SIBD: The Integrated Database System of Zonisig

Martín de Zuviría and Aernout Weeda

[1] Technical Advisor/Systems Specialist of Zonisig
Casilla 14533, La Paz, Bolivia
Fax: (591-2)375 836, Email: martin@zonilp.rds.org.bo
[2] ZONISIG International Coordinator,
E-mail:weeda@zonilp.rds.org.bo

1. Abstract

ZONISIG is a technical cooperation project between The Netherlands and Bolivia, carried out by DHV Consultants in association with ITC. Starting in January 1993, it is foreseen that it will terminate in the year 2000. The project's name "Agro-ecological Zoning and the Establishment of a Database and GIS-Network in Bolivia" relates to one of the objectives, which deals with the design and implementation of a geo-referenced natural resources database at national and regional levels to be used in agro-ecological and land use planning. Another objective is the training of a team of Bolivian professionals able to manage the databases to provide the information required by policy makers and land use planners.

At the national level ZONISIG works with the Ministry for Sustainable Development and Environment as counterpart organization, and at regional levels with departmental governments in the main agro-ecological zones of the country: the Tropical Amazon Region, the Altiplano Region, the Valle Region and the Chaco Region.

This paper is focusses on the Integrated Database System, named "Sistema Integral de Bases de Datos" (SIBD), and on the methodological aspects of the zoning process and to the system structure.

SIBD is a knowledge-based and object-oriented software package accompanied by a manual. It is based on a methodological framework for agro-ecological and socio-economic zoning coupled to a cartographic scheme. Base maps, required in the zoning process, are converted to digital format and analyzed using GIS capabilities, with relevant attribute information retrieved from SIBD. These maps are linked to the different sections of the system.

The main goal of SIBD is to facilitate the collection, storage, organization, selection, retrieval and reporting of data on natural resources and socio-economic data. During the design process, existing national and international systems were analyzed for the different disciplines. The SIBD sections deal with: climate, soils, terrain, vegetation, land use, hydrology, farming systems, production costs, public transport, markets, and others.

SIBD and the cartographic database are linked to expert systems at regional levels for the land suitability assessment in physical, biological and socio-economic terms within the context of sustainable land use.

2. Introduction

ZONISIG is a technical cooperation project between The Netherlands and Bolivia carried out by DHV Consultants and ITC. Starting in January 1993, it will finish in August 2000. At the national level ZONISIG works with the Ministry for Sustainable Development and Environment as counterpart organization, and at regional level with regional governments in the main agro-ecological zones of the country: the Tropical Amazon Region, the Altiplano Region, the Valle Region and the Chaco Region.

At the beginning of the project, a survey of Geographic Information Systems (GIS) (Aronoff 1989; Gutiérrez Puebla & Gould 1994) packages was carried out to select the most suitable for ZONISIG. Institutions working with GIS in Bolivia were visited, and technical, financial and institutional feasibility was evaluated. As a result of this study, the decision was taken to use personal computers in all offices, PC ARC/Info™, ERDAS™ and ILWIS™ in the head office, and ILWIS in regional offices (Zuviría 1993). In addition to GIS software, FoxPro™ and the Automated Land Evaluation System ALES™ (Rossiter 1990 & 1995) were selected for all offices for attribute database management and to help in land suitability evaluation, respectively.

The design and implementation of a knowledge-based and object-oriented software package, named "Sistema Integral de Bases de Datos" SIBD (Zuviría 1996), is one of the project objectives. It deals with geo-referenced natural resources database at national and regional levels to be used in agro-ecological and land use planning. Another objective is the training of a team of Bolivian professionals enabling them to manage the databases and to provide the information required by policy makers and land use planners.

SIBD; structure is a methodological framework for agro-ecological and socio-economic zoning coupled to a cartographic scheme. The base maps required for the zoning process are converted to digital format and analyzed using GIS capabilities, together with attribute information retrieved from SIBD.

The main goal of SIBD is to facilitate the collection, storage, organization, selection, retrieval, maintenance and reporting of natural resources and socio-economic data on personal computers. During the design process, existing national and international systems were analyzed for the different disciplines (FAO-ISRIC 1989; SOTER 1993). SIBD sections deal with (agro)climate, terrain and soils, vegetation, land use, hydrology, farming systems, production costs, public transport, markets, other socio-economic aspects and maps. There is also a user-defined section for information not fitting in previous sections.

Special attention is paid to the fact that digitized maps are sets of spatial entities or layers of elements that, when combined in an appropriate manner, can create a map (Huxhold and Levinsohn 1995; Kraak and Ormeling 1996). Because these virtual maps required a virtual map library to store required files and relationships in a computer and assemble them, a special section of SIBD is assigned to this purpose.

SIBD and the cartographic databases are linked to expert systems at the regional level for land assessment (physical, biological and socio-economic aspects) taking sustainable land use as a basis for analysis.

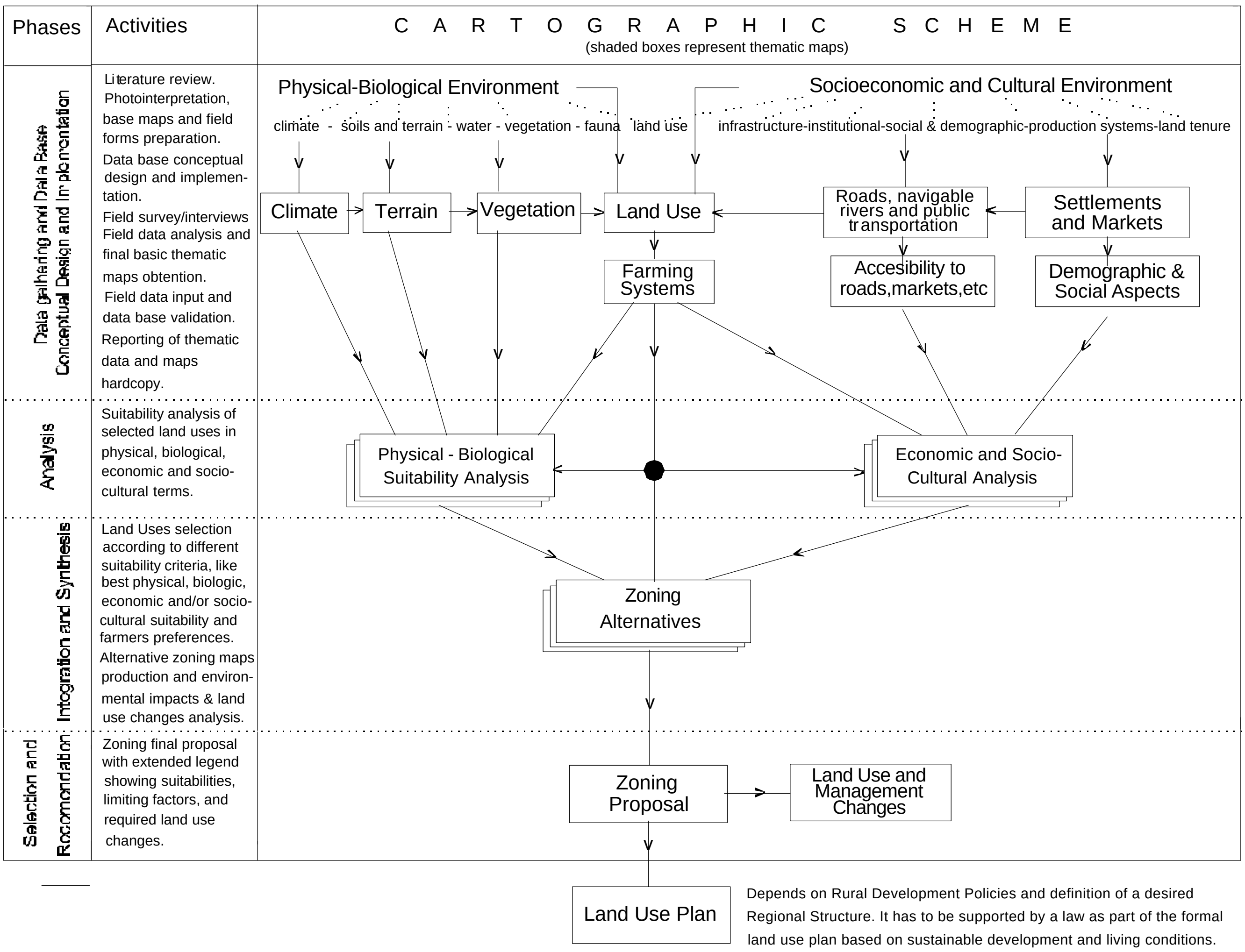
3. Agro-Ecological and Socio-Economic Zoning

The method for agro-ecological and socio-economic zoning is summarized in Figure 1. The role played by thematic maps, represented by shaded boxes, is briefly explained.

Agro-ecological zones are characterized by climate, terrain, soils and (semi)natural vegetation parameters that can be translated into entities of similar biophysical potential for agriculture (FAO 1997).

Socio-economic zones are characterized by land use and farming system parameters that can be translated into homogeneous socio-cultural and economic areas.

FIGURE 1: CARTOGRAPHIC AND CONCEPTUAL AGROECOLOGICAL AND SOCIOECONOMICAL ZONING PROCESS



The definition of agroclimates is fundamental for the selection of land utilization types (LUT) for the suitability analysis performed according to FAO (1976). Agroclimates are defined according to De Fina (1992) and Zuviría (1992) by taking major physiographic areas and, within them, elevation ranges linked to the agroclimatic parameters most related to the land uses.

Terrain units are areas within a certain agroclimatic zone with a distinct pattern of landform, parent material and/or origin. These units were defined by adapting the SOTER database and mapping guidelines (ISRIC 1993) to reconnaissance and semi-detailed scales, keeping emphasis on the soil-terrain relationships. The resulting terrain and soil map is the cartographic base to assess the physical suitability for selected LUTs and for (semi) natural vegetation and for land use mapping by further partitioning of terrain units, following the ITC approach (Zonneveld 1995).

The vegetation map is used to assess the biologic suitability of LUTs with a view to sustainable use of (semi)natural vegetation.

The current land use map is important for the zoning process. It reflects the integration among present physical, biological, socio-cultural and economic conditions within an area. The land use is also the starting point in the assessment of zoning alternatives. Roads and navigable rivers are classified to show public transportation possibilities. This information, along with data on market locations and their importance is used to create maps showing the accessibility of roads, rivers, cities and/or markets. Settlements and surrounding areas are classified to show demographic and social aspects to be used in socioeconomic analyses of living conditions.

Suitability analysis is done in physical and biological terms and economic and socio-cultural settings are analyzed for each LUT. The resulting maps are combined and a final suitability table is obtained, showing suitability ratings and limiting factors, by making full use of GIS capabilities (Zuviría and Valenzuela 1994).

The land use map is converted into a farming systems map by linking physiography to dominant single or combined land use per farm, average farm sizes and product destinations (Fresco *et al* 1994), to be used together with suitability maps (Anaman and Krishnamra 1994).

Alternative zoning maps are produced following a multiple-goal approach by maximizing and minimizing selected development goals (Huizing and Bronsveld 1994; Barredo 1996). For each zoning alternative the required land use/farming system changes and environmental impacts are pointed out (Conesa 1995).

