Exploration Photography

AERIAL POINT SAMPLING
FOR AGRICULTURAL AND LAND USE ASSESSMENT
BY THE RWANDA AGRICULTURAL SURVEYS AND POLICY ANALYSIS PROJECT

Presented to: Development Alternatives, Inc.
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This paper proposes an Aerial Point Sampling Survey (A.P.S.) of Rwanda. It demonstrates why we think this is more appropriate to ASPAP's requirements than 1:20,000 scale aerial photo coverage, and details a complete program of training and acquisition for an in-house capacity at S.E.S.A. to estimate agricultural land use by Prefect, Sector and Commune. Furthermore, we will show that because of the economics of this approach and the willingness of the International Union for Conservation of Nature and Natural Resources to provide training and software at cost, the survey, interpretation and compilation of reports can be completed within our budget for the original aerial photography alone.

In response to a request from Development Alternatives, Inc., in the spring of 1987, Exploration Photography submitted a proposal to fly complete aerial photo coverage of Rwanda at a print scale of 1:20,000 in 70mm color. This application was based on our successful use of medium format enhanced color surveys for resource inventory in several African countries and throughout the American Southwest. Our complete aerial photography of Lesotho, flown in 1983, remains the best available coverage of that country and has proven useful in several branches of land use planning from watershed development to road siting.

However, as ASPAP refined its requirements, this approach became less appropriate to their needs because:

1) The altitude at which this photography is taken. It requires relatively cloudless skys, and to be useful to ASPAP's purposes, it should be flown when crops are in the field. Clear skys are rare during Rwanda's growing seasons, and it became apparent that the coverage could probably not be completed within that time frame.

2) ASPAP had originally considered an area frame sample approach to their farm survey, which utilizes small scale continuous coverage. This methodology has since been rejected and with it the chief justification for the original aerial photography proposal.

As stated, this type of stereographic aerial photography is an invaluable multi-use tool. It provides 100% coverage of the land permitting complete thematic maps and topographic analysis of the terrain, but in a country with Rwanda's climate, it would be expensive and time consumming to acquire. Rwanda has an excellent set of topographic base maps and 1:20,000 scale land use maps that are complete but made from ten (10) year old coverage,and therefore, out of date. ASPAP's and SESA's objective is to update this data base, surveying the countries extremely fragmented farm holdings (one hectare per household with up to 15 different fields reconfigured between the two growing seasons), to identify and estimate

coverage of the 40 most common agricultural crop mixtures. At 1:20,000, each aerial photograph would cover 25sq. kilometers and show a hectare as one half (½) a centimeter wide. Crop mapping at this scale would require highly sophisticated personnel, equipment, and ground truth, probably cost more than the survey, and remain a subjective interpretation based on pattern recognition.

The specific needs of this project can be better met by an aerial point survey, which accurately quantifies an evenly distributed sample of the ground at large scale. The photo aircraft flys a low altitude grid below the layers of cloud cover and, therefore, is much less sensitive to weather conditions and takes single 35mm transparancies at one kilometer intervals (Appendix #1, Survey Operation). Each frame covers .2 hectares and is interpreted at a scale of one centimeter to seven meters, so that a single hectare farm holding is 14 by 14 centimeters on a projected grid. Individual crop species can be identified and their coverage determined by a simple dot/grid overlay (Appendix #2, Interpretation of Sample Photographs). Depending on sampling intensity, the area covered by these frames represents a 1.6 to 3% sample, sufficient for precise polling with estimates derived directly as densities or total numbers within a given defined area such as a commune (Appendix #3, Sample Analysis and Precision).

Aerial Point Sampling was developed by Dr. Norton-Griffiths' of EcoSystem, Ltd., Nairobi, specifically to survey the complex patterns of small holder land use found in Kenya where the average field size for all cereal grains is .2 hectares and the growing seasons are also characterized by extensive cloud cover. During the last six years, EcoSystem has flown and reflown over 1.2 million sq. kilometers and throughly demonstrated its' application and the accuracy of the results. Exploration Photography has worked with EcoSystem, Ltd. in Tanzania, and utilized A.P.S. to assess U.S. rangeland grazing for the Office of Arid Lands Study in Arizona.

The success of APS as a survey tool has been made possible by two relatively recent developments in aerial reconnaissance and resource inventory. One is the availability to small aircraft of on board global navigation computers that allow the exact geographic location of each sample frame to be recorded (see Appendix #1). The second is the development of G.I.S. micro-computer information programs that can layer ancillary data such as administrative divisions, census zones, climate, historical land use, or a digital elevation model, as spatial strata on a geographic base (see Appendix #4). As each sample photograph is accurately located to a geographic point, the tabulated information resulting from its interpretation can be associated with any stratum of information that overlays that point and acquires the attributes of all other relevant stratum. For example, not only can a particular crop be estimated for a given defined area, its production can also be compared as a function of soil type, slope angle, elevation, or historical use. This ability to spacially orient the data into a flexible and manipulable form is the heart of the A.P.S. approach and the factor that provides a clear path from flight and film to usable reports.

Once quantified and imputted into the system, the survey data can be tabulated for selected variables within or across the administrative reporting units. The point samples can also be assigned to cells such as the 5km by 5km UTM grid to display atributes and regional patterns as thematic maps. Thus it becomes possible to build up a highly integrated resource data base from both present and past surveys (the Technosynthesis land use data is apparently available in a pre-rasterized computer tape format), and any other information that can be geographically referenced.

Dr. Norton-Griffith has developed a PC Computer based turn-key point information management system (PIMS) for the sampling data and will provide a comprehensive training program for two SESA staff as part of this proposal (Imple- [illegible] Schedule, Training Program). It will allow them to directly integrate the APS results into a framework of existing information from different sources that can then be recorded into the administrative structure within which Rwandain government planners carry out resource management. One of the inherent problems with previous resource and land use surveys have been their vast quantities of data that could not be assimilated into the context of other existing information or presented in a form sufficiently recognizeable by the end user to be used. To quote Dr. Norton-Griffith: "It matters not from what source the data come, be it satellite images, aerial photos, low level aerial surveys, maps, consulting reports, ground surveys, or national censuses; neither does it matter one jot whether ecological principals suggest that watersheds, or agro-ecological zones, or area of differing slopes and soils should be used as the basis for development; if a Government implements its development by District, Division and Location then <u>all</u> data <u>must</u> be presented by District, Division and Location <u>otherwise</u> the data <u>cannot</u> be used."

IMPLEMENTATION SCHEDULE

AERIAL SURVEY

The first survey should be scheduled for May/June 1989, and immediately follow the training program in Nairobi. There would be some advantages to having the survey flown before the training, mainly that the S.E.S.A. staff could train and establish a data base with their actual imagery, but I feel this is outweighed by the benefits of having pre-trained personnel and the selected local staff participating on the flights, and identifying problem areas as the survey and interpretation run concurrent. The ideal solution to this problem would be to have one or two hundred sample photographs over a pre-selected area in Rwanda with easily verifiable crop compositions, and use them in the training program to learn the interpretation techniques and establish the initial interpretation classes for the project. Under "Additional Cost Options", I have included a possible mechanism and cost for doing this without necessarily having to import the survey plane twice.

Exploration Photography will provide the following equipment for the duration of the survey:

- 2 Canon F-1 35mm cameras with motor drives
- 250 exposure backs, 35mm, 50mm and 85mm lenses
- 1 aerial camera mount for Canons
- film loading equipment for bulk backs
- 1 VHS color video camera and recorder
- 1 aerial mount for video camera
- 1 Top Flight Video monitor and intervolometer for in-flight monitoring of flight lines and exposure control
- light tables for sorting and organizing color slides
- auto-counting hot foil press for labeling film and slide mounts

Exploration Photography staff in Rwanda will consist of the following personnel:

Dana M. Slaymaker
Photographer, survey coordinator with ASPAP and SESA staff
Rate: $250/day, plus per diem

Darragh Davis
Photographic Assistant, film coordinator and French translator
Rate: $100/day, plus per diem

All expenses incurred by Exploration Photography, including film, processing, and travel will be billed at cost and are estimated in the budget.

Aircraft will be provided by Jeremy Block, Nairobi, Kenya, and may be contracted through Exploration Photography or by D.A.I. directly.

Aircraft: Cessna 206, high wing monoplane, long range tanks, GNS500A Series I OMEGA/VLF navigation computer, King Gold Crown radar altimeter, full Avionics, twin 35mm camera hatches, 4 seater configuration.

Cost: $250 per hour, dry lease; lease includes pilot, insurances, navigation fees, landing fees, parking fees; hours timed on aircraft Hobbs meter from leaving Nairobi to returning Nairobi.

Pilot: Fully qualified for APS sample surveys, will require standard USAID per diem while on duty in Rwanda.

Guaranteed Hours: 60, including passage time. Hours in excess of 60 billed at same rate.

Duration of Contract: 45 days; every day in excess billed at $500 if airtime at that point is less than 100 hours. Days on which the aircraft or pilot are unservicable are not counted into 45 day maxium.

Fuel: Current and projected costs currently unavailable in Rwanda. Aircraft uses 50 litres per hour. Best to budget $1.50 per litre.

Notice of Contract: Minimum of three calendar months notice required from start of survey.

Payments: $5,000.00 on exchange of contracts, non returnable unless aircraft or equivalent fails to mobilize within 14 days.
$10,000.00 on mobilization of aircraft and pilot to Rwanda.
Balance on return of aircraft to Nairobi.

Contact: Jeremy Block
TLX: Nairobi 22206 MANDOR

Schedule of Personnel and Estimated Duration of Survey

Exploration Photography will need a set of the 1:50,000 scale topographic maps and a 1:250,000 scale base map of the commune divisions at least a month before the initiation of the training program, and at least seven days staff time to plot flight lines and organize the necessary eqiupment. We should also arrive in Rwanda a week before the aircraft to establish residence and coordinate with ASPAP and SESA before flying begins.

The aircraft should be in-country between 25 and 40 days, depending on the sampling intensity selected, weather conditions (though to a much lesser degree than normal aerial photography) and the extent to which local air turbulance allows us to complete afternoon flights.

Finally, we will remain in Rwanda for about two weeks after the aircraft to complete indexing and collation of the data.

Implementation Schedule

I.U.C.N.N.R. Training Program

Photo-interpretation training course should be scheduled for four weeks immediately preceeding the survey.

Dr. Norton-Griffith has desolved EcoSystem, Ltd., to join the International Union for the Conservation of Natuza and Natural Resources as head of its Eastern Sahel Unit. This is a non-profit organization that has agreed to provide an APS interpretation program to two SESA staff at cost. The objective of this 4 week course is to train 2 English speaking Rwandan personnel in all aspects of analysing data from APS surveys so that in future all work can be carried out in-house in the Ministry in Rwanda. The training course will also be attended by D. Slaymaker, consultant to DAI for this APS survey.

The course will cover the following subjects:

- basic design features of the APS survey method
- georeferencing sample aerial photographs
- filing and cross indexing sample aerial photographs
- analysing land cover off sample aerial photographs
- computer entry of all survey data
- data validation, editing and listing
- creation of a GIS (geographical information system) data base
- use the PIMS (Point Information Management System) GIS

The IUCN will also provide, free of charge, a copy of their most recent version of the PIMS computer programmes for further analysis of APS surveys.

The IUCN training course will be held at the Regional Offices of the IUCN in Nairobi for a period of one month. A three-man team will be involved in the training:

Dr. M. Norton-Griffiths	Head, IUCN Eastern Sahel Unit
E. Shirekuli	Computer Manager, IUCN/ESU
G. Otieno	Chief Photo-Interpreter, IUCN/ESU

Course Outline

The following subjects will be covered during the 4 working weeks of the course:

Week 1: APS sample theory
- APS sample design

- Georeferencing Sample Photographs
- Filing and Cross Indexing Sample Photographs

Week 2: Photo Interpretation

- Basic introduction and theory
- Creation of photo-interpretation key
- Interpretation using the dot grid
- Coding interpreted data
- Studying other land use photographs
- Computer entry and validation of photo data

Week 3: Creating GIS Data Base Using PIMS Software

- Data points
- XY grid coordinates
- Photo Calibrations
- Data Base Creation and Validation

Week 4: Training on PIMS Software

- Module 1: Create New Project
- Module 2: Data Retrieval
- Module 3: File Management and Utilities
- Module 4: Mapping
- Module 5: Modify and Update Data Base

OUTLINE COMPONENT DETAILS

Cross Indexing and Filing

All sample photographs must be filed in sequence, and cross indexed to their physical location on the georeferencing base map. Each sample photograph is given a unique Transect/Sub-Unit identity. This matches the TR/SU data on the map, and also matches an individual data record in the GIS data base.

Photo Interpretation

The first stage is a familiarisation with the photo interpretation procedures and equipment. The creation of a photo interpretation key will be discussed at length, and many examples will be looked at.

A range of sample photographs will then be analysed, with the IUCN staff providing assistance. Mornings will be spent interpretation; and the afternoons in going over the morning's work, discussing it, and assessing reasons for differing interpretations. The absolute necessity for strict quality control will be stressed at all times.

Whenever possible, sample photographs from other parts of Kenya and Tanzania will be looked at, to give experience in as wide a range of land cover types as possible.

