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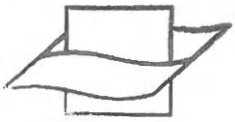

BRACKISH SALTMARSH COMMUNITIES IN THE GLASLYN MARSH TRUST RESERVE

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ABSTRACT

The brackish saltmarsh vegetation in the Glaslyn Marsh Trust Reserve has been described using the National Vegetation Classification as a basis for community definition. The marsh was impounded by Porthmadog Cob or Barrage in 1811, but seawater leakage maintains brackish conditions over much of the lower and middle marsh areas. As a result, a number of unusual, and possibly anomalous, vegeration types have developed and include several nationally rare and scarce plant species. Consequently, the marsh is of major conservation importance and, at a time of ever increasing demand for barrage construction in Britain, it provides a valuable example of the long term possibilities of constructing estuarine barrages which are semi-permeable to seawater. The maritime vegetation was found to have much in common with the low salinity marshes found in the southern Baltic.

INTRODUCTION

Glaslyn Marsh (Fig 1) is situated on the landward side of Porthmadog Cob (or Barrage) in Gwynedd and represents part of the Afon Glaslyn flood plain. The site includes a number of nationally rare plants and, in 1972, it was designated a Site of Special Scientific Interest. Later, in 1974, part of the SSSI east of the Afon Glaslyn was also declared a North Wales Wildlife Trust Reserve and comprises the area covered in the present study (Fig. 1). The Porthmadog Cob was built in 1811 as both a road/rail link and as part of a major reclamation scheme. It prevents much of the seawater from reaching the marsh at high tide but some seawater leakage occurs, resulting in brackish conditions being maintained over much of the lower and middle marsh. This provides a habitat of very limited occurrence in Britain: one normally restricted to small areas of upper saltmarsh where freshwater seepage occurs. Indeed, several of the plant communities are very rare and include species such as *Eleocharis parvula* (dwarf spike-rush) which is now restricted to the joint estuary system of the Afon Glaslyn and Afon Dwyryd in Wales (Jones, 1991a; Byfield, 1992). It was first recorded on the Glaslyn Marsh by Jones (1921) but thereafter no published reference to its presence there appears until Benoit (1959). The plant rarely flowers in Wales and, as the common name suggests, it is the smallest of the British spike rush species (only 1-2 cm). *E. parvula* is, nonetheless, regarded as representative of a distinct type of saltmarsh vegetation, referred to as Eleocharetum parvulae by continental phytosociologists and more

