SIMPLE PHOTOGRAMMETRIC METHODS FOR MAPPING OF VEGETATION POLYGONS BOUNDARIES IN NATIONAL PARKS IN AFRICA

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ABSTRACT

Wildlife management in national parks requires various types of data to be analized. Evaluation of vegetation is one of the most important tasks needed for wildlife control and conservation. National parks in Africa cover large areas and therefore photogrammetric and remote sensing techniques are the most suitable. Since the boundaries of vegetation polygons are not shown on the medium scale topographic maps, therefore there is need for fast and cheap photogrammetric methods to be used for their determination. In a project carried out by the joint Zambia - United Kingdom team, the whole of Kasanka National Park and surrounding Kafinda Game Management Area in Zambia was mapped and then classified into physiognomic habitat types, in respect to vegetation polygons and other features. Low cost GPS technology in conjunction with graphical-analytical aerial triangulation have been used for determination of planimetric control needed for mapping of vegetation polygons boundaries and geometrical positions of other features with the use of an optical rectification device - sketchmaster. Thematic information, concerning types of vegetation and other features, was collected by aerial photography interpretation supported with field verification. A digital data base was created and processed with ARC/INFO software.

1. INTRODUCTION

Preservation of natural beauty in large national parks in Africa requires careful management, control and conservation of wildlife resources. Their proper inventory needs many types of data, which have to be collected, processed, analysed, up-dated and presented. Digital data bases are the most convinient and easiest form to process with the use of various digital mapping, remote sensing and GIS softwares. Mapping and evaluation of vegetation in areas occupied by national parks are very important in wildlife management. National Parks in Africa cover usually large areas, very often partially not available for a direct survey, and therefore aerial photographs and other remote sensing data are the best source for vegetation mapping. Boundaries of vegetation polygons are not shown on medium scale topographic maps, as for example 1:50000, which is the basic map for rural areas in most of Southern African countries, including Zambia.

Conventional photogrammetric methods of aerial triangulation for planimetric control densification and stereocompilation with stereoplotters/analytical plotters for mapping are too expensive, complicated and time consuming to be attractive for supplementing of 1:50000 map of national parks with vegetation polygons and other features. Production of photographic maps from aerial photography or remote sensing imagery is faster and cheaper and because of their pictorial form, large amount of valuable information is available. However, orthophoto technology and even ordinary rectification with mechanical-optical rectifiers have not been implemented in many of African countries, including Zambia. Therefore, there was need to use some other fast and low cost photogrammetric approaches for control determination and mapping of vegetation boundaries in national park.

Simple photogrammetric approaches for field control densification and mapping were proposed and applied by the author in the project concerning mapping of habitat in the Kasanka National Park and surrounding Kafinda Game Management Area in Zambia, for the use in wildlife conservation management and scientific research in this Park. The whole project, which was carried out by the joint Zambian - United Kingdom team, included the following two parts;

(1) Photogrammetric mapping of boundaries of vegetation polygons and other features in the National Park, carried out in the Department of Surveying, University of Zambia [Bujakiewicz, 1993].

(2) Collection of data concerning types of vegetation in the Park, based on aerial photography interpretation and field verification, creation, processing and analysis of digital date base with ARC/INFO software, carried out by the Department of Biological Sciences, Manchester Metropolitan University [Cassels, 1994].

This paper concentrates mainly on the first part of the project, concerning photogrammetric compilation. However, the final results of some GIS processed data will also be presented.

2. PRINCIPLES OF SIMPLE PHOTOGRAMMETRIC METHODS FOR CONTROL DENSIFICATION AND MAPPING

Control densification. Densification of planimetric control proposed by the author for the purpose of this project has applied one of the first graphical methods of strip triangulation, called hand templet method [Manual of Photogrammetry, 1980]. In this method, each photograph is replaced by a transparent templet on which lines have been drawn from the principal point radially through each image point (field control and tie points - both natural features). The templets are assembled and the intersection of all radials common to each identified image point represents the adjusted planimetric position of each point. The points of radial intersection are transferred to the base sheet by pricking through the templets. The whole set of points is determined in an unknown but uniform scale. Therefore, they have to be subsequently transformed to the ground coordinate system through the use of field control. In the original method, which was used more than fifty years ago, both steps concerning assembly of templets and transformation of determined control points to the field coordinate system had been graphically done. In the proposed modified version, the second step is executed with a computer programe of similarity transformation. The planimetric field control can be determined with the use of low accuracy GPS system. The number and distribution of field control for block aerial triangulation based on the above approach, has to satisfied the requirements concerning field control for triangulation of separate strips.

