# CLIMATIC AND EDAPHIC CLASSIFICATION AT A CONTINENTAL SCALE (1 5,000,000) FOR CASSAVA IN SOUTH AMERICA



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## 1/Introduction and purpose of the study.

1.11 The wide range of climatic and edaphic conditions in which cassava is grown in South America becomes apparent from a glance at a map of the crop's distribution (such as is presented in section 2 1 of this study)

This diversity of conditions has not gone unnoticed by the Cassava Programme at CIAT, and research strategies have been tailored according to a preliminary classification of ecosystems for the crop (CIAT 1981, 1982). This framework has, of necessity, been based upon the range of environmental conditions prevalent in Colombia, with a seperate subdivision for the subtropics To use it requires that a place which is to be classified be compared with the Colombian testing sites used by the cassava programme to find the most similar The faults of this system have been recognised by the cassava team From the author's point of view these are, a/ Representatives of the "universe" or "population" of climates in which cassava is grown in South America cannot always be found in Colombia, even if the semi-tropical and subtropical regions are ignored b/ Whilst the differences between the "ecosystems" are based on differences in climatic and/or edaphic conditions which the cassava team recognise as being significant to the plant, there is no indication of the magnitude or importance of the different types of variable used to distinguish an ecosystem Is Palmira more similar to the North Coast of Colombia or to Popayan, being at an intermediate altitude between the two? What is more important for distinguishing ecosystems, differences based on mean annual temperature, annual rainfall, length of dry season, or even edaphic factors?

Somehow these climatic and edaphic variables have to be ranked, in accordance with what is known about the crop, and used to interpret available information The aim of this study is to achieve a new schema which is based on a/traditional climatic and edaphic classification, to identify the characteristics of areas outside of Colombia, and, b/on cassava specific factors, to interpret and order other people's classifications or data for that crop

1 12 This document and the maps are not intended to permit CIAT Cassava Program scientists to be able to predict what the climate or soil will be like at any place on the map The variability in soils and climate at the local scale, such as in a single field, prevent the prediction of environment at anything but a generalised level Furthermore, given that the strategy of the farmer often incorporates careful adaptations to very localised variations in these factors, the real worth of trying to predict

environment through agro-ecozonings etc can be seriously questioned for all but the most broad questions of research-policy orientation

Instead, the maps and descriptions presented here merely attempt to indicate to interested parties the range of environments (combinations of climatic and edaphic conditions) which exist across the area in which the crop is cultivated, and the most probable differences (in a statistical sense) between one area/homologue/ecozone and the next according to environmental factors which affect the cassava plant

The degree of environmental variation within the typical "agroecozone" which usually results from this type of study is what neutralizes their utility, problems of scale prevent all the different "permutations" of environmental conditions which might affect a crop from being represented on a map, hence the supposed homogeneity of a "zone" in fact is rapidly destroyed once somebody tries to use it in the field and finds out that it is extremely heterogeneous Soil scientists have partially overcome this problem by representing soils as associations on a map

To try and resolve this problem for the purpose of environmental classification for one crop, rice, Jones and Garrity (1985) have suggested the use of a hierarchical classification of environments, like a taxonomy This could provide a basis for mapping crop-specific environmental variation In fact it is the classification itself which matters to the user, not the maps which might be used to illustrate the distribution of the distinctive classes, for the above reasons

For cassava, unlike upland rice, there exist few clearly defined parameters which allow the researcher to distinguish between different types of climate, although for soils the task is slightly easier Nevertheless this hierarchical approach has been adopted here as far as is possible, using in part some simple parameters defined by CIAT scientists and in part by examining and modifying other climatic and edaphic classifications to produce something more specific to cassava in each case The hierarchy is primarily climatic Climatic variation is generally of a regional character, easy to map, and there are known differences in varietal response to factors such as mean annual temperature, irrespective of edaphic differences, which suggest climate's importance as a basic distinguishing factor between environments Edaphic differences have been relegated to the bottom level of the hierarchy, because of their spatial variability at a local scale Nevertheless, in many of the climate-soil 'homologues" defined in the final map (Map 4), it is the combination of climate and soil which determines the particular conditions which cassava must tolerate, such as soil water balance To try to incorporate such combined variables into the hierarchical classification is beyond the scope of this study

The resulting classification is very simple, although the resulting maps appear somewhat complex to look at It is worth stressing that it is the hierarchic classification which is of use, and which will require modification as more is learnt about the crop, the maps should be used bearing in mind the above comments about their utility and defects.

1 21 The area included in this study has been restricted to those parts of the South American continental land mass where cassava is grown in quantities that can be represented in available census and other agricultural statistics Hence there are large parts of the Amazon basin and the Chaco which have been excluded, the distribution of the human population in these parts is so sparse as to make it impossible to record the distribution of the crop Nor is it wise to include such areas when available climatic and soils data is similarly sparse, as has been popular with other studies such as the Agro-ecozones project of the FAO (FAO 1979) Similarly those areas where the crop will not grow for reasons of climatic unsuitability have been omitted, these include the tropical Andes above about 2000m, the subtropical Andean zone, and the southern cone countries south of about latitude 30 degrees

Many people will ask why Central America and the Carribean countries have not been included The answer is simply that the accidented topography creates complex patterns of climate and soil as reflected on available climatic and soil maps. The Dry Season map for Latin America (Jones 1984), and the Soil Map of the World Vol III (FAO 1975) both illustrate this Such complexity is not possible to incorporate into a study at this scale and requires much more detailed investigation and mapping at a larger scale In addition very little information is available describing the distribution of cassava in any of the countries of the region, particularly the most important producers, Cuba and Haiti

## 2/Classification and Design of the Maps

2 1 The distribution map for cassava in South America (Map 1) has been compiled from a number of sources of data, published and unpublished, from the period 1971 to 1981 (see Appendix) The map is intended to serve as an indicator of the areas within the continent where cassava is grown It is similar to other crop distribution maps in that dots are used to represent a specified number of hectares In this case one dot is equal to 1000 hectares of cassava, the available data does not distinguish between hectares sown and harvested except in the case of Brazil, the former statistic has been used for that country Each dot was located as far as possible according to the source information, for example in Brazil around each municipio town In other cases CIAT staff were consulted to help in identifying precise areas of production

2 12 Because of the variability in publication dates of the data, and the tentative nature of some of it, the map should be used for comparing areas on the basis of the relative concentration of cassava rather than the exact number of dots present in any part of the map The main areas of concentration of production are the following,

1 Colombia, Andean valleys and the Departments of Santander and Norte de Santander
2 Colombia, The North Coast
3 Brasil, Belem area of Para
4.Brasil, Sao Luis area of Maranhao
5 Brasil, Eastern uplands of Rio Grande do Norte, Paraiba, Pernambuco
6 Brasil, Bahia, particularly around Cruz das Almas, Alagoas and Sergipe, and extending south into Minas Gerais
7 Brasil, Coastal plain in Santa Catalina and Rio Grande do Sul from Blumenau and Florianopolis to Porto Alegre
8 Brasil, Argentina, Parana plateau and valley of the Rio Uruguay including Misiones (Arg ) and the western part of Rio Grande do Sul
9 Eastern Paraguay

### 2 2 Climatic classification and map

2.21 There are two possible approaches to constructing a climatic zonification at a continental scale for a crop such as cassava

Either by utilising one of the more conventional climatic classifications such as those of Thornthwaite (1948), and more recently Papadakis (1970), to highlight the differences in climate in general terms between different parts of the area where the crop is found,

Or, by listing all the variables (temperatures, rainfall etc ) which control cassava's distribution, and subdividing the area where it can grow according to significant "thresholds" in these variables (eg "x" mm mean annual rainfall, or "y" dry months etc.).

