CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) — PART I

Report Symbol U-447

1. PROJECT TITLE	2. PROJECT NUMBER	3. MISSION/AID/W OFFICE
Disaster Recovery Project: Disaster Surveillance Data Collection Subcomponent	511-0581	USAID/Bolivia

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY) 85-10

☒ REGULAR EVALUATION ☐ SPECIAL EVALUATION

5. KEY PROJECT IMPLEMENTATION DATES	6. ESTIMATED PROJECT FUNDING	7. PERIOD COVERED BY EVALUATION
A. First PRO-AG or Equivalent FY 83 B. Final Obligation Expected FY 86 C. Final Input Delivery FY 86	A. Total $ ____ B. U.S. $ 478,000	From (month/yr.) 03/84 To (month/yr.) 01/85 Date of Evaluation Review

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
This subcomponent of the Disaster Recovery project was evaluated by its two designers, each reviewing different portions of the Data Surveillance system. Because of the different foci of the reviews and the slightly different timeframe which the two studies took place, the evaluations did not follow the standard PES format and the two evaluations are being submitted to AID/W individually. The other evaluation of the data system is 85-5.		
1. The data subproject requires someone with more expertise in data processing and with more time to perform the subproject's data processing tasks.	S. Pinzino HHR (USAID/Bolivia)	Continuing
2. The evaluation recommends a simpler and less expensive data collection system which would be sustainable when the system is transferred to the Government of Bolivia.		
Incorporating the recommendations of this evaluation and the ones made in 85-5, the data collection system was modified and transferred to the Bolivian Government in FY 1985.		

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9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

- ☐ Project Paper
- ☐ Financial Plan
- ☐ Logical Framework
- ☒ Project Agreement
- ☒ Implementation Plan e.g., CPI Network
- ☐ PIO/T
- ☐ PIO/C
- ☐ PIO/P
- ☐ Other (Specify) ____
- ☐ Other (Specify) ____

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

- A. ☐ Continue Project Without Change
- B. ☒ Change Project Design and/or ☐ Change Implementation Plan
- C. ☐ Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

Clearances:
DP:WJGarvelink:
DP:AAFunicello:
HHR:SPinzino:
HHR:GRBowers:
PRD:SMiller: 12/27/85

12. Mission/AID/W Office Director Approval

Signature

Typed Name: David A. Cohen, Director

Date

AID 1330-15 (3-78)

FINAL REPORT

Review of Disaster Surveillance Project

January 21, 1985 to February 25, 1985

USAID/Bolivia

Contract 511-0581-S-00-5066

William E. Bertrand

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New Orleans, La 70118

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Summary

The Bolivian Disaster Surveillance Project has been in operation for almost one year with full staffing available for approximately 5 months. Logistic and staffing problems have contributed to a slight delay (8-10%) in data output as per original timetable. Errors in original questionnaire formulation have been corrected and adjustments in field operations are being made accordingly. The result is a working system capable of meeting the design requirements of hte original project. Issues are focused upon getting immediate results from the project and being able to replicate same if proven useful within economic possibilities of GOB. Suggestions for improving current operations are included in Appendix One. It should be noted that the continuing and severe economic and political crisis of the country makes any project difficult and the fact that this one has moved as well as it has is laudable.

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1. Introduction

The document presented here is the result of activities carried out under a scope of work specified in contract 511-0581-S-00-5066 and will be organized according to the tasks outlined in the scope of work. These are:

A. Consult with project personnel regarding data processing hardware and software needs for the project.

B. Review implementation progress of the data collection system and advise on the procedures for collection, processing, and analysis of data.

1. Travel in target areas for the purpose of assessing data data availability and field operations.

2. Meet with technical personnel in government agencies responsible for collecting primary data on which the program depends.

3. Consult with Project staff regarding adequacy of information available, indexes being used and overall system procedures.

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2. Background

As part of the original design team for this project in Feb/March of 1984 this consultant has an informed perspective on the chronology of project development. Brief trips to consult with project personnel in June and November of 1984 added to this information base. The original project plan of hiring field agents, training them and beginning initial data collection by June of 1984 was delayed because of logistical problems relating primarily to the availability of transportation. The actual date for the beginning of collection of data on the short form protocols (see appendix 1) was October 1984 with data entry started in December of 1984. The first reporting of information was available for analysis in January of 1985. This represented data on 10 communities for each of 5 Departments. Data entry and manipulation were accomplished by Oscar Antezana, AID Project Manager and Patrick Marnane, System Director.

The project is within the schedule established in the original plan given the problems associated with logistics. The approximately 6 month delay in the availability of the first pre-test information is due to problems not under the control of project staff. Normal difficulties in commodity acquisition were made more difficult by the continuing economic crisis in Bolivia and its attendant difficulties for the AID mission staff. A summary of suggestions for possible improvement of these procedures is included in Appendix I.

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3. Computer and Data Processing Needs

The IBM-XT which was delivered to USAID in early 1984 for project use has proven adequate for project needs with some exceptions. As is often the case with a helpful new technology several other offices within the mission have found the micro-computer useful with the result that it has remained in the central AID offices and not moved with the project to its new offices in the Condor building. The mission has recognized this as a problem and begun the process of acquiring several micro-computers with one to be directed towards the full time use of the Project in its offices. The physical location of the machine away from the project offices has not affected actual data processing until this point however staff training and practice time on the machine has been reduced markedly. Since the amount of information is increasing dramatically it is necessary to establish the originally planned facility for the project within its offices as soon as possible. The availability of $10,000.00 worth of data processing equipment should not hold up a several hundred thousand dollar project designed to deliver data in a timely fashion.

4. Computer Hardware Considerations

The IBM-XT ordered for the project is still appropriate for its needs. Any new machine intended for the in house needs should have a full graphics capability ,memory expanded to the

full capacity of 640 K and the 8087 coprocessor chip for faster statistical work. Given the current drop in the price of IBM and IBM-compatible equipment I would also strongly suggest the purchase of a dual floppy disk drive machine with 640 K to use for data entry and forms management and as a back up for the IBM-XT should the need arise. This kind of rendundancy in surveillance systems is standard and is well worth the minor added costs. A final suggestion, again within the original budget estimates, would be the purchase of a H-P 110 handheld microcomputer. This machine could be useful as a field data entry device and would also be sufficient for the analysis of small data sets for special studies in the field. The latter would be particularly useful for providing feedback to some of the local institutions with which the project is working. The H-P 110 has the added advantage of being fully battery powered and compatible with the IBM systems for data transfer with the purchase of an added card. All of the above equipment is on the AID approved list and has been field tested under conditions similar to those in Bolivia.

Printers represent the final point on hardware acquisitions with two considerations judged as important. These include printer speed and graphics output capability. Local maintenance and availability of supplies would also be important although probably not a major issue in Bolivia. Since all repairs and maintenance are through third parties. The new IBM dot matrix

printer with significantly faster speed would be our current recommendation.

Mission arrangements to purchase micros and supplies through a local competent supplier are strongly supported. Asesoramiento Empresarial S.A. appears to be the logical choice for a full service purchase agreement and continues to be the suggestion for local supply. A back up source should be located in the states that could provide equipment on short notice should such be required. As of departure and debriefing in La Paz the plans for acquisition of hardware seem appropriate and should respond to the needs of the project.

5. Software

The original software suggested for the project was built around the spreadsheet capabilities of Lotus 123. Lotus has served until the moment with its ability to provide simple summary statistics and data entry capabilities. As the project becomes more complex however its data processing needs are also increasing. For project management as well as data entry activities one of the powerful relational data base managers is suggested. Through the Tulane/Mission co-operative agreement Knowledge Management (K-Man), a powerful relational data base manager has been left with the project. It is intended that this program will be utilized to design data entry and report formats for the project which can later be converted into data files for

statistical analysis. The program also allows for full screen form design and the use of macro commands once files have been defined. It can be utilized to create form and paper management systems for general office and logistic control as well. Other programs are available which do roughly the same type of job however Kman has been consistently rated very highly and is the program of choice currently. Finally SPSS(Statistical Package For the Social Sciences) has developed a rather complete version of its set of programs which can be run on the IBM-XT. Since this is the most utilized statistical package around the world and many people have experience with its format it is the program suggested for this application and has been installed. With these three programs, the usual operating system software and a good word processer (Wordstar has also been left on the system) all data and information processing needs of the project can be met. A budget should be established however to maintain and organize these programs for project use. This can be covered by hiring custom programming work for developing KMAN instructioon sets and doing SPSS program development or given individuals within the project can be trained in all aspects of the above. In general the second option is preferable particularly if there will be expectations that the project is to be handed over to a Bolivian institution in the future. It is therefore suggested that a statistician be employed by the project and trained in the use of appropriate software as well as the presentation of reports and necessary graphics within these reports.

6. Summary of Data Processing and Computer Needs

A. The IBM-XT originally dedicated to the project is still adequate for processing needs if it is made available full time in the project offices immediately.

B. A second IBM-PC with full built up to full capacity would provide low cost security and added capability for office tasks. A Hewlitt Packard 110, a fully battery powered IBM-PC compatible microcomputer, could provide the capability for field data entry and small data processing tasks in the field. This could add significantly to the projects ability to rapidly evaluate alternative data sources and provide some feedback to the communities from whom we are expecting such major co- operation.

C. Software needs are basically met with LOTUS 123 as the spreadsheet package, Wordstar for word processing, Knowledgeman for data entry and record management and SPSS for statistical programming.

D. With greater data processing needs and th software available to manage same there exists a personnel problem which needs to be addressed. No fully trained personnel exist within the project with sufficient time available to dedicate to data processing needs. It is

strongly suggested that an individual be contracted to do these tasks or that more support staff be provided such that the current staff can dedicate more time to this area.

The above represent the major conclusions reached after reviewing all the current data collection and processing activities of the project, individuals responsible for same and equipment available for use.

7. Summary of Field Observations

The six day field trip for the purpose of validating certain items on the protocol and reviewing the physical problems associated with data collection began by leaving from La Paz and going overland to Oruro visiting the village Ancacato. Arriving in Potosi the night of the first day, the overland trip to Pocoata took the better part of the second day where we spent the evening in the local hospital. The third day involved reviewing data collection in Pocoata and driving on to Ocuri to examine the data collection systems of the Instituto Politechnico Thomas Katari where the night was spent. The fourth day was spent partly in Ocuri moving on to Ravelo and finally to Sucre for the evening. From Sucre on the following day we departed to visit two area hospitals in Yamparaez and Tarabuco respectively. The final day involved returning to La Paz via air. While I do not generally consider a travelog as part of a final report it is

included here because of the insights into the logistics of the data collection system designed. In five days we were able to visit 7 towns all of which were on major secondary roads. During 4 of these days rain fell during at least part of our travel making mountain road conditions worse and to some extent physically dangerous. Although we traveled during the first part of the rainy season the rains had been mild and rivers were fairly low. Even with new vehicles, travel through these rural zones is difficult and could create major problems in the flow of data during the rainy season. From the above it seems clear that our original estimate of thirty communities per month randomly seleted from each department is high and can only be met under the most ideal of conditions.

In all of the communities visited the reception to us and the project was positive. This had been an earlier concern of the design team since the project was not directly aiding the individuals who were collaborating in the provision of the information needed. Even well trained and equipped individuals will have difficulty meeting the timelines imposed by the project emphasizing the need for community acceptance. It would be appropriate to feed back information to the individual communities in order to assure that this high level of co-operation continues to exist. Several questions were directed to us regarding when information might be available and how it could be used. It was also clear that expectations existed in the

villages regarding follow on projects that would be forthcoming from AID based on the field agents constantly identifying themselves as from USAID.

The census taking activity which has been undertaken on a pilot basis in several towns is appropriate to mention at this juncture. (More information on the census and the processing options for it is included in appendix II.) There is a demand from key informants in each community to receive information on a regular basis as well as give it. So far the census has provided one of the only basis for this information interchange to take place. By giving local communities some feedback on their own population characteristics the surveillance program has achieved a certain legitimacy while at the same time gathering important data to verify denominators and migration patterns. As a side benefit the census data gathering offered a training ground for all project personnel into the realities of field research in Bolivia. The census therefore has proved valuable in the following ways.

A. providing a useful service to village leadership for participation in surveillance project.

B. providing data relative to migration and population composition in order to supplement surveillance data.

C. provide denomiator figures for morbidity and mortality estimates.

D. Offer training to project staff.

8. Searching for the Hydrostatic Quotient

AID consultants in agriculture at the time of the original project design suggested that an important piece of data might be the "hydrostatic quotient." This was included in the original protocol and since that time several of us have been trying to track down a definition for the term.

The National Oceanic and Atmospheric Administration was contacted for more information and the chief meterologist has indicated that the hydrostatic quotient might be an old term which is not used anymore. He thinks that it refers to the gauge pressure which is the absolute pressure of a liquid in static state minus the atmospheric pressure.

It is given by the following equation:

$$P = egh$$

Where P = hydrostatic pressure
e = density of the liquid (in this case water)
g = gravitational force due to acceleeration
h = height of liquid column on depth of liquid

e the density varies with temperature.

A chart is included to calcuate e. The unit of measure is in grams per cubic centimer (g/cm]3).

On the following charts, the vertical column shows whole degrees in celcius and the horizontal column shows 1/10's of a degree celcius. Thus e at 9.2]oC (for example) is 0.999766 g/cm]3.

The acceleration due to gravity term is dependent on latitude, and is given in cm/sec]2.

E.g. hydrostatic pressure of water at 30]oC in New Orleans (30]oN latitude), at a depth of 2cm is:

$$P = \frac{0.995944g \quad : \quad 979.329 \quad : \quad 2}{cm \qquad\qquad sec]2}$$

= 1950.714 g/cm-sec]2
or 1950.714 dynes/cm]2

since 1 tyne = 1 g-cm/sec]2

Enclosed are two charts useful for the definition.

are held together by nuclear forces of attraction, with exchange forces operating between them. The number of protons is equal to the atomic number (Z) of the element, the number of neutrons is equal to the difference between the mass number and the atomic number ($A - Z$). The number of excess neutrons, i.e. the excess of neutrons over protons, is of paramount importance for the radioactive properties or stability of the element.

Henry's law.—The mass of a slightly soluble gas that dissolves in a definite mass of a liquid at a given temperature is very nearly directly proportional to the partial pressure of that gas. This holds for gases which do not unite chemically with the solvent.

Hess' law of constant heat summation.—The amount of heat generated by a chemical reaction is the same whether reaction takes place in one step or in several steps, or all chemical reactions which start with the same original substances and end with the same final substances liberate the same amounts of heat, irrespective of the process by which the final state is reached.

Hooke's law.—Within the elastic limit of any body the ratio of the stress to the strain produced is constant.

Humidity, absolute.—Mass of water vapor present in unit volume of the atmosphere, usually measured as grams per cubic meter. It may also be expressed in terms of the actual pressure of the water vapor present.

Huygens' theory of light.—This theory states that light is a disturbance traveling through some medium, such as the ether. Thus light is due to wave motion in ether.

Every vibrating point on the wave-front is regarded as the center of a new disturbance. These secondary disturbances traveling with equal velocity, are enveloped by a surface identical in its properties with the surface from which the secondary disturbances start and this surface forms the new wave-front.

Hydrogen equivalent of a substance is the number of replaceable hydrogen atoms in 1 molecule or the number of atoms of hydrogen with which 1 molecule could react.

Hydrogen ion concentration.—The concentration of hydrogen ions in solution when the concentration is expressed as gram-ionic weights per liter. A convenient form of expressing hydrogen ion concentration is in terms of the negative logarithm of this concentration. The negative logarithm of the hydrogen ion concentration is called pH. The significance of pH is still in dispute (ref. J. Am. Chem. Soc. 60, 1094 (1938)).

Water at 25°C has a concentration of H ion of 10^{-7} and of OH ion of 10^{-7} moles per liter. Thus the pH of water is 7 at 24°C. A greater accuracy is obtained if one substitutes the thermodynamic activity of the ion for its concentration.

Hydrolysis is a double decomposition reaction involving the splitting of water into its ions and the formation of a weak acid or base or both.

