ATLANTIC ZONE PROGRAMME

Report No. 9
Field Report 75

A STUDY ON THE SPATIAL DISTRIBUTION OF LAND USE IN THE SETTLEMENT NEGUEV

C.A. Mucher

February, 1992

CENTRO AGRONOMICO TROPICAL DE
INVESTIGACION Y ENSEÑANZA - CATIE

AGRICULTURE UNIVERSITY
WAGENINGEN - AUW

MINISTERIO DE AGRICULTURA Y
GANADERIA DE COSTA RICA -MAG

Location of the study area.

The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

PREFACE

The work presented in this report was carried out within the context of the Atlantic Zone Programme, a collaboration of the AUW, CATIE and MAG. The Programme started in 1986 and its central theme is sustainable land use. A study of the present land use and the changes in land use form an important aspect of the research.

This report is a result of a stay for 6 mnonths, from March 1991 till August 1991, in Costa Rica. The fieldwork was carried out from March 1991 till May 1991 in the Settlement Neguev, as part of a combined research topic for Tropical Crop Science and Land Evaluation.

The present report contains a methodology for interpretation of land use from aerial photographs. The land use maps made with this methodology were used to investigate the effect of various factors on the spatial distribution of the different crops in the Neguev settlement.

The work was supervised by Ir. Don Jansen, who joined the Programme in March 1991. From Wageningen the work was supervised by Dr. Louise Fresco and Ir. Theo Guiking, Department of Tropical Crop Science and by Dr. Johan Bouma, Department of Soil Science and Geology.

SUMMARY

The aim of the study was to clarify which factors influenced the spatial distribution of the land use in the Neguev settlement. Land use maps (1:10 000) for 6 sample areas in the Neguev settlement were produced, for the years 1989 and 1991. The soil map made by the Atlantic Zone Programme was enlarged to scale 1:10 000, for the sample areas.

The main problems for the production of land use maps were:

- many crops were cultivated on very small plots, which made aerial photo-interpretation and mapping difficult or impossible.

- especially cacao was difficult to distinguish from forest.

- farmers were difficult to brace for interviews during field checks.

- for the land use maps of 1991 field sizes and locations were difficult to estimate.

The reader has to keep in mind that the conclusions are based on the produced land use maps that are limited in their exactness by the above mentioned problems.

Main conclusions were that only a small part of the total area was used for cultivation and that at the farm level no more than about 3 hectares were used for cultivation, irrespective of the percentage of "good" soil. On the sub-regional level there existed a crude relationship between soil type and land use. Infrastructure had only such an influence that forest and wasteland were found in the remotest parts of the farm. In the last two years silvo-pasture and pasture diminished in area by five percent, due to change into annuals and perennials. It was striking that palmheart increased its acreage with fifty percent in the last two years, all gained on cacao and (silvo-) pasture.

TABLE OF CONTENTS

LIST OF FIGURES, TABLES AND MAPS

1. OBJECTIVES AND HYPOTHESES OF THE RESEARCH

1.1. Introduction

The Atlantic Zone Programme aims to complete a MGLP model to generate sustainable alternatives for the present land uses, executed on different system levels. The system levels used for analysis and observation are:

-the land use system (LUS)
-the farm system (FS)
-the regional system (RS)

My research is thereby concentrated on the sub-regional level.

As a baseline the actual land use needs to be described and the changes in land use over time. An important tool to investigate the land use and the changes in land use is formed by aerial photographs. An idea of the different land uses can be obtained by the different photo characteristics like pattern, tone and height, recognizable on the photographs.

Also in the context of rural surveys it is important to have an idea of the factors that play a role in the spatial distribution of the present land uses. Aerial photographs are ideal to visualize the spatial distribution of land uses. Factors like infrastructure and field size can be distinguished on aerial photographs.

When a detailed soil map is available it is possible to look at the influence of the different soil types and topographies on the spatial distribution of the existing land uses. More specifically one can look at the influence of the different soil characteristics on the distribution of the present land use.

As stated above the VF Research Programme of the Atlantic Zone Programme has the objective to develop a methodology for defining alternative scenarios for sustainable land use. Until now most students of the Atlantic Zone Programme have been working in the Rio Jiménez and Neguev area. For these areas alternative scenarios for sustainable land use have to be found, regarding the VF research Programme.

Of both areas aerial photographs (1989, 1:10.000) are available. Only for the Neguev area there is a detailed soil map ,1:20.000 (De Bruin, 1990) and a parcel map available. Due to this it was decided to execute the research in the Neguev settlement.

The Neguev settlement is a product of an invasion organized by UPAGRA in September 1979. The Neguev settlement is localized between the coordinates 5.80 and 5.90 longitude and between 2.40 and 2.50 latitude on the cartographic maps of Bonilla (IGN, 1967) and Guácimo (IGN, 1990), in the province of Limón (Oñoro, 1990). See also chapter 2.

1.2. Material used

The following material and data were available that made the objectives realistic:

-A parcel map (Plano Mosaico del Proyecto Neguev) of the Neguev Settlement on the scale 1:20.000 produced by ITCO (IDA) in November 1981.

-A soil map (De Bruin, 1990) of the Settlement Neguev on the scale 1:20.000 produced by the Atlantic Zone Programme.

-Aerial photographs of the Settlement Neguev on the scale 1:10.000 of the year 1989. Photographs used:

Area	photo number
La lucha	46405 R261 L2
	46404
	46406
Matas CR	45030 R256 L5
	45029
	45031
Mascota	45001 R256 L6
	45000
	45002
Silencio	45067 R256 L6
	45066
	45068
El Peje	45027 R256 L5
	45026
	45028
Milano	45032 R256 L5
	45031
	45033

1.3. Objectives

On the regional system level of the VF Programme one is interested in spatial relationships between soil types, cultivations and farm types. The central question of my research would be:

Which factors influence the spatial distribution of the land use in the Neguev settlement ?

For the analysis of the spatial relationship between different crops and soil types it is necessary to have a detailed soil map and a detailed land use map of the same area. Due to non-existence of a detailed land use map of the settlement Neguev the following became the first objective:

-1 The production of land use maps (1:10.000) for several sample areas in the Neguev settlement for the year 1989. The year 1989 was chosen because the aerial photographs (1;10.000) were taken in spring 1989. To check the interpretations from the photographs, farmers were interviewed (March-May 1991). Since it was then also feasible to check the present land use it became also an objective to produce land use maps for 1991 for the same sample areas. This leads to the second objective.

-2 To quantify the changes in land use from the period March 1989 to March 1991. This because the Neguev settlement is a relatively new area and changes in land use occur rapidly.

-3 To produce a small manual as a guide in aerial photo-interpretation. This manual describes the different photo characteristics of the different crops to recognize the land uses in the Neguev.

-4 To quantify the influence of various factors (soil type, infrastructure) on spatial distribution of the different crops in the Neguev settlement.

As said before one is interested in the relationship between the different land uses and soil types, but it is possible that there is no clear relationship between those two and that the spatial distribution of the land use is more influenced by for example infrastructure.

1.4. Hypotheses

Hypotheses on photo interpretation

1-a Most crops that appear in the Neguev settlement are recognizable on aerial photographs.

1-b There is a relationship between field size and crop. Thus field size gives information to identify the crop in a specific field. One expects that the subsistence crops e.g., pumpkin and beans, and intensive (high input) land uses e.g., pineapple, are only found on small fields and that the extensive land uses (low input) such as pasture and forest are only found on large fields.

1-c It is possible to describe a land use by means of photo characteristics so that a land use can be recognized by its features.

Hypotheses on changes in land use

2 In the last two years (1989-1991) some of the forest will be changed in silvo-pasture and some of the silvo-pasture into pasture. Some forest, silvo-pasture and pasture will be changed into annuals or perennials. It is expected that there is an intensification, i.e. from forest into silvo-pasture, from silvo-pasture into pasture and from pasture into crops in the Neguev settlement.

3 The manual made for the Neguev settlement is also applicable for the regions surrounding the Neguev.

Hypotheses on spatial distribution

4-a The spatial distribution of the different crops in the Neguev settlement is mainly influenced by three soil groups: the red infertile soils, the fertile black soils and the badly drained swampy soils.

4-b Infrastructure will have little influence on the spatial distribution of land use on a sub-regional level, because the infrastructure is reasonably good in all the parts of the Neguev settlement. On a farm level annual crops will be found probably nearer to the road than perennial crops and most of the forest will be found in the remotest parts of the farm.

2. THE NEGUEV SETTLEMENT

2.1. Introduction

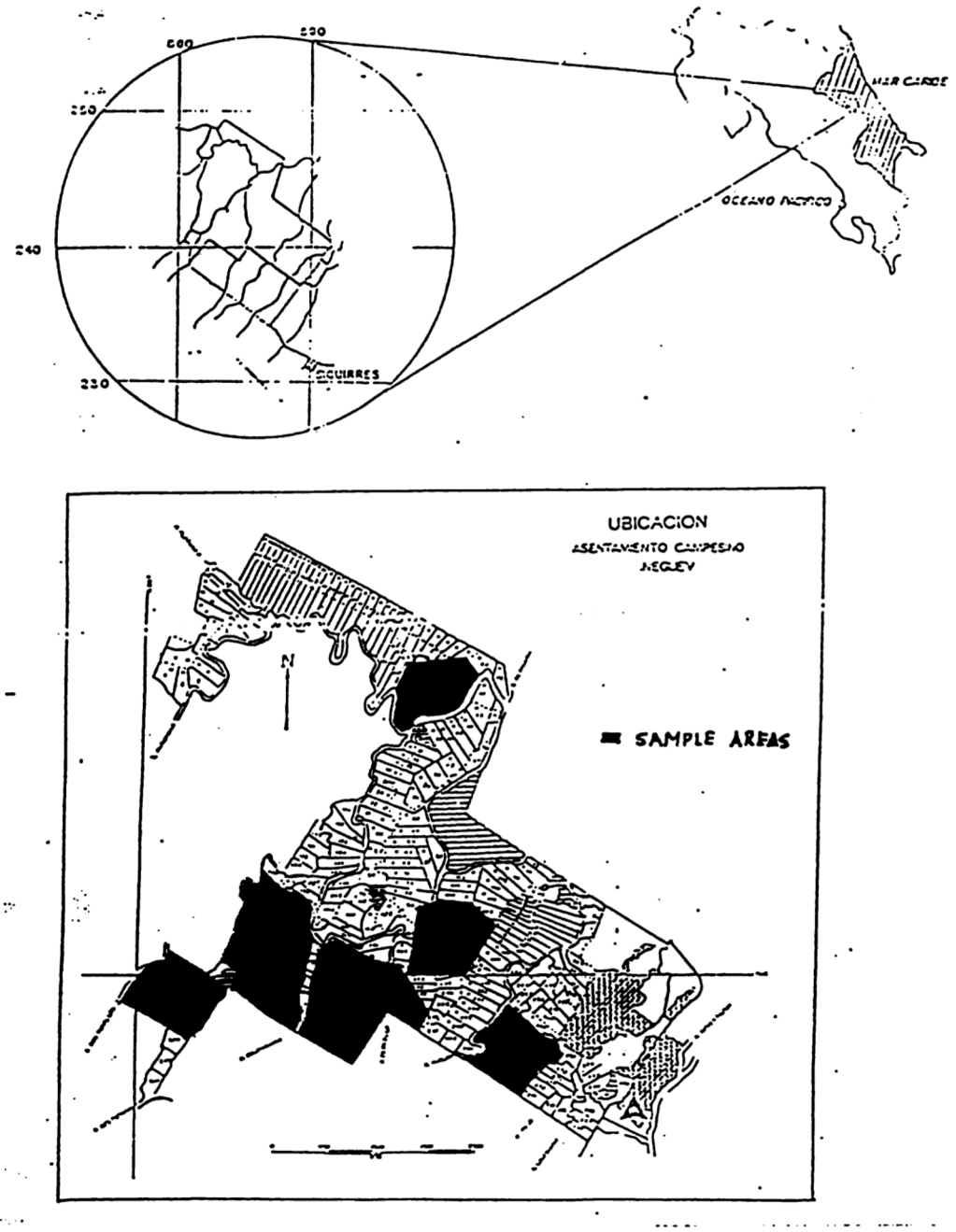
The Neguev settlement is localized in the Atlantic Zone of Costa Rica between 5.80 and 5.90 longitude and between 2.40 and 2.50 latitude on the cartographic maps of Bonilla (IGN, 1967) and Guácimo (IGN, 1990). The settlement is situated between the towns Siquirres and Guácimo, in the province Limon (see Map 2.1.). The settlement itself is surrounded by haciendas and companies like Matas de Costa Rica (ornamentals) and CODELA (Corrugados del Atlantico S.A., cajas de cartón).

The most important rivers that cross the settlement are the river Parismina in the north, the rivers Dos Novillos and Destierro in the west and river Peje in the east (see Map 2.2.).

The Neguev settlement was established after an invasion by farmers organized by UPAGRA, in September 1979. The invaded area belonged to the company named "Empresa agrícola ganadera industrial Neguev S.A.". After the conflict became clear, the institute IDA intervened to supervise the division of the "Hacienda" (Bolaños & Ulate, 1987).

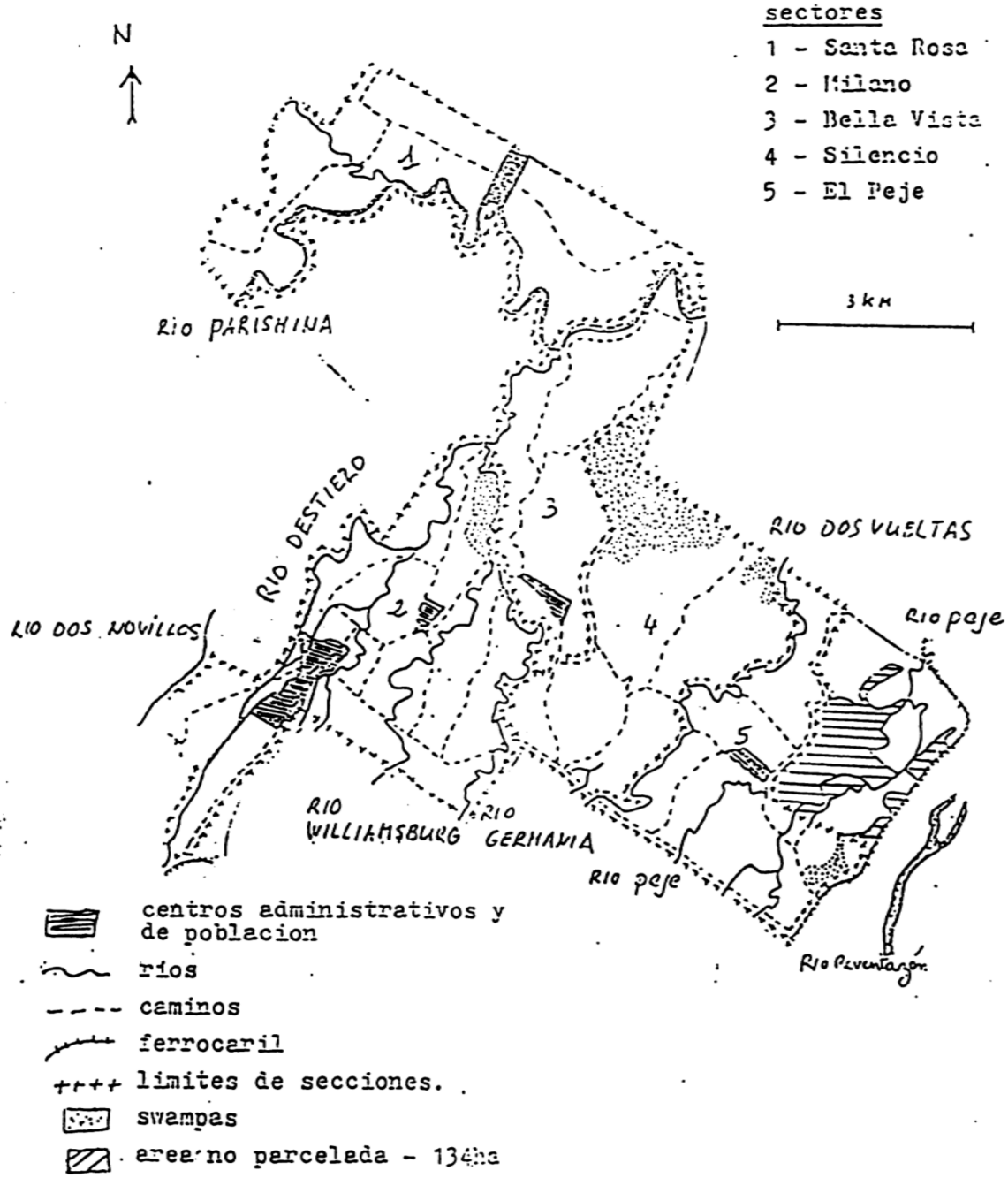
The settlement is divided into five sectors: La Lucha (Santa Rosa), Milano, Silencio, Bella Vista and El Peje (see Map 2.2.). The invasion started in the sector La Lucha after which farmers crossed the river Parismina. The settlement covers now an area of 5,340 ha with 311 farms (parcelas) with size varying between 10 and 17 ha. The sectors La lucha and Milano are less hilly than the other sectors, which are strongly dissected. In easter direction the terrain becomes not only more hilly, but the soils are also more depleted. Most badly drained swampy areas are found in the sectors Bella Vista, Silencio and El Peje. The sector Bella Vista has even a reserve (reserva forrestal) of mainly swamps. The sectors in the eastern part of the settlement are also less accessible than for example the sector Milano. The different sectors are connected by unpaved roads over many small bridges of poor quality. The sector La Lucha is isolated by the river Parismina from the other sectors of the settlement, but is easy accessible from Río Jiménez.

Map 2.1. Location of the sample areas in the settlement Neguev.



Source: unknown

Map 2.2. General map of the Neguev settlement.



Source: unknown

2.2. Climate

The climate in the Atlantic Zone is characterized by high temperatures and abundant rainfall during the whole year. In the Neguev the average rainfall is 3,666 mm. The wettest periods are in the summer months: June, July, August and in the winter months: October, November and December (see Figure 2.1. and Figure 2.2.). In the period March until May some crops like maize may even have problems with drought. The potential evapotranspiration is on average 2500 mm a year, resulting in an excess of rain of more than 1000 mm.

The relative humidity is more than 80% during the whole year.

