposable Income
Tropical Grains	27%	1%
Annuals (Legumes & Corn)	35%	61%
Tree Fruits	15%	54%
Root Crops	14%	26%

The above summary indicates that the variations that can occur are far greater for Disposable Income than for Labour Index.

[1]Figures 9A to 12C are based on Chart 11.

Figure 9A and 9B

Labour Index for Tropical Crops

(A) Temperature Range III

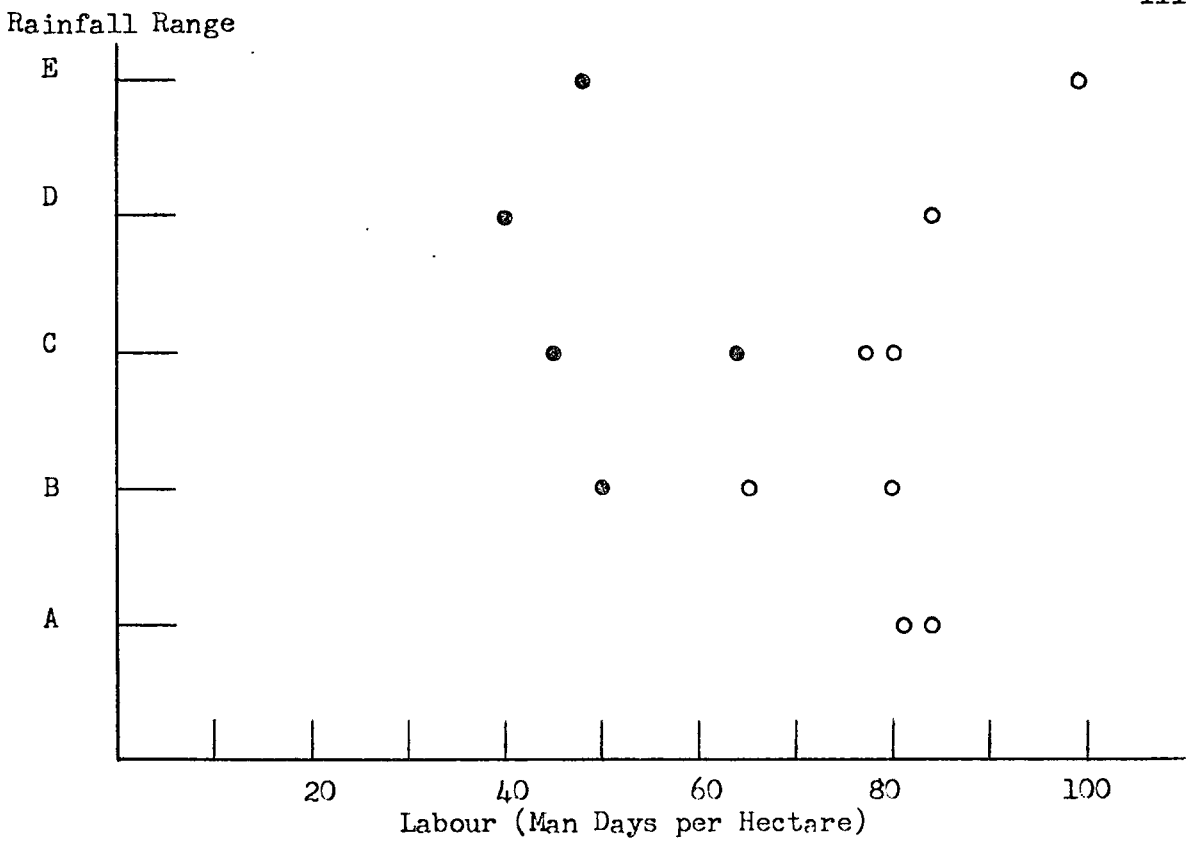
(B) Temperature Range IV

● legumes and corn
○ grains

Figure 10A and 10B

Labour Index for Tropical Crops

(A) Temperature Range III



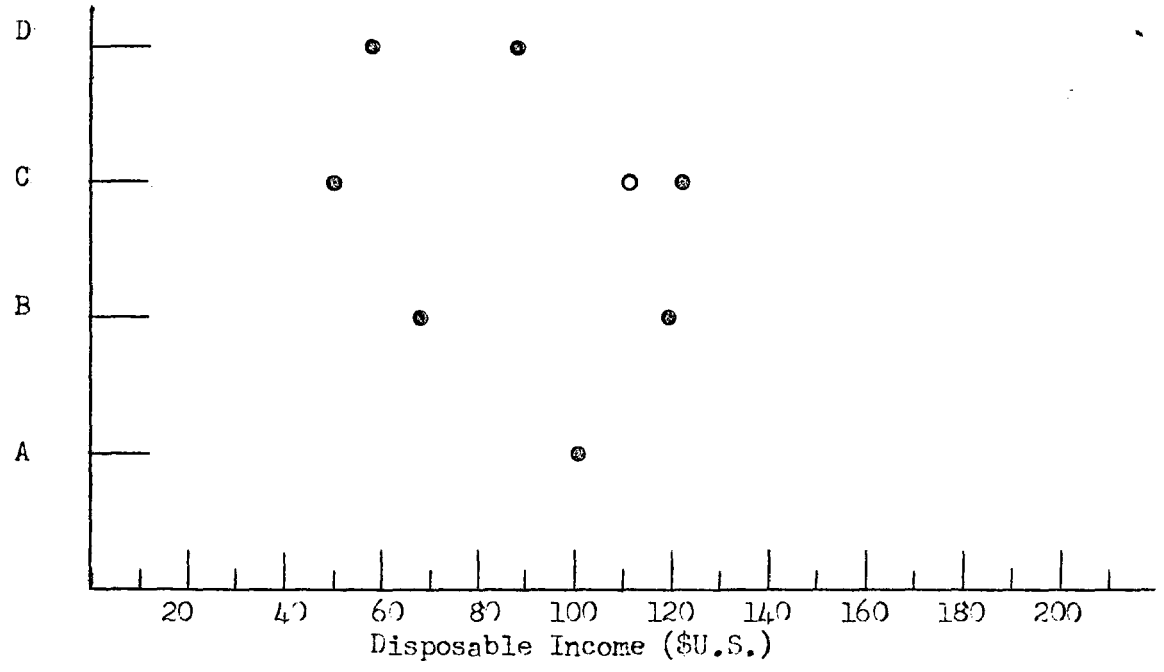
(B) Temperature Range IV

Figure 11A and 11B

Disposable Income for Tropical Crops

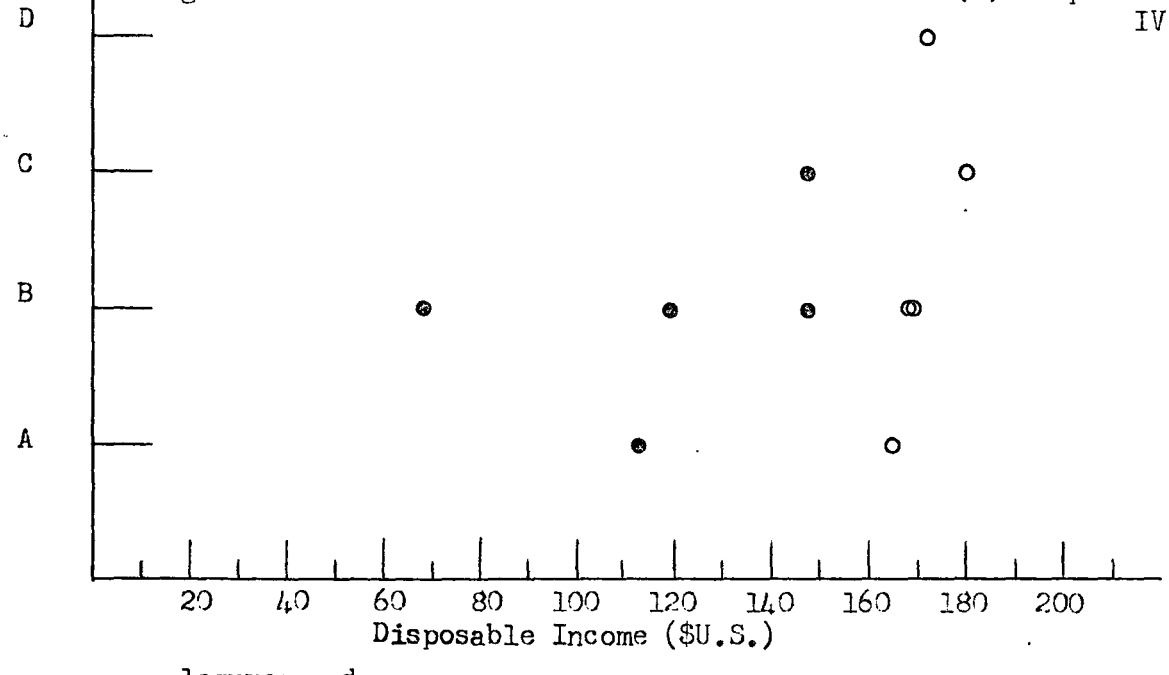
(A) Temperature Range III

Rainfall Range



Rainfall Range

(B) Temperature Range IV

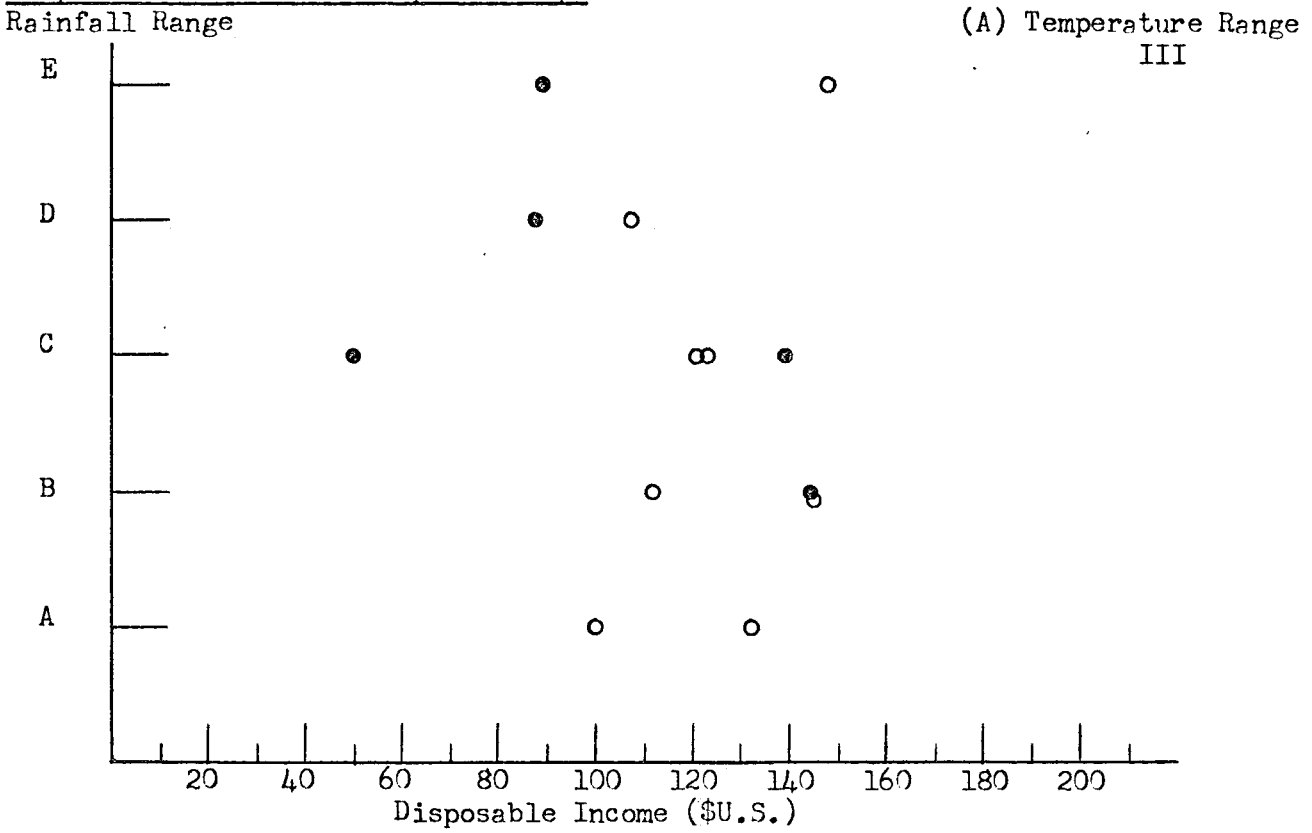


● legumes and corn

○ grains

Figure 12A and 12B

Disposable Income for Tropical Crops



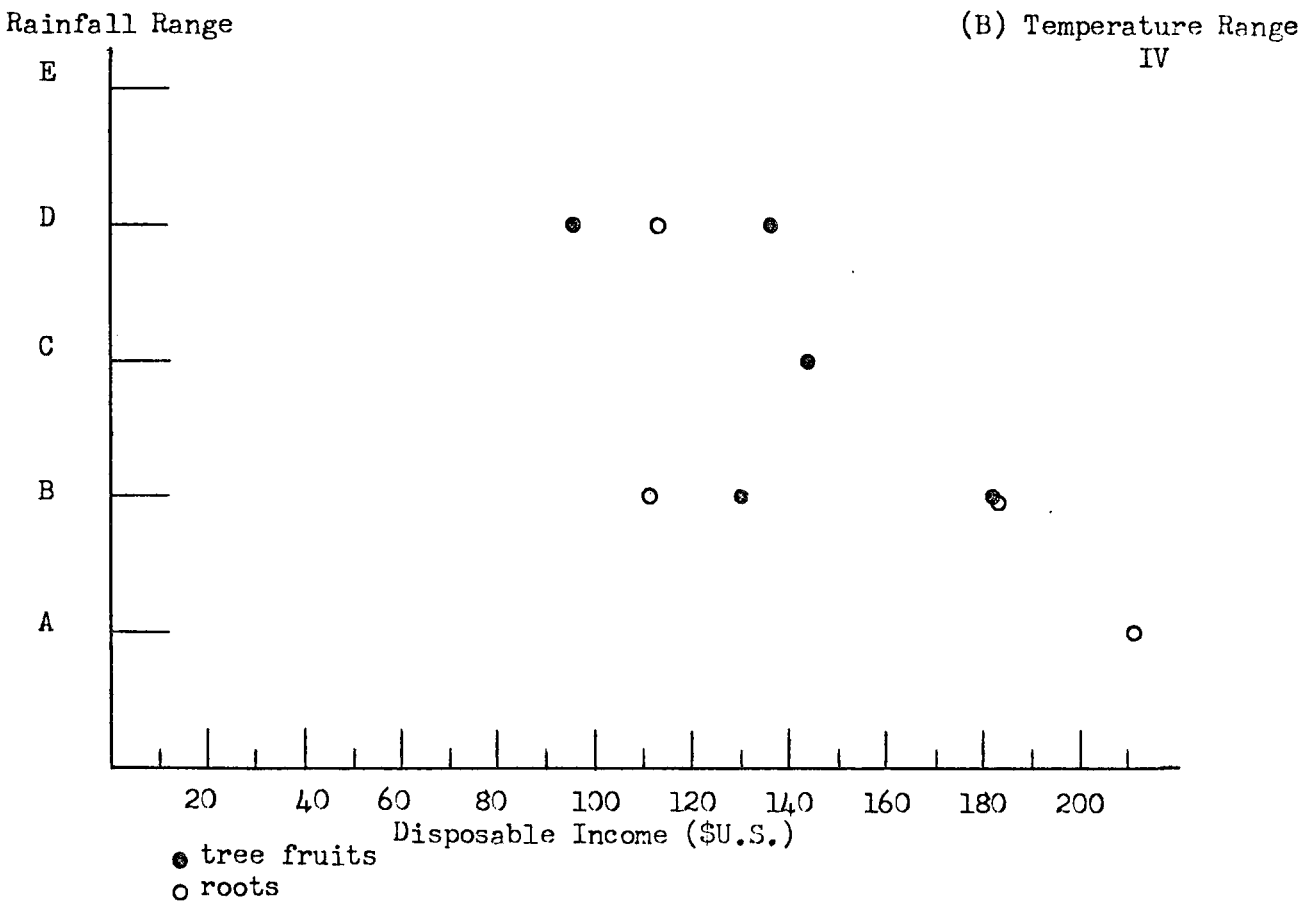
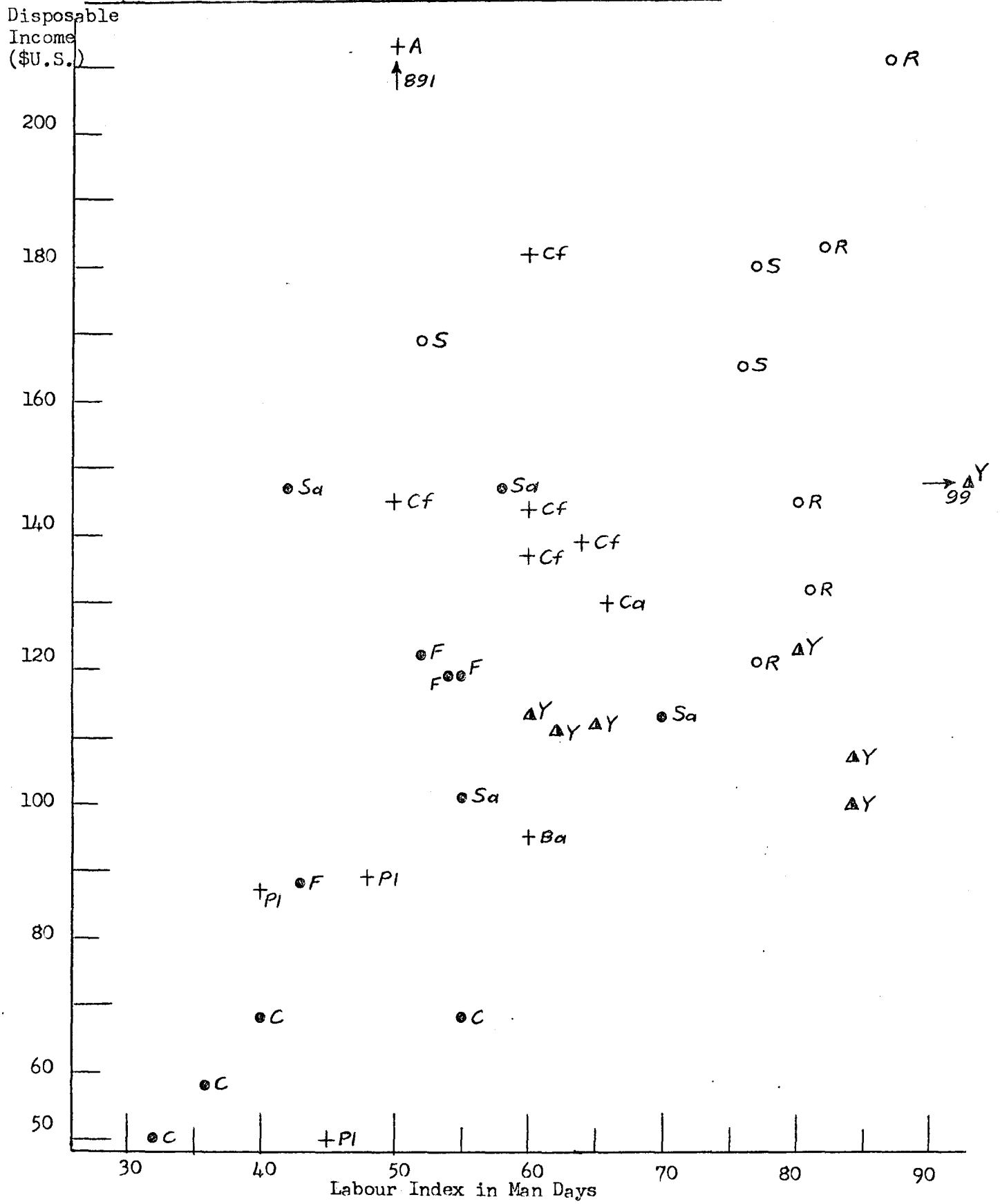


Figure 12C
Disposable Income and Labour Index for all Tropical Crops



● legumes and corn (C:corn, F: frejol, Sa: Soya)
o grains (S: sesame, R: winter rice)
+ tree fruits (Ca: cacao, A: avocadoes, Ba: Bananas, Pl: Plantain, Cf: coffee)
▲ root crops (Y: yuca)

CHART 11

LABOUR INDEX AND DISPOSABLE INCOME

FIGURES FOR TROPICAL CROPS

Crop	Climatic Area	Labour Index	Disposable Income
Corn	IIID	36	58
	IIIB	55	68
	IIIC	32	50
	IVB	40	68
Fréjol (Legume)	IIID	43	88
	IIIB	55	119
	IIIC	52	122
	IVB	54	119
Sesame (Grain)	IVA	76	165
	IVB	52	169
	IVC	77	180
Soya (Legume)	IIIA	55	101
	IVA	70	113
	IVB	42	147
	IVC	58	147
Winter Rice (Grain)	IIIC	77	121
	IIIB	80	145
	IIIA	81	132
	IVA	87	211
	IVB	82	183
Yuca (Root)	IIIC	80	123
	IIIB	65	112
	IIID	84	107
	IIIE	99	148
	IVD	60	113
	IIIA	84	100
	IVB	62	111
Cacao (Tree Fruit) 6th year	IVB	66	130
Avacadoes 6th year	IIC	49	891

CHART 11 - Continued

LABOUR INDEX AND DISPOSABLE INCOME

FIGURES FOR TROPICAL CROPS

Crop	Climatic Area	Labour Index	Disposable Income
Bananas 2nd year	IVD	60	95
Plantain			
3rd year	IIIE	48	89
2nd year	IIIC	45	50
2nd year	IIID	40	87
Coffee	IVC	60	144
6th year	IIIB	50	145
	IIIC	64	139
	IVD	60	137
	IVB	60	182

However, these ranges do represent considerably lower figures than those found using the Wood Classification's grouping.

