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The Value of Salt Marsh as a Sea Defence

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The value of salt marsh as a buffer outside sea walls is appraised. As salt marsh width decreases an almost linear increase in wall height is necessitated until loss of a final thin strip causes an exponential rise in maintenance and construction requirements and costs. A minimum value is placed on salt marsh in its capacity as a sea defence and its use and non-use values are discussed. Except in special circumstances salt marsh has a low capital value, and while sale of land to wildfowling syndicates is found to be the highest direct value, this is far surpassed by the indirect value of savings on both capital and maintenance costs in sea defence terms. Reference is made to the coast of East Anglia in the UK and in particular to that of Essex.

The responsibility for the protection of the Essex coast and tidal estuaries (Fig. 1) lies with the National Rivers Authority (NRA) which maintains 440 km of sea defences against flooding of low-lying land (NRA, 1992a). A further 900 m is protected solely by wide swathes of salt marsh, which can be defined as areas vegetated by herbs, grasses or low shrubs, bordering saline water bodies (Adam, 1990). Where a wide expanse of vegetated ground lies seaward of protected land, a simple clay bank may offer sufficient protection from flooding. It has been widely acknowledged that a generous width of salt marsh, with optimal protection value at 50–80 m depending on site (Hydraulics Research, 1987), can dramatically reduce the construction costs of sea defences. The Anglian Region of the NRA uses a sliding scale of wall construction costs and requirements which is linked to the degree of protection from salt marsh. Many Essex salt marshes are at present in decline (Brampton, 1992), which is putting increasing pressure on flood defences and has economic as well as environmental implications. An average rate of horizontal erosion at the interface between mud flat or creek edge and vegetated marsh on an estuarine bank in the environs of the River Blackwater in Essex, for example, has been measured

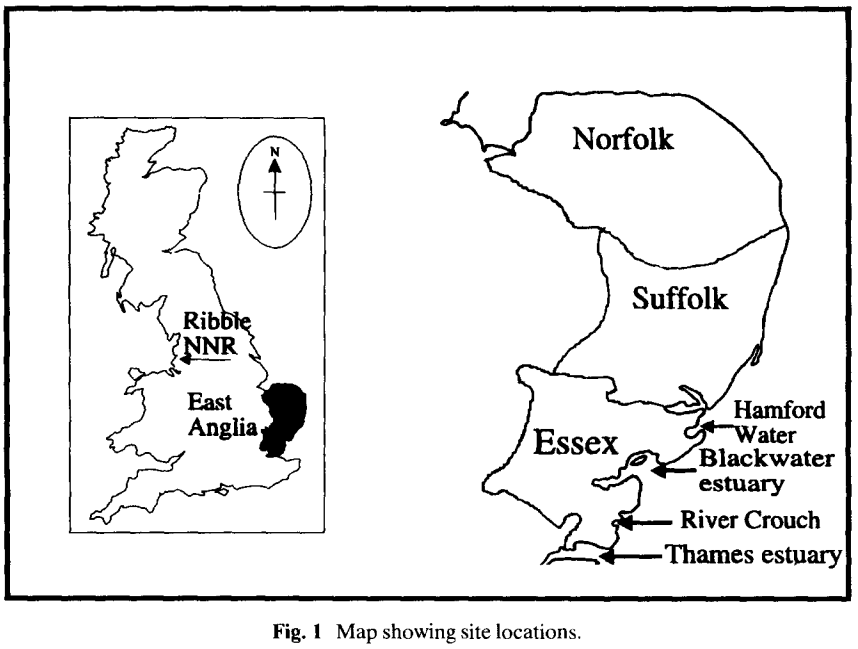

Fig. 1 Map showing site locations.

as 2 m yr^{-1} over a 2 year study by the Institute of Estuarine and Coastal Studies (IECS), while an open coast marsh lost an average of 4.01 m yr^{-1} and a sheltered creek bank an average of 0.305 m yr^{-1} (IECS, 1993). These losses are attributed to wave action and a long-term change which is thought to be due to the increase in wave energy at the shore, which in turn is attributed to increasing nearshore depths caused by a local rise in sea level relative to the coast. In East Anglia the average rise is 2 mm yr^{-1} but it increases to approximately 4 mm yr^{-1} for the area south of the River Blackwater (NRA, 1991a). Such local anomalies are explained by a combination of eustatic changes in regional sea level and long term tectonic land movement in the southern North Sea. Ministry of Agriculture, Fisheries and Food (MAFF) guidance to sea defence authorities advises an allowance of 6 mm yr^{-1} for relative sea level rise in Anglian, Thames and Southern regions. 'Sea defence' applies to measures taken against flood hazard as compared with 'coastal defence' which encompasses all aspects of defence against coastal hazards (floods or erosion), thus including 'coast protection' which refers to measures taken against erosion of the land and other encroachments by the sea (MAFF, 1993a).

Even without a scenario of global sea level rise, which present best estimates are reducing in severity (Intergovernmental Panel on Climate Change, undated), local conditions mean that the outlook for the Essex salt marsh is not encouraging as sea defences prevent their landward shift and limit their ability to react to rapid ecological disturbance. A rise in relative sea level is likely to increase the tidal prism of an estuary, lengthening the shore profile which will result in a squeeze of salt marsh balanced by a gain in mudflat area. Mudflats seaward of the vegetated zone are integrally involved in the local sediment transport regime and sediment movement between these morphological units is likely to be cyclic (Pethick, 1992). This will lead to wider, shallower cross-estuarine profiles and a loss not only of high salt marsh but also of mid-marsh vegetation communities. In the light of predicted sea level rise, Boorman (1992) has predicted a replacement of present salt marsh vegetation by that from a lower zone in any affected area. In addition to sea defence implications, this will have a detrimental effect on the habitat value of terrestrial invertebrates and birds, found most frequently in high salt marsh and bordering environments (IECS, 1993).

