MONITORING OF FOREST AND FOREST RESERVE BOUNDARIES IN GHANA USING SATELLITE (LANDSAT) IMAGERY

By DR. B .E. KWESI PRAH, MSc PhD
GEODETIC ENGINEERING DEPARTMENT
UNIVERSITY OF SCIENCE AND TECHNOLOGY - KUMASI, GHANA

ABSTRACT

The paper investigates a possible alternative technique for the monitoring of general forests and forest reserve characteristics as well as their boundaries. The investigation was broken down into two phases. The first phase dealt with the feasibility of using satellite imagery in delineating the boundaries of the forest stands. The second phase dealt with the determination of changes which have taken place within the forest stands using the satellite imagery and the possible reasons (causes) for these changes. Some practical ways aimed at minimizing the extent and occurrence of such changes are suggested.

KEYWORDS *Thematic maps, reafforestation, taungya system, agro-forestry, Landsat, SPOT, Spectral characteristics.*

INTRODUCTION

In most countries, the ideal ratio of forest reserve to the total general forest stands is about 25% to 75%. In Ghana however, the ratio is only about 10% to 90% and this is even not stable since the reserves are being threatened by encroachment due to human as well as external physical factors such as the current global climatic changes especially the changing rainfall regimes which affect directly the growth of plants.

The present method of monitoring forest reserve boundaries in the country consumes too much time and manpower. There is therefore the need to look for a more dynamic and systematic method to replace it, since foot patrol units alone cannot be relied upon to effectively monitor changes caused to the forest stands due to disease, bush fires, inadequate cultivational practices, etc. The application of aerial photographs for the purpose of monitoring forest volumes is almost non-existent. This limitation is partly due to the fact that the country does not posses its own aerial photographic unit and therefore has to rely on outside assistance, which most often is rather very expensive and consequently not attractive to the appropriate government departments directly involved.

The only viable and modern alternative method to solving the effective monitoring of forest and forest reserve stands problem, is the application of satellite imagery. Since data is received every 16 or 18 days by Landsat and 26 days by Spot programmes, it provides a more dynamic way of information collection and has the advantage of drastically reducing the time and labour requirements. The repetitive nature of the data acquisition makes it possible for a more comprehensive and temporal analysis.

The paper seeks to demonstrate the feasibility of applying satellite imagery to the monitoring of forest stands for the first time in the country. The investigation was broken down into two phases, the first phase dealt with the possibilities of producing thematic maps of forest boundaries using satellite imagery. Efforts were made to revise the existing forest map.

The second phase conducted investigation to determine the causes for the changes of forest boundaries so detected and mapped during the first phase. The paper therefore investigates such causes like, clear cut for timber and its effects on the forest stands, bush fires, disease, illegal farming in the reserve zone, cultivational practices and makes proposals as to how the forest stands could be protected against some of the causes mentioned above, and how to help regenerate the forest stands so damaged especially the forest reserves.

The Study Area

The area under study falls within 6°00'N - 7°45'N and 1°30'W - 3°10'W [Fig.1]. It lies within the Ashanti and Brong Ahafo regions and North West of Kumasi the capital of Ashanti region. The forest reserves in the area include the Mpameso, Bia-Tano, Boukondi, Subin, Bia North, Bosomkese, Desire, Wamisa, Pamu, Berekum, Tain I and II, Amamam shelter belt, Asukesi, Afram Head waters, Tinte Bepro, Tano-Offin and some minor stands. These form part of the main forest zones of the country and part of the Antiaris Chlorophora and the Celtis Triplochiton Association (i.e. ACA and CTA). The area forms part of the heavily exploited regions for timber logs and its related wood products in the country. Cocoa and other cash crops farming is the main occupation of the inhabitants in the subregion. All these activities contribute to enormous amount of forest clearing.

