DIGITAL WORKING BASE MAP PRODUCTION FOR THE GLOBAL SUSTAINABLE CITIES PROGRAMME: THE CASE OF SUSTAINABLE IBADAN PROJECT IN NIGERIA

J. A. Ogunlami,
Director
E. Amamoo-Otchere,
Head, Remote Sensing Applications Unit
P. M. Kibora,
Cartographer
Regional Centre for Training in Aerospace Surveys (RECTAS)
P.M.B. 5545, Ile-Ife, Nigeria.

C. O. Nuga
Niger Surveys, Ibadan, Nigeria.

WG VII/9 - Human Settlements

KEY WORDS: *Remote Sensing, Cartography, Human Settlements, Digitizing, Updating*

ABSTRACT

Since the beginning of the decade, the World Bank has rapidly expanded its environmental and urban activities to address *its Brown Agenda*, and this change has been motivated by a paradigm shift manifested in the Bank's projects and programmes.The Bank, together with the United Nations Centre for Human Settlements (UNCHS) Habitat, the World Health Organization (WHO) and with support from the United Nations Development Programme (UNDP), have launched an Urban Management Programme (UMP) the principal goal of which is to provide planners and managers with improved capability to deal with the challenges of sustainable urban development.The operational arm of the UMP is the Sustainable Cities Programme (SCP), which currently is being actualised in twelve cities throughout the world, with Ibadan as the representative demonstration city project for Nigeria. The Ibadan project is known as *Sustainable Ibadan Project (SIP).*

There is an environmental component of the SCP which requires the use of a geographical information system (GIS) as a management tool. An essential requirement of the GIS is a digital working base map for the urban information system. In the case of the SIP, the Regional Centre for Training in Aerospace Surveys (RECTAS) was consulted to carry out a map survey situation of Ibadan and then compile a special up-to-date edition at two scales: 1:50,000 and 1:25,000. It was also to produce a digital map. To execute the job, RECTAS conducted a map survey of Ibadan for the selection from the existing ones the most appropriate base for the revision. The base maps selected had obvious gaps of both spatial and temporal information.To update them, SPOT satellite data in Panchromatic and Multispectral modes, were utilised.The SPOT data were digitally processed, printed in sub-scenes, and mosaicked at RECTAS. Similarly the interpretation and extraction as well as the transfer of the relevant information and the map drafting activities were achieved at RECTAS. Together with the Niger Surveys and consultants, the digital production was undertaken using the latter's ARC/INFO software. This presentation is on the processes used for the revision, production of the working base map, and the digitisation of the layers.

INTRODUCTION

The Regional Centre for Training in Aerospace Surveys (RECTAS), Ile-Ife, Nigeria has the mandate to undertake research and consultancy services in mapping techniques in order to enable its training staff enrich their knowledge and experience which will be applied to the Centre's main function of *long term training in the applications of aerospace surveying techniques (Photogrammetry, Remote Sensing and Cartography)* for economic development and environmental protection in the African countries. In line with this policy, RECTAS welcomed a consultancy job offered to it by the United Nations Centre for Human Settlements, UNCHS (Habitat). The job involved map-revision and production of a 'Working Base Map' for the *sustainable Ibadan Project (SIP)* in Oyo State of Nigeria. This project is one of the 12 world wide demonstration city projects for SCP under UMP, the principal goal of which is to provide planners and managers with improved capability to deal with the challenges of sustainable urban development.

Ibadan is approaching a mega city with its population approaching 5 million. It is a sprawling city covering approximately 450km^2, located in the south-western portion of Nigeria; and geographic location for exactness is Longitudes E3°47'30" to E4°02'30" and Latitudes N7°17'30" to N7°32'30". By all standards it has a full representation of all the development problems associated with urban sprawl of a developing economy. Its immediate problems have been listed in a resolution passed by the City Forum held in October 1995 in Ibadan. The specific problems mentioned in the declaration were: development of a comprehensive metropolitan plan, property identification, protection of urban water sheds, establishment of an environmental management information system, including hydro-geological surveys, neighbourhood upgrading, drainage and flood control, environmental education and use of media, urban poverty, street trading, transportation and air pollution. Its immediate cross-sectoral problems are water-management, water supply and institutiona-lization of the Environmental Planning and Management process (SIP, 1995).