Hydrostatic pressure at a distance h from the surface of a liquid of density d,

$$P = hdg.$$

The total force on an area A due to hydrostatic pressure,

$$F = PA = Ahdg.$$

Force in dynes and pressure in dynes per cm² will be given if h is in cm, d in g per cm³ and g in cm per sec².

Hyperon.—Any particle with mass intermediate between that of the neutron and the deuteron.—See *Meson*.

Hysteresis.—The magnetization of a sample of iron or steel due to a magnetic field which is made to vary through a cycle of values, lags behind the field. This phenomenon is called hysteresis.

Steinmetz' equation for hysteresis gives the loss of energy in ergs per cycle per cm³.

$$W = \eta B^{1.6}$$

where B is the maximum induction in maxwells per cm² and η the coefficient of hysteresis.

Illumination of any surface is measured by the luminous flux incident on unit area. The units in use are: the lux, one lumen per square meter, the phot, one lumen per square centimeter and the lumen per square foot. (Since at unit distance from a point source of unit intensity the illumination is unity, unit illumination may be defined as that produced by a unit source at unit distance, hence the meter-candle or candle-meter which is equal to the lux and the foot-candle equivalent to one lumen per square foot.)

Indeterminancy principle (uncertainty principle).—The postulate that it is impossible to determine simultaneously both the exact position and the exact momentum of an electron. So this aspect of electrons can only be expressed as a probability.

Index of refraction for any substance is the ratio of the velocity of light in a vacuum to its velocity in the substance. It is also the ratio of the sine of the angle of incidence to the sine of the angle of refraction. In general, the index of refraction for any substance varies with the wave length of the refracted light.

Indicators are substances which change from one color to another when the hydrogen ion concentration reaches a certain value, different for each indicator.

Induced electromotive force in a circuit is proportional to the rate of change of magnetic flux through the circuit.

$$E = -\frac{d\phi}{dt}$$

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ACCELERATION DUE TO GRAVITY AND LENGTH OF THE SECONDS PENDULUM

For Sea Level at Various Latitudes

Based on the formula of the U. S. Coast and Geodetic Survey. The length of the simple pendulum whose period is two seconds, that is which beats seconds, is computed in each case from the corresponding value of the acceleration.

Latitude	Acceleration due to gravity		Length of seconds pendulum	
°	cm/sec.²	ft./sec.²	cm	in.
0	978.039	32.0878	99.0861	39.0141
5	978.078	32.0901	99.1000	39.0197
10	978.195	32.0939	99.1119	39.0244
15	978.384	32.0961	99.1310	39.0319
20	978.641	32.1076	99.1571	39.0382
25	978.960	32.1180	99.1894	39.0508
30	979.329	32.1302	99.2266	39.0656
31	979.407	32.1327		
32	979.487	32.1353		
33	979.569	32.1380		
34	979.652	32.1407		
35	979.737	32.1436	99.2681	39.0819
36	979.822	32.1464		
37	979.908	32.1491		
38	979.995	32.1520		
39	980.082	32.1549		
40	980.171	32.1578	99.3121	39.0992
41	980.261	32.1607		
42	980.350	32.1636		
43	980.440	32.1666		
44	980.531	32.1696		
45	980.621	32.1725	99.3577	39.1171
46	980.711	32.1755		
47	980.802	32.1785		
48	980.892	32.1814		
49	980.981	32.1844		
50	981.071	32.1873	99.4033	39.1351
51	981.159	32.1902		
52	981.247	32.1931		
53	981.334	32.1960		
54	981.422	32.1988		
55	981.507	32.2016	99.4475	39.1535
56	981.592	32.2044		
57	981.676	32.2071		
58	981.757	32.2098		
59	981.839	32.2126		
60	981.918	32.2151	99.4891	39.1680
65	982.288	32.2272	99.6298	39.1836
70	982.608	32.2377	99.5566	39.1964
75	982.848	32.2463	99.5864	39.2066
80	983.030	32.2528	99.6047	39.2144
85	983.178	32.2584	99.6198	39.2191
90	983.217	32.2577	99.6237	39.2207

Free Air Correction for Altitude

—0.0003086 cm/sec.²/m. for altitude in meters
—0.0000941 ft./sec.²/ft. for altitude in feet

Altitude meters	Correction cm/sec.²	Altitude feet	Correction ft./sec.²
200	—0.0617	200	—0.00017
300	.0926	300	.000026
400	.1234	400	.000034
500	.1543	500	.000042
600	.1852	600	.000052
700	.2160	700	.000060
800	.2469	800	.000069
900	.2777	900	.000277

DATA IN REGARD TO THE EARTH

Equatorial radius, 6 378,388 meters, 3 963.34 miles.
Polar radius, 6 356 912 meters, 3.949.99 miles.
Radius of sphere having same volume, 6 371 221.3 meters, 3,958.89 miles.
Quadrant of the equator, 10 019 166.4 meters, 6 225.00 miles.
Quadrant of the meridian, 10 002 288.3 meters, 6,218.12 miles.
1° latitude at the equator = 68.70 miles.
1° latitude at the pole = 69.41 miles.
Mean density of the earth, 5.522 g/cm³ 344.7 lb./ft.³
Mass of the earth, 5.983 × 10²⁷ kg. 6.595 × 10²¹ tons.
Mean surface density of the continents, 2.67 g/cm³. 166.7 lb./ft.³
Mean linear velocity of the earth in its orbit, 29.77 km/sec., 18.50 mi./sec.
Mean linear velocity of rotation of the surface at the equator, 0.465 km/sec., 0.289 mi./sec.

DATA IN REGARD TO THE EARTH (Continued)

Land area, 148 847 × 10⁶ km.² 57 470 × 10⁶ sq. mi.
Ocean area, 361 254 × 10⁶ km.², 139 480 × 10⁶ sq. mi.
Highest mountain (Everest), 8840 meters, 29,035 ft.
Greatest sea depth, 10,430 meters, 34,210 ft.
Thermal gradient of the earth, higher at increasing depths, 30° C per km. 48° C per mi. (uncertain)
Mean distance to the sun, 149 500 000 km or 92 900 000 mi.
Mean distance to the moon, 384,393 km or 238,854 mi.

THE COMMONER CHEMICAL ELEMENTS IN THE EARTH'S CRUST

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The "lithosphere" refers to the rocks only and does not include atmosphere or the oceans. The atom percent column is obtained by dividing the weight percent by the atomic weights and reducing to 100%. The radius is the ionic radius. The volume percent is the weight multiplied by r^3 and reducing to 100%.

Element	Weight %	Atom %	Ion Radius (Å)	Volume %
O	46.60	62.55	1.32	93.97
Si	27.72	21.22	0.39	0.86
Al	8.13	6.47	0.57	0.77
Fe	5.00	1.92	0.83	0.66
Mg	2.09	1.84	0.78	0.56
Ca	3.63	1.94	1.06	1.48
Na	2.83	2.64	0.98	1.60
K	2.59	1.42	1.33	2.14

THE AVERAGE AMOUNTS OF THE ELEMENTS IN EARTH'S CRUST IN GRAMS PER METRIC TON OR PARTS PER MILLION

Reprinted from "Principles of Geochemistry" (1952) with the permission of Brian Mason, author, and John Wiley and Sons, publishers.

O	466,000	N	46	Hf	1.6
Si	277,200	Ce	46	Ho	1.2
Al	81,300	Sc	40	Ge	1.1
Fe	50,000	Y	28	Nb	17
Ca	36,300	Nd	24	Tb	0.9
Na	28,300	Nb	24	Lu	0.8
K	25,900	Co	23	Tl	0.4
Mg	20,900	La	18	Hg	0.5
Ti	4,400	Pb	16	I	0.3
H	1,400	Cu	15	In	0.2
P	1,180	Mo	15	Ta	0.2
Mn	1,000	Tb	12	Cd	0.15
S	520	Cr	7	Ag	0.1
Cl	320	Dy	7	Ir	0.1
Cl	314	Sm	6.5	Re	0.00
Rb	310	Gd	6.4	A	0.04
F	300	Er	6	Pd	0.01
Sr	300	Pr	5.5	Pt	0.005
Ba	250	Sc	5	Au	0.005
Zr	220	Au	5	He	0.003
Cr	200	Hf	4.5	Ta	0.002?
V	150	Dy	4.5	Rh	0.001
Zn	130	U	4	Ru	0.001
Ni	80	Th	3	Ir	0.001
Cu	70	Yb	2.7	Os	0.001?
W	60	Er	2.5	Ru	0.001?
Li	65	Ta	2.1		

CHEMICAL COMPOSITION OF ROCKS

Reprinted from "Sedimentary Rocks" (1957) with the permission of F. J. Pettijohn, author, and Harper Brothers, publishers.

Element	Average igneous rock	Average shale	Average sandstone	Average limestone	Average sediment
SiO_2	59.14	58.10	78.33	5.19	57.55
TiO_2	.61	0.65	0.25	0.06	0.57
Al_2O_3	15.34	15.40	4.77	0.81	13.39
Fe_2O_3	3.08	4.02	1.07	0.54	3.47
FeO	3.80	2.45	0.30		2.08
MgO	3.49	2.44	1.16	7.89	2.65
CaO	5.08	3.11	5.60	42.67	5.89
Na_2O	3.84	1.30	0.45	0.05	1.13
K_2O	3.13	3.24	1.31	0.32	3.06
H_2O	1.15	5.00	1.63	0.77	3.23
P_2O_5	0.30	0.17	0.08	0.04	0.13
CO_2	0.10	2.63	5.03	41.64	5.30
MnO_2		0.04	0.07	0.06	0.06
MnO	0.06	0.06	0.05		
C		0.60			0.58
	99.56	100.00	100.00	99.64	99.85

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HYDROMETER CONVERSION TABLES
(Continued)

SHOWING THE RELATION BETWEEN DENSITY (C. G. S.) AND BAUMÉ AND TWADDELL SCALES FOR DENSITIES ABOVE UNITY.

Density	Degrees Baumé.	Degrees Twaddell.	Density.	Degrees Baumé.	Degrees Twaddell.	Density	Degrees Baumé.	Degrees Twaddell.	Density.	Degrees Baumé	Degrees Twaddell.
1.00	0.00	0	1.20	24.47	40	1.41	42.10	82	1.61	54.94	122
1.01	1.44	2	1.21	25.16	42	1.42	42.80	84	1.62	55.40	124
1.02	2.84	4	1.22	26.15	44	1.43	43.60	86	1.63	56.04	126
1.03	4.22	6	1.23	27.11	46	1.44	44.31	88	1.64	56.58	128
1.04	5.58	8	1.24	28.06	48	1.45	45.00	90	1.65	57.12	130
1.05	6.91	10	1.25	29.00	50	1.46	45.68	92	1.66	57.65	132
1.06	8.21	12	1.26	29.92	52	1.47	46.36	94	1.67	58.17	134
1.07	9.49	14	1.27	30.83	54	1.48	47.03	96	1.68	58.69	136
1.08	10.74	16	1.28	31.72	56	1.49	47.68	98	1.69	59.20	138
1.09	11.97	18	1.29	32.60	58	1.50	48.33	100	1.70	59.71	140
1.10	13.18	20	1.30	33.46	60	1.51	48.97	102	1.71	60.20	142
1.11	14.37	22	1.31	34.31	62	1.52	49.60	104	1.72	60.70	144
1.12	15.54	24	1.32	35.15	64	1.53	50.23	106	1.73	61.18	146
1.13	16.68	26	1.33	35.98	66	1.54	50.84	108	1.74	61.67	148
1.14	17.81	28	1.34	36.79	68	1.55	51.45	110	1.75	62.14	150
1.15	18.91	30	1.35	37.59	70	1.56	52.05	112	1.76	62.61	152
1.16	20.00	32	1.36	38.38	72	1.57	52.64	114	1.77	63.08	154
1.17	21.07	34	1.37	39.16	74	1.58	53.23	116	1.78	63.54	156
1.18	22.12	36	1.38	39.93	76	1.59	53.80	118	1.79	63.99	158
1.19	23.15	38	1.39	40.68	78	1.60	54.38	120	1.80	64.44	160
			1.40	41.43	80				....	.....	...

(*)

ABSOLUTE DENSITY OF WATER

DENSITY IN GRAMS PER CUBIC CENTIMETER, COMPUTED FROM THE RELATIVE VALUES BY THIESEN, SCHEEL AND DIESSELHORST (1900), AND THE ABSOLUTE VALUE AT 3.98° C. BY THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES (1910).

This table is more accurate but covers a narrow range of temperature.

Degrees	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Degrees	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.999841	847	854	860	866	872	878	884	889	895	15	999	984	969	954	938	923	907	*901	*975	*959
1	900	905	909	914	918	923	927	930	934	938	16	0.998943	926	910	893	877	860	843	826	809	792
2	941	944	947	950	953	955	958	960	962	964	17	774	757	739	722	704	686	668	650	632	613
3	965	967	968	969	970	971	972	972	973	973	18	595	576	558	539	520	501	482	463	444	424
4	973	973	973	972	972	972	970	969	968	966	19	405	385	365	345	325	305	285	265	244	224
5	965	963	961	959	957	955	952	950	947	944	20	203	183	162	141	120	099	078	056	035	013
6	941	938	935	931	927	924	920	916	911	907	21	0.997992	970	948	926	904	882	860	837	815	792
7	902	898	893	888	883	877	872	866	861	855	22	770	747	724	701	678	655	632	608	585	561
8	849	843	837	830	824	817	810	803	796	789	23	538	514	490	466	442	418	394	369	345	320
9	781	774	766	758	751	742	734	726	717	709	24	296	271	246	221	196	171	146	120	095	069
10	700	691	682	673	664	654	645	635	625	615	25	044	018	*992	*967	*941	*914	*888	*862	*836	*809
11	605	595	585	574	564	553	542	531	520	509	26	0.996783	756	729	703	676	649	621	594	567	540
12	498	486	475	463	451	439	427	415	402	390	27	512	485	457	429	401	373	345	317	289	261
13	377	364	352	339	326	312	299	285	272	258	28	232	204	175	147	118	089	060	031	002	*973
14	244	230	216	202	188	173	159	144	129	114	29	0.995944	914	885	855	826	796	766	736	706	676
											30	646	616	586	555	525	494	464	433	402	371

(*)

RELATIVE DENSITY AND VOLUME OF WATER

The mass of one cubic centimeter of water at 4° C. is taken as unity.
The values given are numerically equal to the absolute density in grams per milliliter.

(Smithsonian Tables, compiled from Various Authors.)

Temp. °C.	Density.	Volume.	Temp. °C.	Density.	Volume	Temp. °C.	Density.	Volume.	Temp. °C	Density.	Volume
-10	0.99815	1.00186	+0	0.99987	1.00013	10	0.99973	1.00027	20	0.99823	1.00177
-9	843	157	1	993	007	11	963	037	21	802	198
-8	869	131	2	997	003	12	952	048	22	780	221
-7	892	108	3	999	001	13	940	060	23	756	244
-6	912	088	4	1.00000	1.00000	14	927	073	24	732	268
-5	0.99930	1.00070	5	0.99999	1.00001	15	0.99913	1.00087	25	0.99707	1.00294
-4	945	055	6	997	003	16	897	103	26	681	320
-3	958	042	7	993	007	17	880	120	27	654	347
-2	970	031	8	988	012	18	862	138	28	626	375
-1	979	021	9	981	019	19	843	157	29	597	405

this table continues on next page.
The table gives values in g/ml which should be converted to g/cm³ (if extreme accuracy is required).

