HABITAT RESTORATION AND CREATION: ITS ROLE AND POTENTIAL IN THE CONSERVATION OF WADERS

N.C. Davidson and P.R. Evans

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Extensive and continuing losses of wader habitats increasingly raise the necessity of restoration and creation of wetlands as means of ameliorating the losses. The nature and extent of restoration and creation of breeding grounds, and non-tidal and tidal wintering and migration staging sites is reviewed, and the criteria for, and limitations to, the creation of coastal wetlands discussed. Such creation of "alternative sites" is increasingly being offered by developers as mitigation for the development of existing wetlands. However to succeed as mitigation, a created site must provide for all displaced birds, and must be created with a lead time of at least 5 years. Only after this can the success of the attempt at creation be judged. Such sites may provide for at least some waders, but creation of entire wetland ecosystems will prove even more difficult. Methods of intertidal wetland creation have received little experimental testing; such work is a vital precursor for assessing the viability of mitigation proposals. Restoration and creation cannot be an adequate substitute for safeguarding existing wetlands.

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INTRODUCTION

Damage to, and loss of, wetlands and other habitats used by waders during their annual cycle continues to occur throughout the world. The nature of these threats are many and varied, and affect waders on their breeding grounds, staging sites and wintering areas (see Pienkowski, Stroud and Reed; Smit and other papers in this volume). The consequence of the alteration of many areas of wader habitats to suit other, conflicting, land-uses, is to reduce the areas of habitat suitable for waders. It therefore becomes increasingly important to maintain the remaining areas of wader habitat at high quality, or restore those that have become degraded, if they are to continue to support important wader populations.

This paper examines how management, restoration and creation of wader habitats could play a part in conserving wader populations. It focusses especially on intertidal habitats, since these pose some particular problems, but the principles apply equally to other habitats. It examines both the advantages and the limitations of the approach. Creation, restoration and maintenance of habitats might all be components of successful site management. Since the goal, and many of the techniques, of restoration and creation are the same, we discuss management, restoration and creation of habitats for waders as part of the same conservation strategy. However it should be remembered that birds tend to be easier to re-establish than other parts of a wetland ecosystem such as plants and less mobile animals.

BREEDING GROUNDS

Many wader species breed at low densities over very large areas. This is especially so for those breeding in the high arctic, temperate uplands and steppes. Management of such vast areas is particularly difficult and must usually depend on the maintenance and support of large-scale land-use appropriate for breeding waders, and opposition to land-use changes incompatible with the maintenance of breeding wader populations. Such land-use changes, particularly agricultural intensification and afforestation, can have a major impact of large areas (Galbraith, Furness and Fuller 1984, Reed and Stroud 1986, Galbraith this volume, Pienkowski, Stroud and Reed this volume). In the case of peatlands in northern Britain these changes are irreversible, and the primaeval habitat has taken thousands of years to develop.

The management of lowland agricultural land for breeding waders has received much more attention, especially in The Netherlands, where there has been extensive examination of the reasons for the population decline of many wader species that breed on pastures (Beintema 1983). Here the lowering of water-tables and increased application of fertilisers have led to the earlier onset of both farming activities and breeding by waders (Beintema *et al.* 1985). However any advantage gained by starting to breed earlier has been counterbalanced by increased damage to the birds from subsequent intensive grazing and/or earlier mowing of their pasture breeding grounds (Beintema and Muskens 1981, Beintema 1983). From such detailed research, management practices can be recommended, involving *e.g.* limited raising of the water-table, that are compatible with both increased agricultural production and the safeguarding of at least some breeding wader populations (Beintema 1983). Such information can be used also to create appropriate reserve areas for waders (see *e.g.* de Jong 1977), and determine appropriate farming management that is compatible with the maintenance of populations of breeding waders.

Many areas of inland wetlands have been greatly reduced by drainage and land-claim.The small areas that remain can be managed more actively.