Group	Labour Index	Disposable Income
Tropical Grains & Other Annuals	72%	108%
Tree Fruits and Roots	60%	114%

The author recommends that the Wood's grouping of Tropical Crops be subdivided, as shown below, because it gives a more accurate representation of the Land Use System involved:

Tropical Crops: grains
legumes and corn
tree fruits
roots.

In addition to the subdivision, the term "annuals" has been replaced by "legumes and corn" because it more clearly defines the crops concerned.

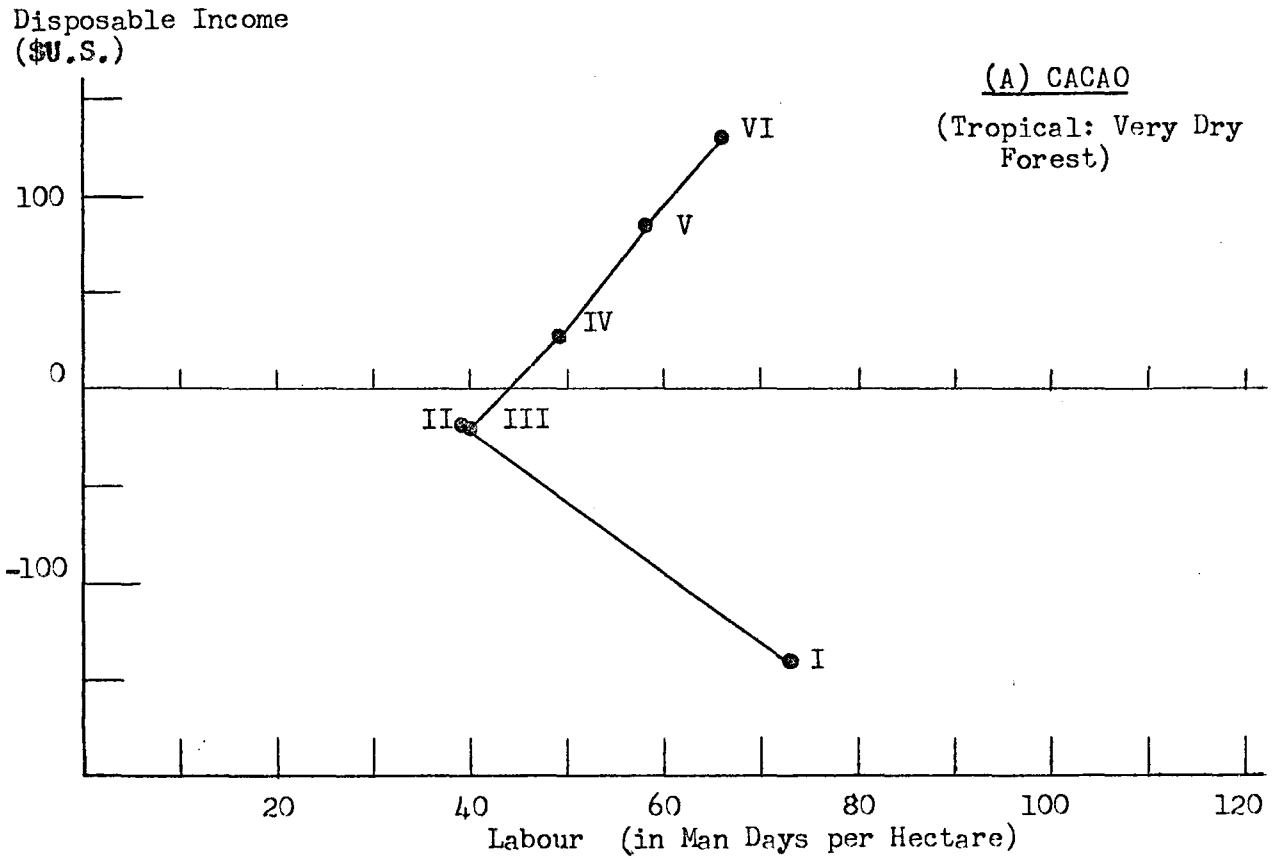
In doing research into tree fruits, the author found one other aspect of this grouping where the classification could be improved. It was felt that perennial crops should be handled more carefully.

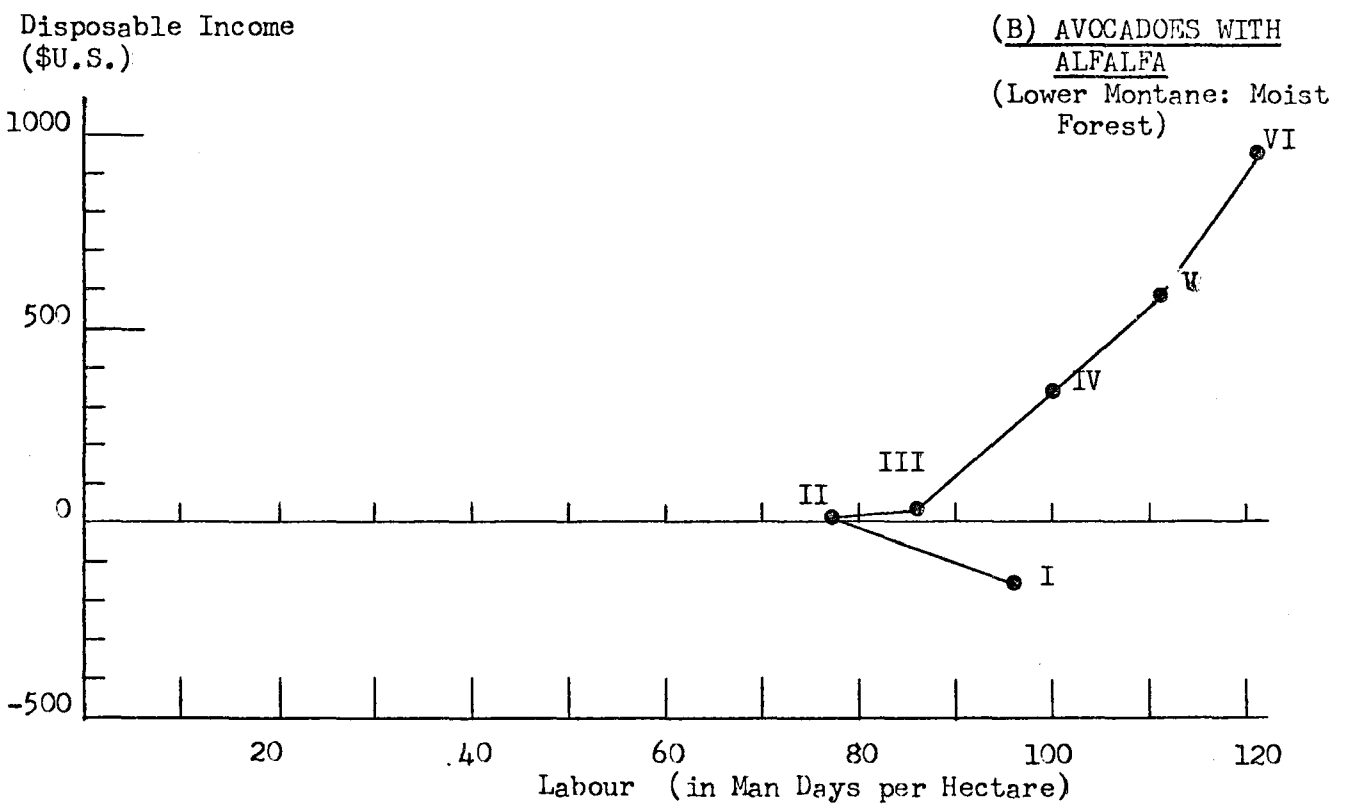
Perennial Crops:

A problem does arise in the classification of tree fruits and other perennial tropical crops. These crops are not immediately productive and must be re-established at regular intervals. Figures 13A to 13F show the change in Disposable Income and Labour Index for a few crops, in specific climatic areas, over a period of years.

Figure 13A and 13B

Perennial Crop Production



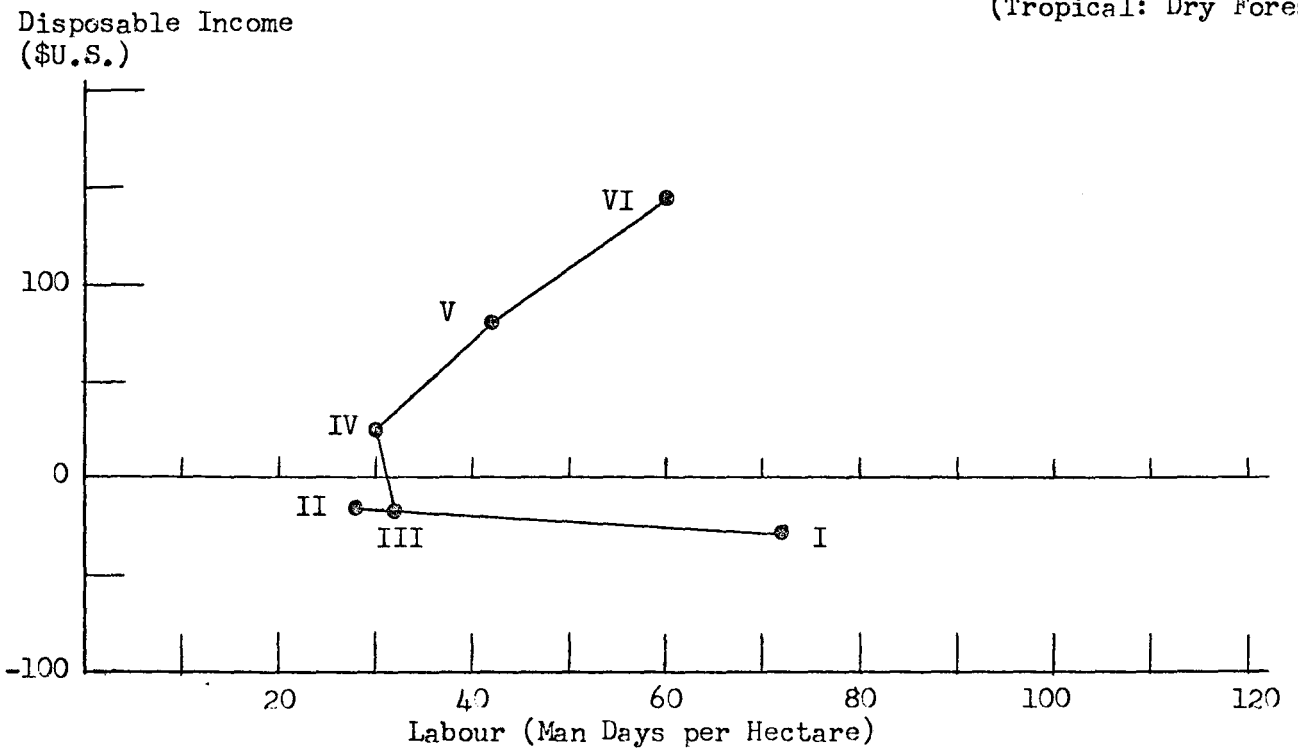


I - VI represent first to sixth year of production.

Figure 13C and 13D

Perennial Crop Production

(C) COFFEE
(Tropical: Dry Forest)



(D) SUGAR CANE
(Subtropical: Wet Forest)

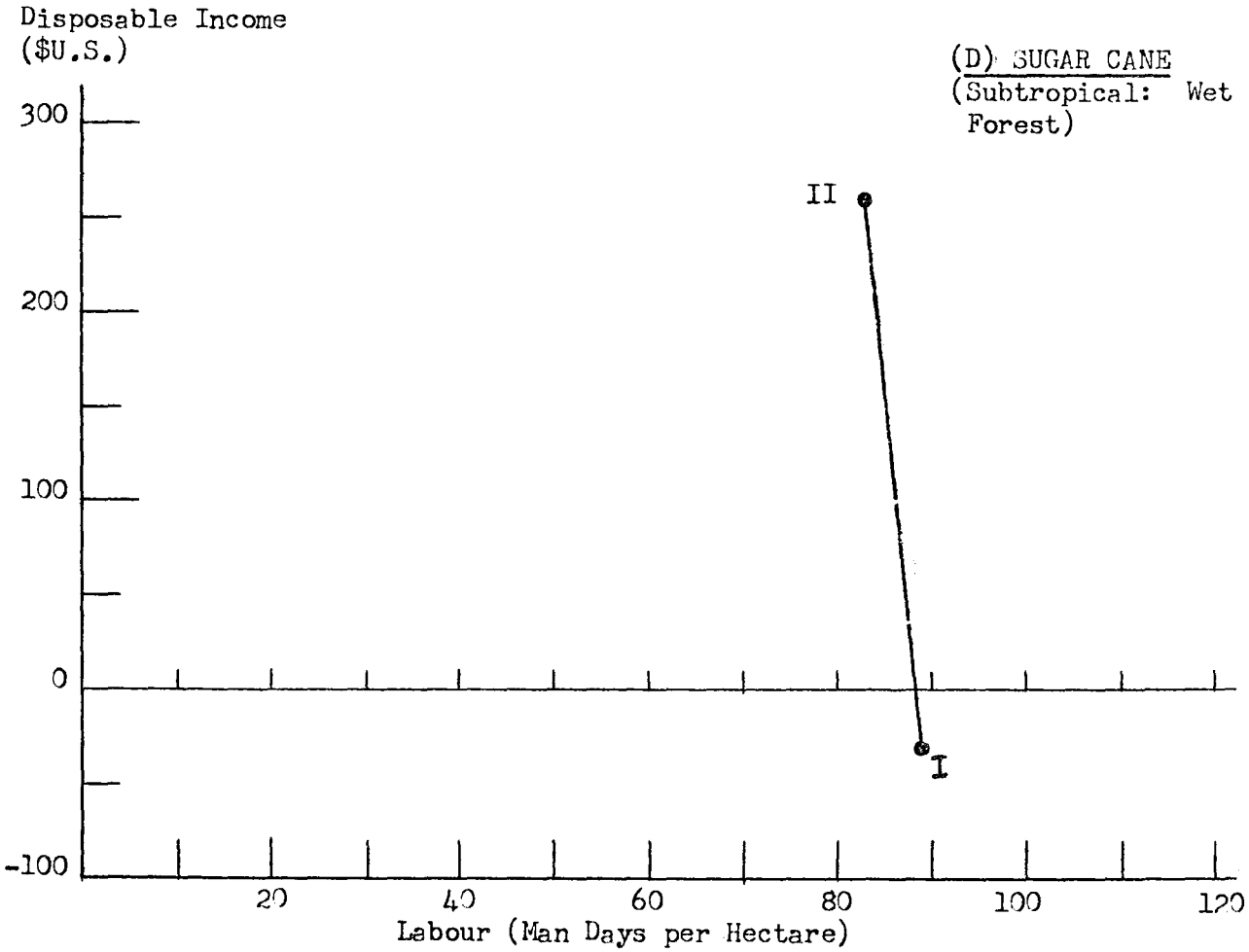
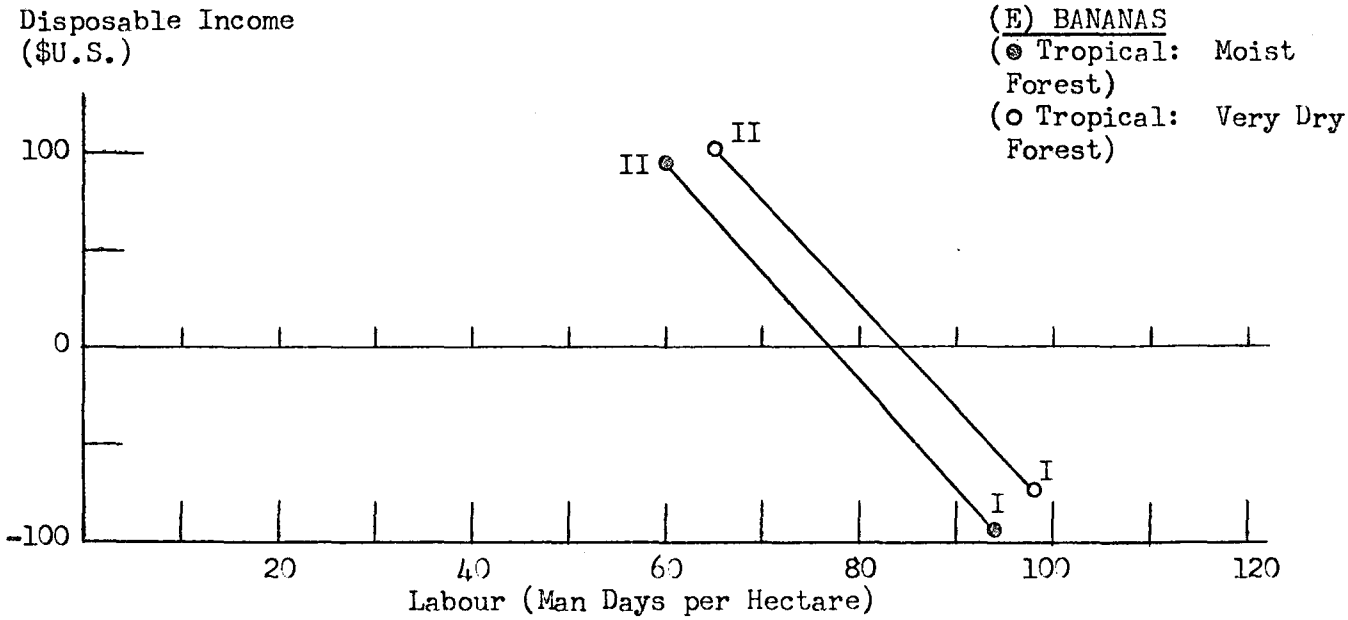
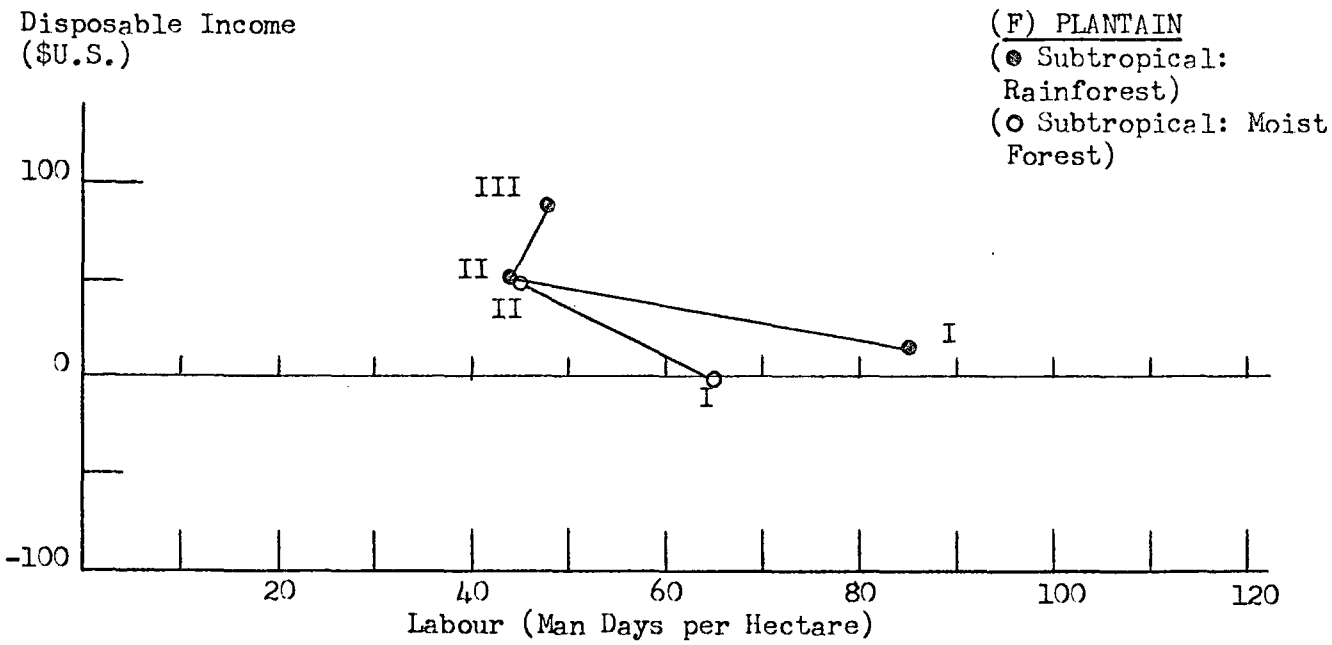