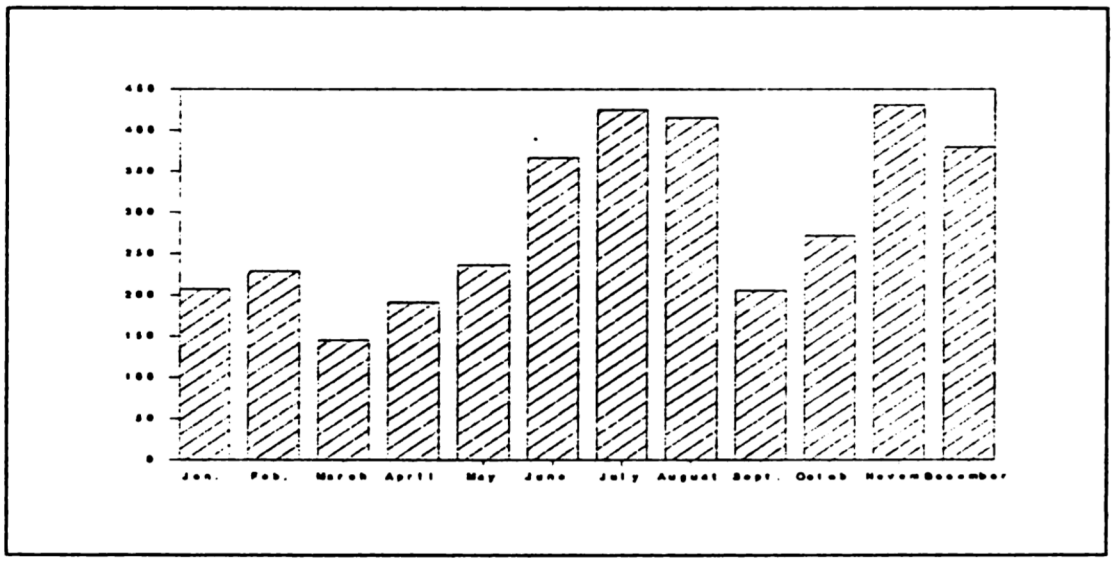


Figure 2.1 Average rainfall (mm) over the period 1977-1985 per month, corresponding to station "El Carmen"

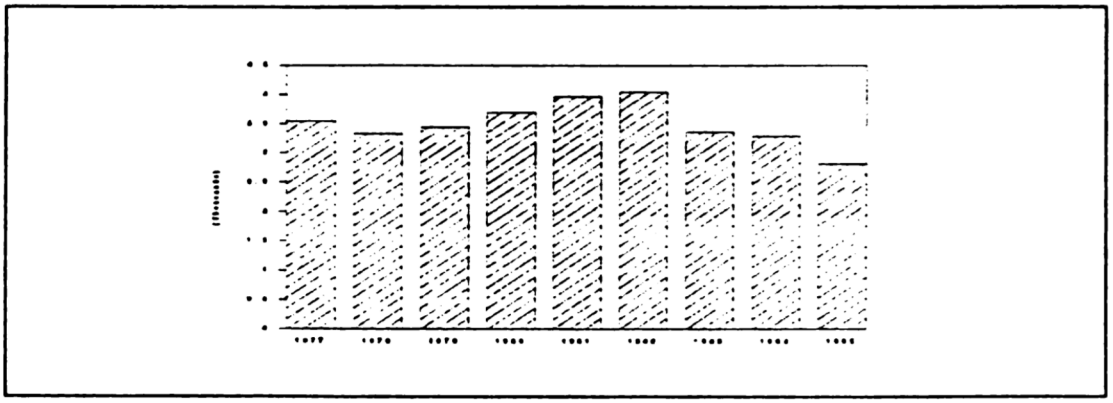


Figure 2.2 Total annual rainfall (mm) over the period 1977-1985, corresponding to station "El Carmen"

The temperature regime is reproduced in Table 2.1.

Table 2.1. The temperature regime (°C), corresponding to station "El Carmen", over the period 1973-1985;

month	max	min	med	month	max	min	med
January	29.4	19.5	23.4	July	30.7	21.4	25.2
February	29.4	19.6	24.0	August	31.0	21.4	25.7
March	30.2	20.4	24.8	September	31.7	22.0	26.0
April	30.5	20.8	25.2	October	31.2	21.7	25.4
May	31.5	21.4	26.0	November	30.2	20.6	25.0
June	30.8	21.9	25.4	December	29.2	19.9	23.8

The mean annual radiation intensity is 4.9 hours a day.

2.3 Geology and Geomorphology

The study area is situated at the northeast section of the foot of the volcano Turrialba. The volcano Turrialba forms apart of the "Cordillera Central". The smoothly undulating landscape of the Neguev is formed by lahar (volcanic mud streams) deposits of different ages, and is strongly dissected by many rivers. In most places the lahar material is strongly weathered giving clayey soils. The sediments have a fluvial origin with a great component of pyroclastic material. The deposits of the river Parismina and Destierro are the most recent and have a high mineral content, mainly due to pyroclastic material that mineralizes quickly (Oñoro, 1990).

2.4 Soils

The names of the soils are according to the soil map of the Neguev (De Bruin, 1990) produced by the Atlantic Zone Programme. The highest criterium is drainage and the second most important criterium is fertility, dividing the soils into three groups. It is assumed that drainage has more influence on the land use than fertility. The soil types are indicated with a letter for their steepness. The gradient classes are:

A	0-3 %	D	16-30 %
B	3-8 %	E	30-55 %
C	8-16 %	F	55-100 %

There are associations of soil types, like Silencio CD+U, which is a combination of the soil type Silencio with swamps. The swamps are hereby found in the vallies.

I Well drained soils

Ia Low fertility. The soil types **Milano, Neguev and Silencio**, that belong to this group, are clayey soils. Milano was formed on the most recent lahar and is less deep than the soils Neguev and Silencio. With respect to other soil types, from the Milano soil type fewer nutrients have been leached than from the other soils.
Since the mother material (lahar) was probably similar for all three soil types, soil type Milano has therefore a higher nutrient content (Nieuwenhuyse, A. , pers. comment).

The soils Neguev and Silencio are strongly acid (between pH 4-5) and many crops, especially maize, have problems to develop in these soils. In contrast, Milano, with a pH 5-5.5, is suitable for many crops. All have problems with compaction but this is most severe in the soil type Silencio, which has the lowest biologic activity. The soils are classified by the farmers as "suelos colorados".

Ib Moderate to high fertility. Other soil types belonging to the well drained soils are the soils formed in alluvial material. The soils **Dos Novillos, Rio Parismina, Destierro** and **Bosque III** all belong to this group, and have a reasonable high content of nutrients and are characterized by farmers as "tierra negra" (Oñoro, 1990).

II Imperfectly drained soils.

This group contains the following soil types: **Williamsburg, Mojado** and **Rio Peje** all with andic properties. **Dos Novillos II, Grisaceo** and **Bosque** have no andic characteristics. Characterized by the farmers as "tierra negra" or suampo, depending on the degree of imperfect drainage. This group is reasonably rich in nutrients.

III Soils with an imperfect to insufficient drainage

To this group belong the swampy areas , containing the soil type **Suampo** ("tropofibrists and tropaquents"). Also characterized by the farmers as suampo.

(De Bruin, 1988)

2.5. General land use and natural vegetation

A main feature of the Atlantic Zone is the highly skewed pattern of landownership, which of course has a high influence on the general land use and natural vegetation. In 1973, landholdings over 200 hectares, owned by some 65 individuals, represented only 3.3 % of all holdings, but concentrated 60 % of the total farm acreage. In that year the largest landowners were the State and the Banana Companies. Most of the rural households were dependent on off-farm work and are working as labourers on the plantations and estates (De Vries, 1986).

In 1980 9.3 % of the population of the Atlantic zone lived in settlement schemes. In the Neguev settlement live about 2000 people now.

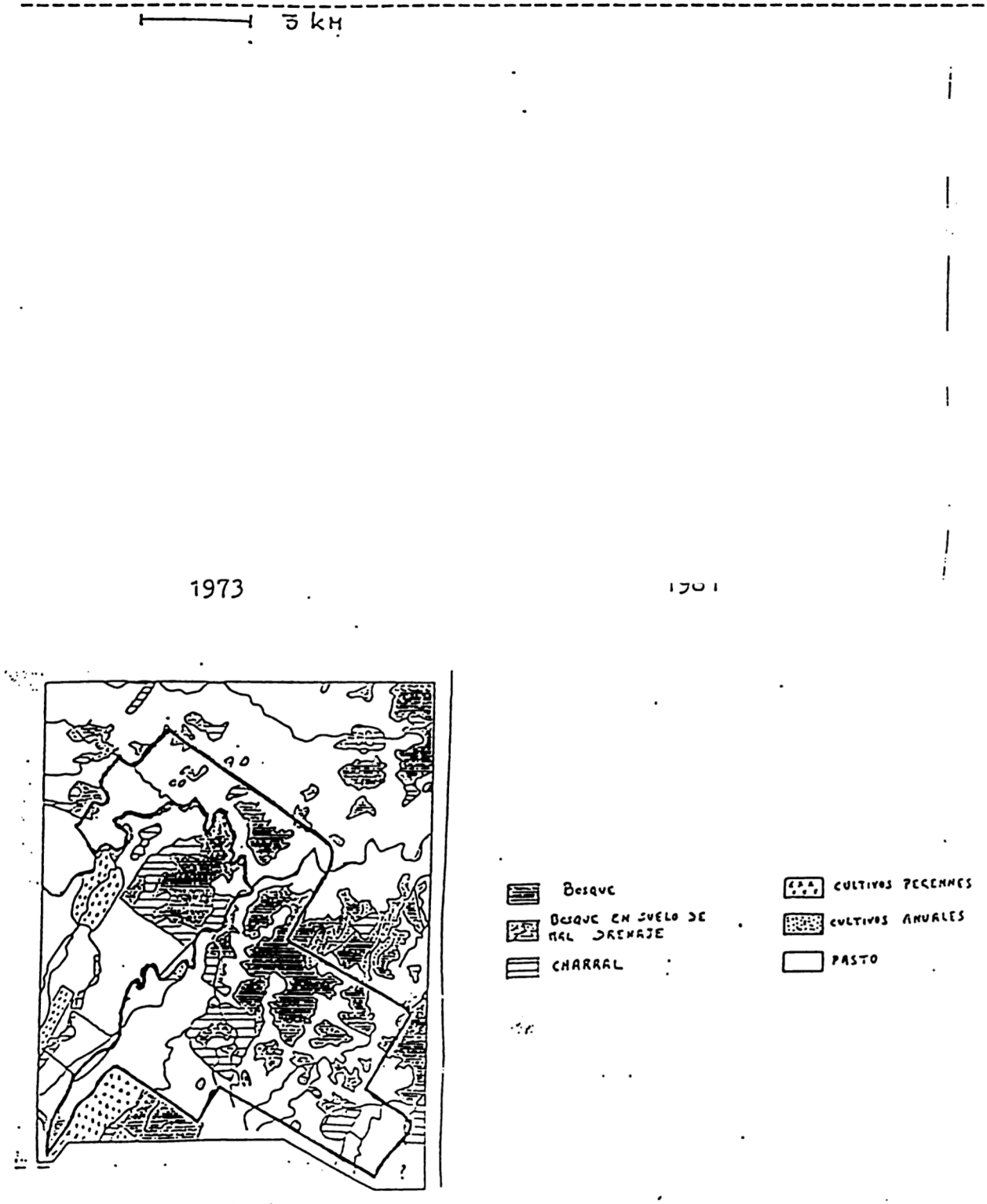
The deforestation of the Neguev settlement began about 45 years ago, when "Mr Johnny" started a farm in this area. For changes in land use from 1973-1984, see Map 2.3. The name of this farm was Mill Colores and had a surface area of about 5200 ha. The most important sources of income of the farm were wood and cattle.

A study of the farm in 1981 (see also Map 2.3.) showed:
a) 1527 ha of improved pasture, sowed by the old owner, located in the sections of Milano and El Peje.

b) 354 ha tacotal (wasteland)

c) 2234 ha forest, nearly all situated in the northeast of the settlement, where about 1000 ha existed of virgin forest.
The rest of the forest was already exploited by the old owner (Verbraeken, 1987).

Map 2.3. Land use (area with forest) of the Neguev in 1973, 1981 and 1984.



Source: unknown

After 1981 the area used for cultivation and pasture steadily increased and every year new crops were introduced.
From the "General Encuesta" (Brink & Waaijenberg, 1990), executed in 1987, the following information was extracted:

Table 2.2. Crops mentioned as most important, second most important and as third most important by farmers in the Neguev settlement.

CROP		1	2	3	T	%
Maize	(maiz)	22	2	2	26	49
Rice	(arroz)	4	3	3	9	17
Beans	(frijoles)	2	8	6	16	30
Cassava	(yuca)	2	11	9	22	42
Maize/cassava				1	1	2
Taro	(chamol)	2	1	1	4	8
Yam	(ñame)		1		1	2
Pumpkin	(ayote)	1			1	2
Pineapple	(piña)		5	1	6	11
Sugarcane	(caña)		2		2	4
Chili	(chile)	5	2		7	13
Oregano	(orégano)					
Cacao	(Cacao)	2	4	3	9	17
Coffee	(café)		1	1	2	4
Coconut	(coco)	1			1	2
Palmheart	(palmito)	2			2	4
Banana	(banano)	1		3	4	8
Plantain	(plátano)	5	4	2	11	21
Plantain/banana			1		1	2
Fruittrees	(frutales)	1			1	2
Soursop	(guanábana)	1			1	2
Pawpaw	(papaya)			1	1	2
have		51	45	33	129	
have-not		2	8	20	30	
N=		53	53	53	159	

1 = most important crop T = total of 1, 2 and 3
2 = second important crop
3 = third important crop

Source: Schipper, 1989

For the scientific names of the crops see Appendix 1.

What these figures do not show is that only a small part of the total acreage was used for cultivation. In January 1986 in Santa Rosa (sector La Lucha) 35% was used for cultivation, in Bella Vista 12 %, in Milano 10 %, in Silencio 7%, and in El Peje 15 %. In total only 16 % of the settlement Neguev was used for cultivation (Soto, 1986).

In general it can be said that the best soils (tierra negra) are used for annual crops like maize and beans. The red soils (suelos colorados) are mostly used for cultivations like palmheart (palmito) and pineapple (piña), if they are not covered by forest or pasture. The suampos are mostly left under forest or under silvo pasture. On the compounds one will see perennials like coconut palms and fruit trees (mandarin, orange, lime, soursop,etc.) and useful plants like medicinal plants (Bolaños & Ulate, 1987).

Wood species that are common in the Neguev settlement and that compose the forests and silvo-pastures in that area are:

-Laurel	(Cordia alliodora)
-Gavilán	(Penthaclethra macroloba)
-Almendro	(Dipteryx panamensis)
-Caobilla	(Carapa guianensis)
-Guácimo blanco	(Goethalsia meiantha)
-Cedro amargo	(Cedrela odorata)
-Jícaro	(Crescentia cujete)
-Anonillo	(Rollinea microsepala)
-Manú negro	(Minguartia guianensis)
-Pilón	(Hieronyme alcherneoides)

(Brink & Waaijenberg, 1990)

3. METHODOLOGY FOR AERIAL PHOTO-INTERPRETATION OF LAND USE

3.1. Introduction

Since a long time aerial photographs are used for the production of soil maps. Aerial photographs and other remote sensing techniques can increase the efficiency of the fieldwork, for sciences like geomorphology, human geography, geology, etc. Areas can be analyzed before the researcher is going into the field, not depending on the weather conditions. Even regions that are almost inaccessible can be analyzed. Without any problems, because the aerial photographs give a three-dimensional view of the landscape, almost equal to reality.

More recently aerial photographs are used to distinguish the different vegetations and land uses. Aerial photographs can give a view of the land use in a certain region and can simplify the identification of the different recommendation domains for farming system analysis; to identify homogenous target groups, composed of farmers operating in approximately the same environment (FAO, 1990).

More specific aerial photographs are used to distinguish the different land uses in the settlement Neguev to relate the land use type to soil type as indicated on the soil map (De Bruin, 1990).

3.2. The different problems of photo-interpretation for the land use in the settlement Neguev

A certain land use can be recognized by the different photo characteristics like tone, texture, pattern, size and shape (see paragraph 3.3.).

The first problem occurs when a land use consists of a mixture of crops, resulting in endless combinations of photo characteristics that makes the recognition of the types of land use impossible. Of course, crops which are hidden under other crops are not visible on aerial photographs.

Land uses, with perennials or annuals, need to have a certain size and homogeneity to identify them. In general it is difficult to distinguish cacao from forest, because the cacao trees are not planted in a specific pattern. Contrary to cacao, fruit trees are often recognized easily because they are mostly planted in a grid pattern.

The larger a field with a certain crop, the clearer the different photo characteristics become. One of the main problems, even with detailed aerial photographs (1:10.000), is to recognize cultivations with a size below 50 * 50 meter, or they must have very clear characteristics, like coconut palms.

In the Neguev settlement many cultivations like pumpkin, beans, rice, maize, taro, sugarcane, and yam are cultivated on a very small scale, mostly for home consumption, which makes it impossible to recognize them. Especially in the home garden, many crops are cultivated in very small quantities. On the land use map, the compound (=cerco=C) is taken as one unit.

Photo characteristics are related to canopy structure (crop development) and yield level. Both can be influenced by cultivation techniques, and field conditions. For example, most of the cassava can be recognized from aerial photographs, because it is cultivated on ridges. These ridges are even recognizable when the crop is harvested. Problems occur when the crop has developed so abundantly, that the canopy is totally closed. Then the ridges can not be seen, and it becomes more difficult to identify the land use, as cassava.

3.3. Description of the photo characteristics for the different crops

The following crops are cultivated on such a small scale and have such a varied appearance that they are not recognizable by aerial photo interpretation:

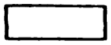
- -rice
- -pumpkin
- -taro
- -beans
- -oregano

Land uses like forest and (silvo)-pasture are described/identified by their structural cover;

-forest:	>90% trees
-silvo-pasture:	>10% and <90% trees
-pasture:	<10% trees
-wasteland:	<10% trees and >30% shrubs

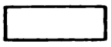
Remark: the herb layer of wasteland is on average 1.5 meter high and is not used by cattle, in this aspect different from pasture.

The different fields are identified by their specific land use or land cover, while the different farms are identified by fences and plot boundaries, visible on aerial photograhs. The parcel map indicates which boundaries one has to take to identify the farm.

Maize 

Pattern: linear
Shape *: rect.-irr. **
Size *: large-small.
Tone : very light (soil)
Height : no

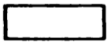
Remarks: maize is already harvested

Cassava 

Pattern: linear
Shape : rect.-irr.
Size : large-small
Tone : medium
Height : medium

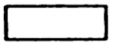
Remarks: individual plants visible as little "balls"

* shape and size of the field
** rectangular-irregular

Plantain 

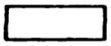
Pattern: linear-irr.
Shape : rect.-irr.
Size : large-small
Tone : dark
Height : medium

Remarks: leaves are visible

Chili 

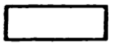
Pattern: blocky
Shape : rectangular
Size : small-medium
Tone : medium
Height : very low

Remarks: chili is planted in square blocks

Fruit trees 

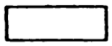
Pattern: grid
Shape : square-rect.
Size : small.
Tone : dark
Height : med.-high

Remarks: individual trees visible

Coconut 

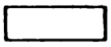
Pattern: linear-irr.
Shape : irregular
Size : med-indv. trees
Tone : dark
Height : high

Remarks: individual trees easily recognizable

Palmheart 

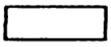
Pattern: linear
Shape : square-rect.
Size : small-large
Tone : medium
Height : low-med

Remarks: rows are very clear

Passion fruit 

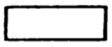
Pattern: blocky/rect.
Shape : rectangular
Size : small-medium
Tone : medium
Height : medium

Remarks: sometimes difficult to distinguish from chili. Poles often visible.