Mapping of features. Vegetation boundaries and other required features, which do not exist on 1:50000 topographic map, can be mapped from aerial photographs with the use of simple and cheap optical device known as a Sketchmaster. The planimetric positions of at least four photo control points for each photograph, determined by graphical-analytical triangulation, should be used to rectify each of photograph for tilt and scale corrections. After orientation of the photo, the photo control images match with their corresponding field points, marked at map scale. Subsequently, all new features are transferred from photograph to a map overlay.
The above approaches for control densification and mapping of features can be used only for terrain with moderate relief, since the relief displacements are neglected in compilation. Assuming that all precautions are taken in the discussed graphical strip triangulation and mapping procedure, the final accuracy of triangulated photo points and mapped features would not exceed the graphical accuracy of points/features at scale of used photographs. Therefore, to obtain the acceptable accuracy of compilation, the scale of photographs should be larger or at least the same than the map scale.

3. DESCRIPTION OF EXPERIMENT

The area of the Kasanka National Park and surrounding Kafinda Game Management Area in Zambia has size of 29.5 km in North-South and 42.5 km in East-West. The relief of this terrain is moderate with 100 meters differences in elevation around the area. Four sheets of existing map at 1:50000 scale for this area were compiled in 1967 and since then have not been updated. Therefore, for creation of a GIS data base for this area, there was need to determine all missing features on the map, such as new roads and settlements as well as boundaries of all vegetation polygons. For acquisition of these data, simple photogrammetric approaches presented in chapter 2, were applied.
A block of 86 aerial photographs distributed in six strips, at 1:30000 scale, taken in May 1990, with 60 % end lap and 30 % side lap, were used. For purpose of this project, 43 natural field control points had been identified in field and on photographs around the Park area, and their planimetric positions were surveyed with a low accuracy Trimble Ensign Global Positioning receiver. The X and Y accuracy of GPS control points, estimated from multi measurement of ten known ground points, were 14 and 16 meters, respectively. This corresponds to 0.27 and 0.31 milimeters at 1:50000 map. For densification of GPS planimetric field control to the total number of 170 tie points - photo control (natural features), distributed uniformly around all photographs, the modified hand templet aerial triangulation was applied. As a result, for each involved photograph, six planimetric photo control points were determined. The accuracy of the applied method was estimated from residuals obtained for 43 GPS field control points, after analytical transformation of each triangulated strip to the ground coordinate system. The average accuracy for these points distributed in six strips was 15 and 13 meters for X and Y coordinates, respectively. This corresponds to 0.30 and 0.26 milimeters at 1:50000 map and 0.5 and 0.4 at photo scale 1:30000. The received accuracy of triangulation for GPS points was within the same range as the accuracy of their field GPS determination. Similar accuracy can be expected for tie points (photo control) since both GPS ground control and triangulated photo control were natural features' points of similar quality. For tie points, common for each two strips, the mean square errors were also calculated from the differences in their positions obtained after transformation of each strip to the ground coordinate system. The avreage mean square errors for all tie points of a block are, for X and Y 17 and 14 meters (0.34 and 0.28 mm at map scale), respectively [Bujakiewicz, 1993]. The positions of GPS ground control and triangulated photo control points within the Park area, covered by photographs distributed in six strips, are shown in figure 1.
Another experiment was carried out in addition in the Department, to compare the accuracy of the modified graphical triangulation with conventional independent models method [Musonda, 1994]. One strip of 13 photographs at 1:20000 scale of East part of Zambia was triangulated twice with the above methods. For independent models triangulation, a computer supported stereoplotter A8 was used for models formation and PAT MR software for their simultaneous adjustment. Results from the modified graphical triangulation were compared with those from independent models method (assumed as accurate). The mean square errors estimated from differences between the corresponding values for X and Y coordinates of 40 tie points, were 7.1 and 7.4 meters (0.15 milimeters for X and Y at 1:50000 map scale or 0.35 milimeters for X and Y at scale of used photographs). Ten field control points were field premarked and determined with field methods. In this experiment, the tie points, triangulated with the use of templet method, were determined with higher accuracy because of their better quality and the fact that the field control points were premarked and surveyed in field with higher accuracy.