The second option theoretically requires analysis of all available meteorological data, and the construction of maps to illustrate the distribution of each chosen parameter Whilst this approach is preferible there does not exist enough information about the effects on cassava of climatic factors to be able to define precisely either variables or thresholds, and instead the two methods were combined

2 22 The Papadakis classification was used to determine the main climatic types for the area where cassava is grown in the following manner The individual classes of this system were each assigned numeric values for a number of variables extracted from the classification system and were then simplified and re-ordered, using a clustering technique to give a group of generalised climates These form a first level in the hierarchy and consist of two major types, Lowland Tropical and Highland Tropical As a second level they are then subdivided, according to the length of dry season, into four subtypes, Humid, Seasonally Dry, Semi-arid, and Arid (Note that mean annual rainfall is not used seperately to form a further level in the hierarchy Rather it is inferred, from the general climatic classes borrowed from Papadakis, and from the length of dry season experienced)

2.23 To this base were added cassava-specific parameters

a/Whilst there exists a logical division between lowland and highland tropics recognised in the Papadakis classification, it is not defined specifically with cassava in mind However, it is known that for cassava there is a significant difference in vigour/growth habit according to whether mean growing season temperatures are above or below 22 degrees centigrade By delimiting those areas with temperatures above or below this level we can quantify the qualitative distinction between highland and lowland tropics for cassava In the tropical Andes the dividing line lies at about 1200-1300 metres above sea level In North-east Brazil, probably because of the influences of the cold Benguelan current, mean annual temperatures of 22 degrees C are experienced at a lower level, probably at about 700-800 metres (SAMMDATA, 1984)

The upper limit of cultivation of cassava in the Andes has been suggested as about 2000-2300 metres with reference to Colombia (Cock 1985) The cassava distribution map (Map 1) shows clearly that the crop does not grow in the Andes south of the line which divides tropical from sub-tropical climates (see d/ below), because of the effect of a winter season at altitudes above approximately 1000 metres In the subtropics, southern Brazil mainly, the distribution map confirms that cassava does not grow above 1000 metres, and barely above 500 metres

Map representation For mapping purposes, the 2000 metre contour line was used as the upper limit to the climatic zonification in the Andes and other tropical regions, in the subtropical area of southern Brazil the 1000 metre contour line was used To delimit the boundary between highland and lowland tropics the 1000 metre contour line was used in the Andes, and the 500 metre line in Brazil Lack of detail on the base map prevented the exact altitudes from being used The areas represented on the maps as "Highland" are therefore slightly larger in extent than the true areas with mean annual temperatures below 22 degrees C

b/The Papadakis climate classification relies on evapotranspiration to define dry months, being those in which rainfall is less than half potential evapotranspiration Given the dearth of evapotranspiration data for much of Latin America it was not possible to use this index and a more simplified one was elected, the Koppen definition (see Stringer, 1972) All months with less than 60 millimetres precipitation are classified as "dry" Obviously this represents a great simplification of the effects of soil and evapotranspiration on the cassava plant, however even if we tried to model evapotranspiration or soil water balance at this continental scale it is unlikely that a more satisfactory answer could be arrived at, given the variability in climatic and edaphic factors pointed out above (1 12) The subdivisions used in the second level of the hierarchy are defined according to length of dry season, where the dry season consists of all months with less than 60 mm precipitation, and where,

0-3 dry months are considered humid,
4-6 dry months as seasonally dry,
7-9 dry months as semi-arid,
and 9-12 dry months as arid

Map representation Using the Koppen definition, a dry season map has been constructed for the whole of South and Central America (Jones 1984) showing length of dry season in months For the purposes of this study this was simplified, slightly modified in one or two areas, and then used to delimit the second level climatic boundaries on the map

c/Severity of environment for cassava, through disease pressure, is associated with mean daily temperature range as well as relative humidity and growing season precipitation (J C Lozano, personal communications) Cassava bacterial blight has been a particularly important concern for the Cassava Programme As an indicator of those areas where disease pressure from cassava bacterial blight is high or low, a further hierarchical subdivision is made according to whether the mean daily temperature range is greater or less than 10 degrees centigrade The climate types "Continental Savanna Tropical" and "Subtropical" (Papadakis) correspond to the former situation, and the types "Humid Equatorial", "Humid Tropical" and "Marine Savanna Tropical" to the latter

Map representation For the lowland tropics the Papadakis climate types were used to delimit these areas once stages a/ and d/ had been mapped To do this a published climate map (FAO, 1971) and available meteorological data (SAMMDATA, 1984) were used Reference to the meteorological data showed that for the highland tropics, the Andean zone is characterised by low daily temperature fluctuation, whilst in Brazil daily temperature ranges tend to exceed 10 degrees

d/Cassava extends in its distribution as far north and south of the equator as 30 degrees, and hence subtropical environments are included in the range of conditions under which it is cultivated The effects of a winter season on the plant are manifest by a slowing or temporary halt of growth processes and occasionally leaf-fall or more extreme effects caused by frost, although growing season conditions in these regions are little different from their tropical equivalents The dividing line between tropics and subtropics has been defined for this study following Koppen (Stringer, 1972), those stations for whom the annual range of mean monthly temperatures is less than 5 degrees centigrade are defined as Isothermic, and those for whom this range is greater than 5 degrees as Non-isothermic Using SAMMDATA the dividing line between the two types was located (see Map 2) Since there are a number of the basic climatic types which are dissected by this line, it is logical to add a final subdivision to the hierarchy of climatic types, ie isothermic or non-isothermic

The area which Papadakis defines as true Subtropical, that of southern Brazil and Paraguay, has been distinguished seperately rather than simply as a subdivision of the humid lowland tropics, because of the higher growing season temperatures (both mean maximum and mean daily temperature ranges being far greater than those of the lowland tropical equivalent), and because of the unreliable nature of rainfall in the area in the warmer months It is also important to note for this area that the true dry season coincides with the winter months in which both plant growth and evapotranspiration are much reduced

Map representation On Map 2 the line drawn between isothermic and non-isothermic climates corresponds to a mean annual temperature range of 5 degrees C Places north of this line are considered Tropical and those south of it are Subtropical

## 2.24 Mapping Units/Climatic Type Descriptors

a. LOWLAND TROPICAL AND SEMI-TROPICAL
(Mean growing season temperatures greater than 22 degrees centigrade)

a 1 Humid Tropical and Semi-tropical
(0-3 dry months [less than 60mm precipitation])

a 1 1 Tropical
(Growing season mean daily temperature range <10'C, Isothermic)

a 1.2 Subtropical
(Growing season mean daily temp range >10'C, Non-isothermic)

a 2 Seasonally dry tropical and semi-tropical
(4-6 dry months)

a 2 1 Semihot/marine savanna tropical and semi-tropical
(Growing season mean daily temp range <10'C)
a 2 1 1 Isothermic
a 2.1 2 Non-isothermic

a 2 2 Hot/continental savanna tropical and semi-tropical
(Growing season mean daily temp range >10'C)
a 2 2 1 Isothermic
a 2 2 2 Non-isothermic

a 3 Semi-arid tropical and semi-tropical
(7-9 dry months, no subdivision made on the basis of daily temperatures)
a 3 1 1 Isothermic
a.3 1 2 Non-isothermic

a 4 Arid
(10-12 dry months, no subdivision made on the basis of daily temperatures, Isothermic)

b. HIGHLAND TROPICAL AND SEMI-TROPICAL
(Mean Growing season temperatures between 18 and 22'C)

b 1 Humid tropical and semi-tropical.
(0-3 dry months)

b 1 1 Tropical
(Growing season mean daily temp range <10'C,
Isothermic)
b 1 2 Subtropical
(Growing season mean daily temp range >10'C,
Non-isothermic)

b 2 Seasonally dry tropical and semi-tropical.
(4-6 dry months)

b.2.1 Andean
(Growing season mean daily temp range <10'C,
Isothermic)
b.2 2 Brazilian
(Growing season mean daily temp range >10'C)
b 2 2 1 Isothermic
b 2 2 2 Non-isothermic

b 3 Semi-arid
(7-9 dry months, no subdivision made on the basis of daily temps.)
b 3 1 1 Isothermic
b 3 1 2 Non Isothermic

b 4 Arid
(10-12 dry months, no subdivision made on the basis of daily temps.,
Isothermic)