Sugarcane 

Pattern: no
Shape : irregular
Size : medium-very small
Tone : dark
Height : medium

Remarks: difficult to recognize

Pineapple 

Pattern: banded
Shape : rectangular
Size : small-medium
Tone : very dark
Height : very low

Remarks: very clear pattern

Height

low :herb- layer
medium :shrub-layer
high :tree- layer

Field size

small < 1 ha
medium 1-2 ha
large > 2 ha

3.4. Relationship between land use and field size

In aerial photo-interpretation field size can be identified, but it is often impossible to distinguish what type of crop is standing on the field. However, if there is a relationship between field size and the type of crop or land use, one can have an idea of the land use by identifying the field size.

For many crops a field needs to have a certain size to be commercial attractive; economies of scale. The size depends on the farmers objectives, subsistence fields are usually much smaller than commercial fields. The fields also have a certain maximum size, because of limitations on labour and/of capital. Capital/labour intensive crops (high input) are usually cultivated on a smaller scale than for example extensive used pasture (low input).

Types of extensive (low input) land uses e.g., forest, silvo-pasture, and pasture are found on fields of all size classes, see Table 3.1. Often small pieces of pasture or forest are found in the Neguev settlement. This does not pose as a problem in aerial photo-interpretation, because they are always easy to recognize on their photo characteristics.

In class E (>5.0 ha.), see Table 3.1., almost only extensive land use types (forest,silvo-pasture, and pasture) are found. In class D (2.0-5.0 ha.), next to the above mentioned land uses, perennials like cacao, coconut, and palmheart, which can be grown quite extensively, are found. In this class maize is also found (5 observations). These maize fields are located in the sector La Lucha, where maize is cultivated on a commercial basis. In the other sectors of the settlement maize is nearly only cultivated on a very small scale.

In class C (1.0-2.0 ha) one can see many cultivations, except crops like rice, pumpkin, beans, and oregano, which are mostly cultivated for home consumption or sold in small quantities.

The problem is that almost all land uses are (also) located in class A (<0.5 ha.) and class B (0.5-1.0 ha). Especially in class A this poses many problems to aerial photo-interpretation of land use. So, if a field is located in class A, field size does not say anything about the land use.

Frequency table 3.2. illustrates that most farming is done on a small scale, since 90% of all the cultivated fields are smaller than 2.0 ha and even 70% of all crops are cultivated on fields of less than 1 ha.

Table 3.1. Number of fields per land use type in a specific field size category

LANDUSE	AAAAA	BBBBB	CCCCC	DDDDD	EEEEE	TOTAL
ARROZ	2					2
AYOTE		1				1
AZUCAR	2		1			3
BOSQUE	23	33	32	29	13	130
CERCADO	31		1			32
CACAO	4	7	12	3		26
CHAMOL	1					1
CHILE	2	3	1			6
COCONUT	6	2	2	3		13
FRIJOLES	2					2
FRUTALES	7	4		1		12
GUANABANA		1			1	2
MAIZ	10	7	9	5	1	32
MARACUYA	2	7	1			10
OREGANO		1				1
PALMITO	4	11	3	3	1	22
PASTO	17	12	15	27	20	91
PINA		3	2			5
PLATANO	7	3	1	1		12
SP	16	7	26	36	39	124
W		5	5	9	1	20
YUCA	5	8	7	1		21
TOTAL	141	115	118	118	76	568

CLASS A < 0.5 HA
CLASS B 0.5-1.0 HA
CLASS C 1.0-2.0 HA
CLASS D 2.0-5.0 HA

4. METHODS USED FOR THE PRODUCTION OF THE DIFFERENT MAPS

4.1. Introduction

To study the relation between soil type and land use for the Neguev settlement, a land use map was made, based on aerial photographs (1:10.000, 1989). Because the settlement is too large to produce a land use map, within the time frame of this study, for the whole settlement, it was decided to produce land use maps for three sample areas of one square kilometer. All together they had to cover more than 70% of all the soil types, of the soil map (De Bruin, 1990). Later on it was decided to take three more sample areas to increase the number of farms, that completely fall in the sample areas, to enable more detailed analysis of data. Sample areas were located, in each of the five sectors of the settlement (see Map 2.1.).

4.2. Methods and problems of the land use maps for 1989

The land use maps of the 6 sample areas, in the Neguev settlement, were made for the year 1989, because the aerial photographs were taken in spring 1989 (Appendix 10a..15a). The legend of the land use maps for the sample areas is found in Appendix 5.

Field visits were made to check the photo interpretations. Because the land use could be changed in the past two years, farmers were interviewed about the land use, two years ago.

Sometimes the interviewed farmer could not remember exactly what was standing on a particular site of his farm two years ago, or sometimes he was working on the farm for less than two years.

A more severe problem was that many farmers were difficult to brace, due to off-farm work, or because they did not live on their farm. Only fourty percent of all the farmers (144) could be braced and interviewed. This made it difficult to check the aerial photo-interpretation and thus mistakes were possible. If possible, information was obtained from neighbours who knew what was standing on the field, and this was accepted if it did not contradict with what was visible on the aerial photograph.

If farmers said that they did not have any crop in that year and the aerial photographs also did not reveal any crop it was assumed that no crop was grown. But it was still possible that small quantities of a particular crop or land use were not mapped.

Considerable mistakes could be made with cacao, if it was not possible to speak with the farmer. In these cases cacao would be mapped erroneously as forest (it was assumed that about 20% of the total area on cacao is mapped as forest).

4.3. Methods and problems of the Land Use Maps for 1991

Land uses of these maps were checked in the field. But still the farmer had to be found to enter the farm and to save time: ask whether there were any crops. Of course, when a farmer was braced, he was interviewed about the present and the past situation of his farm.

A serious problem was the size and the exact location of new fields. If, for example, pasture had changed for a part into a particular cultivation, it was difficult to locate this field exactly, because no photographs were available for 1991. Especially, if the farmer could not be found, it was difficult to estimate the exact size.

So, the land use maps for 1991 (Appendix 10b..15b) are more reliable on the types of crops/land uses, but less thrustworthy on the exact location and the size of the fields than the land use maps for 1989.

Without aerial photographs for 1991 it is also difficult to find changes in the borders between forest and (silvo) pasture. In the field one has no overview over these borders. Also the distinction between silvo-pasture and pasture is derived from the aerial photographs. Changes between the borders of these two land uses are difficult to see in the field. So the land use maps for 1991 are exactly the same for forest and (silvo)-pasture as for 1989, except when these land uses have changed into perennials or annuals.

Thus, for 1991 the acreage of forest and of (silvo-) pasture is incorrect, but together they have the correct acreage.

4.4. Methods and problems of the soil maps

The soil maps made for the sample areas (Appendix 10c..15c) were enlarged from 1:20.000 of the "mapa detallado de suelos del asentamiento Neguev" to a scale of 1:10.000 to compare them with the land use maps. Before the enlarged soil map could be fitted totally with the land use maps, one had to modify the enlarged soil map with the help of a (vertical) sketch master. With the sketch master the soil map was drawn on interpretation sheets.

After this step the soil maps, made for the sample areas, could be compared with the different land use maps, to find the coverage of every soil type by the various land uses. The legend of the soil maps for the sample areas is found in Appendix 6.

Because the produced soil maps were drawn with the help of a sketch master they have a certain inaccuracy. In addition, the soil map of the Atlantic Zone Programme, is not really accurate enough to compare the soil types with the land uses on a farm level. On the farm level the various soil types are not homogenous anymore. For example, on the soil map a farm has only soil type Neguev, but the farmer indicates that there are large differences in fertility and texture of the soil on his farm, and has therefor not everything under the same crop. For the legend of the soil map for the Neguev area made by the Atlantic Zone Programme, see Appendix 7.

5. INFLUENCE OF THE SOIL TYPES ON SPATIAL DISTRIBUTION OF LAND USE

5.1. Introduction

It is clear that some types of soils are more suitable than others for a specific crop (Purseglove, 1985; 1987). For some characteristics of the soil types located in the Neguev settlement, see Appendix 8. Of course most farmers do not have the soil types they would like to have to grow a certain crop. It can happen that a specific soil type gives such a low yield that the farmer decides to grow an other crop. But it can also happen that a certain farmer is satisfied with a low yield and decides to maintain his crop. A reason for this decision can be that the cultivation is not for commercial reasons, but used for home consumption and for this even a very low yield would serve.

So, it can be interesting to investigate which land uses have a specific soil type (paragraph 5.4.), or to focus on which soil types a specific land use is found. To put this information in perspective, the soil requirements of the various crops, grown in the Neguev settlement, are reviewed (paragraph 5.2).

5.2. Soil requirements of various crops

Cacao

In cultivation, cacao requires a well-drained , well-aerated soil with good crumb structure and adequate supply of water and nutrients. The soils should be deep and easily penetrable by roots.

The best soils are aggregated clays or loams or sandy loams, often red or reddish brown in colour. The optimum pH is around 6.5 (Purseglove, 1987).

Cassava

It grows best on sandy or sandy loam soils of reasonable fertility, but it can be grown on almost all soil types provided that they are not waterlogged, too shallow, too stony, or too alkaline. Cassava will produce an economic crop on exhausted soils unsuitable for other production (Purseglove, 1985).

Passion fruit

It can be grown on a wide variety of soils, but very heavy, poorly drained soils should be avoided (source unknown).

Palmheart

It grows best on good drained soils with a deepness of more than fifty centimeters. The optimum pH range is between 4.5 and 6.0 (SEPSA, 1985).

Plantain/Banana

It can be grown on a wide range of soils provided that there is a good drainage and adequate fertility and moisture. Good bananas are usually indicative of good soils (Purseglove, 1985).

Maize

Maize can be grown on a wide variety of soils, but performs best on well drained, well aerated, deep, loams and silt loams containing adequate organic matter and well supplied with available nutrients.

Maize can be grown successfully on soils with a pH from 5.0-8.0, but 6.0-7.0 is optimum (Purseglove, 1985).

Pineapple

The crop can be grown on a wide range of soils, but it will not tolerate waterlogging. Sandy loams with a pH of 5.0-6.5 are preferred (Purseglove, 1985).

5.3. Different groups of soil types

In the figures 5.1-5.11., the soil types, along the x-as, are arranged into three groups:

I well drained soils:

Ia low fertility:

- Silencio
- Neguev
- Milano

Ib moderate to high fertility:

- Dos Novillos 3
- Parismina
- Destierro
- Bosque III

II imperfect drained soils:

- Williamsburg
- Dos Novillos 2
- Bosque

III Soils with an imperfect to insufficient drainage:

- Suampo

(DE BRUIN, 1988)

5.4. Relation between soil types and land use 1989

5.4.1. General land use

Before discussing the distribution of the various land uses, it is important to note that the land use in the Neguev settlement mainly exists of silvo-pasture, pasture and forest. They respectively represent 39.3%, 21.5%, and 20.8%, of the total acreage, which is more than 80% together ,see Table 5.1. .The most important crops in acreage are maize (3.6%), cacao (2.7%), palmheart (2.4%) and cassava (1.6%), see also Appendix 2.

5.4.2. Forest

In Figure 5.1. one can see the distribution of the land use forest on the different soil types (for explanation of abbreviations see Appendix 3). Most of the forest is found in group Ia and in group III. From Table 5.2., it becomes clear that 26% of all the forest is found on Neguev E, while 16.1%, 14.9% and 11.9% is found on respectively Silencio CD+U, Neguev B and Suampo. Logically most of the forest is located on the soil types that are least suitable for cultivations.

One has to keep in mind that the different soil types are not equally represented (Appendix 2). Therefore it is better to look to the percentage of coverage for each soil type with forest, available in table 5.1. One can notice that 60.1% of Dos Novillos 2 is covered with forest. More than half of soil type Dos Novillos 2 is covered with forest, probably because this soil type has frequently problems with inundations. Except from this Dos Novillos 2 is a drained and fertile soil, so inundations is one of the few reasons why this soil type is so little cultivated. The rest of Dos Novillos is under silvo-pasture and pasture.

Further forest is found on the following soil types, with decreasing coverage:

- Suampo (53.9%)
- Neguev E (44.3%)
- Williamsburg (32.2%)
- Neguev D (29.4%)
- Silencio CD+U(26.0%)

Soil type Williamsburg has problems with inundations and drainage, which are the main reasons why so much forest is found on this soil type. The rest of this soil type is mainly under silvo-pasture.

