Chapter (non-refereed)

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Effects of drainage on natural vegetation

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1 Introduction

This paper discusses the extent to which wildlife communities may be affected by changes in land drainage. It identifies the main areas where research is required for conservation purposes. Several references are made to work that has already been commissioned by the Nature Conservancy Council (NCC) from the Institute of Terrestrial Ecology (ITE).

2 What is the problem?

Trafford (1982) summarized the ways in which changes in the soil water regime can upgrade the quality of farmland and, therefore, lead to higher food production. Government policy is to encourage this type of improvement both where it is cost-effective and causes no unacceptable harm to the environment and conservation interests. Encouragement takes the form of capital grant-aid. If agreement cannot be reached locally between the farmer and conservation bodies, cases may be referred to ministers for resolution.

Because most drainage schemes take place on existing farmland, rather than on areas newly reclaimed for farming, the agricultural industry has tended to under-rate the impact of its work on wildlife (Trafford 1978). Spokesmen for the industry have often overlooked the fact that the schemes are intended to destroy the very artefacts of the agricultural landscape which act today as refugia for wildlife, namely the drainage ditches, rhynes and dykes. Over the last 40 years, important changes have taken place in the management of both the watercourses and the adjacent land. In order to raise the agricultural productivity of the wetlands, drainage schemes have been installed to change the extent and periodicity of surface water, and to reduce the levels of water in the ground and watercourses. The less direct effects of drainage improvements include modifications to the management of the bank vegetation and neighbouring wetland pastures, and the ploughing up of that pasture for cultivation.

The precise extent and character of these changes vary both within and between wetland areas. They are, for example, more marked in the Romney Marsh (proper) than in the area to the south-west, the Walland Marsh, which is on the Kent-Sussex border. The example of the Romney Marsh suggests that the scope for transforming the surface and under-drainage of a wetland is now so considerable, and the impact of more intensive forms of grassland management and of cultivation is now so extensive, that few, if any, refugia for pasture and pasture-dyke species will survive, unless explicit steps are taken for nature conservation purposes.

Agricultural land drainage has become 'one of the sharpest points of conflict with conservation' (Trafford 1982). Surveys and research investigations are needed to establish which watercourses in the traditionally wetland areas support a *relic* flora and fauna, and to assess the likely effects of the replacement of one man-induced ecosystem by another. What types of plant and animal are likely to appear and disappear?

3 What is being done?

In recording what is happening in the farming environment, 4 priorities may be identified. These are:

i. to record the chronology and extent of changes in drainage regime;
ii. to record changes in the pattern of agricultural land use and management;
iii. to record changes in the wetland communities, and selected plant and animal species within these communities;
iv. to identify the reasons for change in biological interest, where observed.

3.1 Changes in drainage regime

There remains a general lack of quantitative data on the areas where drainage schemes are being carried out in Britain. On the assumption that nearly all field drainage between 1940 and 1979-80 was grant-aided, and using data available from the Ministry of Agriculture, Green (1979) plotted the areas which benefited on a divisional, county and, from 1973, parish scale. These studies provided a national and regional perspective, but they were of little use in elucidating what was happening on specific tracts of land. For a catchment area in Huntingdonshire, Green (1979) was able to plot the incidence of field drainage and ditching schemes at a scale of 1:10 560, using the manuscript master drainage maps of the Ministry of Agriculture. Because of the way the maps had been annotated, the approximate date of the scheme could be given.

ITE has now demonstrated the value of this data source for studying the incidence and chronology of drainage schemes over much more extensive areas, including the Romney Marsh, Pevensey Levels, Somerset Moors and Levels, and the Misson Levels of the Humberside/Nottinghamshire/South Yorkshire border. About 60% of the Romney Marsh, 30% of the Misson Levels, and 10% of the Somerset Levels have experienced the direct effects of tile drainage schemes. The value of the data source should not, however, be exaggerated. Some extensive drainage schemes are now being carried out without grant-aid, and there is no certain and comprehensive way of monitoring them. Second, no information related to the payment of grant-aid can be published where this would enable activity on individual holdings to be identified.