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RELATIVE DENSITY AND VOLUME OF WATER

(Continued)

Temp. °C.	Density.	Volume.	Temp. °C	Density.	Volume	Temp. °C.	Density.	Volume.	Temp. °C	Density.	Volume
+30	0.99567	1.00435	42	147	861	54	621	398	120	0.9434	1.0601
31	537	466	43	107	901	55	0.98573	1.01448	130	0.9352	1.0693
32	506	497	44	066	943	60	324	705	140	0.9264	1.0794
33	473	530	45	0.99025	1.00985	65	059	979	150	0.9173	1.0902
34	440	563	46	0.98982	1.01028	70	0.97781	1.02270	160	0.9075	1.1019
35	0.99406	1.00598	47	940	072	75	480	576	170	0.8973	1.1145
36	371	633	48	896	116	80	0.97183	1.02889	180	0.8866	1.1279
37	336	669	49	853	162	85	0.96866	1.03237	190	0.8750	1.1429
38	299	706	50	0.98807	1.01207	90	534	600	200	0.8628	1.1590
39	262	743	51	762	254	95	192	969	210	0.850	1.177
40	0.99224	1.00782	52	715	301	100	0.95838	1.04343	220	0.837	1.195
41	186	821	53	669	349	110	0.9510	1.0515	230	0.823	1.215
									240	0.809	1.236
									250	0.794	1.[illegible]

DENSITY AND VOLUME OF MERCURY

BASED ON THE DENSITY OF MERCURY AT 0° C. BY THIESEN AND SCHEEL

(Selected from Smithsonian Tables.)

Temp. °C.	Mass in gr. per ml.	Vol. of 1 gr. in ml.	Temp. °C.	Mass in gr. per ml.	Vol. of 1 gr. in ml.	Temp. °C.	Mass in gr. per ml.	Vol. of 1 gr in ml.	Temp. °C.	Mass in gr. per ml.	Vol. of 1 gr. in ml.
−10	13.6202	0.0734205	30°	13.5217	0.0739552	11	5684	7011	150	2330	[illegible]
−9	6177	4338	31	5193	9580	12	5650	7145	160	2003	7044
−8	6152	4473	32	5168	9820	13	5634	7278	170	1856	[illegible]
−7	6128	4606	33	5144	0063	14	5610	7412	180	1630	[illegible]
−6	6103	4739	34	5119	40087	15	13.5585	0.0737546	190	13.1384	0.0761128
−5	13.6078	0.0734873	35	13.5095	0.0740221	16	5561	7680	200	1148	[illegible]
−4	6053	5006	36	5070	0364	17	5536	7813	210	0913	[illegible]
−3	6029	5140	37	5046	0488	18	5512	7947	220	0678	[illegible]
−2	6004	5273	38	5021	0622	19	5487	8081	230	0443	[illegible]
−1	5979	5407	39	4997	0756	20	13.5462	0.0738215	240	13.0209	0.0767996
0	13.5955	0.0735540	40	13.4973	0.0740891	21	5438	8348	250	12.9975	[illegible]
1	5930	5674	50	4729	2229	22	5413	8482	260	9741	7076[illegible]
2	5906	5808	60	4486	3569	23	5389	8616	270	9507	2161
3	5881	5941	70	4244	4910	24	5364	8750	280	9273	[illegible]
4	5856	6075	80	4003	6252	25	13.5340	0.0738883	290	12.9039	0.0774[illegible]
5	13.5832	0.0736209	90	13.3762	0.0747594	26	5315	9017	300	8806	[illegible]
6	5807	6342	100	3522	8939	27	5291	9151	310	8572	7774
7	5782	6476	110	3283	50285	28	5266	9285	320	8339	[illegible]
8	5758	6610	120	3044	1633	29	5242	9419	330	8105	50[illegible]
9	5733	6744	130	2805	2982	30	13.5217	0.0739552	340	12.787[illegible]	0.0782[illegible]
10	13.5708	0.0736877	140	13.2567	0.0754334				350	7638	[illegible]
									360	7405	[illegible]

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9. Remote Sensing as the Ultimate Cost Effective System

As per discussions with Project personnel in La Paz the possibility of satellite data being used in a surveillance system was investigated using as the base a recent Science article on Land-cover classification using satellite data referred to us by university based remote sensing laboratories (Tucker, Townshend Gaff, 1985) (Appendix III).

These preliminary investigations indicate that it may be possible to use satellite data to predict variations in crop production in the Altiplano areas in order to prdict famines. J. Tucker Compton and Thomas E. Goff, both of the NASA Goddard Space Flight Center in Maryland have been doing both types of satellite-based deforestation work studies in Randonia, Brazil, Borneo and China as well as some crop work (mostly rangeline studies) in Africa for the International Livestock and Cattlemen's Association, a UN based, independently funded group. The following is from telephone conversations with them.

The African studies are of a historical time series design. Using a satellite which has been up since 1979, it is possible to see changes in flora over the continent of Africa changing over several years.

Tucker and Goff are using the AVHR series of satellites for this research as well as for their other work in Brazil, Borneo and China. The AVHRs, at their best resolution, measure 1.1 Km. It is therefore possible to demonstrate the global dynamics of a change process. The AVHR satellites pick up data from each study area two times a day. This type of satellite is ideal for a temporal study but not for one which requires very precise spatial measurements. For example, the deforestation studies demonstrate, quantitatively over a period of time, how many leaves fall and therefore, quantitatively, how much less CO2 and oxygen will be globally available. AVHRs have also supplied information to the U.S. Army on Rift Valley Fever in Africa. Rift Valley Fever is intimately tied to vegetation dynamics. THe AVHR satellites working group is small compared to NASA's Landsat group and could be potentially interested in the Bolivia project.

The Landsat series of satellites represent the area where more work is being done in a well funded effort. Landsat satellites measure in the 30m. bracket which provides a lot of detail. With this series of satellites, too much data makes it difficult to digest things, dependent upon what one is looking for. Landsats measure each study area once every fifteen days. Landsats are suitable for discrete readings but not for temporal readings.

Landsats for example, can tell what crop is growing in which field, whereas AVHRs can measure if the crop is growing more or less but cannot distinguish one crop from another. Were the Disaster Surveillance Project to enlist the use of satellites, many decisions would have to be made as to which questions were to be answered, for satellite series differ greatly in their capacities to measure different variables. Both systems appear to have promise however as potential sources of data for Bolivian famine and other disaster prediction. The field data being collected currently could provide verification needed to estimate current yields and develop models for predictions in the future. It is suggested that the Bolivia Disaster surveillance project investigate further this possible option. Satellite technology will continue to improve and ultimately provide the sort of early warning system so necessary inthe Bolivian case. A small added investment could provide much in the way of potential future sustainable surveillance based upon U.S. technology and with higher potential for valid, sustainable and timely results.

10. Review of Information Currently Being collected.

In this section we will review each of the data items currently being collected in the Bolivia disaster surveillance system. They will be evaluated according to the following criteria.

A. Review of data collected until present using criteria of usefulness to decision makers, variability of the measure and other relevant pieces of information.

B. Interviews with field agents about consistency and utility of information.

C. Field validation of data quality and ease of collection.

Example of Items Collected by the Current System and Suggestions for How They May be Used

What follows is a review of items reported on in the first data submission of the Bolivian Disaster Surveillance System. It combines elements considered as background independant variables and elements that are collected on a periodic basis by the field agents. Comments on these variables indicate the types of concerns that we might have about indicators in a surveillance system based primarily upon the distribution of these elements. This data is being further examined using statistical techniques which search for variance on Tulane's computer systems. The general philosophy is that if the indicator does not vary it cannot predict and hence is an inappropriate element in a surveillance system.

A. Population and Migration

Population data represents the single most important piece of information about the communities surveyed since it provides basic denominator information from which all other indicators take on their meaning. The system is currently collecting four separate items on population and migration including:

Approximate Population- This estimate is taken from key informants, community officials, projections from prior public census data and occasional special censuses. The project has encouraged special census activity in 4 communities which has been discussed, however the majority of data referred to here is somewhat subjectivvo coming as it does from many sources. Significant variance exists in the total population figures and they do provide a direct indication as to the range of village size. When combined with results of the special census activities undertaken by the project these estimates take on more meaning and utility in calculating rates.

B. Approximate Number of Families.

This information is generally derived from the total population figure or house counts and suffers from the same problems mentioned above. It is important in many aspects of decision making related to disasters and should be included. The special census information is showing some interesting results regarding family structure which may help in our understanding of

what number of families really means.

C. Temporal Migration

Migration seems such a universal phenomenon in highland communities that this data item may be unneeded. In all of the communities visited there was some evidence of temporal migration including one ,Pocoata where our reporting system indicated that there was not. In all four of the health facilities where we had a chance to investigate the records there were cases of malaria noted in the last year indicating at least some migration to and from the lowlands. It is doubtful that this indicator will provide information useful to rapid decision making and as such should probably be dropped from the protocol.

D. Permanent Migration.

This indicator is providing mixed results but appears to be demonstrating some variance. Some effort should be put into developing a consistent code for this item and it should be run for a few more cycles (8-12 months) and re-evaluated as to its utility.

E. Location

A useful item for overall classification and one that only needs to be collected once. I would suggest keeping it in a general file on community definition. This type of indicator is not an issue for the monthly collection cycles.

F. Source of Water Within 1/2 km

This item falls into the same category as the above with the exception of drought conditions. Here the source may change or go bad due to pollution. In the altiplano mining runoff can also have the same effect. Not much variance currently however it would be useful to know what the 10 per-cent who list none are doing for water. Would perhaps add an item on source of water and current quality and quantity using a 3 or 5 leveled response.

G. Access Period by Road

Very useful background information but not useful for monthly report form unless phrased as, access by road possible for approximately how many days this month. This would introduce some more variance into the item and perhaps improve current status reports.

H. Railroad Transportation

Again useful for original description but not needed on monthly basis. Some possible utility for overall community well being score.

I. Approx. No. Of Vehicles/Week

This item appears to showing considerable variance and has some potential. Clearly should be retained until we are able to ascertain what are the underlying factors which are creating the

variance.

J. School

Useful for original community profile. Would suggest a ranking element be created i.e. 1=elementary, 2=elem.+Jr. High 3=all. Again might be useful as component of overall community score.

K. Health Center

Same as above with possible ranking as to level of sophistication of service. May also consider periodic check for functioning of service.

L. IBTA Agent

Same as health center .

M. Mothers Club

Of the first three rounds the fact that the majority, 47/50, of the communities has mothers clubs suggests a possible base for other information collection. This network should be examined further as a possible base for expanding the collection of MCH related data. It would also appear to provide an entree to the poorer of a given regions inhabitants which may target the population truly at risk.

N. Services

Should be kept in the base community description file. Useful to note the widespread apparent availability of telegraph service as a possible communication link not dependent upon vehicle transportation.

O. Principal Agricultural Products

Again a useful one time definer. What variation exists is mostly related to ecological concerns.

P. Water Source

Shows some variation and is worth keeping in the overall descriptive file.

Q. Installed Water System

Again some variation is present. In all of the infrastructure services questions estimates of coverage and or change are indicated. i.e. Private system with 50% coverage 18 hours day. This might reflect seasonal and or other events in the area.

R. Epidemiological Data

In discussions with Dr.Angel Valencia , head of the Epidemiological surveillance system, it became evident that while the system is still operant there are numerous problems Data entry is several months behind and publication of the reports are even further off. As a result our original expectations of the

potential use of the data so collected have not been realized. The field agent's collection of the similar data at the community level has other problems associated with its use. These include spotty quality , questionable validity and unknown sensitivity. As a result it is recommended that these indicators be examined closely for their utility. It may be possible to reinforce the Ministry of Health in order to appropriately collect this type of information however such a decision would require policy decisions at the project level. Health indicators may be too difficult to collect at the field agent level. Certainly the special studies needed to verify and validate their meaning are beyond the range of this effort.

While the above only addresses part of the indicator set and is in no way complete it is intended to provide a demonstration of the kind of approach the analysis at Tulane is taking.

11. Alternative Plan for Cost Effective Surveillance System

Due to a number of concerns about the feasibility of continuing the surveillance project, in particular, the costs of maintaining automobiles and field teams in a failing economy the possibility of a far less expensive version is suggested on an experimental basis. The idea would be to select within one department twenty plus villages with roughly the same characteristics as inthe original six department sample. In each

village a key informant would be identified with the same general characteristics as the informants used in the overall survey. Knowledgeable individuals, who have lived in the are for over 10 years and are in a position to observe activities in town. These individuals would be trained by a field supervisor in filling out the same information as is collected by the field agents in the regular system. Each informatn would be reimbursed for his completed information if and when he presents it to a central collection point. This information would then be collated and copies forwarded to Tulane where it would be analyzed independently of the larger systems data collection mechanisms. Implementation of the system would require the short term employment of a field person who would train individuals in each village, approximately 1/2 day should be programmed for each individual with the expectation of all 20-30 sites being covered in a one month period. When this data is processed and compared to regular surveillance system it will provide us with insight as to the feasibility of such a low cost system being developed. For the minimal investment in such a system it seems appropriate to test the hypothesis that a very low lost surveillance system can be developed.

A meeting of the entire AID project staff committee in La Paz approved this concept in principal and began to move in developing it more concretely in mid February 1985.

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APPENDIX I

Summary List of Suggestions for Improving Disaster Surveillance Project

Overall Management

1. In order to improvement administrative efficiency more attention to documenting requests, orders and performance would greatly improve communication up and down the chain of command. (2)

2. Clear assignment of authority and lines of responsability should be a first priority of project team. (2)

Computer Equipment

3. Acquisition of project computer (IBMXT) in project offices should be immediate. (3)

4. Added personnel or release time for Marnane or Antezana should be provided for improving utility of computer equipment. (4)

5. Added computer equipment printers plotter and a back-up IBM-PC could provide low cost security for the project. (4)

6. Original size of sample is probably too high given field conditions and capacity of field team. (7)

7. Some benefit from the project needs to be realized by participant villages. (7)

8. Hydrostatic quotient is not often used and may be difficult to calculate. (8)

9. Remote sensing appears to offer the most cost efferctive solution to disaster surveillance and more intensive work in this area is suggested. (9)

10. First round data provides an example of how items can be critiqued. More basic cost information on agricultural projects is needed. Further analysis on this material using more complex statistical methods is appropriate and underway at Tulane. (10)

11. An alternative plan for a data collection system is proposed which would be sustainable by the Government of Bolivia if as useful as more complex idea. On an experimental basis it is suggested. (11)

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CENSUS PROCESSING USING K-MAN AND

CODEBOOK (PRELIMINARY)

BOLIVIA SURVEILLANCE PROJECT

CENSUS PROCESSING ACTIVITY

As an example of what was possible using the new statistical software installed by Bertrand and because data was already available from the census material programs were designed and developed using Knowledgeman and SPSS to rapidly enter and process the data.

Data Entry

A data entry program for Knowledgman (KMAN) with full screen edit capabilities was developed with parameters as listed in Table I. 169 cases were entered into the table as a test file. This data was then written to a straight data file using another program instruction set for (KMAN). A third and final SPSSPC instruction set was developed which focused on creating a system file within SPSS and developing any descriptive statistics thought appropriate. This entire procedure took place in a 10 day period and is appropriate for all census formats. The following program listings and attachments illustrate all procedures utilized and serve as a model for any data entry activity with resultant input into SPSS. Using this material as a base it should be possible to modify any further program using the K-Man base.