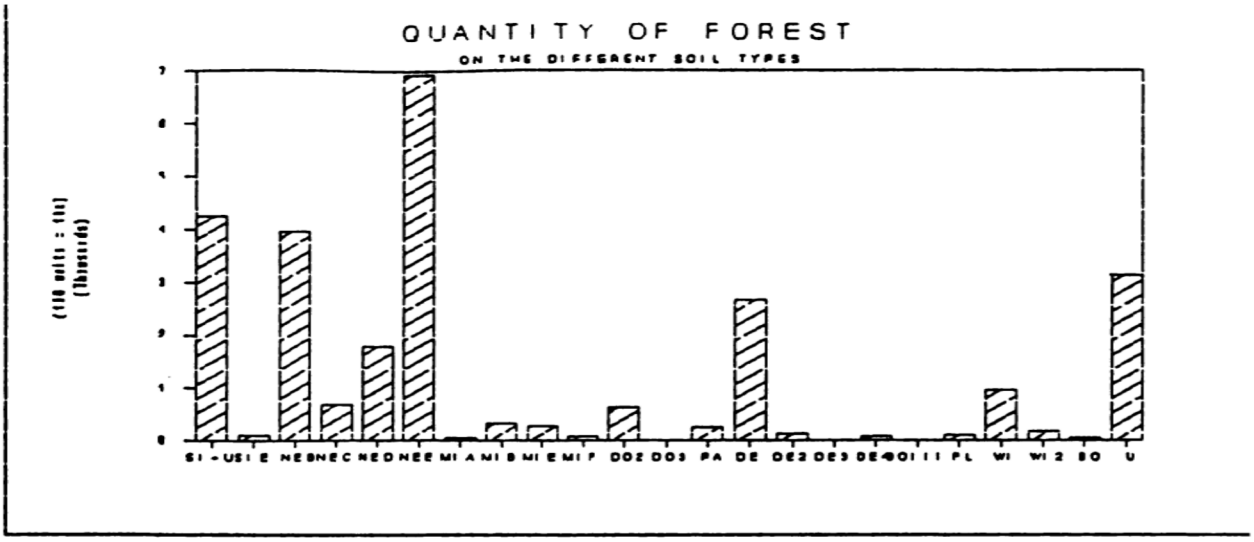


Figure 5.1 Area (ha) of forest on the different soil types

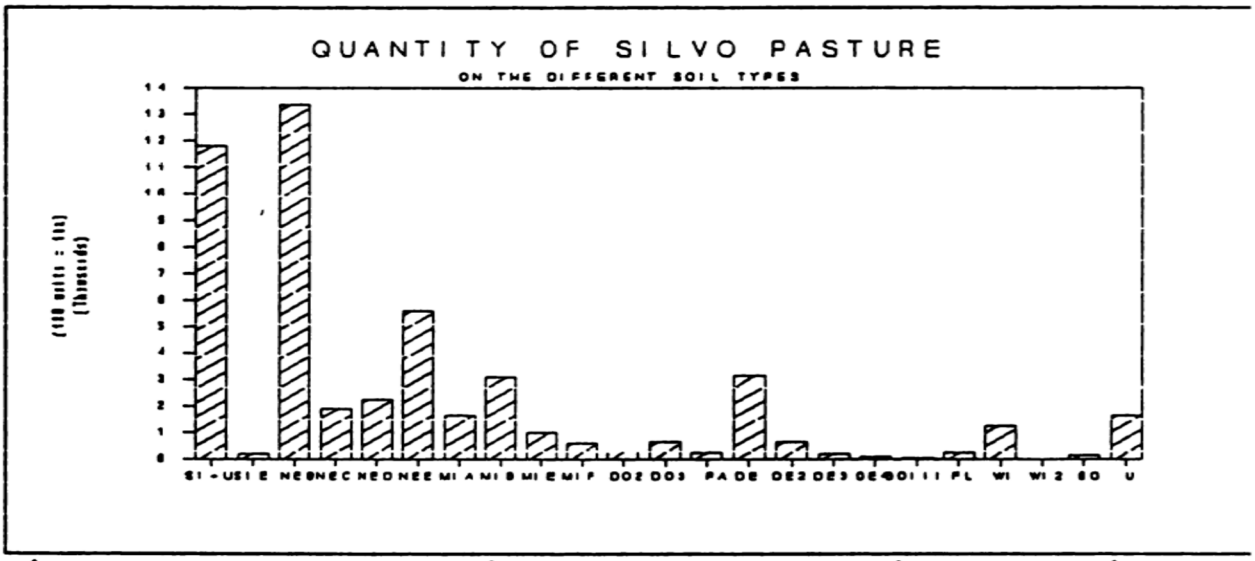


Figure 5.2 Area (ha) of silvo-pasture on the different soil types

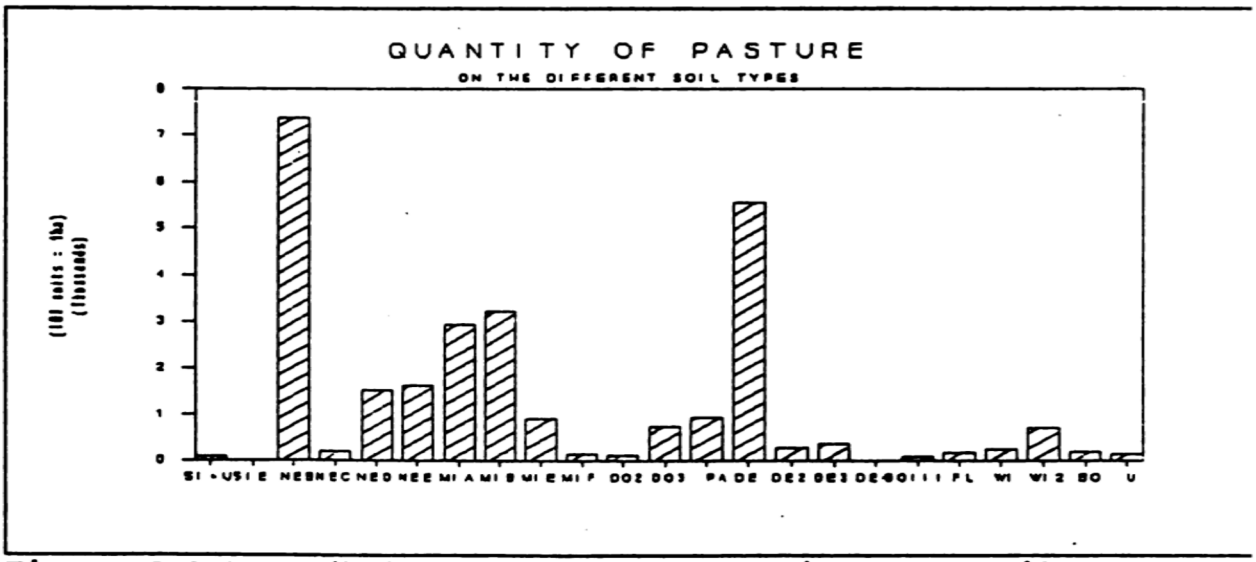


Figure 5.3 Area (ha) of pasture on the different soil types

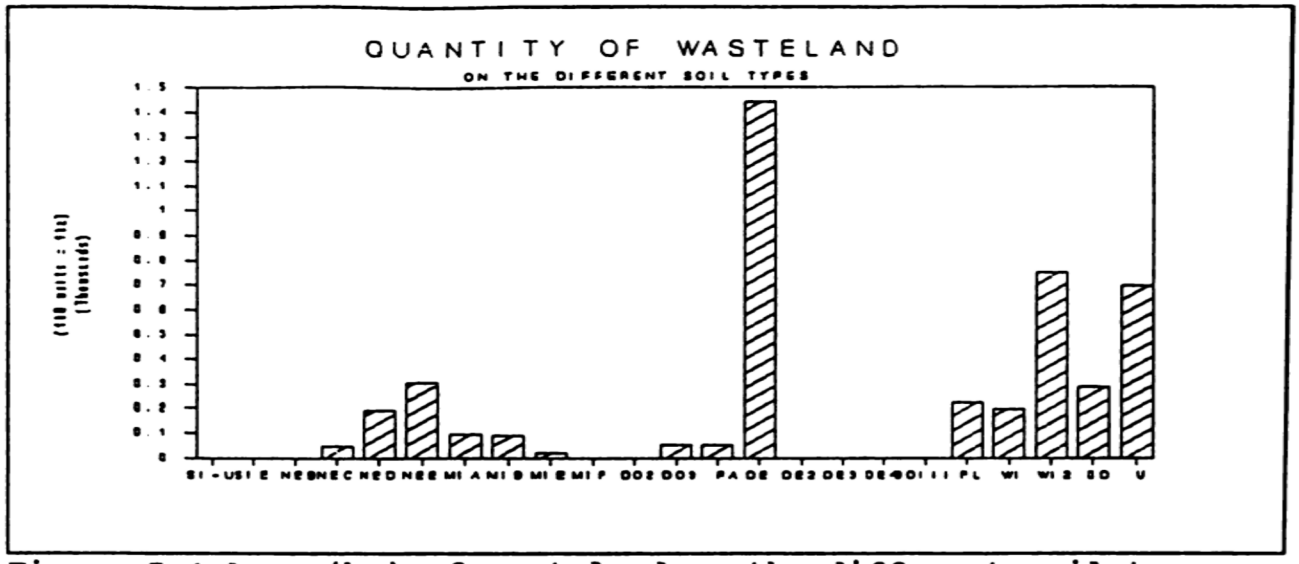


Figure 5.4 Area (ha) of wasteland on the different soil types

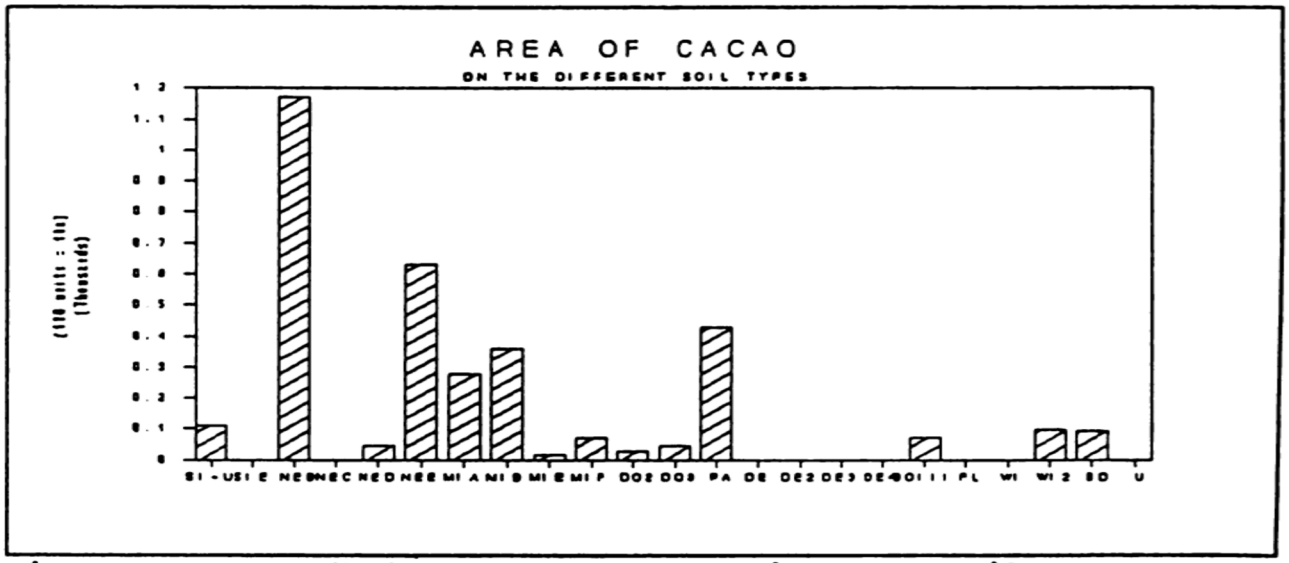


Figure 5.5 Area (ha) of cacao on the different soil types

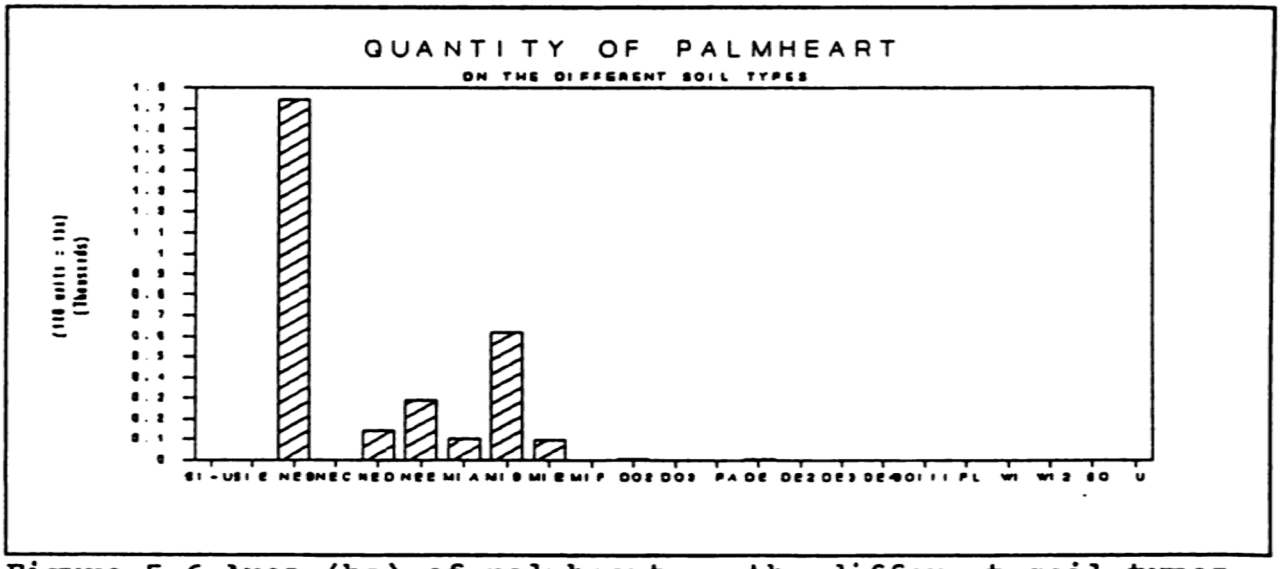


Figure 5.6 Area (ha) of palmheart on the different soil types

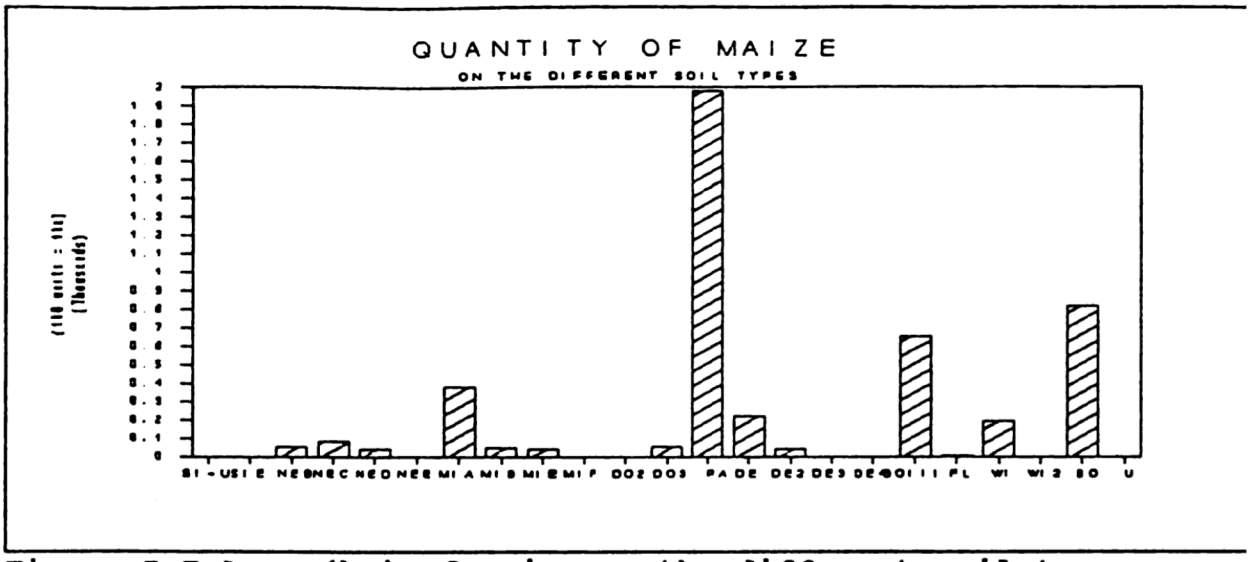


Figure 5.7 Area (ha) of maize on the different soil types

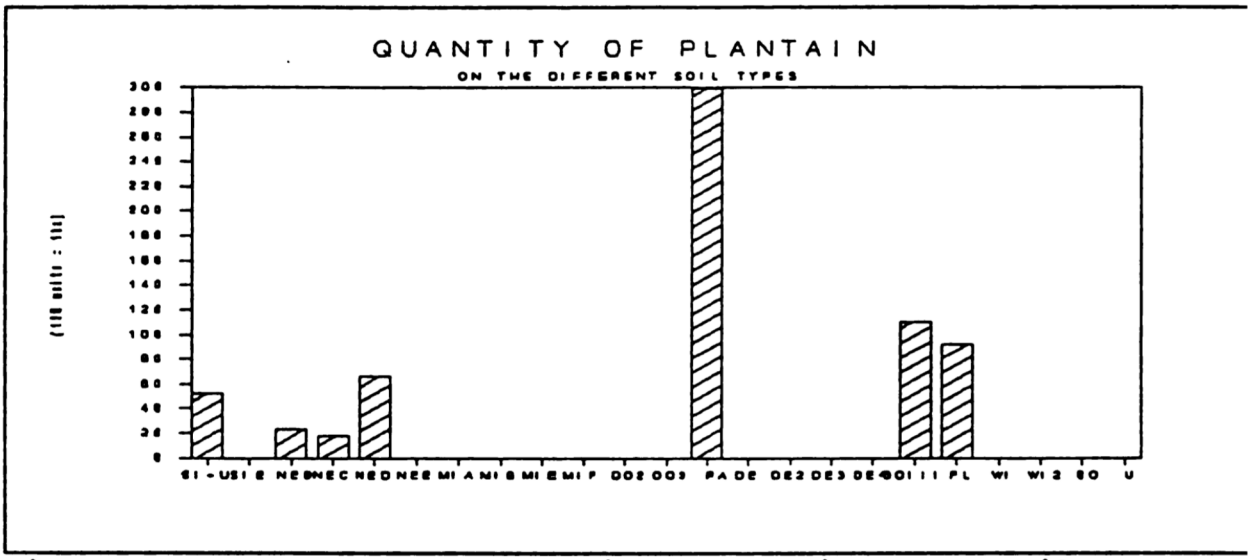


Figure 5.8 Area (ha) of plantain on the different soil types

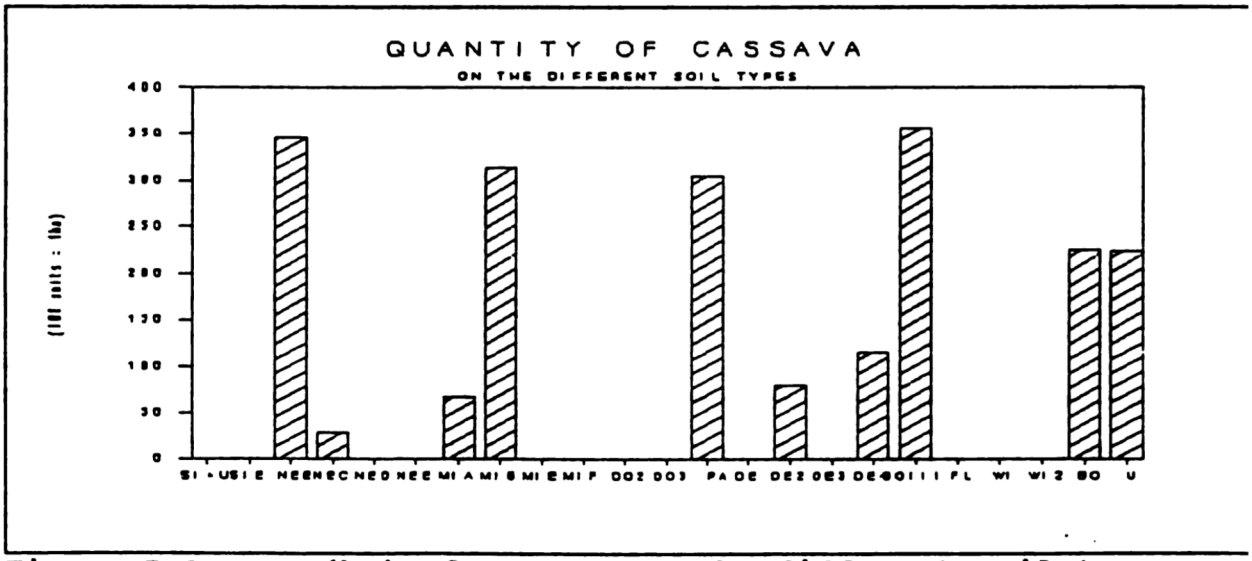


Figure 5.9 area (ha) of cassava on the different soil types

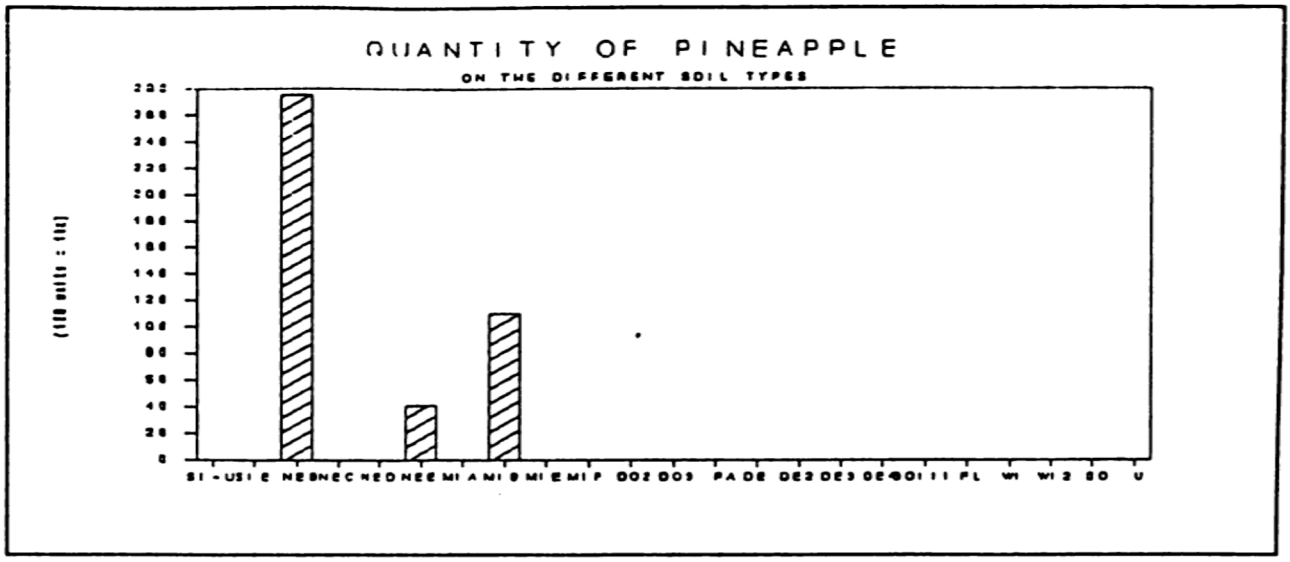


Figure 5.10 Area (ha) of pineapple on the different soil types

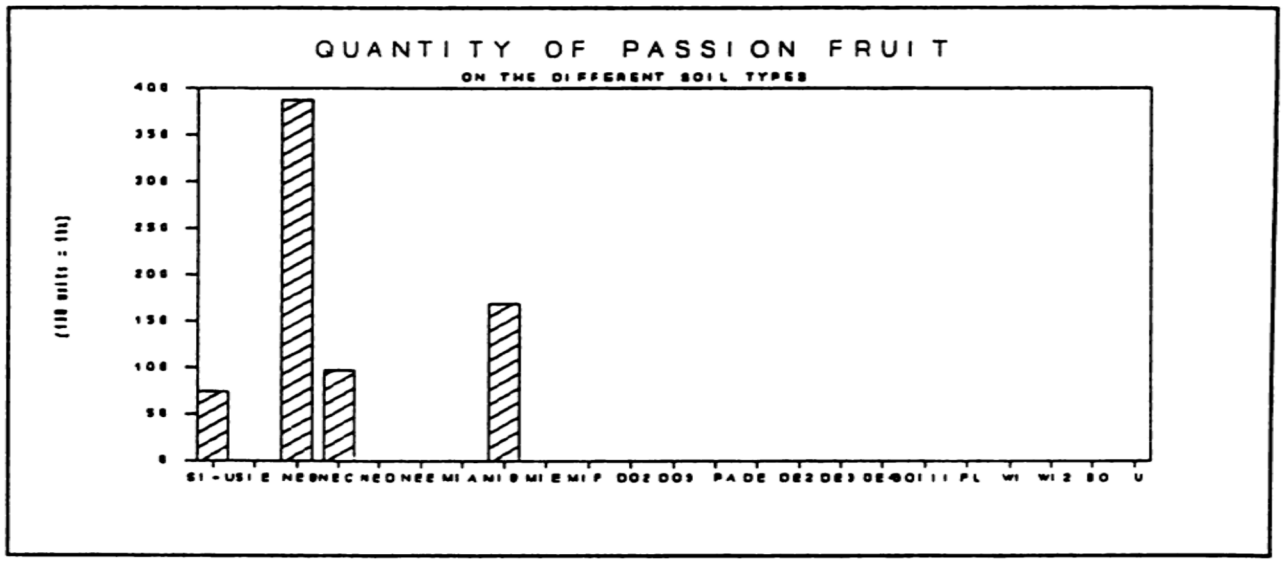


Figure 5.11 Area (ha) of passion fruit on the different soil types

TABLE 5.1. Relation between land use 1989 and soil types (percentages)