The loss of salt marsh along the east coast is causing concern in terms of sea defence and conservation but the economic reality has yet to be fully addressed. As yet few attempts have been made to value salt marsh in monetary terms. In North America, Gosselink *et al.* (1974) evaluated tidal marshes in the context of extensive loss to development and degradation by overloading of waterborne waste. An assumption was made that the full value of coastal fisheries and products of aquaculture could be related to tidal marshes; their waste assimilation role was quantified and primary productivity estimates were used. Little mention was made of their role in energy absorption and reduction of flood damage but their sea wall protection function was not noted and was therefore absent from the economic analysis. It is very difficult to price the functions of shelter and of landscape value for recreational use, the intrinsic value of salt marsh as a landscape form and its value to conservation and scientific research at ecosystem, habitat and species level. Until the last decade, salt marsh has often been conceived as coastal wasteland with minimal economic value, which has led to considerable loss through land reclamation for use as agriculture, caravan sites, industrial developments and marinas. In the following pages comparative values towards the valuation of salt marsh for direct and indirect use are suggested in order to stimulate the debate on economic appraisal of these fragile systems and in the hope that such considerations will be taken into account in the development of management strategies encompassing complete valuation of salt marsh.

Salt marsh and the concept of 'total economic value'

Any attempt to place a value on salt marsh as a discrete economic unit will be a complex process. While it is feasible to give the economic value in terms of simple values tied to sea walls, many questions need to be answered if indirect values and qualities with no monetary value are to be incorporated. Salt marsh products are a tangible output and can be considered as direct use values while those associated with salt marsh functions or contributions to the wider environment have to be indirectly inferred (Winpenny, 1991) and would become indirect use values. When summed such factors would yield a minimum value which would exclude many unquantified facets, each of which would add positive value to the salt marsh in question. By combining values calculated from the products and functions of an ecosystem with those derived from the less easily evaluated fields of options for future use, plus non-use existence values, steps can be taken towards achieving a 'total economic value' (Pearce, 1993). Option values are related to use values in that a value is placed on the retention of, for example, a wetland for possible future use or, termed bequest value, for use by future generations (Barbier, 1993). Existence value is concerned with the preservation of a system or species, in this case salt marsh, in its own right and is not related to present or future use, the latter case being a non-use form of bequest value.

Of the direct use values which can be identified in connection with salt marsh, wildfowling stands alone in that a substantial sum can be commanded for shooting rights, either by sale or by lease. Although wildfowl are a product of the marsh, the value to wildfowlers is in the sport as opposed to the price of the individual birds that they shoot. Rent and sales to wildfowlers should be taken into consideration in valuation but the difference between perceived value and actual prices paid can be difficult to reconcile. Indirect values can be assigned to salt marsh by relating area to the reduced cost of defences in places where a salt marsh buffer is present on the seaward side of a sea wall and this can be compared with agricultural land values directly landward

of the sea wall or in the area protected by the wall. Property prices in vulnerable places can also enter the equation in individual cases. Salt marsh has an ecologically and economically important role as a transitory habitat for fish, providing sheltered feeding and nursery grounds; in addition a flux of nutrients into the tidal waters (Long & Mason, 1983) becomes an integral part of the rich estuarine ecosystem, products of which include fish, oysters and worms for angling bait. Ecological research into salt marsh as a functional unit has resulted in attempts to quantify productivity and nutrient flows (Lefeuvre *et al.*, 1993), offering a potential understanding of their value in nutrient supply and exchange.

Unquantifiable environmental factors, such as values to conservation and recreation, have traditionally been undervalued and left out of the benefit–cost equation. However, alongside an increased awareness of environmental systems, a number of methods by which the intangible facets of the environment can be estimated and incorporated into a scheme of monetary value have been developed. In a review undertaken for the NRA of the various approaches to total valuation of the natural environment appropriate to the case of sea defence, Penning-Rowsell *et al.* (1992) selected the contingent valuation method (CVM) as the most appropriate means of valuing coastal sites. No detailed analysis is yet available for salt marsh but this is the only method which may be used to investigate the magnitude of direct use, indirect use and non-use values when seeking to determine the total economic value of the resource.

Values are assigned to each product and function of the salt marsh. Those which are not easily valued are costed on a 'willingness to pay' scale of prices, reached by thorough testing using questionnaires devised to avoid, where possible, the associated hazards of inaccurate resposes. Penning-Rowsell *et al.* (1992) includes examples of such methods in practice. Figure 2 indicates the difficulty which arises when some indirect use values can be discussed according to a monetary system while others become aligned with the intangible non-use values. Within these last two categories are option value (willingness to pay for use of environment in the future) and bequest values, which have both use and non-use values (willingness to pay for benefit of ones descendants' future use of the salt marsh plus a wish to retain options for descendants to live in a time when salt marsh still exists in that particular place). The latter is unassociated with actual use and puts some store on wilderness in built up areas. Existence value is similarly not associated with actual use but with the existence of species or ecosystems.

A summation of direct values, such as profit from land rent or sale and any other form of local financial gain, plus any other quantifiable indirect value, plus other use and non-use values can be made to give a minimum value to salt marsh, which any other identified but as yet unquantified values would increase. This value could then be counted in benefit–cost equations to work out how much should be spent on either protecting salt marsh in its capacity as a buffer to