Data Entry and Validation

The grinding task of entering the data from hundreds of photographs will again emphasise the absolute necessity for strict operational procedures to avoid mistakes. Validation, editing, and yet more validation and editing reinforces the necessity for care.

Data Base Creation

Creating the GIS data base for Rwanda will highlight yet further aspects of quality control. Activities will include creating the initial data base; input of UTM grid cell coordinates; definition and entry of reporting strata; entry of photo calibration data; final validation of all data; all culminating in the creation of a balanced, error free data base.

Training on the PIMS Software

After the exigencies of analysing and entering the data, and creating the data base, learning how to use the PIMS GIS software routines will seem simple and straightforward. Tables, analyses and maps of the Rwanda survey data will be produced, and a good introduction given into the features and capabilities of the software.

Requirements of SESA Staff: The justification of this program is that the two individuals will form the core of a photo interpretation team to analyze the first and possibly second survey. They would become the senior photo-interpreters responsible for refining the interpretation classes and monitoring the outputs of their staff, as well as producing reports from the tabulated data and seeing to their effective use. Although Dr. Norton-Griffith has some facility with French, they should be able to read and take instruction in English. A background in computer programming is not necessary as the software is introduced as turnkey on an entry level, but they should be willing to master its intricacies.

Since the actual interpretation of the sample photographs is straight forward, requirements for local hire staff would be much less, and a pool of qualified interpreters could be developed. EcoSystems had the best luck with college students in resource disciplines or agricultural field agents in training. This approach has the secondary benefit of familiarizing future land managers with the technique and spreading its acceptance as a resource tool. The long term goal of this project should be the institutionalization of the technique within the Ministry of Agriculture's planning programs. Subsiquent surveys will be less expensive and the data base will become much more powerful as ongoing monitoring, allowing accurate crop projections and the modeling of dynamic simulations for different planning options. In between programs for national coverage, less elaborate surveys over limited areas could be flown with a local aircraft and a simpler camera rig such as the one provided for the test shots.

Equipment List for Photo Interpretation in Rwanda

1) minimum of two (2) interpreter stations, four (4) are recommended. Each station consists of a table, chair, wall mounted projector and dot grid. IUCNNR recommends the Halight daylight projector, available in Nairobi at approximately $600.00 ea.

   a) four (4) projectors - $2,400.00 in Nairobi
   b) tables and chairs obtained locally
   c) dot grids and software will be provided free by IUCNNR
   d) computer requirements: any IBM compatible running MD.DOS 3.0, with at least 640K memory, 30mp hard disk and a full carriage width NLO matrix printer - projected cost $1,500 to $3,000
   e) miscellaneous equipment: approximately $1,500.00
      - photo file folders
      - thumb clickers
      - pencils
      - printing up of data sheets, paper and computer supplies

2) additional cost option for Mr. Slaymaker's presence during training - Because of the importance placed on the training of the SESA staff, I would like to attend

at least the last two weeks of the program at IUCNNR. This would give me a chance to meet and become familiar with the SESA staff within the training environment, and would give us a more common frame of reference in the design and implementation of the survey. This is by no means essential to the project, and, if necessary, I would be willing to do it for per diem alone, but I feel the shared experience in Nairobi whould facilitate communications in Rwanda where most of my time will be spent keeping the plane in the air.

BUDGET FORMAT AND OPTIONS

Sampling intensity and scale is a function of cost. Given the discussion of survey accuracy in Appendix #2, the selection of a sampling intensity for this survey has to be a budget consideration and I will outline three (3) options with their relative costs.

A) 1.6% sample, evenly spaced flight lines 2.5K apart with an exposure every kilometer. This is Dr. Norton-Griffiths standard for tabulating locations in Kenya. It would give acceptable accuracy at the medium commune size of 135 sq. K., but less reliable results if pushed to a smaller sized unit.

B) 2.1% sample with flight lines adjusted between 1.5K and 2.5K to maintain a relatively consistent confidence level of results from communes over a range of size.

C) 3% sample with flight lines adjusted between 1.2K and 2K, as above but pushing the statistical resolution of the system at increased cost and man-hours of interpretation.

A-1) Budget 1.6% sample

1) Aircraft and pilot		
a) 112 hrs. @ $250/hr.	=	$28,000.00
b) 5,600 litres fuel @ $1.50/L	=	8,400.00
c) 20% contingency on above	=	7,280.00
d) estimated ferry from Nairobi	=	2,000.00
e) per diem on pilot	=	3,780.00
TOTAL		$49,460.00
2) Exploration Photography		
a) staff time on site	=	$16,800.00
b) per diem	=	14,112.00
TOTAL		$30,912.00
3) Film & Processing	=	$2,400.00
(shipping costs to and from Nairobi for processing in-house)		unknown
Video tape		300.00
TOTAL		$2,700.00
4) Interpretation		
a) 3 man local hire staff for 4.5 months		$4,050.00
b) 2 senior staff for 5 months		4,000.00
TOTAL		$8,050.00

B-1) Budget 2.1% sample

1) Aircraft & pilot		
a) 147 hrs. @ $250/hr.	=	$36,750.00
b) 7,350 liters fuel @ $1.50/L	=	11,025.00
c) 20% contingency of above	=	9,555.00
d) estimated ferry from Nairobi	=	2,000.00
e) per diem on pilot	=	4,937.00
TOTAL		$64,267.00
2) Exploration Photography		
a) staff time on site	=	$21,350.00
b) per diem	=	17,933.00
TOTAL		$39,283.00
3) Film & Processing	=	$3,200.00
(shipping costs to and from Nairobi for processing in-house)		unknown
Video tape	=	400.00
TOTAL		$3,600.00
4) Interpretation		
a) 3 man local hire staff for 5.5 months	=	$4,950.00
b) 2 senior staff for 6 months	=	4,800.00
TOTAL		$9,750.00

C-1) Budget 3% sample

1) Aircraft & pilot		
a) 210 hrs. @ $250/hr.	=	$52,500.00
b) 10,500 liters fuel @ $1.50/L	=	15,750.00
c) 20% contingency of above	=	13,650.00
d) estimated ferry from Nairobi	=	2,000.00
e) per diem on pilot	=	8,032.50
TOTAL		$91,932.50
2) Exploration Photography		
a) staff time on site	=	$28,700.00
b) per diem	=	24,108.00
TOTAL		$52,808.00
3) Film & Processing	=	$4,600.00
(shipping costs to and from Nairobi for processing in-house)		unknown
Video tape	=	600.00
TOTAL		$5,200.00
4) Interpretation		
a) 3 man local hire staff for 8 months	=	$7,200.00
b) 2 senior staff for 9 months	=	7,200.00
TOTAL		$14,400.00

The other major factor which could directly effect cost is if the photo interpretation staff determined that during the pre-reconnaissance testing that they would not be able to successfully distinguish and identify the extremely fragmented crop

combinations at the base scale of 1:7,000. This is unlikely, but in that case it would be necessary to increase the interpretation scale by reducing the coverage of each frame to 2 hectares and exposing two adjacent frames in rapid succession at each sample point. This would not affect flight costs, but would double film costs and probably increase man days of interpretation by 85%.

D) Cost reductions if second daily flight is possible.

These cost estimates are based on the conservative assumption of flying 4.5 hours a day. It is likely that we will often be able to fit a second shorter flight into the afternoon. This will be a function of air turbulance, severe weather, refueling time, etc. This conservative assumption allows some slack in the estimate, but if ideal or "dumb luck" conditions prevailed, savings could be realized between $6,500.00 (A-1), $9,500.00 (B-1) and $13,500.00 (C-1).

PROJECT COSTS

Independent of Sample Intensity

A) Interpretation	
1) I.U.N.N.R. training program	$10,000.00
2) per diem for SESA staff in Nairobi	7,500.00
3) SESA staff wages	800.00
4) hardware for photo interpretation stations	3,900.00
5) computer and printer	3,000.00
6) air fare for SESA staff to Nairobi	800.00
B) Survey Crew	
1) 10 days staff preparation in U.S.	3,500.00
2) travel expenses	7,000.00
3) complete set of 1:50,000 scale topographic maps plus lamination	in-house

TOTAL COST SUMMERIES

Not Including Cost Options

1) 1.6% Sample	-	$127,622.00
2) 2.1% Sample	-	$153,400.00
3) 3% Sample	-	$200,840.50

ADDITIONAL COST OPTIONS

A) Follow-up consultation

1) E. Shirekuli, Computer Manager, I.U.C.N./E.S.U. and/or G. Arara, Chief Photo-Interpreter, I.U.C.N./E.S.U., would be available on a consulting basis to assist with the interpretation and data compilation, either as participants or by doing follow up reviews of the operation at specific stages to catch complications.
   a) Rates each per week - $500.00
   b) per diem - standard A.I.D.
   c) airfare from Nairobi - $400.00

2) Mr. Slaymaker would also be available as needed after the completion of the survey to assist in the interpretation and compilation.
   a) Rate - $1,250.00 per week
   b) per diem - standard A.I.D.

3) Dr. Norton-Griffith may be available for consultation on a weekly basis, pending his schedule with I.U.C.N.
   a) Rate - $1,250 per week
   b) per diem - standard A.I.D.
   c) airfare from Nairobi - $400.00

B) Attendance of training program by D. Slaymaker
   1) last two weeks, per diem only - $1,890.00

C) Second season survey (December 1989)
   (could be lower sampling intensity than primary)
   1) A-1 Budget, 1.6% Sample = $91,122 00 plus $7,000.00 travel expenses for survey crew to return
   2) B-1 Budget, 2.1% Sample = $116,900.00 plus $7,000.00 travel expenses for survey crew to return
   3) C-1 Budget, 3% Sample = $164,340.50 plus $7,000.00 travel expenses for survey crew to return

D) Optional equipment for photo-interpretation
   1) V.H.S. tape player and monitor to review primary unit flight lines - $1,200.00
   2) C.H.R.I.E.S. computer program - $1,000.00
   3) Heward Packard pen plotter - $3,000.00

E) Acquiring Rwandain sample coverage for I.U.C.N. training program
   A sample of actual coverage and ground truch over Rwanda would prove valuable for the training program in Nairobi, but probably not justify teh expense of a special mobilization of the survey aircraft. However, I could fly a limited survey over a known area with visual navigation and a local aircraft. The flight lines would have to be plotted on the existing aerial photographs to allow accurate geo-referencing and careful adjustments made for altitude, but restricting the sample to a limited area of relatively constant elevation would make this possible. Costs as follows:
   1) additional round trip to Nairobi - $400.00
   2) six hours local aircraft @ $90/hr. - $540.00
   3) 4 day day rate per diem - $1,504.00
      Total additional cost = $2,444.00

SUMMARY

APS is not an aerial photo survey in the normally understood sense of the phrase. It does not map features on the ground or chart plant communities. What it does is enumerate a representative sample of ground cover, classify that information to a geographic grid and extrapolate estimates of crop production or land use by administrative divisions. These estimates can also be correlated with any ancillary factor that can be classified to the same grid. Its advantages are:

1) can identify crops and small fields

2) insensitive to weather conditions (is flown below cloud cover)

3) can be flown efficiently during the optimum crop survey periods

4) interpretation requires simple equipment and skills

5) interpretation is more rapid and far less expensive than for high altitude photography

6) training in techniques of low level photo interpretation, geographical data management, and data analysis are available in Nairobi

Its disadvantages are:

1) only 1.6 to 3% of land area is actually photographed (versus 100% with high altitude photography, but versus only 0.17% of land area measured during the 1984 agricultural census)

2) mapping is not possible (only a small portion of land is photographed)

3) no topographical analysis is possible (but these data already exist)

4) data are of much less general use than high altitude photos

5) coverage does not include non-agricultural areas such as national parks or forests

The principal advantage of the APS approach with its training program and in-house capacity is that it creates an institution within the Ministry of Agriculture that can respond interactly with its governments planning process, producing accurate estimates of agricultural use to the specifics and administrative format required by the end users.

Appendix #1

Aerial Survey and Image Acquisition

The aerial survey will be conducted by Dana Slaymaker and Darragh Davis from Exploration Photography with a plane and pilot leased from Jeremy Block in Nairobi, Kenya. Although we could use a local aircraft if modified for the survey, Mr. Block's is a more appropriate choice for several reasons:

1) The aircraft is a Cessna 206 with long range fuel tanks, a GNS500A Series 1 Omega/VLF navigation computer, a radar altimeter, full avionics and twin camera ports, which means it is already fully equipped for APS. Its pilot has flown this type of survey and is familiar with the necessity of maintaining accurate geographic coordinates and elevation above ground as well as the dangers inherent in a low level survey over rugged terrain.

2) Its availability can be contracted and guaranteed now, and its rates are competitive for its speed, flight duration and on-board equipment.

Mr. Slaymaker will navigate, operate the cameras and record geo-referencing and altitude data for each exposure. He has flown surveys in Kenya, Tanzania, Lesotho, Saipan and throughout the southwest United States, and has worked with Dr. Norton-Griffith on previous projects. Since he will be flying one to two flights every day during the acquisition period, Ms. Davis (his wife) will coordinate shipping the exposed film to Nairobi for processing, retrieving the finished transparancies and loging them to their correct flight data. This is a very important part of the procedure because the film is useless if separated from its geographic coordinates. Ms. Davis will also check the slides for exposure and sharpness to catch any camera malfunction and compare the sample photographs to a video tape of their flight line as a double check of both the geographic coordinates and accuracy of the on-board navigation computer. Ms. Davis is fluent in French, which Mr. Slaymaker is not, and can serve as his translator when needed.

