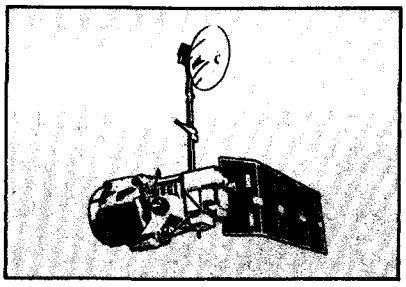

Remote Sensing Images

Editor: M. Duane Nellis
Department of Geography
Dickens Hall
Kansas State University
Manhattan, Kansas 66506
U.S.A.

Spatial Variation in Elephant Impact on the Zambezi Teak Forest in the Chobe National Park, Botswana

M. Duane Nellis
Charles E. Bussing
Department of Geography
Kansas State University
Manhattan, KS 66506
USA

Background to the Imaged Area

The Chobe district of northern Botswana contains six major forest reserves, extending over 400,000 hectares, as well as Botswana's oldest and largest national park, which covers an additional 11,000 square kilometers (Figure 1). This dry deciduous forest is situated on loose kalahari sand on flat to gently undulating terrain. This forest is part of the Zambezi Teak Forest Association which extends from northern Botswana into neighboring parts of Angola, Namibia, Zimbabwe, and southwestern Zambia (Weare and Yalala 1971).

The forest is composed of a vegetative mix. Zambezi teak *(Baikiaea plurijuga),* locally known as mukusi, is the most important species. There are numerous other secondary species in the Baikiaea forest; however, only one species *Pterocarpus angolensis* or mukwa is exploited locally. The understory is composed of variable grass, shrub, and herbaceous species.

The Zambezi Teak Forest is of significance for several reasons. It not only provides firewood and building materials, as well as other resources for the local people, but also is exploited commercially although at a suboptimal level. Teak, one of the fine, heavy-duty timbers of the world, is used primarily for railway and mine sleepers and for production of floor tiles. Additionally, this dry forest is of considerable scientific and educational value by virtue of the range of flora and fauna found there. Because of the unique nature of this ecosystem, it is important to conserve its genotypes for the benefit of future generations (Piearce 1986).

Chobe National Park is regarded as one of the most important wildlife parks in Africa. The park can be divided roughly into three areas. The northern portion of the park consists of the riverine area of floodplains and small pans grading into riparian woodland and forests. The western portion of the park near Savuti is a large marshy area situated in the Nababe Depression. The southern portion of the park consists of Mopani *(Colothospermun mopane)* Baikeia Forest and large pans. The ecosystems here are typical of those in southern Africa and contain a large population of both migratory and resident herbivores such as elephant, zebra, cape buffalo, impala, giraffe, and wildebeests. Of the predators, lions, hyenas, wild dogs, and jackals are noteworthy. These along with a very rich array of bird species live in this mosaic of grassland and forests.

Numerous interrelated factors have impacted the dry deciduous forests in this area. Human use of the forest has made it more susceptible to fire. Teak is typically thin-barked and as a result is very sensitive to fire damage. Additionally, in recent years, elephants have increased dramatically, now numbering more than 50,000 in this area of northern Botswana (Figure 2). These herds comprise one of the largest savanna elephant populations in all Africa. Elephants represent a problem in that they destroy vegetation and peel the bark of some trees, especially Mukwa, leaving the trees open to fungi and ultimate death. Conservationists have expressed concern about the impact of these animals on the deciduous woodlands of northern Botswana; however, at this time available scientific information is limited.

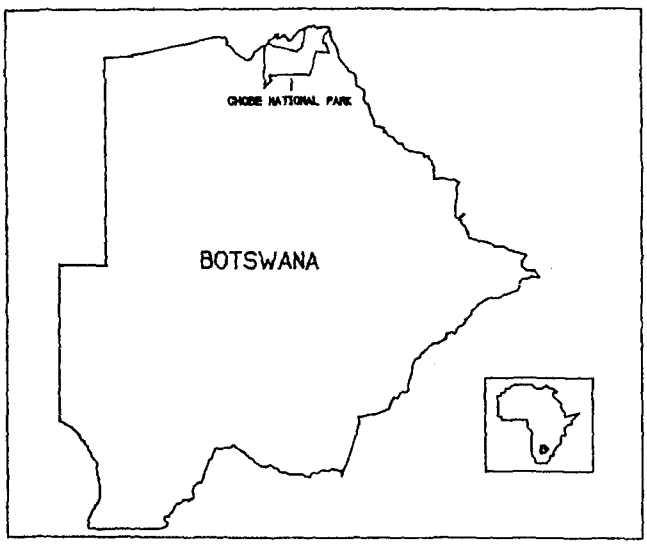

Figure 1. Botswana and the Chobe National Park.

Figure 2. Elephants along the Chobe River, Botswana.

The objective of this analysis was to provide initial information on wildlife impact on the Zambezi Teak Forest within Chobe National Park. This information can be used to assist in management policies which will lead to perpetuating the existence of the forest and the long-term sustainable use of this region.

