14TH INTERNATIONAL CONGRESS OF THE
INTERNATIONAL SOCIETY OF PHOTOGRAMMETRY

HAMBURG 1980
COMMISSION VII

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ECOLOGICAL MONITORING OF BALANCING LAKES BY MULTISPECTRAL REMOTE SENSING

Abstract

The new town of Milton Keynes has within its urban extent several lakes which are used for balancing water supplies. Their function is to regulate water flowing into the River Ouse system. There is an urgent need to develop cost effective methods of monitoring certain characteristics of these lakes, e.g. the extent and distribution of emergent, floating and submerged vegetation. For two successive years multispectral aerial photography has been acquired. This material is assessed to determine its relative value as a source of useful information for the Ecological Section of the Town Development Corporation. Some problems are identified, and recommendations made to guide the users how best they should proceed in the future.

Ecological Monitoring of Balancing Lakes by Multispectral Remote Sensing

A frequently unforeseen side-effect of urban development is a greater liability for flooding caused by the increased surface water run-off from paved surfaces. Planning for the construction of Milton Keynes New Town, which began in 1971, included a strategy for regulating the excess run-off likely to be generated. This involved the provision of a number of balancing lakes which have the capacity to hold back excess flood run-off, for subsequent gradual release into the local stream system.

A multiple-use strategy has been developed for the balancing lakes which includes, as well as the regulation of run-off, fishing, boating, wildlife conservation and picnicking and this recognises the importance of their ecology. Vegetation is important not only for its contribution to the visual quality of the landscape, but indirectly, and perhaps more importantly, for its major role in the establishment of a desirable and stable aquatic environment in which suitable types of plants and animals can become established. Little is known about the type and rate of vegetation succession on balancing lakes, yet this information is important both from the point of view of the management of existing lakes, and for the planning and design of those which are proposed for the future (Kelcey J.G., 1978).

This paper describes an assessment of three types of aerial photographs for monitoring the vegetation of balancing lakes.

Aerial photographs of two lakes were supplied by Milton Keynes Development Corporation, for the two years 1977 and 1978. These included black and white prints, and true colour and colour infra-red transparencies, at a scale of 1:2,500, with a 9 x 9 inch format.

Figure 1 shows a black and white print of Tongwell Lake taken in 1977.

Variations in the quality of the photography flown, in conjunction with insufficient ground control at the time of flight, and the lack of detailed processing information, precluded the direct comparison of results from different lakes, and for different years. This paper therefore deals mainly with vegetation mapping from the 1977 photography of Tongwell Lake, though similar results were confirmed from the other three sets of photography studied.

Tongwell Lake:

Tongwell Lake was constructed in 1974 by the impoundment of water behind a dam. A fairly dense marginal community of emergent vegetation, from water level to approximately two metres in height, has become established. This consists mainly of fairly common aquatic species such as Rushes (Juncus, Scirpus spp.), Reeds (Sparganium spp.), Waterweeds (Myriophyllum spp.), and some flowering plants such as the Yellow Flag Iris (Iris pseudacorus). Some planting of Willows (Salix) has also taken place. A fairly dense community of submerged vegetation, including such species as Pondweed (Potomageton spp.) and Waterweed (Elodea spp.), has also become established. This submerged community usually occurs in thick clumps near to the lake shore, often intermingled with the emergent vegetation. It can easily be seen, since some of the leaves reach the water surface. Large parts of the lake bed are being colonised by mosses and liverworts (Chara spp.), though no specific information on this was available.

Film Types:

Black and white, colour, and colour infra-red photographs were available for this study. In spite of the growing popularity of colour film for vegetation mapping, black and white film is still seen as having many advantages, including higher contrast and larger amounts of data available, less variability in quality due to processing and flying conditions, and lower costs per print. The realistic range of colours available on true colour photography however is often an advantage to workers concerned with plant species composition and condition of vegetation.

Colour infra-red photography is being used in an increasing number of studies, particularly those concerned with vegetation and water resources, due to the high and low levels of reflectance from vegetation and water respectively. It has been used very little in Britain and present evaluations of its use are based on little experience of the film type. There are many misconceptions and claims about the uses and capabilities of colour and infra-red film, mainly stemming from the fact that infra-red reflectance from plant surfaces is not fully understood (Benson 1970).

Air Photo Interpretation:

The aerial photographs were interpreted in the laboratory using a Wild ST4 stereoscope. Vegetation boundaries were marked on a transparent acetate overlay, and were subsequently transferred to a rectified base map using a Bausch and Lomb Zoom Transferscope.