Some restoration of wet meadowland has been attempted. In Sweden, Lake Kavsjon formerly supported large populations of breeding waders on grazed shore-meadows formed after lowering of the water-table during the last century. Cessation of grazing resulted in growth of tall vegetation and the disappearance of breeding waders (Nilsson, Hansson and Hogstrom 1982, Nilsson 1985). Cutting of tall vegetation and the re-introduction of cattle-grazing temporarily restored the low vegetation suitable for wader breeding, but high water-tables, and some problems of continued management, have limited the success of the project as yet (L. Nilsson, pers. comm). Nevertheless the work has demonstrated that at least partial restoration of such habitat is an achievable goal.

Saltmarshes form an important breeding habitat for some waders, for example Redshanks *Tringa totanus*, and high tide feeding grounds for waders, but their major biological importance often lies in their flora and invertebrates, and in the ecosystem it forms. Coastal wetland restoration in California and elsewhere in America has frequently focussed on the restoration of saltmarshes (*e.g.*Josselyn 1982, Gay and Tancredi 1983, Zedler 1984), often because this is seen as the easiest intertidal ecoststem to restore or create. Techniques developed there for the reinstatement of saltmarsh vegetation may be widely applicable, and could form a basis for the restoration of such habitat for breeding waders. Much saltmarsh in Europe has been lost or degraded through land-claim especially for agriculture, but there has been some saltmarsh restoration. Development of saltmarsh from intertidal sandflats and mudflats has been used extensively on the Waddensee coasts of the Netherlands and West Germany as part of improvements to coastal defences (e.g. Kamps 1962), and similar work is underway on the coast of Essex in eastern England. However such saltmarsh development is often at the expense of intertidal feeding grounds used by waders and wildfowl, so the conservation priorities for each area need careful consideration. Similarly the extensive colonisation of sand and mudflats in southern and eastern England by a fertile hybrid cord-grass *Spartina anglica* has resulted in the formation of extensive saltmarshes (Doody 1984). The consequent extensive losses of intertidal feeding grounds for birds mean that the spread of *Spartina* is generally regarded as a threat to coastal waders and wetlands (see Doody 1984). Management of saltmarsh is achievable by controlling the amount and type of grazing. However the best regime for waders may be incompatible with the best for plants in sites of botanical interest (Dijkema 1984, Greig and Evans 1985).

Creation of several types of man-made habitats have incidentally provided suitable breeding habitat for waders that favour open ground, in Europe especially the Little Ringed Plover *Charadrius dubius*. This species is amongst the most widely distributed in Europe (Piersma 1986), and in many countries most of the population now breeds in man-made habitats such as gravel-pits, waste-disposal sites, industrial areas and reservoirs (e.g. Sharrock 1976, Hilden 1983). In Finland and elsewhere, creation of these habitats have benefitted breeding Ringed Plovers *Charadrius hiaticula*, Common Sandpipers *Actitis hypoleucos* and Terek Sandpipers *Tringa terek* (Hilden 1983), as well as Little Ringed Plovers.

Creation of low islets in brackish pools and salt-pans as breeding sites for semi-colonial waders, especially the Avocet *Recurvirostra avosetta* (and also for terns such as Common Tern *Sterna hirundo* and Little Tern *S. albifrons*) has proved very successful, provided vegetation is kept low (Axell 1982, Girard 1985, Pienkowski and Evans 1985).

NON-TIDAL WINTERING AND STAGING SITES

Management and restoration of freshwater wetlands are widely used to maintain suitable habitat for migratory and wintering wildfowl (e.g. Scott 1982). Similar management practices are appropriate for encouraging use of sites by waders. Extensive work, much of which focusses on the manipulation of water levels and the control of growth of tall vegetation that readily colonises the open feeding areas needed by waders, has been undertaken on lagoon-type sewage farm habitats in West Germany (Biologischen Station "Rieselfelder Munster" 1981). Restoration of dry pastures to their former marshy state has proved successful in providing winter feeding habitat for Snipe *Gallinago gallinago* (Harrison 1982), and many of those species that regularly migrate overland benefit from management that provides wet margins and shallow brackish or freshwater pools. Some such sites are managed for waders (Biologischen Station "Rieselfelder Munster" 1981, Harrison 1982, Axell 1982), but many other man-made habitats, especially reservoirs and disused gravel pits that can be used as feeding sites by migrant and wintering waders, are not directly managed for waders.