2 25 As an example to illustrate the use of this classification below are listed the classes into which some of the Cassava Programme's trial sites fall

| | |
|---|---|
| Florencia, | a 1 1 |
| Palmira, Media Luna, | a 2 1 1 |
| Carimagua, | a 2 2 1 |
| Popayan, Mondomo, | b 1 1 |

Depending on the felt need expressed by the cassava team the classification scheme can be expanded If it is not satisfactory that Palmira and the North coast be considered in the same climatic class, the need then is for further subdivision of the hierarchy. This might incorporate for example the bimodal rainfall distribution of the Andean valley environment at Palmira, although few other places on the continent share the same conditions More likely, people may wish to incorporate mean annual or growing season precipitation into the classification The data is available to do so, what are required are parameters to allow the further subdivision of the hierarchy on the basis of that variable

Any more detailed mapping and climatic classification will require a more detailed study, both in terms of the climatic data used and of map scale This should be possible if more precise climatic parameters are designed, for example in relation to phytopathological, entomological, physiological or other factors, but for specific areas and not the continent as a whole A more sophisticated approach to describing dry season length will be possible, pending the general estimation of potential evapotranspiration in SAMMDATA, the climatic database The result would possibly change the climatic map a little, but not necessarily the classification

## 2 3 Soil Restrictions for Cassava, Classification and Map

2 31 As a base for determining and mapping the edaphic subdivisions of the study, the FAO soil map for South America has been selected Undoubtedly this map is a very generalised and sometimes unreliable source of information, because of the scale of working and lack of available data when it was constructed. Nevertheless it is the only complete study available for South America at this level of detail and is based upon a rational and easy to use classification

2 32 Whilst there exists one study which tries to order the individual soil units of the FAO classification specifically with reference to cassava (Sys and Riquier, 1980), this reverts to a land suitability type classification, in which soils are grouped according to degree of suitability for cultivation of cassava Whilst there is nothing inherently wrong with their approach, for the purposes of the present study the delimitation of areas according to "suitability" was discarded

Instead the author opted for the more elementary task of mapping the edaphic restrictions for cassava which can be deduced from the FAO map, and presenting them in an intelligible form for persons not familiar with the FAO classification These restrictions include high clay content, shallow rooting depth, poor drainage, and high acidity (associated with low phosphorous content) (R Howeler, personal communication) The small scale of the study prevents any useful information being included on the map to indicate slope, and it would require a more detailed study, perhaps at a scale of 1 1,000,000, to allow such areas of potential erosion problems to be delimited

2.33 Soils defined in the FAO classification (1974) (and their Soil Taxonomy equivalents) have been grouped according to whether or not they possess the following restrictions

1 Texture finer than Silty Clay Loam (mainly vertisols on the FAO map, other units undistinguishable at the continental scale FAO 1971)
-Pellic Vertisols (Vp) (Pelluderts, Pellusterts, Pelloxererts)
-Chromic Vertisols (Vc) (Chromuderts, Chromusterts, Chromoxererts, Torrerts).

2 Permanent depth constraints (A and B horizons combined less than 50cm )
-Lithosols (I)
-Stony, Lithic and Petric phases

3.Potential depth problems
-Plinthic Acrisols (Ap) (Plinthudults, Plinthustults)
-Plinthic Luvisols (Lp) (Plinthustalfs, Plinthoxeralfs)

4.Seasonal water constraints, annual flooding or drainage problems
-Dystric Fluvisols (Jd) (Fluvents)
-Eutric Fluvisols (Je) (Fluvents)
-Dystric Planosols (Wd) (Albaquults)
-Eutric Planosols (We) (Albaqualfs, etc )
-Humic Planosols (Wh) (? Albaqualfs ?)
-Mollic Planosols (Wm) (Mollic Albaqualfs
-Pellic Vertisols (Vp)
-Chromic Vertisols (Vc)

5.Permanent excess water and/or salinity
-Gleysols (G) (Aquents, Aquepts etc)
-Solonchaks (Z) (Salorthids, Salorthidic subgroups)
-Histosols (O)
-Gleyic Acrisols (Ag) (Aquults etc)
-Solodic Planosols (Ws) ?
-Saline and Sodic phases

6 High Acidity/Low fertility, pH less than 5 5, and CEC less than 10 0 (see FAO Soil Map of the World, various volumes, for representative chemical characteristics of soil classes)
-Ferric Acrisols (Af) (Palexerults, Paleustults etc )
-Gleyic Acrisols (Ag) (Aquults)
-Humic Acrisols (Ah) (Humults)
-Orthic Acrisols (Ao) (Hapludults, Haplustults, Haploxerults)
-Plinthic Acrisols (Ap) (Plinthaquults, Plinthudults, Plinthustults)
-Acric Ferralsols (Fa) (Acrox)
-Orthic Ferralsols (Fo) (Orthox, Torrox, Ustox etc )
-Plinthic Ferralsols (Fp) (Plinthaquox etc )

6.(continued)

| | | |
|---|---|---|
| -Xanthic Ferralsols | (Fx) | (Orthox) |
| -Chromic Cambisols | (Bc) | (Xerochrepts) |
| -Dystric Cambisols | (Bd) | (Dystrochrepts, Dystropepts) |
| -Ferralic Cambisols | (Bf) | (Oxic Tropepts) |
| -Humic Podzols | (Ph) | (Humods etc ) |
| -Orthic Podzols | (Po) | (Orthods etc ) |
| -Albic Arenosols | (Qa) | (Spodic Udipsamments) |
| -Ferralic Arenosols | (Qf) | (Oxic Quarzipsamments) |

Map 3 was compiled using the FAO soil map (FAO, 1971) as a base The map identifies areas with one or more of these restrictions All soil units which are free of these restrictions are labelled seperately on the soil map,

7 Soils without restrictions

| | |
|---|---|
| -Regosols | (R) |
| -Andosols | (T) |
| -Phaeozems | (H) |
| -Kastanozems | (K) |
| -Xerosols | (X) |
| -Eutric Cambisols | (Be) |
| -Calcic Cambisols | (Bk) |
| -Orthic Luvisols | (Lo) |
| -Chromic Luvisols | (Lc) |
| -Ferric Luvisols | (Lf) |
| -Eutric Nitosols | (Ne) |
| -Dystric Nitosols | (Nd) |
| -Humic Ferralsols | (Fh) |
| -Rhodic Ferralsols | (Fr) |

Such soils can be considered to be of coarse to medium texture, with good to excessive drainage, with at least 50cm depth free of rooting restrictions, and without problems of acidity

Note that for the restrictive classes relating to permanent depth and drainage problems, it is practically impossible to grow cassava on soils with such problems Where cassava is indicated as present on these soils it should be assumed that it occurs on the associated soils or inclusions of the relevant FAO mapping unit Following FAO mapping unit conventions, areas of Lithosols associated with other soils are depicted as horizontal bands, the restrictions for any of the associated soils are therefore represented in the same way Elsewhere, soils with more than one restriction are shown with the relevant mapping conventions overlain