The survey will be flown with north/south flight lines spaced between 2.5 and 1.7 kilometers apart depending on the sampling intensity selected for each region. The flight lines will be plotted on a set of the 1:50,000 scale maps laminated into north/south rolls. This will make it easier to verify the accuracy of the on-board navigation and repeat the same flight lines in subsiquent surveys. They will also be used to identify and revisit problem areas that arise in interpretation.

The vertical point photograph will be taken on high speed color diapositive film by a Canon F-1 35mm camera with a 250 exposure back. Flying height and focal length of the lens will be selected to give a nominal scale of 1:7,000 on the 35mm slide, covering 4.2 hectares. I most cases, this will mean an ele-

vation above ground of 1,995 ft. with an 85mm lens, but under low level cloud conditions or light rain, we can drop to 1,150 feet with a 50mm lens. In addition to the 35mm sampling, we will also make a continuous record of the flight lines on video tape and the audio portion of that tape will be used to record the geo-referencing data for each sample. Since the exact scale and location of each photograph is essential to its analysis, the actual foot elevation above ground is recorded from the radar altimeter at the moment of exposure as well as the distance along the flight line from the start point and the distance right or left of track as displayed by the Omega/VLF navigation system. From these two parameters, it is possible to plot the location of each sample photograph onto a map overlay to within 200-300 meters. As the survey progresses, we will plot each sample onto the 1:50,000 scale maps, then transfer the points to a 1:250,000 scale overlay. This overlay can then be used to assign samples to different stratum simply by placing the overlay on the appropriate 1:250,000 scale base map of the stratums boundaries.

Appendix #2

Photo Interpretation of Sample Photography

One of the advantages of APS is the extent to which the extremely large scale photography simplify interpretation, making it possible to compile the data with crews of minimumly trained individuals working under the supervision of a senior interpreter.

The procedure for each sample point is simple and straight forward. With an enlarging system mounted on the wall, each 35mm slide is projected down onto a desk top dot grid at a 10X enlargement factor to give an average interpretation scale of 1:700. The semi-random dot grids consist of an array of 18x12 cells of 2x2 cm in size, with two randomly located dots in each, approximately 1.5mm in diameter, equivalent to 1.5mm on the ground at the average scale. The photo is interpreted only within an inner area of 16x10 cells containing 320 dots, thus overcoming interpretation problems associated with the edges of the field of view.

Count data are simple numerations of objects such as house compounds, buildings with iron sheet roofs, buildings with thatched roofs, or even numbers of individual plants in the case of large crop trees like bananas. In general, the 50% rule is followed, which specifies that 50% or more of the object being counted must lie within the inner interpretation area to be included into the talley.

Area data are measurements of the proportional area of different kinds of land cover, the proportions being expressed in terms of the number of dots falling within each land cover class. Area data can be obtained for individual crops and crop combination, for the canopy cover of natural vegetation, for the land taken up by roads, tracks, or house and for fallow land. The 50% rule is again used to decide if a dot should be included into a particular area measurement.

Qualifiers are recorded on a presence/absence basis and are used primarily to describe the status of land management, the methods of cultivation and the occurance of terracing or contouring.

To the extent that this enumeration requires qualitative judgements, there are procedures to control the accuracy and consistancy of the results. They are reiterative and include the following steps:

1) pre-reconnaissance: the senior staff trained by Norton-Griffith at I.U.C.N.N.R., myself, Dr. Lassiter and other concerned consultants would meet to qualify the range of crop type, crop combination and natural features that should be included as individual photo interpretation classes. This should be

initiated with test flights over known fields before the actual survey (this can be done with a local aircraft and a scaled down camera rig before the training program - see Cost Option E)

2) During the early stages of the survey a wider range of diapositives are examined to check the feasibility of the initial selection of interpretation classes. Classes are subseqently added/deleted, merged/split, and a key formulated which defines the important visual, textural, and other characteristics of each class.

3) At this point, training should proceed with the entire photo interpretation team under the supervision of the senior photo interpreters. Classes are further refined through cross check and discussion between the team. Ground truth in this term is a function of training and interpretive cross checks (see Appendix #3), one of the interpreters should be on any survey flight taken, and make note of the crops, crop combinations, vegetation and anything else they see. In particular, they should note anything they see that they don't understand and these problem areas should be noted on a master map and revisited at the end of the survey so that the observer can clearly see the ground configuration. In this way each member of the interpretation team gains a greater understanding of the context in which the photographs are taken as well as the appearance of land forms and vegetation cover from the air in general, which is difficult to convey without this experience. Additional problem areas encountered during interpretation are bumped up to the senior photo interpreters who can elect to visit them during their next flight to resolve the confusion. A very small portion of the problem areas may require on-site inspection, but in most cases a low overpass and circle by the aircraft will be sufficient. Other than that, there should be little additional actual on site ground truth required once the final interpretation classes have been refined and the visual reference key understood by the team. Typically, some 100 non-overlapping classes will be selected; around 60 covering agricultural land use, 15 classes of intrastructure, and 25 of natural vegetation. Other classes might describe erosion or reclamation activities and a miscellaneous or trash can class. The interpreters record data directly on a tabular sheet which allows efficient visual checking, and the senior interpreter continuously monitors the performance of the interpreters to achieve consistancy of results.

Appendix #3

Sample Analysis and Precision

Aerial Point Sampling is a three level system of the primary unit (the flight lines), secondary units (the photographs taken at spaced intervals), and the quantification of land cover in each photograph. Because administrative divisions, or defined areas within a type (example: communes) are different geographical sizes and therefore contain different amounts of the primary sampling unit, expressing the estimates as densities eliminates the influence of sample unit size on the sample size and the sample variance. If we consider one crop at a time, the basic calculation of this ratio is as follows:

z = the area of the primary sample unit

y = the number of crop hectares enumerated along the primary sample unit (calculated from the individual photographs)

$$R = \frac{\text{total hectares counted}}{\text{total area counted}} = \frac{\sum y}{\sum z}$$

∴ = the survey estimate (Y) for that crop is

$Y = R.Z$

where Z is the total area under survey

The precision of a survey estimate is calculated as follows:

Sy^2 = the variance between the numbers or hectares in all sample units

Sz^2 = the variance between the areas of all sample units

Syz = the co-variance between numbers or hectares and the areas of the sample unit

∴ = the variance of a survey estimate is

$$Var(Y) = \frac{N(N-n)}{n} x (Sy^2 - 2xRxSyz + RySz^2)$$

with standard error $SE(y) = \sqrt{Var(Y)}$

where n = number of sample units in sample
N = total number of sample units from which sample is drawn

The 95% confidence limits of a survey can be calculated by multiplying the standard error by the t value of n-1 degrees of freedom and will improve with the increase of either $\sum y$ or $\sum z$. In other words, an estimate for a larger defined

area will always be more precise than the estimate for a smaller defined area (unless the amount of primary sample unit - flight lines - are increased over the smaller unit), and the estimate of a crop with 10% cover will always be more precise than the estimate of a crop with only 5% cover.

The influence of these factors at a given sampling intensity is shown on Table 1 where the columns of the table represent defined area of different sizes (in square kilometers); the rows of the table represent the mean densities of artifacts or crop areas; and each cell in the table shows, for a given mean density and area, the standard error (expressed as a percentage of the mean) of 95% of all survey estimates. Therefore, this chart can function as a simple look-up table to determine the precision of any particular estimate within that survey.

Given the wide diversity of crops under cultivation in Rwanda, the sampling intensity for an acceptably accurate survey will be determined by the median size of the smallest set of defined areas. In Kenya, which is divided by District, Division, and Location, these are Locations which have a median size of around 200km^2. In six years of surveys covering over 1.2 million square kilometers, EcoSystems Ltd., has found a flight line spacing of 2.5km with a point sample photograph every kilometer to be adequate. At 4.2 hactare coverage, this represents one sample per 2.5 sq. k or 1.6% coverage.

In Rwanda, the smallest defined area would be the communes, which have a median size of 135 sq. k, but also appear to range from 36sq k to 840 sq. k. In these circumstances, I recommend plotting out the communes on the flight maps and actually adjusting the sampling intensity, compressing the flight lines over the smaller units and expanding them over the larger or less densely cultivated. It may also turn out that because of the extreme fragmentation of the Rwandain fields or the types of crop combinations involved, they are difficult to interpret even at the 1 centimeter = 7 meters scale. In that case, we will have to increase the scale of the photographs with a longer lens or lower altitude and then, correspondingly, increase the number of frames exposed at each sample point so as to maintain a 4 hectare sample (a preliminary review of the test flight coverage seems to indicate that this will not be necessary). Since these determinations of adequacy are both subjective and subject to cost, I have included a range of options in the budget.

Two other factors that might have a major affect on the results of the survey are errors and bias in the actual flights or interpretation of the imagery. Errors and bias are two very different things. Errors are random and their cumulative effects cancel out. They affect the precision of the survey estimate and are quantified by its standard error and confidence limits. In contrast, bias is an error in a consistant direction whose cumulative effect does not cancel out. Biases can result from the design of the survey, from the way in which it is flown, or from the analysis of the photographs. They can affect the accuracy of the survey, but can be controlled or held constant and compensated for as long as simple precautions are taken.

For example, it is conceivable that the flight line spacing might harmonize exactly with some feature of the landscape. This possibility is minimized by orientating the flight lines so that they cut across the dominant relief and drainage features in the surveyed area. However, the variances of the estimates from a systematic sample are always biased in an upward (positive) direction. Estimates from systematic samples are therefore, always more precise than indicated by the calculated variances.

Bias can arise from the way in which the aircraft is flown, from inaccurate navigation, poor speed control and poor height control. However, the flight information collected during the survey is used to test whether such biases are present, to estimate their magnitude, and to correct them before the data are analysed.

The GNS500A navigation system virtually eliminates bias from gross errors in navigation. The accuracy of the GNS system has been tested by comparing the GNS lat/long readout recorded when the camera was fired against the lat/long derived from map sheets. The photographs were first plotted on to up-to-date 1:20,000 scale black and white aerial photographs before being transferred to 1:50,000 topographical maps. On a sample of 300 comparisons, the mean error in the GNS navigation system was found to be 380m's (Table 2), which is almost certainly an over estimate.

The height above ground level of the aircraft and [illegible]tained by the radar altimeter is recorded every time a photogra[illegible] is taken so that the scale and area imaged can be calculated exactly. This removes any bias from inaccurate flying. However, if the aircraft is in a straight and level altitude but the ground beneath it is sloping, the area photographed will be larger than that calculated from the height above ground level. The slope of the ground relative to the altitude of the aircraft is, therefore, another potential source of bias.

Table 3 shows the slope angle of the ground under the aircraft for each of 4,200 sample photographs. Also shown is the 'correction factor', namely the amount by which the area of each photograph calculated from the height above ground level must be multiplied to take the slope into account, assuming that the direction of any slope was parallel to the direction of flight. Over the whole set of photographs, the mean correction factor is only 1.0080, so the influence of this source of bias is negligible.

In general, bias from photo interpretation is minimized first by training the photo interpreters on the interpretation key being used, and second by carefully monitoring and checking their performances while the photographs are being analysed.

The presence of bias can be detected by carefully re-analysing a sub-sample of photographs, treating the recounts as giving the more accurate information. Table 4 shows the results of recounting the number of houses and other buildings on a sub-sample of 429 photographs. Over the whole sub-sample, the recount gave a figure of 1,886 buildings compared to the original count of 1,818 buildings, a difference of 3.7%

The most important data derived from the 35mm diapositives are the estimates of crop area, cultivation and other aspects of land use. Table 5 presents an analysis of a recount of 116 'areas' measured off a sample of 35mm diapositives. A total of 258 recounts were carried out on areas ranging from less than 5% of the field of view to over 50% of the field of view. In no case are any of the recounts significantly different from the original counts.

Whereas the data in Tables 4 and 5 test the consistency of the photo interpreters under operational conditions, a controlled experiment was set up to test if there was any bias in the estimation of sizes and shapes arising from the design of the dot grid itself. Seven areas were chosen (Table 6) ranging from 92 m^2 to 3670 m^2 at the average interpretation scale, the expected number of dots ranging from 1 to 40. Each area was counted in seven different shapes in which the ratio of length to breadth varied from 1:1 (Shape A) to 1:25 (Shape F). Shapes A-E simulate fields, while Shape F simulates long thin linear features such as roads and hedges.

Fifty dot counts were carried out on each combination of size and shape (Table 7). The first important result is that none of the estimates show any bias, and in no case is the mean estimate of a size/shape combination significantly different from the expected value. Furthermore, the standard errors of the estimates are all acceptably small. The dot grid is, therefore, providing acceptably precise and apparently unbiased estimates of areas of different shapes. Indeed, a two-way analysis of variance (Table 8) shows that the shape of the area is having no influence at all on the number of dots being counted; the only influence comes from the size of the area.