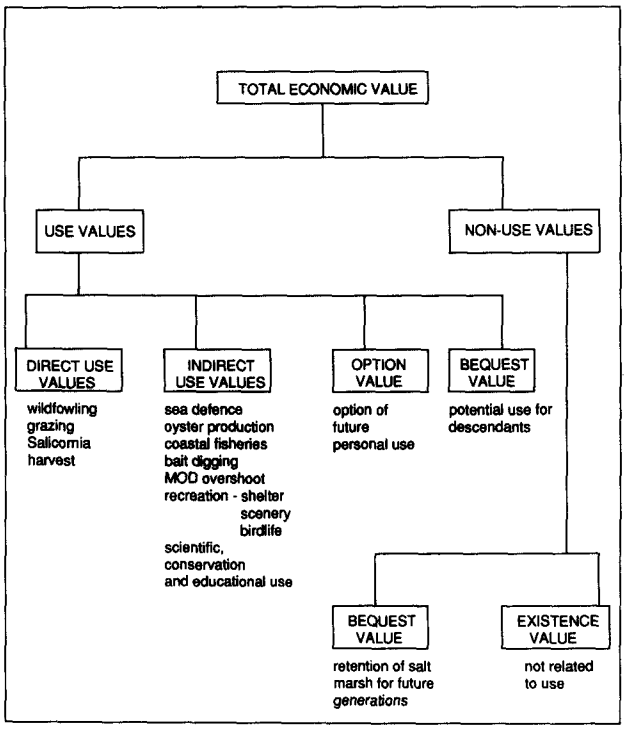

Fig. 2 Use and non-use values of salt marsh. Source: adapted from Barbier (1989).

engineering costs or, more significantly, on research into methods of containing the current situation and on undertaking urgently needed large scale experimental projects to encompass modern geomorphological theory.

Value from land prices and income

Wildfowling. Income from salt marshes in Essex is very small apart from sales to wildfowlers and licenses for shooting rights.* A north Essex farmer was recently offered £70 000 for annual shooting rights to 142 ha (350 acres) of grazing marsh (unimproved reclaimed salt marsh) and salt marsh. At £493 ha^{-1} yr^{-1} (£200 $acre^{-1}$) to provide high level syndicate shooting of pheasant, partridge and duck this price reflects the difficulty inherent in placing a value on such land, especially in the many instances where saltings outside the sea wall are included in the price for shooting on grazing marsh within the sea wall. In 1989, 73 ha (180 acres) in north Essex were sold to local wildfowlers for £80 000 (£1096 ha^{-1}, £444 $acre^{-1}$) although the land valuation at the time was £54 000. In the same area in 1992, 60 ha (150 acres) were sold for £22 500 (£370 ha^{-1}, £150 $acre^{-1}$). This difference not only reflects a fall in land prices but also competition between potential users of salt marsh, as in the former case the wildfowlers were concerned that a conservation organization would purchase the land and ban all shooting. Competition between wealthy wildfowling syndicates can also inflate prices. An example is the Norfolk grazing marsh which was recently sold for £9884 ha^{-1} (£4000 $acre^{-1}$). When such artificial escalation of prices occurs, conservation interests are usually

*Sources on land sales are confidential but can be verified.

outpriced. There is frequently little correlation between the price of land rental and the value of shooting activities, taking account of factors such as available birds, varying weather conditions and the time available to the membership for shooting. A schism can be identified between local wildfowl clubs, frequently with a small membership and limited funding and large consortiums of non-local people who are prepared to pay considerably more than could be expected for high quality shooting rights.

The Crown Estates Commissioners (CEC), who have historically sold inter-tidal land and currently own about 55% of the Essex foreshore, prefer to price salt marsh rental for any purposes on the approximate linear length of foreshore at the high water mark. This costs £120–£150 per km depending on various factors. A shooting lease will generally cover the ground between mean high water (MHW) and mean low water (MLW) but valuation is based on a CEC premise that most of the relevant activities take place around high water where there is most cover for wildfowl, whereas a wide open stretch of vegetated salting may be fairly unattractive to these birds, hence the emphasis on a linear policy. The Commissioners, in company with other lessors of salt marsh, alter the scale of charges depending on activities or use. A low rent is likely if conservation interests are uppermost while shooting rights are likely to attract a higher return. This is itself qualified by other factors, such as the management and policing of an area by the incumbent wildfowlers; in some cases such services outweigh any financial advantage and rents are purely nominal, and charged merely for reasons of legality. A Hamford Water explosives factory has a reciprocal agreement with a wildfowling club which enjoys free shooting rights in exchange for their presence on the salt marsh. This is a useful addition to security arrangements and provides indirect value in the difference between security costs without wildfowlers present.

Positive management by wildfowlers can include the building and maintaining of bridges over creeks (thus allowing access to otherwise inaccessible distant areas, in some cases a questionable advantage); production of a wildfowling plan to be approved by all interested bodies such as English Nature, the Royal Society for the Protection of Birds (RSPB) and the CEC; the setting aside of refuge areas and nesting sites; record keeping and bird counts throughout the winter. In sensitive areas where access by the general public is not advantageous to management or security, the occasional presence of wildfowlers is claimed to act as a deterrent not only against unlicensed individuals but also against unwanted recreational use. This last point is tempered, however, by the fact that wildfowling takes place mainly at dawn and dusk in the winter months whilst much recreational use takes place in the summer. A further facet to this equation are the land owners whose shooting rights have traditionally been set by barter with locals; the two-way flow of goodwill in small communities is not quantifiable in monetary terms. There is a parochial distrust of relatively new organized groups of non-local wildfowlers which have large funds at their disposal and who regard wildfowling as a smarter form of pheasant shooting, since wildfowl are not artificially produced for the sport.

In addition to (and frequently alongside) wildfowling interests, land can be part of a working farm which might include use for grazing. In Essex salt marsh and sea wall grazing is of use only as part of individual management systems which are offset by subsidies. Grazing by sheep is considered advantageous to sea wall structure (by compaction without too great a weight and by keeping the sward short and compact, thus making the wall less likely to fissure or to need mowing). It also aids the ecological diversity of the vegetation and associated invertebrates. In the Ribble estuary on England's west coast (see Fig. 1), annual net income from grazing in a salt marsh nature reserve has been valued at £17 000 for 1113 ha (2750 acres) which can be regarded as £15.27 ha^{-1} yr^{-1} (£6.20 $acre^{-1}$ yr^{-1}). This difference in ability to generate income is likely to rest on the morphological dissimilarities between marshes on the coastal areas under discussion. In France premium prices are paid for salt marsh-grazed lamb. This distinction does not appear to be made in the United Kingdom although it is acknowledged that salt marsh provides clean, parasite-free ground which is a bonus for stock health.