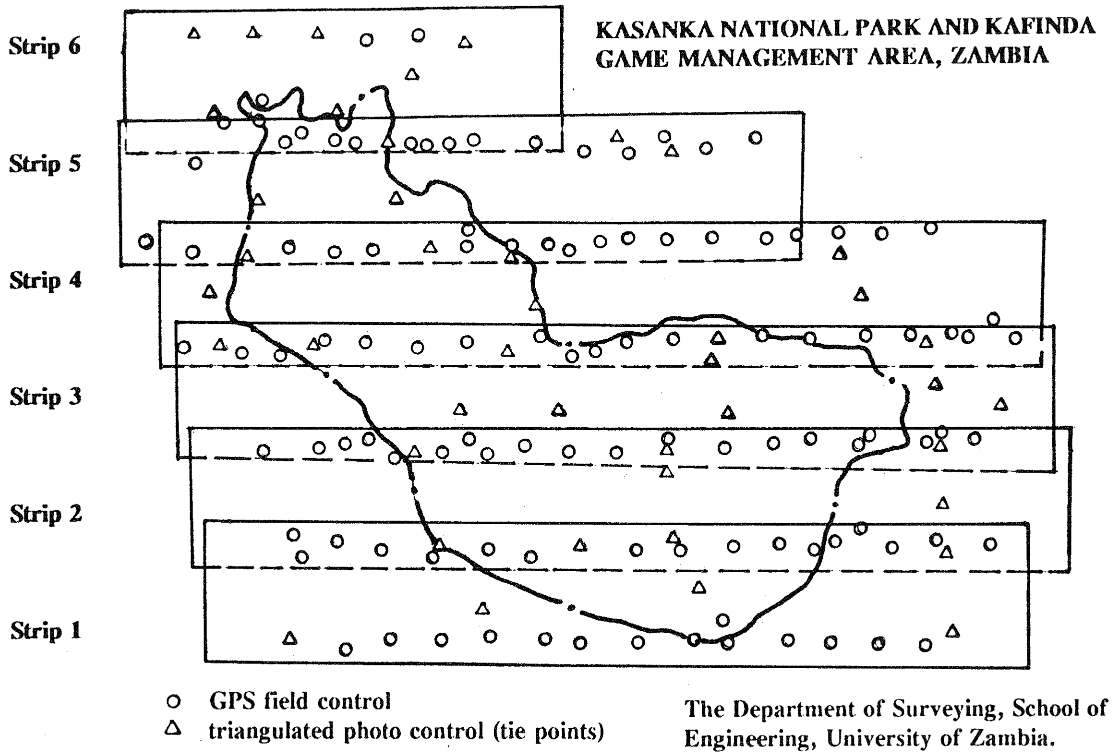

Figure 1. Distribution of GPS field control and triangulated photo control around the project area.

The GPS points and photo control determined by triangulation were plotted on a transparent overlay at 1:50000 scale and used for rectification of each photograph with a Zeiss Jena Sketchmaster. Subsequently, all vegetation boundaries, as well as roads, water bodies and settlements, which had been ealier identified and marked on photographs in field, were transferred from the oriented photographs to the map overlay. A planimetric accuracy of the transferred features depends on accuracy of their identification and photographs' orientation. The estimated accuracy ranged within 0.4 - 0.6 milimiters in the map scale. To match the new map overlay with the original 1:50000 map, six of determined points were identified on the original map. The content of the graphical original map and the graphical overlay with the vegetation boundaries and other new features, compiled with a sketchmaster, was digitized in the Manchester University. The graphic output is shown in figure 2.