After discussions with cooperating organizations the final zoning proposal is agreed upon, to be supported by law as part of the formal land use plan, based on sustainable development and improvement of living conditions. At present, Pando has a fully legalized land use plan (ZONISIG 1996).

4. The Integrated Database System

The Integrated Database System, named "Sistema Integral de Bases de Datos" (SIBD) is a stand-alone object-oriented (Korth and Silberschatz 1993) software, designed and implemented by ZONISIG to facilitate the selection, collection, storage, organization, retrieval and reporting of natural resources and socio-economic information (Zuviría 1996).

The system's structure is based on the methodological framework for agro-ecological and socio-economic zoning. Thematic base maps required during the zoning process are linked to different sections of SIBD. During the design process, existing national and international standards were analyzed for the different disciplines (FAO-ISRIC 1989; ISRIC 1993; ZUÑIGA QUIROGA 1994).

SIBD sections, represented by boxes in figure 2, deal with: climate, terrain and soils, vegetation, hydrology, land use, farming systems, production costs, markets, public transportation facilities, socio-demographic aspects and maps. The updating needs, represented by overlaid boxes in figure 2, are permanent for maps, very high for land use and production costs, intermediate for vegetation, farming systems, markets and socio-demographic aspects, and low for climate, hydrology, terrain and soils.

The attribute information handled by the system is geo-referenced, linked to a point, line or area of the country. Consequently, it can be visualized and queried, resulting in maps and related attribute tables.

The procedures manual describes the role of each section in the zoning process, its logical structure and the characteristics of each attribute. Special attention was paid to the design of user-friendly interfaces linked to paper data entry forms, used during fieldwork.

The terrain and soils data entry form is shown in figure 3, and figure 4 presents one of the SIBD interfaces for terrain characteristics. Main characteristics of this interface, similar to those of other interfaces, are described hereafter.

The Main **Menu System (A)**, on top of figure 4, has six options for easy communicating with the keyboard or mouse. Shortcuts are implemented for all options and suboptions.

- The System menu options allow the use of a calculator, calendar/diary and to abandon the system.
- The SIBD menu option allows to select a desired section.
- Edit allows to cut, copy, paste and delete selected text.
- Application allows to add, copy, delete, find and browse records, filter and order databases, pick-list the display for some fields (Physiography and Lithology codes) and to report selected information.
- Utilities allows database indexing and packing, status bar display and to modify the visual environment.
- SIBD displays general information about the system itself.

FIGURE 2: The Integrated Database System Core Structure

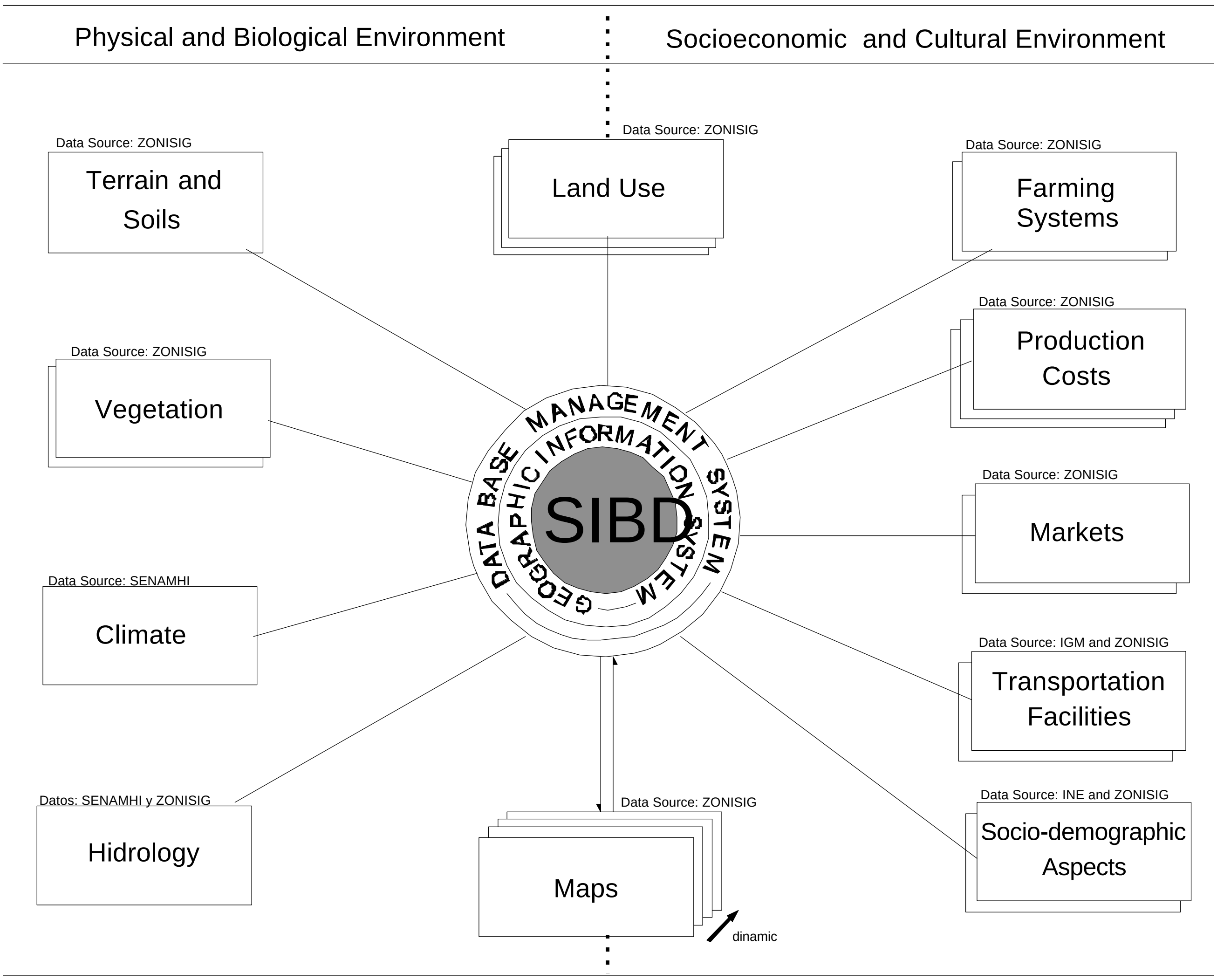


FIGURE 3: TERRAIN AND SOILS DATA ENTRY FORMS

TERRAIN AND SOILS DATA ENTRY FORMS

See in Figure 4 SIBD computer user interface for terrain

TERRAIN UNITS
(fill once per terrain unit)

1. Map ID . . . .
2. Terrain Unit ID . .
3. Physiographic code . / . / . . / . .
5. Area . . . . . . , . km²
4. Lithology . . . .
6. Permanent water surface . . , . %
7. Descriptive name . . . .
8. Disection .
10. Maximum elevation . . . . masl
9. Relief: intensity . / . . . . m; slope class .
11. Minimum elevation . . . . masl
12. Comments . . . .

TERRAIN UNIT COMPONENTS
(fill once per component)

1. Map ID . . . .
2. Terrain Unit ID . .
3. Physiographic code . / . . / . .
13. Terrain Unit Component ID .
14. Descriptive name . . . .
15. Proportion of terrain unit . . . %
16. Maximum and minimum elevation . . . . and . . . . masl

Land Use types/proportion of component		Land Cover types/proportion of component	
Main	. . . . / . . . %	Main	. . . . / . . . %
Secondary	. . . . / . . %	Secondary	. . . . / . . %
Minor	. . . . / . . %	Minor	. . . . / . . %

18. Gradient of slope .
20. Length of slope .
19. Form of slope .
21. Lithology . . . .
25. Surface drainage .
22. Depth to bedrock . . , . m
26. Frequency of flooding .
23. Surface rockiness .
27. Duration of flooding .
24. Surface stoniness .
28. Start of flooding . .
29. Types of erosion . .
31. Degree of erosion .
30. Area affected .
32. Surface sealing .

SOIL PROFILES

33. Profile ID . / . . / . . . .
37. Latitude UTM . . . .
35. Sampling date . . / . . / . . . .
38. Longitude UTM and zone . . . . - . .
36. Author . . . .
39. Latitude (geographic) S . . °. . ' . . "
40. Longitude (geographic) W . . °. . ' . . "
41. Location . . . .
42. Elevation . . . . m
43. Gradient of slope . . . %
44. Form of slope .
45. Topography .
46. Position . .
47. Micro topography . .
48. Land cover type . .
49. Land use type . . .
50. Grass/forb cover .
51. Surface organic matter .
52. Human influence . .
53. Effective soil depth .
54. Lowest roots depth .
55. Watertable depth .
56. Drainage .
57. Internal drainage . .
58. External drainage .
59. Moisture condition .
60. Classification FAO . . . .
61. Classification versión . . . .
62. Soil Taxonomy . . . .
63. Phase . .
64. Diagnostic horizon . .
65. Diagnostic property . .
66. Soil temperature regime . .
67. Soil moisture regime . .
68. Comm ents . . . .

SOIL PROFILES-TERRAIN UNIT COMPONENTS RELATIONSHIPS

1. Map ID . . . .
2 y 14. Terrain Unit and Component IDs . . / .
33. Profile ID . / . . / . . . .
34. Representative profile ? .

SOIL PROFILE HORIZONS DESCRIPTION

Horizon		Depth		Colour	Mottles					Tex-ture	Struct.			Consisten.				Cutans				Cem/Comp				Pores				Rock fragm.					Nodules							Car	Biolog		Roots		Bound.		pH	Sa
des	n°	up	low		ab	si	ct	bo	co		ty	gr	si	dr	mo	st	pl	qu	co	na	lo	co	es	gr	ti	ab	si	ty	gr	ab	si	sh	we	na	ab	si	ki	sh	ha	na	co		ab	ki	ab	si	wid	top	wat	y/n
				moist dry																																													.	
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				moist dry																																													.	
				moist dry																																													.	