Figure 13E and 13F

Perennial Crop Production





It can be observed that large differences exist from year to year which would directly affect the productivity of a Land Use System involved. While each farm is likely to include areas devoted to installation of perennial crops, as well as areas actively producing, no allowance has been made in the Wood classification to show areas which are significantly out of line with the normal re-establishment pattern. The author suggests that a number be added to the Land Use Phase to indicate an other than standard ratio between immature, producing, and old areas of perennial crops. No data is available for individual crops on the standard ratios which exist, but if it were considered normal (or was unknown) the classification could stand as it is.

Those crops which would be involved for which available data concerning the cost of production and the labour input for each year up to production are as follows:

1. onions
2. alfalfa
3. pyrethrum
4. naranjilla
5. coffee
6. avocadoes
7. cacao
8. chirimoya
9. citrus fruit
10. bananas
11. plantain
12. sugar cane
13. oil palm
14. babaco

The Horticulture Group:

Wood considers horticulture a Land Use Type, not a form of specialization, which is distinct on the basis of a labour input of 150 man days per hectare per year.

An examination was made of all data for garden vegetables to determine if the Labour Index, Disposable Income and Productivity Ratios were similar not only for individual garden crops, but also for a variety of climatic areas.

Chart 12 gives the index figures for all crops available.

For all of the above cases, no machinery is being used but animal traction is employed in land preparation.

In 7 of the 8 cases listed as "Vegetable Crops" the Labour Index is 150 M.D./H./YR. or greater. For the individual crops listed, each one when multiplied by two, for two-crops a year, brings the Labour Index to 150 M.D./H./YR. or greater. The wide variation in Disposable Income, however, leads the author to suggest that for this Land Use System the Wood Classification be changed to read a minimum of $300.00 per hectare per year.

Because the labour response, no matter what the climate characteristics, is similar in all cases, horticulture as a distinct Land Use Type should remain unaltered.

The Temperate Crop Group:

An examination of the Disposable Income and Labour Index figures for temperate crops on Chart 13 suggested that not all crops respond similarly. The variations lead to the following tentative grouping:

(1) temperate grains (wheat, barley, rye and oats)

(2) legumes and corn (haba and fréjol beans, lentils and arveja)

CHART 12

INDEX FIGURES FOR INDIVIDUAL HORTICULTURAL CROPS

Crop*	Labour Index	Disposable Income ($U.S.)	Productivity Ratio ($U.S.)
1. Tomatoes	148	482.50	3.27
2. Watermelon	91	457.60	5.03
3. Watermelon	82	411.50	5.02
4. Garden Vegetable	187	328.00	1.76
5. Garden Vegetable	150	338.25	2.25
6. Garden Vegetable	144	338.25	2.35
7. Garden Vegetable	150	338.25	2.25
8. Garden Vegetable	150	336.50	2.24
9. Garden Vegetable	150	339.10	2.26
10. Garden Vegetable	156	375.00	2.40
11. Red Onions	95	438.75	4.62
12. Melons	87	462.40	5.31
13. Melons	83	460.00	5.54
14. Garlic	71	281.00	3.96
15. Sweet Potato	75	93.00	1.24
16. Garden Vegetable	214	448.00	2.09

*All figures are calculated from Calles except No. 16, which is taken from the Cayambe Report.

CHART 13

LABOUR INDEX AND DISPOSABLE INCOME FIGURES FOR TEMPERATE CROPS

Crop	Climatic Code	Labour Index	Disposable Income
Wheat (grain)	IA	33	$71.00
	IB	36	72.25
	IC	34	70.25
	IIA	28	61.25
	IIB	40	61.25
	IIC	37	53.00
Rye (grain)	IA	48	43.50
	IIA	27	39.00
Barley (grain)	IA	28	34.20
	IB	34	44.75
	IC	39	24.75
	IIA	30	26.75
	IIB	34	35.50
	IIC	38	44.00
Haba Beans (legume)	IA	42	43.00
	IB	33	66.50
	IC	33	66.25
	IIA	37	54.50
	IIB	33	63.50
	IIC	50	59.50
Fréjol Beans (legume)	IB	52	91.35
	IIA	50	121.75
	IIB	53	93.35
	IIC	50	121.75
Lentils (legume)	IB	52	126.75
	IIB	53	143.25
	IIC	53	143.25
Arveja (legume)	IB	49	67.75
	IIB	49	68.25
	IIC	53	75.50

CHART 13 - Continued

LABOUR INDEX AND DISPOSABLE

INCOME FIGURES FOR TEMPERATE CROPS

Crop	Climatic Code	Labour Index	Disposable Income
Corn	IA	50	50.05
	IIA	55	49.30
	IIB	49	51.00
	IIC	64	77.40
Potatoes (root)	IA	102	182.05
	IA	86	180.50
	IB	105	234.75
	IC	68	169.35
	IIA	102	270.50
	IIB	119	251.00
	IIC	113	245.50
Red Onions (vegetable)	IIA	95	438.75
Garlic (vegetable)	IC	71	281.00
Pyrethrum (specialty)	IIB	62-282	
Alfalfa (specialty)	IIA	130	271.00

(3) root and vegetable crops

(4) specialty crops (pyrethrum and alfalfa)

Figures 14A and 14B illustrate the differences in labour requirements for temperate crops according to the above grouping. It can be observed that all grain crops, with one exception, show the lowest labour requirements. Thirteen of the fourteen examples fall between 26 and 40 man days per hectare per year.

Legumes and corn, with the exception of haba beans in four of the six climatic areas, all fall withon 40 to 64 man days per hectare per year. This represents sixteen of twenty examples.

All root and vegetable crops exceed 60 man days per hectare per year. Specialty crops do not exhibit a definite labour range.

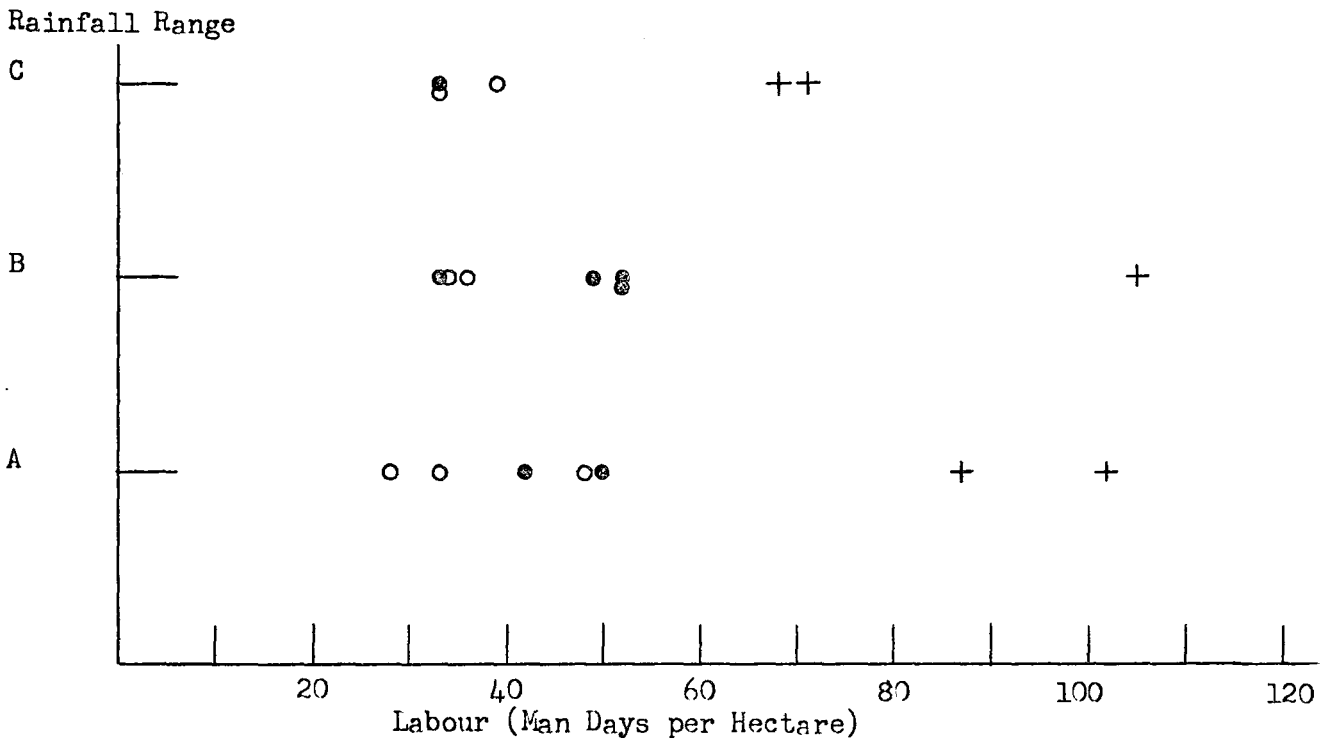
This separation of the crop groups is further substantiated by the results of the Disposable Income patterns of Figures 15A and 15B. Root and vegetable crops have Disposable Incomes well in excess of $100.00 per hectare per year. Legumes and corn range between $40.00 and $77.00 in sixteen of twenty examples. With one exception, all grains have a Disposable Income of under $40.00 per hectare per year. Figure 15C shows the Disposable Income plotted against the Labour Index for all Temperate crops. The differences in the response of each group are clearly evident.

The average of the ranges expressed as a percentage of the average figure was calculated for each group:

Figure 14A and 14B

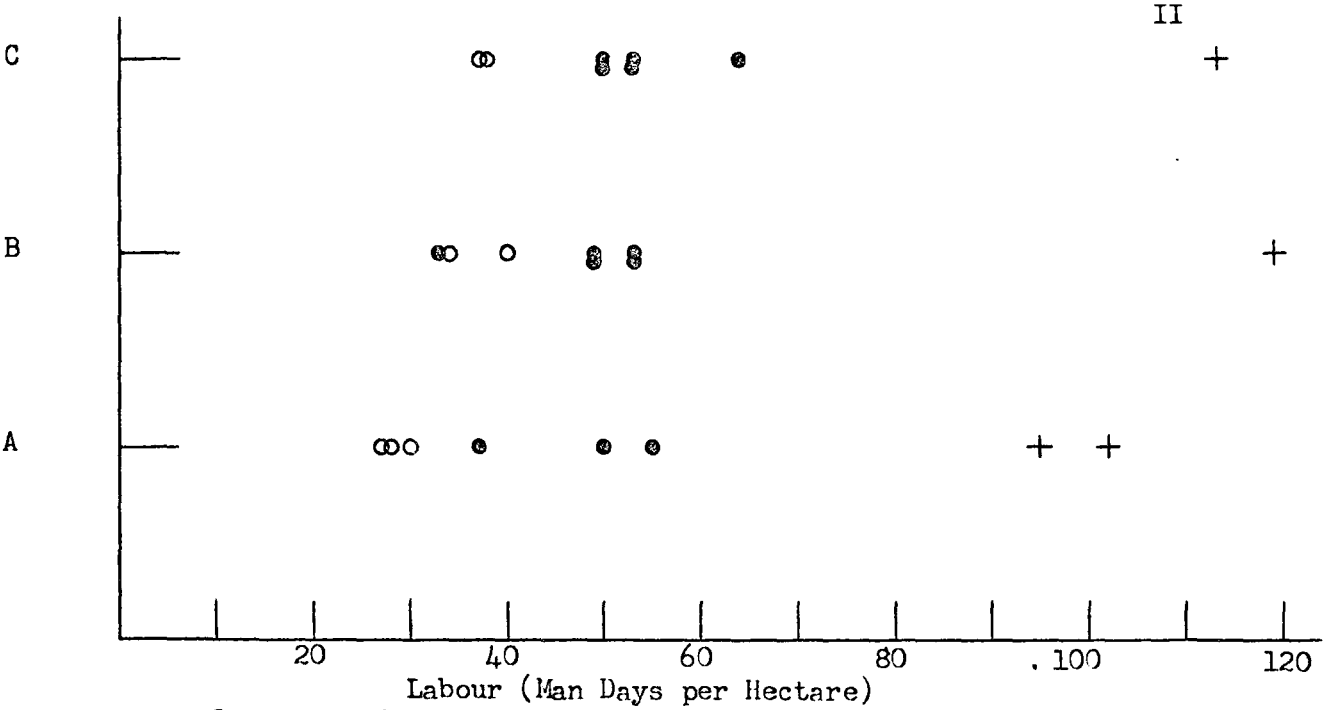
Labour Index for Temperate Crops

(A) Temperature Range I



Rainfall Range

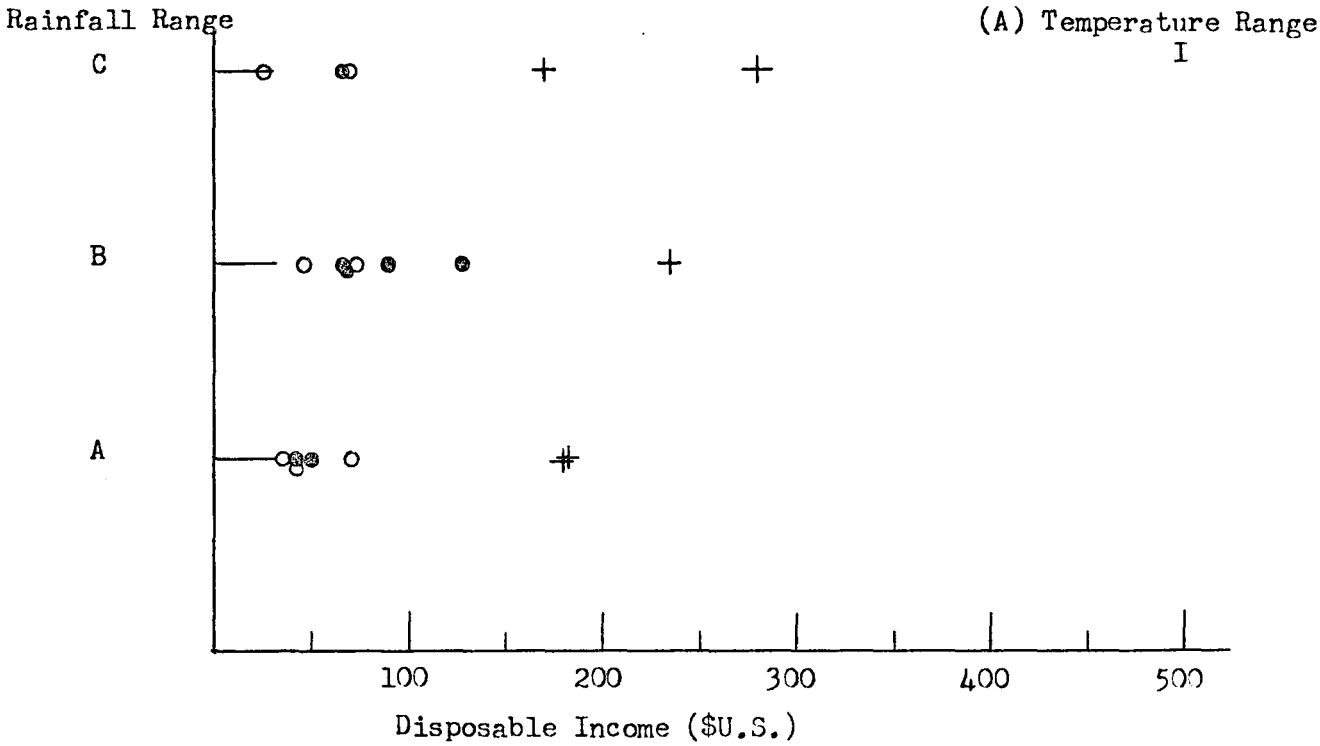
(B) Temperature Range II

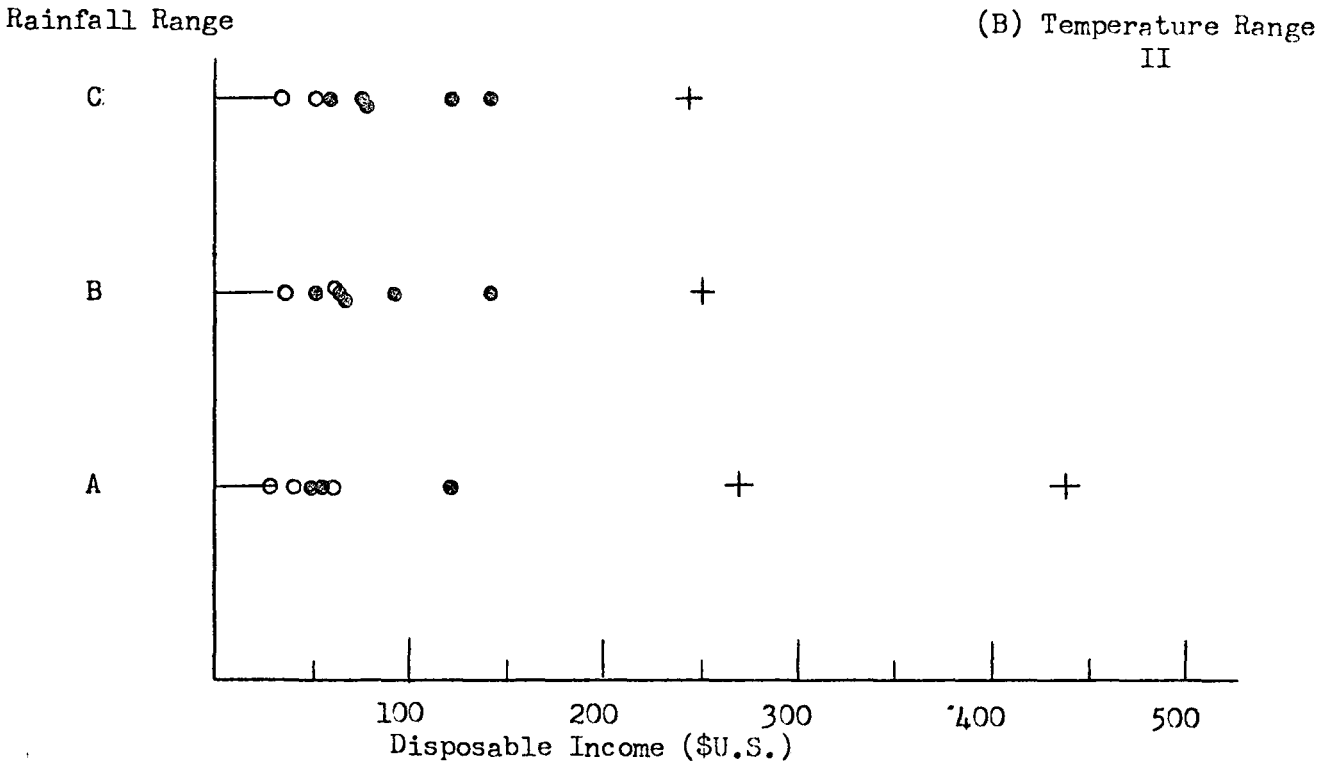


● legumes and corn
o grains
\+ root and vegetable crops

Figure 15A and 15B

Disposable Income for Temperate Crops





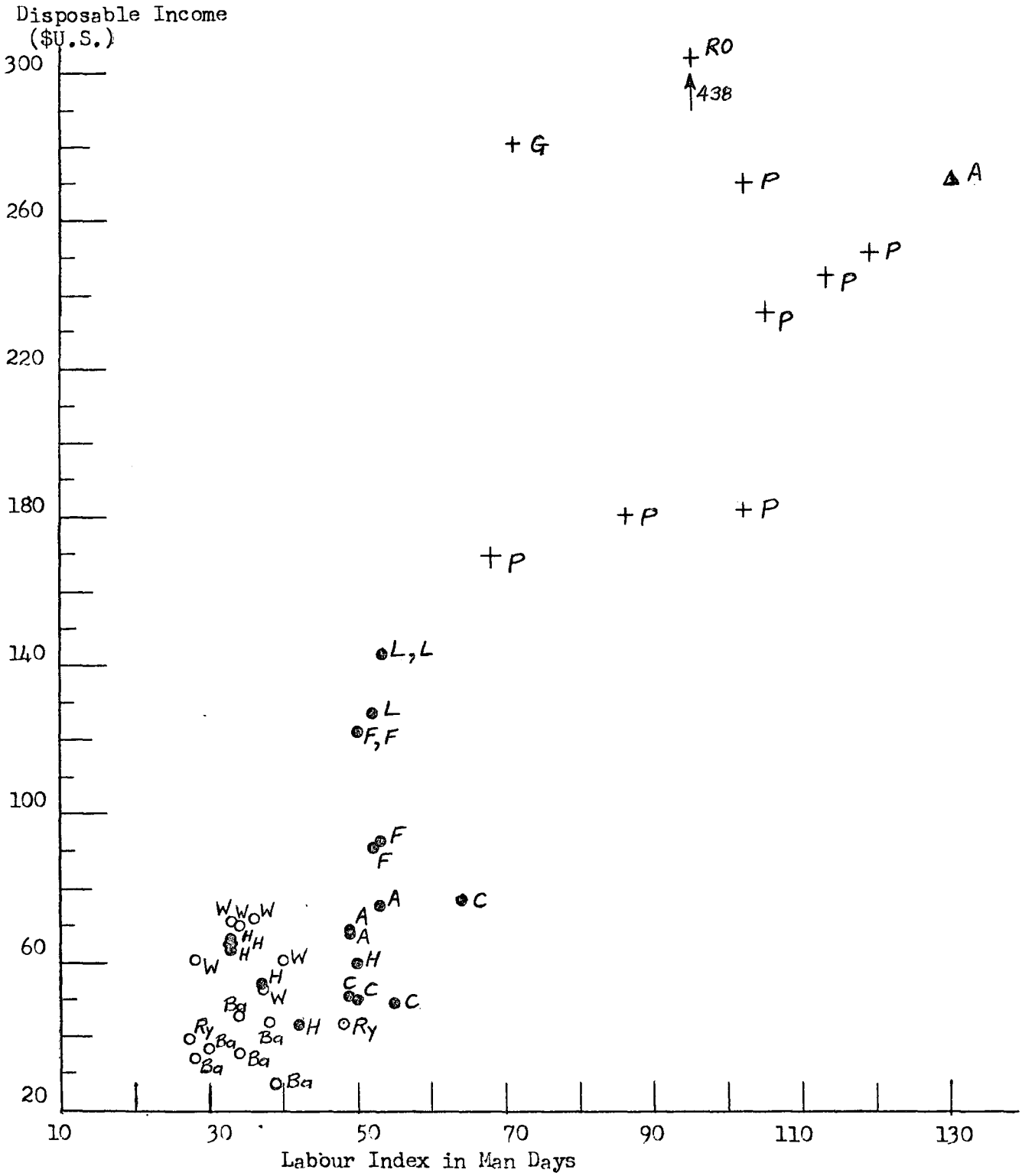
o grains

\+ root and vegetable crops

● legumes and corn

Figure 15C

Disposable Income and Labour Index for all Temperate Crops



Group	Labour Index	Disposable Income
Grains	17%	60%
Legumes and Corn	35%	68%
Root and Vegetable Crops	6%	49%

The above summary indicates that the variations that can occur are greater for Disposable Income than for Labour Index, as was the case for Tropical crops. However, the ranges do represent considerably lower figures than those found when all of the crops are grouped together as in the Wood Classification:

Labour Index: 116%

Disposable Income: 178%

The author recommends that the Wood Classification of Temperate crops be subdivided according to this analysis for a more accurate representation of Land Use Systems involved.

Summary:

The foregoing analysis proves that a four-fold division of both Tropical and Temperate crops results in a more accurate representation of both Labour Index and Disposable Income for the Land Use Systems involved since the range in figures is substantially reduced with the subdivision.

The recommended subdivision is as follows:

1. Tropical: grains
   legumes and corn
   tree fruits
   root crops

2. Temperate: grains
legumes and corn
root and vegetable crops
specialty crops

Horticulture as a distinct Land Use Type is a valid separation.

All of the Land Use Types as outlined above do represent different Land Use Systems, in that measurable differences occur in both labour requirements and Disposable Incomes.

CHAPTER V

THE USE OF AERIAL PHOTOGRAPHS FOR LAND USE CLASSIFICATION

Purpose:

The purpose of this chapter is to examine the extent to which the aerial photographs can be used to determine and measure individual components of the classification and resulting Land Use Systems.

Methodology:

The application to Ecuador of the Land Use Classification for the American Tropics can be briefly outlined as follows:

1. The selection of aerial photographs containing representative Land Use Systems of Ecuador.
2. The interpretation of the aerial photographs to
   a. determine and separate out areas of homogeneity which were expected to represent different Land Use Systems, and
   b. the classification of the above "agricultural units" on the basis of the existing classification.
3. The preparation of a questionnaire to facilitate the collection of data in the field.
4. Field work consisting of
   a. the verification of the existence of different Land Use Systems as located on the aerial photographs

b. The collection of data from one farm characteristic of each homogeneous unit.

c. The gathering of any available relevant agricultural statistics.

5. The calculation of Labour Index, Disposable Income and Productivity Ratio for each farm for which data has been collected.

6. The revision, in light of the data collected, of the original classification into Land Use Systems.

7. A general evaluation of the limitations in the use of aerial photographs to determine and measure individual components of the classification.

I. The Selection of Aerial Photographs:

It was necessary to obtain aerial photograph coverage for areas which were considered typical of the variety of Land Use Systems found in Ecuador. This meant that some samples had to be taken from the Sierra region with its moderate-to-low temperatures, and extremes in rainfall and relief. Other samples were taken from the coast which is tropical in climate, with level to undulating relief.

It was decided to take all sample areas from the province of Pichincha for three reasons. First, this province contains most of the physical variations found throughout Ecuador and most of the existing Land Use Systems.

Second, a current pilot study is being done in Pichincha by the Ecuadorian government in preparation for a large-scale development scheme for the entire Sierra Region. Third, the limitation of area to be studied would simplify the problem of transportation in the field.

The aerial photographs were provided by the Instituto Geográfico Militar, Quito. The actual selection was done by Mr. Roy Ryder[1] who had become acquainted with the province after eight months of residence and geographical study. His final choice of areas was based on the advice of Engineers from the Ministerio de Agricultura who considered each to contain Land Use Systems representative of those found in Pichincha. The author considered the choices for the Sierra valid on the basis of field observations, made in the company of Engineers from the Ministerio de Agricultura, in July and August, 1969.

While aerial photograph coverage was obtained for eight areas, and all were subsequently analyzed, for purposes of illustration only three will be used in this chapter. These are as follows:

1. Valle de los Chillos

   Date: 1956

   Nominal scale: 1: 70,000

[1]Mr. Ryder was a PhD. graduate student with the Geography Department of McMaster University. He had been living in Ecuador since April, 1969, to collect data for his research.

2. Jerusalem - Guyllabamba

   Date: March 7, 1963

   Nominal scale: 1:60,000

   Real Scale: 1:40,000

3. South of Santo Domingo 41 Km.

   Date: 1967

   Scale: 1:20,000

II. Aerial Photograph Interpretation:

A. Criteria Used In Aerial Photograph Interpretation:

The purpose of the original aerial photograph interpretation was to determine and separate out those areas of apparent agricultural homogeneity. These units were expected to represent different Land Use Systems and were subsequently classified according to the Wood Classification. At this stage, these areas are referred to as "agricultural units" since they could not justifiably be called Land Use Systems until field checked.

As has been previously indicated, the criteria on which a Land Use System is based are as follows:

1. The proportion of the total area which has been developed, and the reasons for non-development of certain sections.
2. The general land use emphasis.
3. The seasonality of production.
4. The specific items or groups of items produced.
5. The level of technology used in production.
6. The influence of certain specific physical conditions (if applicable.)

The percentage of occupied land could be read directly from the photograph. For "occupied rural land", 80 per cent of the land was to be used for crops or pasture. Since these areas are indicated by extensive fields, this category was easily determined. If any doubt existed concerning the actual percentage, it could be calculated.

"Unusable" land was easily identified with stereoscopic glasses if the surface appeared too steep, rocky or poorly drained, and showed no signs of agricultural activity.

The measurement of partially occupied rural land, and the declaring of an area as completely uncleared, was done by measuring those areas which had been cut-over.

The only cleared non-agricultural land encountered was clearly urban.

Land use emphasis was arrived at indirectly through the identification of crops and the ratio of cropland to pasture. Crop identification was determined by an examination of the tonal value, textural characteristics, height above the ground, and general relief and climatic characteristics. Field size was also considered an indication of Land use emphasis.

Seasonality of production was determined through the implications of moisture availability either in the form of irrigation canals, or abundance of ground cover either natural or artificial.

The specific items produced were suggested by the Land use emphasis.

The level of technology was interpreted partially by field size and dwelling density. Where high dwelling density was accompanied by very small fields, it was assumed that land holdings were small and insufficient capital was available for a mechanized agriculture. Large fields and associated widely spaced dwellings were taken to imply the existence of large landholdings and enough available capital for mechanized agriculture, if the slope of the land permitted. Where a rectangular field pattern existed over a large area, a higher level of technology was assumed than where the fields were characterized by a lack of any consistent orientation or regular shape.

The influence of certain specific physical conditions were evident in the relief and vegetation characteristics of the land.

From the above, the list of the criteria used to delimit "agricultural units" can be drawn up:

Primary Criteria:

1. natural vegetation and/or lack of
2. field size
3. dwelling density
4. the ratio of cropland to pasture
5. crop type
   a. tone
   b. texture
   c. height above the surface
   d. altitude
   e. relief

   (d. and e. – and implied climatic and soil characteristics)

Secondary Criteria:

6. the degree of order in field organization
7. fences and evidence of pasture improvement
8. existence of drainage or irrigation canals
9. lines indicating the use of machinery in the fields.

In summary, the above criteria were used to separate out areas of homogeneity which at this stage are referred to as "agricultural units." These "agricultural units" were considered possible Land Use Systems and were subsequently classified according to the criteria in the Wood classification.

B. Delimitation and Classification of Agricultural Units:

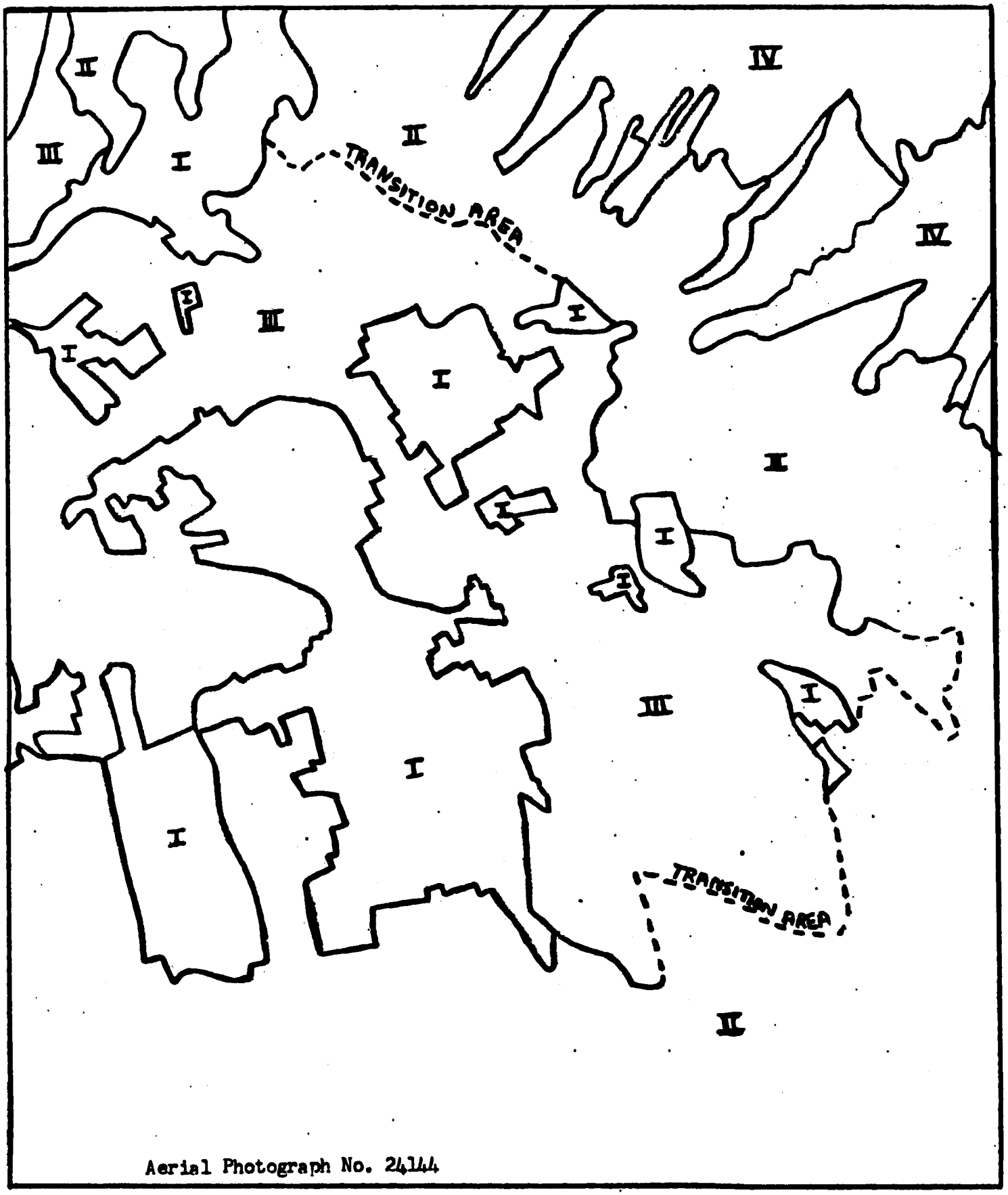
The following outline is an illustration of the use of the criteria listed on page 104 in the delimitation and classification of "agricultural units". One representative photograph from each of the three series has been included. Reference should be made to the aerial photograph illustrations provided. The boundary lines on each of the photographs separate the "agricultural units" as they were delimited prior to revision following field work.

(I) Valle De Los Chillos:

Initially, areas of non-agricultural land were separated from agricultural areas.

On the aerial photograph, the non-agricultural land is Area IV. It is characterized by the absence of fields and dwellings. The boundary was drawn where fields began on the lower slopes. The dark tone, and the relatively smooth texture at such a high altitude, would denote paramo grassland.