3.2 Changes in land use and management

Drainage is intended to increase the productivity of existing grass and ploughed land, or, in an increasing number of cases, to prepare the way for the conversion of long-established grassland to arable production. The precise relationship between drainage activity and land use varies both in time and place. In parts of the Romney Marsh, tile drainage was installed in the late 1960s as a means of ensuring that the potato crop could be lifted in a wet autumn. It encouraged improvements to arterial drainage which, in turn, made possible the ploughing up of land that had previously been suitable only for grass production.

Some impression of the pattern of land use in the past, and the chronology of change, may be gained by using a combination of sources. An Annual Census of Agriculture (the June returns) has been made each year since 1866. The manuscript returns on a parish basis can be consulted in the Public Record Office and appropriate offices of the Ministry of Agriculture. However, because of the variable size of parishes and the frequently wide variety of land forms within each parish, these returns are of limited value in large-scale studies of land use change. The Land Use Surveys carried out in the 1930s, and in the early 1960s, suffer from the limitations common to all *ad hoc* surveys: they vary in the amount of detail shown and are available for very few points in time.

Vertical air photographs taken by the RAF in the mid- to late 1940s provide an important base-line for land use studies, but it has often been difficult to obtain prints. Recently, satellite imagery has developed to a point where it will be of considerable value in documenting environmental change. Details of field boundaries and watercourses, as derived from large-scale Ordnance Survey maps, can be superimposed on the images. If there is adequate ground-truth for the present time, these images may provide insights into land use changes over the previous decade.

3.3 Changes in biological interest

Generally, it is easier to find archival data on plants than on animals, with the possible exception of birds, and the amount of detail varies widely between localities. Among the more relevant sources for the plant life of Romney Marsh are the published flora of Kent (Hanbury & Marshall 1899) and of Sussex (Wolley-Dod 1937), and the field notes of local naturalists (made since the War).

To assess the present situation, ITE has used a stratified random sampling approach. The length of ditch is measured in representative areas of each soil type, with sites allocated in proportion to the calculated total length of ditches in the entire area of each soil series. Sites to be examined are located using random grid co-ordinates, and 100 m samples are recorded, examining both bank and water. Other sites are chosen where earlier site-specific data are available. In the Romney Marsh, those sites recorded in the 1940s and 1950s were revisited in order to assess how far the grazing marshes might have altered in the succeeding 30 years. The composition of each list will be influenced by the season of the year, the ability of the recorder to identify species, the management phase at the time of visit, and the purpose of the data collection. When the coarse distribution of species (at the 10 km square, tetrad or parish level) was the primary objective of the survey, many recorders did not bother to record common species in any detail. These omissions can give a misleading impression of the overall vegetation, within which rarer plants may occur.

A proportion of sites must be visited more than once in order to ensure that the conclusions reached are not based entirely on a 'single frame' in the dynamic 'moving picture' of individual ditches. Watercourses in drained or undrained land, and those in pastoral or arable systems, each have their own characteristic species complement. However, the proportions of each plant may differ from year to year, reflecting both natural and man-induced factors.

3.4 Reasons for change

A growing body of literature focuses attention on the close relationship between drainage activity and land use change, and on the implications for nature conservation (Lukehurst 1977; Wade & Edwards 1980; Driscoll 1983; Swales 1982a, b). For its study areas, ITE has established (i) where and when under-drainage and ditch improvement schemes have taken place; (ii) the period of land use change, and the prevailing pattern of agriculture over the last 100 years; and (iii) the distribution of vascular plants in the late 19th century, *c.* 1950, and the early 1980s.