	SICD+																									
TOTAL	U	SI	E	NE	B	NE	C	NE	D	NE	E	MI	A	MI	B	MI	E	MI	F	DO2	DO3	PA	DE	DE2	DE3	DE4	BOIII	FL	WI	WI2	BO	U	TOTAL
ARROZ				0.1		0.5																											0.0
AYOTE																														0.6			0.0
AZUCAR								0.1													9.3								0.3				0.1
BOSQUE	26.0	30.5		13.3		21.8		29.4		44.3		0.6		3.6		11.4		7.7		60.1		5.4		20.3		10.5		26.5	0.6	12.2	32.2	10.0	2.9	53.9	20.8
CERCADO				1.6				0.1		0.3		2.6		1.9				1.6				0.7		0.1							0.9				0.8
CACAO	0.7			3.9				0.7		4.0		4.2		4.0		0.7		8.2		2.8		2.5		9.0					5.4			5.6	5.0		2.7
CHAMOL																						0.2							1.5						0.0
CHILE	0.1											0.3		2.5		2.4															0.3				0.3
COCONUT				0.8		0.4		0.4		0.7		4.8		0.6								2.1							1.4				1.2		0.7
FRIJOLES																						0.9									0.7				0.1
FRUTALES				0.7		1.2				0.3		4.1		1.2		1.1						1.6									0.1		1.0		0.6
GUANABANA												6.1								1.1	8.8														0.5
MAIZ				0.2		2.7		0.6				5.6		0.6		1.7					3.0	41.6		1.7		3.7			47.7	0.7	6.7		43.8		3.6
MARACUYA	0.5			1.3		3.1								1.9																				0.6
OREGANO				0.2						0.1																									0.1
PALMITO				5.9				2.3		1.9		1.5		6.9		4.0				0.5				0.0											2.4
PASTO	0.5			24.9		5.7		24.7		10.3		43.8		36.1		37.5		16.4		9.2		39.1		19.5		42.7		23.7		64.1	4.9	19.0	9.0	40.7	10.3	2.2	21.5
PINA				0.9						0.3				1.2																					0.3
PLATANO	0.3			0.1		0.6		1.1														6.3							8.0	11.5					0.5
SP	72.1	69.5		45.0		61.6		37.2		35.8		24.2		34.9		40.3		66.1		26.3		34.6		5.2		24.0		55.1		35.2	35.4	4.5	28.6	43.3		8.1	28.2	39.3
WASTELAND						1.5		3.2		1.9		1.4		1.0		1.0						2.7		1.1		11.1						28.0	6.9	42.8	15.6	11.9	3.5
YUCA				1.2		0.9						1.0		3.5										6.4				7.0		38.1	26.0				12.1	3.8	1.6
TOTAL	100	100		100		100		100		100		100		100		100		100		100		100		100		100		100		100	100	100	100	100	100	100	100.0

TABLE 5.2. Relation between land use 1989 and soil types (percentages)

	SICD+																									
TOTAL	U	SI	E	NE	B	NE	C	NE	D	NE	E	MI	A	MI	B	MI	E	MI	F	DO2	DO3	PA	DE	DE2	DE3	DE4	BOIII	FL	WI	WI2	BO	U	TOTAL
ARROZ				71.4		28.6																											100.0
AYOTE																														100.0			100.0
AZUCAR								2.7													92.0								5.3				100.0
BOSQUE	16.1	0.3		14.9		2.6		6.7		26.1		0.1		1.2		1.0		0.3		2.3		1.0		10.0		0.5		0.3	0.0	0.4	3.5	0.7	0.2	11.9	100.0
CERCADO				49.0				0.9		5.1		17.8		17.8				1.4				3.4		1.6		0.4					2.6				100.0
CACAO	3.2			33.9				1.3		18.3		8.1		10.4		0.5		2.1		0.8		1.3		12.4					2.1			2.8	2.7		100.0
CHAMOL																						33.3							66.7						100.0
CHILE	4.7											6.2		69.5		17.8																1.9			100.0
COCONUT				27.4		1.2		2.7		12.4		35.4		5.4								10.9							2.1				2.5		100.0
FRIJOLES																						69.2									30.8				100.0
FRUTALES				25.2		4.9				6.4		34.6		13.2		3.4						9.7									0.4		2.3		100.0
GUANABANA												69.9								1.9	28.3														100.0
MAIZ				1.2		1.8		0.8				8.2		1.1		0.9					1.2	42.9		4.8		0.9			14.1	0.1	4.2		17.7		100.0
MARACUYA	10.2			53.3		13.3								23.2																					100.0
OREGANO				67.6						32.4																									100.0
PALMITO				58.2				4.6		9.7		3.3		20.6		3.2				0.2				0.2											100.0
PASTO	0.3			26.9		0.7		5.5		5.9		10.7		11.7		3.3		0.5		0.3		2.7		3.4		20.3		1.0		1.3	0.2	0.6	1.0	2.6	0.7	0.5	100.0
PINA				64.6						9.6				25.8																					100.0
PLATANO	7.9			3.5		2.7		10.0														45.3							16.7	13.9					100.0
SILVO PAS	23.6	0.4		26.7		3.8		4.5		11.2		3.2		6.2		1.9		1.2		0.5		1.3		0.5		6.2		1.3		0.4	0.2	0.1	0.5	2.5		0.3	3.3	100.0
WASTELAND						1.1		4.3		6.8		2.1		2.0		0.5						1.1		1.2		32.3						5.0	4.5	16.8	6.5	15.6	100.0
YUCA				16.8		1.4						3.2		15.2										14.8				3.9			5.6	17.3			10.9	10.9	100.0
TOTAL	12.9	0.2		23.3		2.5		4.7		12.3		5.3		7.0		1.9		0.7		0.8		1.5		3.7		10.2		0.9		0.4	0.2	1.1	0.6	2.3	1.4	1.5	4.6	100.0

5.4.3. Silvo-pasture

Most of the silvo-pasture is found, like forest, in group I. While forest has most of its acreage on Neguev E, silvo pasture has most of its acreage on Neguev B, see Figures 5.1. and 5.2. Silvo-pasture has 26.7% of its acreage on Neguev B, 23.6% on Silencio CD+U, and 11.2% on Neguev E, see Table 5.2. On other soil types silvo-pasture is represented in smaller percentages.

If focused on the coverage of every soil type by silvo pasture it can be noted that soil types

Silencio CD+U
Silencio E
Neguev C
Milano F
Destierro 2

are covered for more than 50% by silvo-pasture. Most other soil types are covered for more than 25% by silvo-pasture. Only Bosque, Parismina and Bosque III are covered by less, respectively 8.1%, 5.2%, and 4.5%.

5.4.4. Pasture

Contrary to silvo pasture one will find (almost) no pasture on Silencio CD+U and Silencio E (Figure 5.3.). Furthermore pasture is also well represented in group II. In Table 5.1 the highest coverage by pasture is found on soil types:

Destierro 3 (64.1%)
Milano A, (43.8%)
Destierro (42.7%)
Williamsburg 2.(40.7%)

Even a very good soil like Parismina is still covered for 19.5% by pasture.

5.4.5. Wasteland

Wasteland mainly exists of bushes and high grasses and is not used for any cultivation. It is found especially on the very poorly drained soils and some is found in group Ia. An exception is soil type Destierro, where most of the wasteland is found on one soil type, (see Figure 5.4.). Of this soil type 32.3 % is covered by wasteland. Table 5.1. shows that the imperfect drained soil type Williamsburg 2 has the highest coverage (42.8%) by wasteland. The rest of Destierro is under (silvo-)pasture and forest. Reasons for the lack of crops on Destierro are probably inundations.

5.4.6. Cacao

Cacao is almost only found on well drained soils, but as well in group Ia as in group Ib. In acreage most of the cacao is found on Neguev B and Neguev E, see Figure 5.5. On Neguev E it is the most important cultivation, while on Neguev B palmheart is the most important cultivation, see Table 5.1.

In table 5.1. the highest coverage by cacao, per soil type, is found on soil types:

-Parismina (9.0%)
-Milano F (8.2%)
-Williamsburg 2(5.6%)
-Bosque III (5.4%)
-Bosque (5.0%)

It is odd to find cacao on soil types Williamsburg 2 and Bosque, because these are imperfect drained soils, while cacao needs a well-drained , well-aerated soil. May be on these plots the soil is better drained than the soil map indicates.

5.4.7. Palmheart

In Figure 5.6. the cultivation is only found in the group of well-drained soils with a low fertility. On soil type Neguev B 17 ha of palmheart is located, while in the second place 6 ha is located on soil type Milano B. In other words, 58.2% of all palmheart is found on Neguev B and 20.6% of all palmheart on Milano B (Table 5.2.).

It is very particular that no palmheart is found on soil type Silencio, while this soil type also belongs to group Ia. It is possible that the pH is too low on this soil type, but it is more likely that there are problems with compaction (Spaans e.a., 1989).

On soil types Neguev B, Neguev D, Milano B and Milano E palmheart or palmito is the most important cultivation (table 5.1.).

5.4.8. Maize

Maize is the most important crop in the Neguev settlement, with 46 ha (see Figure 5.7 and Table 5.1). Indeed, as stated in paragraph 5.2, maize can be found on many different soil types. In Figure 5.7. it is found in all soil groups, except on the badly drained swampy soils.

But on most soil types it is found in small quantities, mainly for home consumption. Most of the maize is located in the sector La Lucha on the soil types: Parismina, Bosque and Bosque III,respectively: 42.9%, 17.7% and 14.1% (Table 5.2.). In this sector it is an important cash crop.

It is strange that more maize is found on the imperfect drained soil type Bosque, than on the well drained soil type Bosque III. May be there are not so many problems with drainage in spring as the soil map indicates, or may be the imperfect drainage is even an advantage in the dry season. This might be the reason why it is cultivated in spring on soil type Williamsburg.

The following soil types are almost for the half covered with maize: Bosque III (47.7%), Bosque (43.8%) and Parismina (41.6%). All other soil types are covered by less than 7% by maize (Table 5.1.). So maize is especially grown in distinct quantities on soil types with a high fertility.

5.4.9. Plantain

In Figure 5.8. plantain is almost only grown on well drained soils, but is not only cultivated on soils with adequate fertility. Plantain can be found on soil types like Neguev and Silencio, with a low fertility. An explanation for this can be that plantain on these soil types is cultivated for home consumption, near the house.

5.4.10. Cassava

This cultivation is found in all three the soil groups, see Figure 5.9. The reason why it is also found in group three is not clear, because it can be grown on most soil types provided that they are not waterlogged. Most of the cassava is found on Bosque III (17.3%), Neguev B (16.8%), Milano B (15.2%) and Parismina (14.8%), all well drained soils.

Only 1.6% of all the land is covered by cassava and also the coverage of most soil types by cassava is low. One will see that this is changing.

5.4.11. Pineapple

Just like palmheart, pineapple is only located in group Ib. On soil type Neguev B 2.8 ha is found and on soil type Milano B 1.1 ha, see Figure 5.10. The total acreage of pineapple is not more than 4.3 ha. In other words, it is only 0.3% of the total acreage of the sample areas, see Table 5.1.

This does not suppose that it is not a economical important crop, but the problem is that it is an expensive crop to cultivate. Without sufficient credit possibilities it is difficult for farmers to cultivate pineapple. According to an IDA assistant, pineapple would be cultivated more extensive, if there were more credit possibilities, because soil types like Neguev and Milano are excellent to grow pineapple.

Also for pineapple it is particular to notice that this crop is not found on the soil type Silencio.

5.4.12. Passion fruit

Like pineapple and palmheart, it is only found on well-drained soils with a low fertility, see Figure 5.11. But contrary to the other two cultivations it is also found on soil type Silencio CD+U. Since passion fruit is only found for less than 1 ha on Silencio CD+U, it does not mean that this cultivation is better adapted to soil type Silencio CD+U.

The total acreage of passion fruit is a little bit more than that of pineapple, namely 7.3 ha. Of this cultivation 53.3% is found on Neguev B and 23.2% on soil type Milano B (Table 5.2.). But only 1.3% and 1.9% is dedicated to this cultivation on respectively Neguev B and Milano B (Table 5.1.).

5.5. Conclusions

It is obvious that in the Neguev settlement most crops are only cultivated on a small scale and that forest, silvo-pasture and pasture represent more than 80% of the total land use. This could indicate that most of the land in the settlement has a poor quality, but can also indicate a shortage of labour and capital. Soil group Ia covers 71% of all the land in the sample areas.

Land uses like forest, silvo pasture, pasture are found on almost all soil types, while cultivations like palmheart, pineapple and passion fruit are only found in soil group Ia. Between these two groups cultivations are found like, maize, cassava, cacao and plantain, which are located on a larger variety of soil types.

In contrary to the soil requirements of some crops one finds them on imperfectly drained soils. It is possible because it can be an advantage in a relatively dry period or because the plots have a better drainage than indicated on the soil map.

Almost no cultivations are found on soil types Silencio CD+U and Silencio E. Reasons for this could be problems with compaction, low pH, steepness and inaccessability.

Note

Of all the maize, plantain and cassava respectively 77%, 76%, and 54%, is located in the sector La Lucha, while this sector only covers 11% of all the land of the sample areas. But in the sector La lucha none is found of crops like palmheart, passion fruit and pineapple for the year 1989. In the sector El Peje 48% of all the palmheart is located. So, there is an obvious difference between the sectors of the settlement. In general the sector La Lucha is more commercial oriented.

6. RELATIONSHIP BETWEEN LAND USE AND VARIOUS FACTORS

6.1. Relation percentage good soil and land use

6.1.1. Introduction

From chapter 5, it is clear that there is a (crude) relationship between soil type and land use. The approach followed in that chapter assumes implicitly that farmers have a free choice to grow any crop anywhere. However, farmers are restricted to their piece of land, and the distribution of soil types is not equal over all farmers. Some will have a higher fraction of the land on "good" soils than others (take note that in the Neguev all farms are almost of the same size). If there would be an absolute relation between soil type and land use, farmers with a higher percentage of "good" soil would grow a corresponding percentage of crops. On the other hand, if also the fact that the farmer wants or need to grow crops , influences the decision where to grow which crop, there would be a non-line.

In the following part it is investigated if there is any linear relationship between the percentage of "good" soil of a farm and the acreage, expressed in hectares, of annuals and perennials.
But first it has to be decided what a "good" soil is.

6.1.2. Definition "good" soil

Of course, to select a "good" soil type is only possible by definition. The definition for a "good" soil type is derived from a guide on the determination of the land use capacity of the soils of Costa Rica (Bolaños, 1991). In this guide classes I, II, and III, allow the development of any activity, including the cultivation of annuals (Bolaños, 1991). So, these classes are taken as a definition for a "good" soil type. In this way, the following soil types belong to the class I, II, or III:

- Milano A
- Milano B
- Dos Novillos 3
- Parismina
- Destierro
- Destierro 3
- Destierro 4
- Bosque III

For each farm, the total area of these "good" soils is divided by the farm size, times 100, to get the percentage of"good" soil per farm.

6.1.3. Analysis

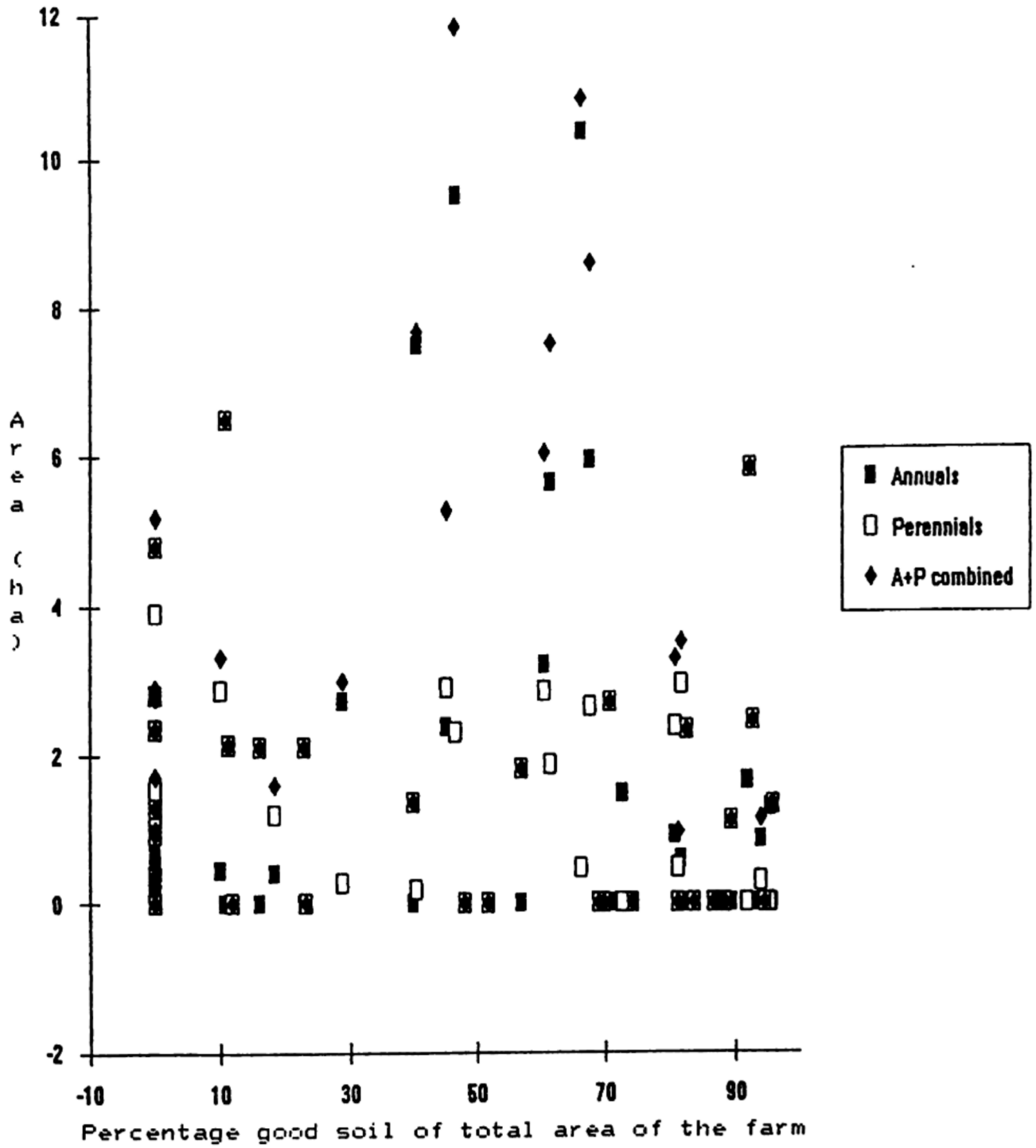
Figure 6.1. shows that there is no linear relationship between the percentage of good soil and the acreage of perennials or annuals. Neither is there a linear relationship between the percentage of "good" soil and the total of annuals and perennials per farm. Most farmers do not cultivate more than about 3 ha, irrespective of the percentage of "good" soil on their farm. Only in the sector La Lucha larger areas are cultivated with annuals and perennials.

Striking is that many farms, with a high percentage of "good" soil, do not have any amount of annuals or perennials, see Figure 6.1. These farms have only forest and (silvo)-pasture. Maybe this is due to the fact that farmers are more dedicated to off-farm work. Of the 63 farms 29 had no annuals or perennials at all, which is almost 50% of all the farms in the sample areas. Even when omitting these farms, there was still no linear relationship.