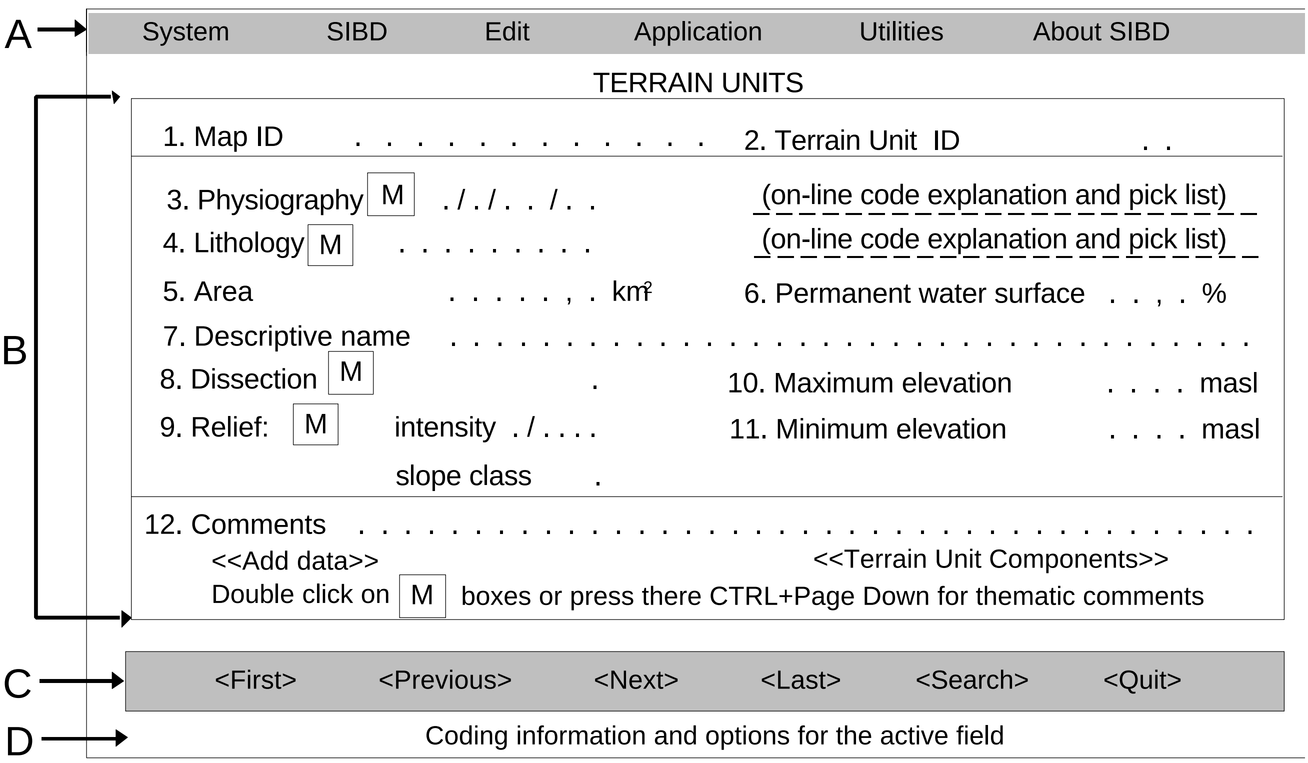
The **Central Body (B)** displays twelve items with terrain units attribute data. Each item has a reference number corresponding to the description in the procedures manual. In the lower part of this body are two push buttons to add records, to close this interface and open the terrain unit components. Boxes containing an "M" (Physiography, Lithology, Dissection and Relief) can be activated to obtain on-line comment. The description of visualized codes appears in the central body (Physiography and Lithology) and allows selection of additional options through pick-lists; it has the flexibility to consider new options.

The **Control Bar (C)** allows to visualize the first, previous, next and last record of the selected database, to search one or more records matching a specified condition, and to quit the interface.

The **Bottom Line (D)** shows the coding options and the description for the active item.

In addition, guidelines for data query and classification linked to suitability analysis are indicated in the procedures manual. Figure 5 presents the data entry form for production unit plots and land use types. Dashed boxes are for office use. Management levels are defined using conversion tables like the one presented in figure 6. Yield classes are defined for every land use type and management level after analysis of the production data. Suitabilities are defined following the FAO framework (1976) for selected land utilization types using ALES software (Rossiter 1990 and 1995). For terrain, soils, vegetation and production costs, queries are designed to export required data from the SIBD to ALES. Results from physical-biological and economic analysis are indicated in dashed boxes for cross-examination of the adequacy of the suitability models applied.

FIGURE 4: SIBD USER INTERFACE FOR TERRAIN CHARACTERISTICS



A = main menu system

B = central body

C = control bar

D = bottom line

FIGURE 5: DATA ENTRY FORM FOR PRODUCTION UNIT PLOTS AND LAND USE TYPES

data input on subsection corresponding to Land Use

office use

FARM

1. Farm ID . / . . / . . . . (for details on farm items surveyed see SIBD manual)

FARM PLOTS

1. Farm ID . / . . / . . . . 59. Plot ID . .

1. Land Use Map ID . . . . 1'. Terrain Map ID . . . .

2. Land Use Unit ID . . 2' y 13'. Terrain Unit/Component IDs . . / .

60. Distance to road . . , . km 61. Travelling time to road . . , . . hours

62. Single or Compound Land Use ID . . . .

SINGLE LAND USE TYPES (SLUT)

1. Farm ID . / . . / . . . . 59. Lot ID . .

63. Descriptive name of Single Land Use Type (SLUT) . . . .

64. Plot surface occupied by SLUT . . . . . . , . . hectares

65. Soil Conservation Methods . . . .

66. Physical-Biological factors reducing present yields . . . .

67. Irrigation source and system . . . .

68. Production destinations (up to 6)

69. Proportion to each destination %

70. Places where (main) product is sold and/or exchanged . . . . .

71. Transportation means employed to deliver products . . .

72. Community ID where products are delivered (department ID/province ID/community ID) . / . . / . . . .

CROPS AND FRUIT CULTURE	Management level	Yield Class	Land Use Suitabilities Physical-Biological	Economic

Pest controlers & fertilisers	Labour force	Machinery	Cultural operations	Yield kg/ha	Seeding/Planting system	Fruit trees density	PRODUCTION CALENDAR lot preparation	seeding/planting	harvest
. . . .	. . .	. . . . .	. . . .	. . . . .	.	. . . . . tr/ha	. . . .	. . . .	. . . .

LIVESTOCK (see additional data in farm data entry form)	Management level	Production/ Yield Class	Land Use Suitabilities Physical-Biological	Economic

GRAZING SYSTEM	MONTHS PER YEAR GRAZING IN LOT	FEEDING	HEALTH AND REPRODUCTION	PRODUCTS
. . . . .	. .	. . . .	. . . .	. . . .

FORESTRY	Management level	Production/ Yield Class	Land Use Suitabilities Physical-Biological	Economic

PREPARATION AND TREE SEARCH ACTIVITIES	ROADS / PATHS PLANNING	MACHINERY TO CUT & EXTRACT	LOWEST DBH TO CUT (cm)	CLOSING LABOURS	TIMBER VOLUMES m^3/ha SP.1	SP.2	SP.3	SP.4	Total
. . . . . .	.	. . . .	. . . .	. . . . . .	. . , .	. . , .	. . , .	. . , .	. . . .

OTHER EXTRACTIVE LAND USES	Management level	Production/ Yield Class	Land Use Suitabilities Physical-Biological	Economic

Name of product . . . .

Amount of product . . . .

Measuring unit . . . .

Comments . . . .

. . . .

. . . .

FIGURE 6: SIBD CONVERSION TABLE USED TO DETERMINE RAINFED AGRICULTURE MANAGEMENT LEVEL IN A STUDY AREA

Management Level	External Input Requirements for Rainfed Agriculture		
	Seeds, Pest Controlers and Fertilisers	Labour Force	Machinery
VERY LOW	it does not match requirements for the low management level		
LOW	at least one of the following: - certified seed - fertilisers (chemical) - manure (organic) - herbicides - fungicides - insecticides	Human, Animal and/or Mechanical	at least one of the following: - tractor - plough - harrow - clod breaker - manure spreader - other*
MEDIUM	at least two of the following: - certified seed - fertilisers (chemical) - manure (organic) - herbicides - fungicides - insecticides	Animal and/or Mechanical	tractor and at least one of the following: - plough - harrow - clod breaker - manure spreader - other*
HIGH	at least three of the following: - certified seed - fertilisers (chemical) - manure (organic) - herbicides - fungicides - insecticides	Mechanical	tractor and at least two of the following: - plough - harrow - clod breaker - manure spreader - other*
VERY HIGH	at least four of the following: - certified seed - fertilisers (chemical) - manure (organic) - herbicides - fungicides - insecticides	Mechanical	tractor and at least three of the following: - plough - harrow - clod breaker - manure spreader - other*

* specified in the corresponding section of the SIBD manual

5. The Zoning Process in the Department of Pando visualized through Maps

The agro-ecological and socio-economical zoning of the Department of Pando was completed in 1996 and in early 1997 a detailed report accompanied by maps was published (ZONISIG 1996 & 1997). Some of these maps, illustrating the zoning process, are presented and briefly commented.

The Department of Pando is entirely located in the tropical Amazon region of north Bolivia (**Map 1: The Department of Pando**). It comprises 63827 km2 between 9°30' and 12°30'S and 69°35' and 65°17'W. The elevation ranges between 90 and 290 masl; rainfall fluctuates from 1700 to 1900 mm/year and the average temperature from 25.4 to 26.2°C. The main vegetation type is a thick forest and the population of about 38,000 inhabitants, is concentrated in the cities of Cobija, Puerto Rico and Riberalta and their surroundings (**Map 2: Population Density**). In the rest of the area population density is very low because of social, economical and political constraints (land tenure, deficient infrastructure, government policies, etc) and the limited natural resources.

Map 1-12. See at the end of this paper.

Terrain, vegetation and land use features were analyzed by means of remote sensing (Landsat TM data from 1986) and field data, and a combined map showing physiography and (semi)natural vegetation (***Map 3: Terrain Units***) was used as a spatial basis for the land-suitability assessment of selected Land Utilization Types (FAO 1976) taking present land use as a starting point to assess zoning alternatives (***Map 4: Land Use; Map 5: Timber Extraction Areas***).

Thematic maps resulting from the classification of relevant land attributes were produced and used during the zoning process (Map 6: Geomorphologic Units; Map 7: Floristic Types; Map 8: Brazil Nut Trees Density; Map 9: Rubber Trees Density; Map 10: Timber Volumes).

Close relationships were found between travelling times to the main cities, rural settlements characteristics, present land use, and terrain features, and a map showing travelling time estimates was produced (***Map 11: Travelling Times to Cobija, Riberalta and Puerto Rico***).

The map of the land use plan (***Map 12: Land Use Plan***), legalized by the president and accompanied by a land use plan, was produced after the integrated analysis of zoning alternatives; all of them oriented to link sustainable development to social and economic development and to minimize conflicts.