TABLE 1. Standard errors of survey estimates (expressed as per cent of the estimate)

Ha/ km²	Area (km²) 50	100	200	400	600	800	1000	2500	5000	>5000	%
0.02	95	68	50	36	30	27	24	17	13	11	8
0.04	68	50	36	27	23	20	18	13	11	9	3
0.06	57	41	30	23	19	17	16	11	9	8	3
0.08	50	36	27	20	17	15	14	11	9	7	2
0.10	45	33	24	18	16	14	13	10	8	7	6
0.20	33	24	18	14	12	11	10	8	7	6	9
0.40	24	18	14	11	10	9	9	7	6	6	7
0.60	21	16	12	10	9	8	8	6	6	5	5
0.80	18	14	11	9	8	8	7	6	6	5	5
1.00	17	13	10	9	8	7	7	6	5	5	9
2.00	13	10	9	7	7	6	6	5	5	5	10
4.00	10	9	7	6	6	6	5	5	5	5	7
6.00	9	8	7	6	6	5	5	5	5	4	3
8.00	8	7	6	6	5	5	5	5	5	4	2
10.0	8	7	6	5	5	5	5	5	4	4	5
20.0	7	6	5	5	5	5	5	4	4	4	7
40.0	6	5	5	5	5	4	4	4	4	4	4
60.0	5	4	4	4	3	3	3	2	2	1	2
80.0	5	4	3	3	3	2	2	2	2	1	3
%	10	19	29	14	10	5	3	6	3	1	100

TABLE 2. Comparison between GNS500A position fixes and map references

	Absolute error	East-West error	North–South error
No. of comparisons	300	300	300
Mean (m)	380	250	240
Standard deviation (m)	210	200	180
Standard error (m)	12	12	10
Nominal accuracy (m)	261	185	185

TABLE 3. Correction factors for mean slope angles

Slope angle (degrees)	f (%)	Per cent of photographs	Correction factor*
0	7	10	1.0000
1	21	22	1.0003
2	18	17	1.0011
3	14	14	1.0026
4	12	9	1.0046
5	7	7	1.0073
6	4	4	1.0105
7	3	3	1.0143
8	3	3	1.0188
9	2	2	1.0239
10	1	1	1.0297
11	1	1	1.0361
12	2	1	1.0433
13	1	1	1.0512
14	1	1	1.0599
15	1	1	1.0649
16	1	1	1.0798
17	1	1	1.0910

TABLE 4. Recounts of houses and structures from 35 mm diapositives

No. of frames	Mean of first counts	Total houses on first count	Total houses on second count	Per cent difference	Mean of second counts	SE (%)
126	1	126	128	+1.6	1.02	9.6
63	2	126	136	+7.9	2.16	7.2
83	3	249	262	+5.2	3.16	6.3
32	4	128	135	+5.5	4.22	5.4
21	5	105	112	+6.7	5.33	6.8
26	6	156	163	+4.5	6.27	7.2
8	7	56	59	+5.4	7.38	6.4
18	8	144	151	+4.9	8.39	3.9
16	9	144	147	+2.1	9.19	3.4
8	10	80	80	0.0	10.00	3.2
8	11	88	90	+2.3	11.25	3.8
4	13	52	53	+1.9	13.25	3.5
4	14	56	56	0.0	14.00	3.6
4	15	60	62	+3.3	15.50	3.6
4	16	64	65	+1.6	16.25	3.2
4	19	76	76	0.0	19.00	3.8
4	27	108	111	+2.8	27.75	1.9
429	4.24	1818	1886	+3.7	4.40	2.5

TABLE 5. Recounts of crop areas from 35 mm diapositives

Crop cover	Original counts			Re-counts		
	n	Mean	SE (%)	*n*	Mean	SE (%)
0–5	16	3.2	6.6	37	3.2	4.5
5–10	23	7.3	3.9	51	7.3	2.7
10–15	12	12.6	3.7	29	12.7	2.2
15–20	8	16.3	1.7	19	16.3	1.4
20–30	26	22.9	2.3	57	23.3	2.5
30–40	14	37.2	2.2	30	36.9	1.5
40–50	7	46.7	2.4	13	46.1	2.0
>50	10	63.9	5.3	22	63.1	3.5

TABLE 6. Shapes and sizes for testing dot grid bias

Expected dots:	1.0	3.5	8	13	20	29	40
Hectares:	0.01	0.03	0.07	0.12	0.18	0.27	0.37
Square metres	92	321	734	1193	1835	2661	3670
Dimensions of shapes (m)							
A 1:1	10×10	18×18	27×27	35×35	43×43	52×52	61×61
B 1:1.5	8×12	15×23	22×23	28×42	35×53	42×63	49×74
C 1:2	7×14	13×26	19×38	24×48	30×60	38×76	43×86
D 1:4	5×20	9×36	14×56	17×68	21×84	26×104	30×120
E 1:11	3×33	6×66	8×88	10×110	13×143	16×176	18×198
F 1:25	2×50	3×107					

Note: Dimensions (m) of each shape A–F are approximate.

TABLE 7. Results of bias test on dot grid

Shape		Expected dots						
		1.00	3.50	8.00	13.00	20.00	29.00	40.00
A 1:1	x	1.06	3.72	8.00	13.14	19.68	28.14	39.20
	SD	0.76	1.01	1.26	18.60	3.64	4.72	3.19
	SE	0.11	0.14	0.18	0.26	0.51	0.67	0.45
	SE (%)	11	4	2	2	3	2	1
B 1:1.5	x	1.02	3.52	7.84	13.28	20.47	29.26	40.16
	SD	0.84	1.20	1.62	1.80	2.10	2.66	3.09
	SE	0.12	0.17	0.23	0.25	0.30	0.38	0.44
	SE (%)	12	5	3	2	1	1	1
C 1:2	x	1.18	3.54	7.60	13.24	20.33	29.24	39.80
	SD	0.94	1.22	1.56	1.42	2.46	2.95	3.39
	SE	0.13	0.17	0.22	0.20	0.35	0.42	0.48
	SE (%)	11	5	3	1	2	1	1
D 1:4	x	1.18	3.60	7.62	13.00	20.52	29.50	39.98
	SD	0.94	1.34	1.61	1.84	3.05	2.96	3.10
	SE	0.13	0.19	0.23	0.26	0.43	0.42	0.44
	SE (%)	11	5	3	2	2	1	1
E 1:11	x	0.96	3.50	7.56	12.78	19.58	27.84	39.82
	SD	0.86	1.49	2.17	2.89	3.61	5.29	5.63
	SE	0.12	0.21	0.31	0.41	0.51	0.75	0.80
	SE (%)	13	6	4	3	3	3	2
F 1:25	x	0.98	3.62					
	SD	0.91	1.32					
	SE	0.13	0.26					
	SE (%)	13	7					

Appendix #4

Option for Geographical Information Systems

The users guide for the IUCNNR's Point Information Management System is included in this appendix and contains an exhaustive explanation of the program with examples of data output. However, a more general discussion of G.I.S.'s is warrented, since these systems have been subject to misunderstandings that lead to disappointment on the part of the end user about their capacities and limitations.

Part of this confusion rises from the fact that the range of apparantly very similar G.I.S. programs available actually represent a case of convergent evolution, in as much as they developed from two different disciplines with different objectives; resource management and cartography. To oversimplify this history, there are two basic types of G.I.S. which are only partially compatible at the P.C. level. The vector based system stores and expresses data as points, arcs, and polygons. It grew out of the computerization of cartographic plotters where the emphasis was on digital elevation models and the quality of map products. ARC/INFO from Environmental System Research Institute of Redland, Ca., represents state-of-the-art for this type. The other type of G.I.S. files data in reference to cells within a spacial grid. They are the result of rescurce management programs concerned primarily with the efficient tabulation and comparison of atributes. Map preparations are limited to thematic displays of revelent cells, but data manipulation is faster and more efficient. Ofcourse, as the systems attempted to co-exist, programs have developed to vectorize grid cells and rasterize vectors, but they can be slow and difficult to operate at the micro-computer level. For instance, E.S.R.I. has a grid cell conversion program in their main frame program but not P.C. - ARC/INFO. On the other hand, proponents of Michigan States' Comprehensive Resource Inventory and Evaluation System (C.R.I.E.S.) which is probably the state-of-the-art grid program, claim to be able to produce maps indistinguishable from a vector based system.

P.I.M.S. is firmly esconced in the grid system. Therefore, if S.E.S.A. or ASPAP wants to expand its capacities to produce maps or format digital elevation programs and terrain feature analysis (line-of-site determinations or detailed slope modeling, etc.), it will have to add on additional systems that remain compatible with the original data base.

The Technosynthesis land use maps are available on computer tape, in a rasterized and multi-strata form. These could prove an invaluable data base to the program, but will probably have to be reformated to whatever system is used.

I've talked to proponents of both systems and remain confused myself as to their relative virtues. However,

ARC-INFO costs $15,000.00, whereas G.R.I.E.S. project at Michigan State supplies their program on a non-profit basis for $1,000.00. Also, Scott Witter has said they could convert the Italian tapes for the project.

ANNEX 1

P-O-I-N-T I-N-F-O-R-M-A-T-I-O-N M-A-N-A-G-E-M-E-N-T S-Y-S-T-E-M

User Guide For Release 4.0

IUCN Eastern Sahel Unit
Nairobi, Kenya

May 1988

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CHAPTER 1: Overview of PIMS

1.1. The Concept of a PIMS Data Base

A PIMS data base is made up of a set of data records each of which represents a unique **sample point**. The sample points are spread throughout the geographical area for which the data base is created. They can be distributed randomly, or systematically, at an even density or at variable densities. They can be systematically distributed in some parts of the study area, and randomly in others; and at varying densities in both.

If necessary, the sample points can represent the precise location at which an observation was made, for example from a sample aerial photograph. Alternatively, they can represent the centre points of UTM grid cells, or AVHRR pixels, or the centroids of a set of polygons such as population census zones.

The sample points can represent whatever the user of PIMS needs to set up his data base. However, they set the ultimate resolution of the PIMS data base, for data cannot be integrated, stored or analysed at a resolution finer than that of the individual sample points.

PIMS recognises each individual sample point by a unique **transect/sub-unit** code (the etymology of the transect/sub-unit dates from the early origins of PIMS), and there is a one-to-one correlation between an individual sample point and an individual record in the data base. Both share the same transect/sub-unit code.

The first step, therefore, in creating a PIMS data base is to establish the precise location of the sample points and their unique transect/sub-unit codes. An overlay, at various scales, is also essential, so that the sample points can be physically represented on maps and other thematic material.

The next step is to assign the sample points to whatever polygons the user wants. These polygons can be Districts, Divisions and Locations; population census units; agro-ecological zones; altitude or slope classes; AVHRR/NDVI strata; distance from roads or rivers; catchment areas of boreholes, hospitals or service centres; soil types; vegetation zones; or UTM grid cells.

The polygons fulfill two purposes in a PIMS data base. First, they allow any data associated with a set of polygons to be incorporated into the data base. For example, the characteristics of each soil type can be brought into the data base; or the population density and age structure within each census unit; or the transport cost at varying distances from a road; or the climatological variables associated with each agro-ecological zone. Second, the polygons are used for the output of data.

These are the two basic functions of PIMS, which permit PIMS to integrate data from different spatial units. For example, rainfall can come into a PIMS data base by agro-ecological zone, and be tabulated by District. Or population density can come in from census units, and be tabulated by soil type, and mapped by UTM grid cell. Data are in effect "atomised" at the sample point level, and are later condensed again in any appropriate format.

The data structure of PIMS is very simple. All data variables are associated with all sample points and with all data records, and every data record has a value for every variable in the data base.

Assume, for example, that the sample points are coded for Districts. There will be a variable in the data base called "DISCODE", which will have a set of permitted values, such as "01" for Kericho, "02" for Kiambu, "03" for Narok, and so on. Each sample point is associated with an individual District, and so is each data record. Every record will have a value for the variable "DISCODE".

The sample points may also be coded for distance from a main road. Again, the data base will hold a variable called "DISTROAD" with values "01" for within 5km, "02" for within 10km and so on. Every data record will have a value for "DISTROAD".

There might be a transport cost "TRANCOST" associated with each value of "DISTROAD", 50 units for within 5km, 290 units for within 10km and so on. Every data record will have a value for "TRANCOST". It will come into the data base in the form of a look-up table, which will give a value of "TRANCOST" for each value of "DISTROAD". Once the data base is updated with TRANCOST, then the average transport cost for each District can be calculated.

By atomising all data at the sample point level. PIMS provides instantaneous overlays of all polygons and their data, in any combination. Furthermore, since every data record has a value for every variable, it is straightforward to recombine and modify variables in the data base.

PIMS follows the conventions of the dBaseIII standards, so all data files and output files are freely transferable between packages. PIMS provides data integration, and does not attempt to emulate statistical or mapping packages. Data may be transferred to such packages for processing as and when required.

A final point to note about PIMS is that it is designed for regional applications at reconnaissance level. Typical PIMS data bases cover areas of between 5,000 and 60,000 square kilometres, with a resolution of one sample point to 3Km2 in the smaller areas and perhaps 1/25Km2 in the larger areas. PIMS is not designed for high resolution data bases in small study areas.