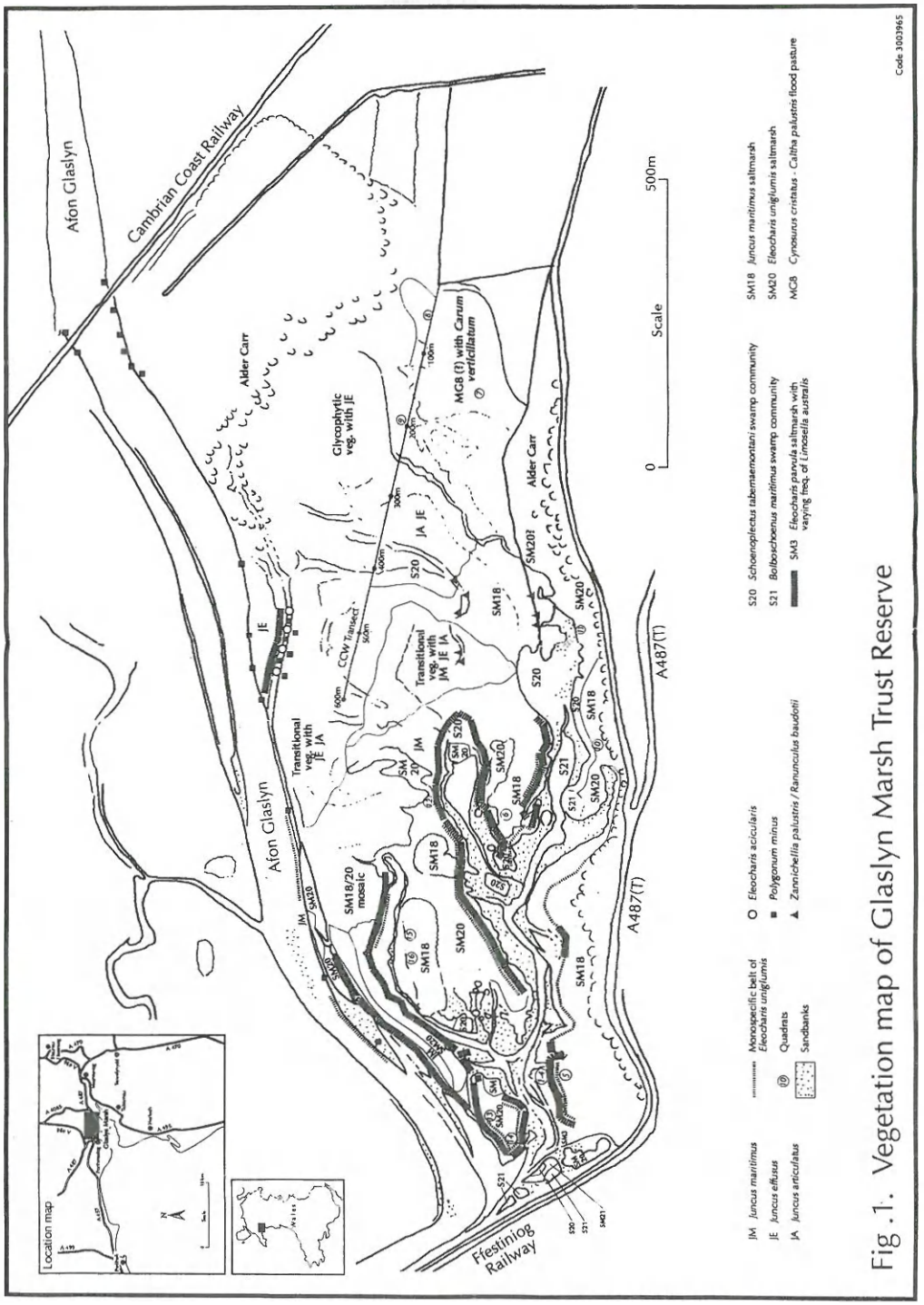

Fig .1. Vegetation map of Glaslyn Marsh Trust Reserve

recently described in the National Vegetation Classification (Rodwell, in prep.) as representative of a rare saltmarsh community type (*E. parvula* saltmarsh). *Limosella australis* (Welsh mudwort) is another extremely rare species found on the marsh and, apart from a few other sites in Wales, it is found nowhere else in Europe. The species was first recorded on the marsh in 1916 by Andrews (1934) although its status as a British native species has recently been questioned (Jones, 1991b). Since the marsh also provides refuge for a number of other uncommon plant species, including the nationally scarce *Juncus acutus* (sharp rush), *Eleocharis acicularis* (needle spike-rush) and *Polygonum minus* (small water-pepper) it was decided that a more detailed account of the vegetation was warranted.

Methodology

Between the 24th and 28th of August 1993, a survey of the vegetation within the boundary of the Glaslyn Marsh Trust Reserve (Fig. 1) was carried out. The main objective was to describe and map the unusual brackish water saltmarsh communities on the seaward edge of the marsh using the National Vegetation Classification (Rodwell, in prep.) but efforts were also made to characterise some of the transitional vegetation types and the glycophytic communities that have developed on the middle and upper marsh.

In accordance with NVC methodology, all the homogenous stands of different maritime vegetation were identified and mapped. This was done with the help an aerial photograph taken on the 8th. May 1991. The boundaries of a number of different vegetation types could be seen on the photograph and these were sketched onto an acetate overlay. A $4m^2$ quadrat was then used to estimate the cover abundance, using the Domin scale (*sensu* Dahl & Hadac, 1941), of all taxa found within selected stands of each vegetation type (Fig. 1). Storage and handling of the quadrat data was assisted by the use of the computer software package VESPAN II (Malloch, 1988).

Percentage Cover	*Domin Value*	*Frequency*
<4% with few individuals	1	I = 1-20%
<4% with several individuals	2	II = 21-40%
<4% with many individuals	3	III = 41-60%
		IV = 61-80%
4-10%	4	V = 81-100%
11-25%	5	
34-50%	7	
51-75%	8	
76-90%	9	
91-100%	10	

which was specially designed for managing and analysing NVC data. Tables 1-4 show the Domin values and frequency of the species found within each community. However, because the National Vegetation Classification for saltmarsh vegetation was still in draft, some of the community floristic data was not available. Therefore, no form of objective analysis was carried out. For more details of NVC methodology see Rodwell (1991, 1992).