The successful interpretation of vegetation using aerial photographs depends to a large extent on the botanical experience of the interpreter in being able to draw upon his knowledge of site and situation of plant species. It also depends upon his knowledge of the area. Both these factors were found to be important in this particular study. Increasing familiarity with the photography, as well as a field trip to confirm laboratory observations, enhanced the usefulness of the black and white and the colour photography, as opposed to the initially more useful colour infra-red.

Colour Infra-Red Photography:

The colour infra-red photography showed high contrast between vegetation and the water surface, and even in areas of shallow water, the bright red tones of the vegetation contrasted sharply with the blue-black tone of the water. It was thus relatively easy to map the waterline using colour infra-red photography, particularly where open water adjoined the managed grass bankings of the lakeshore. Where emergent vegetation standing in the lake adjoined the grass bankings, tonal differences between the two were not so marked, and in cases of difficulty, the rougher texture of the emergent lake vegetation indicated the position of the waterline. Mapping of the waterline was therefore complete, using colour infra-red photography (see A on Figure 2).

Colour infra-red film was also found to be effective for identifying the boundary between the emergent vegetation and the adjacent, submerged vegetation (see B on Figure 2), due to the paler, orange-red colour of the latter. This boundary was particularly visible on colour infra-red photography because these two types of vegetation stand out clearly, in contrast with the very dark colour of the water.

However, the low level of light reflectance in the infra-red wavebands, from the water surface, posed difficulties for the interpretation of submerged vegetation at a depth of one metre or more. Submerged species occurring near to the surface could be readily identified, but lake bed species could not be seen. It is significant that on the colour infra-red photography, it was possible to confidently distinguish any submerged vegetation which could be seen, from other sub-surface features such as sediment, lighter patches on the lake bed, or shallow areas, due to the distinctive red coloration of the vegetation.

True Colour Photography:

True colour film is more sensitive than colour infra-red film to light reflected from water, and is also moderately sensitive to vegetation, so that it was more difficult on this film type to distinguish between the two. This was particularly so in areas where the emergent vegetation was patchy, and was interspersed with stretches of open water. Where these conditions adjoined the grass bankings of the lakeshore, it was often difficult to identify the position of the waterline (see A on Figure 3), and more emphasis had to be placed on textural criteria and associated features. Additionally, in areas of shallow water, the light brown coloration of the lake bed was indistinguishable from the sand exposed on the shore at low water levels. Thus, the transparent appearance of the water on colour film also poses difficulties for delineation of the waterline (see B on Figure 3).

The colour photography was found to be ineffective for distinguishing between emergent and submerged vegetation, for two reasons. Firstly there was no consistent tonal difference between the two types of vegetation. Secondly the situation was confused by the difficulty of distinguishing the vegetation itself from the water and from the lake bed, due to the predominantly blue-green tones of all of these features. Thus the line at C on Figure 3 which separated emergent from submerged vegetation, remains indistinct.

The transparency of the water on the true colour photography did allow some depth penetration, and detail on the lake bed could be distinguished as faint tonal variations. However, the pale green-browns of the lake bed vegetation did not contrast sufficiently with the pale browns of the unvegetated parts of the lake bed to allow a distinction to be made. Boundaries were obscure (see D on Figure 3), particularly in the deeper areas.

Black and White Photography:

Due to the limitation to shades of grey on the black and white photography, it was difficult to distinguish between vegetation and the water surface. The waterline was thus delineated using mainly textural criteria and inference from associated features, and it therefore remained indistinct in places (see A on Figure 4).

It was also virtually impossible to distinguish between emergent and submerged vegetation using black and white photography (see B on Figure 4) since there was no significant difference between shades of grey. As with the true colour photography, the situation was additionally confused by the inability to separate the vegetation itself from the grey of the water surface and lake bed (see C on Figure 4).

Although black and white photography showed a significant amount of underwater detail, the limitation to shades of grey meant that it was impossible to distinguish the vegetated from the unvegetated parts of the lake bed. For example it was impossible to tell, from the black and white photography alone, whether the distinct line at D on Figure 4 represented a vegetation boundary or whether it corresponded to a sudden break of slope on the lake bed.