The next stage in the ITE study will examine more rigorously the apparent correlations between (i) and (ii), and the changes identified under (iii). The examination currently falls into 3 parts.

i. Trials of 4 wetland species (lesser water-parsnip, greater water-parsnip, flowering rush and branched bur-reed) have begun at Monks Wood to ascertain how depth of water, or height above water, can affect production and growth. These trials should demonstrate the demands of the individual species, and how the conversion of a gently sloping bank to a steep, trapezoidal channel section may limit available habitat.

ii. A trial has been set up in the Romney Marsh, whereby a ditch has been cleared of its dominant common reed, and specimens of 4 species typical of shallow pasture ditches have been introduced (fool's water-cress, tubular water-dropwort, frogbit and tufted forget-me-not). Because the ditch lies in arable land, the experiment should provide the opportunity to separate the effects due to shade created by tall emergents (eg the reed) from other factors brought about by the conversion from pasture. The reed will continue to be suppressed and the input of nutrients monitored. The trial should help in answering the question "how far is the decline in 'pasture species' a result of conversion to arable land as opposed to the establishment of tall dense emergent vegetation?"

iii. ITE is collaborating in an experiment which has been set up by the Grassland Research Institute in Devon, which uses what are essentially 1 ha field lysimeters to observe the effects of drainage and varying nitrogen applications on the production of bullocks in terms of live weight gain. ITE is monitoring the changes in the composition of the turf under the different forms of management and drainage regimes.

These trials represent only a very small proportion of those required to investigate the inter-relationships between drainage activity, land use and management, and the species composition of grazing marsh vegetation (Figure 1).

4 What needs to be done?

The paper has cited some research being done by ITE to provide a basis for prescribing what aspects of the drainage/wildlife interface need to be investigated over the next few years. ITE has adopted an archival and field survey approach, complemented more recently by field trials. So far, the study has been confined to vascular plants. Four further lines of enquiry are as follows.

i. To assess conclusions reached with respect to plant species and communities in relation to changes in bird, mammal and invertebrate groups.

ii. To collaborate with soil scientists, hydrologists, drainage engineers, agronomists and land econ-