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PROYECTO MULTISECTORIAL
Ministerio de Planeamiento
Gobierno de Bolivia y
USAID

CENSO DE LOCALIDAD

Fecha de nacimiento no se pudo obtener

Localidad: Prado

Fecha: d / m / a

No. Serial 177

Dirección:

Calle: 4

Lugar o Depto: 0

Sect. 1 1 1

Mzna: 1 0

Lote: 0 4

I-Ent: I-Cont: ✓

II-Ent: II-Cont:

III-Ent: III-Cont:

1 No.	2 Nombre y apellido de los miembros del hogar	3 Relación con jefe	4 Sexo: Varón Mujer	5 Fecha de nacimiento d/m/a	6 Años Cumplidos (Si <1 año marcar "00")	7 ¿CUAL ES SU OCUPACION PRINCIPAL?	8 ¿DONDE RESIDE HABITUALMENTE?	9 ¿EN CUALES DE LOS ULTIMOS DOCE MESES SE AUSENTO DEL PUEBLO POR MAS DE 15 DIAS? (Marque con una "X" cada mes que el habitante estaba afuera)	10 ¿CUAL FUE EL MOTIVO DE SU AUSENCIA?
1	Jefe: [illegible] Cadenas	Jefe 1	V/M V	1/1/09	35 años ✓	Agrícola 1 Comercio 2 Lab/casa 3 Estudios 4 Otros 9	En esta Loc. Aquí: 1 En otra Loc. Loc: Prov: Dept:	Ninguno 00 01 02 03 04 05 06 07 08 09 10 11 12	Trabajo 1 Negocios 2 Estudios 3 Familiares 4 Otros N/A 9
2	Esposa: [illegible] Cardenas	Espos. 2	V/M M	1/1/49	26 años ✓	Agrícola 1 Comercio 2 Lab/casa 3 Estudios 4 Otros 9	En esta Loc. Aquí: 1 En otra Loc. Loc: Prov: Dept:	Ninguno 00 01 02 03 04 05 06 07 08 09 10 11 12	Trabajo 1 Negocios 2 Estudios 3 Familiares 4 Otros N/A 9
3	[illegible] Zorrilla	Hij. 3 Padre 4 Madre 5 Otro:	V/M V	1/1/69	15 años ✓	Agrícola 1 Comercio 2 Lab/casa 3 Estudios 4 Otros 9	En esta Loc. Aquí: 1 En otra Loc. Loc: Prov: Dept:	Ninguno 00 01 02 03 04 05 06 07 08 09 10 11 12	Trabajo 1 Negocios 2 Estudios 3 Familiares 4 Otros N/A 9
4	[illegible] Zorrilla	Hij. 3 Padre 4 Madre 5 Otro	V/M V	1/1/72	2 años ✓	Agrícola 1 Comercio 2 Lab/casa 3 Estudios 4 Otros 9	En esta Loc. Aquí: 1 En otra Loc. Loc: Prov: Dept:	Ninguno 00 01 02 03 04 05 06 07 08 09 10 11 12	Trabajo 1 Negocios 2 Estudios 3 Familiares 4 Otros N/A 9
5	[illegible] Zorrilla	Hij. 3 Padre 4 Madre 5 Otro	V/M M	1/1/84	0 años ✓	Agrícola 1 Comercio 2 Lab/casa 3 Estudios 4 Otros 9	En esta Loc. Aquí: 1 En otra Loc. Loc: Prov: Dept:	Ninguno 00 01 02 03 04 05 06 07 08 09 10 11 12	Trabajo 1 Negocios 2 Estudios 3 Familiares 4 Otros N/A 9

Reduced Version of Census Form

Fe Doc Noviembre 9, 1984

Si necesita espacio adicional usar el reverso

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3

GENERAL INSTRUCTIONS FOR DATA ENTRY

TO DELETE RECORDS FROM FILE

TO DELETE RECORDS	- Mark in CENSO with true range (1,12) - ( ) items in range to be deleted - Compress CENSO

PARA ENTRAR DATOS DEL CENSO

OPERADOR	MAQUINA
1. Prender (vea instrucciones para prender)	
2. KMAN	User Name:
3. Bertrand	Password:
4. Zort15	-
5. Use CENSO	-
6. CREATE RECORDS	"Screen" para entrar datos para el censo
7. - [ ]	(Vea hoja entrar datos)

ESC ESC BYE

localidad
Dept Provincial localidades

fecha de observacion
dia mes ano

num serial

sect

Manz

Censo actual

Nobre
apellido nombre

Relacion un jefe
vea codigos

Sexo
V=1 M=2

Fecha nacimiento
dia mes ano

Anos cumplidos
asi es

Ocupacion principal
Vea codigos

Donde reside
Aqui=1

Si en otra loc
prov. Dept

mes ausente
EN FB MZ AB MY JN JL AG ST OT NV DC

motivo de ausencia

One - Transport files
Two - right justify macro

PROGRAM IN KMAN FOR SCREEN DESIGN

```
FORM CENFRM AT 2,28 PUT "CENSO ENTRADA DE DATOS"
AT 5,6 PUT "DEPTO"
AT 5,12 GET DEPTO
AT 5,15 PUT "PROVINCIA"
AT 5,25 GET PROVINCI
AT 5,35 PUT "LOCALIDAD"
AT 5,45 GET LOCALIDA
AT 8,6 PUT "DIA"
AT 8,10 GET DIA
AT 8,15 PUT "MES"
AT 8,20 GET MES
AT 8,25 PUT "ANO"
AT 8,30 GET ANO
AT 8,35 put "SERIAL"
AT 8,45 GET SERIAL
AT 8,50 PUT "SECTION"
AT 8,60 GET SECTION
AT 10,6 PUT "MANZ"
AT 10,12 GET MANZ
AT 10,18 PUT "APELLIDO"
AT 10,30 GET APPELLID
AT 10,45 PUT "NOMBRE"
AT 10,57 GET NOMBRE
AT 12,6 PUT "RELACION"
AT 12,16 GET RELACION
AT 12,18 PUT "SEXO"
AT 12,24 GET SEXO
AT 12,26 PUT "FECHA DE NAC"
AT 12,40 PUT "DIA"
AT 12,44 GET DIA1
AT 12,48 PUT "MES"
AT 12,53 GET MES1
AT 12,58 PUT "ANO"
AT 12,63 GET ANO1
AT 12,70 PUT "EDAD"
AT 12,75 GET EDAD
AT 14,6 PUT "OCUPACION"
AT 14,15 GET OCCUPACI
AT 14,20 PUT "RESIDENTE"
AT 14,30 GET DRESIDE
AT 14,35 PUT "OTRA LOCATION"
AT 14,50 GET OTRALOC
AT 16,6 PUT "EN"
AT 16,9 GET EN
AT 16,11 PUT "FB"
AT 16,14 GET FB
AT 16,17 PUT "MZ"
AT 16,19 GET MZ
AT 16,22 PUT "AB"
AT 16,25 GET AB
AT 16,28 PUT "MY"
AT 16,32 GET MY
AT 16,34 PUT "JN"
AT 16,36 GET JN
AT 16,39 PUT "JL"
AT 16,41 GET JL
AT 16,43 PUT "AG"
AT 16,45 GET AG
AT 16,47 PUT "ST"
AT 16,50 GET ST
AT 16,53 PUT "OC"
AT 16,55 GET OC
AT 16,58 PUT "NV"
AT 16,61 GET NV
AT 16,63 PUT "DC"
AT 16,65 GET DC
AT 18,6 PUT "MOTIVO"
AT 18,15 GET MOTIVO
AT 18,25 PUT "POR FAVOR CHEQUEA LOS DATOS ANTES DEL PROXIMO"
ENDFORM
```

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DISENO DE REGISTRO

	VARIABLE	CAMPOS
Departamento	DEPTO	(1)
Provincia	PROV	(3-4)
Localidad	LOCALID	(6-7)
Fecha de observ.	DIAOB	(9-10)
	MESOB	(12-13)
	ANIOB	(15-16)
Numero serial	SERIE	(18-21)
Seccion	SECCION	(23-25)
Manzana	MANZANA	(27-30)
Nombre	APELLIDO	(32-46)
	NOMBRE	(48-57)
Relacion con el jefe	RELACION	(59)
Sexo	SEXO	(61)
Fecha de nacimiento	DIANAC	(63-64)
	MESNAC	(66-67)
	ANONAC	(69-70)
Anos cumplidos	EDAD	(72-73)
Ocupacion Principal	OCUPAC	(75-76)
Donde reside	RESIDE	(78)
Otra localidad	RESPROV	(80-81)
	RESDEPTO	(83-84)
Mes ausente	EN	(86)
	FB	(88)
	MZ	(90)
	AB	(92)
	MY	(94)
	JN	(96)
	JL	(98)
	AG	(100)
	ST	(102)
	OC	(104)
	NV	(106)
	DC	(108)
Motivo de ausencia	MOTAUSEN	(110-111)

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SPSS PROGRAM FOR CENSUS PRE-PROCESSING

```
  DATA LIST FIXED FILE = '\SPSS\CENSO.OUT'
/DEPTO 1/ PROV 1-2/ LOCALID 1-2/ DIA 1-2/ MES 1-2/ ANO 1-2/
SERIEL  1-4/ SECCION 1-3/ MANZANA 1-4,
RELACION 1/SEXO 1/ DIANAC 1-2/ MESNAC 1-2/ ANIONAC 1-2/
EDAD 1-2/ OCUPAC 1-2/ RESIDA 1-2/ RESPROV 1-2 RESDEPTO 3-4/
EN 1/ FB 1/ MZ 1/ AB 1/ MY 1/ JN 1/
JL 1/ AG 1/ ST 1/ OC 1/ NV 1/ DC 1/ MOTAUSEN 1-2.
VARIABLE LABELS DEPTO 'DEPARTAMENTO' PROV 'PROVINCIA'
LOCALID 'LOCALIDAD'
DIA 'DIA DE OBSERVACION' MES 'MES DE OBSERVACION'
ANO 'ANXO DE OBSERVACION' SERIEL 'NUMERO DE HOGAR'
RELACION 'RELACION CON EL JEFE' DIANAC 'DIA DE NACIMIENTO'
MESNAC 'MES DE NACIMIENTO' ANIONAC 'ANIO DE NACIMIENTO'
OCUPAC 'OCUPACION PRINCIPAL' RESIDA 'LUGAR DE RESIDENCIA'
RESPROV 'RESIDENCIA EN OTRA PROVINCIA'
RESDEPTO 'RESIDENCIA EN OTRO DEPARTAMENTO' EN 'ENERO'
FB 'FEBRERO' MZ 'MARZO' AB 'ABRIL' MY 'MAYO' JN 'JUNIO'
JL 'JULIO' AG 'AGOSTO'
ST 'SEPTIEMBRE' OC 'OCYUBRE' NV 'NOVIEMBRE'
DC 'DICIEMBRE' MOTAUSEN 'MOTIVO DE AUSENCIA'.
VALUE LABELS DEPTO 5 'CHUQUISACA' 1 'LA PAZ' 2 'ORURO'
/PROV 3 'ZUDANEZ' 13 'AROMA' 8 'INGAVI' 2 'AVAROA'
/LOCALID 4 'PRESTO' 4 'ANCACATO' 7 'AYO AYO' 4 'TARACO'
/RELACION 1 'JEFE' 2 'ESPOSA' 3 'HIJO' 4 'PADRE' 5 'MADRE' 9 'OTRO
/SEXO 1 'VARON' 2 'MUJER'
/OCUPAC 1 'AGRICOLA' 2 'COMERCIO' 3 'LABORES DE CASA' 4 'ESTUDIOS'
9 'OTRO'
/RESIDA 1 'RESIDE EN ESTA LOCALIDAD' 0 'RESIDE EN OTRA LOCALIDAD'
/EN 1 'AUSENTE EN ENERO'
/FB 1 'AUESNTE EN FEBRERO'
/MZ 1 'AUSENTE EN MARZO'
/AB 1 'AUSENTE EN ABRIL'
/MY 1 'AUSENTE EN MAYO'
/JN 1 'AUSENTE EN JUNIO'
/JL 1 'AUSENTE EN JULIO'
/AG 1 'AUSENTE EN AGOSTO'
/ST 1 'AUSENTE EN SEPTIEMBRE'
/OC 1 'AUSENTE EN OCTUBRE'
/NV 1 'AUSENTE EN NOVIEMBRE'
/DC 1 'AUSENTE EN DICIEMBRE'
/MOTAUSEN 1 'TRABAJO' 2 'NEGOCIOS'
3 'ESTUDIOS' 4 'FAMILIARES' 9 'OTRO'.
FREQUENCIES VARIABLES=MOTAUSEN.
SAVE OUTFILE='\SPSS\ARNLD.SYS'.
```

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OBSERVATIONS AND CODES FOR CENSUS DATA PROCESSING
THE FIRST 176 CASES

38

OBSERVACIONES EN FORMULARIOS
DEC 1 A 176

Registros con double alternativa		Registros acumulados
Preg 7	Preg 10	
18	32	30
28	39	34
37	40	39
66	42	42
67	89	53
71	119	61
89	147	62
		63
		84
		86
		88
		91
		93
		101
		109
		113
		115
		120
		121
		123
		124
		137
		147
		148

NOTA: En registros del 1 al 18 se anoto en "motivo de ausencia" el codigo 09 a todos los que contestaran NA. Debe corregirse a 00.

CODIGOS

Pregunta Nº 7

Agricola	1
Comercio	2
Lab/casa	3
Estudios	4
Agricola y commercia	5
Agricola y Lab casa	6
agricola y estudios	7
otra combinacion	8
otro	9

Pregunata Nº 10

En alternativas dobles mantener la principal

CODIGOS PARA ARGENTINA, BRAZIL, Y CHILE

Pregunta: Otra localidad ___ ___ ___ ___
provincia departamento

Codigos: Argentina Departamento 77
Provincia
Salta 01
Mendoza 02
Ledezma 03

Codigos: Brazil Departamento 12

Chile Deparamento 13

Otors Departmento 14

PRELIMINARY

LA PAZ

1 02 09	Huarina	1 02	Omasuyos
1 02 11	Belen	1 02	Omasuyos
1 03 05	Camacho	1 03	Pacajes
1 03 05	Caquiaviri	1 03	Pacajes
1 03 10	Jesus de Machaca	1 03	Pacajes
1 03 14	Santiago de Machaca	1 03	Ingavi
1 04 01	Escoma	1 04	Camacho
1 04 02	Humanata	1 04	Camacho
1 08 13	Viacha	1 13	Ingavi
1 10 04	Taraco	1 10	Ingavi
1 12 03	Tambillo	1 12	Los Andes
1 13 07	Ayo Ayo	1 13	Aroma
1 13 12	Patacamaya	1 08	Aroma
1 18 08	Curahuara	1 18	Gualberto Villarroel

ORURO

2 01 01	Paria	2 01	Cercado
2 01 10	La Joya	2 01	Cercado
2 02 02	Sevaruyo	2 02	Avaroa
2 02 11	Tacagan	2 02	Avaroa
2 03 06	Corque	2 03	Carangas
2 03 07	Choquecota	2 03	Carangas
2 06 03	Pazna	2 06	Pazna
2 09 04	Ancacato	2 06	Poopo
2 09 08	Sabaya	2 09	Atahuallpa
2 09 09	Coipasa	2 09	Atahuallpa
2 10 05	Toledo	2 10	Saucari

POTOSI

3 01 05	Yocalla	3 01	Thomas Frias
3 03 04	Betanzos	3 03	Saavedra
3 03 11	Chinoli	3 04	Saavedra
3 04 06	Pocoata	3 04	Chayanta
3 04 09	Ravelo	3 04	Chayanta
3 04 13	Corquechaga	3 04	Chayanta
3 05 08	San Pedro de Buena Vista	3 05	Charcas
		3 06	Nor Chicas
3 06 01	Vitichi	3 07	Alonzo de Ibanez
3 07 07	Sacaca	3 10	Sud Chichas
3 10 13	Tupiza	3 12	Quijarro
3 12 02	Porco	3 12	Quijarro
3 12 03	Rio Mulatos	3 12	Quijarro
3 12 10	Tomava	3 04	Chayanta
3 04 12	Macha		Linares
3 -- 13	Cucha Injenio	3 06	Nor Chicas
3 06 14	Cotaganta	3 03	Saavedra
3 0- 16	Pina	Linares	
3 06 17	Tupiza	3 00	Nor Chicas

COCHABAMBA

4 02 08	Omereque	4 02	Campero
4 03 03	Morochata	4 03	Ayopaya
4 06 01	Arque	4 06	Arque
4 07 05	Sta. Ibanez	4 07	Capinota
4 08 04	Tarata	4 08	Jordan
4 11 02	Tapacari	4 11	Tapacari
4 12 07	Totora	4 12	Carrasco
4 13 09	Mizque	4 13	Mizque
4 13 10	Tin Tin	4 13	Mizque
4 14 06	Vacas	4 14	Punata