In most areas of the United Kingdom with extensive salt marsh, glasswort (*Salicornia* spp.) is harvested for personal consumption and in parts of East Anglia it is harvested as a crop for sale locally and in London markets as a luxury item. Records are not kept of sales figures which are likely to be insignificant on a production/acreage scale but make some contribution to the local economy.

Values from use of the environment

Sea defence value. The data in Table 1 may be used to calculate a value (£ m^{-2}) of salt marsh based upon the saving which is made as a consequence of the protection afforded to the sea wall and includes calculation of a similar saving by reference to linear sea wall. Wide expanses of vegetated marsh are valued, in this way, at a lower price per unit area than thin strips which run along the toe of the sea wall. This artificial valuation makes no concession to the fact that in many situations a thin strip is less likely to be sustainable than a larger area but is useful to illustrate the cost of salt marsh loss in these circumstances.

Figure 3 indicates that the first 6 m width of salt marsh beside the sea wall would appear to save between £1500 and £3500 m^{-1} length of wall comparing the cost of building a 12 m wall with that of building a 6 m wall protected by a 6 m strip of salt marsh. This depends on the type of wall construction used which, in turn, depends on various environmental and economic factors and would give salt marsh immediately adjacent to a sea wall a value of between £250 and £600 m^{-2}. At the given intervals, the next 24 m of salt marsh saves £700 m^{-1} length of wall (£30 m^{-2} of salt marsh), comparing the cost of building a 6 m wall with that of building a 5 m wall. The next 30 m saves £10 m^{-2} of salt marsh and the outer 20 m £5 m^{-2} of salt marsh.

TABLE 1

Comparison of sea wall building and maintenance costs and savings with amount of salt marsh protection.

Width of salting (m)*	Wall height (m)*	Cost of new wall (£ m^{-1})*	Maintenance cost (£ m^{-1} yr^{-1})*	Saving on building cost of new wall (£ m^{-1} wall)†	Saving on cost of wall maintenance (£ m^{-1} wall)†
80	3	400	1	2600–4600	49
60	4	500	5	2500–4500	45
30	5	800	15	2200–4200	35
6	6	1500	25–30	1500–3500	20–25
0	12	3000–5000	50	0	0

*Source: NRA (1992b).
†Calculated data.

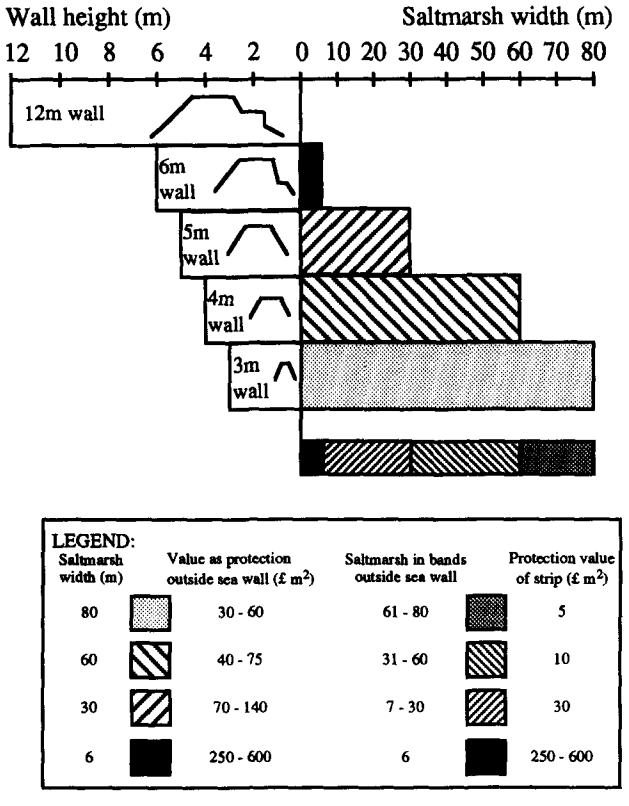

Fig. 3 Saving afforded by salt marsh on capital wall-building costs.

Evaluation of an 80 m width of salt marsh as a whole rather than in hypothetical strips permits a comparison with the cost of sea wall rebuild in a situation with no salt marsh. This yields a saving of at least £2600 m^{-1} length of wall (rising to £4600 at the top construction rate) and a blanket value over the whole area of between £30 and £60 m^{-2} or £300 000–£600 000 ha^{-1} (£121 400–£242 800 $acre^{-1}$), which is approximately a 300-fold increase on the highest price a wildfowling group might pay.

In reality these figures will be obscured by the fact that maintenance of banks is the norm in preference to building new embankments or walls and that as salt marsh is lost, piecemeal measures are taken to improve wall structures, resulting in a situation where each stretch of wall must be treated individually. Maintenance figures, illustrated in Table 1 and Fig. 4, exhibit a similar but less costly gradation from an annual saving of £20–£25 m^{-1} length of wall (cutting the highest maintenance costs by almost half) where only 6 m of marsh are left to protect the toe of the wall to a saving of £49 m^{-1} wall length where a full width of 80 m or more still remains and this increase in savings with width of salt marsh reflects most accurately the value of wider swathes of salt marsh in sea defence. This would give a blanket value of 60p m^{-2} to those wide expanses, which at nearly £6000 ha^{-1} (£2400 $acre^{-1}$) is in excess of the value of most Grade 1 agricultural land. If regarded in strips as progressive loss occurs, the outermost salt marsh would save 20p m^{-2} and the final 6 m would save between £3 and £4 m^{-2}. At the last comprehensive survey in 1983, 300 km of Essex sea walls had a salt marsh toe; this reduces to about 220 km where more than a narrow strip is present. However, at present sea walls are still being constructed using the scale illustrated in Table 1 but ignoring the fact that in places there is an arguably non-sustainable (in the short term) width of salt marsh (NRA (M. Dixon), pers comm., 1994a). Maintenance cost varies from year to year and in Essex the average cost for tidal and sea wall maintenance is £2 188 000 yr^{-1}, protecting 431 km at an average £5.00 m^{-1} yr^{-1} (NRA, 1991b, 1992a, 1993a). This corresponds with a hypothetical sea wall height of 4 m and a salting width of 60 m.