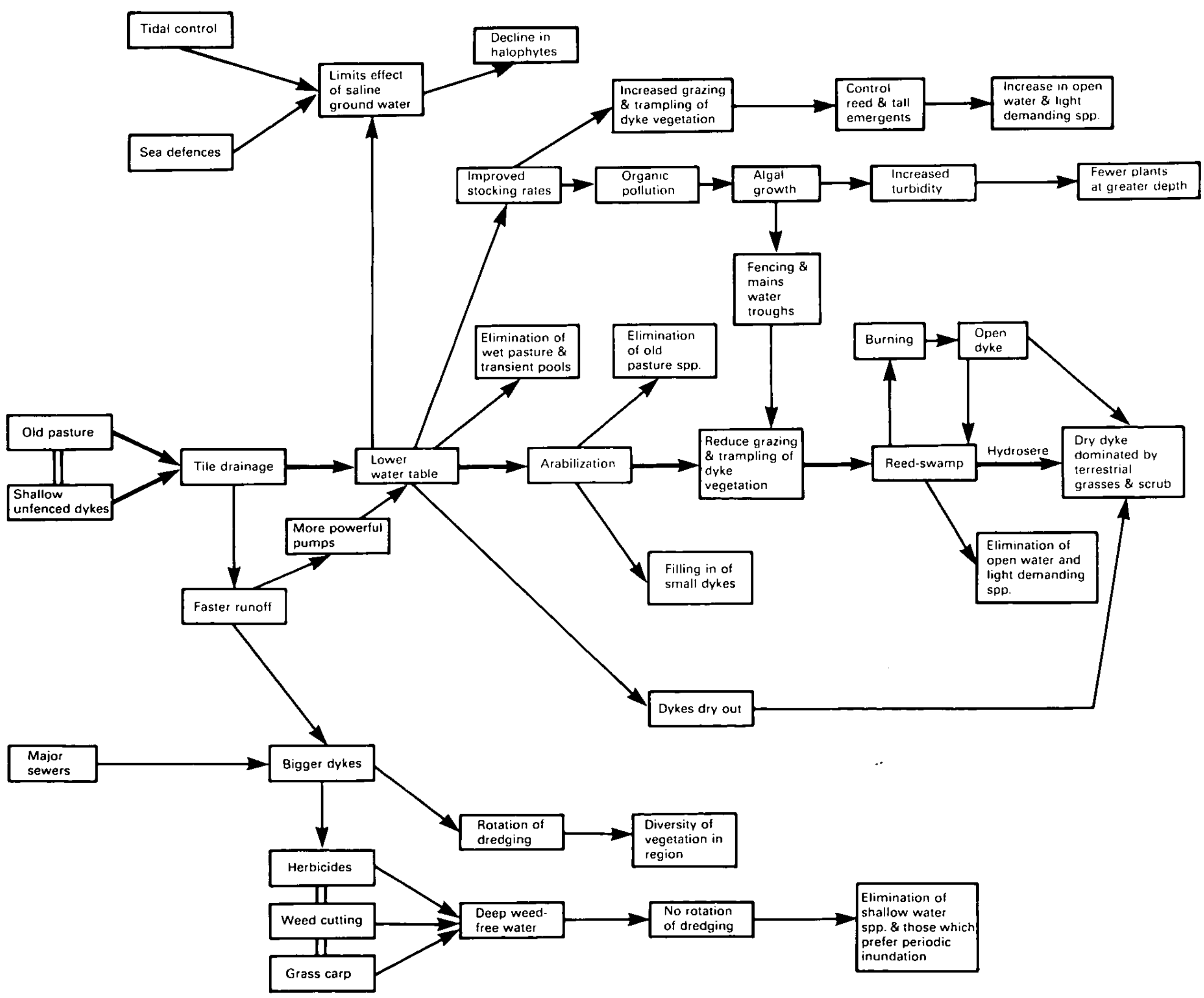

Figure 1. The inter-relationship of drainage, land use and management, and botanical status

omists in order to describe precisely the result of drainage operations. Without a greater appreciation of the findings, methods and techniques of these other disciplines and professions, there can be little precision in answering the question 'how does a specific form of drainage, applied at a specific point in time, in a specific place, on a certain soil type, affect a particular kind of plant or animal life?'

iii. To acquire and compare a greater range of base-line data, derived from the past and present, from a wide range of wetland systems in order to monitor future trends more rigorously. We need to demonstrate the considerable variety of conditions prevailing within each wetland area, and the bearing this variety has on such questions as 'are the effects of contemporary agricultural change unprecedented in that area?' and 'how far do the drainage techniques being applied in one area have a similar impact on wildlife to those in another?'

iv. To obtain more detailed knowledge of the autecology of the species affected by drainage and land use change, and, especially, of the ecological processes that can affect the rate and character of species displacement and colonization.

5 Summary

In order to assess the extent to which wildlife communities may be affected by land drainage, a greater knowledge is required of the chronology and extent of drainage in the past, changes in land use and management, and changes in wildlife. The methodology used by ITE in a study of grazing marsh vegetation is described. Priorities for research in monitoring and predicting trends include obtaining comparable knowledge of changes in birds, mammals and invertebrates, collaboration with agricultural scientists, collection of more base-line data from a wider range of habitats, and autecological studies of species liable to displacement or to become colonizers.

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The effects of eutrophication on aquatic wildlife

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1 Introduction

This paper reviews the eutrophication process, and in particular the effect of so-called 'cultural' eutrophication on lakes. Appropriate case histories relevant to agriculture are presented, and current and potential research is reviewed in relation to ameliorating the worst ecological effects of excessive nutrient input.

Biological productivity in fresh waters throughout the world has been the focus of many recent research projects, especially those initiated during the International Biological Programme. Over the last 2 decades, there has been an increasing awareness of problems associated with excessive growth of algae and higher aquatic plants, particularly in lakes, and to a lesser extent in rivers and estuaries.

Normally, as lakes age they undergo change, and a natural process of maturation takes place. Precipitation and natural catchment drainage contribute nutrients which support and enhance the growth of algae and macrophytic vegetation. However, the activities of man in agriculture, urbanization, and the discharge of sewage and industrial wastes increase the amounts of organic and inorganic sediments and the nutrient input to lakes. In these ways, the natural processes of enrichment and sedimentation are accelerated, and the quality of the water changes materially, often at a relatively rapid rate.

There is no simple relationship between the process of eutrophication and the actual amounts of nutrients present or entering the waters concerned. Rawson