ORIGINAL SEPARATION OF AGRICULTURAL UNITS
VALLE DE LOS CHILLOS



Aerial Photograph No. 24144

ORIGINAL SEPARATION OF AGRICULTURAL UNITS
VALLE DE LOS CHILLOS

Aerial Photograph No. 24144

24144


24144

Included in this area are the steep valley walls which are barren in places due to erosion. This characteristic does not appear in the classification because it is limited in extent. The region was tentatively classified as IVP.[1]

The remainder of the photograph was considered fully occupied land due to the complete network of fields. A closer examination was made of this area in an attempt to discover any additional visual evidence which would lead to a further subdivision of the agricultural land. On the basis of the criteria outlined in Section A, three types of homogeneous units emerged.

Area I:

These areas are characterized by very small fields and a high dwelling density. Those conditions imply small land holdings and intensive farming. The availability of capital would be limited by the size of the holdings (measured to be approximately one hectare).

Consequently it was expected that little or no machinery would be used, and that the level of technology would therefore be rudimentary.

Field size and the small scale of the photograph prevented positive crop identification, but because land use was thought to be intensive and rudimentary, the crops are probably vegetables. Grains of temperate climates would be expected because of the moderate temperatures of the valley floor, and the need for some type of cereal crop in a subsistence agriculture. Very few livestock were expected because of the small size of the holdings.

[1]Refer to Appendix "B" for symbolization.

A canal network through parts of these areas indicates that water is available for irrigation. The irrigation and the complete vegetation cover on all level areas indicate a Moisture Category which would allow two crops a year. The subsequent classification of this land was IA2tR.

Area II:

This area, located on the slopes, is in complete contrast to Area I. The upper boundary marks the beginning of the paramo and the end of cultivation, while the lower boundary follows approximately the edge of the valley floor.

The fields are large and dwellings are far apart which suggests large land holdings and available capital for mechanized agriculture. In addition, the fields seem too large to be using hand labour for crops, and the slope is not great enough to prevent the use of machinery. The fact that this area is mechanized is further supported by evidence of widely spaced furrows in some fields and fine dark parallel lines in others.

The light tone and smooth texture of some fields suggest cereal crops which are likely to be wheat, barley and oats because of the cooler temperature of this altitude. Other fields are rough in texture and dark in tone. These characteristics, combined with the lack of evidence of machinery, suggest pasture land. The dark fields of smooth texture are possibly devoted to forage crops such as alfalfa. These types of "land cover" would indicate a farming system with mixed emphasis.

Approximately 50 to 75 per cent of the land of Area II appears to be crops and the remainder is pasture.

The emphasis would, therefore, be on temperate crops. Because of the rough nature of what was considered to be pasture fields, and the low percentage of forage crops, this area was classified as general cattle raising in emphasis rather than dairy or beef fattening.

As in Area I, the evidence of some canals and the complete lack of barren land indicated sufficient moisture for two crops.

This area was classified as IM2tcT.

Area III:

This agricultural unit encompasses the valley floor with the exception of those areas characterized by the small farms of Area I. The field size and dwelling density falls midway between those of Area I and those of Area II. This pattern suggests medium sized farm holdings. Parallel light lines in almost all the fields indicate either a mechanized farming system or the use of animal traction. Further evidence of mechanization is suggested by a well organized field pattern closely related to irrigation ditches.

Eighty per cent of this land is dark in tone which suggests pasture and forage crops, and cattle-oriented farming system. Because the farms are moderate in size, and this area is near the Quito market it was thought likely to specialize in dairy cattle. Fields of light tone were interpreted as fallow land or oats for cattle feed.

Because there is a higher density of irrigation ditches here than anywhere else on the photograph, this area was considered to belong in Moisture Category 3 and was therefore classified as IG3dT.

(2) Jerusalem - Guayllabamba:

Guayllabamba presents a different set of physical conditions from those of Valle de los Chillos. The aerial photograph shows marked evidence of aridity and a variation in moisture conditions over short distances.

Area Ix:

The fields in this area are very small, but building density is extremely low. These conditions imply that production might be low because the area cannot support a dense population. This idea is further supported by very light tones throughout the area which might indicate dry soils. There is also a lack of surface drainage. There is a definite contrast between Area Ix and the dark irrigated field crops which it borders. The boundary lines between the fields are very faint and have been obscured for some reason.[1]

The small field size and hypothesized low productivity imply a rudimentary farming system belonging to a moisture category that does not produce even one reliable crop.

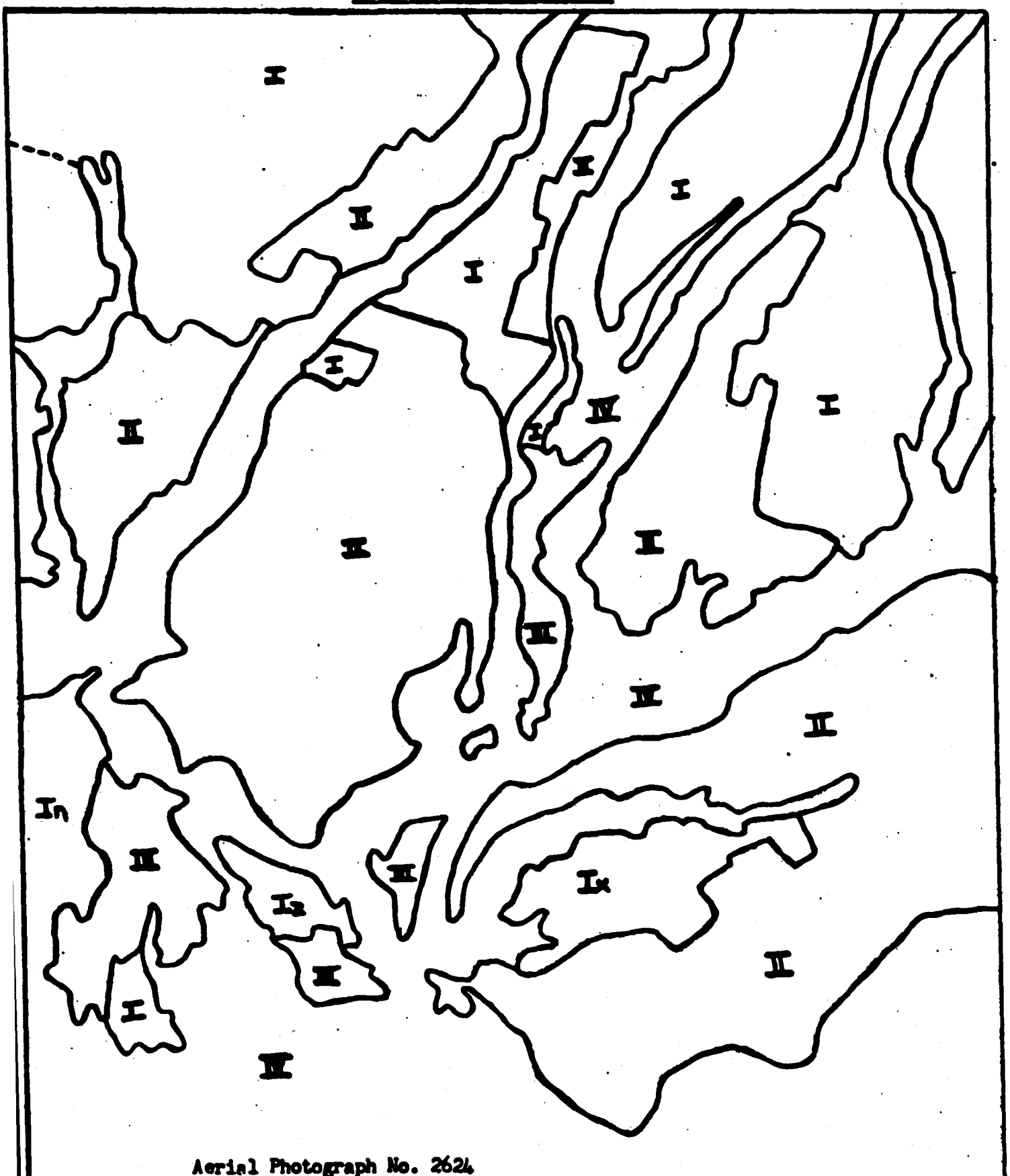
There would not be enough moisture for vegetables, and the field size is too small for extensive livestock grazing. This area was considered to contain the cereal crop corn because of the possibility of a subsistence agriculture.

The area was classified as IAOtR.

[1]It was found to be blowing sand in subsequent field work.

ORIGINAL SEPARATION OF AGRICULTURAL UNITS

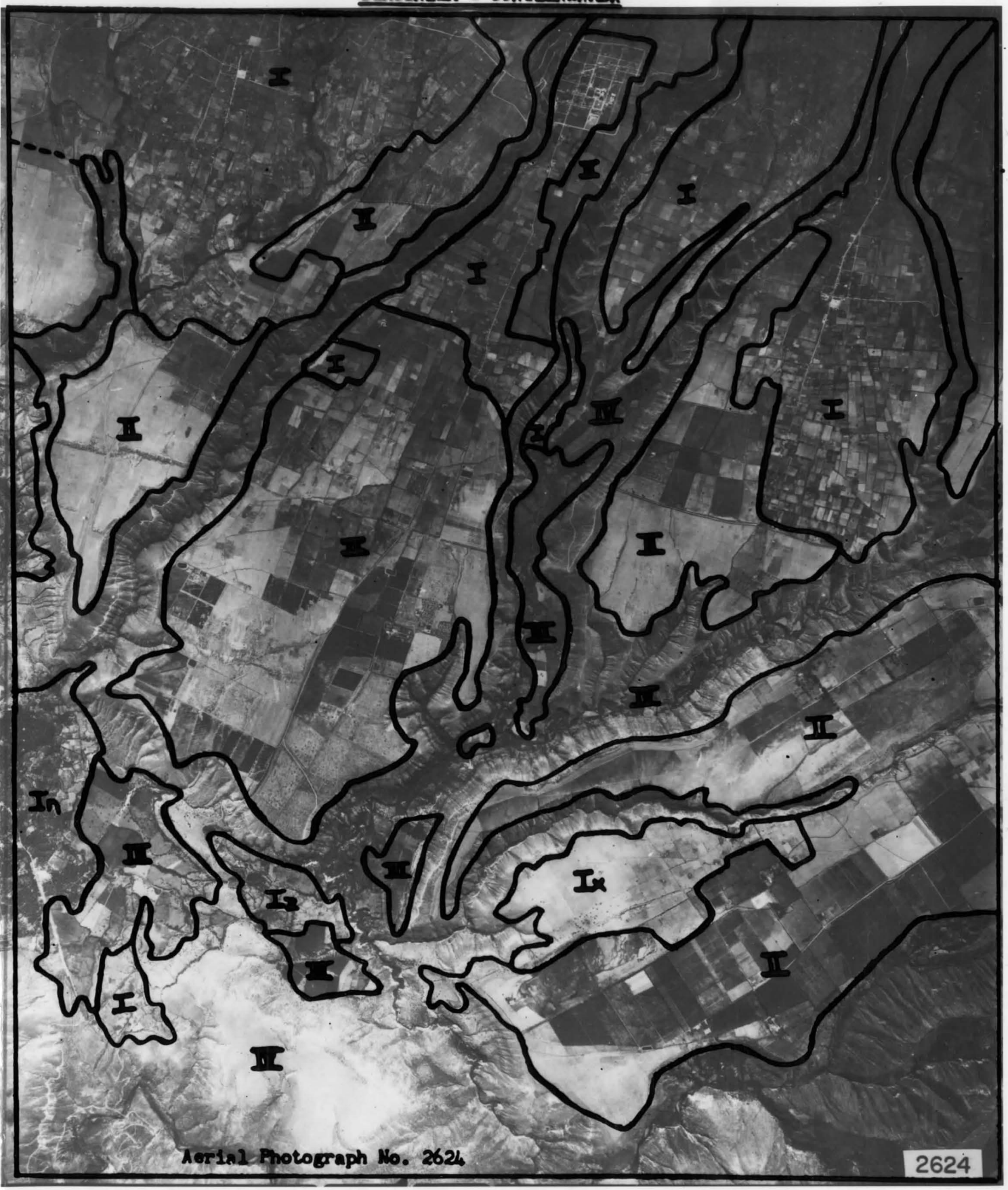
JERUSALEM - GUAYLLABAMBA



Aerial Photograph No. 2624

ORIGINAL SEPARATION OF AGRICULTURAL UNITS

JERUSALEM - GUAYLLABAMBA




2624

Area Iz and In:

Area Iz contains very small fields but only a moderate dwelling density, indicating that field size is probably dictated by the crop rather than the size of the land holdings which are larger than in the preceding area. This implies vegetable and/or fruit farming.

Actual crop identification was prevented again by field size and the scale of the aerial photograph. However, 10 percent of this area showed organized rows of trees in some places indicating the existence of fruit. The possibility that this area might have a horticultural emphasis was further supported by the high density of irrigation ditches, and warmer temperatures associated with its lower altitude.

The area was not classified as having a horticultural system because the distinguishing criteria of the latter is the labour input and this data was not available until provided by field investigations. The area was classified as general agriculture, with a fruit emphasis, in Moisture Category 3 because of the availability of irrigation water. The level of technology was in doubt. Because the land holdings were around 10 hectares and the area was one of intensive production, it seemed certain that the area would not be using rudimentary production techniques, and was subsequently classified as "semi-technified": IA3fS.

Area In exhibits the same characteristics as Iz with the major exception that 90 per cent of the land is in fruit trees and 10 per cent in crops.

It was not known what type of fruit trees were being grown, and whether the area had a definite specialization. This area was classified as IA3fS as well, but it was certain that field checking would clarify the tree crop emphasis.

Area I:

This region had all of the visual characteristics of Area I in the Valle de los Chillos photograph with the exception of a slightly greater slope. It was, therefore, given the same classification: IA2tR.

Area II:

Area II is characterized by field sizes much larger than those found on the rest of the photograph, and is accompanied by the lowest dwelling density of the agriculturally productive areas. The fields, however, fall into two size ranges with different tonal and textural qualities.

There exist within this area very large fields of rough texture and light tone. These fields contain light toned "trails" and are irregular in shape. It was considered that these were pasture land for general cattle raising. These pasture areas are broken by dark toned, smooth textured, smaller fields. These fields are crossed by irrigation ditches. It was thought that these were primarily for fodder crops such as alfalfa.

This area would, therefore, be one of mixed emphasis. About 50 per cent of the land is devoted to pasture and the remaining to crops, some of which is alfalfa.

There was a problem as to the Moisture Category to which this land belonged since one half appeared dry and one half was irrigated. A compromise was reached in placing it in Category 1. The level of technology was thought to be "semi-technified" because crops suggested some mechanization but pasture areas appeared unimproved. Included in this area was part of the valley floor which was characterized by the same field size and contrasted with the small land holding of Areas Ix and In.

Area IV:

The light tones characteristic of Area IV, combined with evidence of advanced erosion and limited natural vegetation, indicate land which is very dry. This area was separated out as non-agricultural. There is no evidence of subdivision into fields, and the lack of vegetation cover would prevent even extensive grazing. This land was classified as IVB.

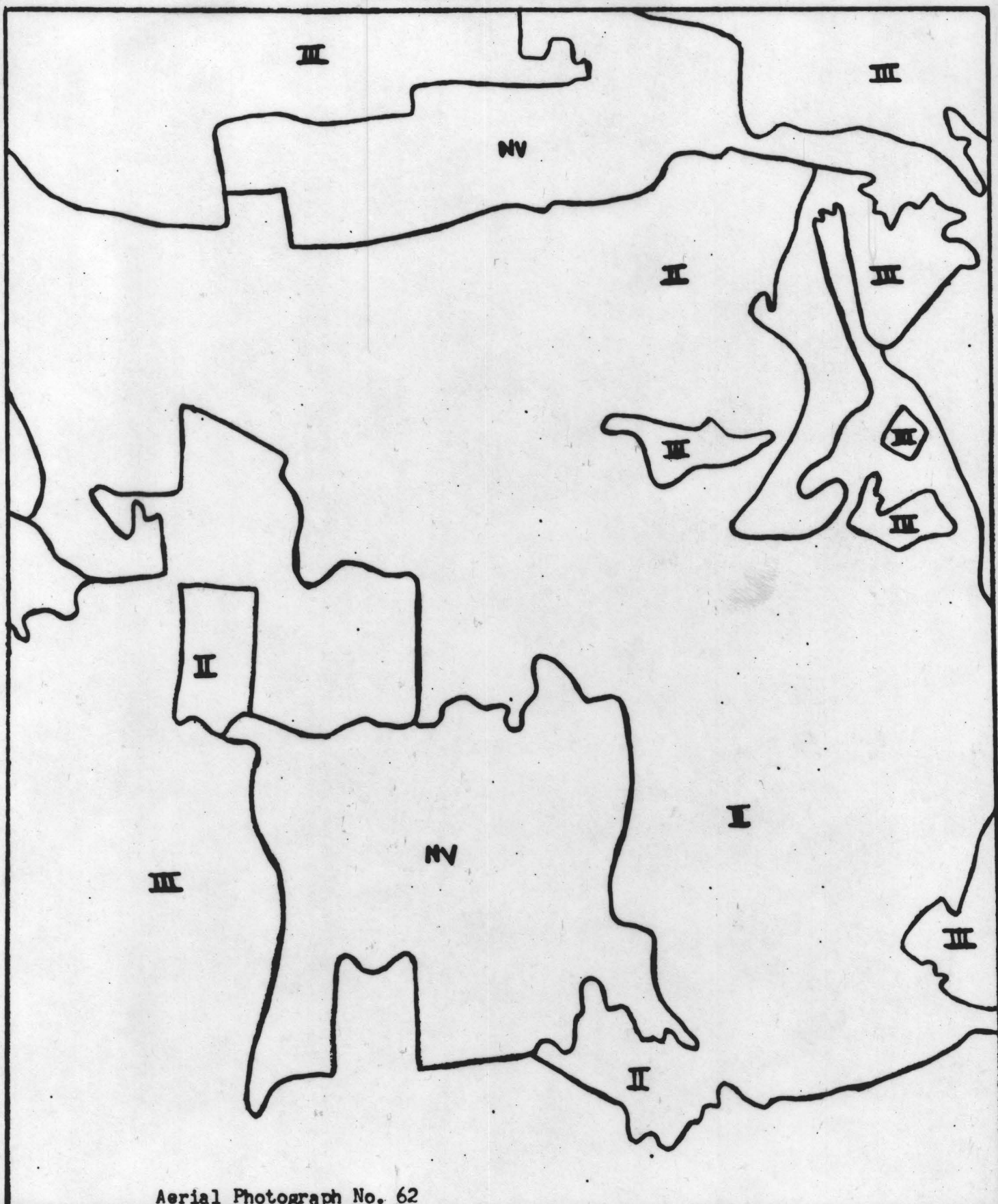
The remainder of the photograph was subdivided into five relatively homogeneous agricultural units primarily on the basis of field size and those features indicating moisture availability .

(3) South of Santo Domingo:

The initial separation of non-agricultural land presented a problem in this photograph series. Those areas indicated by "NV" represent heavily cut over natural vegetation, and the problem existed as to whether these areas should be combined with Area II or left separate as non-agricultural. If they were combined with Area II, it would reduce the entire area to "partially occupied."

ORIGINAL SEPARATION OF AGRICULTURAL UNITS

SOUTH OF SANTO DOMINGO 4 1km.