The UNCHS (Habitat) recognises that an accurate, up-to-date and reliable topo-map and digitized Working Base Map will initiate a move into the digital technology and a subsequent cross-sectoral use of the tools of Geographical Information System (GIS) for the long term management goals of SIP.

The Working Base Map, therefore, appeared to be *sine qua non* basic requirement of the SIP. It was planned at two scales: (i) a global series at 1:50,000 scale in one sheet, covering virtually the entire metropolitan area comprising of five municipal local governments and six peri-urban Local Governments; (ii) a sector series of 4 map sheets at 1:25,000 containing relatively more detailed information for local government level planning, particularly in the core areas of Ibadan.

To produce the two scale series, there was the need to evaluate and select from the existing topographic maps over Ibadan, the most appropriate to be used as the base.

MATERIALS AND METHODOLOGY

For the job, the UNCHS (Habitat), Nairobi, Kenya, supplied a quarter scene SPOT P data stored on CCT and a hard copy photographic product. RECTAS supplemented with a full scene SPOT XS, the latter to cover as much as possible the parts of the metropolitan region not covered by the quarter scene. The map revision and digital production spanned over the following phases: survey of map situation at Ibadan for base map selection and identification of map producers and users in the city; processing of the satellite data and interpretation of the imageries; ground truthing for rectification of existing map information and image interpretation; field editing, overlaying for transfer of image interpretation onto the map transparency (compilation); field editing for correction of place names, scribing of the compilation and photographic reproduction in transparent copies of the layered information, and finally the digital production of the layered information on digital files.

Map Situation Survey and Base Map Selection

It would appear that between 1918 and 1990 about sixteen topographical maps have been produced, yet there still exist information gaps - spatial gaps and temporal gaps (RECTAS SIP Report, 1996).
Out of the sixteen series, copies of some of which could not be available to be procured, two series were selected as the most appropriate base for the compilation of the Working Base Map. These were the 1:50,000 national series compiled nation-wide between 1964 and 67 (Fed. Surveys, Nigeria; Canadian Aerospace Services, 1964/1967) and a special project mapping for the Water Corporation of Oyo State, Nigeria, (Ogunleye/Geosystems, 1990) commis-sioned to be produced at a scale of 1:10,000. The latter covers the municipality only while the

former is of nation-wide coverage and therefore contains the whole of Ibadan and its environs.

The survey revealed improper records keeping and co-ordination of the mapping activities in Ibadan as well as apparent lack of awareness of mapping activities.
Neither of the two base maps selected reflected the rapid expansion of the city in the last thirty years. The 1:10,000 scale series which was compiled in 1990 covers only the inner city. The other base map, which covers the entire metropolitan region, was however compiled between 1964 and 1967 grossly outdated in view of the rapid city expansion in the seventies and eighties. The most effective source of information for quick updating was the high resolution imagery of SPOT P (10m, which could be sharpened to 7.5m), and SPOT XS (20m, in three bands, which could be composited in colours). The revision used the two modes combination effectively.

As part of the SIP's principle of grassroots consultation for *"planning for the people by the people"*, the map situation survey was not only for the base map selection, but partly also to determine the preferences of Ibadan actual and potential map users. The survey was partly consultative with the result that the global scale of the Working Base Map was requested by the Local Government planning authorities to cover all the eleven Local Government secretariats of the Metropolitan area. The 1:50,000 map sheet was therefore a "special edition" with a format of interior frame of the surface area being 73.5cm by 70cm and a print size of 93cm by 85cm. The revised format accommodated all the eleven Local Government Secretariats.

The preliminary draft of the map was exhibited in the first city (consultation) forum held in Ibadan in October 1995, to assess its acceptability by all stake holders. It was well accepted and all the comments made were accordingly incorporated for improved accuracy and reliability of the final maps.

Processing of the SPOT Data for Updating the map:

The SPOT satellite imagery data used were KJ 067/335, the P mode taken in December 1993 by SPOT 3 and the SPOT XS-mode taken in December 1986 by SPOT 1. The P-mode data provided the cartographic-precision information for the UTM projection which was requested for as per Nigerian national projection system specifications. The XS-mode was useful for land use information and also for areas not covered by the P data. The two data sets were further processed from their CCT storage medium. The digital image processing was performed using the MULTISCOPE software on COMPAQ 486 computer system at the Remote Sensing Laboratory at RECTAS. Subscenes of 20cm x 20cm format were printed on thermal wax transparency and paper. These were mosaicked to correspond with the sheet size of the 1:50,000 scale series maps. The same process was repeated for the 1:25,000 scale.