Apparently, it depends more on the farmer's management and (labour) resources, than on its amount of "good" soil, what acreage of annuals and or perennials he has. There are also farmers with a low percentage of "good" soil who have a reasonable amount of perennials and/or annuals.

For example, one farm (farm 270) has no "good" soil, but it has 1.3 ha of annuals and 3.9 ha perennials. But its more common that a farm with a high percentage of "good" soils has (almost) no annuals or perennials. This is extreme in the sample area Mascota. Probably there are more problems with inundation on the soil type Destierro than can be read from the table with characteristics of the different soil types (Appenix 8.).

Figure 6.1. Area (ha) under annual and/or perennial crops in relation to percentage of good soils



6.2. Relation between land use and infrastructure

6.2.1. Introduction

Land use is influenced by many factors like soil type, topography, farm resources (capital, labour, total farm size) and farmer's objectives. One of these factors is also infrastructure. On a regional level, intensive cultivations are expected near a town and extensive cultivations are expected at remoter places. On the farm system level it is expected to find the bulky and/or intensive crops nearer to the road than extensive land uses like pasture or forest.

6.2.2. Method used

The index used for the distance to the road is measured as follows: two times the shortest distance plus one time the largest distance. When measuring the distance to the road, properties of other farmers are not crossed, assumed that farmers will transport a crop over their own property to the road.
In this way, two fields of the same acreage and both along the road, but with a different shape, are getting a different value, when one field has its shortest side along the road and the other field its longest side along the road.

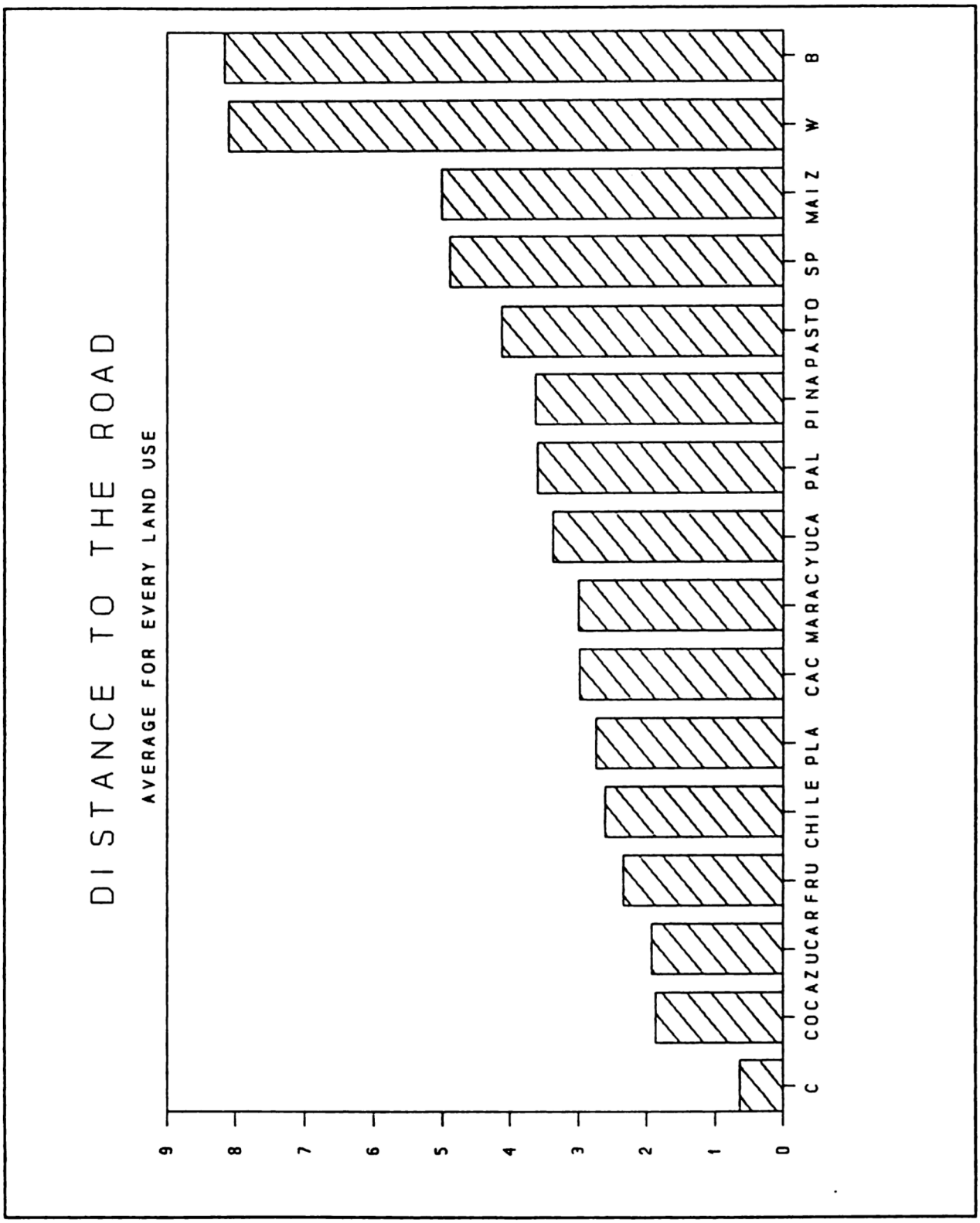
6.2.3. Analysis

Figure 6.2. illustrates that extensive cultivations like forest, wasteland, silvo-pasture and pasture have the longest distance to the road. Also maize has a large distance to the road. This is because many times the maize is cultivated in small amounts on the black soils along the river, which is often situated at the end of the farm .

In Figure 6.2. crops like cacao, passion fruit, cassava and palmheart are found in the middle, while cultivations like coconut, sugarcane, fruit trees, chili, and plantain are found near the road. This because these cultivations are grown most of the time near to the house and the compound/house is almost always located next to the road. These crops, mainly for home consumption, are more related to the distance to the house than to the soil type. For example, plantain is found near the house on very poor soils, like Silencio. Whereas normally it is found on dark fertile soils.

Figure 6.2. shows the average index (for distance to the road) for every land use. A problem is that there is a lot of variation in the distance to the road for one type of land use. Most averages have a standard deviation that is half the average.

Figure 6.2. Distance to the road.



7. CHANGES IN LAND USE FROM 1989 TO 1991 FOR THE SAMPLE AREAS

7.1. Introduction

The Neguev settlement is a relatively new settlement. The first farmers started clearing the forest on the occupied land some twenty years ago. These farmers started to experiment with crops like beans, maize, and rice. These crops were the most important subsistence crops. On many sites the soil was not suitable for these crops and they had to look for alternatives (Oñoro, 1990). Some changed to other crops while other changed to cattle farming or abandoned their farm. Off-farm work was all the time an important source of income.

When the settlement improved its infrastructure (programme "0-34" started in April 1981) it became more incorporated into the market system and cash crops like cacao, passion fruit and pineapple gained more importance. Cacao lost its importance in the last few years for the settlement Neguev, due to bad varieties (problems with incompatibility) and diseases like monilia. The most recent introduced cash crop is palmheart or palmito that looks very successful.

From all this an image can be formed of changes in land use. It can be asked whether the present land uses or cultivation techniques are more adapted to the biophysical conditions than two decades ago, based on farmers experience. Changes in present land use is mainly influenced by market prices and credit policy.

In the following part the changes in land use from 1989 to 1991 will be analyzed.

7.2. Methods used

The land use maps for the different sample areas were produced for 1989 by aerial photo-interpretation in combination with farm interviews. For 1991 land use maps were produced by field visits in combination with farm interviews. This made it possible to compare the land use of 1989 with that of 1991 for the various sample areas. Changes in land use were quantified by measuring the surface of the changed areas in square millimeters (100 mm2 = 1 ha on a scale of 1:10.000).

A constraint is that no changes of forest into silvo-pasture or pasture could be recognized or the other way around because no aerial photographs were available for 1991. Without photographs for 1991 it is almost impossible to see changes in boundaries between forest and silvo-pasture or pasture. Even more difficult is to see changes in boundaries between pasture and silvo-pasture without aerial photographs for both years.

In the field it is difficult to get a clear overview for these land uses. For this reason no changes were made in the land use maps for 1991 for these land uses. Only if the land uses were changed into annual or perennial crops, which one can see clearly in the field.

An other constraint is that many crops like maize, pumpkin, rice, and beans are cultivated on very small areas for home consumption, which can not be indicated on the land use maps if lesser than 2500 m2 (that is 5 * 5 mm on the land use map).

It can also happen that these small quantities of crops are not discovered, when not clearly indicated by a farmer in an interview.

Table 7.1. Changes in land use from 1989 to 1991 for the sample areas

91\89	B	CAC	CAC PLAT	CAC #	CHIL	FRIJ	MAIZ	MAIZ FRIJ	MARAC	PAL	PAL PLAT	PAL YUCA	PASTO	PINA	PLAT	SP	W	YUCA	YUCA FRIJ	TOTAL
B	#															N.A.				0
CAC		#																		0
CAC+PLAT		70	#																	70
CAC+#			92	#																92
CHILE					#															0
FRIJ					58	#	34													92
MAIZ	57		75				#	10					165		15	471	38	779		1610
MAIZ+FRIJ							11	#								65				76
MARAC					85				#				21			136				242
PAL	58	385					14			#			403			390		63		1313
PAL+PLAT											#					13		66		79
PAL+YUCA							25					#	12							37
PASTO	N.A.	52		223	80		752		235				#	182		N.A.	145			1669
PINA				60									239	#		11		26		336
PLAT							511						36		#	51		70		668
SP	N.A.				95		283	30					N.A.		83	#		278		769
W																41	#			41
YUCA					20	45	815						1828			937		#		3645
YUCA+FRIJ																964			#	964
TOTAL	115	507	167	283	338	45	2445	40	235	0	0	0	2704	182	98	3079	183	1282	0	11703

100 units= 1 ha

#:CACAO + PALMITO/AYOTE/FRUTALES/CHILE
N.A.:These changes were not possible to be recognized.

Table 7.2. Percentages gained by the different land uses, in the period 1989-1991

	GAIN	LOST		TOTAL GAIN HA	LANDUSE 89	% GAINED
BOSQUE	0 -	115	=	-115	26524	0
CACAO	0 -	507	=	-507	3457	-2
CACA0+PLATANO	70 -	167	=	-97		
CAC+#	92 -	283	=	-191		
CHILE	0 -	338	=	-338	321	-100
FRIJOLES	92 -	45	=	47	65	
MAIZ	1610-	2445	=	-635	4620	-14
MAIZ+FRIJOLES	76 -	40	=	36		
MARACUYA	242-	235	=	7	728	0
PALMITO	1313-	0	=	1313	2993	44
PALMITO+PLATANO	79 -	0	=	79		
PALMITO+YUCA	37 -	0	=	37		
PASTO	1669-	2704	=	-1035	27372	-4
PINA	336-	182	=	154	426	36
PLATANO	668-	98	=	570	660	86
SILVO PASTO	769-	3079	=	-2310	50017	-5
'WASTELAND'	41 -	183	=	-142	4463	-3
YUCA	3645-	1282	=	2363	2058	115
YUCA+FRIJOLES	964-	0	=	964		

7.3. Analysis of net changes in land use

Forest: For forest (bosque) no changes are indicated only that 1 ha of forest is changed into crops see Table 7.1.

Silvo-pasture: Silvo-pasture has lost 5% of its acreage, see Table 7.2. Table 7.1. shows that silvo-pasture is mainly converted into cassava (yuca) and in the second place into palmheart (palmito) or into maize.

Pasture: Pasture (pasto) has lost 5% of its acreage (Table 7.2.) to cassava and in the second place to palmheart (palmito).

Chili: In table 7.1. chili lost its total acreage of 3.5 ha. This was equally changed into beans, passion fruit, pasture and silvo pasture.

It sounds odd that chili (chile) has changed into silvo-pasture. This is possible if one takes the surroundings into account. If the surroundings exist of silvo-pasture, it can not said that in between the trees there is some pasture. The whole area is called silvo-pasture.

Maize: In Table 7.2. maize lost 14% of its acreage, from 46 ha in 1989 to 40 ha in 1991. It mainly changed into pasture, silvo pasture (same argument as stated above) and plantain (platano), see Table 7.1.

Passion fruit: Some passion fruit (maracuya) changed into pasture, but passion fruit was also gained on silvo-pasture and chile that changed into passion fruit. So the total acreage stayed stable.

Palmheart: Table 7.2. shows that palmheart increased its acreage with almost 50% from its 30 ha in 1989. especially pasture, silvo-pasture and cacao were changed into palmheart.

Pineapple: Pineapple has only 4 ha in all the sample areas together. Pineapple (piña) increased its acreage only with 1.5 ha.
Plantain: It almost doubled its acreage from 6.5 ha to 12.3 ha (Table 7.2.). Mainly maize was turned into plantain (platano).

Cassava: Cassava more than doubled its acreage, from 21 ha in 1989 to 44 ha in 1991, and this is the most significant increase of all land uses. Almost one third of all changes in land use were towards cassava (yuca). It gained its acreage respectively on pasture, silvo pasture and maize.

Cacao: In Table 7.2. cacao lost 5 ha on its total acreage of 35 ha. The total acreage is probably higher, but is many times not distinguished from forest. Cacao was mainly turned into palmheart.

7.4. A focus on maize, cassava and palmheart

7.4.1. Introduction

Maize, cassava and palmheart are the most important cultivations for the Neguev settlement, at least in their acreage. One has to keep in mind that forest, silvo-pasture and pasture formed 80% of all the land use in 1989. On the moment palmheart is one of the most promising cultivations.

In the last two years the changes in acreage of maize, cassava and palmheart took place on different soil types. It is interesting to look on which soils types the most important changes took place, for each crop.

7.4.2. Maize

Maize had 43% of its acreage on soil type Parismina and 32% of its acreage on soil types Bosque and Bosque III in 1989 (Table 5.2.). These three soil types are all found in the sector La Lucha. Maize was also found on other soil types, but mainly in small quantities for home consumption.

Maize gained most of its acreage on soil types Parismina, Suampo, and Bosque, respectively 20.0%, 18.5% and 18.3% (see Figure 7.1.). But maize respectively lost 38.1%, 17.6% and 15.3% on soil types Parismina, Bosque and Milano AB, on the total lost of 7 ha in two years. So in total there was more lost than gained on the soil types Parismina and Bosque. In figure 7.1. it becomes obvious that maize has lost 6 ha on soil type Parismina and 1.5 ha on soil type Bosque, in the last two year. On the other hand maize gained 3 ha on soil type Suampo.

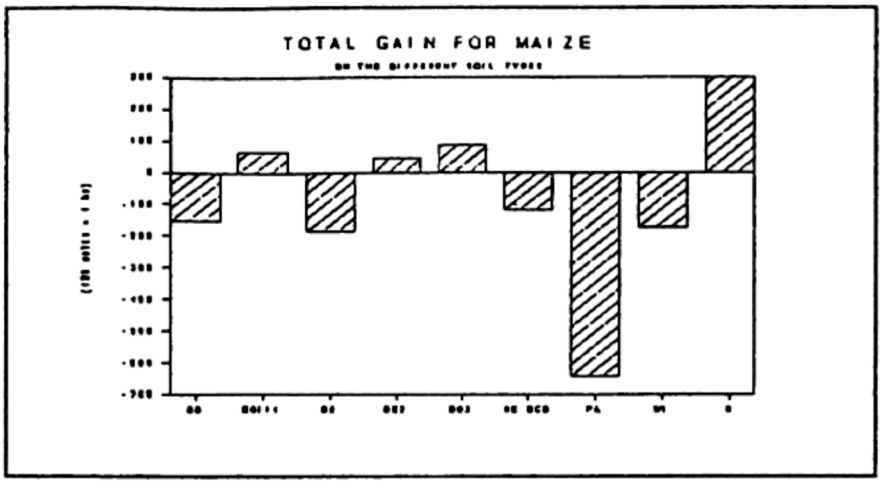


Figure 7.1 Total gain for maize, in the period 1989-1991

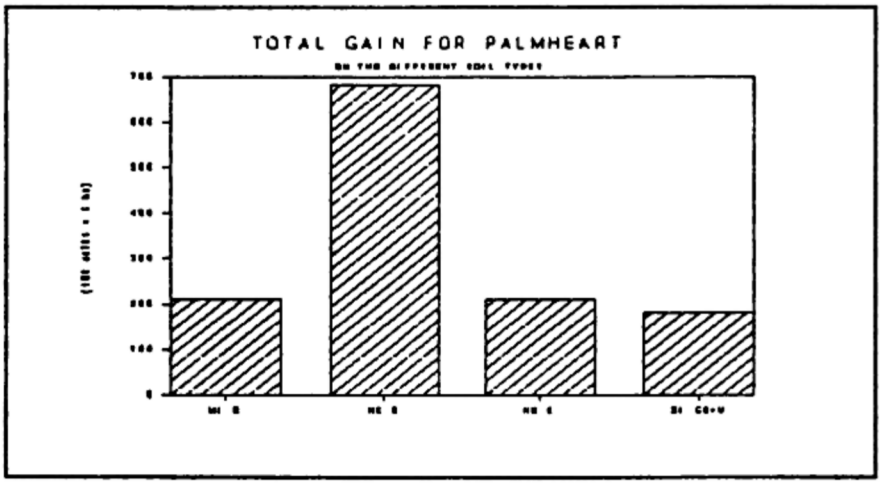


Figure 7.2 Total gain for palmheart, in the period 1989-1991

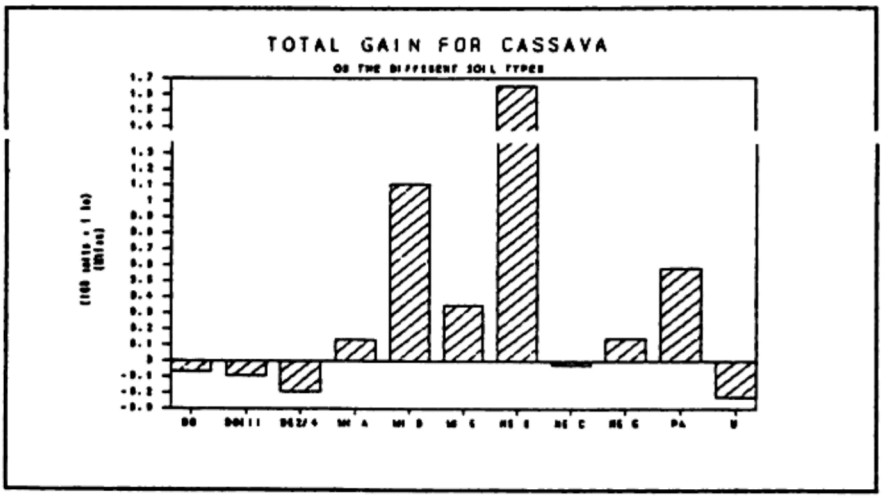


Figure 7.3 Total gain for cassava, in the period 1989-1991

7.4.3. Cassava

The most important soil types for this cultivation in 1989 were Bosque III, Neguev B, Milano B, and Parismina, respectively 17.3%, 16.8%, 15.2% and 14.8% (see table 5.2.). In the preceding paragraph it was stated that cassava more than doubled its acreage in the last two years.