1.2 PIMS Features

Programming Language

PIMS is a suite of modular programmes written in Clipper (Winter '86) which is a compiled version of the Ashton Tate dBase3+. Although a detailed knowledge of dBase3+ is not required to use the PIMS system successfully, a passing knowledge will be of advantage.

Since all PIMS data files and data structures follow the dBase3+ conventions, it is easy to transfer data to and from PIMS. For example, completed Tables can be sent to any word processing package to be included into a Report; or data can be sent to Lotus 123 or to a statistical package for sophisticated modeling or analysis.

Projects, Variables and Files

Projects

In the PIMS environment, individual data bases are identified by a four character **Project Code**. All data reside in a directory named with this same code, and all data files have the code as the first four characters of their names. A special file in the PIMS directory called the **Projects File** keeps track of all projects created by PIMS.

Variables

Each variable in a PIMS data base is identified by a two character code, a data type, a short name, and a full name. The unique two character code is generated automatically by PIMS and is used primarily for internal housekeeping purposes. They are mostly transparent to the user.

The data type tells PIMS where variables are, and what to do with them. Five data types are recognised, class, index and numeric, and two special 'CC' and 'DD' types which are held in a packed format.

The eight character short names are used for all routine data base applications, and form the column and row headings of Tables. In contrast, the 40 character full name allows a much more complete description of each variable, and is used in Table and Map headings. Furthermore, each value of a class variable has an individual short name and full name.

Housekeeping

PIMS has very efficient housekeeping functions which keep track of all activities. File names are generated automatically, and only the description of the file must be entered. A special **Files File**, residing in the PIMS directory, holds details of all created files. PIMS even selects the most appropriate file for each application. This selection is usually correct, but can always be overruled. All other aspects of file management and variable management are transparent to the user.

1.3 PIMS System Modules

PIMS consists of five modules all driven by menus, the opening system menu giving access to all system modules. The user operates along branches spreading away from the opening menu.

MODULE 1: Create New Project

By creating a small, self-contained Project holding just those variables of interest for just the areas of interest, a planner can concentrate on the data of immediate importance to him, and keep his special files, data and analyses separate from all other users.

Hint: It is also extremely useful to have a small project for learning the PIMS routines on and for trying out the data retrival and manipulation procedures.

The user first enters a four character Project Code and a description of the project which are entered into the Projects File. PIMS then creates a new directory named with the project code, and all project files and project data reside within this directory. Furthermore, PIMS uses the project code as the first four characters of all file names created for the project.

The user next selects all, or a range, of data records from the data base and all, none, or a range, of variables from each data record. The short names of all variables are displayed on the screen and the user simply indicates which ones are wanted. PIMS then copies the requested data records and variables over to the new directory, naming the files as it does so.

MODULE 2: Data Retrieval

Creating a Table

Data are retrieved from a PIMS data base in the form of Tables. The rows of the tables are restricted to one of the class data variables, while the columns of the Table can be any variable in the data base.

From a screen display of all short names, the user simply selects a row variable and a column variable. For example, selecting Divisions and Maize will produce a Table showing the hectares of maize in each Division (Table 1).

The five data types are treated somewhat differently in the table routines. Numeric, 'DD' and 'CC' data types are totaled within each selected stratum to show the total numbers or hectares within each (e.g. Table 1). In contrast, index variables are averaged and show, for example, the average slope angle within each Division (Table 2).

Class data are treated quite differently in the Cross Tabulation routines. These produce a Table showing the area (in square kilometres) of each value of the class variable within each stratum. Table 3, for example, shows the square kilometres of land classified as being of 'High', 'Medium' and 'Low' potential in each Division.

A third kind of Table is the Frequency Table which analyses the area of each stratum and the number of sample points falling in each (Table 4). They are used primarily for validating a new stratum, or class variable, after it has been entered into the PIMS data base. They are also used to validate the selection of only a few out of a range of strata.

A Condition can be defined when creating any of these Tables. For example, Maize "above 500 meters".

Manipulating Tables

During Table creation, PIMS restricts Tables to a single row variable (e.g. Divisions) and a single column variable (e.g. Maize). It does this to keep things as straightforward as possible, and so that each Table can be checked individually. Subsequently, the Tables can be manipulated in many different ways.

Tables can be merged so that their data appear together. For example, Table 5 contains the data on Maize from Table 1 and Average Slope Angle from Table 2.

Hierarchical tabulations are achieved by Appending Tables onto one another. Table 6 shows the population for each Division followed by the population for each Location in each Division. This was achieved by making individual tables of population for Divisions and Locations, and then appending them.

New Variables can be made in a Table once it has been created. In Table 6, the new variable POPDEN displays population densities as opposed to population totals. It was made by dividing the variable POP79 by the AREA of each stratum.

MODULE 3: File Management and Utilities

This module contains a useful set of file management routines and file utilities. They allow a user to find out all about the files relating to a particular project.

Project Description

This facility list all information on all files in a Project. It allows a user to obtain a complete listing of all data variables and all data files, with their full descriptions.

File Catalogue

This provides a printed catalogue of files for a given project. The catalogue can contain all the files or just a selected file type, for example only Table files. The catalogue lists the file name, date of creation and a short description of each file.

File Structures

These routines list the structures of all, or selected, files. The structures show the file name, the date of creation, the number of records in the file, and the individual variables. This is extremely useful for the precise identification of files. Up-to-date file structures should always be obtained when creating new variables from existing variables.

File Contents

These routines print the contents of all, or selected, files in a standard format.

File Maintenance

These consist of a number of specialised utilities for file maintenance.

Backup and Restore creates backup copies of files, and later restores them to use. Export Files allow files to exported out of the PIMS environment for use by other software packages such as Lotus 123, dBase3+ or SPSS.

Selective Copy and Merge allows selected little bits to be cut out from a number of files and merged for polished data presentation. Delete Variables allow unwanted variables to be dumped, while Delete Files allows whole files to be deleted from the system.

Change Defaults

This allows the current PIMS configuration to be changed. PIMS can be switched between Projects; entire Projects can be deleted; printers can be changed; and new ones defined for PIMS to use.

MODULE 4: Grid Square Mapping

UTM grid cells form extremely convenient thematic mapping units, and any variable or combination of variables in a PIMS data base can be mapped. These UTM grid cell maps provide a significant aid to development planning and compliment the always somewhat dry data tabulations by showing the distribution of resources throughout the planning area.

Creating Maps

Map Files are really just specialised Table files, only the data are tabulated for each individual UTM grid cell. From a full screen display of all variables, the user simply selects a variable for mapping.

Numeric data types are converted to show the numbers per square kilometer or the hectares per square kilometres within each grid cell. Thus, a grid cell map of maize will show the hectares /km2 in each cell, while one of population will show the numbers of people /km2 in each grid cell. Index data types are averaged, as they are in normal Tables. A map of elevation will thus show the average elevation in each grid cell.

Class data types are treated quite differently and are presented as the most frequent value in the grid cell. A map of agro ecological zones will thus show the most frequent value for AEZ in each grid cell.

Printing Maps

Maps can be produced for the whole of a planning area or for a selected part of it (known as a "window"). Headings and legends are provided by the user at the time of mapping, and a map key is created automatically. The map key refers to the entire map; but if a window is printed PIMS makes a separate key just for the window, but does not store it permanently.

Manipulating Map Files

Map files can be manipulated in same kinds of ways as other files. Files can be merged so that a single file contains many variables for each UTM grid cell, new data variables can be created, and files can be exported to other software packages.

MODULE 5: Modify Data Base

PIMS provides powerful routines for modifying and updating a data base. The three important routines are Create New Variables, Input a Lookup Table and Input a New Stratum.

Hint: New users are strongly advised to practice these procedures on a small test project created specifically for this purpose.

Create New Variables

New variables (Newvars) can be created at any time in a PIMS data base, and they differ from new variables in the Tables or Map files in that these routines make a permanent change to the data base. PIMS places two important restrictions on the ways in which Newvars are created and data variables are manipulated.

First, a new variable must be defined in full to PIMS, including the two character code, the data type, the storage requirements, and the short and full names, before it can be entered into the data base.

Second, no variable already existing in the data base can be modified directly. It must first be copied into a new position with a new name. These two restrictions avoid the worst sort of disasters in which important data variables are overwritten or modified by mistake.

Newvars are created interactively using the dBase3+ language, using the variable **codes**. This is the only place in PIMS where the codes are used, and it is **most advisable** to have a recent listing of the structure of the Position File **before** starting to modify the variables.

Using the dBase3+ language potentially gives enormous flexibility to the ways in which data variables can be manipulated and transformed. In principal, population might be projected to ten and twenty years ahead to generate insights into demand for land and services; or elevation, temperature and rainfall might be related through a regression equation to predict the yield of a certain crop. Data might also be manipulated to create new class variables, of crop suitabilities, or land potentials, or areas of projected surplus/deficit of resources. These new classes can themselves form new strata for analysing data.

In practice, however, the PIMS routines are deliberately restrictive, and the user is encouraged to carry out complex data manipulations outside the formal PIMS environment, using dBase3+, Lotus or SPSS. The PIMS data file will not be affected by this, so long as the new variable has been defined in advance to PIMS, and so long as the basic structure of the data file is not altered. It is most adivsable to make a copy of the Position File (using selective copy) before modifying and manipulating data variables.

Note: The 'DD' and 'CC' variables that are held in a packed format cannot be manipulated until they are unpacked by converting them to the NN or ID format and passing them up into the main Position File.

Input New Look-Up Tables

Completely new data are entered into a PIMS data base in a way very similar to that in which data are retrieved from it. In data retrieval, Tables are created which summarise selected data for selected strata,

for example maize hectares for each Division. In data entry, a **Look-Up Table** is created which contains new data for the same set of strata.

In this way, any data relating to any existing stratum in the data base can be entered by means of a Look-Up table. For example, data on crop production, health and school attendances which have been collected for all (or some) locations can be entered by simply creating a Look-Up table. In the same way, all data associated with the agro ecological zones can be entered into the data base. This is one of the most powerful and useful features of the PIMS software.

When creating a Look-Up table, the user first defines to PIMS the strata (for example Divisions) and each of the variables to be entered (in terms of codes, data types, and names). PIMS then creates the Look-Up table ready for manual entry of data. The Look-Up table can then be listed, validated and edited before the data are finally entered into the data base. Table 7 shows a Look-Up Table holding the rates of population increase in each Division.

Once the the Look-Up table has been created by PIMS, the data may be entered into it by any other programme (dBase, Lotus, SPSS etc) just so long as its basic structure remains unchanged. This gives quite extraordinary flexibility to the ways in which data can be manipulated. Data can first be organised and retrieved in the form of a Table; exported to a statistical analysis package for detailed analysis; and then the results can be taken back into the data base in the form of a Look-Up table.

Input New Strata

It may sometimes happen that a completely new set of strata are required in the data base either for for data retrieval, or for data entry, or for both. Examples might include special development areas within which different approaches to development are planned; geological strata for investigating mineral potentials; or catchments and sub-catchments for watershed management.

In each of these examples a new set of strata must be entered into the data base. This is achieved by simply assigning each individual data record in the PIMS data base to an individual stratum. PIMS has simple routines for doing this, and for checking that all records are assigned, that no record is assigned to more than one stratum, and that no rogue or non existent records are entered.

The data identifying a new stratum is entered from a **From-To** file (Table 8). Here each record assigns a set of data records to an individual stratum.

Once a new stratum is entered it can be used for both data retrieval and for data entry. It is used in data retrieval by selecting the new stratum as the row variable in a Table. It is used in data entry by selecting the new stratum as the basis of a Look-Up table.

Hint: Two important tests should be carried out before a new stratum is used. First, make a frequency table and check that the areas agree with the map. Second, **map** the stratum to ensure that all TR/SUs were assigned correctly.

CHAPTER 2: SYSTEM STRUCTURE

2.1 Disk Management

Selecting The Disk Drives

PIMS will run on any combination of disk drives, but is most usually configured to run on a hard disk. In any event, run time prompts at the opening menu allow the designated drives to be changed.

The PIMS Directory

The PIMS programmes and system files must reside in a directory called PIMS. This directory will contain the following files:-

PIMS.BAT	a batch file to load the programme
APS.EXE	the PIMS programmes
ECOSYSIMS.$$1	control file with configuration data
SKELETON.DBF	a skeleton file structure
APSREPLY.PRG	must be there to fool MS.DOS
PROJECTS.DBF	a housekeeping file logging all PIMS projects
FILES.DBF	a housekeeping file logging all PIMS files
name.PDF	printer definition files

Running PIMS

PIMS can be run in two ways. The most convenient is to include a path to PIMS in the normal AUTOEXEC.BAT file. PIMS can then be run from anywhere on the disk simply by typing PIMS. Alternatively, go to the PIMS directory (cd\PIMS) and load PIMS.

PIMS Programming Language

PIMS is written in Clipper (Winter '86), a compiled version of dBase3+, so the data files and data structures all follow the conventions of dBAse3+. Although a detailed knowledge of dBase3+ is not required to use PIMS successfully, a passing knowledge will definitely make life easier.