In North America the water-levels of man-made impoundments are extensively managed to provide feeding habitat for wildfowl (e.g. Whitman 1982). Waders do respond to such management intended for wildfowl (Meeks 1969), and Rundle (1980) has assessed the management of impoundments for waders and rails. He found that gradual draw-down to provide shallow water and progressive exposure of soft mud was effective in attracting many migrant waders, especially during autumn. Rundle also pointed out that the management practices used for attracting wintering and migrating wildfowl are not generally compatible with those for waders. This may be an important feature in establishing restoration and management priorities for many wetlands.

Waders readily feed on brackish man-made or man-modified habitats, whether or not they have been established deliberately for their benefit, provided that an appropriate food supply is available. For example, a 225 ha brackish lagoon has created at Margrethe-Kog in the Danish Wadden Sea to partially mitigate for the loss of important intertidal feeding ground for waders and wildfowl by construction of a new dike (Figure 1). Water levels are managed by pumping sea water into the southern end of the lagoon during high tide, with an outlet at the northern end. This has allowed colonisation of benthic inverterates especially around the inlet (Kiis in litt.), and the lagoon has attracted migrant waders of many species (Kiis 1986). Studies are underway to examine the quality of the feeding conditions that this area now offers (Nohr and Bang 1986).

At Teesmouth in north-east England, several wader species, especially Dunlin *Calidris alpina*, Redshank and Curlew *Numenius arquata*, fed extensively on a suite of man-made and man-modified wetlands peripheral to their main

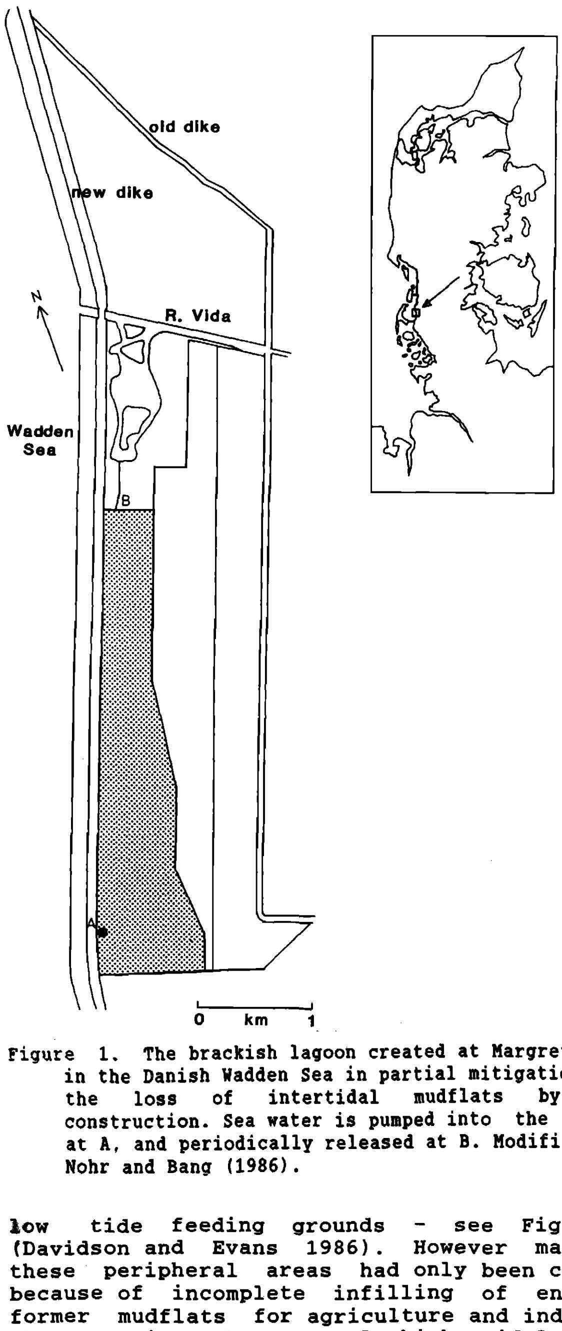

Figure 1. The brackish lagoon created at Margrethe-Kog in the Danish Wadden Sea in partial mitigation for the loss of intertidal mudflats by dike construction. Sea water is pumped into the lagoon at A, and periodically released at B. Modified from Nohr and Bang (1986).