Interpretation and Ground Truthing

The aim of the spectral enhancement processing and the interpretation of the enhanced images was to obtain the relevant topographic and landuse information conforming to and acceptable as the standard 1:50,000 and 1:25,000 topographic map series.

It has already been remarked that the revision was effectively showing the zone of rapid urban expansion during the last thirty years when the 1:50,000 topographic maps were compiled. The imageries provided the main source of information for the compilation of the roads, building densities, vegetation and other land use and topographic features. Although the geometric correction and pixel resampling sharpened the spatial resolution much higher to 7.5m instead of 10m, this improvement did not resolve the problem of spectral confusion of some topographic features. For example bare ground of reddish soil confused with rusted roofs of the old buildings; water and vegetation in the panchromatic imagery often appeared in the same tone for areas with moist conditions. There was extensive ground truth to resolve the spectral confusion.

Field Editing

The map survey revealed that the existing topo maps selected for the compilation did contain a considerable number of wrong toponyms including mis-spelling and misplacement of place names. The corrections also demanded very extensive field editing. Ibadan as a sprawling city has a massive outer zone growth with characterization similar to the blight of the congested inner zone of old and decayed buildings. In addition, the housing of the outer zone proceeded rapidly without proper consideration for planned provision of common amenities and infrastructures. The public buildings that exist are mixed up together with the residential houses, making it impossible to separate and annotate the former directly with the imagery. Field pointing with

imageries had to be very intensive for the purpose of accurate representation of the main public buildings such as schools, churches, mosques, etc.

CARTOGRAPHIC PROCESSES

These included the overlaying of map and imagery for compilation, scribing and peeling process for line map production and layering of the map information on positive line film.

Overlaying for the Compilation

The base map to be updated was converted to map transparency and superimposed on the transparent copy of the imagery to ease transfer of the image information for updating the base map.

Scribing and Peeling Processes

The scribing was done by having the emulsion of the scribe coat removed as a kind of engraving, with the result that the line produced is more stable and finer. The phonograph needle was very effective for maintaining a very stable line quality. Peeling removed an area for screening to present areal features. These techniques were applied in drafting the line and areal information respectively.

Layering of the Map Information

Conventional topographic map production is done in layers of map information. At the scribing and peeling stages the information layering is organized sheet by sheet. For our case, as it is in other standard processing, the layers were organized according to the colours of the final maps (See Table below) into five layers for various conventional classes or groups of features.

Photographic Processing of the Layers

The scribed and peeled sheets were combined for each thematic colour and photographically processed using contact printing method. It involved first of all obtaining a line film negative, duffing out the anomalies and then reproducing a positive transparent original of each colour theme. It was this product that served as the digitizing document. The advantage of the positive transparent line film is that it facilitates high definition digitizing.
The stages of production of the digitizable product are graphically presented in the Figure of the annex, for the 1:50,000 series. The same processes were followed for the 1:25,000 series.

Table showing layered information features

Black colour	Black Text, frame lines, planimetric features like roads, transmission lines, etc.
Brown colour	Contour lines, other landform features, rock outcrops, etc.
Blue colour	Hydrographic lines, lake borders, grid lines and grid values, etc.
Red colour	Road in-filling for principal routes, etc.
Green colour	vegetation, forest reserve, etc.

Digital Map Production

For fidelity reasons the digitizing took off using the original transparent layers prepared in the drafting stages. Within the ARC-Info starter kit, ARCEDIT provides all of the facilities for digitizing coverages with a highly comprehensive set of graphic editing commands. Locational as well as descriptive (attribute) data can be edited and manipulated.

For a more detailed explanation, the transparent layers containing roads and buildings for example were digitized via a coding system to differentiate between different types of roads and buildings and the attribute data entered in the attribute database which is linkable with the spatial database. This same process is valid for all different kinds of information.

Once all data, both spatial and attribute, had been entered and all editing realised, the map design process started. This involved entering the legend, titles and text.
Finally hard copies of the produced maps were plotted with a pen plotter. Digital back-ups were stored on diskettes to be delivered along with other products.

All the contour data were digitized during the digitization process with the corresponding elevation data attached. These data (in vector format) were rasterized according to elevation coding. After rasterization, the ARC-INFO isolines generation and interpolation modules created a digital elevation model (DEM) which were stored on diskettes.