The great advantage of following the dBase3+ standard is that PIMS data can be easily transferred from PIMS to other packages, such as dBase3+ itself, LOTUS 123, SYSTAT, SPSS among others. Similarly, data created by these packages can easily be taken into the PIMS data base environment.

It is therefore possible to gain access to the PIMS data files "through the back door" by using dBase3+ rather than PIMS. However, users are **strongly warned against doing this.** PIMS is a very tight system, with numerous cross checks and housekeeping routines. If you break in through the back door, the system may well crash in some spectacularly unpredictable ways. Users are also **strongly advised** not to crash out of PIMS (Alt C) instead of going out through the menus. Although this is often a bore, it allows PIMS to tidy up all the work files and put the data safely to bed.

Project Directories

All the data files for a PIMS data base reside in a project directory. This directory is named with a user selected, four character **Project Code.** All data files for this project have this four character code as

the first four characters of their name, and the code is stored, along with a description of the project, in the **Projects File** in the PIMS directory.

When using PIMS, the first screen prompt is to select a project. The four character code is entered, and this sets a path to the correct directory. The path is changed whenever a new project is selected.

When a new project is created, by selecting a sub-set of data from the main data base, PIMS stores the code and project description in the Projects File, creates a new directory, and sets a new path. PIMS also renames all files and data transferred across into the new project.

When a project is deleted, PIMS deletes all files in the directory, deletes the directory, and removes the project code and description from the Projects File.

HINT: If a project is deleted by mistake, use undelete utilities (such as NORTON). First undelete the directory; next undelete the files. This will work if you undelete immediately, and have not done anything else on the disk. You will then have to use dBase3+ to put the project code and description back into the Projects File; and the name of every file and its description into the Files File, both in the PIMS directory. Good Luck! it is best not to delete the project by mistake.

Housekeeping

PIMS has very exact housekeeping routines to help you along, especially concerning files. Every file is named by PIMS when it is created. A full description of the file must be entered, after which the name and description is stored in the **Files File** in the PIMS directory. The file descriptions **are** important. They remind you what is in the file when you come back in six months.

When creating and naming a file, PIMS automatically selects both the correct file type and the correct generation number. Generation numbers run from 01 to 99, after which files must be deleted before new ones can be created (PIMS fills in the gaps when files are deleted).

When deleting a file, PIMS removes it from the directory, and purges its name and description from the Files File.

Generally speaking, PIMS will always select the correct file and generation number for whatever routine is being used, the convention being that the most recently created files is the one that is to be worked on. However, this selection can always be overruled.

2.2 Data Variables

All variables in a PIMS data base are described by their code, data type, field width and decimal points, short name and full name. These details are stored in the **Code File** (Table 9), and the PIMS housekeeping routines updates the Code File when new variables are created, and removes them from both the code file and from all data files if they are deleted. A deleted variable is truly deleted, and there is no way of bringing it back to life.

Data Codes

Each variable is defined by a unique two character **Code.** These codes are generated automatically by PIMS and are used mainly for internal housekeeping. There remains, however, one routine where the codes must be used.

Data Types

PIMS recognises five **Data Types**, class, index and numeric, and two special 'CC' and 'DD' types that are held in a packed format. The data type tells PIMS where the variables are, and how to use them in the data base routines.

Class (Type CL)

Class variables have discrete values which cannot be treated mathematically. Thus, the class variable "Nation" might have the values '01', '02' and '03', indicating 'English', 'French' and 'American'. Table 10 shows the values of the class variable 'District'. Each value is quite distinct; there is no such thing as an 'average District'.

In the PIMS environment, these class variables usually represent contiguous geographical strata. They have two important uses. First: they are used to analyse data (Table 1), each value of the class variable forming a row of a Table. Second: they can be used to create a Look-Up Table for entering new data into the PIMS data base.

Numeric (Type NN)

Numeric data types store **totals**; the total hectares of maize, the total number of people, the total number of houses, the total hectares of natural vegetation. When analysed, numeric variables return the totals within each selected stratum (Table 1).

Index (Type ID)

Index data types store continuously varying values which are to be **averaged** rather than totaled. Examples are slope angle, elevation, distance from towns, maize yields (Tonnes/Ha), rates of population increase. Within a stratum these values are averaged (Table 2) to give the average slope angle, the average elevation, the average maize yield, the average distance to towns.

Special Cases (Types 'CC' and 'DD')

The 'CC' and 'DD' variables are numeric data types, derived from sample aerial photography, and packed in a special format to reduce disk storage requirements. 'CC' variables generate **total numbers** (the 'CC' indicating a count on an aerial photograph) and 'DD' variables generate **total hectares** (the 'DD' indicating that the data derived from a dot-count on an aerial photograph).

Note: Some versions of PIMS may show 'SC' variables. These are derived from strip counts in low level air surveys, they are also stored in a packed format, and they generate total numbers (of animals) like the 'CC' variables.

These variables are packed to save disk storage but are accessible for analysis by the ordinary PIMS routines. They cannot, however, be manipulated or changed while they are packed, but must be first

unpacked. There is a special routine in the Modify Data Base module for doing this.

Field Width and Decimals

This defines the width of the data field required by a variable, and the number of decimal places. These follow the dBase3+ conventions, in that the decimal point is **included** in the field width. The field xxxx.yy is thus defined as width=7, decimals=2.

Short and Full Names

The short and full names are used by PIMS as column headings (short names) and Table headings (full names). The short names are particularly important, for they appear in all variable selection routines. The eight character short names should therefore give a good indication of what the variable is. The name XX01/4 is quite valid, but means little to the casual observer. In contrast, POP79 suggests the variable has something to do with population numbers in the year 1979.

Important Note:

The individual values of each class variable also have short and full names (Table 10). The short names, however, must be chosen with care because they are used to create **variable names** in cross tabulation routines. Therefore, the short names must begin which a character; and can contain only the characters A - Z, 0 - 9, and the underline; in other words they must conform to the dBase3+ convention for variable names.

Defining a New Variable to Pims

Any new variable entered into the data base, or created within the data base from existing variables, must be defined in full to PIMS. PIMS automatically selects the two character code, using the next one available while avoiding certain illegal or reserved codes. The user, however, must enter the data type, the field width and decimals, and the short and full name. These are all stored in the Code File.

Control Variables

PIMS makes use of a number of control variables which are mainly transparent to the user.

TRSU	N 7.0	The transect/sub-unit uniquely codes each record in the data base. The TR/SU also **relates** directly to an individual sample point within the study area which is defined by the same TR/SU code.
TR	N 4.0	The individual transect number.
SU	N 3.0	The individual sub-unit number.
Big_A	N 8.2	The area (km2) represented by each sample point in the study area.
Little_A	N 8.2	The area (hectares) of each sample photograph at each sample point (if sample photographs were used as a source of data).

NSAMPLES	N 5.0	Returns the number of sample points falling in any stratum of the data base.
XYL	C 4	The XX-YY internal code for UTM grid cells. Note that although this is a Class variable it is not available for use as a stratum since the code XY is reserved for system use only.
AOL	C 4	A copy of the XYL variable. This Class Variable is available for use, either for making tables of XY values, or for entering into the data base data organised by UTM grid squares.

Three of these variable concern the user of PIMS. Big_A generates in every table the area (in square kilometres) of every stratum, while NSAMPLES generates the number of sample points in each stratum (see Table 1). These are useful, for they can be used for weighting the rows of the Table should the data be exported to a statistical programme for analysis.

The third important control variable is the **TR/SU**. This identifies uniquely each individual record in the data base, and it relates directly to a sample point in the study area. The TR/SU are used to define new strata to the PIMS data base, by assigning each sample point, and therefore each data record, to an individual stratum.

2.3 PIMS FILES

File Names

File names are created automatically by PIMS from the project code, the file type and the generation number.
The file name **DEMOPS01** is thus made up as follows:-

Project:	DEMO	
File Type:	PS	Postion File
Generation:	01	The First PS File Created

All files with the same project code reside in a directory of the same name. Each file type is used in different parts of the PIMS data base routines, and the generation numbers are updated automatically whenever a new file is created.

There cannot be more than 99 generation numbers for an individual file type. Files must therefore be erased from time to time, after which new generation numbers are created, filling in first any missing gaps.

File names are all stored in the Files File which is found in the PIMS directory, along with the user-supplied description of the file. These descriptions are important for they remind the user as to what is in the file. File names are erased from the Files File whenever a file is deleted.

The Main Data Base Files

Four kinds of files hold all the PIMS data and control variables. These are the code file, the label files, the position file and the main data file.

Code File (Type CD)

The Code File (Table 9) holds the code, data type, field width and decimals, and short and full names for every variable in the data base. It is updated whenever a new variable is added or created, and a variable is erased from the file whenever it is deleted from the data base.

Label File (Type LB)

Label Files hold the individual values for each class variable, along with their short and full names (Table 10). Note that the short names must follow the dBase3+ conventions for variable names. The Label File is named in a different way, in that the generation number is replaced by the two character code of the class variable. Thus, the label file shown in Table 10 is named **DEMOLBA3**: this is interpreted as project dame **DEMO**, file type **LB** (label file), for the class variable coded **A3**.

Position File (Type PS)

This is the most important file in the data base. It contains one record for each sample point in the study area, both coded by a unique TR/SU; all the control variables; and all **CL**, **NN** and **ID** variables.

All new data go into the Position File, both Class Variables in the form of new strata, and Numeric and Index Variables in the form of Look-Up Tables. Furthermore, the Position File is where new variables are created by manipulating existing ones.
When the packed data types are unpacked (the SC, CC and DD data types), they are transferred to the Position File where they are converted to the NN or ID format. This now allows them to be manipulated to create new variables.

Variables can be deleted from the Position File, and Position Files can be merged together. Whole sections may also be copied out into a new Position File with a new generation number (selective copy of variables).

In general, it is a good idea to keep the first generation number Portion File as the source data base, and add to it all new variables as the data base is updated. For analysis, or for variable manipulation, just those variables needed can be selectively copied into a new Portion File, leaving the original untouched. A new variable created by manipulating existing ones can always be copied back into the original file if required.

Main Data File (Type MD)

The main data file contains the packed CC, DD and SC data types. This is a special file set up only when aerial photographic or census strip count data are incorporated into the PIMS data base.

The packed data variables can be accessed for normal tabulations and mapping, but cannot be manipulated to create new variables. To do this, they must first be unpacked and transferred to the Position File, where their format is changed to the NN (total numbers, or total hectares) or ID (numbers/km2, or Ha/km2) formats. Note that they are removed from the Main Data File when they are transferred to the Position File.

Data Retrieval Files

Table Files (Type TB)

The Table Files are the main vehicle for data retrieval from the PIMS data base. The simplest table contains a single variable (NN or ID) analysed for a single stratum, as is shown in Table 1. Table files can, however, be merged together so that many variables for a set of strata occur together (Table 5). Furthermore, new variables can be made in a Table File (Table 6), and variables may also be deleted. Table Files may also be appended together (Table 6). This is particularly useful for hierarchical analyses.

Finally, a Table File can be **exported**, either to a word processing package such as Word Star, or to a statistical package for analysis. It is here that the Area and Number of Samples is useful for weighting the data in each of the strata.

Whenever a new Table is created, a Table File with a new generation number is opened by PIMS. The user-supplied description of the Table File is stored in the Files File along with the file name. All this is erased from Files File when the Table File is deleted.

The Cross Tabulation File (Type XT)

The Cross Tab File is created whenever two class variables are analysed together (Table 3). They can be merged and appended in the same way as Table Files, variables can be created in them and variables can be deleted. They are exported in the same way for word processing or statistical analysis.

The Frequency File (Type FQ)

The Frequency File is used only to find the size of a set of strata and the number of sample points within each. It is used for cross checking after a new stratum has been added to the data base, or if a stratum has been modified in some way by manipulating variables.

Mapping Files

Map Files (Type XY)

Map files are created to make UTM grid cell maps, and they have a record for each XY grid cell, along with the Area and the number of samples in each. The XY file is really just a special kind of table file, but the data types are treated somewhat differently.

Index (ID) data types are averaged in each cell, as indeed they are in ordinary tables. In contrast, Numeric (NN) and the packed **SC**, **CC**, and **DD** types are all expressed as densities per square kilometres, in other words as numbers/Km2 or as hectares/Km2 (percent cover). Finally, Class (CL) data types are treated quite differently. Each cell contains the **most frequent** class value or, in the case of a tie, the first.

Key Files (Type KY)

PIMS automatically generates a map key for each map file, the generation number matching the map file to which it relates. The lay out of the keys is explained fully in the next chapter.

Data Base Modification

Look-Up Tables (Type LU)

A Look-Up Table is the way in which new numeric (NN) or index (ID) variables are entered into a PIMS data base. An individual look-up table is created for an individual class variable, and data for each stratum is then entered. Table 7 shows a simple Look-Up table for each Division in a study area.

Being a dBase3+ file, the Look-Up table can in fact be made outside the PIMS environment, once its format has been created by PIMS. This allows flexible interchange of data between PIMS and other packages.

From-To Files (Type FT)

The From-To files define completely new strata to the PIMS data base. A new stratum is defined by the sample points falling within each, and the From-To file allows sets of data points to be assigned. Table 8 shows a section of a From-To file. Each record defines a set of sample points (data records) and assigns them to a stratum. The class variable will have already been defined to PIMS in terms of its code, field width, short and full name, and each of the class values will have been entered into a label file.