low tide feeding grounds - see Figure 2 (Davidson and Evans 1986). However many of these peripheral areas had only been created because of incomplete infilling of enclosed former mudflats for agriculture and industry, thus removing the natural high tidal level mudflats formerly available as feeding grounds for waders. Waders were forced to use such peripheral sites to extend their feeding period over high water beyond that available on the main mudflats (the upper levels of which had been lost through enclosure). Smaller numbers of waders used some of these peripheral sites when strong winds made feeding difficult on exposed mudflats at low tide. These sites retained many of the estuarine invertebrate species of the former mudflats, and so provided good feeding opportunities for waders. The provision of such sheltered peripheral areas may be especially important in the enhancement of wader habitat for some species such as Redshank, which seem particularly vulnerable to the effects of strong winds (Davidson 1981, Speakman 1984).

INTERTIDAL SANDFLATS AND MUDFLATS

Many species of arctic and boreal-breeding waders depend on estuaries and other coastal intertidal habitats throughout the 9-10 months of the year when they are away from their breeding grounds. Much intertidal habitat on estuaries and coasts throughout the world has been lost or modified through a variety of engineering works. Some estuaries such as Teesmouth have lost almost all their tidal mudflats and sandflats have been lost. Many estuarine areas remain threatened by further habitat losses from land-claim for farming and industrial projects, from port development, construction of dams and barrages for water storage, flood protection and tidal power generation, inshore oil exploration, and pollution by industrial effluents.

Despite these extensive and continuing habitat losses, there have been few attempts to restore or create intertidal wetlands. Yet the progressive loss of habitat means that the quality of the remaining areas needs at least to be maintained if reductions in wader populations through loss of feeding grounds are to be minimised. Since some waders readily feed on wetland habitats of various kinds created by man, provided they have an appropriate food supply, it follows that the creation, restoration or enhancement of intertidal habitats may sometimes be a viable approach to the conservation of some waders, although possibly inappropriate for other parts of the estuarine ecosystem at the same time. Thus the approach is unsatisfactory in that it involves the loss of natural systems and replacement by only paet of these systems.

There have been some attempts to restore intertidal wetlands in California. At For example at Los Cerritos in southern California, a project involving the restoration of about 400 ha of brackish and intertidal habitats, will be used experimentally to design future projects (Zedler 1984). Elsewhere in southern California, 16.5 ha of tidal wetlands in Upper Newport Bay were restored in 1982 from silted-up salt evaporation ponds and salt-flats. The site was excavated to mid-tidal level and now has unrestricted tidal flow over silt and sandy-mud sediments. Three years after restoration the site is extensively used by wintering waders, with some species, especially those that feed on small prey (e.g. American Avocets *Recurvirostra americana*, and also plovers *Charadrius* and *Pluvialis* spp.), occurring at similar densities to those in other parts of the estuary (Wilcox 1986). Although densities of most other waders, even small species such as *Calidris* sandpipers, have also increased since restoration, many are still well below those on other parts of the estuary. No monitoring of the invertebrate fauna has been reported from this site since restoration, so the reasons for this interspecific variation in response to habitat restoration are unclear, although failure to establish high invertebrate populations wouls seem likely.

Non-estuarine shores are increasingly being found to be very important for some temperate wintering populations of waders (*e.g.* Moser and Summers in press). However loss and damage to these shores is slight compared to those of estuarine soft shores, and consequently there has been little need to examine techniques for the restoration of such shores for waders.

A semi-natural cause of loss of estuarine feeding grounds in Britain has been the spread of cord-grass *Spartina anglica* to form a dense sward over the upper mudflats of many estuaries, resulting in major loss of feeding grounds for waders. Few waders can feed amongst