TARIJA

6 01 09	Jonacas	6 01	Cercado
6 02 07	Padcaya	6 02	Arce
6 02 08	Colonia Linares	6 02	Arce
6 02 12	Bermejo	6 02	Arce
6 02 13	Papaya	6 02	Arce
6 04 05	Concepcion	6 04	Aviles
6 05 01	San Lorenzo	6 05	Mendez
6 05 02	Iscayachi	6 05	Mendez
6 05 03	El Puente	6 05	Mendez
6 06 10	Narvaez	6 06	O'Connor
6 06 11	Entre Rios	6 06	O'Connor

CHUQISACA

5 01 01	Yotala	5 01	Oropeza
5 03 04	Presto	5 03	Zudanez
5 03 05	Zudanez	5 03	Zudanez
5 04 06	Padilla	5 04	Tomina
5 04 07	Alcala	5 04	Tomina
5 04 09	Sopachui	5 04	Tomina
5 05 11	Monteagudo	5 05	Hernando Siles
5 06 02	Yamparaez	5 06	Yamparaez
5 06 03	Tarabuco	5 06	Yamparaez
5 08 08	Villa Serrano	5 08	Belisario Boeto
5 08 10	Nuevo Mundo	5 08	Belisario Boeto
5 09 12	Villa Abecia	5 09	Sud Cinti

LA PAZ	01
ORURO	02
PATOS	03
COCHABAMBA	04
CURAHUARA	05
TUNIJA	06

DEPT. PREV

LA PAZ 01

MURRILO	01
ONAZUGOS	02
PACAJES	03
CAMACHO	04
MUNECA	05
LARECAJA	06
FRANZ TAMINGO	07
INGURI	08
LONYZA	09
INQUISIRI	10
SUD YUNGAS	11
LOS ANDES	12
AROANCE	13
NOR YUNGAS	14
ALTO HURRALDE	15
BAUTISTA SAAVEDRA	16
MANCO KAPAC	17
GUALBERTO VILLA-ROEL	18

COCHABAMBA 04

CERCADO	01
CAMPERO	02
AYO PAYA	03
ESTEBEN ARCE	04
ARANS	05
ARQUE	06
CAPINOTA	07
GERMAN JORDURS	08
QUILLACOLLO	09
CHAPANE	10
TAPANARS	11
CARRASCO	12
MISQUE	13
PUNUTA	14

ORURO	02
CERCADO	01
SOAROA	02
CARRANGAS	03
SAJAMA	04
LITORAL	05
POOPO	06
PANTELON DAKNCE	07
LADISLAO CABRERA	08
ATAHUALLPA	09
SUACARI	10

POTASIO 03

THOMAS FRIAS	01
RAFAEL BUSTILLO	02
CORNELIO SAAVEDRA	03
CHAYANTA	04
CHARCAS	05
NOR CHICAS	06
ALFONSO _____	07
SUD CHICAS	08
NOR LIPEZ	09
SUD LIPEZ	10
JOSE M LINARES	11
QUIJARRO	12
GRAL. BILBAO	13
DANIEL CAMPOS	14
MODESTO OMISTE	15

TARIJA 06

CERCADO	01
ARCE	02
GRAN CHACO	03
ARILEZ	04
MENDEZ	05
O'CONNOR	06

CHUGUISUCU 05

OROPEZA	01
AZURDUY	02
ZUDANEZ	03
TOMINA	04
HERNANDO SILER	05
YAMPARUEZ	06
NORCINTI	07
BELISARIO BOETO	08
SUD CINTI	09
LUIS CALVO	10

Copy of Forms and

Documentation Reviewed as part of

Consultants Activity

...TISECTORIAL
... de Planeamiento
... de Bolivia y
USAID

Hoja de Trabajo

FALLECIMIENTOS

Pag.___de ___

Fecha: d___ m___ a___
Dpto: _____
Prov: _____
Comunidad: _____
CODCOM: [ ][ ][ ][ ]

A	B		D	E	F	G	H	I	J
Nombre y apellido del niño	Fecha de nac. d m a	Fecha de nac. d m a	Causa de Muerte	Lugar de Muerte	Lugar de Residencia del fllcdo.	Nombre del Informante	Cargo del Infrmnte.	Inst. del Infrmnte.	Comentarios
	/ /	/ /							
	/ /	/ /							
	/ /	/ /							
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7/84

Firma _____

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[illegible] MULTINACIONAL
[illegible] de Planeamiento
[illegible] de Bolivia y
(PAIB)

Hoja de Trabajo
NACIMIENTOS

Pg. ___ de ___

Fecha: día ___ mes ___ año ___

Código: [ ][ ][ ][ ]
Depto: _____
Prov.: _____
Comunidad: _____

A	B	C	D	E	F	G	H
Nombre y apellido del niño	Fecha de nacimiento d m a	Lugar de nacimiento	Nacionalidad de la madre	Nombre del informante	Cargo del informante	Institución del informante	Observaciones
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MORBILIDAD

PROYECTO MULTISECTORIAL
Ministerio de Planeamiento
Gobierno de Bolivia y
USAID

Hoja de
Trabajo e Informe
MORBILIDAD

Fecha: d___ m___ a___
Dpto: _____
Prov: _____
Comunidad: _____
CODCOM [ ][ ][ ][ ]

I. IDENTIFICACION

1. Nombre de servicio: _____ (PS) (PM) (CHS) --- (SOB) (SA) ___
2. Periodo de Información: d___ m___ a___ hasta d___ m___ a___ [ ][ ]

II. MORBILIDAD ATENDIDA

CLINICA

3. Número de casos registrados TOTAL..... _____
4. Número de niños menores de 5 años.... _____
5. Número de personas mayores de 5 años... _____

PROCEDENTES DE COMUNIDAD REFERIDA

6. Numero de casos de comunidad referida TOTAL..... _____
7. Numero de niños menores de 5 años de comunidad..... _____
8. Numero de personas mayores de 5 años de comunidad... _____

III MORBILIDADES ESPECIFICAS DE PERSONAS DE COMUNIDAD REFERIDA

Enfermedad	Numero de casos	
	Niños < 5	Pers. à 5
1. Diarrea		
2. Gastroenteritis no especifica		
3. Influenza		
4. Respiratoria no influenza		
5. Tifoidea		
6. Sarampión		
7. Malaria		
8.		
TOTAL		

Version 22/7/84

Firma _____

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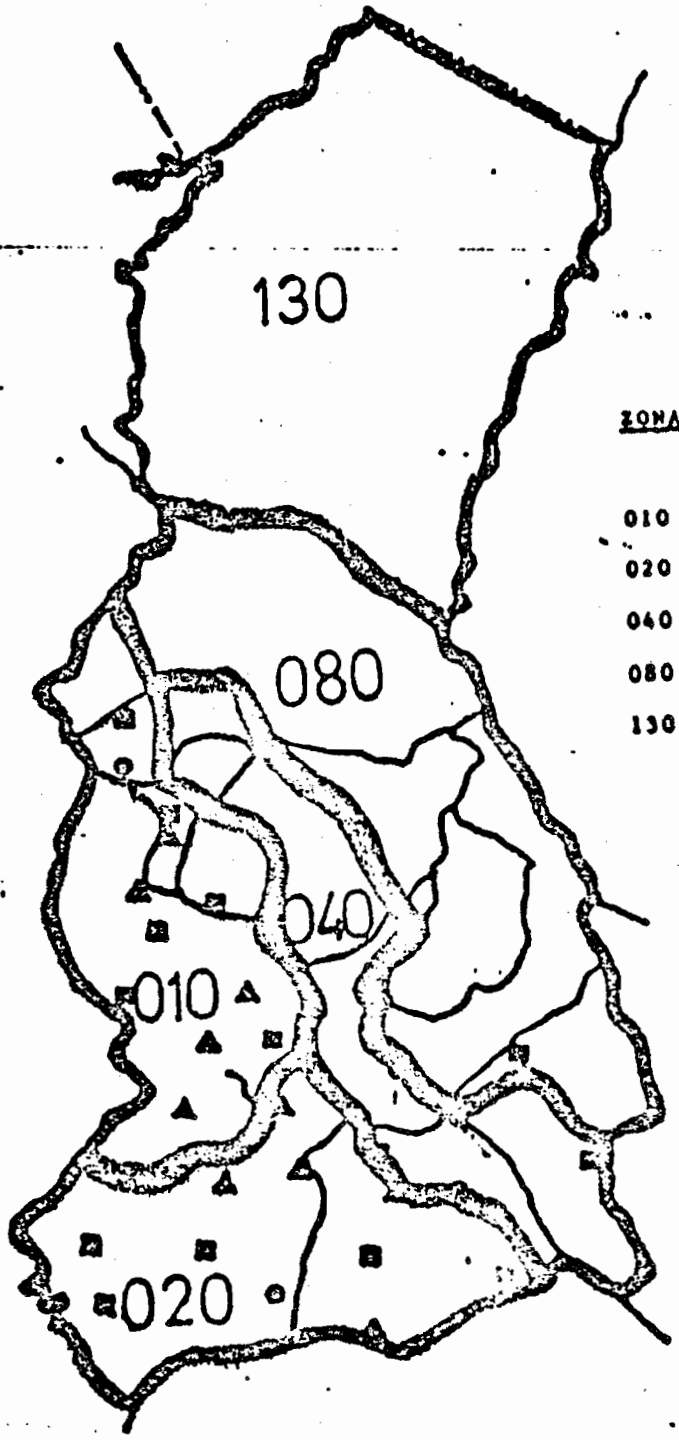
DEPARTAMENTO DE LA PAZ



ZONAS ECOLOGICAS

010 Altiplano Norte

020 Altiplano Central

040 Valles Cerrados

080 Yungas del Norte

130 Amazonica

Ref.

▲ COMUNIDADES EN EJECUCION

● COMUNIDADES A INCLUIRSE EN ENERO/85

■ COMUNIDADES A INCLUIRSE POSTERIORMENTE

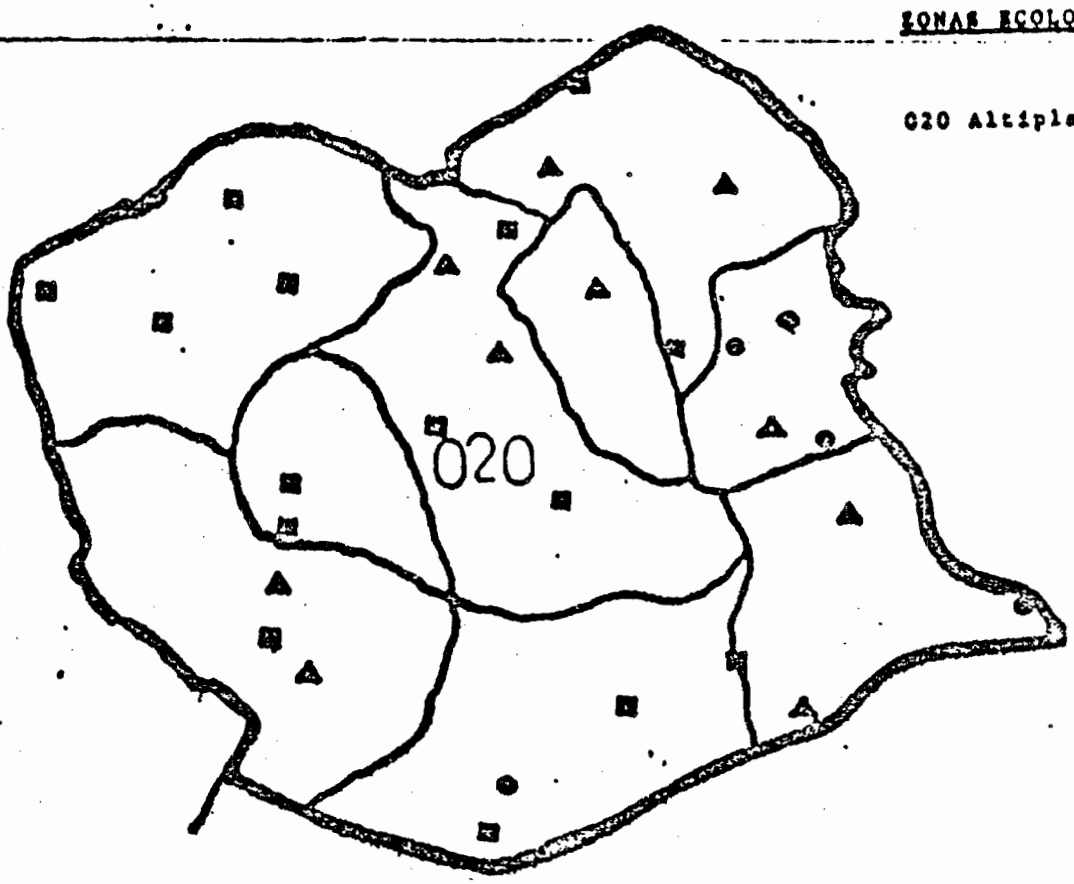
- ENERO 1985

50

DEPARTAMENTO DE ORURO

ZONAS ECOLOGICAS

020 Altiplano Central



Ref.