Keeping to National Standards:

A digital base map production for city planning requires that the base map to be digitized be revised adequately to cater for the cross-sectoral interests of the stake holders. The map revision is bound to conform with the national standards for cartographic production, namely the national projection system, the format of the map sheets, the cartographic symbols and the sheet layout. All countries keep as much as possible to international cartographic standards. The revision and production are closely supervised to ensure that national and internationally accepted standards are kept. All these imply that before the digital stage, the conventional methods and the outputs are vetted by the mapping authorities. For the job done for the UNCHS, the supervision was by the statutory body, the Oyo State Survey Department of the Ministry of Lands, Housing and Physical Planning assisted by the SIP team of planners responsible for co-ordinating the project. The final products of the conventional methods had to be passed before the digitizing stage.

OUTPUTS/DELIVERABLES

The deliverables/outputs were the positive line (vector) maps at the two scales, (the 1:50,000 series and the 1:25,000 series), the digital versions of the two map series, a digital elevation model of the inner city area, and a report of the map situation survey of the city. The vector maps were delievered in both transparencies and paper copies, while the digital versions were in ARC/INFO format stored on diskettes and in pen-plotted colour-coded paper copies.

CONCLUSION

The results have been enthusiastically received by the opinion leaders, planners, urban managers and other stake holders of Ibadan city. In the proceess of the production, the consultations with actual and potential map users helped in raising the awareness of the importance of a working base map as a primary document for the derivation of a wide range of services and utility maps of the city. The successful execution of the project enhances RECTAS's capability in utilizing critical capacities built-up at RECTAS for providing consulting services in the area of such mapping projects of other cities, and most importantly in the training of the indigenous African manpower to handle the aspects of the mapping and map data programmes.

Ibadan as a mega city presents the most difficult mapping problem. The successful execution of the job indicates that RECTAS can do similar jobs much more easily for Nigeria and other African countries. The output will help in effectively resolving environmental issues associated with Ibadan economic growth and physical expansion as well as other cities in future. The results will help to compare the Sustainable Ibadan Project (SIP) in Oyo State, Nigeria, with eleven other demonstration Sustainable City Projects (SCP) selected world-wide.

RECTAS has already been drawn into the SIP programmes to use its capability in raising the local manpower for the implementation of the digital map/data production and management and remote sensing applications.

RECTAS plans to organize seminars later on this project to spread the experience gained and the methodology for sustainable cities development/urban management programmes. We welcome relationship with other organisations involved, or intending to be involved in similar projects.
The success of this project would have helped SIP tremendously in the preparatory activities towards the Second United Nations Conference on Human Settlements (Habitat II) in Istanbul, Turkey in June 1996.