In Figure 7.3. one can see that cassava (yuca) mainly gained acreage on soil types Neguev B, Milano B and Parismina. But also losses were found on these soil types except for Milano B. Figure 7.3 shows a gain for cassava on soil type Neguev B of 16 ha and on soil type Milano B a total gain of 11 ha. These are the most important net gains. Most important net losses were found on Suampo and Destierro 2/4, respectively 2.5 ha and 2.0 ha. The cassava on the suampo changed into cultivation of maize.

7.4.4. Palmheart

This crop has located 58% of its acreage in 1989 on soil type Neguev B and for 21% on soil type Milano B (see table 5.2.). In the last two years it increased its acreage with 44% (see table 7.2.).

It is interesting to see in table 7.1 that palmheart did not lose any of its acreage in the last two years. Probably palmheart is such an attractive investment that no farmer will change it into an other crop.

It gained acreage on soil types Neguev B, Neguev E, Milano B and Silencio CD+U, which is an association between soil type Silencio and Suampo. In figure 7.2. one can notice that palmheart did gain almost 7 ha on soil type Neguev B and about 2 ha on each of the other soil types, mentioned above.

So on the red soils palmheart is the most important cultivation and even increased its importance on these soils.

7.5. Conclusions

It is obvious that changes in land use are very dynamical, even if the net area of a specific cultivation does not change on a sub-regional level. A problem is that these changes are only monitored for the last two years. So about the change from one annual into an other annual not much can be concluded, because it is not necessarily a tendency, but a rotation. That chili lost all of its acreage and that maize lost 14% of its acreage does not say much in itself.

But it is important to note that silvo-pasture and pasture each lost 5% of their acreage, due to cultivation of annuals and perennials, and that palmheart increased its acreage with almost 50%, gained on (silvo)-pasture and cacao.

It was expected to find a larger loss in the total acreage of cacao. Most farmers told that the crop served for nothing and wanted to cut down the trees. Probably there will be a more significant decrease on the total acreage of cacao in the near future.

It was also expected that the increase of pineapple would be more significant, because most of the red soils are highly suited for the cultivation of pineapple and the cultivation is lucrative. Probably farmers have problems with getting credit. Most farmers can not cultivate this crop without sufficient credit.

That maize gained 3 ha on the soil type suampo is possible because the suampos are improved in the last two year by drainage and the cultivation of maize took place in the first months of 1991, which is a relatively dry period and an imperfectly drainage can even be an advantage in this period. But it is odd that 2 ha of maize is gained from cassava on this soil type. May be the plot is better drained than indicated on the soil map or there exist an error in the land use map 1989, see also figure 5.9.

8. Conclusions and recommendations

8.1. Outcome of the study

The most striking outcome of the study is that in general not more than three hectares is used for cultivation, even if the farm has a high percentage of "good" soil. A reason for this can be that most farmers prefer to work outside the farm, where they can earn more money. For off-farm work there are enough possibilities. They keep their farm as a kind of social security, upon which they rely in more difficult times. As a result eighty percent of the total area (all sample areas together) is under forest and (silvo-) pasture. The only exception is the more commercially oriented sector La Lucha, where on the farm up to twelve hectares is used for cultivation.

Ninety percent of all crops are cultivated on fields of less than 2 hectares and seventy percent of all crops are cultivated on fields of less than 1 hectare.

On the sub-regional level there is a crude relationship between soil type and land use. Passion fruit, palmheart and pineapple are only found on the red infertile soils. In this soil group 70% of all the forest is found and 80% of all the silvo-pasture. Contrary to the expectations a quarter of all the pasture is located on black fertile soils. Crops like maize and plantain are especially found on the fertile black soils, but are also represented on other soil types in small quantities.The most important crops in acreage are respectively maize, cacao, palmheart, and cassava.

With respect to the influence of infrastructure on the spatial distribution of land use, infrastructure has such an influence that forest and wasteland are found in the remotest parts of the farm and crops like coconut palms, sugarcane, fruit trees and plantain are found near the road.

Land use changes rapidly, even if the net acreage of a specific crop does not change on an aggregated (sub-regional) level. Not much can be concluded from changes of an annual into an other annual, because it does not imply necessarily a structural change. It is important to notice that silvo-pasture and pasture diminished in area by five percent, due to change into annuals and perennials. It is striking that palmheart increased its acreage with fifty percent in the last two years, all gained on cacao and (silvo-) pasture.

In the near future land use in the Neguev settlement will probably change more rapidly, because banana plantations are highly interested in buying the fertile black soils along the river Parismina. If farmers along the river Parismina will sell their farm to the banana companies, it will have a distinct influence on the land use in the whole settlement.

8.2. Conclusions in relation to the methodology

On aerial photographs (1:10 000) the land use of small plots, less than a quarter of a hectare, is not recognizable, unless the land use has very clear photo characteristics, like coconut palms. In the Neguev settlement many crops e.g., pumpkin, beans, rice, taro, sugarcane and yam are cultivated on a very small scale, mostly for home consumption, which makes it impossible to recognize them by aerial photo-interpretation. On the aerial photographs it is also difficult to distinguish cacao trees from forest. So, next to aerial photo-interpretation for land use mapping, field surveys remain indispensable. But during the field checks it was often difficult to brace a farmer. The reader has to keep in mind that the land use maps contain errors, due to all these problems, and that the conclusions are based on these land use maps.

Still a lot of work has to be done on the description of photo characteristics of land uses, how these photo characteristics change with the development of a crop, how they are related to yield levels, and how these photo characteristics, of a specific land use, can be extrapolated to other areas.

It is obvious that there is still a large gap between the actual land use and the potential land use. More research has to be done about the backgrounds of the gap between the actual and the potential land use.

REFERENCES

- BOLANOS, R., D. CUBERO e.a., 1991. Metodología para la determinación de la capacidad de uso de las tierras de Costa Rica. San José, Costa Rica.

- BOLANOS, C. & C. ULATE, 1987. Diagnóstico de los problemas jurídicos de la Provincia de Limón. Working Documents No. 4. Programma Zona Atlantica. Turrialba, Costa Rica.

- BRINK, M. & H. WAAIJENBERG, 1990. Base de datos de una encuesta de caracterización de fincas realizada en el norte de la Zona Atlántica de Costa Rica, 1987. Working document No. 7. Programa Zona Atlántica (CATIE-UAW-MAG). Turrialba, Costa Rica.

- DE BRUIN, S. 1988. Estudio detallado de los suelos del asentamiento Neguev. Atlantic Zone Programme, Costa Rica.

- DE BRUIN, S. e.a., 1990. Mapa detallado de suelos del asentamiento Neguev, escala 1:20 000. Programa Zona Atlántica (CATIE-UAW-MAG). Turrialba, Costa Rica.

- DE BRUIN, S. 1991. Estudio detallado de los suelos del asentamiento Neguev. Atlantic Zone Programme, Costa Rica.

- DE VRIES, P.A. 1986. Explotory Survey in the Atlantic Zone. Sociological report. Field report no. 2. Atlantic Zone Programme, Costa Rica.

- FAO, 1990. Land Evaluation and Farming System Analysis for Land Use Planning.

- IGN, 1967. Mapa topográfico de Bonilla, escala 1:50 000, hoja 3446 II. Clasificación de campo en 1965. San José, Costa Rica.

- IGN, 1990. Mapa topográfico de Guácimo, escala 1:50 000, hoja 3446 I. Clasificación de campo en 1986. San José, Costa Rica.

- JANSSEN, O.E. 1991. In en uitgaande geldstromen in relatie tot bodem en krediet. Atlantic Zone Programme Costa Rica.

- LANDSU, A. Soil structure under four land use types in the settlement Neguev. Field report no.18. Atlantic Zone Programme Costa Rica.

- MORA, L.J., R.V. PANIAGUA, 1990. La agricultura de cambio y la reproducción de la unidad campesina. Asentamiento Campesino Neguev. Heredia, Costa Rica.

- ONORO, M.T. 1990. El Asentamiento Neguev: Interacción de campesinos y estado en el aprovechamiento de los recursos naturales. Programme paper No.7. Atlantic Zone Programme Costa Rica.

- PURSEGLOVE, J.W., 1987. Dicotyledons. Longman Scientific and Technical. Essex England.

- PURSEGLOVE, J.W., 1985. Monocotyledons. Longman Scientific and Technical. Essex England.

- SCHIPPER, R.A. 1989. Una caracterización de fincas en Neguev, Rio Jímenez y Cocori. Atlantic Zone Programme Cota Rica.

- SOTO, L.G.R. 1986. Informe General Asentamiento Neguev. IDA.

- SPAANS, E.J.A., J. BOUMA, A. LANSU & W.G. WIELEMAKER, 1989. Satured and unsatured flow in a Humitropept under forest and pasture in Costa Rica. Tropical Agriculture, Trinidad.

- VAN UFFELEN, J.G. 1989. Evaluacion de las tierras segun agricultores y segun la clasificacion tecnica en el asentamiento Neguev. Atlantic Zone Programme Costa Rica.

- VERBRAEKEN, J. 1987. Deforestacion, vegetacion y manejo agroforestal en la Zona Atlantica de Costa Rica. Un estudio de las subareas Rio Jímenez, Neguev y Cocori. Atlantic Zone Programme Costa Rica.

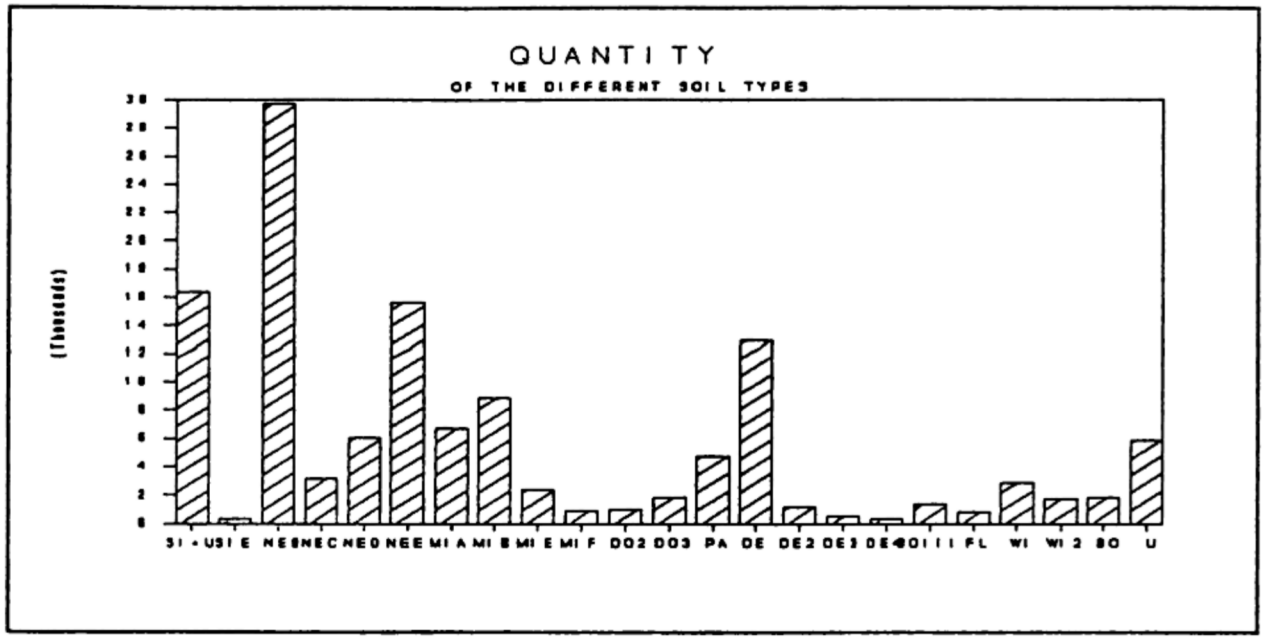
GLOSSARY

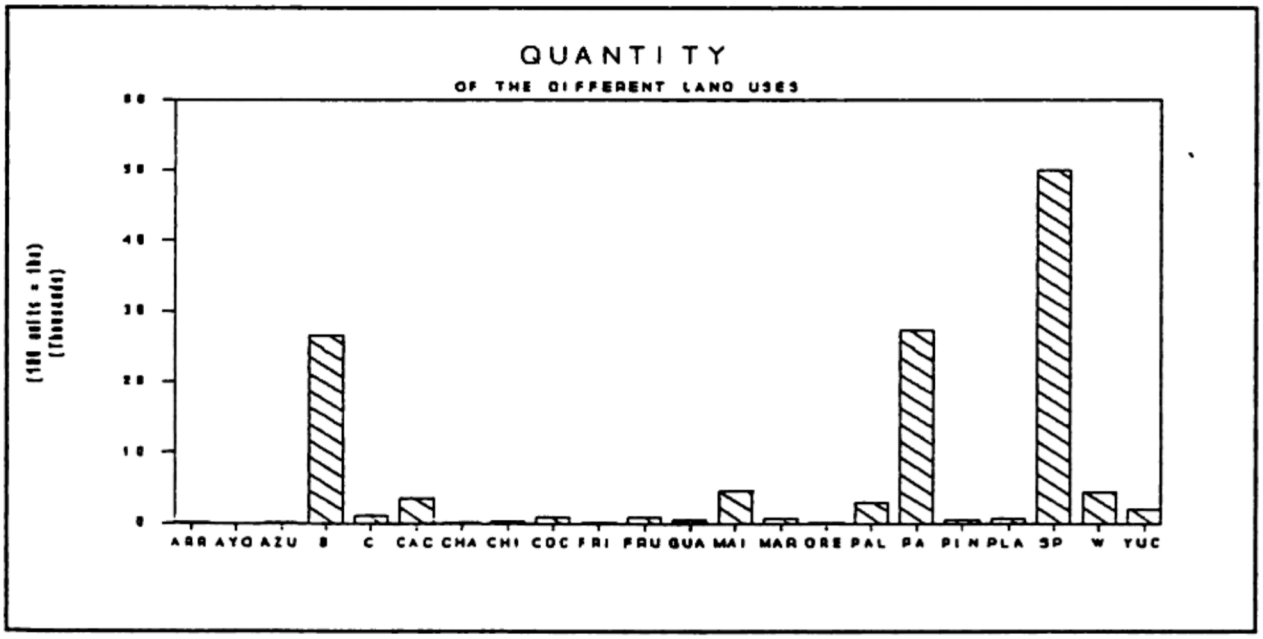
AUW	Agricultural University Wageningen
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CNP	Consejo Nacional de Produccion
CODELA	Corrugados del Atlantico S.A., cajas de cartón
IDA	Instituto de Desarollo Agrario (before ITCO)
ITCO	Instituto de Tierras y Colonización
MAG	Ministerio de Agricultura y Ganadería
MGLP	Multiple Goal Linear Programming
UPAGRA	Unión de Pequeños Agricultores del Atlántico

Appendix 1. SCIENTIFIC NAMES.

ARROZ	=	RICE	=	Oryza sativa
AYOTE	=	PUMPKIN	=	Cucurbita sp.
AZUCAR	=	SUGARCANE	=	Saccharum sp.
(B)OSQUE	=	FOREST		
(C)ERCADO	=	COMPOUND		
CACAO	=	CACAO	=	Theobroma cacao
CHAMOL	=	TARO	=	Colocasia esculenta
CHILE	=	CHILI	=	Capsicum spp.
COCO	=	COCONUT	=	Cocos nucifera
(FRIJ)OLES	=	BEANS	=	Phaseolus vulgaris
FRUTALES	=	FRUIT TREES		
GUANABANA	=	SOURSOP	=	Annona muricata
MAIZ	=	MAIZE	=	Zea mays
MARACUYA	=	PASSION FRUIT	=	Passiflora edulis
OREGANO	=	OREGANO	=	
PALMITO	=	PALMHEART	=	Bactris gasipaes
(PA)STO	=	PASTURE		
PINA	=	PINEAPPLE	=	Ananas comosos
PLATANO	=	PLANTAIN	=	Musa AAB
(S)ILVO (P)ASTO	=	SILVO PASTURE		
YUCA	=	CASSAVA	=	Manihot esculenta

Appendix 2. FIGURES ON AREA (HA) OF LAND USES AND SOIL TYPES FOR TOTAL SAMPLE AREA.





Appendix 3. CROSS TABLE OF LAND USES AND SOIL TYPES.

TOTAL.	STCD+U	ST	E	NE B	NE C	NE D	NE E	MT A	MT B	MT E	MT F	DO2.	DO3	PA	DE	DE2.	DE3	DE4	BOTTT	FL.	WT	WT2.	RO	U	TOTAL.
ARROZ.				40	16																				56
AYOTE																						10			10
AZUCAR						5							173								10				188
BOSQUE	4261	91	3941	681	1776	6931	39	321	276	68	608			255	2643	120		80	8	98	938	174	55	3160	26524
CERCADO			473		9	49	172	172		14				33	15		4				25				966
CACAO	111		1171		45	631	280	360	18	73	28	46		429					74			98	93		3457
CHAMOL.														10					20						30
CHILE	15						20	223	57													6			321
COCONUT			249	11	25	113	322	49						99					19				23		910
FRIJOLES														45							20				65
FRUTALES			200	39		51	275	105	27					77							3		18		795
GUANABANA							408				11	165													584
MATZ.			55	84	39		377	50	42			56	1982	223	42				652	6	195		817		4620
MARACUYA	74		388	97				169																	728
OREGANO			46				22																		68
PALMITO			1743		138	290	99	616	96		5				6										2993
PASTO	75		7375	178	1494	1606	2939	3214	907	145	93	730	930	5549	271	353			67	152	261	711	193	129	27372
PINA			275				41		110																426
PLATANO	52		23	18	66									299					110	92					660
SP	11829	207	13350	1921	2247	5597	1623	3109	975	585	266	647	247	3125	629	194	107		61	229	1263		151	1655	50017
WASTELAND				48	194	304	94	91	23			51	54	1443						224	200	748	291	698	4463
YUCA			346	28			66	313						305		80		115	356				225	224	2058
TOTAL.	16417	298	29675	3121	6038	15635	6714	8902	2421	885	1011	1868	4765	13004	1142	551	302	1367	801	2915	1747	1866	5866	127311	

Appendix 4. FREQUENCY TABLE OF LAND USES ON EACH SOIL TYPE.

	SICDST	ENE	BNE	CNE	DNE	EMT	AMT	BMT	E	MT	FDO2	DO3	PA	DE	DE2	DE3	DE4	BOTTFL	WT	WT2	BO	U	TOTAL
ARROZ			1	1																			2
AYOTE																				1			1
AZUCAR					1														1				2
BOSQUE	16	2	36	10	14	48	2	6	5	2	7		4	27	1		1	2	5	14	2	2	17	223
CACAO	3		14		2	7	6	6	1	1	1	1	4					2			3	1		52
C			19		1	4	2	7		1			1	1		1					1			38
CHAMOL.													1					1						2
CHTLE	1						1	4	2															8
COCONUT			6	1	2	5	5	2					4					2				1		28
FRIJOLES													1							1				2
FRUTALE			8	2		2	6	2	2				2							1		1		26
GUANABANA							2				1	1												4
MATZ		2	1	1			5	1	1			2	15	3	1			6	1	4		4		47
MARACUY	2		6	2				2																12
OREGANO			1			1																		2
PALMITO			13		3	10	3	5	2		1			1										38
PASTO	1		39	2	6	23	10	17	9	2	1	6	8	16	2	1		2	3	4	4	5	6	167
PINA			4			2	1																	7
PLATANO	3		1	1	2								7					1	2					17
SP	29	2	72	14	19	46	9	13	5	9	4	10	6	17	4	2	1	1	4	13		3	19	302
W				1	3	4	1	2	1			1	1	7					2	2	3	2	9	39
YUCA			8	1			1	3					6		1		1	5				3	2	31
TOTAL	55	6	229	36	53	152	54	70	28	15	15	21	60	72	9	4	3	22	17	40	14	22	53	1050

Appendix 5. LEGEND LAND USE MAPS OF THE SAMPLE AREAS.