Conclusion:

The results of this study suggest that the best overall film type for monitoring the emergent and submerged vegetation of balancing lakes is colour infra-red film. This is due mainly to the high and low levels of reflectance from vegetation and water respectively on this film type. The bright red tones of the vegetation thus stand out against the dark, blue-black of the water surface. The lack of depth penetration facilitated the mapping of emergent and shallowly submerged communities, and probably produced the slight difference in tone which allowed these two types to be distinguished. Although more underwater detail could be seen on the colour and black and white film than on the colour infra-red, insufficient tonal contrast on these types meant that vegetation could not be identified as distinct from other features. Where submerged features could be seen on the colour infra-red film, they could be confidently identified as vegetation or as another specific feature.

The other three sets of photography studied generally confirmed these findings, with the exception of the 1977 photography of Mount Farm Lake. The colour infra-red photography in this set had considerably better depth penetration than either the black and white or the true colour, and distinctive communities of lake bed vegetation could be mapped. This could be a result, either of different film processing, or weather conditions at the time of flight, though unfortunately exact details were not available. Cuplin's hypothesis, namely that the slight over-exposure of colour infra-red film gives better depth penetration, (Cuplin 1978), might help to explain this phenomenon, and further work along these lines may prove to be significant in terms of the monitoring of aquatic habitats from remote sensing platforms.

References

Benson, M.L. and Sims, W.G. (1970), The truth about false colour film - an Australian view. Photogrammetric Record, Vol. VI, No. 35, pp. 446-451.

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Figure 1. TONGWELL 1977 extract from Black and White aerial photograph scale approximately 1: 2500

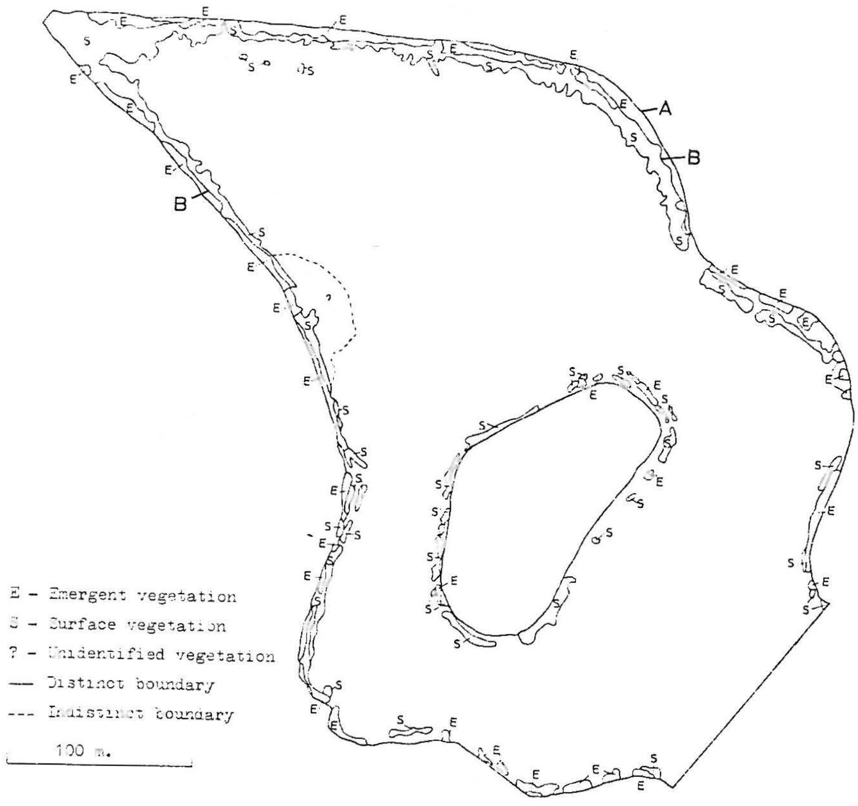

Figure 2. TONGWELL LAKE
MACROPHYTIC VEGETATION
Information derived from 1977
CIR aerial photographs.