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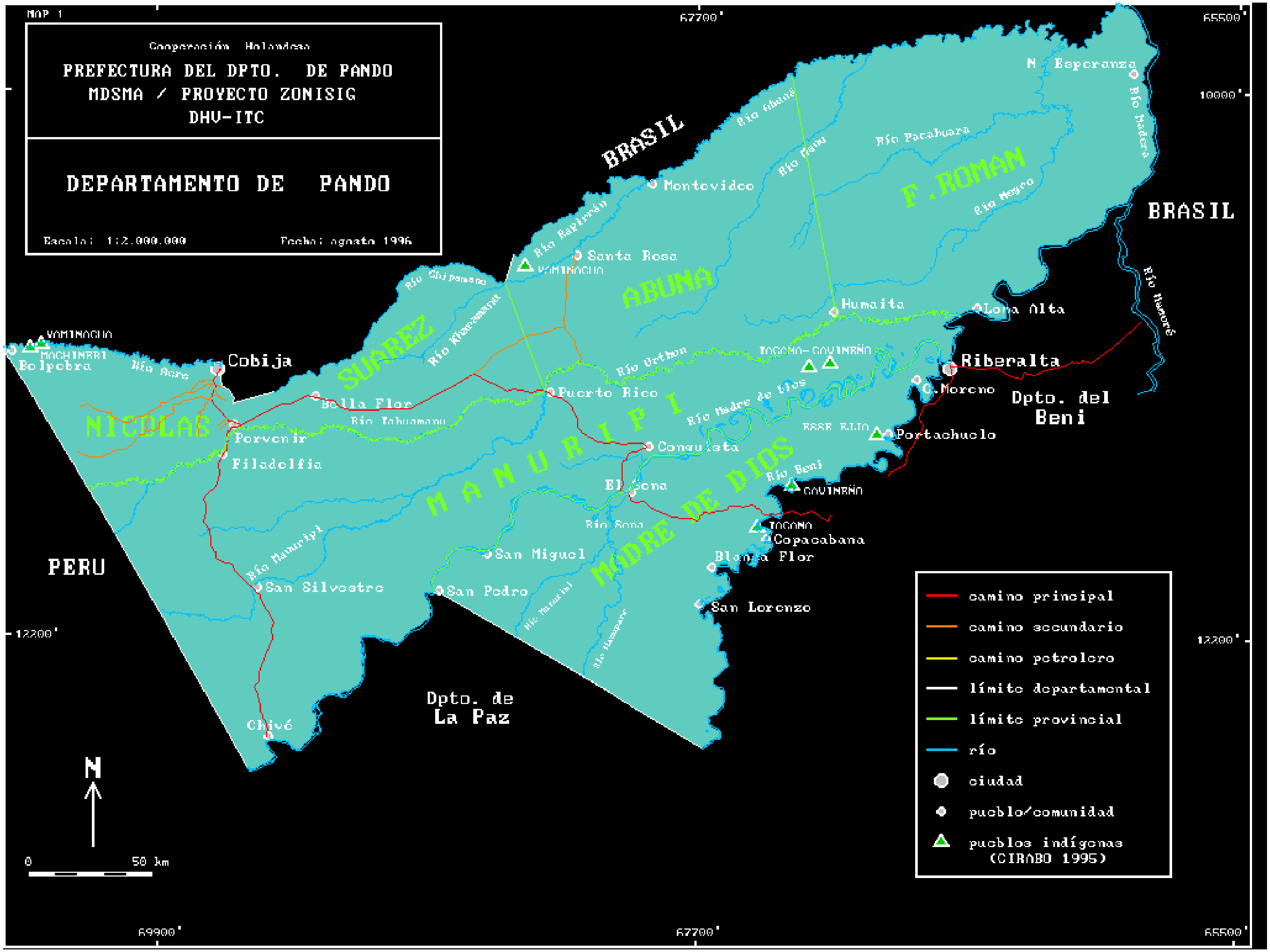
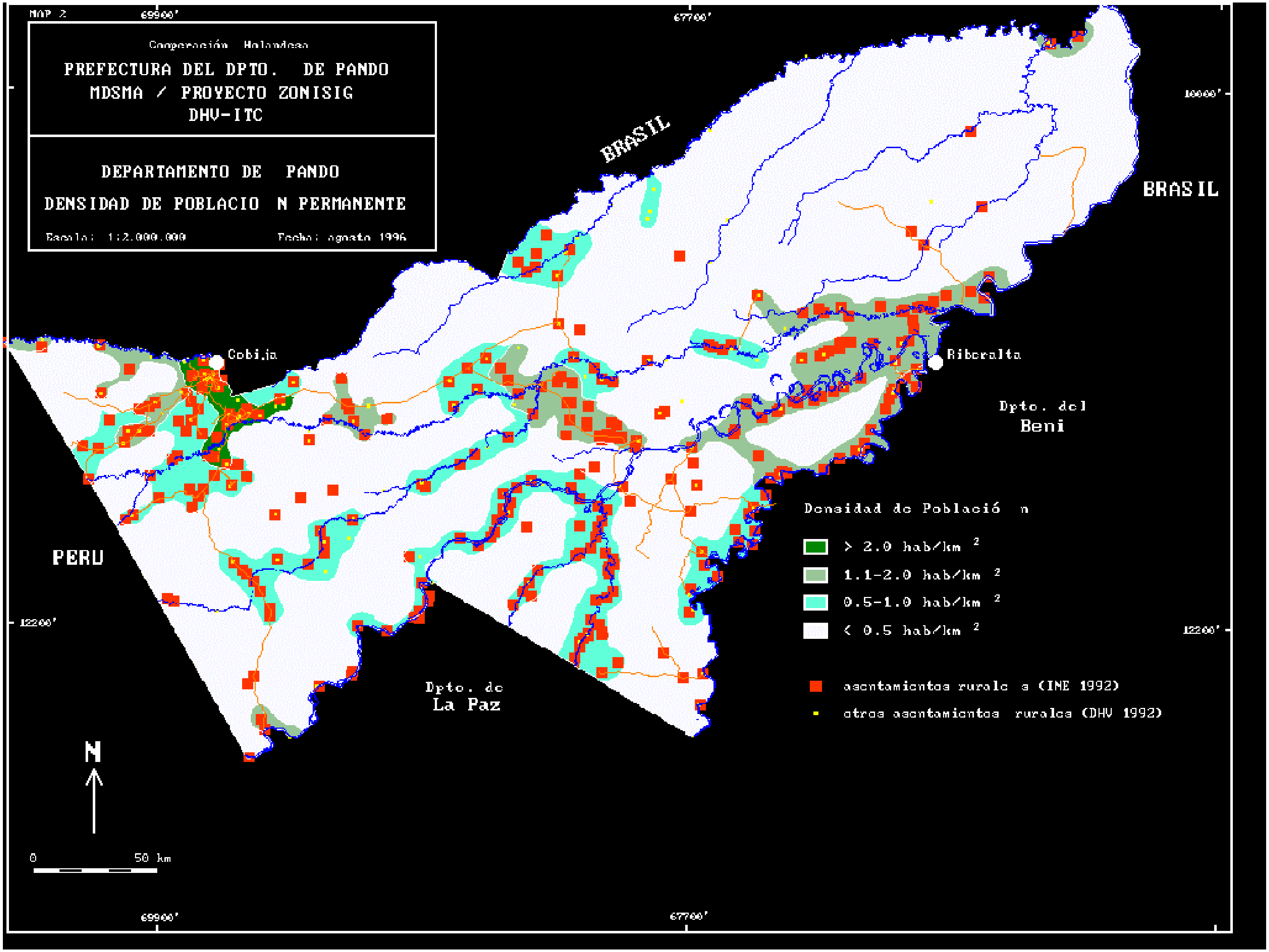
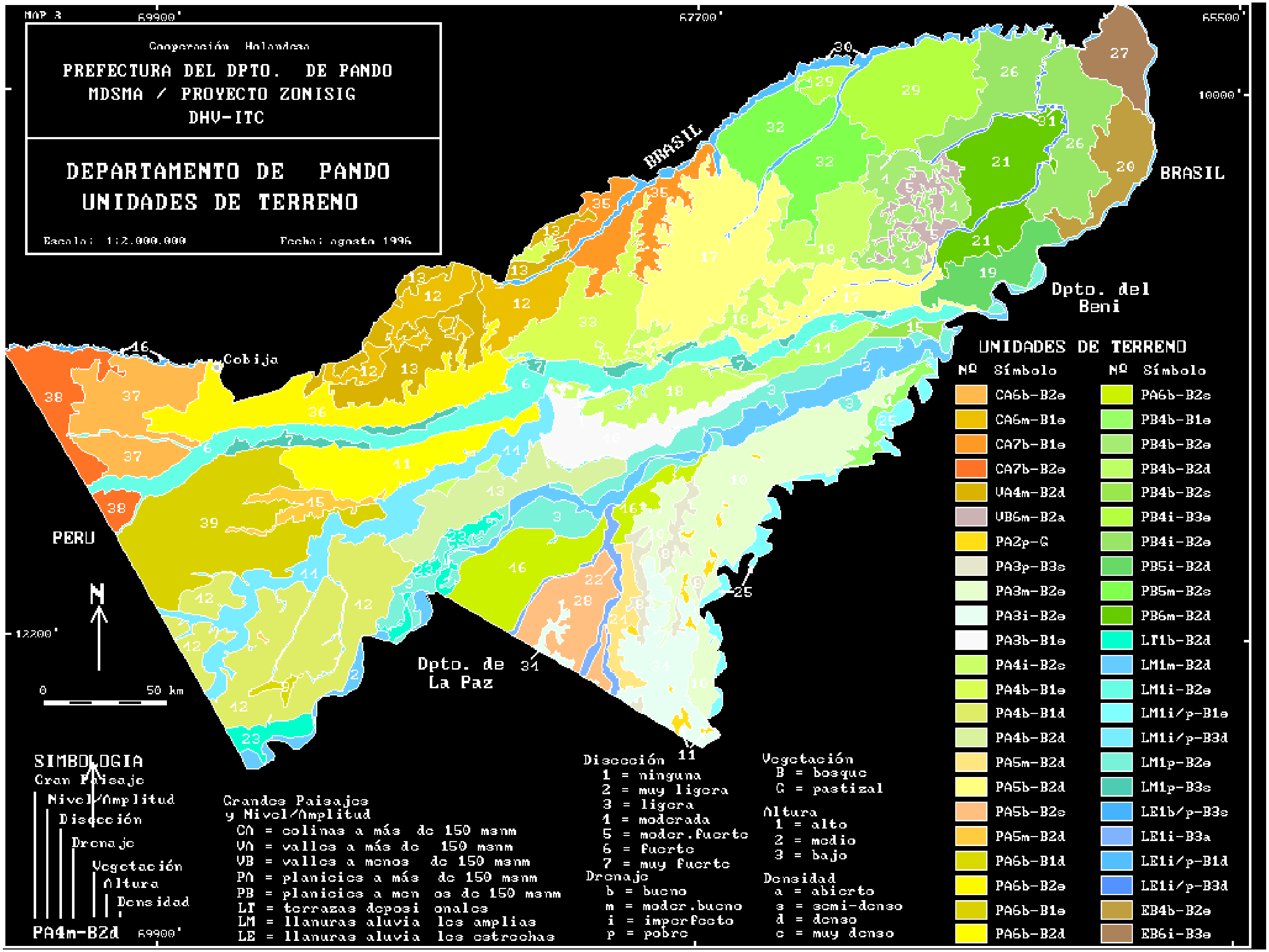
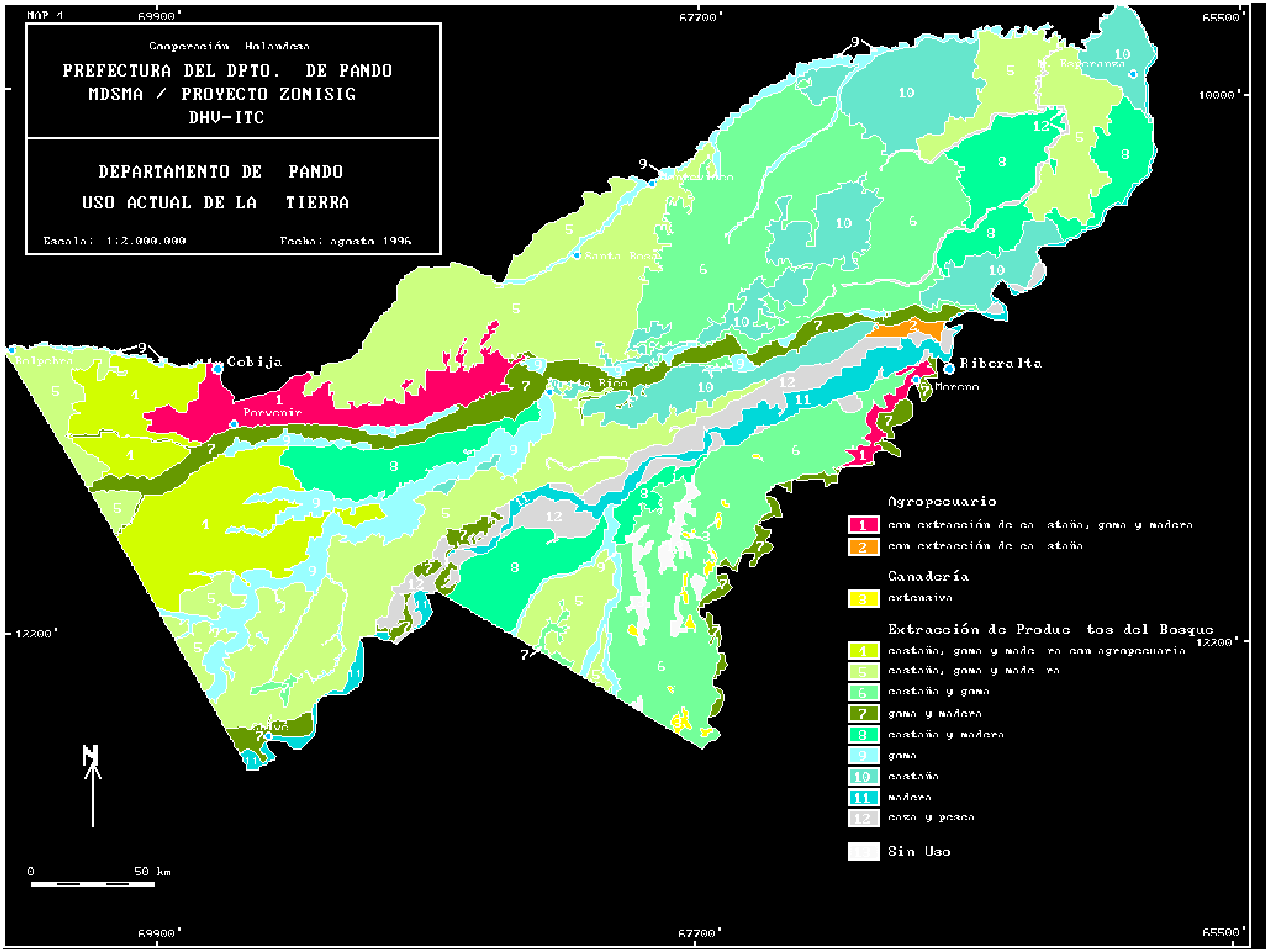
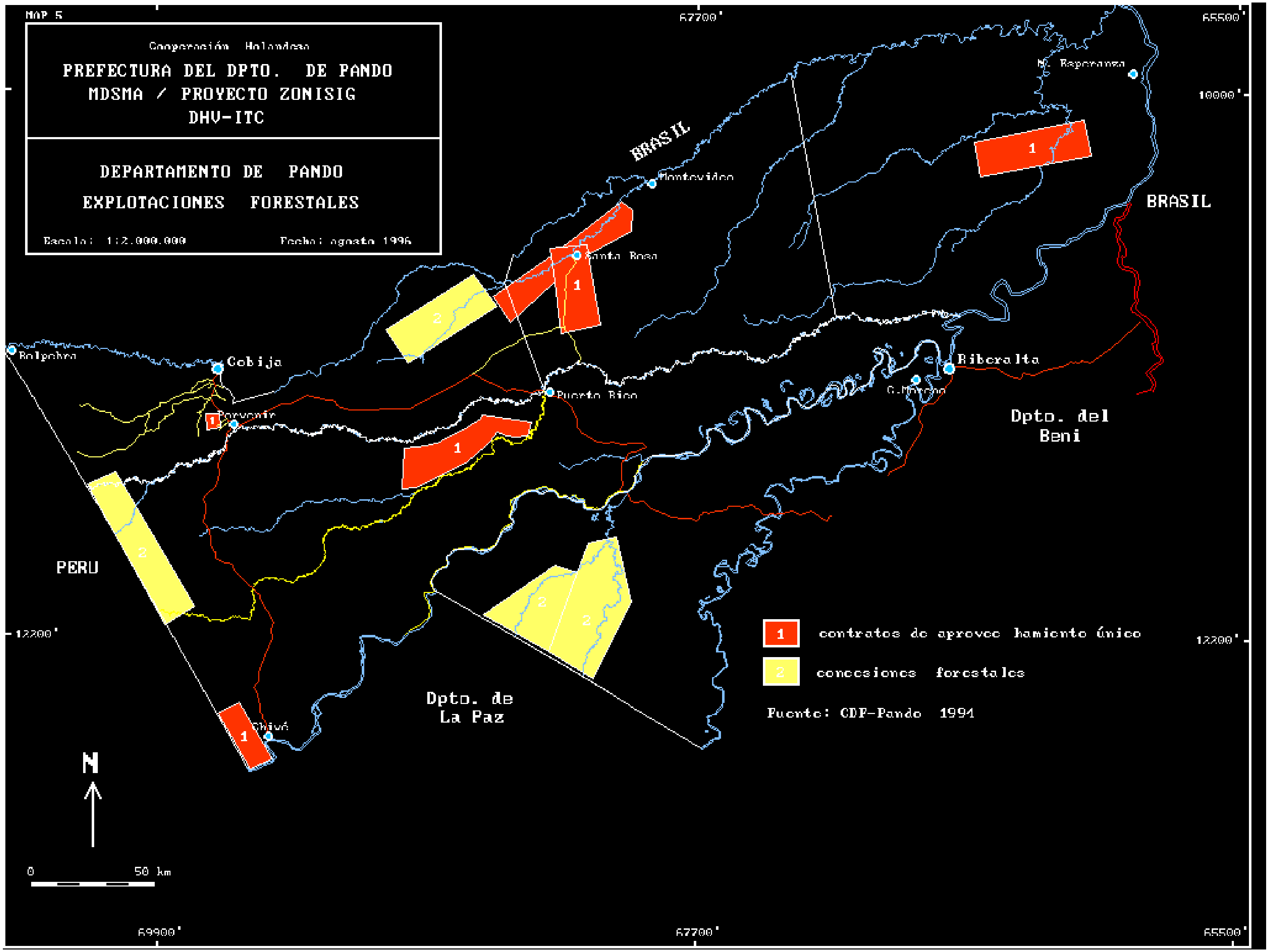