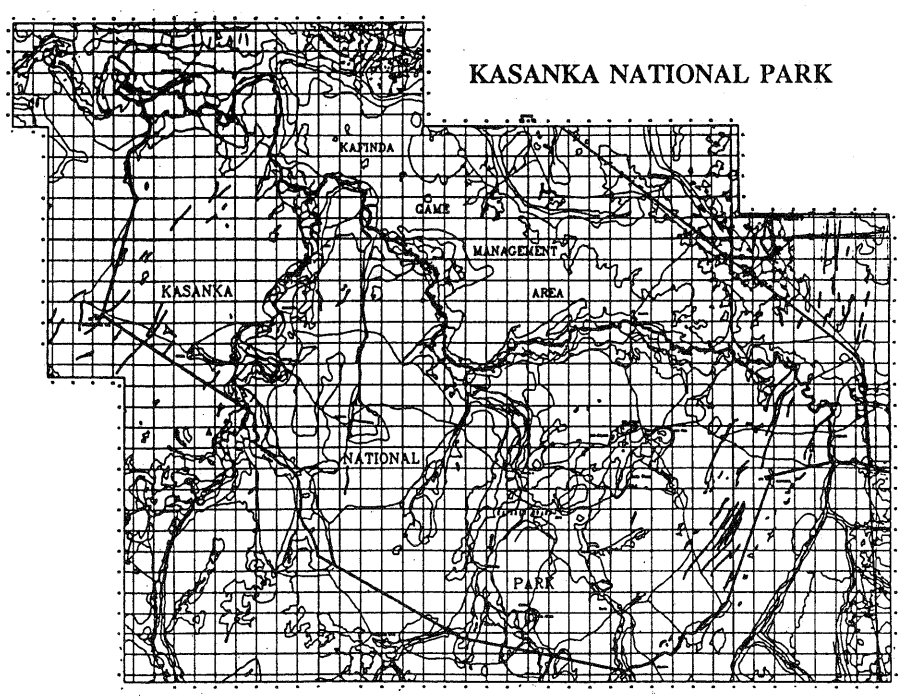

Figure 2. Vegetation polygons boundaries and other features around the project area.