The soil restriction classes form, at present, the bottom level of the heirarchy of environment types, no attempt has been made to differentiate one as more important than the other

3/Climate Soil Homologues for Cassava Producing areas in South America

Figure 1 illustrates the hierarchical climatic classification described above, and the edaphic restrictions which form the bottom layer of the hierarchy Map 4 shows the distribution of the combined climate and soil homologues These are based on maps 2 and 3 which were superimposed, each area having a distinct climate and soil restriction type (or combination of soil restrictions) is delimited A numeric and alphabetic code is used to describe the soil restriction and climate of each These are explained in the map key

Map 4 represents one attempt to distinguish spatial units based on the hierarchical classification described above For reasons stated in part 1 the mapped "homologues" cannot in fact be considered homogeneous at anything but a very generalised level Soils information in particular is only based on the major soil unit of the published FAO map Associated soils and Inclusions (FAO 1971) have been omitted from the mapping units

Map 4 can be used to indicate the likely extent of climatic types and specific variables It cannot be used to compare particular places, such as trial sites, this requires precise site description The value of the approach used here is in the hierarchical classification, rather than the final map It is not complete, but nevertheless allows us to examine smaller areas of interest in greater detail, using the same frame of reference and mapping units as Map 4 Work being undertaken in the Agroecological Studies Unit on the definition of Micro-Regions is one example of this

The hierarchy should be modified as more information about crop-environment interaction becomes available for cassava Future acquisition of climatic data by the Agroecological Studies Unit, and projected calculations of potential evapotranspiration and relative humidity will facilitate this task We now need feedback from Cassava Programme scientists, to begin the process of modifying and refining the classification and to enhance our capabilities for environmental description

NOTE The originals of Maps 1 to 4 are available at 1 5,000,000 in the Agroecological Studies Unit, to allow more careful identification of areas of interest from political and other maps of the same scale and projection

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APPENDIX SOURCES OF CASSAVA PRODUCTION STATISITICS USED IN THE CONSTRUCTION OF MAP 1