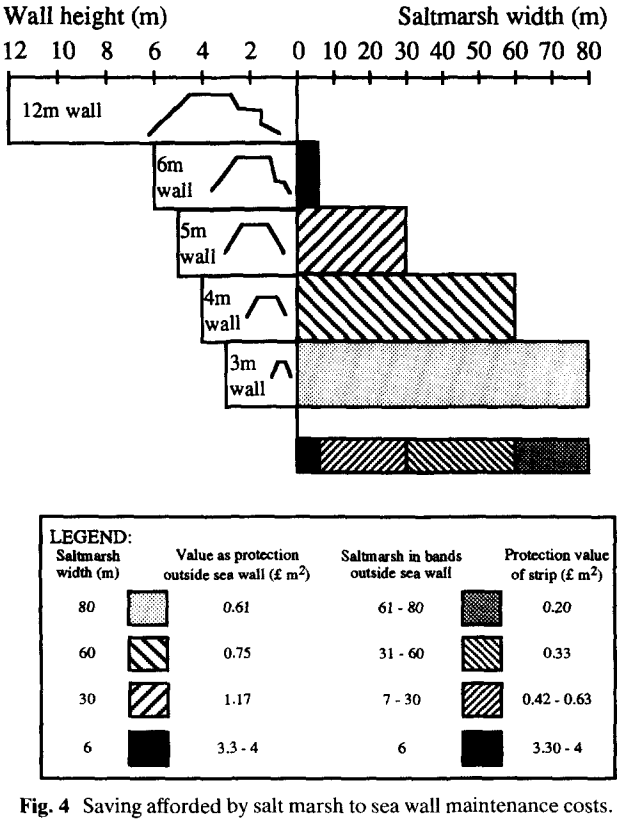

Fig. 4 Saving afforded by salt marsh to sea wall maintenance costs.

If the Essex salt marsh continues to erode at the current rate (an average of 19% of vegetated marsh was lost from the seaward side of Essex sea walls between 1973 and 1988 (after Burd, 1992) both capital and maintenance spending on sea defence would seem bound to increase. A comparison with Norfolk and Suffolk indicates that 426 km of tidal and sea defences are maintained at an average of £2.70 m^{-1} yr^{-1} (NRA, 1991c, 1992c, 1993b). This difference can be explained by the extensive areas of sea coast in Norfolk and Suffolk which have sand dunes, salt marsh or a combination of the two as a first line of sea defence backed only by low clay banks with little need for hard defences. A closer link can be made with the ronds of the Norfolk Broads. These are linear stands of brackish or saline marsh which form buffer strips on the tidal rivers between the sea wall and main river channel. Erosion caused by boat wash and a number of lesser factors results in loss of the rond with consequent need for expensive and unsightly sheet steel piling. By the same comparison one could tentatively value vegetated rond in the lower reaches by linear metres at £400–£600 m^{-1} using a sheet piling price of £800–£1000 m^{-1} in conjunction with the cost of building a low bank. NRA (Anglian Region) have recently costed rond erosion and have concluded that in many locations a cost-effective solution, with added environmental benefits, is to work to maintain 6 or 7 m of healthy rond (NRA (B. Ayling), pers. comm., 1994b).

The saving in sea defence costs allowed by the presence of salt marsh outweighs the value of agricultural land; this is revealed by a comparison with current (1993/1994) land prices. Grade 1 agricultural land is currently sold at between £3950 and £5436 ha^{-1} (£1600 and £2200 $acre^{-1}$) or 40p–55p m^{-2}. The Agricultural Land Classification grades land from 1 (highest quality) to 5 (lowest), the bottom two (4 and 5) showing severe limitations to crop production. Essex coastal land under cultivation tends to be a heavy grade 3 or 4 and is specific to particular farming methods. Grazing marsh and salt marsh are both classified as grade 4 land. Agricultural land grades 3 to 4 value from £2720 to £3000 ha^{-1} (£1100–£1200 $acre^{-1}$) (27p–30p m^{-2}) for heavy coastal land (up to £3460 ha^{-1} or £1400 $acre^{-1}$ for normal grade 3). Where coastal land is unimproved grazing (rare) it is only worth about £740 ha^{-1} (£300 $acre^{-1}$) or 7p m^{-2}. According to a national land-owning charity and a leading land management firm, salt marsh will normally sell for £620 to £740 ha^{-1} (6–7p m^{-2}, £250–£300 $acre^{-1}$).

In 1994 the Salt Marsh Habitat Scheme (MAFF, 1994a) was introduced in order to enable payments to be made to farmers and landowners over a 20-year period for the creation of salt marsh from agricultural land. Payments are at two levels; £525 ha^{-1} yr^{-1} (0.05p m^{-2}) for land which was arable prior to inundation and £195 ha^{-1} yr^{-1} (0.02p m^{-2}) for land which was permanent grassland. Over the 20 years these payments will amount to £10 500 ha^{-1} for former arable land (£1.05 m^{-2}) and £3900 for former grassland (0.39p m^{-2}). The extent to which these payments are taken up is likely to relate to a realistic assessment of the balance between income forgone by farmers and the level of payments, seen in the context of alternative aid in the form of subsidies. The scheme is only practical where it is compatible with flood defence concerns.