System Files

PIMS has a few system files which are important to know about. **PROJECTS.DBF** holds the project codes and descriptions while **FILES.DBF** holds the names and descriptions of all PIMS files. **SKELETON.DBF** is a skeleton file structure used within PIMS, while **ECOSYSTM.$$1** holds all kinds of control data and logos. Finally, **name.PDF** indicates a printer definition file, the name being the name of the printer, and any **name.TXT** file is a PIMS file that has been exported in ASCII format (delimited or undelimited) for word processing or other uses.

Table 1: Hectares of Maize in Each Division of a Study Area

Recd.	NAME	ABL	AREA	NSAMPLES	MAIZE85
1	MWALA	441	1419.9800	231	16398.04
2	KILOME	442	1407.7200	226	11935.26
3	MBOONI	443	565.8700	93	6503.67
4	MAKUENI	444	1973.6200	323	19836.81

Notes: Recd: record in the Table File
Name: short name of each Division
ABL: the code, and value, of each Division
AREA: area (Km2) of each Division
NSAMPLES: the number of sample points in each Division
MAIZE85: the short name for the variable Maize

Table 2: Mean Slope Angle in Each Division

Recd.	NAME	ABL	AREA	NSAMPLES	SLOPEDEG
1	MWALA	441	1419.9800	231	5.54
2	KILOME	442	1407.7200	226	8.58
3	MBOONI	443	565.8700	93	8.84
4	MAKUENI	444	1973.6200	323	4.69

Notes: as for Table 1
SLOPEDEG as average slope angle

Table 3: Land Suitability in Each Division

Recd.	NAME	ABL	HIGH	MEDIUM	LOW	TOTAL
1	MWALA	441	724.53	541.48	153.97	1419.98
2	KILOME	442	51.84	1072.40	263.58	1407.72
3	MBOONI	443	135.25	373.27	57.35	565.87
4	MAKUENI	444	513.93	531.51	928.18	1973.62
5	TOTALS		1425.55	2518.66	1422.98	5367.19

Notes: as for Table 1
HIGH, MEDIUM, LOW in square kilometers

Table 4: Frequency Analysis of Divisions

Recd.	NAME	ABL	AREA	PERCENT	FREQUENCY
1	MWALA	441	1419.98	26.46	231
2	KILOME	442	1407.72	26.23	226
3	MBOONI	443	565.87	10.54	93
4	MAKUENI	444	1973.62	36.77	323
5	TOTAL		5367.19	100.00	873

Table 5: Merged Data from Tables 1 and 2

Recd.	NAME	ABL	AREA	NSAMPLES	MAIZE85	SLOPEDEG
1	MWALA	441	1419.9800	231	16398.04	5.54
2	KILOME	442	1407.7200	226	11935.26	8.58
3	MBOONI	443	565.8700	93	6503.67	8.84
4	MAKUENI	444	1973.6200	323	19836.81	4.69

Table 6: Population Data for Divisions and Locations

Recd.	NAME	ABL	AREA	NSAMPLES	POP_1979	POPDEN
1	**MWALA**	**441**	**1419.9800**	**231**	**148385.06**	**104.5**
2	Mbiuni	4411	154.9800	27	30243.24	195.1
3	Mwala	4412	179.0000	25	26813.25	149.8
4	Wamunyu	4413	195.9000	30	16186.80	82.6
5	Muththni	4414	159.0300	27	19296.36	121.3
6	Masii	4415	154.9800	27	22320.63	144.0
7	Kitauni	4416	200.9400	34	12939.72	64.4
8	Kalawa	4417	375.1500	61	20585.06	54.9
9	**KILOME**	**442**	**1407.7200**	**226**	**166203.51**	**118.1**
10	Mukaa	4421	539.7500	85	43552.30	80.7
11	Kasikeu	4422	266.8500	45	24093.90	90.3
12	Kalama	4423	176.0400	27	28925.37	164.3
13	Kilungu	4424	144.1000	22	27393.52	190.1
14	Kithembe	4425	93.0600	18	20400.84	219.2
15	Ukia	4426	187.9200	29	21837.58	116.2
16	**MBOONI**	**443**	**565.8700**	**93**	**94002.14**	**166.1**
17	Tulimani	4431	131.0000	20	25395.40	193.9
18	Mbooni	4432	133.9200	24	33150.72	247.5
19	Kiteta	4433	85.0500	15	14490.60	170.4
20	Kisau	4434	215.9000	34	20965.42	97.1
21	**MAKUENI**	**444**	**1973.6200**	**323**	**127781.31**	**64.7**
22	Makueni	4441	251.9400	39	13422.63	53.3
23	Kathnzni	4442	887.8800	147	44161.74	49.7
24	Nzaui	4443	603.9000	99	43185.78	71.5
25	Mbitini	4444	229.9000	38	27011.16	117.5

Notes: Two Tables were made, one analysing POP_1979 by Divisions and one analysing POP_1979 by Locations.

These two Tables were then Appended. Since the codes were hierarchical, each Division (eg 444) is followed by its constituent Locations (eg 4441 - 4444).

POPDEN is a New Variable created in the Table by dividing POP_1979 by AREA.

Table 7: A Look-Up Table

Recd.	NAME	ABL	AREA	HBN
1	MWALA	441	1419.98	4.2
2	KILOME	442	1407.72	3.5
3	MBOONI	443	565.87	5.0
4	MAKUENI	444	1973.62	4.5

Notes: The variable HBN represents the rate of population increase (%/pa) in each Division.

Table 8: A From-To File

Recd.	TRANSECT	FROM	TO	HBL
1	1	1	3	01
2	1	4	6	02
3	1	7	11	03
4	2	1	6	04
5	2	7	10	03

Notes: Each TRANSECT/FROM/TO assignes a set of sample points (data records) to and individual stratum.

Table 9: A Code File

CODE	TYPE	WD	DC	SHORT	FULL NAME
AB	CL	3	0	DIVCODE	Division Code
AC	CL	4	0	LOCCODE	Location Code
BC	ID	3	0	SLOPEDEG	Slope Angle (degrees)
BH	NN	9	2	MAIZE85	Area of Maize (includes Sorghum) (1985)
BJ	CL	1	0	LANDSUIT	Land Suitability for Smallholders (KSS)
HA	NN	10	2	POP_1979	1979 Population from CBS National Census

Notes: Each variable is defined by the Code, Type, Field Width & Decimals, Short Name and Long Name. Codes and Names can be matched against the Tables above.

Table 10: A Label File

VALUE	SHORT	FULL NAME
441	MWALA	MWALA Division
442	KILOME	KILOME Division
443	MBOONI	MBOONI Division
444	MAKUENI	MAKUENI Division

Notes: This Label Files holds the values for the Class Variable AB. Each value (441 - 444) has a Short name and a Full Name. Match the values and names in the Tables above.

Appendix #5

Review of Test Project Photography

In order to better assess the applicability of point sampling to Rwandain crop patterns and terrain, we decided to run a test flight over some sample fields utilizing a local aircraft and D.A.I. personnel. Elaine Aderhold agreed to undertake the flight and arrange the use of available aircraft, a Cessna 150. We had a simplified version of our camera mount constructed to clamp to the door of a 150, and shipped over with a supply of Ecktachrome 400 film, Canon F-1 with 85mm lens, motor drive and intervolometer.

The results illustrate the product well, but also show the necessity for tight navigational and elevation control. Drs.' Lassiter and Aderhold had plotted transects over known fields at specific altitudes, giving us coverage of the standard scale of 1:7,000 (1,995 ft. a.g.l) and 1:4,000 (1,100 a.g.l.) should the former prove inadequate to differentiate the crop types. These would have answered the question as to whether single or multiple exposures would be necessary at each sample point and formed the ground truth for initial Rwandain interpretation classes during the I.U.C.N. training. Unfortunately, the pilot turned out to be less experienced than he had let on to Elaine and got them lost, so she had to expose the film over an unknown area. He also varied his altitude a 1,000 ft. or more between transects and appears to have still been at least a 1,000 ft. too high at his lowest point. Elaine was able to determine the general area of the transects on a topographic map, but, as you can see by comparing it with the slides, it is literally impossible to locate the frames once that initial control is lost. I have only included examples from the first roll, which is the largest scale, but it still appears to be samller than 1:7,000.

However, these examples do display distinctly discernable classes within the extremely fragmented field structures they cover. I can easily differentiate bananas, coffee, and sorghum, as well as different beans and small vegetable gardens.

If we undertake the A.P.S. project, it would be useful to refly a test sample of coverage over known fields before the U.U.C.N. training program, and I have included a budget for this under Additional Cost Options. One way to do this would be to have the trainees actually walk a series of fields and chart their crop structure, then mark them with white paper crosses just before the flight. As detailed in the option, I could come into Kigali just before the program started and fly these areas plus a limited grid pattern, using the existing aerial photos to maintain sufficient geographic accuracy without the Global Navigation System. This would allow the S.E.S.A. staff to train on Rwandain coverage and still participate in the major survey afterwards.

EXPERIENCE OF TRAINING PERSONNEL

Dr. Michael Norton-Griffiths

Dr. M. Norton-Griffiths has been involved in low level, aerial survey methodology since 1969. Starting in the Serengeti National Park, Tanzania, he helped develop many of the methods that are today considered standard.

His method of Aerial Point Smapling (APS) was evolved in the course of 12 years experience in carrying out through his company EcoSystems Ltd. land use surveys on behalf of all the major donor agencies working in Africa. To date he has surveyed well in excess of 1.5 million square kilometers of eastern and southern Africa, the Middle East and South America.

His geographical information system PIMS (Point Information Management System) was developed alongside the aerial survey methods. There are not five field installations, three in Kenya, one in Tanzania, and one in Senegal.

Each field installation required a careful training exercise for the users who were usually meeting a computer and a data base for the first time. The training course is therefore geared toweads first time users.

Evans Amwiro Shirekuli

1. Personal Details

Nationality:	Kenyan
Passport:	055624 expiring June 1992
Marital Status:	Married, 2 daughters

2. Education

1962 - 1968	Ruiru Primary School, Kiambu (CPE)
1969 - 1972	Kijabe High School, Kijave 'O' Level passes in English, Mathematics Physics, Chemistry, Biology, Swahili, Geography, History, Religious Knowledge, Oral English
1973 - 1974	Kapsabet School, Kapsabet 'A' Level passes in Mathematics, Physics, Chemistry, General Paper

3. Professional Experience

1975-1976: Programmer/System Salesman, Business Machines Ltd., Nairobi
Initial training in programming and software sales on Olivetti and Hewlett Packard equipment.

1976-1977: Programmer, KST Advanced Systems Ltd., Nairobi
Development of customer software and customising packages for WANG 2200 mini computers.

1977-1983: Senior Programmer, EcoSystems Ltd., Nairobi
Reporting to the Systems Manager, I was responsible for the development of EcoSystems' "Aerial Survey Analysis Package". Written in Wang BASIC, this package analysed low level SPF aerial survey data and integrated them with ancillary and environmental data. Output included statistical analysis and graphics routines. I was also responsible for managing the entry and validation of all survey data, and for producing the required tabular and graphical outputs. Working with the Systems Manager, I assisted in developing a complex digitising/graphics package, and software systems for analysing both LANDSAT and NOAA/AVHRR satellite data.

1983-1984: Data Processing Manager, Agricultural Development Corporation, Nairobi
Reporting to the General Manager, I was in charge of all data processing on three Olivetti mini computer installations in Nairobi (Headquarters), Nakuru and Kitale. My duties included coordinating the development of software by RML Ltd. (the Olivetti agents) for the ADC management; managing all data entry, validation and analysis (primarily accounting data for ADC farm operations); and providing management with the necessary reports and analyses.

1984-1987 Systems Manager, EcoSystems Ltd., Nairobi
Reporting to the Managing Director, I am responsible for all data processing activities in the company. My most important task has been to supervise the switch from Wang 2200MVP mini computers to Olivetti M24 micro computers. I developed a full Geographical Information System to handle low level aerial survey data, aerial photographic data, and environmental data, writing the GIS in compiled dBase3+. I have full responsibility for managing the entry, validation and analysis of all data from survey activities; and I am responsible for organising customer training programmes and software support for three field installations (Kisumu, Machakos, and Lodwar).

1988 - Present: Systems Manager, IUCN Eastern Sahel Unit
Reporting to the head of the IUCN Eastern Sahel Unit, I am responsible for maintaining the IUCN Sahel data bases, the IUCN Sahel GIS data base, and setting up computer modem links to overseas data bases for downloading information.

4. Specific Experience in Systems Management, Programming and Training

Systems Management

I have had full responsibility for managing the creation, validation and analysis of landuse data bases from the following survey projects carried out by EcoSystems Ltd.:-

Country	Region	Client
Tanzania	Rukwa	NORAD
	Tabora	IBRD
	Arusha	USAID
	Shinyanga	IBRD
Kenya	Machakos (2)	EDF
	Western Kenya	Netherlands Technical Assistance
	Turkana (3)	EDF
	Kiambu	USAID
	Muranga'	SIDA
	Kwale	CIDA
	SW Kenya	CIDA
Sudan	Jonglei (3)	EDF

I have also been involved in the analysis of LANDSAT and NOAA/AVHRR satellite data, including graphics output; I have set up and managed data bases for the FAO genetic resources laboratory (grasslands) at Kitale and for the armyworm team of the East African Desert Locust Control Organisation; I have recently created a Kenyan National Environmental and Land Use Data Base for the CIDA sponsored Long Range Economic Planning Team at the Ministry of Finance and Development planning; and I am just completing the creation of a single data base, using all of EcoSystems' data from 1.5 million square kilometres of Africa, as part of the R&D for the FAO ARTEMIS satellite monitoring system.