MAP 1
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
Escala: 1:2.000.000
Fecha: agosto 1996
67700'
65500'
10000'
12200'
69900'
BRASIL
BRASIL
PERU
Dpto. del Beni
Dpto. de La Paz
F. ROMAN
ABUNA
SUAREZ
NICOLAS
M A N U R I P I
MADRE DE DIOS
Esperanza
Montevideo
Santa Rosa
Humaita
Loma Alta
Riberalta
Moreno
Portachuelo
Cobija
Bolpebra
Bella Flor
Porvenir
Filadelfia
Puerto Rico
Conquista
El Sena
San Miguel
San Pedro
San Silvestre
Chivé
Copacabana
Blanca Flor
San Lorenzo
YAMINAGUA
MACHINERI
TOCANA
GOVINENO
ESSE EJJA
Río Madera
Río Pacahuara
Río Negro
Río Mamoré
Río Acre
Río Tahuamanu
Río Orthon
Río Madre de Dios
Río Beni
Río Sena
Río Manuripi
Río Chipamano
Río Rapirrán
Camino principal
camino secundario
camino petrolero
límite departamental
límite provincial
río
ciudad
pueblo/comunidad
pueblos indígenas (CIRABO 1995)
N
0
50 km


MAP 2
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
DENSIDAD DE POBLACIO N PERMANENTE
Escala: 1:2.000.000
Fecha: agosto 1996
BRASIL
BRASIL
Cobija
Riberalta
Dpto. del
Beni
PERU
Dpto. de
La Paz
Densidad de Població n
> 2.0 hab/km 2
1.1-2.0 hab/km 2
0.5-1.0 hab/km 2
< 0.5 hab/km 2
asentamientos rurale s (INE 1992)
otros asentamientos rurales (DHV 1992)
N
0
50 km