At least 20 areas of housing in Essex have salt marsh protection outside sea walls; some are single farms or houses, others can be extensive, including whole villages such as Salcott on the River Blackwater. Techniques of valuation which analyse the relationship between certain environmental quality characteristics and price of private goods are those of property value, land value and the hedonic price method (Hufschmidt *et al.*, 1983). The latter method, whereby the environmental variables which affect market value are differentiated and evaluated, would be likely to reflect a considerable devaluation where flood protection is reduced by lack of salt marsh. The hedonic pricing method could also be used where agricultural land is protected by salt marsh but a greater differential could be expected to occur in the case of property, where prices are higher and the perceived consequences of flooding more extreme.

Essex rural sea walls have also been ranked by value of land protected per metre length of wall (Wetlands Advisory Service, 1992). Urban sectors were excluded and over 225 km values ranged from £4.25 m^{-1} to £1 m^{-1} with a mean of £87 m^{-1}. It should be noted that this valuation covers area of agricultural land protected by sea wall (priced in metre length) as opposed to consideration of the price of salt marsh by comparison with its functions or products.

Salt marshes as part of estuarial and coastal nutrient cycles

Salt marshes are acknowledged to be important sites for the transformation of various materials (Adam, 1990) but any figures related to primary productivity tend to be very site specific. *Spartina* salt marsh in America has been most frequently studied and Adam (1990) has noted that as a result of the spread of *S. anglica* the primary production of many salt marshes has shown a large increase. In order to consider the wider economic implications of such a system it is necessary to view the salt marsh as part of the wider estuarine or coastal ecosystem of mudflats, tidal creeks and open water.

Comparative studies of four European salt marsh processes are currently being made Lefeuvre *et al.* (1993), with the stated aim of determining the relationship between salt marshes and adjacent ecosystems, estuaries and coastal waters. They report that young, building salt marshes are flood-dominated systems and net importers of sediments and organic matter while exporting mineral nutrient. Mature or over-mature marshes (such as those found in Essex), are ebb-dominated and are net exporters of both sediments and organic matter. Boorman & Wells (1993) report a net aerial primary productivity from an Essex study site of 975 and 1031 dry wt g^{-1} m^{-2} yr^{-1} (approximately 10 t ha^{-1}) for upper and lower marsh, respectively, while NRA figures indicate an annual mean of 0.5 t of nutrients ha^{-1} outflowing from the Essex marshes

(NRA, 1992b). This wide difference illustrates the difficulty entailed in the evaluation of primary productivity by different methods and with different temporal and seasonal regimes (Carpenter, 1994). Adam (1990) warns of the danger of extrapolating productivity measurements derived from limited areas of salt marsh, given its likely wide variations in physico-chemical characteristics.

Salt marshes are widely held to act as nursery areas for some species of fish, which tend to move inshore at planktonic stage while others visit at high tide on a seasonal basis. In summer grey mullet browse on algae on the creek banks, bass feed on the invertebrate fauna and flat fish such as flounder and plaice can move into creeks at high tides. Lobsters find shelter and food beside mooring tackle and eels are commercially fished. Essex is the home of a thriving oyster industry and both native oysters (*Ostrea edulis*) and the hardier, faster-growing Pacific oysters (*Crassostrea gigas*) are produced in commercial quantities. The flux of nutrients from the salt marsh and sheltered farming conditions in the creeks are locally attributed to the success of the industry. The River Crouch in Essex has a mean summer temperature several degrees above that of the Solent on England's south coast, where first year native oysters are produced for export to Essex. There is a positive relationship between summer warmth of seawater, influenced by heat-absorbing mudflats, and oyster growth (Spencer, 1990). Particular value is placed, by oyster farmers, on sites where a concentration of salt marsh nutrients is channelled into a localized area of oyster production and which results in the fattest, most succulent oysters for sale to the highest quality hotels. The luxury trade from Mersea Island on the River Blackwater includes the 'green-bearded oyster', a speciality which is improved, to the gourmet, in taste and colour by a unicellular green alga in the gills. Such oysters are exported to restaurants in Paris, Germany and Belgium, selected in preference to those produced on the continent by virtue of their superior size and flavour.

The notoriously fluctuating oyster industry is currently showing an improvement due, it is perceived, to the decrease of tributyltin (TBT) in local waters (Dowson *et al.*, 1993). No complete figures are available for oyster production and sales. It is impossible at present to quantify the contribution made by salt marsh nutrients and shelter by values of fish catches and shellfish production. Fish and shellfish are not a product of the salt marsh but are an associated unspecified value group, as is the collection of worms for personal and commercial bait.

Recreation

Recreational uses can be divided into general and specific user groups, although there are likely to be overlaps in some situations. While the latter group includes such cases as wildfowling and bird-watching, the former includes use for watersports and as a scenic backdrop for rambling, dog-walking and sketching. A craft industry has been generated by marshland atmosphere and ethos as a whole and covers a wide range of allied subjects. These include watercolours of boats, birds and creeks for sale to tourists or art aimed toward a particular sporting theme such as wildfowl paintings, the carving of decoy ducks or individual yacht portraits in oils.

Physical protection is afforded to harbours, marinas and sheltered moorings for both working craft and yachts. The presence of an entire regional boating industry can depend on the proximity of adequate mooring facilities in addition to other historical and economic factors and would be virtually impossible to price. Some idea of the value of recreational and working craft moorings can be obtained from the situation in the River Blackwater, where an estimated 3000 moorings attract a net profit from rental of well over £1 000 000. Recently a mooring was sold for £3000. Many are protected by salt marsh (for example Tollesbury Saltings, West Mersea anchorage, Essex) and although loss of salt marsh would increase the area available for moorings in a still relatively sheltered estuary, much of the character would be lost as would the sheltered sailing areas. Heavier ground tackle would be needed and an increase in damage would be expected from strain to boat fittings and from an increased incidence of failure of mooring gear. Expensive additional engineering might become necessary where marinas are at present protected by salt marsh, as is Bradwell marina on the River Blackwater by the already-eroding Pewet Island.