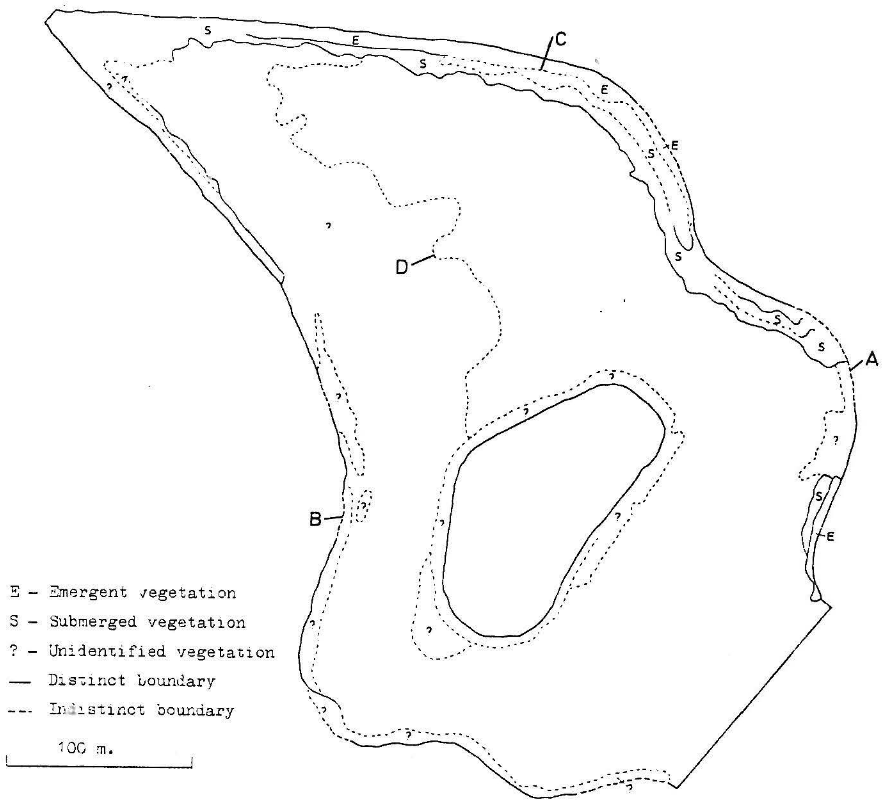

Figure 3. TONGWELL LAKE
MACROPHYTIC VEGETATION
Information derived from 1977
Colour aerial photographs.

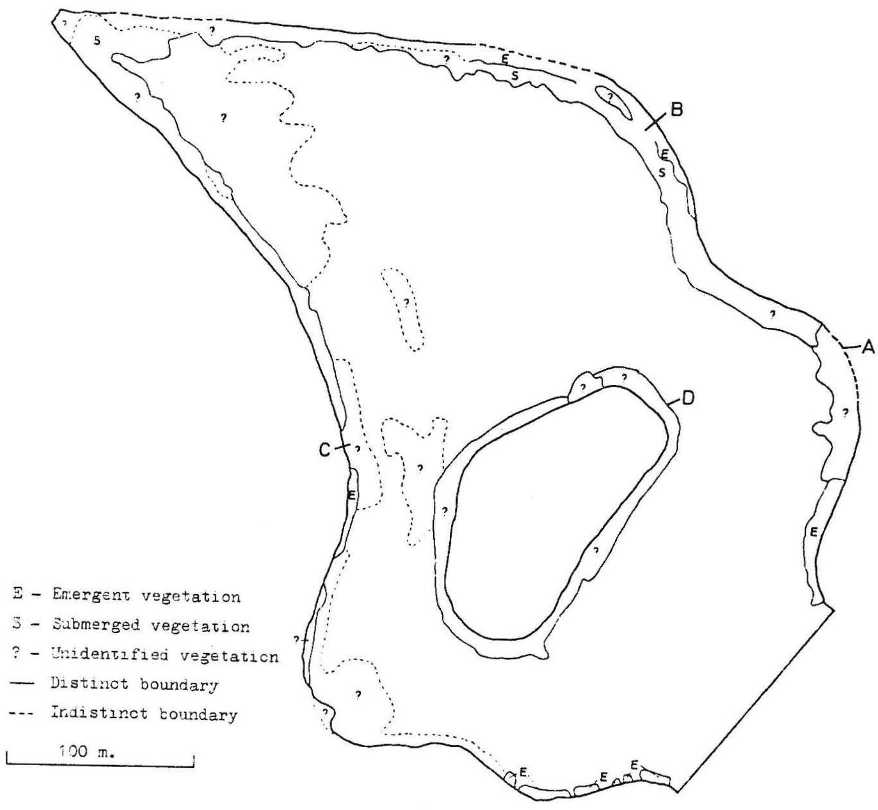

Figure 4. TONGWELL LAKE
MACROPHYTIC VEGETATION
Information derived from 1977
Black and White aerial photographs.