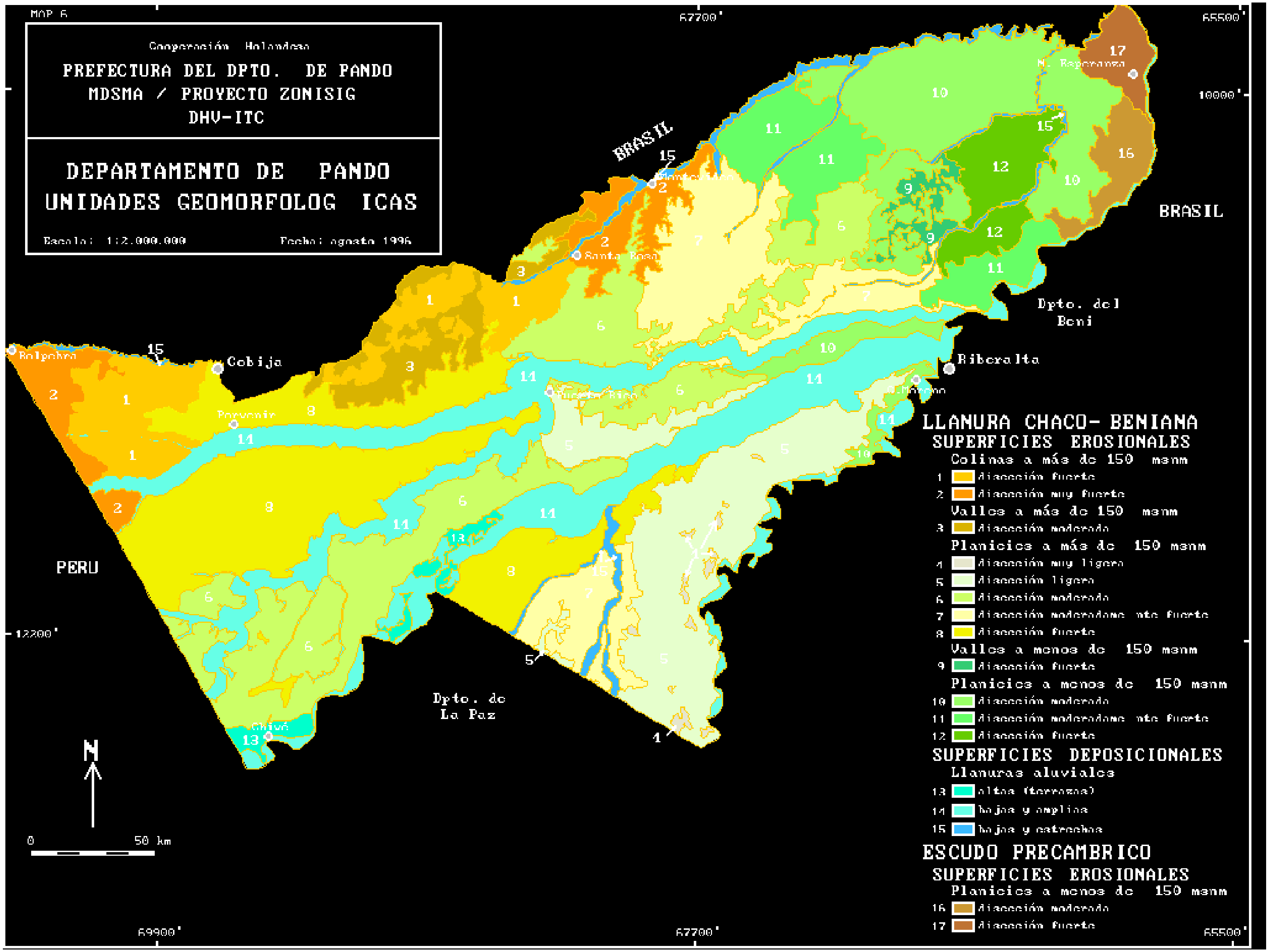

MAP 3
69900'
67700'
65500'
10000'
12200'
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
UNIDADES DE TERRENO
Escala: 1:2.000.000
Fecha: agosto 1996
BRASIL
BRASIL
Cobija
PERU
Dpto. del Beni
Dpto. de La Paz
N
0
50 km
UNIDADES DE TERRENO
Nº Símbolo
CA6b-B2a
CA6m-B1a
CA7b-B1a
CA7b-B2a
VA4m-B2d
VB6m-B2a
PA2p-G
PA3p-B3a
PA3m-B2a
PA3i-B2a
PA3b-B1a
PA4i-B2a
PA4b-B1a
PA4b-B1d
PA4b-B2d
PA5m-B2d
PA5b-B2d
PA5b-B2a
PA5m-B2d
PA6b-B1d
PA6b-B2a
PA6b-B1a
PA6b-B2d
Nº Símbolo
PA6b-B2a
PB4b-B1a
PB4b-B2a
PB4b-B2d
PB4b-B2a
PB4i-B3a
PB4i-B2a
PB5i-B2d
PB5m-B2a
PB6m-B2d
LT1b-B2d
LM1m-B2d
LM1i-B2a
LM1i/p-B1a
LM1i/p-B3d
LM1p-B2a
LM1p-B3a
LE1b/p-B3a
LE1i-B3a
LE1i/p-B1d
LE1i/p-B3d
EB4b-B2a
EB6i-B3a
SIMBOLOGIA
Gran Paisaje
Nivel/Amplitud
Disección
Drenaje
Vegetación
Altura
Densidad
PA4m-B2d
Grandes Paisajes y Nivel/Amplitud
CA = colinas a más de 150 msnm
VA = valles a más de 150 msnm
VB = valles a menos de 150 msnm
PA = planicies a más de 150 msnm
PB = planicies a menos de 150 msnm
LT = terrazas deposicionales
LM = llanuras aluviales amplias
LE = llanuras aluviales estrechas
Disección
1 = ninguna
2 = muy ligera
3 = ligera
4 = moderada
5 = moder.fuerte
6 = fuerte
7 = muy fuerte
Drenaje
b = bueno
m = moder.bueno
i = imperfecto
p = pobre
Vegetación
B = bosque
G = pastizal
Altura
1 = alto
2 = medio
3 = bajo
Densidad
a = abierto
s = semi-denso
d = denso
c = muy denso

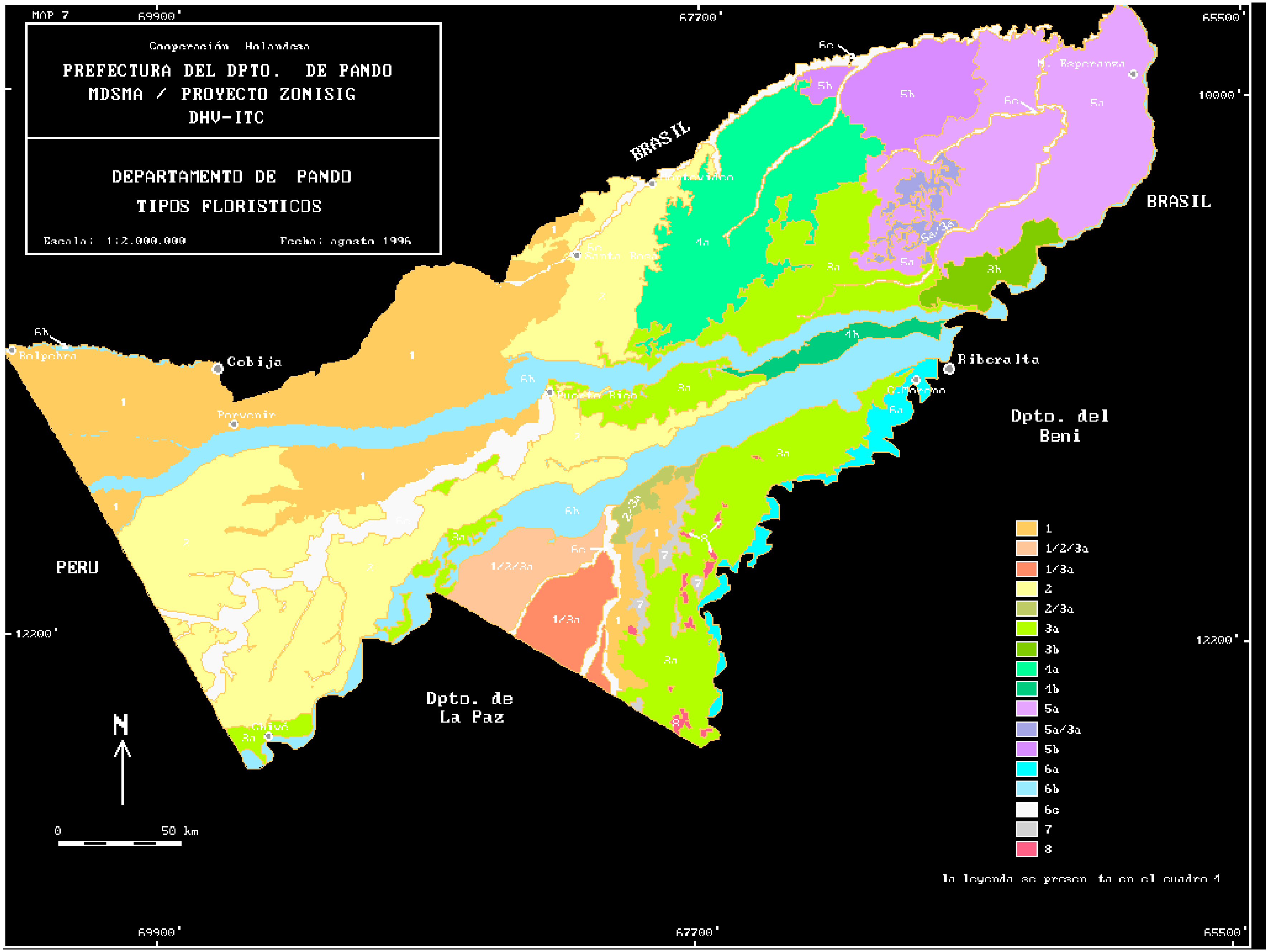


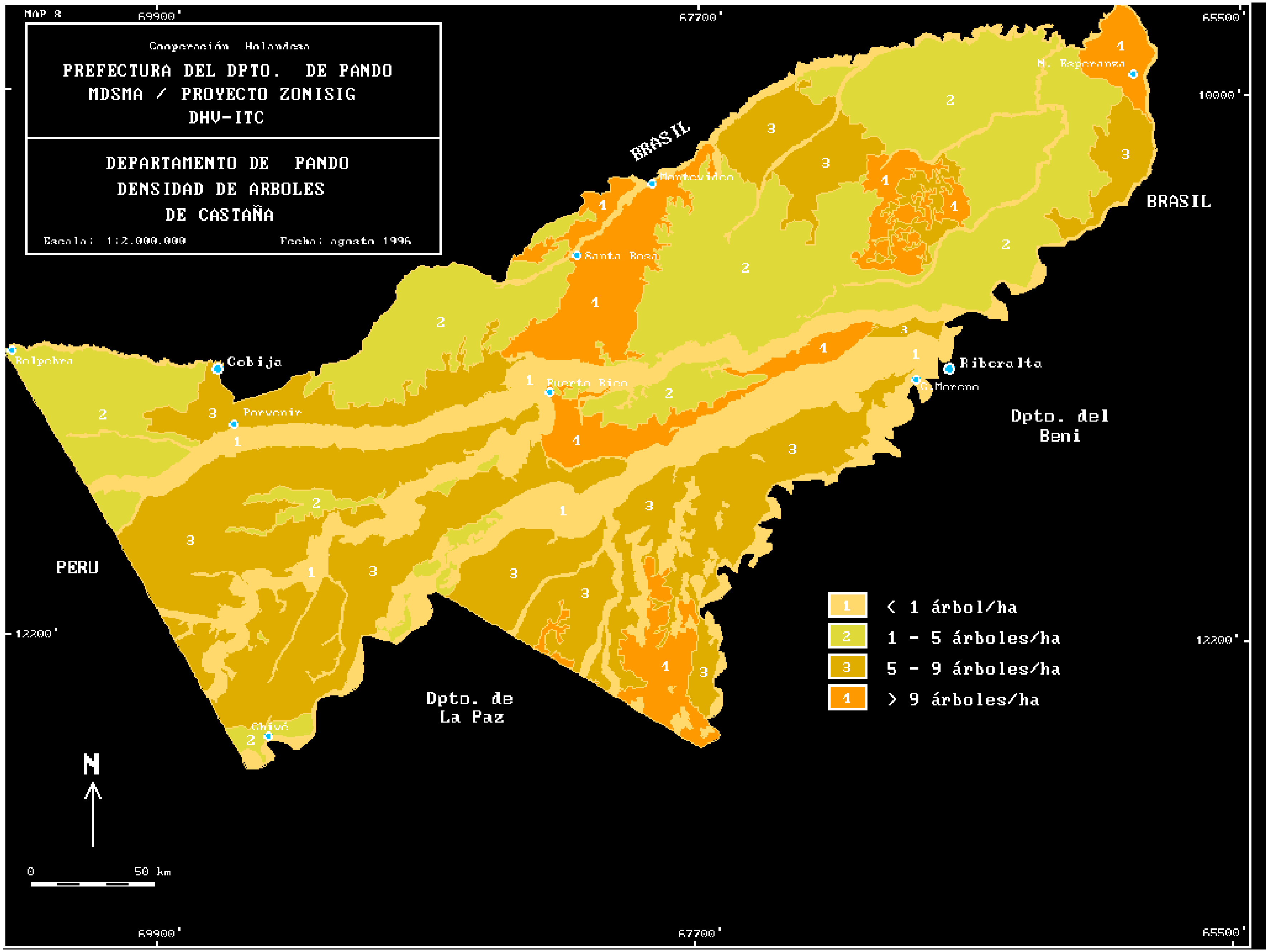
MAP 1
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
USO ACTUAL DE LA TIERRA
Escala: 1:2.000.000
Fecha: agosto 1996
69900'
67700'
65500'
10000'
12200'
Cobija
Porvenir
Puerto Rico
Santa Rosa
Riberalta
Moreno
N
0 50 km
Agropecuario
1 con extracción de castaña, goma y madera
2 con extracción de castaña
Ganadería
3 extensiva
Extracción de Productos del Bosque
4 castaña, goma y madera con agropecuario
5 castaña, goma y madera
6 castaña y goma
7 goma y madera
8 castaña y madera
9 goma
10 castaña
11 madera
12 caza y pesca
Sin Uso