The uneasy and artificially promoted partnership of farming, recreation and conservation is well illustrated by the problems involved in the case of salt marsh and sea walls. These sheltered waters provide ideal situations for many recreational watersports (sailing, swimming, jet-ski riding and water-skiing). Water-skiers and jet-skiers do considerable erosive damage to the salt marsh edge and in some cases beyond, by using the edge as a convenient seat and launch pad and by jet-skiing over the vegetated surface in shallow water at high tide. They can also cause disturbance to nesting, roosting and feeding birds. Many stretches of sea wall include a public footpath along the crest and users of the sea wall, frequently dog-walkers, can cause disturbance to grazing sheep.

The suppression of recreational interests would be likely to have a beneficial effect on farming and conservation and would also benefit sea defence expenditure. If Essex sea walls were re-profiled with a longer backslope and were grazed everywhere, the public right of way being rescinded, not only would sheep be protected from dogs and grazing become more feasible, thus encouraging a low cost improvement of sea wall quality, but also nesting birds could return to the sea walls. Pressure from recreation interests is such, however, that an abandonment of sea wall footpaths is as unlikely as the banning of water-ski boats and jet-skis from eroding salt marsh areas and the need to compromise is accepted by the agencies responsible for their care.

Salt marsh as wilderness

Apart from pure recreational needs salt marsh is an area of open wilderness, possessed of a particular

muted beauty, which is intrinsically valued for its existence where it occurs in temperate coastal wetlands. This very emptiness has led, until the near present, to it being treated as wasteland, with little control of reclamation and development. This situation has now largely changed in Great Britain. While existence value is essentially non-use, as it refers to willingness to pay for the existence or preservation of natural resources, it may be of great magnitude. In Essex salt marshes are seldom used, apart from the dry footpath along the adjacent sea wall, as a place to walk because they are so difficult to traverse. In areas where the vegetation is firmer, the substrate less muddy and the levels higher, as in the north Norfolk coast, the salt marsh is utilized for walking and swimming to a far greater extent, engendering an option value for those able to visit the locality, both the resident population and tourists from further afield. In the more remote areas access problems, with the only footpaths provided by wildfowlers for their own purposes, protect the salt marsh from overuse in most situations. A portion of the salt marsh flora is susceptible to damage by trampling (Adam, 1990), the soft substrate facilitating the shearing and compacting forces which damage soil structure while vulnerable vegetation suffers physical damage. A combination of these effects can cause localized changes to occur.

Education and scientific research

Salt marsh provides rich grounds for research on plants and animals which might have a bearing on future economics (such as toleration of salinity and plant mechanisms for resistance to stress) and they are also valuable teaching resources, allowing access to studies on plant zonation and resistance of flora and fauna to a medley of environmental parameters.

Value of salt marsh to conservation

High numbers of waders and wildfowl, many making seasonal use of the rich invertebrate fauna and associated plant life, feed on the mudflats at the outer boundaries of the vegetated area and use the salt marsh and grazing marshes as shelter, roosting grounds and in some cases feeding grounds at high tide. At the time of the proposal in the 1970s for the third London airport to be built on Maplin sands, extensive ecological studies took place (Boorman & Ranwell, 1977) following which extensive areas of the Essex coast were given statutory protection (as Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNRs)), in order to protect what was seen as a threatened and extremely valuable habitat. Eighty percent of the salt marsh in the British Isles is currently scheduled as SSSI (Davidson, 1991). The area now includes sites protected under the RAMSAR convention (for the protection of bird habitat) and was declared an Environmentally Sensitive Area (ESA) by MAFF in March 1994 (MAFF, 1994b). This will attract additional grant aid to coastal farmers for environmental enhancement.

Ministry of Defence use

Owing to their inaccessibility salt marshes are used around the UK by the Ministry of Defence (MOD) as precautionary overshoot buffer zones, which need less policing than sea-bound ranges. An example are the Fingringhoe ranges in Essex, where the salt marsh is managed for wildlife by the Essex Wildlife Trust and benefits from the lack of disturbance generated by the range. Inland ranges have buffer zones of moorland or farmland, the latter rented for minimal return since access is affected. Ranges which fire out to sea have attendant craft to police the water. A depressed rent is paid for MOD farmland as a result of restrictions in use. There is a lack of available information on rents and on the cost of policing marine ranges and co-operation would be required from the MOD for valuation purposes.

Discussion

It has been established that land for wildfowling purposes has the highest direct value, however the highest single value of salt marsh is the enormous saving it can afford to capital sea defence costs (see Table 2). Ironically, the narrower the strip of salt marsh outside a sea wall, the greater the potential saving on building or maintenance costs, a reflection of the vastly escalated structural costs of sea walls in unprotected situations, and the greater the value of the salt marsh. The value of salt marsh to sea defences in many parts of the UK are now in need of extensive repair or replacement (Farndale, 1993), thus facing a rapid escalation in costs, a situation that has been compounded by the continuing loss of salt marsh. It has been calculated that complete loss of all Essex salt marsh would incur minimum costs of over £600 million for rebuilding of sea walls. Salt marsh should consequently be regarded as a valuable asset.

The disparity between the generally low price of salt marsh as a land commodity as opposed to its high value in sea defence terms reflects the lack of a high value direct product unless a quality wildfowling site is involved. Owners of salt marsh are frequently not the beneficiaries of its buffering effect. It can be the sea defence authorities, funded by the tax payer, or the owners of land inside the sea wall who stand to gain. Direct values derived from salt marsh can be summed with sea defence value, although care should be taken to

TABLE 2

Comparison of uses and values.

Uses and values	Value £ m^{-2}
Sea defence: capital savings	30–60
maintenance savings	0.6
Wildfowling (sales)	0.4–1
(annual licence)	0–0.5
Grazing	0.15
Grade 1 agricultural land	0.44–0.6
Grade 3 agricultural land	0.35
Essex coastal land, Grade 3	0.3
Salt marsh	0.6
Unimproved grazing marsh	0.6
MAFF Habitats scheme (yr^{-1})	0.02–0.05

ensure that these activities are mutually compatible before multiple uses are implied by their addition. Indirect uses beyond those of sea defence (such as those derived from specific recreational activities or the less tangible functions or values), can be expected to evince further positive values.