Programming Experience

ASAP - Aerial Survey Analysis Package
Written in WANG Basic for the WANG 2200MVP mini computer, the ASAP package accepted low level SRF aerial survey data and integrated it with environmental and other ancillary data variables. The system modules included observer data entry, validation and conversion; entry, validation, and integration of environmental and ancillary data; multi level stratification for statistical analyses and reporting; grid square mapping routines; digitiser input for polygon analyses; and graphics (plotter) output - including the production of camera ready plates for multi colour map production.

Under the direction of the Systems Manager, I was responsible for the system design of a number of modules, and in total I wrote about 80% of the code. WANG Basic remains one of the most powerful versions of Basic to be developed, including the present versions of Basic available on micro computers.

PIMS - Point Information Management System
I have had the sole responsibility for developing a complete GIS system for Olivetti M24 micro computers in compiled (Clipper) dBase3+. Using

many of the concepts developed for ASAP, PIMS concentrates on the integration of data from a wide variety of sources (low level aerial survey, satellites, aerial photographs, maps and thematic data, tabulated data) and produces relatively straightforward statistical, tabular and mapping output. However, the PIMS data files integrate easily with specialised packages such as Lotus 123, Systat, SPSS, ERDAS and Wordstar. PIMS therefore manipulates and integrates data, and interacts with other packages for statistical analysis, graphics output, and reporting.

A second important aspect in the development of PIMS was to make it very easy to use. As a result, we now have three field installations where Clients have the land use data base and the PIMS software installed on their own micro computers.

Training Experience

In the course of switching from mini to micro computers, I have become fully conversant with all the standard micro computer packages (word processing, spreadsheet, data base, graphics); micro computer utilities (cweep, LDIR, QDOS, OPTIMIZE, Sideways etc); and communications. I use all this experience in designing training courses for Clients for whom we create and install land use data bases.

Our standard training includes MSDOS (1 day); 2 days each on dBase3+, Lotus and Wordstar 4; and 10 days detailed training on the PIMS package. I have now run three such training courses for Clients who were starting computer applications from scratch.

I have now completed four training courses for users of the PIMS software system, and have made two extensive visits to Senegal, on behalf of the UNDP, to install PIMS and give training inits use.

GORDON OTIENO ARARA
Chief Photo-Interpreter, IUCN Eastern Sahel Unit

1. **Personal Details**

Date of Birth	:	17th December, 1959
Nationality	:	Kenyan
Marital Status	:	Married in 1984 with one son

2. **Education**

1975 - 1978	Ramba Secondary School 'O' Level in English, Mathematics, Biology, Physical Science, Literature in English, History, Religious Knowledge and Geography.
1979 - 1980	Kabaa High School 'A' Level in Mathematics, Chemistry, Biology and General Paper.

3. **Professional Experience**

1981 - Trainee Airphoto/Data Management Technician

Initial training on airphoto interpretation/data management at EcoSystems Ltd and the Regional Centre for Services in Survey and Mapping.

1982 - 1987 Senior Airphoto/Data Management Technician

Reporting to the Project manager. My duties include :

a) Training of other photo interpreters
b) Supervision of four other interpreters
c) Data entry, validation and analysis
d) Organising helicopter surveys for crop data

1988 - Present: Senior Airphoto/Data Management Technician, IUCN/ESU

4. Specific Experience as Airphoto/Data Management Technician/Trainer

Have had full responsibility in the following projects:-

Country	Region	Client
Kenya	Machakos Rural Access Roads	EDF
	Western Kenya	Netherlands Techn. Assistance
	Turkana (3)	EDF
	Kiambu	USAID
	Muranga	SIDA
	Kwale	CIDA
	Tana River	
	Turkwel	NORAD
	Molo-Litein Road	MASCOTT
Tanzania	Shinyanga	IBRD
	Tarangire	AWF

In the Tarangire project, I trained staff from Serengeti Ecological Monitoring Programme in georeferencing, interpretation of aerial photos and data entry, validation and analysis using the PIMS software developed at EcoSystems Ltd.

Recently, I have completed a training session in Senegal on behalf of the UNDP and the Centre du Suivi Ecologique. The training covered all aspects of photo-interpretation, data entry and validation.

DANA M. SLAYMAKER

Professional Experience

Exploration Photography, Sole Proprietor 1980 - Present

Aerial and ground photography; architectural and forensic applications. Major clients include: Texasgulf Western, Iliff-Thorn, Coldwell Banker, U.S.A.I.D. (involved in a nationwide survey of the country of Lesotho, providing 1:20,000 70mm aerial photography, low altitude grid pattern coverage as a data base to assess agricultrual development and range management objectives), and Bendix Corp. as a consultant to set up a 70mm Photogrammetric camera system for the Remote Sensing Center in Cairo, Egypt.

Development Alternatives, Inc. - 1980

Consultant. Color aerial photography and photo processing to provide photo mosaics of Tanzanian village areas for rural development activities.

S.E.A. Photography, Inc. 1975 - 1980

Vice President and General Manager. Established as an associate firm to Southwestern Exploration Associates. Aerial photography and photo processing for clients such as Texas Gas Exploration Corp., Felmont Oil, The U. OF A., Gulf Mineral Resources, Phelps Dodge, Texasgulf, Anaconda, Amax, Exxon, Getty Oil, Amoco and Conoco.

Slaymaker Photography 1973 - 1975

Sole Proprietor. Specialized in photographic applications for research. Completed large contract for Nuclear Utility Systems Corp. to provide aerial photography of 1,000 miles of possible corridors for a transmission line and to provide detailed vegetation maps and descriptions of each link.

University of Arizona 1969 - 1973

Staff photographer for the Department of Biological Sciences at the University. Developed ecological applications for remote sensing while in this position. Also involved with assessment of the vegetation mosaic in the Sonoran Deser: for the I.B.P. Desert Biome Program.

Education

The Linda Vista School of Fine Arts 1969 - 1973

Photography

The University of Arizona 1965 - 1969

Biology and Scientific Illustration

Projects and Publications

NASA sponsored Projects (Co-authored two): EROS #14-16-008-613 and NASA-21819 -- Interpretation of space-acquired signatures for Desert Plant Species and Communities. Both of these projects were investigating remote sensing applications to Arid Lands Studies.

Cooperative Regional Surveys for Mineral Exploration with Red-Enhanced Film in a 70mm Camera. Presented at the International Symposium on Remote Sensing of Environment, Second Thematic Conference, Remote Sensing for Exploration Geology, Fort Worth, Texas, December 6-10, 1982.

Information for Rural Land Planning in Arusha Region, Tanzania.

Presented to the Arusha Planning and Village Development Project and the Regional Development Directorate, Arusha. Co-authored by Christopher Dunford and David A. Mouat.

Remote Sensing for Rural Planning in Africa. Co-authored with Dr's Christopher Dunford, David Mouat, and Michael Norton-Griffith. Accepted by "The Journal for the International Institute for Aerial Survey and Earth Sciences".

Assisted in the following works:

Structure of Ecosystems, the Desert Biome - part of a major I.B.P. project.

Altruistic Behavior in Mexican Jays, by Dr. Jerram Brown.

Reptiles and Amphibians of the Sonoran Desert, by Dr. Charles H. Lowe (illustrations for a book)

Natural History of the Saguaro Cactus, by Scott Sternburg and Dr. Charles H. Lowe (illustrations for a book)

Personal

DARRAGH DAVIS

Professional Experience - Tucson, AZ.

Exploration Photography (P/T) 1984 - Present

Indexing of slides, negatives and maps; negative and slide organization; flight line preparation.

S.E.I.S., Inc. (P/T) 1987 - 1988

Sales representative of Central American Imports; wide variety of duties including receiving, shipping, inventory assistance, display and participation in trade shows.

Rochelle K 1984 - 1986

Sales, inventory control, shipping and receiving, responsible for store management in absense of owners, and daily sales journals.

Philadelphia, PA.

Cameo Stores, Inc. 1982 - 1984

Stock control, sales level bookkeeping, display and sales.

Explorers (part time) 1983

Sales, specializing in gifts from Central America and Africa.

Grundy Design 1981 - 1983

Assisted in the interior design and construction of Bobby's Seafood Restaurant; setting up working systems such as staff coordination, menu planning and general day-to-day operations.

Freelance Caterer (part time) 1981 - 1982

Complete catering service. Catered cocktail parties, wedding showers and one five-course sit-down dinner for the Victorian Society of Philadelphia.

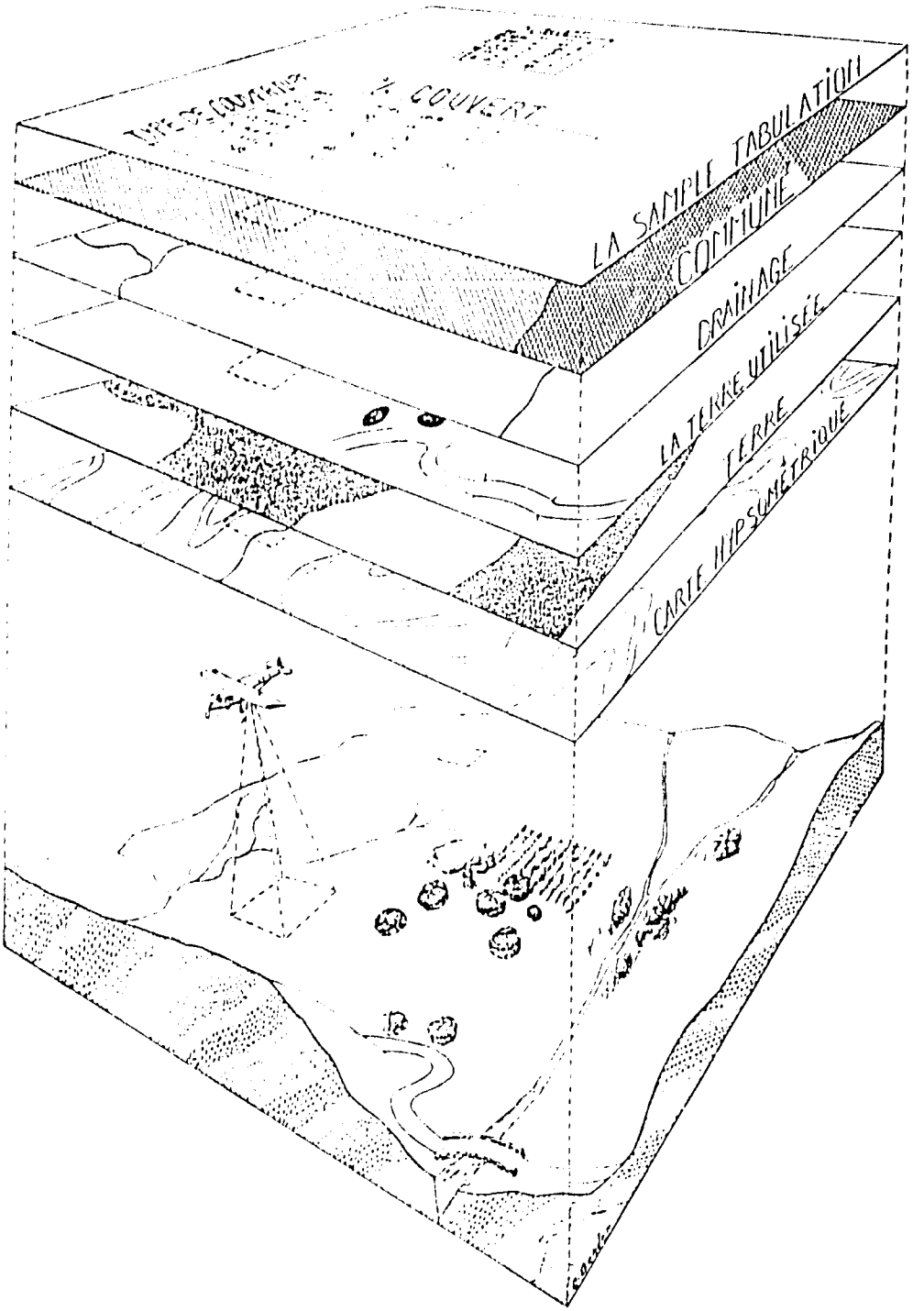
Carlton's Restaurant - 1980

Assistant Manager. Involved in all phases of opening a restaurant. Organizational duties included purchasing equipment, hiring the staff and menu planning.

Education

University of Virginia, Charlottesville, Va.
B.A. in Art History. Graduated 1978

Languages: English and French


COUVERT
LA SAMPLE TABULATION
CONTIGUE
DRAINAGE
LA TERRE UTILISÉE
TERRE
CARTE HYPSOMÉTRIQUE