Aerial Photograph No. 62

ORIGINAL SEPARATION OF AGRICULTURAL UNITS

SOUTH OF SANTO DOMINGO 41km.

Aerial Photograph No. 62

62


62
62

There was some question as to whether "NV" was being used as a "food forest", and this could not be confirmed until it had been field checked. Due to this possibility, it was combined with Area II. Thus, no nonagricultural land was shown on this photograph.

Area III:

The large fields and extremely low dwelling density indicates that Area III is made up of very large land holdings. The uniformity of tone and texture over such a wide area, combined with the tropical climate, indicate plantation agriculture.

The height of the vegetation above the surface is characteristic of a tree crop. This was identified as bananas.

Because of the size of the holdings, and the general nature of plantations, it was considered that this area would be at least "technified", if not "highly-technified."

It was also put into Moisture Category 3 because of the abundance and height of the natural vegetation and the known climatic requirements of bananas.

The classification of Area III was IS3baT.

Area II:

Area II is characterized by a combination of two types of land use: pasture and fruit. For each of these uses, field size differs. The comparatively large fields of pasture were identified by their rough texture. The small fields of fruit found throughout the area could not be identified as to fruit type but it was known that these were cultivated fruits because of the alignment of the trees.

The dwelling density and field size indicate large land holdings but not on the scale of the plantations in Area III.

The pasture land occupies at least 60 per cent of the cleared area. This suggests a mixed farming emphasis. The cattle orientation in this area was thought to be beef-fattening because of the rich nature of tropical pasture and absence of a nearby market.

Although there is evidence of fences in the pasture area, the rough texture of most of the fields indicates little improvement, and was subsequently classed as "semi-technified".

The classification of this area was $\frac{\text{IIM3eS}}{\text{T}}$.

C. Problems Encountered In Aerial Photograph Interpretation:

1. Identification of "Land Cover":

The greatest problem in the aerial photograph interpretation was the inability of the author to identify most crops. This was partially due to the scale of the aerial photographs, particularly in the Sierra. Here, only by relating temperature, moisture conditions, general tonal value, texture and field size, could a reasonable speculation be made regarding crop type. Crop identification was easier in coastal areas because of the scale of the photographs (1:20,000), as well as the perennial nature of the crops, the large land holdings, and the fact that many areas contained tree crops.

The problem of identification of "land cover" would be partially solved with an increase in the scale of the photograph and with experience gained through aerial photograph interpretation in tropical areas.

2. Vegetative Cycle:

Those photographs acquired for the Sierra regions were taken in March, at which time most crops have attained an adequate height for identification, if scale permits, since planting is done between October and December. For coastal areas, however, the perennial nature of the tree crops can present a problem if a plantation has been photographed in its early stages of growth. It is only by field checking that the crops in these areas can be positively identified.

3. Natural Vegetation:

In the Land Use Classification for the American Tropics, the natural vegetation is very carefully classified according to type, percentage of ground cover and height. The author found precision difficult to attain in certain areas. In the arid regions of Guayllabamba it was impossible to measure the height of the scrub growth due to the scale of the aerial photograph. This, then, had to be estimated until field checked. For the lowland areas, the tree height could be mechanically measured since the scale of the photographs was larger and thus there was less of a problem.

4. Areas of Transition:

Another problem of photograph interpretation was presented by transition in crop combinations over distance, where no clear boundary exists. In coastal areas this occurred between those areas with cattle-fattening emphasis with secondary production of fruit and root crops, and those areas of fruit and root crop emphasis and limited cattle raising. An equally difficult boundary line had to be drawn in areas of the Sierra where a transition exists from areas with inadequate moisture for one reliable crop to area of adequate moisture for one crop. Here the boundary line was drawn on the basis of density of dwellings which was considered to reflect to some extent the population which the area was supporting.

Areas in a state of transition over time were also a problem. It was certain that those regions in some of the photographs along a river and the edge of the jungle were in a state of transition from clearing of forest to some type of land use system. It was, however, impossible to determine what type of farming was evolving until field work produced the necessary information.

In summary, the purpose of the aerial photograph interpretation was to differentiate areas of homogeneity which were later to be field checked to verify their identity as a separate Land Use System.

The criteria on which these "agricultural units" were differentiated indirectly reflected the criteria for distinguishing a Land Use System according to the classification.

III - Field Work:

A - The Questionnaire:

The original classification of the agricultural units was to be checked through investigations in the field. It was considered necessary to obtain data for each distinct agricultural unit on each set of aerial photographs. This data was to be supplied primarily through interviews with farm owners or managers. To facilitate these interviews, a questionnaire was drawn up from which the necessary information could be interpreted.

B - Farm Interviews:

Contact was made with Ing. Leopoldo Moncayo, Chief of the Agricultural Extension Office for the Province of Pichincha. Ing. Moncayo provided introduction to the Extension Officers for each of the study areas.

Initially, each set of photographs was examined by Ing. Moncayo and the Extension Officer for that particular area. The existence of the homogeneous agricultural units as outlined, was confirmed. Time did not permit the personal checking of each boundary line, but by correlating the landscape and the aerial photograph, the general boundary accuracy was confirmed. Field size associated with relief features was considered the best indicator of change from one Land Use System to another because

the data collected verified the relationship between field size and Land Use System.

The Extension Officer was personally acquainted with many farmers in his area. On the basis of his knowledge, he selected farms for interview within the boundaries of the various agricultural units on the aerial photograph. The farm in each unit was chosen primarily because it was considered typical of the area, and secondly because the farm owner or manager was most likely to give reliable information regarding his production.

During July and August, 1969, the author became acquainted with the areas of Cayambe, Guayllabamba and San Antonio - Pomasqui on field trips accompanied by representatives from the Ministerio de Agricultura. A general knowledge of the Land Use Systems and physical conditions within these areas was acquired at that time. This background information and the co-operation of the Ministerio de Agricultura, in particular of Ing. Moncayo, reduced the time spent in the field, in 1970, to three weeks. For each area, it was possible to stop after completing only one farm interview per agricultural unit because of its typical nature and co-operative farm manager.

The only drawback in carrying out these interviews was the time consumed in travelling. This was the result of the poor condition of many roads, and the rough terrain.

IV - Revision Of Original Classification And Boundaries:

Upon completion of the farm interviews, calculations were made from the data sheets to determine each of the following:

1. The total value of the agricultural products.
2. The total cost of production, excluding labour.
3. The Disposable Income (the difference between 1 and 2) in American dollars at the current rate of 21 sucres to the dollar.
4. The Labour Index (the number of days worked per hectare per year.)
5. The Productivity Ratio (the income per work day or the Disposable Income divided by the Labour Index.)

With the above information and the original farm data, it was now possible to determine not only the accuracy of the original classification of agricultural units, but also whether they were distinct as Land Use Systems.

It was found that the original aerial photograph interpretation which divided each study area into "agricultural units" was almost completely accurate, in that different Land Use Systems were represented within each of the boundary lines. This accuracy would indicate the validity of the criteria used in the determination of these units through aerial photograph interpretation. In other words, changes in homogeneity of field size, dwelling density, crop emphasis and crop/pasture ratio denote a change in Land Use System.

In many cases, however, the original classification of these units was incorrect. The errors in classification were partially the result of Land Use Systems being encountered in Ecuador which are not found in the Wood Classification. This situation resulted in their addition to the classification. The other reason for errors in the author's classification of units was because of inadequacies in detail in certain criteria within the Wood Classification.

1. Valle De Los Chillos:

Field observation in this area revealed a high degree of accuracy for the original aerial photograph interpretation. The existence of three farming systems, as previously described, was verified.

Area II:

This area was originally classified as IM2tcT. The accompanying data for Farm A was considered representative of the Land Use System of the slopes of Valle de los Chillos. The fact that a small section of this farm was located on the valley floor was not considered significant.

This farm is 2400 hectares in size, but 2/3 is rented. This would mean that the farm, for the purpose of this study, could be considered as 800 hectares. Calculations were done, however, for a farm of the size of 570 hectares because this was the amount of land being actively utilized, the rest being unused paramo and coming within the boundary of Area IV.

The final classification of this area was IM1*tdT. The cattle emphasis is towards dairying rather than the general cattle as was originally classified.

The symbol 1* has been used to indicate adequate moisture for two crops but the existence of only one because lower temperatures result in a longer growth period than is normal in the "tropics." Corn requires 7 - 8 months to mature in this area.

Potatoes ripen in 8 months, however a new variety which has just been introduced only requires 5 months. Since barley and wheat ripen in 7 months, these two crops are grown in rotation.[1]

The original classification of this area was reasonably accurate, with the exception of its being a one crop area rather than two. In the future, the limitation of low temperature due to altitude must be more carefully considered in the aerial photograph interpretation.

The following is a description of the new system:

1M1*tdT Location: high valleys of Ecuador with a mean annual temperature of 10 C. and an average of 900 mm. rainfall.

Operation: livestock are dairy cattle, kept on pastures which are chemically fertilized and re-seeded every 5 to 10 years. Cattle density of less than 1 hectare per head.

[1]Ing. Agronomo Luis Cornejo, I.E.R.A.C., 1971.

About 50 per cent of the land is in crops and includes wheat, potatoes, barley and beans. Potatoes are grown in rotation with the cereal crops. Almost all farming operations are mechanized with the exception of the milking of the cattle.

Labour: by hired hands; work continues most of the year

Summary: Labour Index: 13.8 days/hectare/year
Disposable Income: 170.50 sucres/hectare/year
Productivity Ratio: 12.35 sucres per work day

Area III:

Area III was originally classified as IG3dT. This designation was unchanged by the collection of farm data. (Farm B)

Area I:

The original classification of this area was IA2tR.

Farm C was selected by the local Extension officer and is the one case where the farm is not typical of the entire area. This is because the farmer also works part of co-operatively owned land in the valley of Rio Toachi, and because most of his income comes from the production of cheese. In view of this, the statistics for the farm were recalculated with the omission of his income from cheese production and the exclusion of labour used in the valley of Rio Toachi and cheese production.

The final classification of this area was IA1*tR_2 because it is a one crop area due to low temperatures, and because it would belong to the Rudimentary II level of technology as outlined

in Chapter II. This farm is typical of many found in the Sierra where hogs and perhaps other small animals are contributing a great deal to the income. It is the contribution from hogs which almost doubles the income.

This represents a Land Use System which was not found by H. A. Wood and some method should be found to include a farming system where hogs contribute a large amount to the Disposable Income. They cannot be considered as having any real costs and only require seven days per pig per year in labour.

The paramo area in this area had been classified as unused. It is, however, used only for beef fattening of steers which is carried on throughout the year.[1] The cattle are herded in densities of about 2 - 3 heads per hectare. They are checked by the owner once a year and vaccinated. There are 2 herders per 100 animals. The animals are sold at $2\frac{1}{2}$ to 3 years of age. When they are put on the land they are worth 1000 - 1500 sucres per head, but when they are brought down they are worth 2500 - 3000 sucres per head. They are fattened further for 2 or 3 months on lowland pastures then sold. The profit per head is then $48.00, $71.00, $95.00. The burned patches on the photographs indicate cattle fattening areas.

2. Jerusalem - Guayllabamba:

The original aerial photograph interpretation for separating agricultural units was relatively successful in that no changes in

[1]Ing. Agronomo Luis Cornejo, I.E.R.A.C., 1971.

boundary lines were necessary with the exception of three subdivisions of Area II which had erroneously been classified as comprising a single farming system. All other boundary lines differentiated the existing Land Use Systems.

Area I:

Area I had been classified as IA2tR.

The accompanying data for Farm D made necessary the revision of this classification to $IA2tR_1$ because only occasional use is being made of pesticides and fertilizers.

This area was accurately classified as a two-crop area because the lower altitude provides an average annual temperature of 17.5 degrees C. and the moisture supply is supplemented by irrigation in 40 per cent of the area.

Area Iz:

This area was originally classified as IA3fS until field work produced evidence of a horticultural Land Use System for which the primary criterion is labour input.

The revised classification is IA3hS because the labour input is 208 days/hectare/year for Farm J.

Area In:

Area In was originally classified as IA3fS because the type of tree crop in this area remained unidentified in the aerial photograph.

Farm I, taken from this area, indicates avocado trees, however, a greater percentage of the income is derived from poultry.

This type of Land Use System is impossible to identify from an aerial photograph but through field checking of areas close to market centres it would be possible to locate a Land Use System with poultry emphasis.

Area Ix:

This area was originally classified as IAOtR and from the collection of field data, this was revised to $IAOtR_1$ according to the author's modification of category R.

The data for Farm K and O indicate an unreliable crop production due to extreme aridity and the lack of irrigation.

Area II:

Area II was first classified as IMItS. Included in this area is rough grazing land and irrigated crops on the more gentle slopes, and that part of the valley floor that contained the same size of irrigated fields.

Following field investigations this one area was subdivided into three separate Land Use Systems:

1. The land under irrigation on the gentle slopes was classified as IA3tS, since over 50% of the land was planted in crops. The Land Use System was identical to one studied in another area of the Sierra.
2. The rough grazing land was classified as $\frac{IVxR}{xf}$ because extensive goat grazing was taking place. This land Use System can be described as follows:

Location: on arid valley slopes of the Sierra where rainfall is an unreliable 50 mm. and the average annual temperature is 12.5°C.

Operation: extensive goat and burro grazing with an animal density of ½ to 2 hectares per goat.

Labour: by women and children - work continues all year.

Summary: Labour Index: 1.82 days/hectare/year (women counting ½ labour day)

Disposable Income: $2.10/hectare/year

Productivity Ratio: $1.05 per work day

3. The valley floor was classified as IA3hS on the basis of the accompanying data for Farm H.
   Farm H contains somewhat more land in fruit trees than other parts of this subdivision of Area II, but, because it is entirely characterized by fruit and vegetable crops, and the labour input is 150 days/hectare/year, this represents a horticultural farming system. This area differs from the horticultural farms of Area Iz only in the size of land holdings which are much larger (104 hectares compared to 12 hectares.)

More vegetables are being grown in Area Iz than Area II which resulted in a more intensive use of the land. This difference in use would account for the discrepancies in labour input and profit.

Area IV:

Area IV had been accurately classified as IV B, since the ground cover is less than 10 per cent due to erosion and aridity.

3. South of Santo Domingo, 41 Km:

Area III:

Area III was originally classified as IS3baT, and this classification remained unchanged following the collection of the accompanying data for Farm N.

The summary figures for this Land Use System would indicate the current maximum for Disposable Income in coastal Ecuador. As a result of recent difficulties in marketing bananas, most areas make less than $215./hectare/year profit because they cannot sell their bananas. This problem has resulted in an abandonment of many plantations on the coast, or the slow conversion of these areas to a beef-fattening farming system.

The Disposable Income for banana plantations is expected to vary within wide margins due to price and tax differences.

Area II:

Area II was originally classified as $\frac{\text{IIM3eS}}{\text{T}}$.

On the basis of the accompanying data, this designation was changed to IM3eS. The area has been reclassified as fully occupied because the large areas of heavily cut-over natural vegetation were left separate and the remaining area is about 80 per cent occupied.

The area was classified as "e" even though it contained both beef fattening and beef raising, because this is the common situation throughout the coast of Ecuador. The criteria "e" and "b" in the Wood Classification is not a meaningful distinction to make for Ecuador because these areas are not separated. Profit per animal differs, however, in the two farming systems:

beef raising: $48. profit in two years per animal

beef fattening: $48. profit in one year per animal.

Cattle density varies with pasture organization:

with fences: 3 head per hectare

without fences: 1½ head per hectare

in partially cleared land: 1 head per hectare.

Farm P represents a beef raising area using fences and fertilizer. Pasture lands are seeded when established. These operations would indicate a semi-technified system. Ninety per cent of this particular farm is pasture and 10 per cent grows citrus fruit and papaya indicating a mixed-emphasis. Throughout the area, pasture occupied about 60 per cent of the land with the remainder in fruit trees and scrub growth.

The following is a description of this Land Use System:

IM3eS Location: on low lying coastal plains with 3000-3500 mm. of rainfall and an average annual temperature of 22 to 23 degrees C.

Operation: 70 to 90 per cent of the cleared land is devoted to pasture for beef fattening and beef raising. 10 to 20 per cent grows citrus fruit and papya. Fenced pastures are originally seeded and are maintained with fertilizer. Cattle densities are between 1.5 and 3 head per hectare.

Labour: by hired hands, work continues all year.

Summary: Labour Index: 53 days/hectare/year

Disposable Income: 93.70 sucres/hectare/year

Productivity Ratio: 1.77 sucres/work day

The areas formerly designated as "NV" were classified as $\frac{IV}{M_3}$ because it is not being used even as a "food forest" as was speculated during aerial photograph interpretation. The large trees have long been removed, reducing the vegetation height to 20 meters.

Summary:

The six Land Use Components worked quite well for determining different Land Use Systems from the aerial photographs.

Land Use Order:

The percentage of occupied land was easily read or measured from the aerial photographs. Fully occupied land is characterized by a complete field pattern, around which a boundary line can be quickly drawn.

Land which is unused is most easily identified by its absence of field boundaries. It is usually characterized by complete forest cover in humid tropical areas.

In the Sierra, non-agricultural land was also characterized by an absence of field boundaries, and in many cases contained severe erosion and/or absence of natural vegetation, or a complete paramo grassland cover.

In arid areas where vegetation is sparse and in areas of paramo, it is not possible on an aerial photograph scale of 1:40,000 to 1:70,000 to determine if extensive grazing is being carried on. This is one possibility which should always be field checked in the application of the classification.

The Land Use Group:

Areas of General Agriculture were always identified correctly by the author. They are best arrived at by the process of elimination. If the area is characterized by a lack of uniformity in texture and tone, then it is not specialized or semi-specialized agriculture. If the percentage of pasture is less than 50 per cent, it cannot be classified as a livestock oriented area. Because the land does not belong in these categories, it is placed in General Agriculture.

Specialized and Semi-Specialized Agriculture were easily identified through uniformity of tone and texture. In some cases, crop height can also be an aid, if it is uniform over a wide area.

Livestock raising areas could be separated by isolating land with over 90 per cent in pasture. These areas have two forms:

a) Area may show a rough texture and uneven tone of unimproved or slightly improved pasture fields, sometimes accompanied by cattle trails. Fenced boundaries usually occur between these two and fields are large.

b) Area may show a smooth texture and the dark tone of fodder crops such as alfalfa, sometimes accompanied by cattle trails. Fenced boundaries occur between these areas and fields are moderate in size.

The same criteria used to identify crop land and pasture were used to separate out areas of mixed farming where 10 to 50 per cent of the land is in crops.

Identification was not possible for those areas where hogs, poultry or small animals were being kept on farms where all the land was in crops. The author noted through field observation on the coast that farms which raised hogs on a semi-technified or technified level provided long open barns in which these animals were penned. These barns would provide a clue to the identification of hog raising, if the land under crops is considered with them.

Apart from the small clue provided by the barns the presence of hogs and poultry in these areas must be determined through the local Department of Agriculture, and then field checked.

The use of uncleared land was not encountered by the author, and the only cleared non-agricultural land encountered was easily identified as urban in the orientation and density of dwellings.