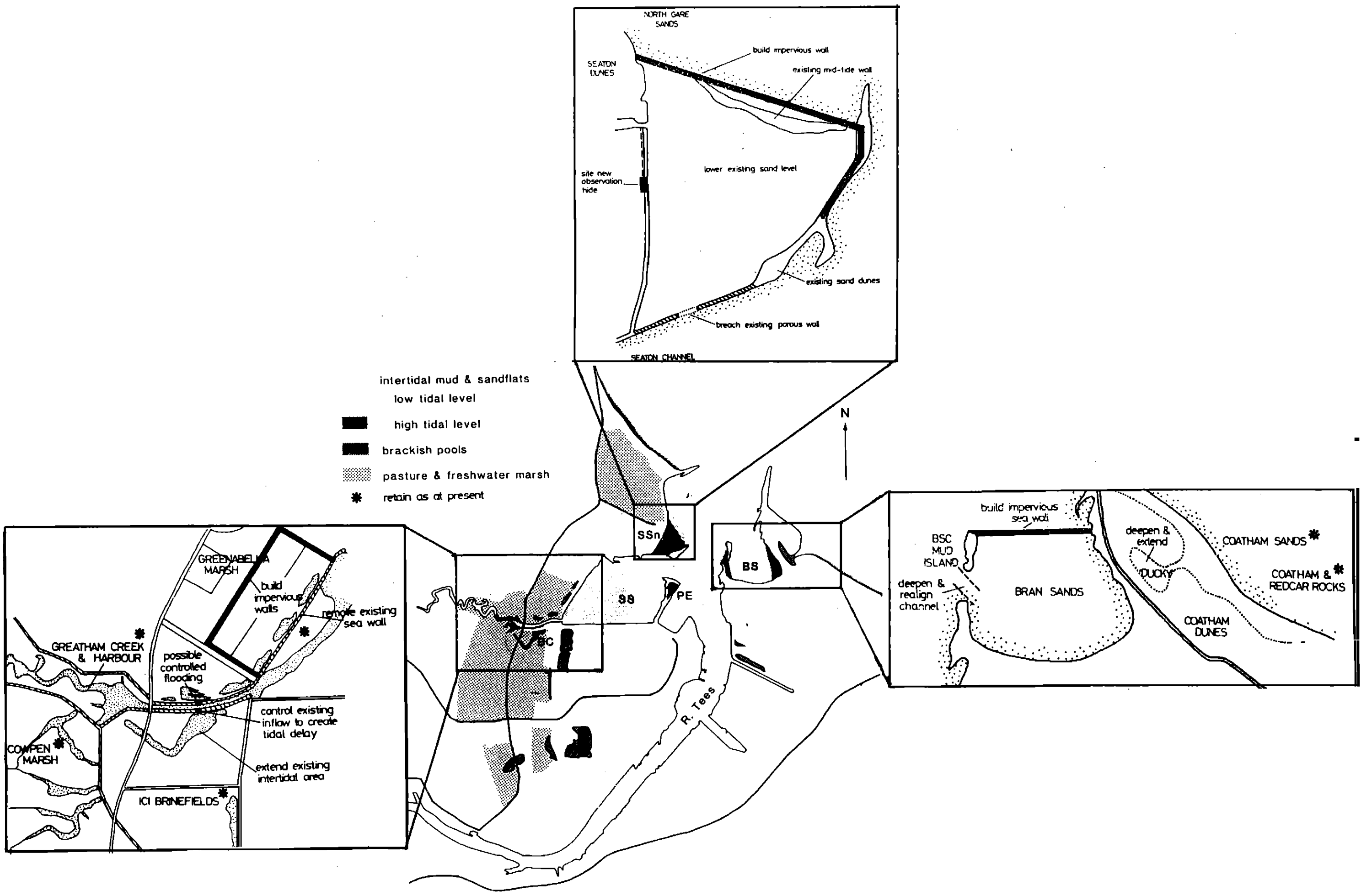

Figure 2. Design proposals for the development of intertidal wetlands to compensate for the proposed loss of the main intertidal mudlfats, Seal Sands, at Teesmouth. Letters refer to wetland sites, as follows: SS Seal Sands, SSn Seaton Snook, BS Brinefields Creek, GC Greatham Creek, PE Peninsula Enclosure. Modified from Davidson (1980), and Davidson and Evans 1982, 1986).

this dense grass-sward (Millard and Evans 1984). Restoration of these swards to open mudflats has been achieved on a limited scale at Lindisfarne, north-east England and elsewhere, using the herbicide Dalapon (Corkhill 1984). After clearance, several wader species at Lindisfarne readily used the newly-exposed mudflats, and preferred to feed on these areas more than on the adjacent open mudflats that had never been colonised by *Spartina*: probably a consequence of temporarily-elevated prey densities following clearance (Evans 1986).