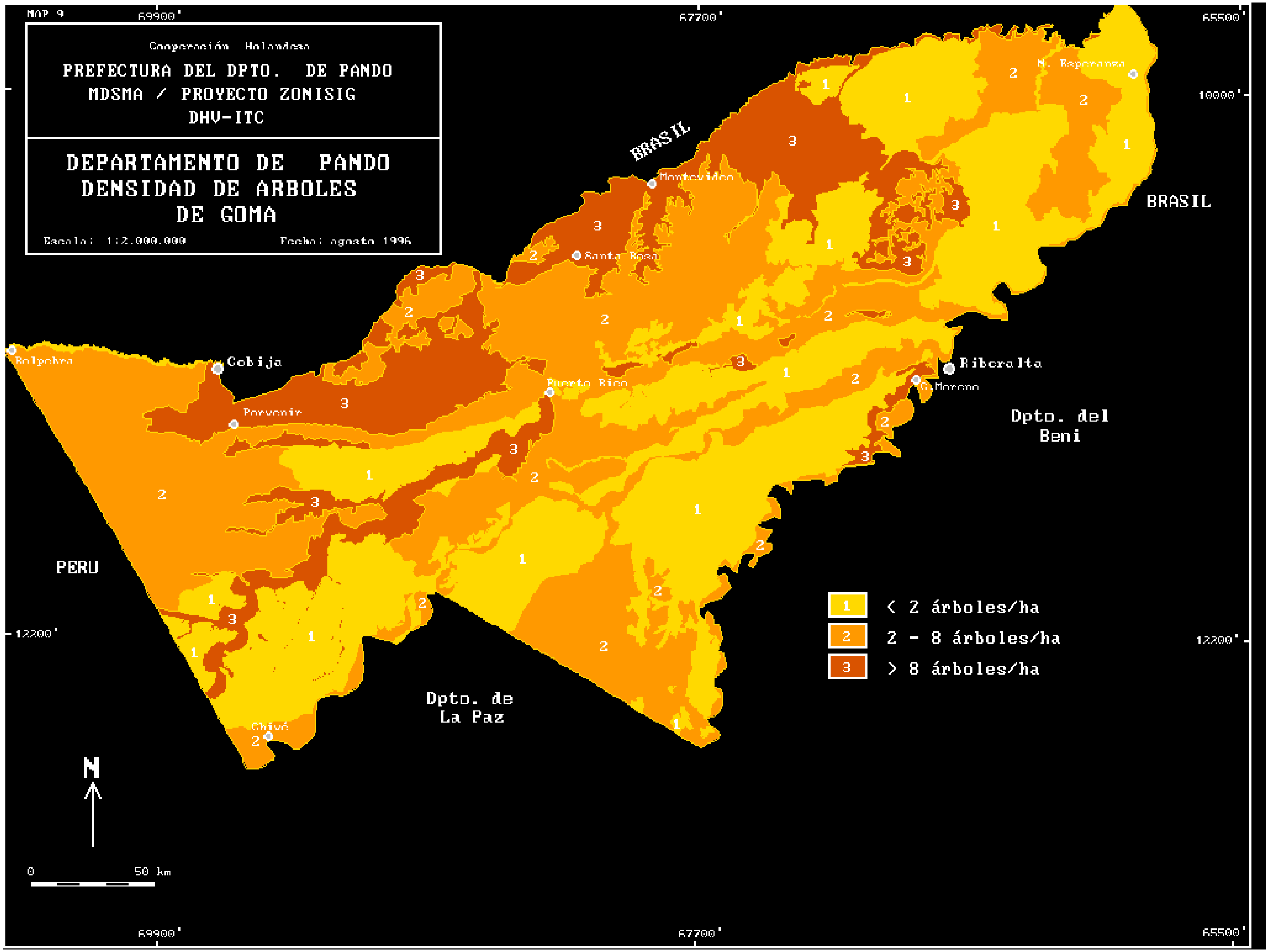


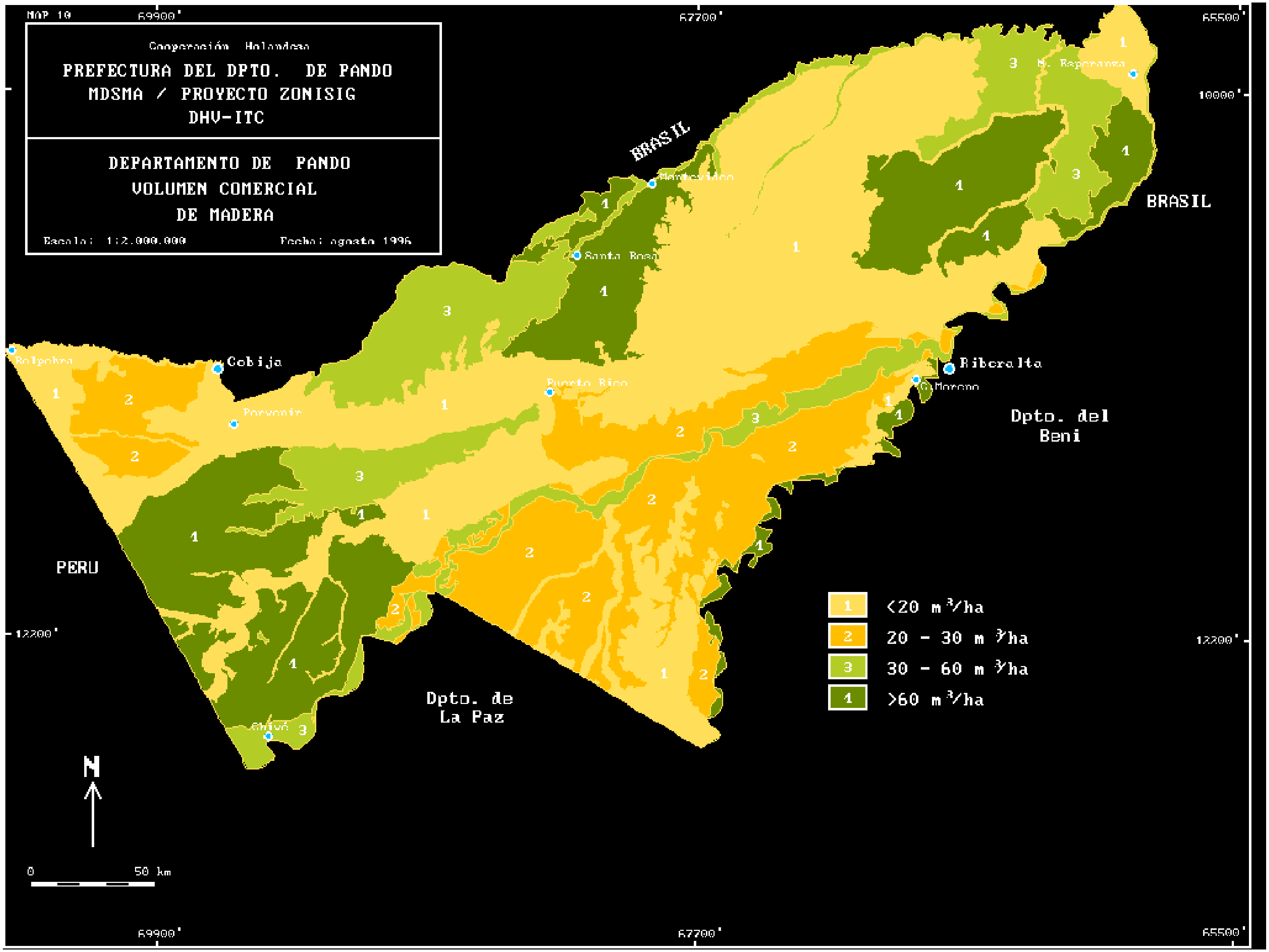
MAP 5
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
EXPLOTACIONES FORESTALES
Escala: 1:2.000.000
Fecha: agosto 1996
67700'
65500'
10000'
12200'
69900'
BRASIL
N. Esperanza
Montevideo
Santa Rosa
Bolpebra
Cobija
Porvenir
Puerto Rico
Riberalta
G.Moreno
Chivé
PERU
Dpto. del Beni
Dpto. de La Paz
1 contratos de aprovechamiento único
2 concesiones forestales
Fuente: CDF-Pando 1994
N
0 50 km