| | |
|---|---|
| ARGENTINA | -Anuario Estadistico de la Republica Argentina 1973<br>-FAO production yearbook 1981 |
| BRAZIL | -Censo Agropecuario 1975 IBGE, 1979 |
| BOLIVIA | -Brown B and LeBaron A 1977, An investigation of resource management options in Bolivian agriculture<br>-Gomez E 1974, Economic analysis of the agricultural sector in Santa Cruz, Bolivia PhD Thesis |
| COLOMBIA | -O P S A Data from R O Diaz, Cassava Programme, CIAT Period 1977-1980 |
| ECUADOP | -Censo Agropecuario 1974<br>-Agricola del Ecuador Ano 1980. Ministerio de Agricultura |
| FRENCH GUIANA | -FAO Production Statisitics Yearbook, 1981 |
| GUYANA | -Trip Reports, Cassava Programme, CIAT |
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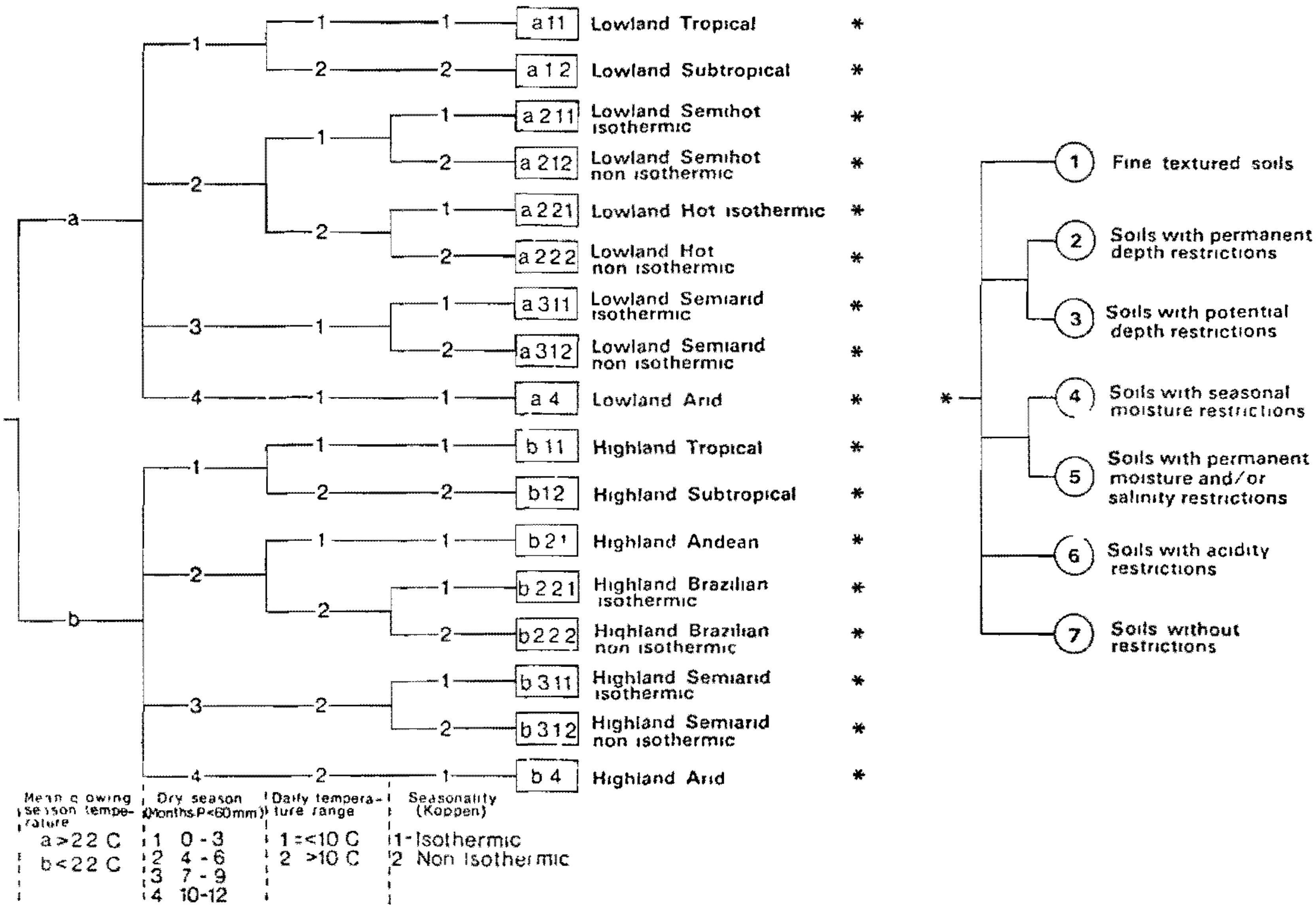
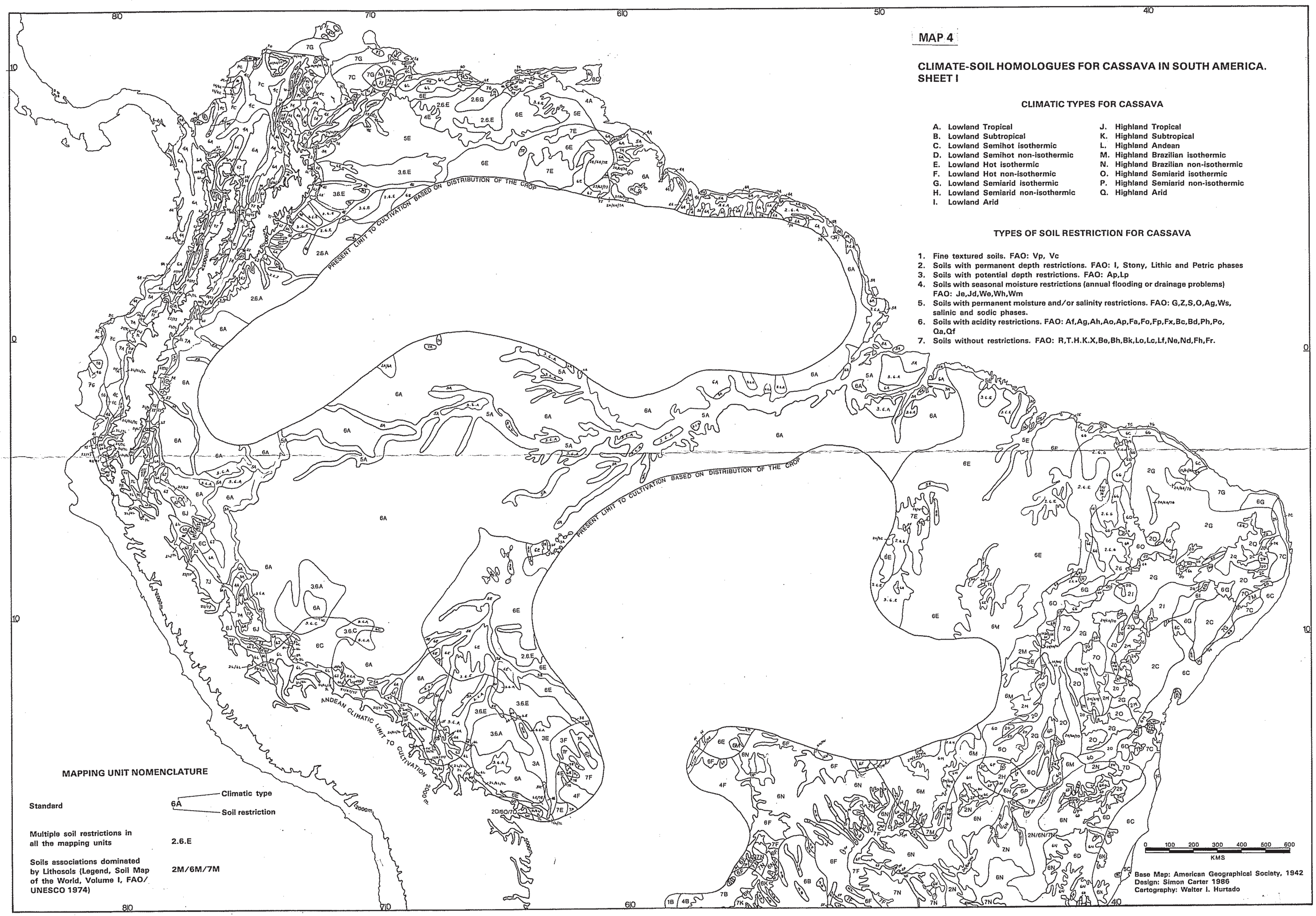
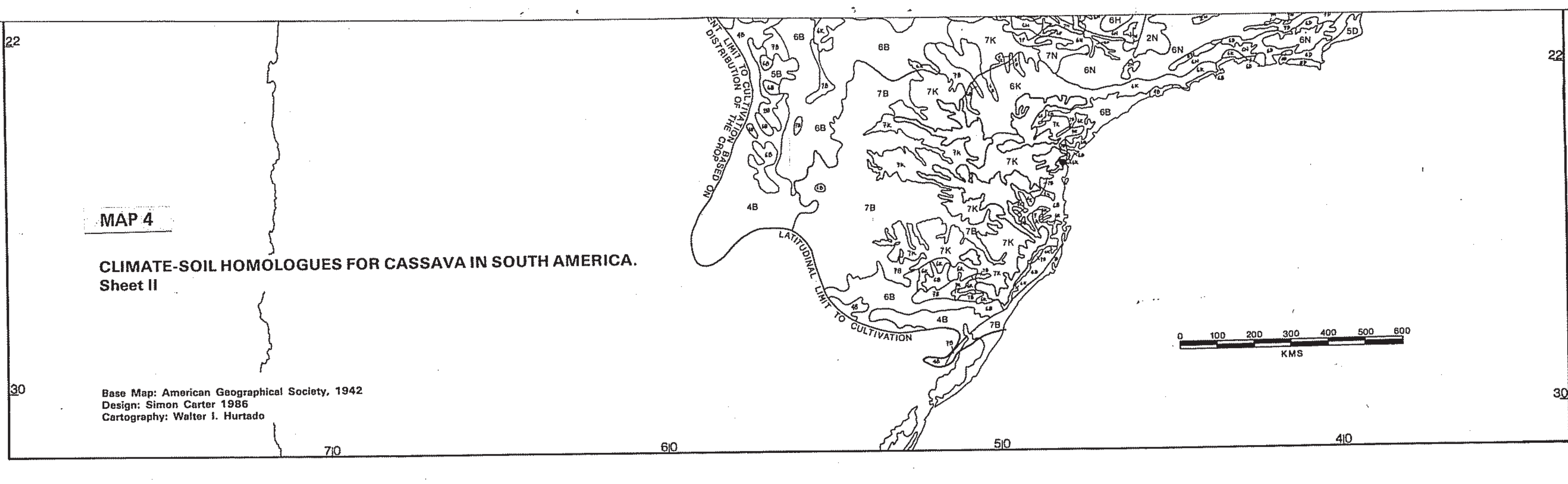
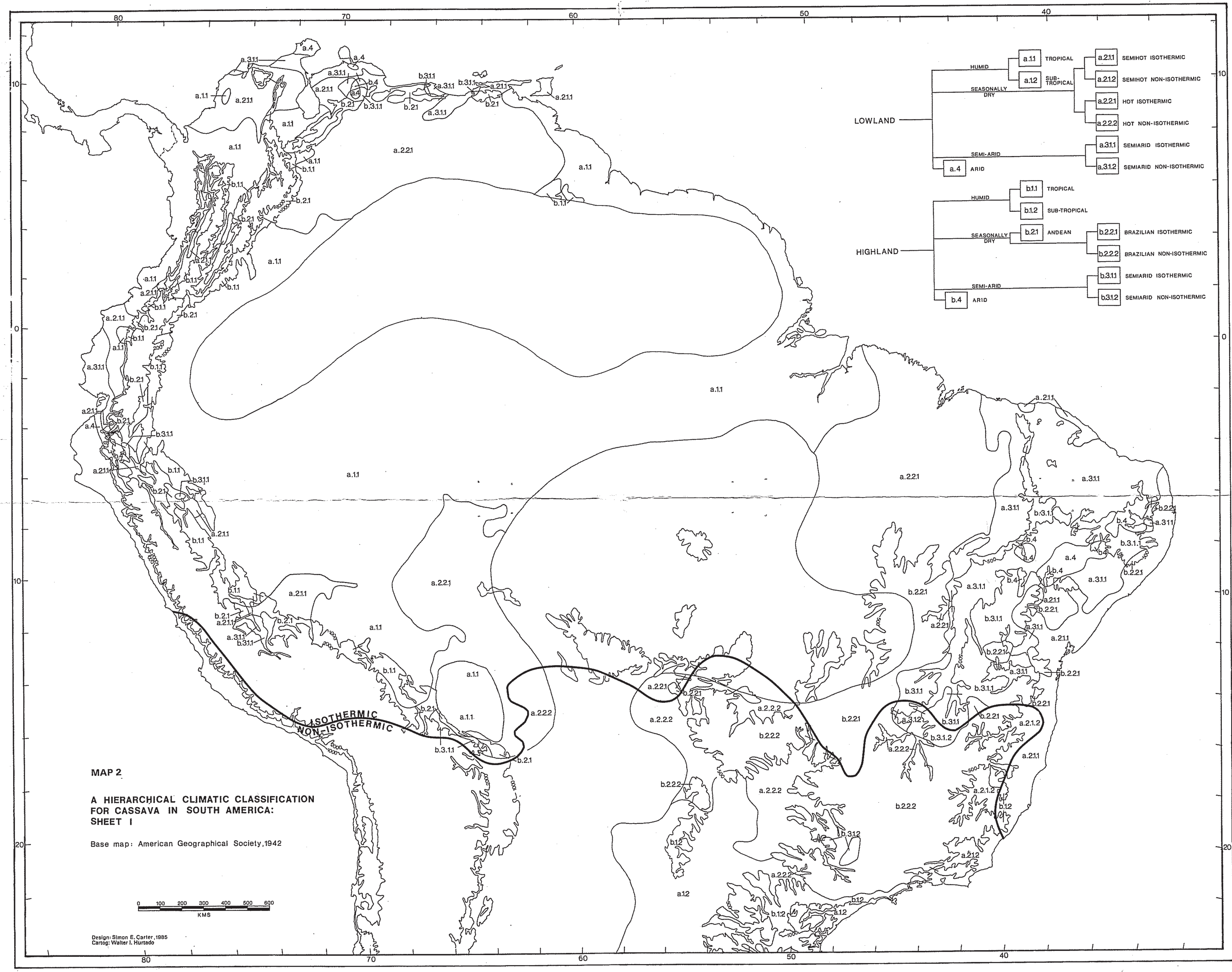