The Land Use Series:

Moisture conditions can quickly be categorized through aerial photograph interpretation. Areas where moisture is insufficient for a reliable harvest of any quick annual crop are usually light in tone, low in dwelling density, and usually exhibit faint field boundaries for small fields.

Areas where moisture is sufficient for a reliable harvest of some quick growing annuals are characterized by a lack of irrigation canals, a continuous crop cover but an under abundance of natural vegetation. Dwelling densities in these areas are fairly high.

In high altitudes (above 9,000 ft.) there can be sufficient moisture for two crops, but low temperature may limit the area to one crop. The criteria used at lower altitudes which indicate abundant moisture are, therefore, of limited value in high altitudes.

Areas which are capable of growing two crops a year are usually found below an altitude of 9,000 ft.

Areas with no significant moisture deficiency contain either a dense network of irrigation canals and a high dwelling density accompanied by a complete crop cover, or are indicated by the abundant, complete tree cover of the natural vegetation.

Only a limited amount of work was done by the author concerning the vegetation of uncleared areas. In humid tropical areas, the height of the crown canopy can be mechanically measured but in arid areas, the height of the vegetation must be estimated on the basis of the percentage of ground cover. These estimates can be fairly accurate but should be field checked.

A trained interpreter could identify areas which have been cut over for valuable species, but this too should be field checked. If an area has been modified by selective planting, this fact would probably show up in the alignment of trees and the uniformity of tone and texture. Recently burned, or heavily cut-over areas would show as "patchy" in nature.

The Land Use Type:

Set A:

If an area is one of temperate crops, it is usually found at an altitude of more than 9,000 feet. If the area is one of general temperate crops, it will be characterized by variations in field size, tone and texture. If the area is primarily devoted to cereal crops it will be uniformly light in tone, relatively smooth in texture and have generally large fields.

Tropical crop emphasis is found at low altitudes, where

the abundant natural forests indicate high temperature and rainfall. If the area has a root and tree fruit emphasis, it will generally have small fields, with aligned trees interspersed by areas containing a variety of tones and textures. If the area has tropical grains and other annuals, it will lack the orchards and small plantations of tree crops.

Horticultural areas are indicated by extremely small fields (less than one hectare) and a moderate to high dwelling density and are generally found in areas where the Moisture Category is three.

Set B:

The type of livestock found in an area for Ecuador is, at best, speculation because of the lack of barns.

Sheep are generally found in higher altitudes (greater than 9,000 feet), on rocky slopes and areas of paramo grassland. Goats and donkeys are characteristic of arid areas, with sparse natural vegetation on eroded slopes.

Dairying is found in areas with level to undulating terrain with orderly fields which include fodder crops.

Beef cattle fattening and beef cattle breeding can not be differentiated. They are usually found in areas with lush pastures showing a rough texture and cattle trails in tropical areas.

Undifferentiated cattle and livestock raising cannot be determined from an aerial photograph.

Set C:

The identification of a crop in a specialized or semi-specialized area is very difficult. With experience, and the aids of field sizes, tone, texture, shape of crown canopy, and height above the ground, specific crops can be isolated. Identified by the author were bananas, citrus fruit, alfalfa and grains. Additional experience with tropical crops might result in the identification of more than these crops.

Set D:

In the author's opinion, field work and a greater background knowledge are necessary to be able to determine the use of the natural vegetation as one of the activities which can be determined from an aerial photograph.

The Land Use Level:

Rudimentary levels of technology are usually indicated by small fields and high dwelling densities. Small land holdings (1 to 10 hectares) indicate insufficient capital available for agricultural improvement. There is no way that level R_1 can be distinguished from areas of R_2 where chemicals are occasionally used.

Semi-technified areas are generally indicated by small fields and moderate land holdings of 10 - 20 hectares.

Technified farms are never found on steep slopes (over 12 per cent) and are usually characterized by large fields and low dwelling densities indicating large land holdings. In some cases, furrows and other lines made by machines can be seen

within the field boundaries. Irrigated areas usually indicate at least a semi-technified level of technology depending on the accompanying farm and field size.

In summary, the only information that was not satisfactorily obtained from aerial photographs is as follows:

1. actual crop type
2. use of uncleared land
3. undifferentiated livestock and cattle raising areas
4. hog and poultry areas.

The actual differentiation of Land Use Systems on aerial photographs was not found to be a time consuming task for these areas in Ecuador which were examined. The boundary lines were also reasonably accurate. However, the author emphasizes the need for field checking, primarily to confirm specific land use emphasis in each system, and to determine the extent to which agricultural chemicals are being used within either a Rudimentary or Technified technological level.

The use of aerial photographs will substantially reduce the amount of time spent in collecting an inventory of Land Use Systems within an area.

CHAPTER VI

SUMMARY AND CONCLUSION

(A) Summary:

This study has been an anlysis of two basic assumptions of the H.A. Wood Land Use Classification for the American Tropics. The first assumption examined was that the classification must include the elements of production techniques and the length of the productive period in order to give a true indication of the output of economic goods and the level of employment which any form of land use can maintain, or the effectiveness with which the natural resources of any area are being exploited.

This assumption has been analyzed, for crop production only, by using the measure of a Land Use System: Labour Index and Disposable Income.

The influence of technology on the Land Use System was examined by using a variety of crops, in one climatic area, at different technological levels. The author assembled seven technological levels from the available data and examined the changes which occurred for each crop with advances in five of these levels.

The Disposable Income was found to increase with each advance in technological level, except with movement from a recommended animal - traction operation to a less than recommended mechanized operation. Not all crops showed a marked response to mechanization.

Those crops which require a great deal of hand labour at all levels were responsive to the application of agricultural chemicals, and when chemicals were applied in an animal - traction operation, little change occurred with movement into a mechanized operation.

The Labour Index showed a marked increase with the application of chemicals and increased land preparation in an animal - traction operation and a sharp decline from there into a mechanized operation. The smallest changes between levels are for those crops requiring a great deal of hand labour at all levels. The only crop showing an increase in labour with an increase in mechanization is potatoes. This increase corresponds to increases in yield which still require hand labour for harvesting.

The nature of farm operations was found to change between levels, since additional land preparation and more agricultural chemicals characterized the higher levels. This increase corresponds to a marked decrease in labour requirements, for those crops which can be mechanized.

Productivity Ratios followed the predicted pattern by increasing with each advance in technological level except for potatoes which dropped in a less than recommended mechanized operation.

The Wood categorization of technological levels describes the Rudimentary Level as using hand labour and/or animal - traction with ineffective use made of agricultural chemicals. The Sub-Technified category uses both machinery and chemicals with some

effect. No allowance has been made, therefore, for machinery and chemicals to be used without an appreciable effect, or for a highly productive hand labour/animal-traction operation.

The author re-defined the Wood categories of technology and subdivided the Rudimentary level. These divisions are briefly outlined below:

Rudimentary I: The use of hand and/or animal traction with little or no use of agricultural chemicals.

Rudimentary II: The use of hand and/or animal traction with effective use of agricultural chemicals.

Sub-Technified: The use of rented machinery and agricultural chemicals in a less than recommended manner.

Technified: The effective and recommended use of agricultural chemicals and rented machinery.

Highly Technified: The effective and recommended use of agricultural chemicals and owned machinery.

Using all available data, the range as a percentage of the average was calculated for each category. By subdividing the Rudimentary level, the range was reduced from 98 per cent for the Labour Index to 40 per cent, and from 110 per cent for the Disposable Income to 64 percent. The revised categories, therefore, represent an improvement on the Wood Classification.

Since it was not possible to examine the seasonality of production, the temperature and rainfall were analyzed as it affected single crop production. For a variety of crops, in a number of climatic areas, the Disposable Income and Labour Index were calculated for comparison purposes. Throughout the climatic areas, each crop was at the same general technological level.

Wood assumed that temperature was not an important factor in determining a Land Use System. From the examination of fifteen crops, this was found to be a valid assumption since the range in Disposable Incomes was small even for those eight crops which did exhibit some indication of a pattern. The author did not feel a range of 33 per cent necessitated complicating the classification with yet another component.

Wood also assumed the total rainfall variations were not important within a moisture category. For those crops found in Tropical areas, the Disposable Income and Labour Index were examined for two rainfall categories for each crop. No single pattern could be established in any area. This lack of pattern would indicate the validity of the assumption that total rainfall can be ignored within a moisture category.

The balance of labour between wet and dry areas was examined in the breakdown of labour requirements to determine whether additional labour was required for harvesting and weeding in wetter areas. Total labour requirements had not been found to consistently increase with rainfall. The average of the range as a percentage of the average figure was 21 per cent for weeding and 15 per cent for harvesting. If labour operations do balance between wet and dry areas, it is not in any single operation.

Irrigation requirements were assumed by Wood to balance with other tasks in wet areas. The data for irrigated crops was limited, but the author suspects from that which was available, that the

classification should be modified to indicate an irrigated operation because it can require considerably extra labour.

The author was not satisfied with the crop grouping of the Wood Classification. The Labour Index and Disposable Income were calculated for crops in Tropical and Temperate climatic areas. These figures were examined for similar response patterns to determine a valid grouping.

Wood had combined Tropical grains and other annuals and Tropical tree fruits and roots. By separating both of these the range was reduced from 72 per cent for Labour Index to 27 and 35 per cent for grains and other annuals respectively, and from 60 per cent to 15 and 14 per cent for tree fruits and root crops respectively. For Disposable Income, the range was reduced from 108 per cent to 1 and 61 per cent for grains and other annuals, and from 114 per cent to 54 and 26 per cent for tree fruits and root crops respectively.

Since the range is considerably reduced by making the Tropical group four-fold, this separation represents an improvement to the classification. Furthermore, the author suggests that "other annuals" be changed to read "legumes and corn" since it is a more accurate indication of the crops involved.

Wood combined all temperate crops. The range of this combination is 116 per cent for Labour Index and 178 per cent for Disposable Income. By separating temperate crops, these ranges become for Labour Index, 17 per cent for grains, 35 per cent for legumes and corn, and 6 per cent for root and vegetable crops.

A fourth division should be made for specialty crops, such as pyrethrum, which are not similar in response.

The author also suggested that the classification be modified to include an indication of areas of perennial crops where an other-than-standard ratio occurs between productive and unproductive areas. Evidence was given in the study of the wide variations that can exist in both Labour Index and Disposable Income for the different stages of growth.

Horticultural areas were designated by Wood as a separate Land Use Type on the basis of 150 man days per hectare, irrespective of climatic area. The author examined a variety of horticultural crops in a number of climatic areas and found this a valid assumption. Disposable Income, however, should be given no upper limit in this Land Use System because of the wide range found.

The foregoing summary indicates that the following Land Use Types respond differently in any given climatic area:

1. Tropical:
   (a) grains
   (b) legumes and corn
   (c) tree fruits
   (d) root crops

2. Temperate:
   (a) grains
   (b) legumes and corn
   (c) root and vegetable crops
   (d) specialty crops

3. Horticultural

Variations in temperature do not affect the Land Use System of each type, nor do variations in total rainfall within a single crop moisture category.

The second assumption examined in this paper was that much of the information required to determine existing Land Use Systems can be obtained from aerial photographs.

Eight sets of photographs were acquired from the Instituto Geografico Militar in Ecuador and interpreted to determine areas of agricultural homogeneity. These areas were thought to be distinct Land Use Systems. The agricultural units were classified according to the Wood Classification.

To measure the accuracy of the aerial photograph interpretation, a questionnaire was drawn up to be answered on farms which were typical of each area. Through the Ministerio de Agricultura and the Instituto Geografico Militar, the areas of photograph coverage were visited, boundary lines verified and farm data collected.

Using the original farm data the agricultural units were re-classified if necessary following the calculation of Labour Index, Disposable Income and Productivity Ratio.

In this study only three examples are used to illustrate the procedure and problems. The greatest problems in interpretation were encountered in the identification of actual crop type, use of uncleaned land, undifferentiated livestock and cattle raising areas, and areas of hog and poultry production.

A reasonable degree of accuracy was possible for the five main Land Use Components:

1. The proportion of the total area developed.
2. The general land use emphasis.

3. The seasonality of production.

4. The specific items or groups of items produced.

5. The level of technology used in production.

With additional experience, and photographs of a larger scale, the degree of error could be greatly reduced. Only a limited amount of field work would be necessary in most areas.

(B) Conclusion:

The level of technology, as a component determining a Land Use System, must be included in the classification since it greatly alters the economic output and labour requirements in any given area.

The seasonality of production is the most important aspect of climate in determining the characteristics of any Land Use System. Variations in temperature and rainfall within the moisture category is not significant.

All Tropical and Temperate crops do not respond similarly in their economic productivity, and their labour requirements. Both of these groups must be subdivided to more accurately define a Land Use System.

Most of the information required to map an area according to the Wood Classification can be acquired from aerial photographs. For complete accuracy in determining the nature of the Land Use Systems, which have been delimited on the photographs, some field investigation is necessary.

Throughout this study, the Land Use System, which is the basic unit of the Wood Classification, was found to clearly reflect the economic productivity of an area and the level of employment which any form of land use can maintain.

APPENDIX "A"

ORIGINAL FARM DATA FROM ECUADOR

ORIGINAL FARM DATA FROM MACHACHI

FARM A

Size:

800 Hectares

2/3 is rented and brings in 160,000 sucres/year.

Crops:

1.	wheat	150 hectares
2.	barley	100 hectares
3.	potatoes	50 hectares
4.	horse beans	20 hectares
5.	pasture	250 hectares
	Total	570 hectares

(calculations done for farm size of 570 H.)

Production:

1.	wheat 50-60 qq./H. @90 sucres (of this 30 qq. consumed on farm)	810,000
2.	potatoes 400-500 qq./H. @30 sucres (of this 60 qq. consumed on farm)	750,000
3.	barley 50-60 qq./H. @80 sucres (of this 30 qq. consumed on farm)	480,000
4.	170 milking cows 50 dry 50 young cows 20 horses 80 sheep 2 oxen 85 heifers	

Milk:

2,000 litres of milk/day at 1.74 sucres	1,270,200
(if use figures from Cayambe of 353,155 litres/day	614,489)

Meat:

a.	85 young bulls a year at 150 sucres	12,750
b.	old animals 20-25/year	
	3 sucres/lb. 700-800 lbs.	48,000

Total production 2,715,239 sucres
(have used Cayambe's milk production)

Cost Of Production:

1.	artificial insemination	
	40-50 sucres each x 220 animals	9,900
2.	medical attention	50,000
3.	fertilizer @ 130 sucres per qq.	
	6 qq./H. wheat x 150 H.	117,000
	6 qq./H. barley x 100 H.	78,000
	30 qq./H. potatoes x 50 H.	195,000
4.	Labour:	
	10 permanent labourers at 15 sucres x 240 days[1]	36,000
	3 permanent tractor labourers @ 800 sucres x 12 months	28,800
	4 management @ 1500 sucres x 12 mo. 1000 sucres x 12 mo. 600 sucres x 12 mo. 450 sucres x 12 mo.	42,600
	20-30 occasional labourers @ 15 sucres a day for 5 months	4,500

[1]According to the Department of Agriculture, in Machachi, men work 270 to 280 days a year. These figures are calculated for 240 days according to the information from Ing. Moncayo.

5. Seed:

wheat 323 qq. @ 80 sucres/qq.	25,846
barley 2 qq./H. @ 100 sucres/qq. x 100	20,000
potatoes 357 qq. @ 230 sucres/qq.	82,110
pasture 500 sucres/H. over 5-10 year period	12,500

6. Additional Costs: (from Cayambe farm data)

maintaining equipment	36,000
gasoline and oil	48,000

Total Production Costs: 674,350

(not including labour)

Disposable Income:

Total production	2,715,239 sucres
Total costs	674,350 sucres

2,040,889 sucres/570 Hectare
or
$U.S. 170.50/Hectare

Labour Index:

10 permanent labourers	2400 days
3 permanent tractor labourers	810 days
4 management	1080 days
20-30 occasional for 5 mo.	2200 days[2]
12 milking women	1092 days[3]
	7582 for 570H
	13.3 days/Hectare

[2]If a permanent worker works 270 to 280 days a year, then an occasional worker has been estimated to work 22 days a month.*

[3]According to the Department of Agriculture, women milkers in Machachi work 4 hours a day (mornings only), 7 days a week. This counts as .25 of an adult male's labour day. Where irrigation is carried on, women may spend an additional 2 hours cleaning which would total a 6 hour day with the milking.*

*Information provided by Ing. Agronomo Luis Cornejo of I.E.R.A.C. (1971).

Productivity Ratio:

12.82 $U.S. per work day.

ORIGINAL FARM DATA FROM MACHACHI

FARM B

Size:

130 Hectares

10 hectares are valueless

all irrigated with natural and artificial irrigation

Crops:

all pasture

Production:

143 milking cows
28 Dry
25 heifers
80 young
5 horses

produce 1600 litres of milk a day of which (200 is used on the farm).

1.	1600 litres day @ 1.75 sucres x 365	1,022,000
	or for 1400	912,500
2.	sell 40-50 bulls a year @ 150 sucres	7,500
3.	sell of old cattle for meat $\frac{\text{herd of cows}}{12}$	
	$\frac{143}{12}$ x 2,500 sucres	30,000
Total production	for 1600 l/day	1,059,000
	for 1400 l/day	950,000

Cost of Production:

1.	buy skim milk for 80 calves @ 120 litres per day @ .70 sucre/litre	30,660
2.	medical attention	100,000
3.	artificial insemination	15,000
4.	Pasture Maintenance:	
	a. fertilizer 2qq./H. every 6 months @ 130 sucres/qq. (2 x 130 x 2 x 120)	62,400
	b. seed (every 3 years when the pasture is old for each hectare)	
	20 lbs. alfalfa x 20 sucre/lb. 10 lbs. clover x 20 sucre/lb. 80 lbs. rye grass x 600 sucre/qq. x $\frac{120H}{3YRS}$	
	Total maintenance cost	251,260

Disposable Income:

for 1600 l./day	$296.06/H.
for 1400 l./day	$255.95/H.

Labour Index:

34.7 man days/H.

Productivity Ratio:

$7.31 - $8.46 per man day.

ORIGINAL FARM DATA FROM MACHACHI

FARM C

(These calculations do not include the farmers cheese productions).

Size:

1 Hectare

level

no irrigation

Crops:

1. corn and beans ½ Hectare
2. pasture ½ Hectare

Production:

1.	corn - total 30 qq. @ 50 sucre/qq.	1500
2.	beans - total 5 qq. @ 150 sucre/qq.	750
3.	2 young cows - non productive	
	11 pigs - 7 sold a year at 400 sucre each, but will use here only 4 (as in other 1-4 H. farms) because he is feeding them milk from his cheese production.	
	4 @ 400 sucres	1600

8 chickens 2 burrows 6 rabbits 15 guinea pigs	home consumption	
	Total production	3850

Cost:

1. fertilizer 65 sucres
2. seed - corn 50 sucres
   beans 30 sucres
3. insecticides 10 sucres
4. oxen for 4 days @ 30 sucres/day 120

Total cost 275 sucres

Disposable Income:

$170 U.S./H/year.

Productivity Ratio:

$4.25 U.S. per hectare per year.

Note On Labour:

Child of less than 10 years counts for nothing

Child from 10-12 years counts for $\frac{1}{4}$

Child from 16-18 years is an adult

Source: Ing. Agronomo Luis Cornejo at I.E.R.A.C.