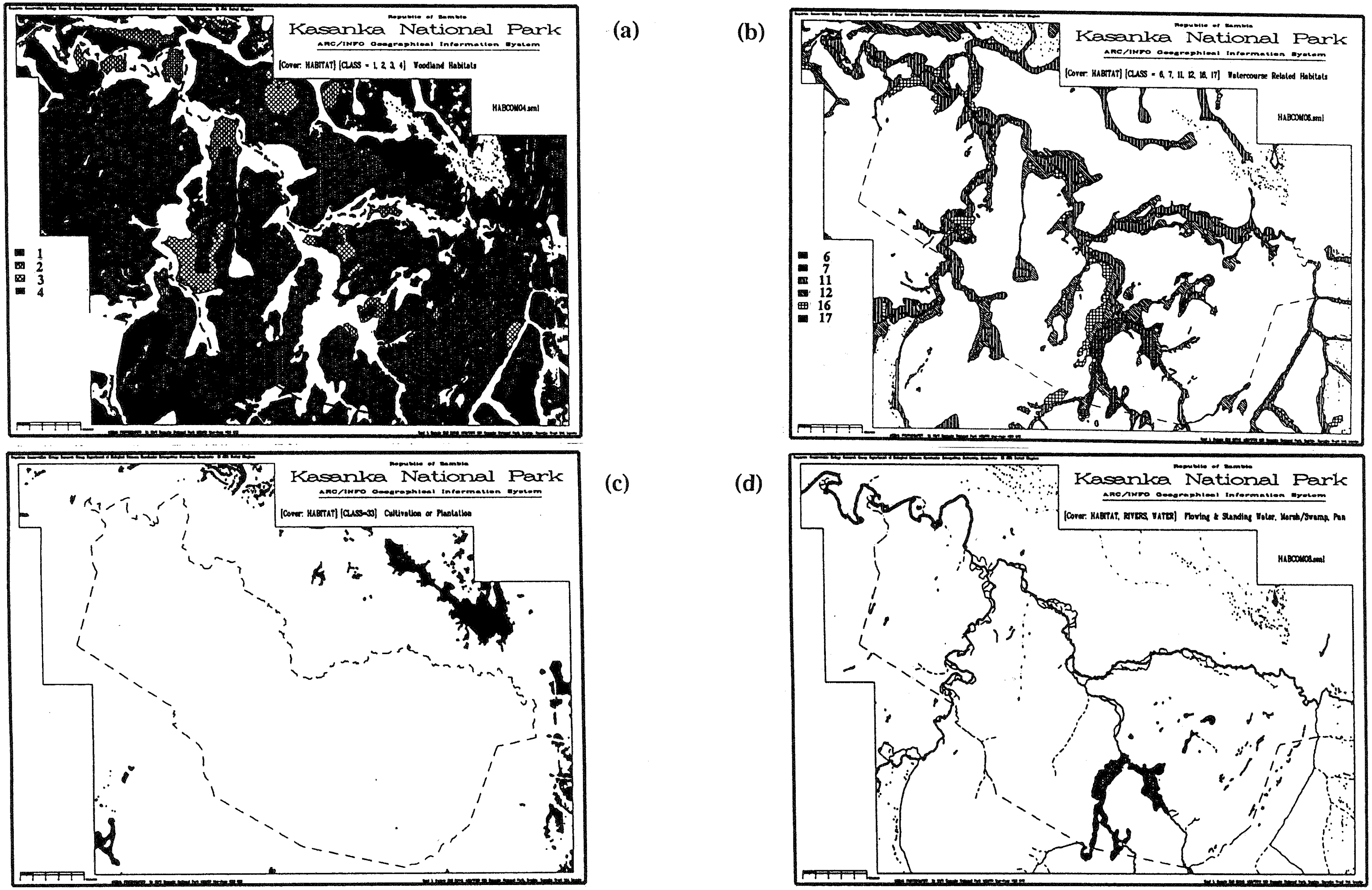

Figure 3. Graphic outputs showing combination of various vegetation coverages; (a) classes 1-Miombo Woodland,2-Munga Woodland,3-Chipya Woodland,4-Chitemene Woodland (b) 6-Riverine Forest,7-Mushitu Forest,11-Wet Grassland,12-Termitaria,16-Bush Group,17-March/Swamp (c) 33-cultivation (d) rivers and other water bodies.

The second part of the project, carried out by the United Kingdom team included mainly identification of all vegetation types within the particular polygons and other thematic information from panchromatic photographs, initial and final field verification within the project area, digitizing of all features from the original map and the new overlay and processing and analysis of all geometric information with the corresponding thematic data with ARC\INFO, to obtain the final results. The classification and analysis process was concerned with incorporation of 13 vegetation classes and 9 non-vegetation classes into the habitat coverage [Cassels, 1994]. The vegetation classes were selected as follows; 1 - Miombo Woodland, 2 - Munga Woodland, 3 - Chipya Woodland, 4 - Chitemene Woodland & scrub, 6 - Riverine Fringing Forest, 7 - Mushitu Swamp Forest, 8 - Mateshi Dry Forest, 11 - Seasonally Wet Grassland, 12 - Seasonally Wet Grassland/Termitaria, 16 - Bush Group, 17 - March or Swamp, 18 - Papyrus Swamp, 33 - Cultivation. The other classes were concerned with water, geology, roads and settlements.
Examples of the graphic outputs showing combination of various vegetation coverages are presented in figure 3, (a) - classes 1,2,3,4, (b) - classes 6,7,11,12,16,17, (c) - class 33. Rivers and other water bodies are shown in figure 3 (d).

4. CONCLUSION

The use of simple photogrammetric methods concerning field control densification and mapping of vegetation boundaries and other features in area of the Kasanka National Park and surrounding Kafinda Game Management Area in Zambia allowed to create a GIS data base at low cost and within short time. Both, the cost and the time were at least a half of those needed for conventional methods of aerial triangulation and mapping.

Such simple photogrammetric methods can be recommended for mapping other national parks of large areas in Africa.

The project has delivered the initial information, in a form of the GIS data base, on habitat in the project area. The subsequent research related to wildlife management in this Park will be greatly enhanced with the availability of these data. The new types of information and the changes in time to the Park habitats caused by fire, weather, firewood collection, grass cutting, movement of wild animals, poaching, fishing and other, can be examined and introduced to the basic GIS data base. This allows the control of overall wildlife resources and their changes.

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