Dr. Kwesi Prah

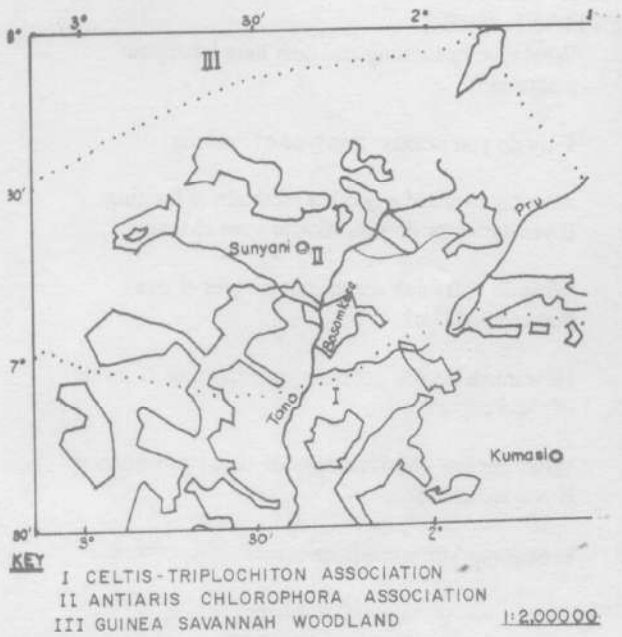

Fig 1: A reference map showing forest zones and forest reserves distribution, study area for the project. It was compiled by the Forestry Department of Ghana 1969.

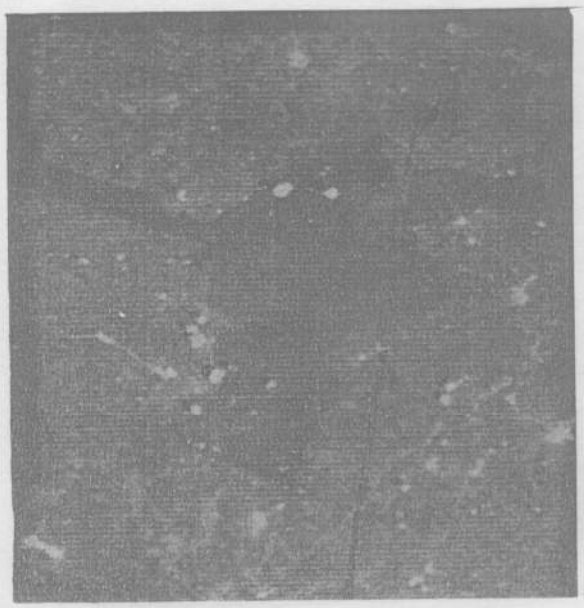

Fig 2: A Landsat image showing the Bosomkese Forest Reserve area (see Fig. 2a for the interpretation).

This was the most affected area in the country, during the 1982 - 1983 bush fires.

Method

Visual interpretation using satellite images, aerial photographs and reference maps was employed since this seemed the best technique at the moment. This is because the objective is not to classify the forest stands into tree types which is in itself very difficult even with the aid of computers, given the heterogenous nature of the tropical forest which makes spectral classificational method [2] very difficult, since the trees have similar reflectance response. For example in Ghana it is very common to find several individual tree types like wawa, okoro, opranplan, onyina, odum, sapele, mahogany just to name a few of them in a parcel of land of only one acre. Because of the generally non-clustering nature of the tropical trees, selection of sites for training is very difficult since reflectance responses are only unique for those sites and can not be representative enough for the rest of the portions of the forest to be classified. The reason for this is that tree variety is very extensive and it is not possible to have all types in a training site.

A multiscale and multitemporal method [1] of analyses was employed in this investigation. Landsat images both colour and black/white and of 1:1000000 and 1:200000 scales were used [Figs.2 and 3]. The images were 1973 and 1974 Landsat MSS products. [illegible] 1969 aerial photographs covering one of the forest reserves (Bosomkese forest reserve) was used for detail analyses using mirror stereoscopes in that reserve area. These photographs were of 1:30000 scales. Forest maps of 1:500000 and 1:2000000 scales compiled in 1969 and 1979 by the Forestry Department were used as reference materials for the interpretation. The interpretation of the black/white and the colour images were used to complement each other for the general study area.