ORIGINAL FARM DATA FROM GUAYLLABAMBA

FARM D*

Size:

4 hectares — 10-20% level, 30% unusable

30% of farms are owned

30% pay ½ of harvest for land

40% are rented

500 sucres/H/year for land
350 sucres/year for water

for purpose of illustration we will assume the farm is rented and is irrigated

(40% of the farms here are irrigated)

Crops:

1. beans — 1 Hectare
2. corn — 2 Hectares
3. potatoes — ½ Hectare
4. alfalfa — ½ Hectare

Production:

1. corn — 10qq./H. 20qq. (sell 20%) at 50 sucres/qq. 2000
2. beans — 15qq. (sell 20%) at 150 sucres/qq. 4500
3. potatoes — 25qq.(½H.) (sell 60%) at 50 sucres/qq. 2500
4. alfalfa — 350qq./H./yr. 175 @ 5 sucres/qq. x 4 cuttings 3500

in addition:

10 chickens - sometimes sells eggs

Total production	12,500 sucres

1 cow - farm use
15 guinea pigs - farm use
10 rabbits - farm use
20-30 sheep - sell 3 lbs. wool a year from each at 5 sucres/lb. 450
6 pigs - sell every 15 months for 400 sucres profit each (about 4 a year) 1,600

Total production	14,550 sucres

Labour:

family

works 5 days on large farm, 2 days on small farm

corn requires	(40 days/H./yr.(2 crops))	160
potatoes	(30 days/H./yr.)	30
alfalfa	(40 days/H./yr.)	20
beans	(40 days/H./yr.)	80
Total		290 days

Cost Of Production:

(Does not include rent of 2,000 sucres/yr.)

1. water 350
2. fertilizer 260 (20% fertilized with 2qq./H. @ 130 sucres/qq.)
3. pesticides 500 (on potatoes)
4. seed

beans	60 x 2	120
corn	50 x 2 x 2	200
potatoes	100	100
Total		420

5. alfalfa cuttings 3,500

Total cost 5,030 sucres

Disposable Income:

$U.S. 113.33 per H./year.

Labour Index:

72.5 days/H./years

Productivity Ratio:

$U.S. 1.55 per M.D.

*The information for this farm was obtained from the agricultural specialist for the area. It is considered typical of all farms.

ORIGINAL FARM DATA FROM GUAYLLABAMBA

FARM J

Size:

12 Hectares

all is level

all is irrigated

Crops:

1. cucumbers 1 H.
2. red peppers ½ H.
3. alfalfa 2½ H.
4. babaco 2 H.
5. watermelon 2½ H.
6. rest preparing

Production:

1.	cucumber	20,000 sucres/H.	20,000
2.	red peppers	20,000 sucres/H.	10,000
3.	alfalfa 230 qq. x 4 cuttings @ 5 sucres qq. x 2.5 H.		
4.	babaco	60,000 sucres/H.	120,000
5.	watermelon	50,000 sucres/H.	125,000

5 cows - young - no production

15 rabbits - owner gets them

Total production 286,500

Cost Of Production:

1. Rent (not included in production costs for D.I.) — 25,000 sucres/year
2. Fertilizer 50qq. @ 130qq. — 6,500
3. pesticides (one year) — 6,000
4. labour - 8 permanent @ 15 sucres/day - 6 days/week — 37,440
   (not included for D.I.)
5. seed

alfalfa	1800	(this does not include babaco plantation establishment which occurs every 2 years.)
watermelon	625	
peppers	125	
cucumber	150	
Total	2700	

6. Feed:

   Alfalfa 11,500

7. Babaco costs - 15,000 x 2 — 30,000

Total Costs:

(not including rent and labour)

56,700

Disposable Income:

$876.62 U.S. / H. / year

Labour Index:

208 days / H. / year

Productivity Ratio:

$4.21 U.S. per Man Day.

ORIGINAL FARM DATA FROM GUAYLLABAMBA

FARM I

Size:

2 H.

all avocadoes with other fruits in between

income from the avocadoes, rest home use

10% is steep land

all irrigated

Costs:

1.	fertilizer	130 sucres
2.	pesticides	2,000 sucres

Labour:

1. one premanent - 240 days per year
2. 2 family workers 7 days a week

   (2 x 7 x 52 728 days)

Production:

1.	from avocadoes	12,000 sucres
2.	2 pigs @400 sucres ea.	800
3.	80 eggs day @80 eggs x 365	23,360
4.	80 chickens year @ 40 sucres	3,200
	Total Production	39,360

Disposable Income:

$ U.S. 886. per hectare

Labour Index:

485 days/hectare/year

Productivity Ratio:

$ U.S. 1.83

Notes:

1. 2 pigs - sell when fat for 500-600 sucres, usually at 15 mo.
2. has 118 chickens - sells eggs - 70% of hens are laying or about 80 eggs/day @ .80 each egg.
3. 30 guinea pigs - but only for home consumption are worth 12 sucres each.

ORIGINAL FARM DATA FROM GUAYLLABAMBA

FARM K

Size:

1 hectare or less

Crops:

1.	seed 1qq. @ 50 sucres	50
2.	oxen for preparing land (3x20)	60
		110

Production:

1.	5 qq. of corn at 50 sucres	250
2.	2 pigs at 400 sucres each	800
		1050

in a good year

12 qq. @ 50	600
(pigs)	800
	1400

Labour:

by family who work 1 day week on farm and rest of time in city

50 days for corn

14 days for pigs

64 days/H./year

Disposable Income:

$ U.S. 44.80 to $ U.S. 61.30

Productivity Ratio:

$ U.S. 1.76 to $ U.S. 2.45

ORIGINAL FARM DATA FROM GUAYLLABAMBA

FARM O

Size:

1 Hectare - All corn

Costs:

1.	Seed $1\frac{1}{2}$ qq. @ 50 sucres/qq.	75 sucres
2.	Oxen 3 days @ 30 sucres /day	90 sucres
		165 sucres

Production:

1.	20 qq. of corn @ 50 sucres (one $\frac{1}{2}$ is sold)	1000	
2.	10 chickens sold a year @35 sucres - 40 sucres	350 - 400	
3.	3 pigs a year at 3 sucres/lb. buy for 100 and sell for 500 sucres	3x400	1200
		2550	2600

Labour:

1.	hilling and weeding 1 day each	2
2.	harvesting - 10 M.D.	10
3.	preparing land with oxen	3
4.	planting by hand 1 day	1
		16 days
5.	consider 7 days/year/pig	21 days
	Total	37 days/H./year

Disposable Income:

$ U.S. 113.50/H./year

Productivity Ratio:

$ U.S. 3.07/M.D.

1. some farms in this area are 2 - 3 Hectares
2. corn not grown every year - sometimes peas and potatoes (individual preference)
3. owns land - all level - fertilizer from pigs
4. no irrigations - even a shortage of drinking water
5. farmer works in Quito 6 days/week
6. owns 20 chickens

ORIGINAL FARM DATA FROM GUAYLLABAMBA

FARM H

Size:

500 H.

50 are level

104 have crops and are irrigated

100 are useless because it is too steep

Crops:			And
1.	alfalfa	20 H.	20 milk cows
2.	tomatoes	4 H.	18 young cows
3.	fruit	80 H.	10 heifers, 8 horses

Production:

1. chirimoya and fruit @ 10,000 sucres H./year
   (avocadoes are not producing yet)
   (10,000 x 70) 700,000 sucres

2. tomatoes, 2,000 boxes of 50 lb. boxes

   @ 30 sucres /box (2,000 x 30 60,000 sucres

3. alfalfa (all consumed on farm)

   (300 qq. x 4 cuttings per H. @5 sucres/qq.)

   (this had not been added in because it would have to be taken away in costs)

4. milk 120 litres day @1.75 sucres/litre 210 sucres/day
   or 76,650 sucres/year

Total 836,650 sucres/year

Costs:

1.	Fertilizer - 200 qq. @ 130 per qq.	26,000
2.	Pesticides	2,000
3.	Seeds - tomato 1 lb. per hectare @250 sucres	1,000
	alfalfa (50 lbs. H.) @ 1 lb.	1,000
	avocadoes @ 10 sucres each 156 trees/H. 10 hectares	15,600
4.	Medicine - cows	3,000
	Total Cost	48,600 sucres

Disposable Income:

$ U.S. 361.00 per hectare

Labour Index:

50 permanent at 15 sucres/day for 240 days
15 occasional at 15 sucres/day for 240 days
150 days/H./year — 15,600

Productivity Ratio:

$ U.S. 2.40/workday

ORIGINAL FARM DATA FROM SOUTH OF SANTO DOMINGO

FARM N

Size:

270 H.

240 bananas (400 plants per H.)

30 waste

Production:

700 packages a year per H. @ 1 sucre

Profit 168,000 sucres profit

Cost Of Production:

11 sucres per package 1,848,000 sucres

this includes labour:

40 permanent @ 30 sucres - 75 sucres/ day $5\frac{1}{2}$ d/wk. 440

40 - 50 occasional $5\frac{1}{2}$ d/wk. x52 22,880

assuming an average cost of 40 sucres/labour day

22,880 days x 40 sucres 915,200 labour cost

production costs 1,848,000

labour costs 915,200

932,800 production costs less labour

Disposable Income:

$ U.S. 215/H.

Labour Index:

95 days per hectare per year

Productivity Ratio:

$ U.S. 2.26/workday.

ORIGINAL FARM DATA FROM SOUTH OF SANTO DOMINGO

FARM P

Quevedo Road

(farm 21 km from S.D.)

Size:

50 H. - 30% has a gentle slope

Crops:

1. citrus fruit 5 Hectares
2. pasture 45 Hectares

Production:

1.	citrus profits are 10,000 sucres/H./yr	50,000 sucres
2.	beef cattle, 62 head, in a normal year would sell 30, but this farmer is raising cattle which are not mature enough yet, therefore, 8 head @ 2,000 sucres	16,000 sucres
		66,000 sucres

Cost of Production:

1.	medication for cattle @20 sucres head	1,240
2.	maintaining pasture cleaning - 80 sucres/H. fertilizer - 1 qq. @ 130	10,350
	1 M.D. to apply 20	
	(cost 2,000 sucres/H. to establish the pasture)	

for seed and labour)

3. citrus cost 10,000 sucres/year (from 1-5)

   to maintain costs 4,000/H./year after year 5

Total Cost Of Production: 11,590

Normal Year:

farmer would sell 30 cattle

Index Figures For A Normal Year:

Disposable Income: $U.S. 93.70 per hectare

Labour Index: 52.9 days per hectare

Productivity Ratio: $ U.S. 1.77 per workday

APPENDIX "B"

THE DIFFERENTIATING CRITERIA

AND THEIR SYMBOLIZATION

FOR THE

WOOD CLASSIFICATION

FIRST SYMBOL: THE LAND USE ORDER

Symbol	Meaning
I	Occupied rural land. At least 80% of the usable land is cleared and/or being used for cultivation or grazing.
II	Partially occupied rural land. Between 5% and 80% of the usable land is cleared and/or put to agricultural use. If, as seen on aerial photographs, some sections of the undeveloped area have the patchy appearance indicating former piecemeal land clearance and abandonment, such sections are less than 50% as extensive as the cleared areas.
III	Areas of shifting cultivation. Between 5% and 80% of the usuable land is cleared. Within the uncleared land, an area at least half as extensive as that presently cleared, shows, on air photos, evidence of former use for shifting cultivation.
IV	Uncleared land. Less than 5% of the usable land is developed.
V	Cleared Non-agricultural land.
Note:	In Land Use ORDERS of Categories, I, II, and III, the extent of non-agricultural land should be estimated as a percentage of the total area (correct to the nearest 10%). If the percentage is 15% or more, an integer should be placed in the form of a superscript attached to the ORDER Symbol. The integer will represent the percentage of non-agricultural land as a multiple of 10%; e.g. "2" will indicate 15% - 25%; "3" will represent 25% - 35% and so on.
	Non-agricultural land is taken to include urban land, land used for military purposes or mineral exploitation, wooded land (grazed or ungrazed; small patches may also be devoted to cultivation, but not more than 5% of the total area), and undeveloped areas of natural grassland. The latter are defined as grassland areas which have not been subdivided into holdings used for grazing, which have no fences or organized water supply, and which have not been grazed sufficiently to produce any significant change in the natural vegetation cover. Some cattle or other livestock may, however, be present.

SECOND SYMBOL: THE LAND USE GROUP

Set A. Agriculture and Livestock Raising.

A symbol from the set must follow every Land Use ORDER symbol of categories I, II, III.

Symbol	Meaning
A	General Agriculture. Over 50% of the cleared land is planted with crops at some single period during the year. No specialization, as specialization is defined under "D" and "S" below.
D	Semi-specialized Agriculture. Over 50% of the cleared land is in crops; 50% to 80% of the crop land is devoted to one of the specialties listed under "Land Use Types" below.
S	Specialized Agriculture. Over 50% of the cleared land is in crops; over 80% of the crop land is devoted to one of the specialties listed under "Land Use Types" below.
M	Crop and Livestock Farming. Between 10% and 50% of the cleared land is planted in crops. The remainder is used for grazing.
G	Livestock raising. Less than 10% of the cleared land is in crops. The remainder is used for grazing.

Set B. Uncleared Land.

A symbol from this set must follow every Land Use ORDER symbol of category IV.

Symbol	Meaning
none	Available for development
R	Recreational reserve
T	Military reserve
W	Watershed protection area
F	Forest reserve
N	Wildlife reserve
X	Reserved for reasons other than those specified.

Set C. Cleared Non-agricultural land.

A symbol from this set must follow every Land Use ORDER symbol of category V.

Symbol	Meaning
U	Urban Land
Z	Mineral exploitation
Y	Unspecified non-agricultural uses

THIRD SYMBOL: THE LAND USE SERIES

Set A. Moisture Conditions

A symbol from this Set must follow every Land Use GROUP symbol of Set A.

Symbol	Meaning
0	Moisture is insufficient for a reliable harvest of any quick-growing annual crop. Cattle grazing is only seasonal.
1	Moisture is sufficient for a reliable harvest of some quick-growing annuals. All-year low-density cattle grazing.
2	Moisture is sufficient for two successive crops of quick-growing annuals and for many drought-tolerant perennials. All-year moderate density cattle grazing.
3	No significant seasonal moisture deficiency.

Set B. Vegetation in Uncleared Areas

To be used where the Land Use ORDER is of Categories II, III, or IV, and to appear as the first symbol in the Denominator of the Fraction.

Symbol	Meaning
T	Tall evergreen broadleaf trees. Main crown canopy more than 30m. above the ground.
M	Medium evergreen broadleaf trees and tall semideciduous trees. Main crown canopy more than 20m. above the ground.
L	Low or medium semidecidous trees. Main crown canopy more than 10m. above the ground.
R	Scrub. Low trees and shrubs under 10m. tall.
E	Pine Forest. More than 50% of the trees are pines; crown cover over 50%.
Y	Palm Forest. More than 50% of the trees are palms; crown cover over 50%.
V	Mangrove Forest, plus associated lagoons and salt flats.
C	Low xerophytic forest; trees over 3m. high; vegetation height under 3m. or ground cover under 80%.
X	Semi-dessert. Xerophytic scrub and cacti; vegetation height under 3m. or ground cover under 80%.
B	Barren. Rocky, saline, desert or eroded areas; ground cover less than 10%.
S	Savanna. Natural grassland with widely spaced trees. Crown cover less than 50%.
P	Paramos. Mesophytic and hygrophytic shrubs and grasses.
W	Marsh. Grasses and reeds; may be dry in the dry season.

Where desirable, past modifications in the vegetation cover may be indicated by the addition of a numeral using the following code:

1	Cut-over for valuable species
2	Modified by selective planting
3	Recently burned or heavily cut-over
Note:	Where the natural vegetation is of two very different types in close association, use two Land Use SERIES symbols of Set B separated by a slash mark "/".

FOURTH SYMBOL: THE LAND USE TYPE

Set A. One of the following symbols to follow the SERIES symbol in Land Use GROUPS A and M, or to be placed, if appropriate, directly after ORDER symbol IV.

Symbol	Meaning
g	General tropical crops; emphasis on grains and other annuals.
f	General tropical crops; emphasis on roots and tree fruits.
h	Horticultural crop emphasis.
t	Temperate crop emphasis.
Note:	if Type g occurs in GROUP M, the TYPE symbol may be omitted.

Set B. One of the following symbols must follow the SERIES symbol in Land Use GROUPS G and M, or may be placed, if appropriate, directly after ORDER symbol IV.

Symbol	Meaning
c	Cattle raising, undifferentiated.
b	Beef cattle breeding.
e	Beef cattle fattening.
d	Dairying.
s	Sheep raising.
x	Goats and donkeys.
u	Livestock undifferentiated.

Note: If TYPE c or u occurs in GROUP M, the TYPE symbol may be omitted. If, in GROUP M, TYPE symbols appear from both of sets A and B, they should be placed in the order of relative importance of the activities they represent.

Set C. One of the following symbols must follow the SERIES symbol in Land Use GROUPS D and S.

Symbol	Meaning	Symbol	Meaning	Symbol	Meaning
ag	Agave	co	Cotton	ru	Rubber
ba	Bananas	ct	Citrus	sc	Sugar cane
cc	Cacao	lg	Lemon grass	sf	Sugar cane and coffee
cf	Coffee	pp	Pineapples	tb	Tabacco
cn	Coconuts	ri	Rice	tf	Tree fruits undifferentiated

Note: In certain circumstances it may be desirable to use a Land Use TYPE symbol of Set B together with a TYPE symbol of Set A or Set C. If this procedure is followed, the symbols should be placed in order of importance of the activities they represent, and separated by a slash mark "/".

Set D. One or more of the following symbols to be placed in the denominator of the fraction after any SERIES symbol of Set B, (Natural vegetation type).

Symbol	Meaning
p	Removal of precious woods.
t	Removal of construction, industrial, and precious woods (if any).
f	Extraction of fuel: firewood and/or charcoal.
r	Extraction of chicle.
m	Extraction of miscellaneous roots, saps, fruits, nuts.
x	No use.

FIFTH SYMBOL: THE LAND USE LEVEL

One of these symbols must follow each Land Use TYPE symbol in the numerator of the fraction, except in Order IV. Optionally, one may also be placed after a TYPE symbol in the denominator of the fraction. If in the latter location, and the operations are under effective government control, add letter C.

Symbol	Meaning
R	Rudimentary procedures and implements used.
S	Semi-technified procedures and implements used.
T	Technified procedures and implements used.
H	Highly technified procedures and implements used.

SIXTH SYMBOL: THE LAND USE PHASE

Where a phase is recognized, one of the following symbols is placed, including the brackets, at the end of the fraction.

Symbol	Meaning
(d)	Low precipitation
(f)	Seasonal flooding
(i)	Isolated
(w)	Warm
(t)	Seasonal shortage of drinking water
(p)	Fishing an important complement to other forms of land use.

Modification to the Classification

Although the framework of the classification is complete as set out above, the listed TYPES and PHASES are, for the most part, those actually encountered in the field study upon which the classification is based. If, in the application of the classification, new TYPES and PHASES are found, they should be added to the classification, together with the appropriate symbolization.