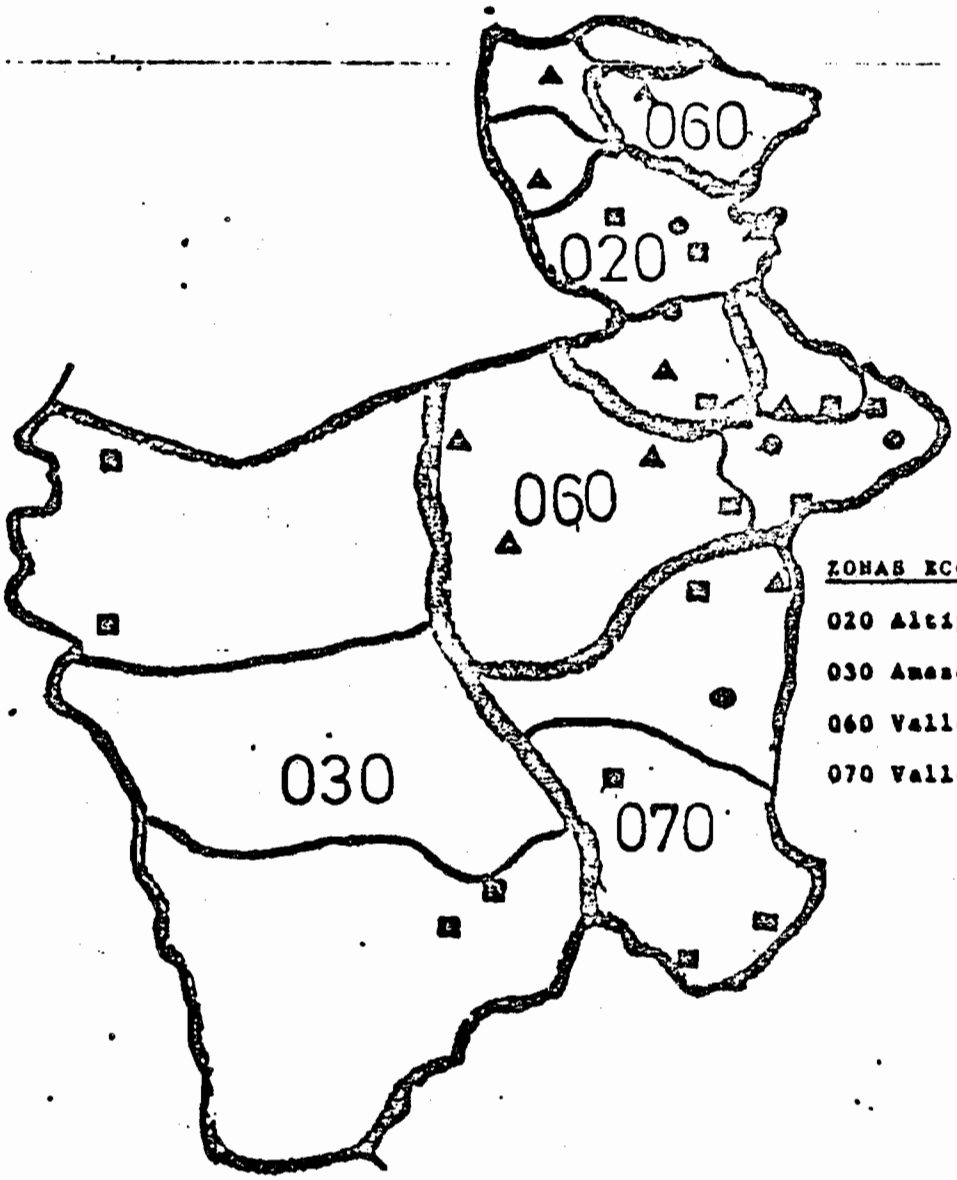
▲ COMUNIDADES EN EJECUCION

● COMUNIDADES A INCLUIRSE EN ENERO/85

■ COMUNIDADES A INCLUIRSE POSTERIORMENTE

ENERO 1985

DEPARTAMENTO DE POTOSI



ZONAS ECOLOGICAS

020 Altiplano Central

030 Amazonica

060 Valle Central

070 Valles del Sur

Referencias

▲ COMUNIDADES EN EJECUCION

● COMUNIDADES A INCLUIRSE EN ENERO/85

■ COMUNIDADES A INCLUIRSE POSTERIORMENTE

ENERO 1985

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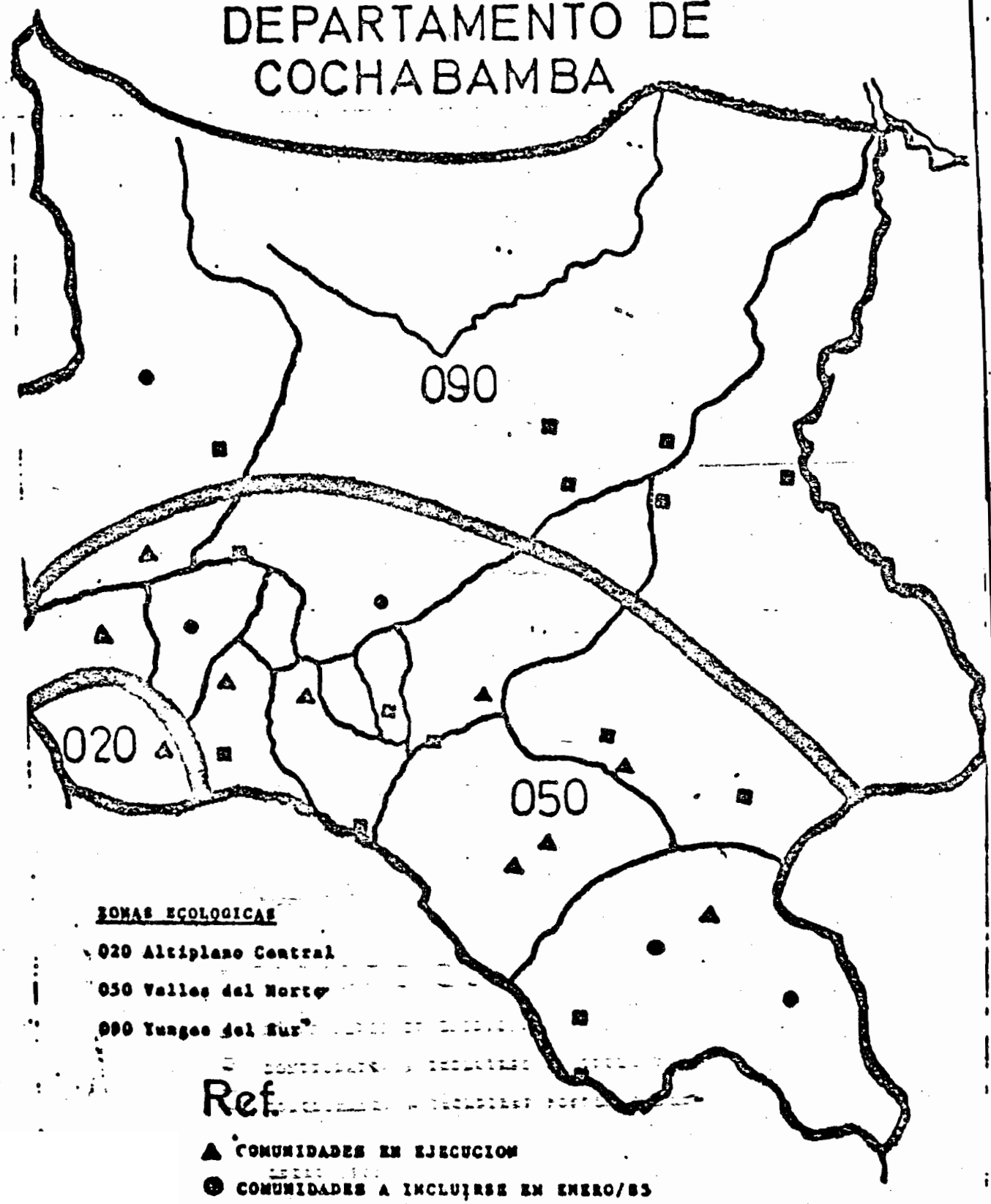
DEPARTAMENTO DE COCHABAMBA



ZONAS ECOLOGICAS

020 Altiplano Central

050 Valles del Norte

090 Yungas del Sur

Ref.

▲ COMUNIDADES EN EJECUCION

● COMUNIDADES A INCLUIRSE EN ENERO/85

■ COMUNIDADES A INCLUIRSE POSTERIORMENTE

ENERO 1985

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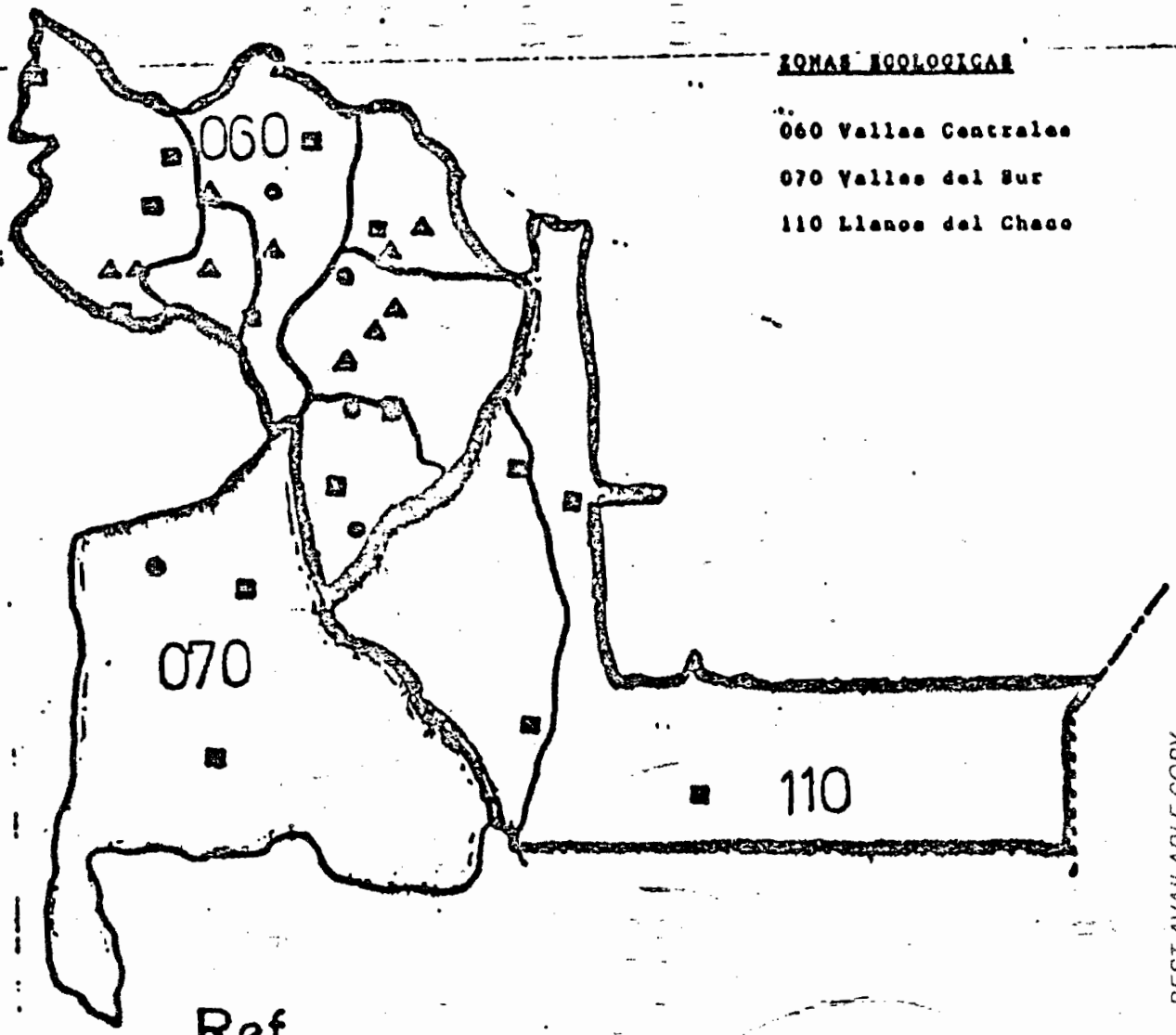
DEPARTAMENTO DE CHUQUISACA



ZONAS ECOLOGICAS

060 Valles Centrales

070 Valles del Sur

110 Llanos del Chaco

Ref.

- COMUNIDADES EN EJECUCION
- COMUNIDADES A INCLUIRSE EN ENERO/85
- COMUNIDADES A INCLUIRSE POSTERIORMENTE

ENERO 1985

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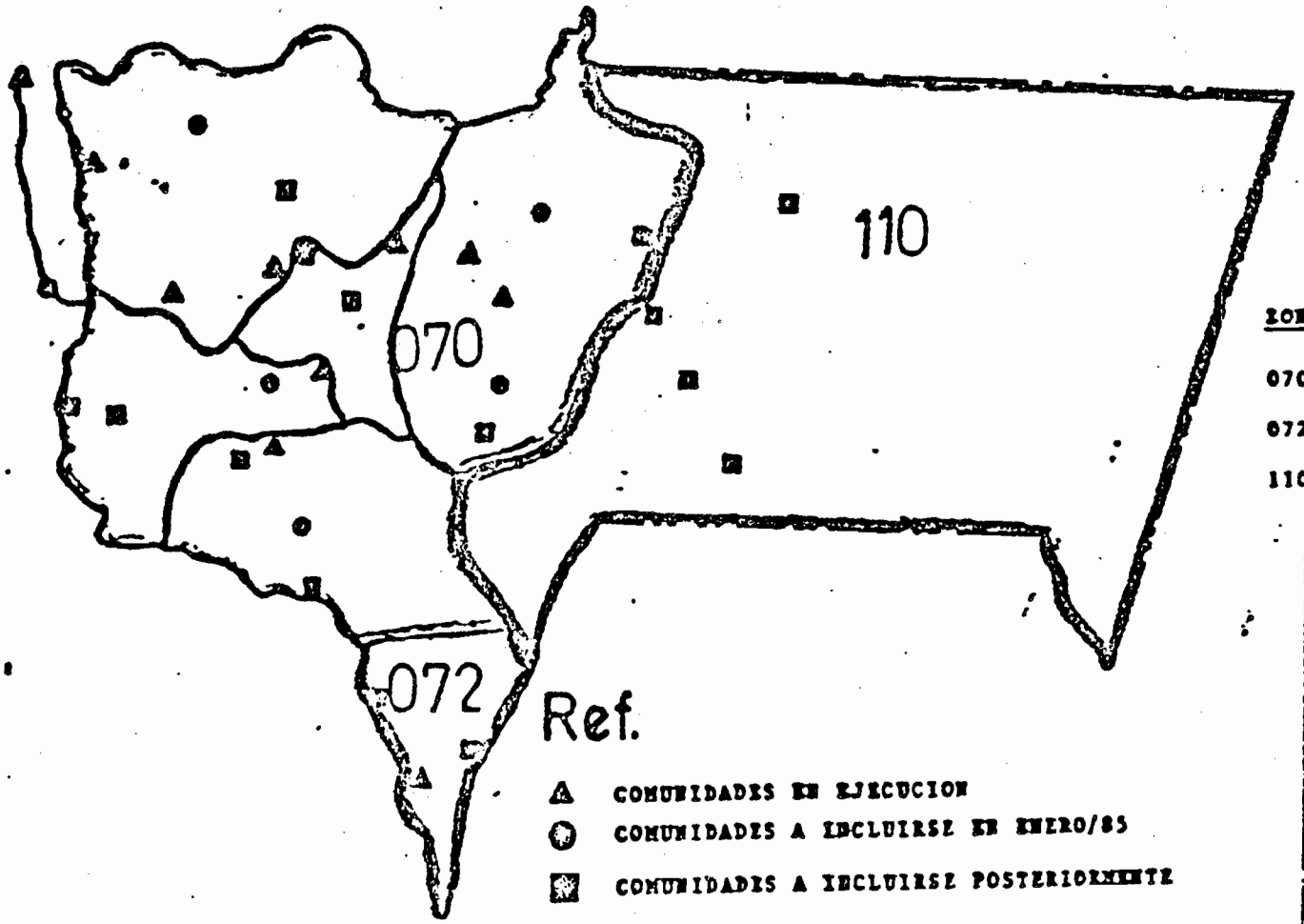
DEPARTAMENTO DE TARIJA



ZONAS ECOLOGICAS

070 Valles del Sur

072 Valles del Sur - Caña

110 Llanos del Chaco

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AFRICAN LAND-COVER CLASSIFICATION USING SATELLITE DATA

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25 January 1985, Volume 227, Number 4685 SCIENCE

African Land-Cover Classification Using Satellite Data

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Summary. Data from the advanced very-high-resolution radiometer sensor on the National Oceanic and Atmospheric Administration's operational series of meteorological satellites were used to classify land cover and monitor vegetation dynamics for Africa over a 19-month period. There was a correspondence between seasonal variations in the density and extent of green-leaf vegetation and the patterns of rainfall associated with the movement of the Intertropical Convergence Zone. Regional variations, such as the 1983 drought in the Sahel of western Africa, were observed. Integration of the weekly satellite data with respect to time for a 12-month period produced a remotely sensed estimate of primary production based upon the density and duration of green-leaf biomass. Eight of the 21-day composited data sets covering an 11-month period were used to produce a general land-cover classification that corresponded well with those of existing maps.

Accurate, timely information on the distribution of vegetation on the earth's surface is a requisite for understanding how changes in land cover affect phenomena as diverse as the atmospheric CO_2 concentrations, terrestrial primary productivity, the hydrologic cycle, and the energy balance at the surface-atmosphere interface. Such information about vegetative cover is also required in determining the rates of change of the earth's biotic resources and the ways in which land use is adjusting to increasing demands on these resources.

Traditionally, the principal source of such information has been vegetation mapping by ground survey. If large areas are surveyed, it is inevitable that the observations of many different observers must be synthesized, which introduces all the problems of reconciling disparate observations. The magnitude of the task is apparent in the maps of, and ancillary texts on, the vegetation of Africa (*1, 2*) and is further illustrated by the widely varying estimates of the surface area of world terrestrial ecosystems (*3, 4*). An alternative approach is to use satellite remote-sensing data with its synoptic overview as a basis for mapping. In numerous studies such remotely sensed data have been used to accurately map vegetation, crops, and other land-cover types (*5*). The majority of these studies have used Landsat data, and none of them have attempted classification at continental scales.

One reason why it has not been possible to accomplish continental-scale vegetation classifications from Landsat data is because of its 80-m spatial resolution. This spatial resolution of the Landsat multispectral scanner system (MSS) and associated 185- by 185-km scene makes it necessary to accumulate a substantial quantity of data (about 1100 individual Landsat images) to cover an area as large as Africa. Thus logistical and financial problems are sizeable if a continental-scale analysis is to be performed in a digital mode with Landsat MSS data.