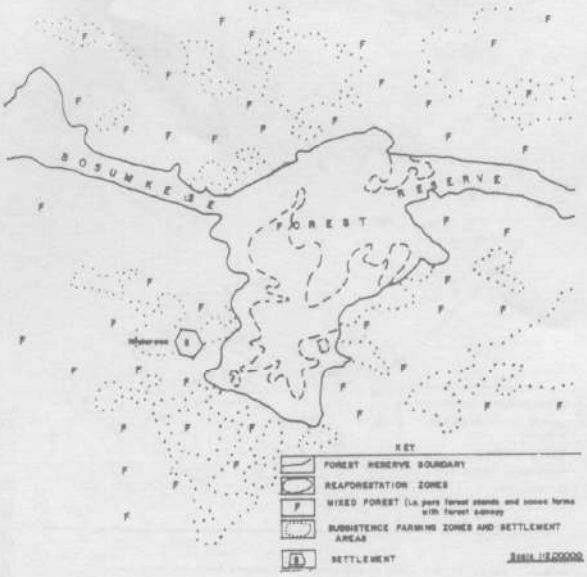

Fig. 2a: An interpretation of a Landsat imagery (25-11-73) showing details of the Bosomkese forest reserve area. The reaforestation zones represent areas either presently under or yet to be, but had been either affected by clear cut bush fires before. Mixed forest zones are areas either of pure forest stands or cocoa form with Forest Canopy.

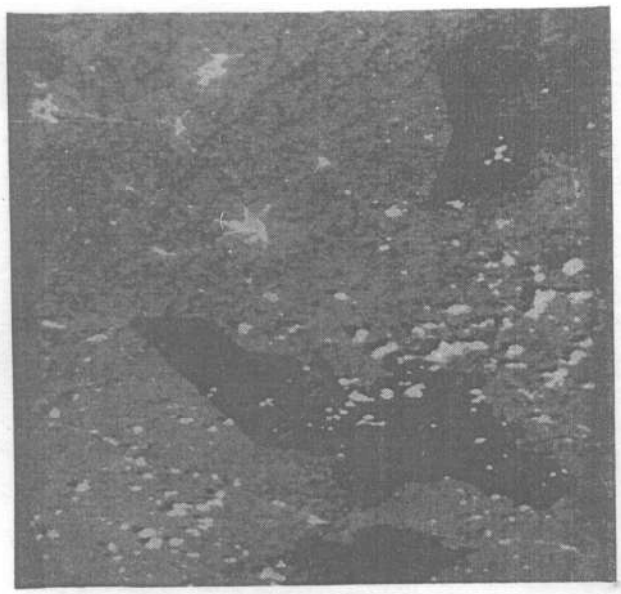

Figure 3

The Bosomkese forest reserve area was chosen for a much detail analysis due to the diverse spectral characteristics of the area and also its central position with respect to the study area. A field trip with the aim of collecting ground truth was undertaken and interviews conducted with a cross section of the inhabitants of the area who are mostly farmers, based on the questionnaire below.

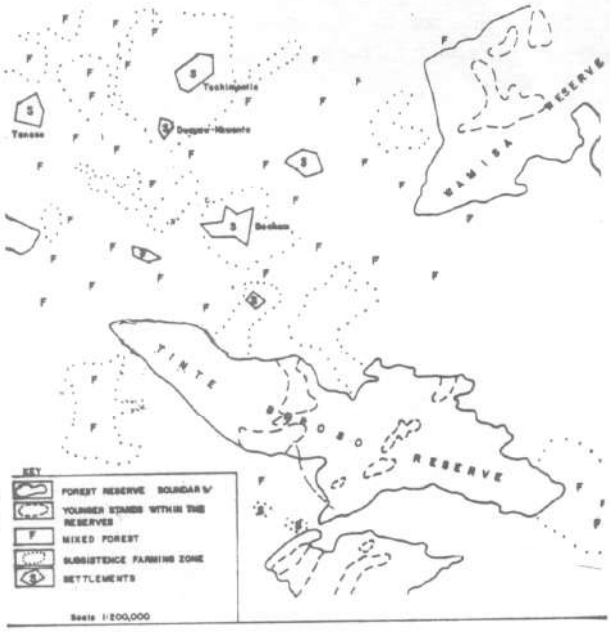

FIGURE 3c: Interpretation of a Landsat imagery showing forest reserves boundaries, mixed forest (i.e. pure forest stands and areas farms with forest canopy), farming zones and settlements