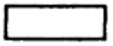
			FABER-CASTELL COLOR
ARROZ	=	RICE	= 15
AYOTE	=	PUMPKIN	= 28
AZUCAR	=	SUGARCANE	= 42
(B)OSQUE	=	FOREST	= 37
(C)ERCADO	=	COMPOUND	= 14
CACAO	=	CACAO	= 26
CHAMOL	=	TARO	= 7
CHILE	=	CHILI	= 54
COCO	=	COCONUT	= 23
(FRIJ)OLES	=	BEANS	= 2
FRUTALES	=	FRUIT TREES	= 54
GUANABANA	=	SOURSOP	= 45
MAIZ	=	MAIZE	= 17
MARACUYA	=	PASSION FRUIT	= 1
OREGANO	=	OREGANO	= 27
PALMITO	=	PALMHEART	= 58
(PA)STO	=	PASTURE	= 33
PINA	=	PINEAPPLE	= 12
PLATANO	=	PLANTAIN	= 9
(S)ILVO (P)ASTO	=	SILVO PASTURE	= 35
(W)ASTELAND	=	WASTELAND	= 32
YUCA	=	CASSAVA	= 22

Appendix 6. LEGEND SOIL MAPS OF THE SAMPLE AREAS.

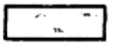
FABER-CASTELL COLOR

SILENCIO = 12

NEGUEV = 14



MILANO = 15



DOS NOVILLOS = 33

PARISMINA = 32

DESTIERRO = 25

BOSQUE III = 37

FLORIS = 28

WILLIAMSBURG = 45

BOSQUE = 42

SUAMPO = 56

LEYENDA

FASES DE PENDIENTE:
- A: Planos o casi planos
- B: Onduladas
- C: Inclinadas o fuertemente onduladas
- D: Colinadas o moderadamente escarpadas
- E: Escarpadas
- F: Muy escarpadas

SUELOS BIEN DRENADOS DE REACCION ACIDA, CON UNA FUERTE ALTERACION DE LOS SEDIMENTOS ORIGINARIOS

Serie Silencio. Muy profundo. 7.5 YR o más roja en matiz, arcilla sobre estratos arenosos y limosos meteorizados. Onic Humitropepts, familia muy fina, caolinítica, isohipertérmica.

Unidades cartográficas:

- Si / ee — Silencio, fases de pendiente
- Si / D-E + u — Complejo Silencio, fases quebradas a escarpadas - 10-15 % unidad u
- Si / C-D + u — Complejo Silencio, fases fuertemente onduladas a quebradas - 10-15 % unidad u

Serie Neguev. Muy profundo, 10 YR en matiz, arcilla con cascajo poco meteorizado a profundidades superiores a los 120 cm. Andic Humitropepts, familia muy fina, caolinítica, isohipertérmica.

Unidades cartográficas:

- Ne / ee — Neguev, con fases de pendiente

Serie Milano. Profunda, 10 YR en matiz, arcilla a franco arcillosa con cascajo poco meteorizado dentro de 120 cm de profundidad. Andic Humitropepts, familia fina, caolinítica, isohipertérmica.

Unidades cartográficas:

- Mi / ee — Milano, con fases de pendiente
- MiK2 / B — Milano, fases onduladas, 0.1-3% pedregosas en la superficie

SUELOS MODERADAMENTE BIEN O BIEN DRENADOS DE REACCION NO ACIDA, CON UNA MODERADA ALTERACION DE LOS SEDIMENTOS ORIGINARIOS

Serie Dos Novilles. Superficial a moderadamente profunda, franco arenoso sobre arena y a veces grava. Typic Udivitrands, familia arenosa, mixta, isohipertérmica.

Unidades cartográficas:

- Do3 — Dos Novilles, fases moderadamente profundas
- Do3K2 — Dos Novilles, fases moderadamente profundas, 0.1-3% piedras en la superficie
- Do2 — Dos Novilles, fases superficiales

Serie Río Parismina. Moderadamente profunda a profunda, franco arenoso fino a franco limoso sobre arena. Andic Dystropepts, familia francosa-gruesa, mixta, isohipertérmica.

Unidad cartográfica:

- Pa — Consociación Río Parismina

Serie Destierro. Moderadamente profunda a profunda, franco a franco limoso sobre arena francosa. Andic Eutropepts, familia francosa-gruesa, mixta, isohipertérmica.

Unidad cartográfica:

- De — Grupo no diferenciado Destierro y variantes

Serie Destierro: variante franco arcillosa. Profunda, franco arcillosa.

Unidad cartográfica:

- Ds — Consociación Destierro, variante franco arcillosa

Serie Destierro: variante franco arcillosa sobre piedras y grava. Superficial a profunda, franco arcillosa, sobre piedras y grava.

Unidades cartográficas:

- Ds4 — Destierro, variante franco arcillosa sobre piedras y grava, fase profunda

Serie Ligia. Profunda, franco limoso a franco arcillo limoso. Andic Eutropepts, familia francosa-fina, mixta, isohipertérmica.

Unidad cartográfica:

- Li — Consociación Ligia

Serie La Lucha: variante moderadamente bien drenada. Moderadamente profunda, franco a franco arenoso sobre arena. Con moteados grises y anaranjados.

Unidad cartográfica:

- LuIII — Consociación La Lucha: variante moderadamente bien drenada

Serie Bosque: variante moderadamente bien drenada. Moderadamente profunda, franco a franco limoso con moteados grises y anaranjados.

Unidad cartográfica:

- BoIII — Consociación Bosque: variante moderadamente bien drenada

SUELOS BIEN DRENADOS DE REACCION ACIDA CON MUY POCA ALTERACION DE LOS SEDIMENTOS ORIGINARIOS

Serie Flores. Muy superficial, pardo grisáceo muy oscuro, arena francosa a franco arenosa sobre material estratificado que varía en textura de arena a franco arenoso. Tropofluvents, familia arenosa, mixta, isohipertérmica.

Unidad cartográfica:

- Fl — Consociación Flores

SUELOS IMPERFECTAMENTE DRENADOS, DE REACCION NO ACIDA CON UNA MODERADA ALTERACION DE LOS SEDIMENTOS ORIGINARIOS

Serie La Lucha. Moderadamente profunda, franco a franco arenoso sobre arena. Andic Eutropepts, familia francosa-gruesa, mixta, isohipertérmica.

Unidad cartográfica:

- Lu — Consociación La Lucha

Serie Williamsburg. Moderadamente profunda, franco limoso a franco arcilloso. Clasificación preliminar: Andic Eutropepts, familia francosa-fina, mixta, isohipertérmica.

Unidad cartográfica:

- Wi — Consociación Williams

Serie Williamsburg: variante sobre piedras y grava. Franco limoso a franco arcilloso sobre grava y piedras.

Unidad cartográfica:

- Wi2 — Williamsburg: variante sobre piedras y grava, fase superficial

Serie Bosque. Imperfectamente a escasamente drenada, moderadamente profunda, franco arcilloso a arcilla sobre estratos de arena fina limo y arcilla. Aquandic Tropaquepts, familia fina, mixta, isohipertérmica.

Unidad cartográfica:

- Bo — Consociación Bosque

SUELOS ESCASAMENTE O MUY ESCASAMENTE DRENADOS

Fluvaquentic Troposaprists. Suelos orgánicos (Turberas) bien descompuestos con una capa mineral de textura franco arcillosa. Escasamente drenados.

Unidad cartográfica:

- Tu — Fluvaquentic Troposaprists

Grupo no diferenciado Tropofibrists y Tropaquents. Este grupo incluye las áreas pantanosas (ciénagas).

Unidad cartográfica:

- u — Grupo no diferenciado Tropofibrists y Tropaquents

Cuadro 5.1 Algunas características y la capacidad de uso de las unidades cartográficas.

Código de la Unidad Cartográfica	Descripción	Pendiente Lim. inf. Lim. sup. (%)	Text. (1) (Clase)	Prof. (cm)	pH(H2O)	Dren. (2) (Clase)	Pedreg. superf. (%)	Riesgo inund. (3) (Clase)	Cap. de uso (Clase)
Si/C	Silencio, fases fuertemente onduladas	5 a 8 10 a 16	Ac*	>300	4-5	4	<0.01	0	IX e2,3
Si/D	Silencio, fases quebradas y moderadamente escarpadas	10 a 16 20 a 30	Ac*	>300	4-5	4	<0.01	0	IX e1,e2,3
Si/E	Silencio, fases escarpadas	20 a 30 45 a 65	Ac*	>300	4-5	4	<0.01	0	IX e1,e2,3
Si/C-D + W	Complejo Silencio, fases fuertemente onduladas a quebradas - Grupo no diferenciado Tropofibrista y Tropaquente	5 a 8 20 a 30 - 0	Ac*	>300	4-5	4	<0.01	0 a 4	IX e1,e2,3
Si/D-E + W	Complejo Silencio, fases quebradas a escarpadas - Grupo no diferenciado Tropofibrista y Tropaquente	10 a 16 45 a 65 - 0	Ac*	>300	4-5	4	<0.01	0 a 4	IX e1,e2,3
Ne/B	Neguev, fases onduladas	1 a 3 5 a 8	Ac*	>150	4.2-5.5	4	<0.01	0	VI e2,3
Ne/C	Neguev, fases inclinadas o fuertemente onduladas	5 a 8 10 a 16	Ac*	>150	4.2-5.5	4	<0.01	0	VI e2,3
Ne/C-D	Neguev, fases fuertemente onduladas a quebradas	5 a 8 20 a 30	Ac*	>150	4.2-5.5	4	<0.01	0	VII e1,e2,3
Ne/D	Neguev, fases quebradas o moderadamente escarpadas	10 a 16 20 a 30	Ac*	>150	4.2-5.5	4	<0.01	0	VII e1,e2,3
Ne/E	Neguev, fases escarpadas	20 a 30 45 a 65	Ac*	>150	4.2-5.5	4	<0.01	0	VIII e1,e2,3
Mi/A	Milano, fases planas o casi planas	0 1 a 3	FAc-Ac	80-120	4.6-5.8	4	<0.01	0	IV e3
Mi/B	Milano, fases onduladas	1 a 3 5 a 8	FAc-Ac	80-120	4.6-5.8	4	<0.01	0	IV e3
MiK2/B	Milano, fases onduladas, superficie pedregosa	1 a 3 5 a 8	FAc-Ac	80-120	4.6-5.8	3	0.1-3	0	IV e3
Mi/E	Milano, fases escarpadas	20 a 30 45 a 65	FAc-Ac	80-120	4.6-5.8	4	N.D. (4)	0	VIII e1
Mi/F	Milano, fases muy escarpadas	45 a 65 no hay	FAc-Ac	50-80	4.6-5.8	4	N.D.	0	X e1,e1
Do2	Dos Bovilles, fase superficial	0 1 a 3	Fa	25-50	5.5-6	3	<0.01	2	X e1
Do3	Dos Bovilles, fases moderadamente profundas	0 1 a 3	Fa	50-80	5.5-6	4	<0.01	0-1 (4)	III e1
Do3K2	Dos Bovilles, fases moderadamente profundas, superficie pedregosa	0 1 a 3	Fa	50-80	5.5-6	4	0.1-3	0	III e1
Fa	Consociación Rio Parismina	0 1 a 3	Fa-FL	60-12	6-6.5	4	<0.01	1	II/III d1
De	Grupo no diferenciado Destierro y variantes	0 1 a 3	F-FL	50-120	6-6.5	3-4	<0.01	2	VI e1,3
Fc	Destierro, variante franco arcilloso	0 1 a 3	FAc	80-120	6-6.5	3-4	<0.01	2	VI d2
Fc2	Destierro, variante franco arcilloso, substrato pedregoso y gravoso, fases superficiales	0 1 a 3	FAc	25-50	6-6.5	3-4	<0.01	1	X e1
Fc3	Destierro, variante franco arcilloso, substrato pedregoso y gravoso, fases moderadamente profundas	0 1 a 3	FAc	50-80	6-6.5	3-4	<0.01	1	III e1
Fc4	Destierro, variante franco arcilloso, substrato pedregoso y gravoso, fases profundas	0 1 a 3	FAc	80-120	6-6.5	3-4	<0.01	1	II/III d1
Li	Consociación Ligia	0 1 a 3	FAc	>98	6-6.5	3	<0.01	0-1	III e1,d1
LuIII	Consociación La Lucha, variante moderadamente bien drenada	0 1 a 3	Fa-F	50-80	6-6.5	3	<0.01	1	III e1,d1
BoIII	Consociación Bosque, variante moderadamente bien drenada, franco limoso	0 1 a 3	F-FL	50-80	6-6.5	3	<0.01	1	III e1,d1
Fl	Consociación Flores	0 1 a 3	a-aF	5-25	5.5-6	4-5	<0.01	2	X e1,d2
Lu	Consociación La Lucha	0 1 a 3	Fa-F	50-80	6-6.5	2	<0.01	2	VI d1,d1.2
Wi	Consociación Williamsburg	0 1 a 3	FAc-Ac	50-80	5.5-6	2	<0.01	2	VI e1,d1.2
WiK	Williamsburg, variante substrato pedregoso y gravoso, fases superf.	0 1 a 3	FL-FAc	25-50	5.5-6	2	<0.01	1	VI d1,e1
Bo	Consociación Bosque	0 1 a 3	FAc-Ac	50-80	6-6.5	1-2	<0.01	2	VI d1,2
Tu	Fluventic Tropeasaprists	0 1 a 3	N.D.	N.D.	N.D.	1	<0.01	2	IX d1,2,e2
W	Grupo no diferenciado Tropofibrista y Tropaquente	0 1 a 3	N.D.	N.D.	N.D.	0-1	<0.01	3-4	IX/X d1,2

(1) a : arena Fa : franco arenoso
Ac : arcilla FAc: franco arcilloso
Ac*: >60% arcilla FL : franco limoso
aF : arena francosa

(2) 0 : Muy escasamente drenado: la capa freática permanece en la superficie o sobre ésta
1 : Escasamente drenado: el suelo permanece mojado por largos periodos de tiempo
2 : Imperfectamente drenado: el suelo se mantiene mojado durante periodos muy apreciables, pero no todo el tiempo
3 : Moderadamente bien drenado: el perfil permanece mojado durante periodos cortos pero apreciables
4 : Bien drenado: el agua es eliminada del suelo con facilidad, pero no rápidamente
5 : Muy excesivamente drenado: el agua se elimina rápidamente del suelo

(3) 0 : Ninguno
1 : Inundación ligera: el agua se estanca o se inunda el terreno por periodos de unos días de algunos años
2 : Inundación moderada: el agua se estanca o se inunda el terreno por periodos de varios días en la mayoría de los años
3 : Inundación severa: el agua inunda el terreno por algunas semanas todos los años
4 : Anegado: el agua está encima del suelo durante casi todo el año

Apppendix 9. FARMS THAT ARE TOTALLY INCLUDED IN THE SAMPLE AREAS.

Farm numbers:

MASCOTA
204, 205, 206, *207, 212, 214, 216, 218, 211, 213, 215, 217, 219, 220, 221, and 222.

LA LUCHA
57, 56, 55, 54, 53, 52, 51, 50, and 49.

EL PEJE
270, 272, 275, 277, 279, 280, 258, 260, 262, 264, 266, 268, 257, 259, 261, 263, 265, 267, and 269.

SILENCIO
228, 227, 241, 240, 101, 98, 97, 99, and 100.

MILANO
* 153, * 155,* 154, 151, 149, 144, 147, 148, 152, 156, 157, 158, 202, 203, 201, 163, 162, 161, 160, 159, 174-A, 175, and 179.

MATAS CR
176, 178, 180, 182, 184, 185, 186, *191, 190, 177, 181, 187 188, # 189, 234, 231, and 230.

* These parcels are almost included in the sample areas.

189-A is included in parcel 236.
parcel 237 and 238 are not divided.

Appendix 10a. LAND USE MAP 1989 OF THE SAMPLE AREA "LA LUCHA". 1989

1989

NR 46405 R 261 L2
1:10.000

CA MÜCHER

Appendix 10b. LAND USE MAP 1991 OF THE SAMPLE AREA "LA LUCHA"

1991

NR 46405 R 261 L2
1:10.000

CA MÜCHER

Appendix 10c. SOIL MAP OF THE SAMPLE AREA "LA LUCHA".

1:10.000

CA MÜCHER

Appendix 11a. LAND USE MAP 1989 OF THE SAMPLE AREA "MASCOTA".

1989

NR 45001 R 256 L6

1:10.000

CA MÜCHER

Appendix 10a. LAND USE MAP 1989 OF THE SAMPLE AREA "LA LUCHA". 1989

1989

NR 46405 R 261 L2
1:10.000

CA MÜCHER

Appendix 10b. LAND USE MAP 1991 OF THE SAMPLE AREA "LA LUCHA"

1991

1991

NR 46405 R 261 L2
1:10.000

CA MÜCHER

Appendix 10c. SOIL MAP OF THE SAMPLE AREA "LA LUCHA".

1:10.000

CA MÜCHER

Appendix 11a. LAND USE MAP 1989 OF THE SAMPLE AREA "MASCOTA".

1989

NR 45001 R 256 L6

1:10.000

CA MÜCHER

Appendix 11b. LAND USE MAP 1991 OF THE SAMPLE AREA "MASCOTA".

1991

NR 45001 R 256 L6

1:10.000

CA MÜCHER

Appendix 11c. SOIL MAP OF THE SAMPLE AREA "MASCOTA".

Appendix 12a. LAND USE MAP 1991 OF THE SAMPLE AREA "MILANO"

Appendix 12b, LAND USE MAP 1989 OF THE SAMPLE AREA "MILANO".

NR 45032 L5 R 256
1:10.000

C.A MÜCHER

Appendix 13a. LAND USE MAP 1989 OF THE SAMPLE AREA "MATAS CR".

Appendix 13b. LAND USE MAP 1991 OF THE SAMPLE AREA "MATAS CR".

Appendix 13c. SOIL MAP OF THE SAMPLE AREA "MATAS ĆR".

1:10.000

CA MÜCHER

Appendix 14a. LAND USE MAP 1989 OF THE SAMPLE AREA "SILENCIO".

Appendix 14b. LAND USE MAP 1991 OF THE SAMPLE AREA "SILENCIO".

- Appendix 14c. SOIL MAP OF THE SAMPLE AREA "SILENCIO".

L4

C.A. MUCHER

Appendix 15a. LAND USE MAP 1989 OF THE SAMPLE AREA "EL PEJE".

NR 45027 R256 L5

1:10.000

C.A. MÜCHER

Appendix 15b. LAND USE MAP 1991 OF THE SAMPLE AREA "EL PEJE".

1991
45027 R 256 L5

1:10.000

C.A. MÜCHER

Appendix 15c. SOIL MAP OF THE SAMPLE AREA "EL PEJE".

NR 45027 R 256 L5

1:10.000

C.A. MÜCHER