Analytical Procedures and Analysis

Ringrose *et al* (1986) and Vujakovic (1987) have provided initial investigations on the use of Landsat multispectral scanner data for mapping the density of woody vegetation cover, and the woody component of rangeland vegetation in Botswana. These and other studies (Ringrose, 1987 for example) provide evidence of the role remote sensing can contribute to the development of a suitable information system critical to Botswana's land use planners and resource managers.

Figure 3 was derived using an unsupervised classification cluster routine applied to an August SPOT HRV multispectal twenty meter spatial resolution satellite data set. In this particular data transformation and color enhancement, a two-pass sequential clustering algorithm was applied to the SPOT data set. In the first pass, the program read thorugh the entire data set, and sequentially grouped the points in spectral space based on parameters the researchers selected after conducting a field transect through the research site. In this procedure a mean is computed for each of the derived clusters. These clusters become the signatures used to assign classes in the output geographic information system land use file.

The second pass of the clustering algorithm classifies each pixel in the data set according to a minimum distance classifier. The algorithm calculates the spectral distance between the candidate pixel and the mean value for every cluster, using the mean values that were

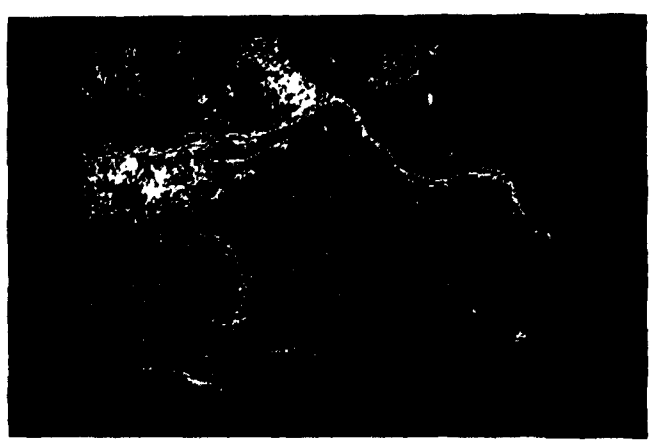

Figure 3. Classified HRV Multispectral SPOT scene of the Chobe National Park illustrating variations in elephant impact. Landscape units include (with associated hue): (1) Zambezi teak association (green); (2) moderately impacted Zambezi teak association (dark brown); (3) heavily impacted Zambezi teak association with significant reduction in Mukwa (light brown); (4) heavily impacted areas lacking vegetative cover (white); (4) Elephant Grass/riparian areas (red); (6) short grass/riparian areas (black); and (7) water-primarily Chobe River (blue).

computed in the first pass (after Nellis and Briggs, 1988). The cluster approach to spatial analysis yielded seven distinct classes of landscape type within the Zambezi Teak Forest of the Chobe. The general landscape types range from heavily impacted areas (bare soil) to the preserved Zambezi Teak Forest Association. Land areas adjacent to major water sources and associated with elephant routes to water sources are well defined (in white hue) using this procedure. In addition, processes of spatial transition away from intense elephant impact areas can be effectively documented using SPOT data.

Conclusions

SPOT HRV multispectral data offers critical insight as to the spatial pattern of elepant impact within the Chobe National Park of Botswana. The pattern of the elephants movements to and from the Chobe River offer interesting insight as to the extent of damage to vegetation, particularly Mukwa.

The forest reserves and national park in Chobe District represent an exceedingly important national asset. Existing utilization of the resources in the district for the most part is suboptimal, and the exploitation now taking place is not sustainable. The government needs to understand the impact of both wildlife and various human activities on the ecosystem. Image enhancement algorithms of SPOT satellite data provides an initial source of understanding of wildlife impact in one of Botswana's critical resource areas.

References

Nellis, M. D. and Briggs, J. 1988. SPOT Satellite Data for Pattern Recognition on the North American Tall-Grass Prairie Long-Term Ecological Research Site, *Geocarto International*. Vol. 3, pp. 37-40.

Piearce, G. D. 1986. How to Save the Zambezi Teak Forests. *Unasylva* Vol. 38, pp. 29-36.

Ringrose, S. 1987. The Development of a Land Use/Land Cover Classification System and an Application of its Usage in Botswana. *Botswana Notes and Records*. Vol. 19, pp. 75-81.

Ringrose, S. 1986-1987. The Use of Remote Sensing Techiques to Determine Density of Woody Vegetation Cover in the Southeast Botswana Kalahari. *Forestry Association of Botswana Journal*. pp. 60-71.

Vujakovic, P. 1987. Mapping the Woody Component of Rangeland Vegetation Using Landsat Satellite Data, Ngamiland, Botswana. *Botswana Notes and Records*. Vol. 19, pp. 69-73.

Weare, P. and Yalala, A. 1971. Provisional Vegetation Map of Botswana. *Botswana Notes and Records* Vol. 3, pp. 131-147.

Acknowledgement

This research was funded through the U. S. Agency for International Development as part of the Kansas State University Agriculture Technology Improvement Project. The authors wish to thank SPOT IMAGE CORPORATION for providing the original data for this project. We also wish to thank Craig Ackermann for his cartographic assistance.