QUESTIONNAIRE

1. What type of farming and how long have you practised it?
2. Why do you practise this type of farming?
3. Are you aware of any other method of farming If yes then why do you stick to your old one?
4. What do you think are the advantages of this farming practice?
5. How much do you get from your farming in terms of yield per unit?
6. What are the disadvantages of using this method if you are aware?
7. In what ways do you influence the fertility of the soil?
   - i. natural fertilizers
   - ii. artificial fertilizers
   - iii. non application of fertilizers
8. Are you aware of the hazards of water and wind erosion, if so how do you check it?
9. How do you know that the fertility of your piece of land is gone low?
10. Do you have any knowledge of the rainfall pattern over the years and what do you think is the contribution of the felling of timber and general clearing of the bush on rain fall distribution.
11. Are you aware of any natural or artificial disaster which might have caused a lot of damage to forest stands where you farm.
    - i. disease
    - ii. bush fire
    - iii. stagnant water due to flooding
12. Do you have an idea as to why people farm in the forest reserve.

RESULTS AND DISCUSSION

From the available Landsat imagery it became clear that forest boundaries could be mapped out especially the forest reserves [Fig.2]. The forest reserve appeared very distinctive on both the black/white and the colour composite. As was expected channel 7 was most useful in the forest boundary delineation. The reserve appear very distinct because in most cases their immediate surroundings had been

farmed for cash crops like cocoa or made up of scattered tall trees due to recent clear cut for timber. Within the forest reserves it was possible to distinguish between the boundaries of young tree stands from that of the old due to the different tonal spectral responses. A good example of such classification was made on the Pamu-Berekum and the Bosomkese reserves. From the image [Fig.3] the Bosomkese reserves appeared to have been affected by illegal lumbering activities which became rampant some years back.

Upon the interpretation of aerial photographs and ground verification it was learnt that some parts of the reserve had been clear cut for timber in the early 1960's, legally by Mim Timbers Company, and has been affected by bush fires in the 1960's. An attempted afforestation programme had failed in the 1970's due to bad selection of trees. However, the Forestry Department had kept on with the reafforestation programme with teak trees and it is progressing steadily.

It was during the ground verification trip that a hitherto unknown programme of reafforestation within the forest reserves was made known to the writer and indeed to most of the professional community outside the Forestry Department. This programme is known as the TAUNGYA system. This system came into existence as a result of the need for the village communities in the vicinity of the reserves to search for arable land to farm for food crops since they had put almost all available land under cash crop cultivation (especially cocoa). They therefore approached the government and asked to be allowed to farm in the forest reserves. At the same time the farmers were searching for land to farm, the Forestry Department was also looking for funds to carry out its reafforestation programmes. So the department and farmers together worked out this new system. According to the rules governing this system, the farmers form co-operative-like groupings led each by an elder who is responsible to the Department of Forestry. Each individual is allocated a plot within that given to the group in accordance to the direction of afforestation as declared by the Forestry Department. The farmers clear the land to be reafforested and prepare the land for planting. Any food crop could be planted except the cassava plant. During the following rainy season the Forestry Department plants the approved type of tree for that particular reserve zone. This agro-foresting system goes on until the trees are matured enough for their roots to be disturbed by the agricultural practices. By this co-existence the farmers got their foodstuffs while the Forestry Department received the necessary man-labour for the reafforestation programme.