Figure 1 A simple climatic and edaphic classification for cassava producing areas in South America


MAP 4
CLIMATE-SOIL HOMOLOGUES FOR CASSAVA IN SOUTH AMERICA.
SHEET I
CLIMATIC TYPES FOR CASSAVA
A. Lowland Tropical
B. Lowland Subtropical
C. Lowland Semihot isothermic
D. Lowland Semihot non-isothermic
E. Lowland Hot isothermic
F. Lowland Hot non-isothermic
G. Lowland Semiarid isothermic
H. Lowland Semiarid non-isothermic
I. Lowland Arid
J. Highland Tropical
K. Highland Subtropical
L. Highland Andean
M. Highland Brazilian isothermic
N. Highland Brazilian non-isothermic
O. Highland Semiarid isothermic
P. Highland Semiarid non-isothermic
Q. Highland Arid
TYPES OF SOIL RESTRICTION FOR CASSAVA
1. Fine textured soils. FAO: Vp, Vc
2. Soils with permanent depth restrictions. FAO: I, Stony, Lithic and Petric phases
3. Soils with potential depth restrictions. FAO: Ap,Lp
4. Soils with seasonal moisture restrictions (annual flooding or drainage problems) FAO: Je,Jd,We,Wh,Wm
5. Soils with permanent moisture and/or salinity restrictions. FAO: G,Z,S,O,Ag,Ws, salinic and sodic phases.
6. Soils with acidity restrictions. FAO: Af,Ag,Ah,Ao,Ap,Fa,Fo,Fp,Fx,Bc,Bd,Ph,Po, Qa,Qf
7. Soils without restrictions. FAO: R,T,H,K,X,Be,Bh,Bk,Lo,Lc,Lf,Ne,Nd,Fh,Fr.
PRESENT LIMIT TO CULTIVATION BASED ON DISTRIBUTION OF THE CROP
ANDEAN CLIMATIC LIMIT TO CULTIVATION
MAPPING UNIT NOMENCLATURE
Standard
6A
Climatic type
Soil restriction
Multiple soil restrictions in all the mapping units
2.6.E
Soils associations dominated by Lithosols (Legend, Soil Map of the World, Volume I, FAO/ UNESCO 1974)
2M/6M/7M
KMS
Base Map: American Geographical Society, 1942
Design: Simon Carter 1986
Cartography: Walter I. Hurtado

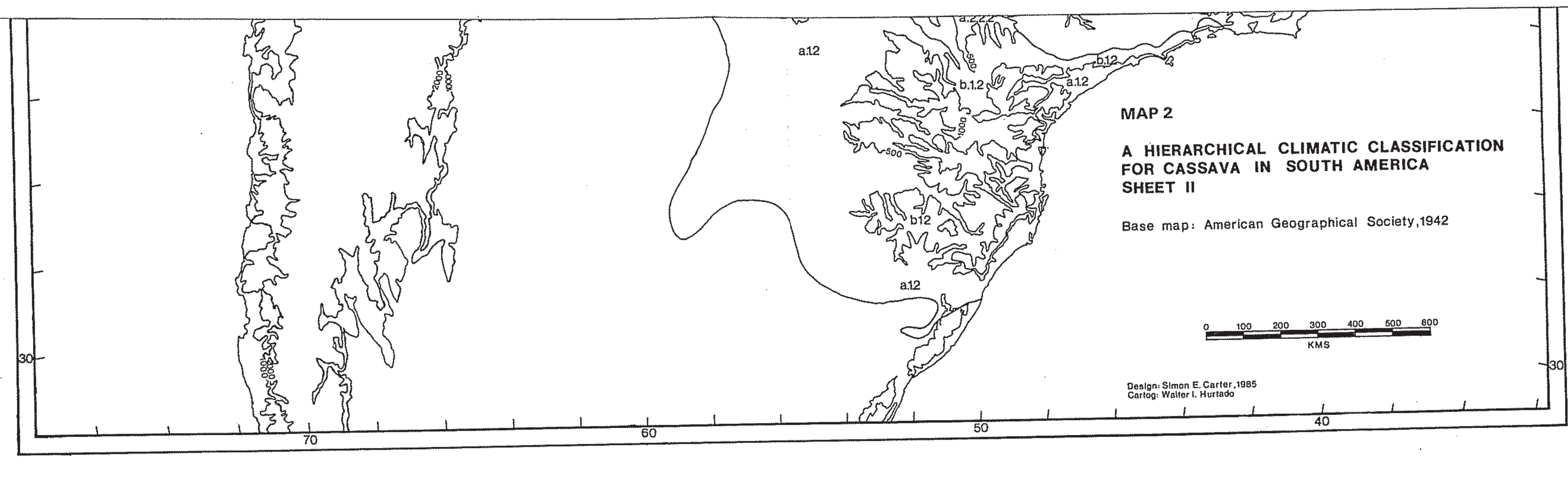

MAP 4
CLIMATE-SOIL HOMOLOGUES FOR CASSAVA IN SOUTH AMERICA.
Sheet II
LATITUDINAL LIMIT TO CULTIVATION
KMS
Base Map: American Geographical Society, 1942
Design: Simon Carter 1986
Cartography: Walter I. Hurtado