Pethick (1993) has indicated that attempts to retain the status quo in an estuary by protecting salt marsh from erosion are likely to exacerbate the instability of the system as natural processes rework the sediment toward a wider and shallower profile. Salt marsh is at present protecting much of the Essex sea wall frontage and several experimental schemes are underway to investigate means of stimulating salt marsh development and reducing erosion. A scenario of continuing salt marsh loss and the building of ever more massive sea walls is aesthetically displeasing and financially inappropriate, although without funding constraints the Dutch solution of a concrete coastline might become more politically pleasing. It is even possible to envisage habitat creation in such circumstances, incorporating design of sea defences as artificial cliffs and hard intertidal surfaces which are uncommon in East Anglia. A different long-term approach to sea defence is required and managed retreat has recently become a contender in sea defence options. The term 'managed retreat' has been defined as 'the concept of retreating inland from the existing line of flood defence or coast protection works, while monitoring and maintaining an awareness of the consequences of the retreat' (Birks, 1993). Where land to be inundated in the course of retreat is of a sufficient height above sea level the operation can be managed with an intention to create salt marsh as protection for low, inexpensive sea walls or as the sole protection where a gradual rise in the land occurs. This is now regarded by MAFF as an option to be considered in benefit–cost appraisal of coastal engineering schemes and is thus an integral part of valuation of salt marsh as a sea defence (MAFF, 1993b). However, Pethick (1993) warns that retreat projects implemented with insufficient awareness of the implications to estuarine tidal regimes may increase degradation and erosion by causing an increase in tidal prism and water velocities. In the delicate situation of salt marsh loss which is currently the subject of considerable research, no single solution is likely to be found. A multi-disciplinary approach is being taken in order to reach a workable strategy for the future.

With the development of greater understanding of sediment sources and transport and concern about engineered coastal structures, has come a view held by an increasing number of engineers and scientists that the coastline should be treated in its entirety. A piecemeal approach to coastal defence, combined with lax control on activities such as dredging, is blamed for exacerbating problems of coastal land loss by erosion while also starving low-lying accreting coastlines of material with which to maintain a balanced sediment budget. A current tendency towards coastal zone management within coastal cells only partially addresses the issue, since it is unlikely that sediment movement is restricted entirely to closed cells and coastal defence is not only just one of the issues covered by such procedures but is also that which is most easily subject to authoritarian claims for unsympathetic engineering requirements. An integrated approach to wetland management, guided by an enabling authority not subject to ministerial and departmental power struggles, might result in combined management of riverine flood defence with agricultural set-aside (the decommissioning of agricultural land to reduce surplus production) which is currently under fire for its lack of environmental benefit. By targeting river flood plains buffer zones of washland could be provided with the added benefit of creation of wetland habitat. Similar principles applied to coastal issues by the same potential authority would readily embrace such themes as managed retreat and the integrated management of complete estuarial systems.

Although coastal defence authorities have taken note of the coastal defence implications, others who may be adversely affected by salt marsh loss are as yet unconcerned. Yacht servicing agencies might well start to count the cost of loss of protection for their estuarine moorings, should the present rate of salt marsh-loss continue. The servicing of sporting and leisure activities linked with salt marsh is of great significance. For example, the yachting industry (marinas, boatyards, sailmakers, chandlers, clothing, victualling, club administration, public houses and the yachting press) and the wildfowling industry (guns, ammunition, clothing, dogs for breeding and training and the shooting press). A future scenario of complete salt marsh loss over wide areas may indicate a complete change in patters of coastal leisure activity. Proprietary interests in shoreside facilities or moorings threatened with degradation and exposure are of more immediate concern, since strong local lobbies can drive attempts to maintain local protection to the detriment of the wider environment. Local concerns should be fully informed of the developments in understanding of this emotive situation.

While recreation interests are frequently vociferously championed, a further blow to local economies in many parts of the world will be the effect on already beleaguered coastal fisheries. If a proven link could be made between fisheries, in particular the oyster fishery in the case of Essex, a direct value could be assigned to salt marsh from the profits of that industry. Oyster production and other inshore fisheries which currently benefit from salt marshes, however indirectly, could feel measurable adverse affects if widespread salt marsh loss continues. That some linkage with the oyster industry occurs is indisputable but that the oyster fisheries depend on salt marsh for their existence is not. In the UK, many values are less clear-cut than those from the USA since fisheries are not seen to depend on salt marsh in the same way. Small amounts such as rental of oyster pits for peppercorn rents still change hands but since these sums are invariably below three figures and are mostly kept up as an insurance against future need as opposed to current use, they can hardly be considered in the same scale of calculations. With no proven linkage, oyster production should not be

included in direct valuation but could be considered as a value awaiting further studies on estuarine food webs and in particular work on the effect of a concentration of salt marsh nutrients on speed of growth and eventual size of oysters. Placement of fisheries under 'indirect value, value unknown' may be more acceptable at present.

Valuation of salt marsh as a sea defence can be deemed a separate exercise from the complete valuation of salt marsh as an abstract, multi-faceted ecosystem and this has yet to be satisfactorily achieved. Changing perspectives on salt marsh, which was once regarded as intertidal wasteland open to improvement and development, have led toward higher valuation in a sphere which is somewhat removed from the field of conservation and wildfowling organizations. It was not, however, until the loss of this important habitat impinged upon the economic viability of sea defences that projects were commissioned to stem erosion and create new salt marshes. With continued salt marsh decline and forecast sea level rise, increased emphasis will be placed on its value in both economic and aesthetic terms and in areas of extensive coastal wetlands, a subtle reshaping of coastal topography will occur. The eventual contribution of salt marsh in terms of sea defence, recreation, fisheries and its less tangible functions will be a product of the research-led policy decisions which are made in the near future.

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