It is highly desirable to collect several images each year to overcome cloud cover problems while monitoring changes in vegetation over time (*6*). Multiple imaging within a given year allows classification to be based on phenological changes in different vegetation types (*5*). Such an approach becomes essential in Africa if land-cover types are to be spectrally discriminated because of the asynchronous responses of vegetation to seasonal rainfall north and south of the equator and the marked wet and dry seasons.

As an alternative to Landsat images, we propose the use of advanced very-high-resolution radiometer (AVHRR) data from the National Oceanic and Atmospheric Administrations (NOAA) meteorological satellites. Such data have been shown to have significant potential for assessing and mapping vegetation over relatively modest areas (*7, 8*), and similar levels of classification accuracy have been reported between Landsat MSS and NOAA AVHRR data for some natural vegetation types (*9*). AVHRR data have a much coarser resolution (1 and 4 km at nadir) and hence a lower data volume and cost than Landsat MSS data, and their temporal resolution is much higher with 4-km imagery globally available on a daily basis.

It should be stressed that we are attempting to map physiognomic types or vegetation formations according to land-cover criteria rather than any alternative criteria that have been proposed, such as environmental characteristics, phylogeny, or individual form features (*10*). Our approach is based upon satellite data collected daily for 19 months for the continent of Africa and uses the satellite-recorded multitemporal characteristics of land cover for large-scale classification purposes.

Methods

The AVHRR sensor of the NOAA satellites was chosen to provide the data (*11*). Earlier data from this sensor co-

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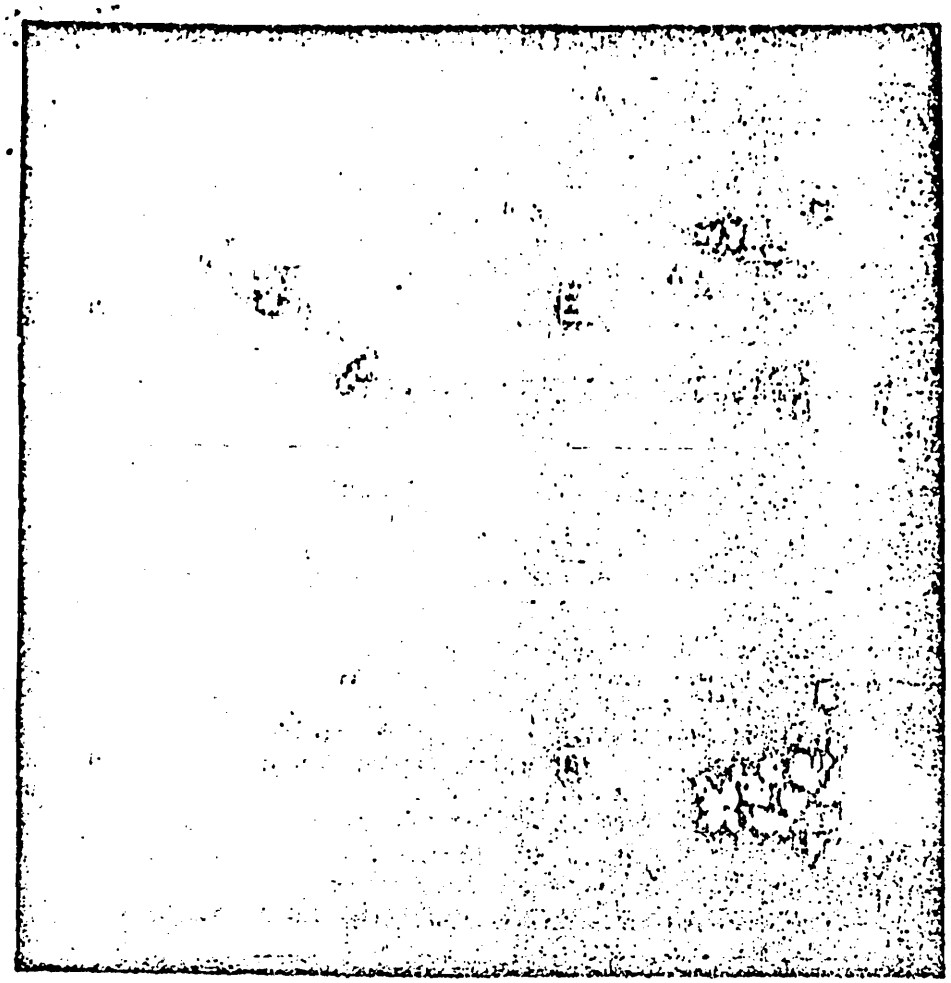

Fig. 1. The spectral vegetation index from Africa for four selected 21-day periods: (A) 12 April to 2 May 1982; (B) 5 to 25 July 19[illegible]; (C) 27 September to 17 October 1982; and [illegible] 20 December 1982 to 9 January 1983. Their [illegible] are the maximum normalized-difference values from 3 weeks of the NOAA global vegetation-index product and have a spatial resolution of 15 km at the equator. The tan and brown colors represent no green leaf vegetation, and the reds and purples represent the highest amounts. Values for green-leaf vegetation range from approximately 0.05 to 0.60.

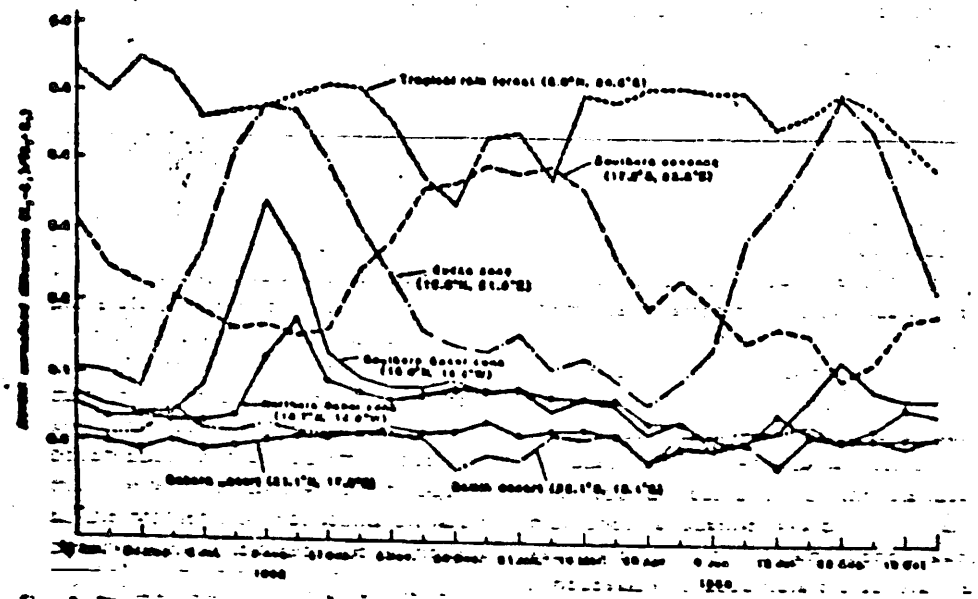

Fig. 2. The spectral-vegetation-index from April 1982 to November 1983 at seven African locations. One value is plotted per location for each 21-day period. The first day of each 21-day period is indicated on the x-axis (thus 12 April is actually 12 April to 2 May 1982). Each value plotted represents the average of nine picture elements or approximately 2500 km².

board the Television and Infrared Observing Satellite (TIROS) were unsatisfactory because of the overlap between the visible and near-infrared bands, which made it impossible to produce a spectral green vegetation index (*12*). Global-area coverage (GAC) data with a 4-km resolution were chosen rather than the finer resolution local-area coverage (LAC) data with a 1-km resolution, since the 4-km data were available daily for the whole continent.

The 4-km GAC data are partly resampled 1-km LAC data, the first four 1-km picture elements are averaged, and this average is then used to represent a 3 by 5 picture element block (*11*). The GAC data are tape-recorded onboard the satellite and subsequently transmitted to receiving stations in either Virginia or Alaska.

Fourteen NOAA-7 orbits cover the entire world each day. The daytime global AVHRR 4-km channel 1 (C_1) and channel 2 (C_2) data are mapped by NOAA into 1024 by 1024 element arrays for the Northern Hemisphere and Southern Hemisphere every day. These data, available from NOAA on a daily basis or as a weekly composite, have a grid cell size of ~15 km at the equator and ~30 km at the poles (*13*). Ratio or linear combinations of the C_1 and C_2 radiances can be used to generate spectral indices that are used to nondestructively estimate the green-leaf biomass or green-leaf area of plant canopies (*14*). Recent researchers have reported very high correlations between the spectral green-leaf indices and the photosynthetically active radiation absorbed by plant canopies (*15*). Spectral green-leaf indices are also affected by off-nadir viewing, sun angle, background material reflectance, and atmospheric aerosols (*16, 17*), and these indices have an asymptotic or saturation response to high levels of green-leaf density (*18*).

The weekly global composite data are formed by selecting the highest spectral index for each grid cell location from the individual daily data for that week (*13*). We have taken the weekly C_1 and C_2 values from mid-April 1982 to November 1983, mapped them to a Mercator projection, formed the C_2/C_1 and $(C_2 - C_1)/(C_2 + C_1)$ ratios, and selected the highest value over a 3-week period for both spectral ratios for each grid cell location for Africa. Selecting the respective maximum spectral ratio for a 3-week period simultaneously minimized the effects of sun angle, off-nadir viewing, atmospheric path length and aerosols, and clouds, all of which can only decrease the spec-

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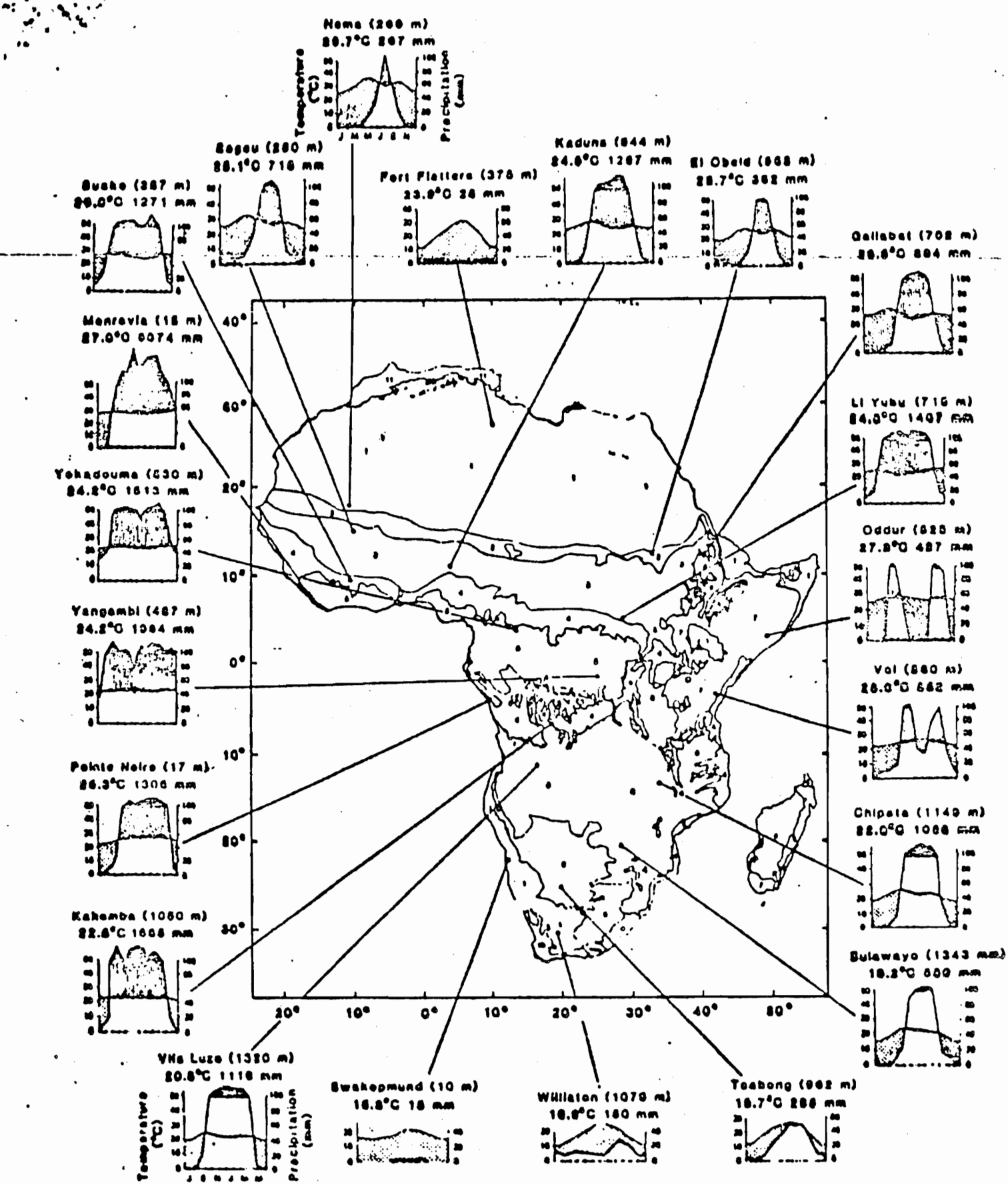

Fig. 3. Major vegetation types of Africa and Madagascar, simplied from White (*71*), with selected climate and elevation data after Walter and Lieth (*73*) and Walter *et al.* (*24*): 1, desert and semidesert shrubland-grassland; 2, wooded grassland and bushland (Sahel); 3, Sudanian woodland and grassland; 4, forest transition and mosaic; 5, forests; 6, woodlands, predominately Somalia-Masai; 8, Kalahari wooded grassland and bushland; 9, Karoo grassy shrubland and highveld grassland; 10, Cape and Karoo shrubland, and 11, Mediterranean vegetation. Climate data for selected sites are given in terms of the station name, elevation, average mean temperature (in degrees celsius), and average precipitation (in millimeters). The average monthly precipitation is plotted against time on a linear scale (stippled portion) and on a logarithmic scale (solid portion). Those months for which potential evapotranspiration exceeds precipitation are noted by the dotted areas. The average monthly temperature is also plotted against month. The months begin with January north of the equator and with July south of the equator.

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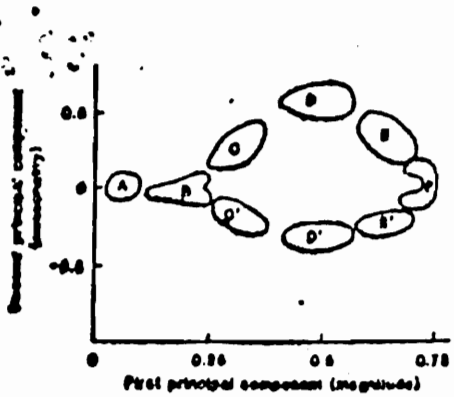

Fig. 4. A diagrammatic representation of the classification feature space formed between the first and second principal components from 21-day periods between April 1982 and February 1983. The first principal component was found to be highly similar to the integrated image appearing as the cover figure. The second principal component represents cover-type seasonality. Known surface areas were selected and used to label the feature space. The resulting labeling resulted in classes of water (A), desert (B), semiarid seasonal grasslands (C and C'), dry savannas (D and D'), wet savannas (E and E'), and tropical forest (F).