**MAP 2**

**A HIERARCHICAL CLIMATIC CLASSIFICATION FOR CASSAVA IN SOUTH AMERICA: SHEET I**

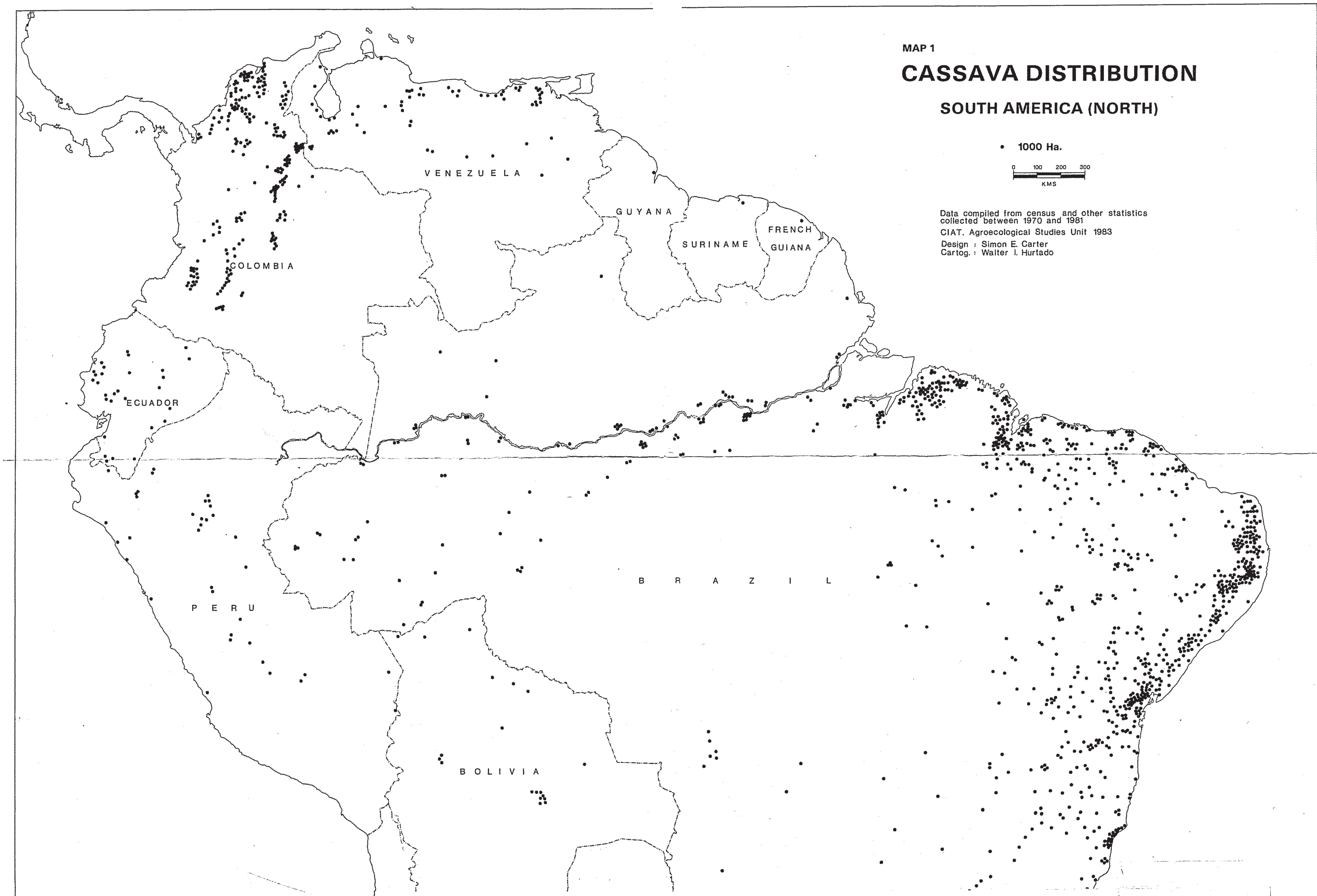
Base map: American Geographical Society, 1942