Apart from *Spartina*-clearance, there have been no large-scale attempts to restore or create intertidal mudflats in Europe. However, several studies have examined the potential for such work, to mitigate further losses through land-claim, notably at Teesmouth (Davidson 1980, Davidson and Evans 1982). These studies were designed to examine the feasibility of creating intertidal habitats in compensation for the potential loss to port development of the last remaining low tidal mudflat at Teesmouth, Seal Sands. The proposals, summarised in Figure 2, aimed at providing a similar total area of intertidal land at a variety of tidal levels, and of similar sediment types, to that which might be lost by further port development. They involved restoration of high tidal level sandflats to more productive mudflats and the creation of tidal flats from adjacent pasture land. Engineering works needed for the creation and enhancement of coastal wetlands are largely straightforward, involving chiefly construction of sea-walls and the extensive excavation and redistribution of sediments. However, the design of such sites is critical, since they must be placed and constructed in such a way as to ensure the settlement and stabilisation of the finer sediments most suitable for supporting the high densities of intertidal invertebrates needed by waders as food. Since estuaries are highly dynamic systems, and the presence of intertidal mudflats depends on a fine balance between sedimentation and erosion, such hydrological work is critical to the success of restorations. Furthermore the methods have not yet been experimentally tested, except for the small-scale attempts at restoration in America, described above (Wilcox 1986).

The work at Teesmouth has not progressed beyond establishing the feasibility of mudflat creation on this estuary. There are two major obstacles to progress of such projects: cost and the availability of land. Absolute costs of such restoration work are considerable, although they often form only a very small percentage of the capital cost of the development for which they are designed as mitigation. Land, whether terrestrial or intertidal, that is needed for mudflat restoration, is often already designated for other purposes such as future industrial developments, and so is not readily available. Land may also be under private ownership and so not readily available for wetland restoration.

One restoration project that is underway arises from the provision of US $1 million at Delaware Bay in the eastern United States, by developers expanding power station facilities. Delaware Bay is the single most important site for waders migrating along the Atlantic coast of North America in spring, with over one million shorebirds passing through the area (Myers 1985). The monies will be used to develop a plan for the restoration of several hundred metres of intertidal lands degraded by coastal construction, in addition to the safeguarding by purchase of several kilometers of beaches that are important feeding grounds for waders.

LIMITATIONS TO THE CREATION OF COASTAL WETLANDS

The factors that must be examined and taken into account when planning to restore or create coastal wetlands are many and complex. Hence, as pointed out by Evans and Pienkowski (1983) in discussing impact assessment of proposed coastal engineering schemes, they need to be made by persons with considerable experience of the relevant species and habitats. As part of impact studies on British estuaries we have developed criteria for the creation and restoration of coastal wetlands (Davidson 1980, Davidson and Evans 1982, 1985, 1986, Davidson, Evans and Pienkowski in prep.). Amongst the most important are:

1. Restoration or creation of a wetland must not damage any features of existing conservation importance on that site. Since peripheral wetlands frequently offer the best opportunities for enhancement, their existing value must be particularly carefully assessed. This can prove to be considerable (e.g. Davidson and Evans 1986).
2. A created or restored wetland should provide similar substrate types and invertebrate fauna to the site to be destroyed, otherwise it is unlikely to support the species of waders that will be displaced. Such habitats may prove impossible to provide at some estuaries beause of their configuration and sedimentation patterns, or the lack of availability of suitable adjacent lands (see *e.g.* Davidson and Evans 1985).
3. Satisfactory compensation is achieved only if all birds displaced from the destroyed site can settle and survive on the new wetland. In practice, this means that the new wetland must be at least as large as the destroyed site, unless greater densities of invertebrate foods can be established, and which may allow waders to feed at higher than previous densities without intraspecific interference reducing their feeding success appréciably. Satisfactory compensation cannot be provided by the development of different habitats to those of the destroyed site, since this will provide for species other than those to be displaced by the proposed development (Davidson and Evans 1985). Such an inappropriate type of compensation is increasingly being proposed by developers as mitigation for the loss of intertidal wetlands, but is unacceptable.
4. Creation or restoration should provide also for the establishment of other features of nature conservation interest, not just waders.
5. Wetlands must be created and established well in advance (the lead time) of the date of loss of the area for which they are intended to compensate. The lead time will usually exceed a minimum of about 5 years prior to the loss of a site. (This is longer than the time between first proposal and the implementation of many coastal engineering works.) The long lead time is needed to:

1. identify suitable sites;
2. then acquire, design, and construct the sites;
3. then allow settlement and stabilisation of a sufficient depth of suitable sediments; and
4. allow colonisation and growth of sufficient densities of invertebrate animals large enough to provide food for waders. On northern estuaries such growth can take 2-3 years (Evans, Herdson, Knights and Pienkowski 1979). Little is known of the rates of colonisation of newly-created intertidal mudflats, although experiments are in progress at Teesmouth. These indicate that for some invertebrates, rates of recolonisation may be slow, even when there are existing adjacent populations that can act as a reservoir (Evans and Uttley 1986).

A further consideration concerns the identity of the waders that will colonise the newly-created mudflats. Wintering waders of many species show strong site fidelity, so that individuals already present on the estuary may well continue to feed on the existing mudflats during the lead time development of a compensatory site. However, once the compensatory site has been developed there will be a period before the destruction of the existing mudflats when the total area of suitable habitat on the estuary for waders will actually temporarily increase. If the compensatory site provision is proving successful, the new areas are likely to be occupied by the same species, but by different individuals, perhaps from amongst those (*e.g.* immatures) that would otherwise have been displaced by competition to other wintering sites (*e.g.* Townshend 1985). When the ld-established birds are then displaced by destruction of their feeding grounds, the compensatory sites will already be occupied, so that these displaced birds may be unable to settle there. Thus whilst the development of suitable compensatory sites, if successful, may ensure maintenance of the overall population sizes of waders, they may not always aid the continued survival of those individuals that formerly fed on the destroyed site.

We have discussed here the ways in which wetlands might be manipulated to the benefit of waders, but it must be recognised that the complete estuarine ecosystem may not be so rapidly or readily re-created, yet such re-creation should be the only acceptible conservation goal. However such manipulation can only be a final line of mitigation: many sites are so important that their loss or damage should not even be considered as an answer to a development threat.

A CAUTIONARY TAIL

The provision of compensatory sites is increasingly being proposed by developers as mitigation when seeking to gain permissions to destroy wetland habitats, whether they are intertidal, brackish or freshwater. Such provision is seen by many decision-makers as a ready solution to the land-use conflicts involved. Whilst, on current evidence, restoration or creation of intertidal lands appears feasible in at least some situations, it must be recognised that the techniques and processes needed for successful implementation remain largely untested, and their long-term effectiveness unknown. There is a great and urgent need for carefully-designed experimental studies to develop the techniques and processes of successful wetland habitat creation for many types of animals and plants (not only for birds), and for detailed long-term monitoring of those habitats that have been established. So far, few attempts to restore wetlands have been monitored adequately, so that the reasons for their success or failure cannot be determined. Under no circumstances should such experiments on feasibility be attempted on sites that currently support important populations of waders (or other wildlife) since the risks of damage to these populations remain high. However such quasi-experimental habitat restoration is increasingly being proposed as part of environmental impact amelioration when permission for developments affecting wetlands and wader populations is sought.

Furthermore, the outcome of any restoration or creation project can be judged only after a prolonged lead time, by which time the development it is intended to mitigate is likely to be irreversible. Should the restoration then prove to have failed, it will be too late to reverse the development decision, regardless of whether or not approval for the development was originally dependant on the provision of compensatory wetlands.

Thus the restoration and creation of wetlands is a final resort when all attempts to protect existing areas have failed, and may be used on some occasions to enhance existing wetlands for use by waders, whether or not this is in direct response to a development threat. The approach cannot be regarded as an appropriate direct substitute for the safeguarding of the existing wetland resources and wader populations of an area.

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