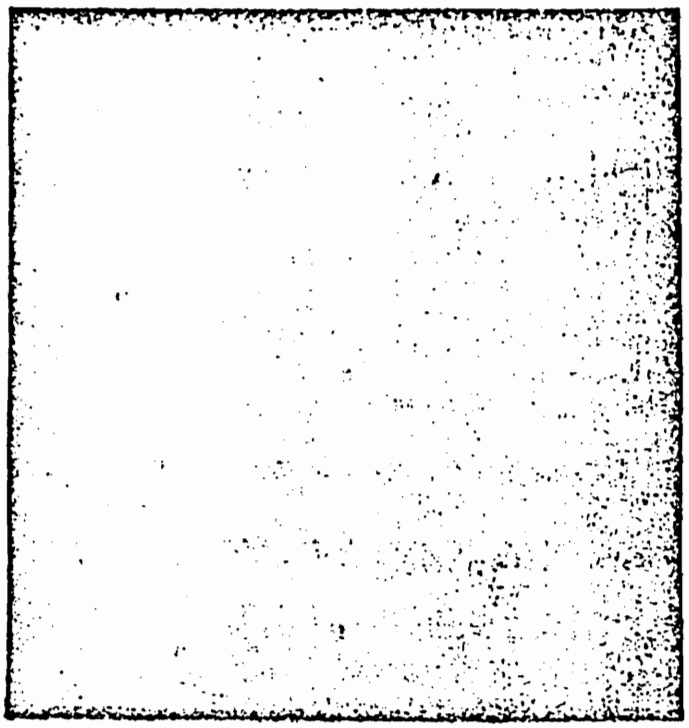

Fig. 5. Principal components land cover classification of Africa produced from eight 21-day composited images (12 April to 2 May 1982, 24 May to 13 June 1982, 9 to 25 July 1982, 6 to 26 August 1982, 27 September to 16 October 1982, 8 to 28 November 1982, 20 December 1982 to 10 January 1983, and 11 January to 19 February 1983). The feature space used to label land-cover classes is shown in Fig. 4. The tan areas are desert and semidesert, the light green areas semiarid wooded grassland and bushland, the purple areas Sudanian woodland and grassland, the dark blue areas interspersed tropical forest and grassland, the red areas tropical rain forest and montane forest, the dark green areas woodland and especially Miombo woodland, the light blue areas bushland and thicket, and the yellow areas wooded grassland and deciduous bushland (see also Figs. 1 through 4).

Table 1. Net primary productivity and phytomass of terrestrial ecosystems. The adapted conversion of dry matter to carbon is 0.45 [from Ajtay *et al.* (*3*)].

Ecosystem type	Average net primary production of dry matter ($g\ m^{-2}\ year^{-1}$)	Living phytomass (above and below ground) dry matter ($g\ m^{-2}$)
Forests		
Tropical humid	2,300	42,000
Tropical seasonal	1,600	25,000
Temperate evergreen	1,300	30,000
Temperate deciduous	1,300	28,000
Temperate woodland	1,300	18,000
Chaparral, mesquite	600	7,000
Savanna		
Low tree-shrub savanna	2,100	7,300
Grass-dominated savanna	2,300	2,200
Dry savanna thorn forest	1,300	15,000
Dry thorny shrubs	1,200	5,000
Temperate grassland		
Moist	1,200	2,100
Dry	500	1,300
Desert and semidesert scrub		
Scrub-dominated	200	1,100
Sandy, hot, and dry	10	60

trial ratios (*17*). This process resulted in the selection of data that tend to occur near nadir, are largely cloud-free, and are characterized by low-aerosol conditions. A subjective appreciation of the results of this process may be gained from an inspection of Fig. 1, where no boundaries between satellite paths can be detected.

Compositing was performed on the Hewlett-Packard 1000 and Ramtek image-processing system at the Sensor Evaluation Branch, Goddard Space Flight Center. The importance of combining data over periods of time to minimize clouds, sun angles, directional reflectance, and atmospheric effects while maintaining the ability to record the temporal dynamics of vegetation must be stressed and is fundamental to the work we describe. The 3-week composites reduced cloud cover to less than 2 percent, with the balance of those clouds percent occurring over coastal Gabon and Cameroon.

Multitemporal Dynamics of Green-Leaf Biomass

The ability to successfully composite daily satellite data on a continental scale provided the means to overcome the problems of extensive cloud cover in equatorial and other areas and the degrading effects caused by variations in sun angle, the atmosphere, and the satellite-target viewing geometry. Once cloud-free data were available at frequent intervals and the various degrading influences minimized, the large-scale multitemporal dynamics of green-leaf biomass could be recorded. Almost identical results were found for the C_2/C_1 ratio and the $(C_2 - C_1)/(C_2 + C_1)$ normalized difference vegetation index. Accordingly, we present only results from the normalized difference series of analyses and henceforth refer to the normalized difference as the spectral vegetation index.

Figure 1 illustrates the seasonal changes in green-leaf biomass as expressed in the spectral vegetation index for Africa at four selected 21-day intervals from April 1982 to January 1983. The movements of the Intertropical Convergence Zone were evident in the development of green-leaf biomass after periods of precipitation. Inspection of the 3-week data and their variation with time showed the growing season dynamics from seven selected locations (Fig. 2). The data presented in Fig. 1 represent four of the 28 3-week periods presented in Fig. 2 for seven selected locations. We

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observed seasonal variation in our spectral vegetation index for almost all vegetated areas of Africa including tropical rain forest: deserts and semideserts were the only areas observed to be temporally invariant (Fig. 2). The nested curves for selected areas in the Sahel and Sudan zones, the southern savanna, and the tropical rain forest areas in Fig. 2 reflect the climatic conditions of the time period from April 1982 to November 1983 and are in general agreement with the 30-year climatic averages from similar African areas (Fig. 3). Higher values of the spectral vegetation index were observed during the 1982 rainy season in the West African Sahel than during 1983 (Fig. 2). This reduced spectral vegetation index in 1983 corresponded to a major drought in the northern and central Sahel zone in 1983 (*19*).

Seasonal variation in the spectral vegetation index was also observed in tropical rain forest, tropical seasonal forest, and savanna areas. Although this seasonality is expected for tropical seasonal forests and tropical savannas, it also occurs in most tropical rain forests (*20, 21*). Compared with rain forests on other continents, the African tropical rain forest is relatively dry and receives between 1600 to 2000 mm of rainfall per year. White (*1*) reported that areas receiving more than 3000 mm of rainfall per year are largely confined to coastal areas of Upper and Lower Guinea and that only a small part of the Zaire basin receives more than 2000 mm per year.

Not only is the rainfall in Africa lower than in rain forest regions elsewhere, but also its distribution throughout the year is uneven. Virtually nowhere in the African tropical rain forest is the mean monthly rainfall higher than 100 mm for every month of the year. South of the equator and toward the Atlantic coast but still at equatorial latitudes, the length and severity of the dry period increases (*1*). Consequently, the variation observed in the spectral vegetation index from African tropical rain forest areas is consistent with observed vegetation seasonality (*22*) and climatic data (*23, 24*) (Fig. 3). In addition, dry periods are more severe and frequent than the climate diagrams indicate, as the climate diagrams are based upon long-term mean values (*1, 23, 24*). Because of the marked wet and dry periods for African vegetation types, we observed the same spectral vegetation index for savanna areas as for tropical rain forest areas at times (Fig. 1A), higher spectral vegetation indices for tropical forests than for savanna areas at times (Fig. 1B), and higher spectral vegetation indices for savannas than for tropical rain forest areas at other times (Figs. 1D and 2).

To quantify the yearly vegetation response for Africa we have integrated the spectral vegetation index with respect to time for the period from April 1982 to April 1983 (see cover). This technique has been used to approximate the primary production within a given vegetation type for the period of observation. This is so because the spectral vegetation index is highly correlated to the green-leaf biomass or projected green-leaf area (an indication of the area of the photosynthetic absorbing surface), which is one of several variables related to the rate of photosynthesis. Frequently collected spectral data, when integrated with respect to time, have been shown to be highly correlated to the total dry matter accumulation for wheat (*6*), corn (*25*), pastoral ecosystems (*7*), and crop yield (*26*). Essentially, the integrated spectral green-leaf indices are estimates of the integral intercepted visible radiation (*15*). Monteith (*27*) has reported that net production per unit of intercepted visible radiation was remarkably constant for crops as diverse as apples, barley, potatoes, and sugar beets in the United Kingdom. Although this integration technique has not been tested across different ecological zones or at continental scales, the data we report on are well suited for this purpose.

The integrated spectral index produced a zonation of Africa in which deserts and semideserts, dry savannas and dry grasslands, and forests and wet savanna were differentiated from each other (see cover). There is general qualitative agreement between the integrated image in the cover figure and various primary production data from different ecosystem types (Table 1). Tropical forest and tropical savanna have similar integrated index values. Primary production data (*3, 20*) and the fact that African tropical rain forests are relatively dry as compared to rain forest in other continents (*1*) tend to support the integrated data in the cover figure (Table 1). We acknowledge a range of primary production estimates (*28*). Detailed quantitative verification of the zonations presented in the cover figure will be a tedious and time-consuming process.

Land-Cover Classification

There is a high correlation between the integrated image (cover figure) and the major land-cover types found in Africa (Fig. 3). For example, the highest values correspond to the forest and wetter savanna areas, and the lowest to desert and semidesert areas. These relationships, along with the distinctive temporal variation of different cover types (Fig. 2), suggested that a continent-wide land-cover classification should prove feasible and the following procedure was adopted. From the 23 cloud-free geographically referenced data sets, eight dates between April 1982 and February 1983 were used for classification purposes. These were chosen since their spacing provided an opportunity to use seasonal phenological changes in green-leaf biomass to classify the land cover. We chose the spectral vegetation index as the variable used to define the feature space for two reasons. (i) For a given vegetation type, this index is related to variables such as the projected green-leaf area, green-leaf biomass, or the intercepted fraction of photosynthetically active radiation. (ii) Use of the spectral vegetation index meant that differences in radiance received at the sensor as a result of differences in solar elevation would be largely eliminated.

A principal-components classification procedure was used for eight 3-week periods of data between April 1982 and February 1983 (*29*). The spectral vegetation index was the variable used from time 1 to time 8. The n principal components P are related to the original variables by

$$P_i = \sum a_{ij} NDVI_j \qquad (1)$$
$$i = 1, 8$$
$$j = 1, 8$$

where a_{ij} are the eigenvectors ranked in order corresponding to the size of the eigenvalues and $NDVI$ is a spectral vegetation index for time j. Each eigenvector represents the relative contribution of each time period to the principal component and is obtained by solving the equation

$$C\lambda_{ij} = a_{ij}\lambda_i \qquad (2)$$

where C is the covariance matrix of the spectral vegetation indices for the nine time periods and λ_{ij} is the positive eigenvalue representing the variance of each principal component (*29*). The first eight principal components were generated and the first and second principal components used for classification purposes.

The first principal component had near equal eigenvector weightings for all eight dates and has been reported to be nearly identical to the integrated spectral vegetation index (*30*). The second principal component showed a quasi-sinusoidal structure with marked negative and high positive values in the dry and wet sea-

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zone, respectively, in both hemispheres, reflecting the [illegible] sequence of rainy seasons in the two hemispheres of Africa. Areas of the Sudan and Sahel zones had high positive values while similar areas of vegetation in southern Africa had low negative values, and desert areas showed no seasonal changes and had second principal component values close to zero (Fig. 4). We selected areas of known vegetation types for classification training-site purposes on the basis of the African field experience of the authors and agreement among the various vegetation maps (*1, 2*). These training areas, which represented less than 5 percent of the African surface area, were used to label the feature space formed between the first and second principal components for each pixel of the African data. Boundaries of the various vegetation types were determined on the basis of the location of the training areas in the feature space and the classification image produced (Fig. 5).

Several qualifications need to be stated concerning the land-cover map shown in Fig. 5. We stress that we did not primarily attempt definitive or even quasi-definitive land-cover classifications of Africa but instead attempted to evaluate the feasibility of using NOAA-7 AVHRR data for this purpose. No formal performance evaluation has been carried out. Our evaluation has been hindered by the substantial lack of agreement among existing vegetation maps for many locations of Africa. We therefore have no quantitative basis for comparison as yet. Field checking will clearly be extremely time-consuming, and a satisfactory sample of test sites may take several years to collect. Nevertheless, we intend to carry out such a field program. At present, we must rely on the African field experience of ourselves and colleagues along with a qualitative comparison with existing vegetation maps such as that shown in Fig. 3. Comparisons with such maps suggests a considerable measure of agreement, although certain errors can be noted. The classification of desert north of the equator includes both deserts and other semiarid zones with precipitation up to approximately 300 mm/year (Fig. 5). As such, this includes a portion of the Sahelian zone (200 to 400 mm/year). The extent of closed-canopy forest in eastern Africa is probably overestimated. In coastal Gabon and Cameroon the amount of rain forest may have been somewhat underestimated because of the remarkably high frequency of clouds and haze in the early afternoon in this area.

The classification of vegetation on the Mediterranean coast is described in the same terms as that in the text of the map. We also recognize the error introduced by using data from a 1-year period, which does not account for yearly variation in climate. This is evident in Fig. 2 for the Sahel zone between 1982 and 1983. In future more detailed mapping we plan to use multiyear data accompanied by labeling on the basis of the known differences in the assemblage of vegetation formations.

Conclusions

The mapping of the AVHRR images to a common geographically referenced data base provided the basis for image compositing to produce near cloud-free images of the entire African continent, in which atmospheric and satellite-target viewing geometry effects were minimized. A spectral vegetation index was calculated to allow the green-leaf dynamics of the African surface to be monitored for the whole of Africa and was used to construct a continent-wide land-cover classification based on the multitemporal responses of land cover. There was qualitative agreement with the reported distribution of vegetation (*1, 2*) for most of the continent. In some areas errors occurred, and thus refinements to existing classification methods need to be developed. In particular, data from several years are needed to overcome yearly climatic variation. Despite these important qualifications, the results suggest the prospect for internally consistent mapping and repeated monitoring of the main cover types of continental areas based on the use of multitemporal coarse-resolution satellite data.

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31. We thank J. Weber, R. Money, D. Cobb, and J. Gallin for their assistance and C. Jacobs and A. M. Hoasly for their encouragement.

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Prooxidant States and Tumor Promotion

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In cellular prooxidant states the intracellular concentration of activated forms of oxygen is increased, presumably because cells either overproduce these reactive substances or are deficient in their ability to destroy them. The major forms of active oxygen are superoxide, O_2^-, and its conjugate acid the hydroperoxy radical, $HO_2\cdot$; singlet oxygen, O_2^*; the hydroxyl radical, $\cdot OH$; and hydrogen peroxide, H_2O_2. Prooxidant states vary, depending on the type of target cell and on the induction mechanism, and can result in ubiquitous cell damage through readily oxidizable target molecules. Major reactions include initiation of autoxidation chain processes by hydroxyl and hydroperoxy radicals and of branching reactions by alkoxy radicals, addition of hydroxyl radicals and singlet oxygen to double bonds, hydrogen abstraction from allylic carbon atoms by hydroxyl radicals, and oxidation of sulfhydryl, thioether, and amino functions (*1*). The biological consequences are mutations, sister chromatid exchanges, chromosomal aberrations, cytotoxicity, carcinogenesis, and cellular degeneration related to aging. In carcinogenesis active oxygen appears to play a role mostly in the promotion phase, during which gene expression of initiated cells is modulated by affecting genes that regulate cell differentiation and growth. In a subsequent step, usually referred to as progression, mostly benign neoplasms are stimulated to more rapid growth and malignancy. Active oxygen is known to induce chromosomal aberrations with high efficiency and could play a role in progression (*2*).

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Evidence for a Role of Prooxidant States in Carcinogenesis

The human hereditary diseases ataxia telangiectasia, Fanconi's anemia, and Bloom's syndrome are characterized by increased cancer incidence and spontaneous chromosomal breakage (*3*). There are indications in all three diseases of abnormalities in oxygen metabolism (*4*). Cultured skin fibroblasts from patients with these diseases are hypersensitive to agents that induce prooxidant states. For example, fibroblasts from patients with ataxia telangiectasia are hypersensitive to x-rays, bleomycin, and neocarcinostatin; those from patients with Fanconi's anemia show sensitivity to mitomycin C and psoralen; and those from patients with Bloom's syndrome are sensitive to near-ultraviolet radiation. This last agent also induces excessive DNA strand breakage in fibroblasts from Bloom's syndrome patients. Increased oxygen tension causes excessive amounts of chromosomal aberrations in Fanconi's anemia. Serum from patients with ataxia telangiectasia and Bloom's syndrome contains clastogenic factors (CF's), and cultured fibroblasts release CF's into the culture medium. These factors break chromosomes in test cultures of lymphocytes from healthy donors. The CF from Bloom's syndrome fibroblasts was inhibited by CuZn superoxide dismutase (SOD), indicating the intermediacy of O_2^- in the clastogenic process (*5*). The