ACKNOWLEDGEMENT

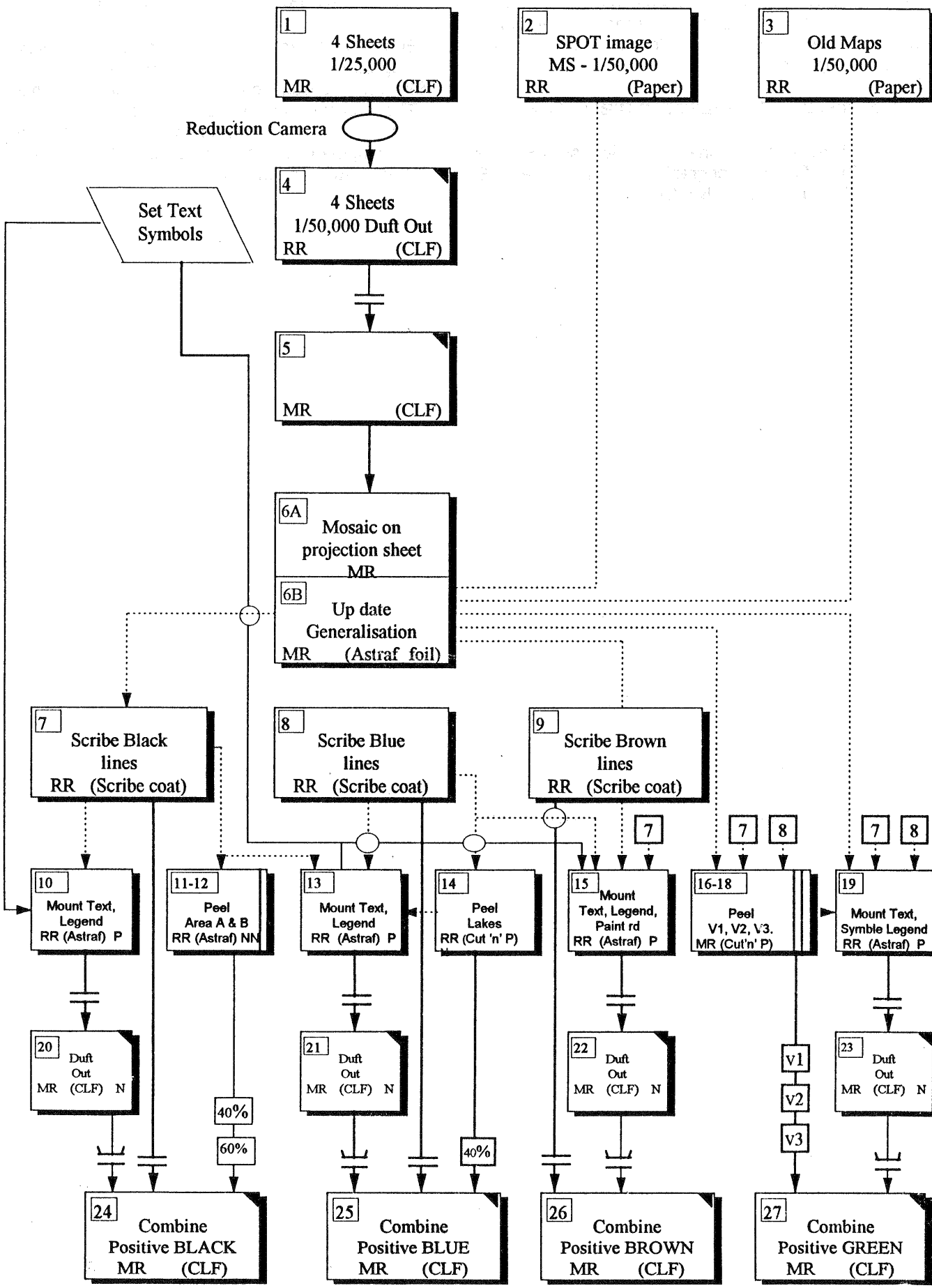
We wish to acknowledge the critical capacities and capabilities at RECTAS which have been built-up with the Technical Assistance of Donor organisations/countries such as the European Union, the French Government and the Netherlands Government under the EEC/ITC/GDTA/RECTAS support project, amongst others. The UNCHS (Habitat), Nairobi, for giving us the opportunity to execute this project. The SIP planning team for their effective, sharp criticism and comments/advice and engaged control of the project. The Centre acknowledges with gratitude the additional efforts of the Federal Government of Nigeria, the host country of RECTAS, in providing funds for capital development expansion to ensure the accommodation of the critical capacity equipment being provided RECTAS under Technical Assistance. Without all the above, the execution of the project would not have been possible.

We therefore seize this opportunity to thank all of them for their respective contributions. Once again, we acknewledge and thank the French Government for sponsoring RECTAS participation in this 1996 ISPRS Congress.

REFERENCES OR SELECTED BIBLIOGRAPHY

- Federal Surveys (Nigeria) Canadian Aero-Service (1967). 1:50,000 topographic series: Ibadan NE, Oyo SE, Apomu NW, Iwo SW.
- Ogunleye/Geosystems (1990). 1:10,000 Topographic maps for Water Corporation of Oyo State.
- RECTAS SIP Report (1996). Report of the Survey of Map Situation of Ibadan, Oyo State, Nigeria.
- SIP City Consultation (1995). Ibadan Declaration: The Consultation on Environmental Issues for Managing the Sustainable Growth and Development of Ibadan, 23-27 October 1995, Sustainable Ibadan Project.

FIGURE SHOWING FLOW DIAGRAM OF PROCESSES FOR THE REVISION AND PRODUCTION OF 1/50,000 WORKING BASE MAP OF IBADAN & ENVIRONS



RR: Right Reading
MR: Mirror Reverse

P: Posititve
N:Negative
CLF: Clear Line Film

V1: Light Forest
V2: Woodland
V3: Open Grassland