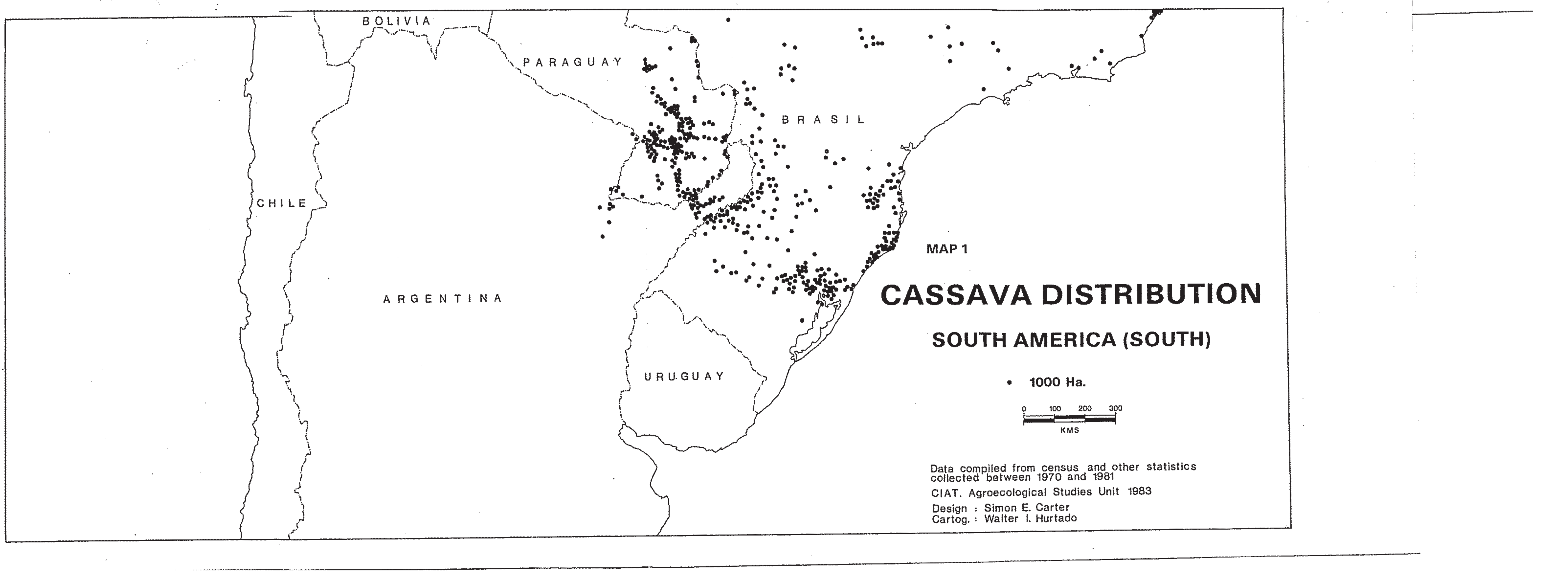


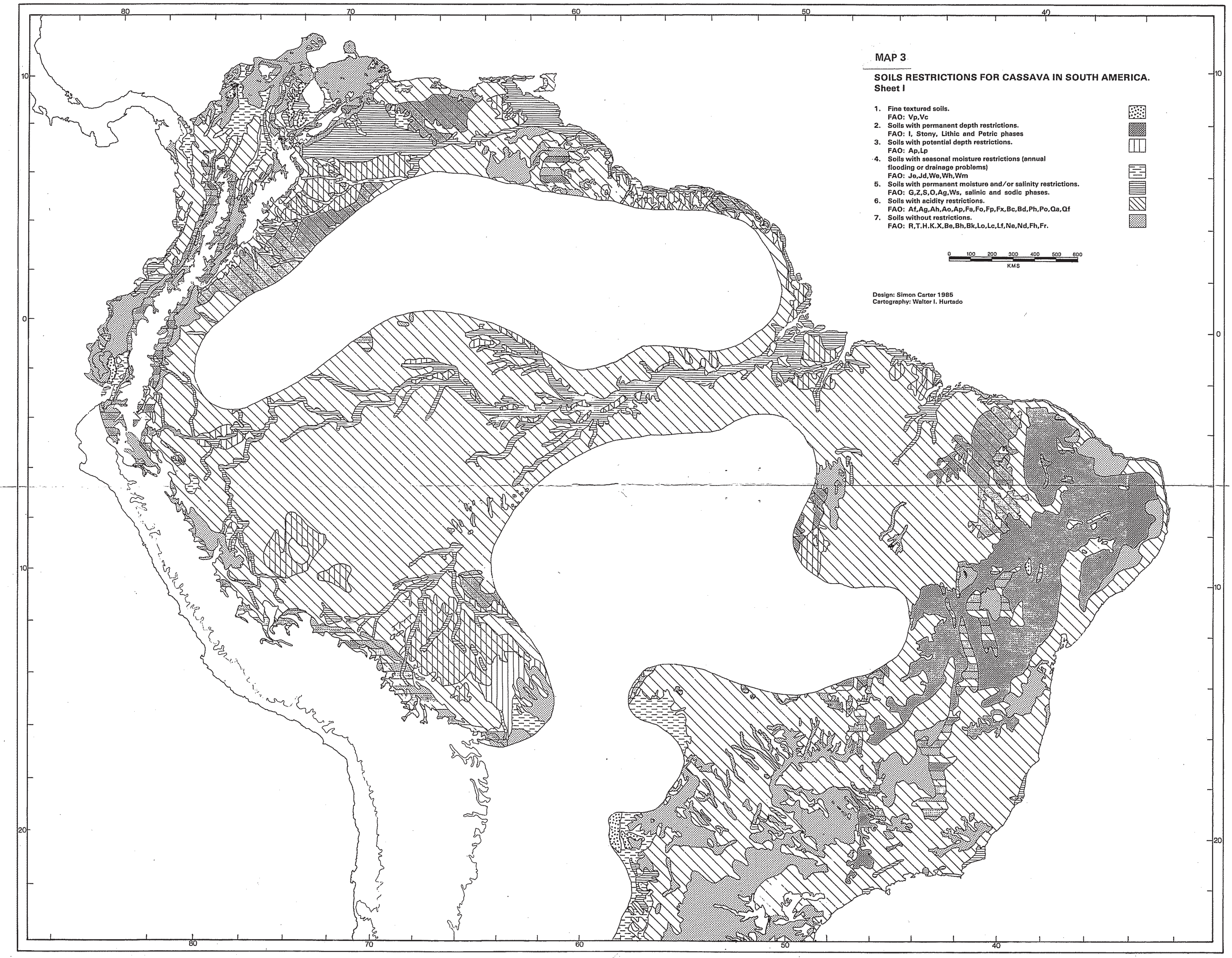

**MAP 2**

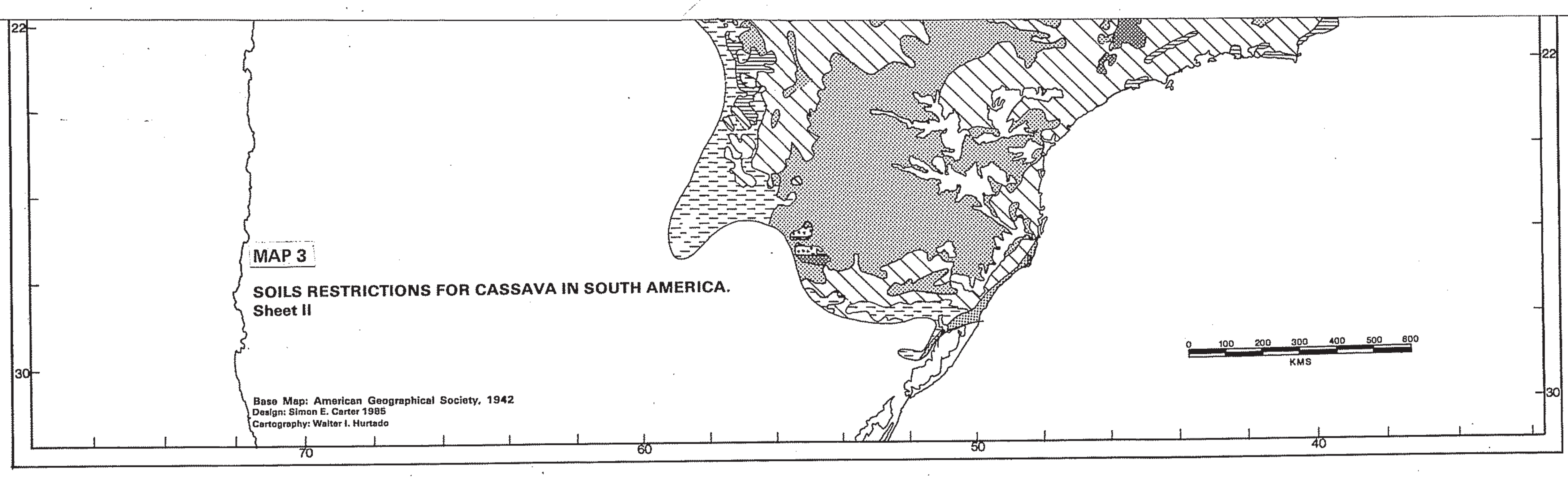
**A HIERARCHICAL CLIMATIC CLASSIFICATION FOR CASSAVA IN SOUTH AMERICA SHEET II**

Base map: American Geographical Society, 1942


MAP 1
CASSAVA DISTRIBUTION
SOUTH AMERICA (NORTH)
1000 Ha.
0 100 200 300
KMS
Data compiled from census and other statistics collected between 1970 and 1981
CIAT. Agroecological Studies Unit 1983
Design : Simon E. Carter
Cartog. : Walter I. Hurtado
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
ECUADOR
PERU
BRAZIL
BOLIVIA


BOLIVIA
PARAGUAY
BRASIL
CHILE
ARGENTINA
URUGUAY
MAP 1
CASSAVA DISTRIBUTION
SOUTH AMERICA (SOUTH)
1000 Ha.
0 100 200 300
KMS
Data compiled from census and other statistics collected between 1970 and 1981
CIAT. Agroecological Studies Unit 1983
Design : Simon E. Carter
Cartog. : Walter I. Hurtado


MAP 3
SOILS RESTRICTIONS FOR CASSAVA IN SOUTH AMERICA.
Sheet I
1. Fine textured soils.
FAO: Vp,Vc
2. Soils with permanent depth restrictions.
FAO: I, Stony, Lithic and Petric phases
3. Soils with potential depth restrictions.
FAO: Ap,Lp
4. Soils with seasonal moisture restrictions (annual flooding or drainage problems)
FAO: Je,Jd,We,Wh,Wm
5. Soils with permanent moisture and/or salinity restrictions.
FAO: G,Z,S,O,Ag,Ws, salinic and sodic phases.
6. Soils with acidity restrictions.
FAO: Af,Ag,Ah,Ao,Ap,Fa,Fo,Fp,Fx,Bc,Bd,Ph,Po,Qa,Qf
7. Soils without restrictions.
FAO: R,T.H.K.X,Be,Bh,Bk,Lo,Lc,Lf,Ne,Nd,Fh,Fr.
0 100 200 300 400 500 600
KMS
Design: Simon Carter 1985
Cartography: Walter I. Hurtado
80
70
60
50
40
10
0
10
20


MAP 3
SOILS RESTRICTIONS FOR CASSAVA IN SOUTH AMERICA.
Sheet II
0 100 200 300 400 500 600
KMS
Base Map: American Geographical Society, 1942
Design: Simon E. Carter 1985
Cartography: Walter I. Hurtado
22
30
70
60
50
40