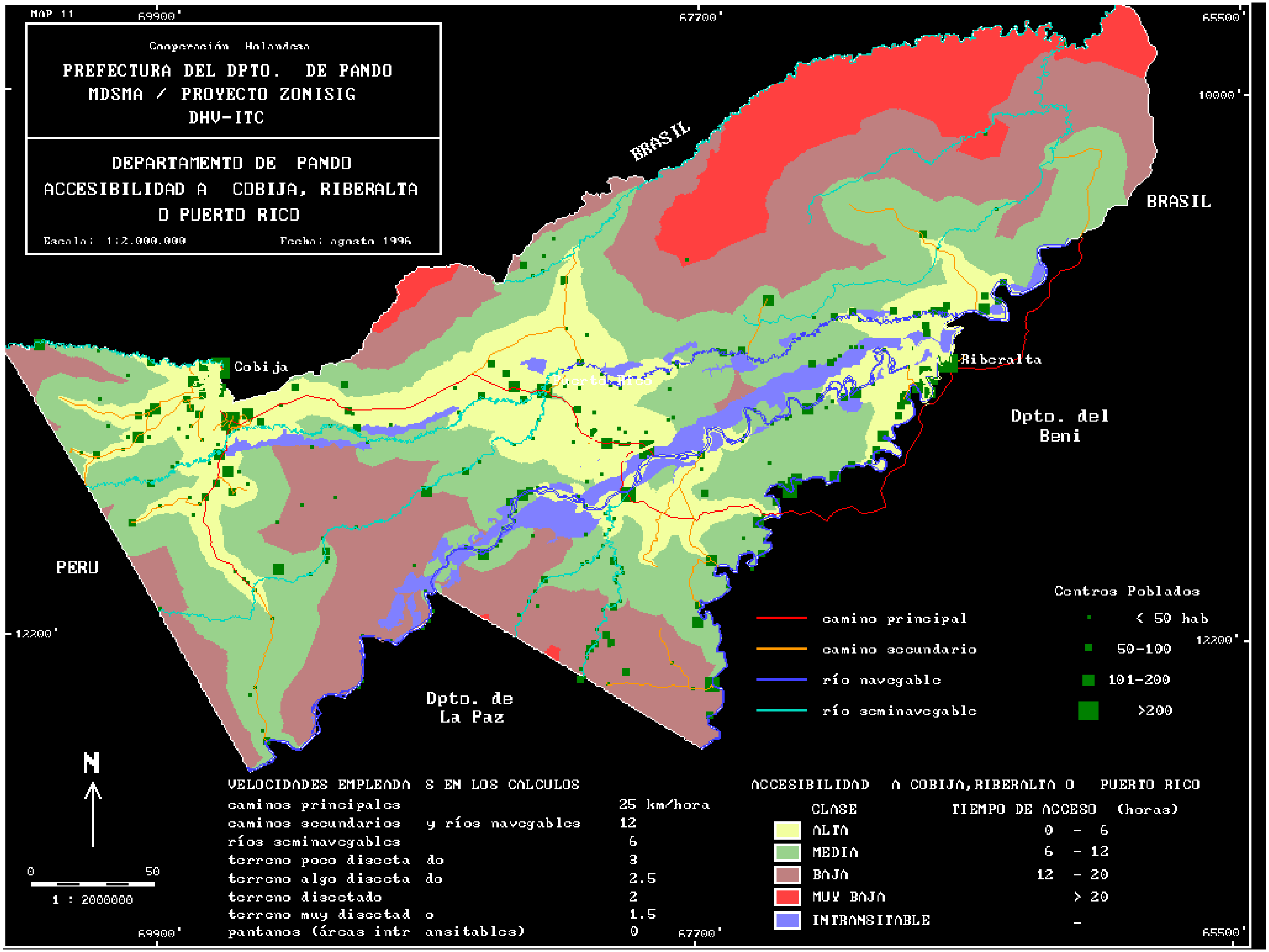

MAP 6
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
UNIDADES GEOMORFOLOGICAS
Escala: 1:2.000.000
Fecha: agosto 1996
BRASIL
Cobija
Bolpebra
Porvenir
Santa Rosa
Riberalta
PERU
Dpto. de La Paz
Dpto. del Beni
BRASIL
Chivé
N
0 50 km
67700'
65500'
10000'
12200'
69900'
LLANURA CHACO-BENIANA
SUPERFICIES EROSIONALES
Colinas a más de 150 msnm
1 disección fuerte
2 disección muy fuerte
Valles a más de 150 msnm
3 disección moderada
Planicies a más de 150 msnm
4 disección muy ligera
5 disección ligera
6 disección moderada
7 disección moderadamente fuerte
8 disección fuerte
Valles a menos de 150 msnm
9 disección fuerte
Planicies a menos de 150 msnm
10 disección moderada
11 disección moderadamente fuerte
12 disección fuerte
SUPERFICIES DEPOSICIONALES
Llanuras aluviales
13 altas (terrazas)
14 bajas y amplias
15 bajas y estrechas
ESCUDO PRECAMBRICO
SUPERFICIES EROSIONALES
Planicies a menos de 150 msnm
16 disección moderada
17 disección fuerte


MAP 7
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
TIPOS FLORISTICOS
Escala: 1:2.000.000
Fecha: agosto 1996
69900'
67700'
65500'
10000'
12200'
BRASIL
BRASIL
PERU
Cobija
Bolpebra
Porvenir
Puerto Rico
Santa Rosa
Riberalta
Chive
Dpto. del Beni
Dpto. de La Paz
N
0
50 km
1
1/2/3a
1/3a
2
2/3a
3a
3b
4a
4b
5a
5a/3a
5b
6a
6b
6c
7
8
La leyenda se presen ta en el cuadro 4

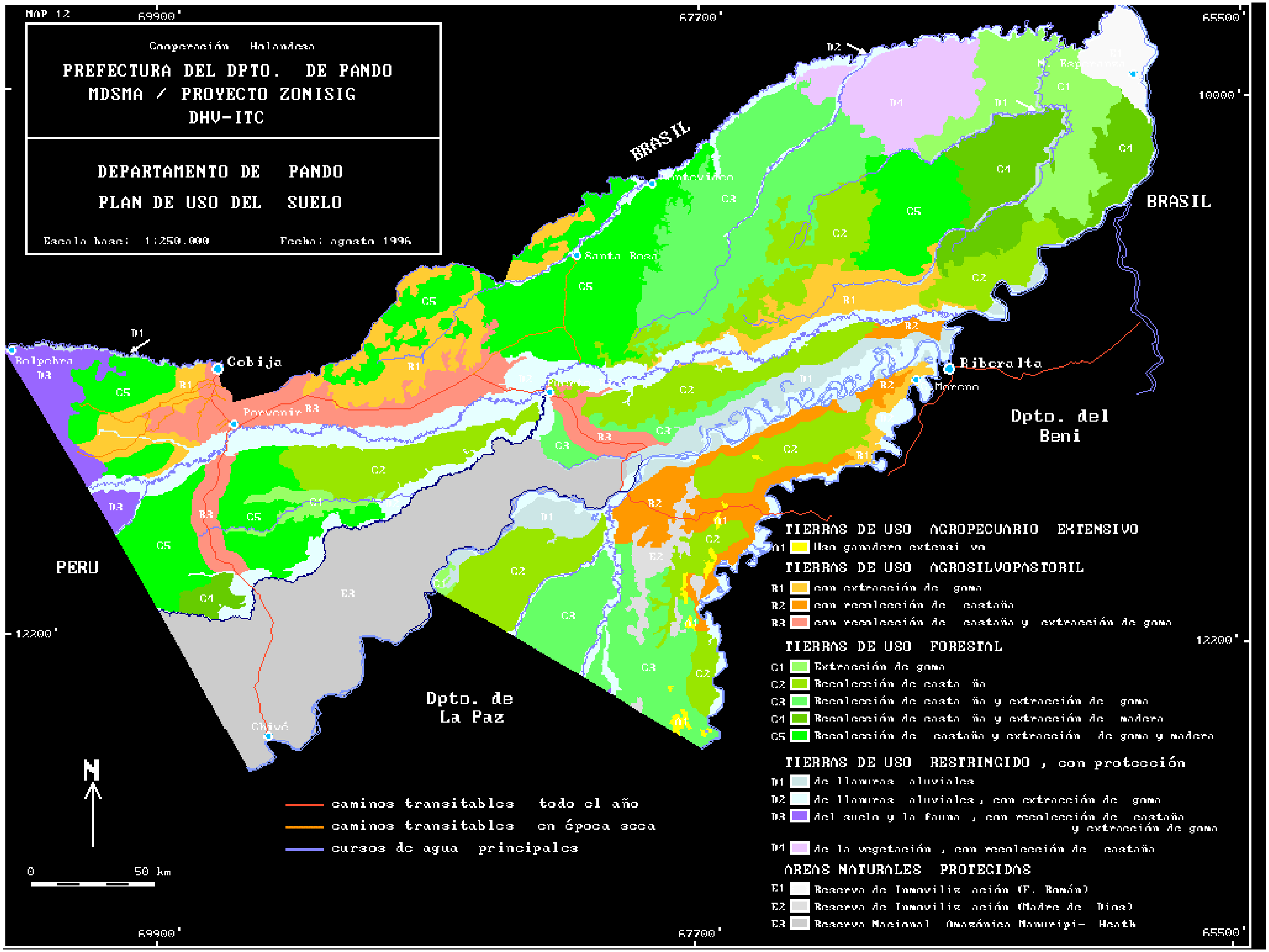

MAP 8
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
DENSIDAD DE ARBOLES
DE CASTAÑA
Escala: 1:2.000.000
Fecha: agosto 1996
69900'
67700'
65500'
10000'
12200'
BRASIL
BRASIL
PERU
Cobija
Riberalta
Dpto. del
Beni
Dpto. de
La Paz
1 < 1 árbol/ha
2 1 - 5 árboles/ha
3 5 - 9 árboles/ha
1 > 9 árboles/ha
N
0 50 km


MAP 9
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
DENSIDAD DE ARBOLES
DE GOMA
Escala: 1:2.000.000
Fecha: agosto 1996
69900'
67700'
65500'
10000'
12200'
BRASIL
BRASIL
PERU
Dpto. del Beni
Dpto. de La Paz
Bolpebra
Cobija
Porvenir
Puerto Rico
Santa Rosa
Montevideo
N. Esperanza
Riberalta
G. Moreno
Chivé
1 < 2 árboles/ha
2 2 - 8 árboles/ha
3 > 8 árboles/ha
N
0 50 km


MAP 10
69900'
67700'
65500'
10000'
12200'
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
VOLUMEN COMERCIAL
DE MADERA
Escala: 1:2.000.000
Fecha: agosto 1996
BRASIL
Montevideo
Santa Rosa
N. Esperanza
BRASIL
Bolpebra
Cobija
Porvenir
Puerto Rico
Riberalta
G.Moreno
Dpto. del Beni
PERU
Dpto. de La Paz
Chivé
1 <20 m^3/ha
2 20 - 30 m^3/ha
3 30 - 60 m^3/ha
1 >60 m^3/ha
N
0 50 km
69900'
67700'
65500'



MAP 11
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
ACCESIBILIDAD A COBIJA, RIBERALTA
O PUERTO RICO
Escala: 1:2.000.000
Fecha: agosto 1996
69900'
67700'
65500'
10000'
12200'
BRASIL
BRASIL
Cobija
Riberalta
Dpto. del Beni
PERU
Dpto. de La Paz
Centros Poblados
camino principal
camino secundario
río navegable
río seminavegable
< 50 hab
50-100
101-200
>200
N
0
50
1 : 2000000
VELOCIDADES EMPLEADAS EN LOS CALCULOS
caminos principales 25 km/hora
caminos secundarios y ríos navegables 12
ríos seminavegables 6
terreno poco disectado 3
terreno algo disectado 2.5
terreno disectado 2
terreno muy disectado 1.5
pantanos (áreas intransitables) 0
ACCESIBILIDAD A COBIJA, RIBERALTA O PUERTO RICO
CLASE
TIEMPO DE ACCESO (horas)
ALTA 0 - 6
MEDIA 6 - 12
BAJA 12 - 20
MUY BAJA > 20
INTRANSITABLE -


MAP 12
Cooperación Holandesa
PREFECTURA DEL DPTO. DE PANDO
MDSMA / PROYECTO ZONISIG
DHV-ITC
DEPARTAMENTO DE PANDO
PLAN DE USO DEL SUELO
Escala base: 1:250.000
Fecha: agosto 1996
69900'
67700'
65500'
10000'
12200'
BRASIL
PERU
Dpto. del Beni
Dpto. de La Paz
Cobija
Bolpebra
Porvenir
Santa Rosa
Montevideo
Riberalta
Chivé
TIERRAS DE USO AGROPECUARIO EXTENSIVO
A1 Uso ganadero extensivo
TIERRAS DE USO AGROSILVOPASTORIL
B1 con extracción de goma
B2 con recolección de castaña
B3 con recolección de castaña y extracción de goma
TIERRAS DE USO FORESTAL
C1 Extracción de goma
C2 Recolección de castaña
C3 Recolección de castaña y extracción de goma
C4 Recolección de castaña y extracción de madera
C5 Recolección de castaña y extracción de goma y madera
TIERRAS DE USO RESTRINGIDO , con protección
D1 de llanuras aluviales
D2 de llanuras aluviales , con extracción de goma
D3 del suelo y la fauna , con recolección de castaña y extracción de goma
D4 de la vegetación , con recolección de castaña
AREAS NATURALES PROTEGIDAS
E1 Reserva de Inmovilización (F. Román)
E2 Reserva de Inmovilización (Madre de Dios)
E3 Reserva Nacional Amazónica Manuripi- Heath
caminos transitables todo el año
caminos transitables en época seca
cursos de agua principales
N
0 50 km