During the interview with the farmers on the site visit, it became clear that the farmers were very knowledgeable about so many of the factors which affect the earnings from the land they farm. For example about 90% of the farmers asked about the application of artificial fertilizers, said they were aware of it but applied it only for vegetables and not for other food crops. Asked about the reason why they only applied it for vegetables, majority of them answered that it was not cost effective to use fertilizers for food crops since the local prices were low. Asked why they kept on with the shifting cultivation activities, majority of them said they were not aware of any other farming practice except that. The rest who knew about other agricultural practices also could not practise them because of the difficulties in acquiring the necessary capital. The farmers were asked whether they knew of the problem of soil erosion. About 60% said they were not aware, the 40% who were aware also did not think it is a serious problem. Answering a question on the problem of the changing rainfall pattern, they all apportioned the blame on the massive indiscriminate felling of trees for timber in the forest regions. Asked if they could recollect either from history or their own experience about any natural disaster which might have caused a lot of damage to the forest stands like disease, flooding and bush fires, they could all not remember any such problems except the 1960 and the 1982-83 bush fires which have since become a common phenomenon in the country.

CONCLUSION

The research project on which this article is based is only in its early stages and therefore much experience would be gained as it progresses. However, some important conclusion can be drawn pertaining to the work already done.

1. All the forest reserves in the area under study could be identified and accurately mapped out using Landsat images of 1:1000000, and 1:200000 scales which were available for the project.

2. Outside the forest reserves, it was very difficult to identify pure forests from the "agro-forests" stands. This difficulty is normally associated with tree crops like cocoa which grows under the canopies of tall trees appearing as if it were the undergrowth of the normal forest stands. The fact that in Ghana the various "stools and skin" elders decide on which parts of their lands are to be farmed, gives rise to the situation where large stretches of land has been farmed in patches, thus making interpretation very difficult since there is no uniform and continuous spectral signature registration. This was where the use of the aerial photography in the project helped a lot. It became apparent from the aerial photographs that portions of the satellite imagery [Fig.3] with light brownish purple tone generally corresponded to mostly short and young trees with open spaces between them, while portions with deep brownish purple tone in general corresponded to well vegetated and tall matured stands. Despite the above difficulties Landsat images could be used on the regional bases to identify vegetation cover be it pure forest or tree crop stands. This was also confirmed by the results of the interpretation of the aerial photographs.

3. It became obvious that Landsat images could serve as an effective tool for the revision of the existing forest maps

especially the forest reserve maps. This would be very cost effective considering the cost and time involved in compiling data for the production of the map.

4. From the results of the interview with the farmers in the forest zones examined, it can be concluded that they are aware of the parameters, such as effect of shifting cultivation, bush fires and indiscriminate felling of trees for timber which lead to the degradation of the forest stands though some more education may be necessary to get them actively involved in the implementing the solutions to the problems such as the introduction and development of the Taungya systems outside the forest reserve zones.

From results of the investigations, it could be proposed:

1. That the monitoring be extended to cover the whole country and that a section dealing mainly with the application of Remote Sensing Data be set up in the Forestry Department so that the investigation could be conducted jointly with them.

2. That education in the application of satellite data be started in the country which will help build up the necessary professionals ready to help with the utilization of such data.

3. That the farmers living in and around the forest zones should be encouraged and helped to form fire fighting brigades to minimise the extent and damage to the forest stands due to bush fires.

4. That SPOT image be used since they could be viewed stereoscopically. This would enhance most likely classification of forest types which is a likely problem when using Landsat images.

ACKNOWLEDGEMENT

The author wishes to thank Mr S Atuobi, Mr Kuma both of UST, Kumasi and the ODA group of Britain based in the Forestry Department at Kumasi for the use of some of their Landsat imagery collections during his analysis. Further thanks go to the Director of Surveys, Alhaji I Abu and his Regional Director, Mr Mohenu for their help in obtaining aerial photography and some ground truth data.

REFERENCES:

1. *American Society of Photogrammatry, Manual of Remote Sensing Vol.II [1975]*

2. *Forest Resource Classification of the McCloud Range District. Final Report [1980]*

3. *Nemeth Ferenc: Applications of Satellite and Aerial Photographs in Forestry. Budapest [1979]*

4. *F. F. Sabins Jr. Remote Sensing Principles and Interpretation. Freeman and Company, New York [1978].*

5. *T. M. Lilles and R. W. Kiefer: Remote Sensing and Image Interpretation. John Wiley and Sons, New York [1976]*

6. *E. C. Barrett and L. F. Curtis: Introduction to Environmental Remote Sensing. Chapman and Hall, London [1976].*