TABLE 1 Eleocharis parvula *saltmarsh*

Species	Quadrat Number 1	4	13	Frequency
	Domin Values			
Eleocharis parvula	6	6	6	V
Schoenoplectus tabernaemontani	5	3	4	V
Agrostis stolonifera	5	3	4	V
Spergularia marina	1	1	4	V
Triglochin maritima	2	1	2	V
Eleocharis uniglumis	2	1		IV
Limosella australis	2	1		IV
Aster tripolium		4		II
Juncus gerardi		1		II
Samolus valerandi	1			II
Bolboschoenus maritimus			1	II
Number of species per sample	8	9	6	

VEGETATION DESCRIPTION

Glaslyn Marsh is a very complex ecosystem. The elaborate creek system, flood regime and salinity gradients have created an intricate pattern of different vegetation types. Initially, there appears to be no obvious order to the vegetation but closer inspection reveal that it can be divided into a series of zones. The main zonation pattern is clearly associated with a general landward salinity gradient, but superimposed upon this are local zonation patterns associated with each of the creek systems. It is usually within these latter areas that the main maritime communities occur (Fig.1), and these can often be classified into four main vegetation types. The most seaward of these are the creek, brackish water, swamp communities usually represented by almost monospecific stands of *Schoenoplectus tabernaemontani* (grey club-rush) but also occasionally including clonal cells of *Bolboschoenus maritimus* (sea club-rush) swamp. Both of these communities are partially submerged in brackish water on most high spring tides and represent the main pioneer communities. In a fully saline situation, pioneer communities are usually represented by either Salicornetum (glasswort community) or Spartinetum common cord-grass community). On the creek margins, the swamp communities usually merge into a narrow zone of *Eleocharis parvula* dominated saltmarsh (Table 1). This was then followed by a broader zone of *Eleocharis uniglumis* (slender spike-rush) dominated saltmarsh (Table 2) which in some cases was represented by almost pure stands of *E. uniglumis*. In a fully saline situations, you would expect to find Puccinellietum (common saltmarsh-grass community) and possibly Festucetum (red fescue community) in these lower-middle marsh locations, with *Atriplex* (*Halimione*) *portulacoides* (sea-purslane) fringing the creek margins. Saltmarsh dominated by *Juncus maritimus* (sea rush) (Table 3) represents the most landward of the true saltmarsh communities and forms a fairly extensive zone (Fig. 1), but this is not atypical in Wales—both the Dyfi and Cefni estuaries, for example, support large areas of a similar vegetation type (Yapp *et al.*, 1917; Packham & Liddle, 1970). On its landward extremity, the *J. maritimus* saltmarsh gives way to a landward transition zone supporting both halophytic and glycophytic elements. Characteristic species include *J. maritimus*, *J. effusus* (soft rush), *Triglochin maritima* (sea arrowgrass), *T. palustris* (marsh arrow-

TABLE 2. Eleocharis uniglumis *saltmarsh*

Species	Quadrat Number 2	3	5	11	12	14	Frequency
	Domin Values						
Eleocharis uniglumis	5	6	4	5	6	5	V
Agrostis stolonifera	6	3	10	9	5	9	V
Juncus gerardi	4	4	4		7	4	V
Glaux maritima	5	1	4			6	IV
Schoenoplectus tabernaemontani	4	4		2	2		IV
Triglochin maritima	4	4	3			4	IV
Aster tripolium	1		1			1	III
Samolus valerandi	2	2			1		III
Leontodon autumnalis			2			1	II
Oenanthe lachenalii			1			1	II
Plantago maritima			1			1	II
Ranunculus flammula			1	4			II
Spergularia marina	1	3					II
Limosella australis	1	3					II
Alisma plantago-aquatica				3			I
Alopecurus geniculatus					2		I
Cardamine pratensis			1				I
Carex nigra			1				I
Phragmites australis				2			I
Potentilla anserina					1		I
Trifolium repens					4		I
Callitriche seedling/sp				1			I
Juncus c.f. *articulata* * *acutiflora*			1				I
Eleocharis parvula		4					I
Number of species per sample	10	10	15	7	6	10	

grass), *Eleocharis uniglumis* and *E. palustris* (common spike-rush). Eventually *J. maritimus* peters out leaving *J. effusus*, *J. articulatus* (jointed rush) and *J. acutiflorus* (sharp-flowered rush) as the dominant rush species, and forms a vegetation type similar to the community classified as a *Juncus acutiflorus-Galium palustre* (sharp-flowered rush—common marsh-bedstraw) rush pasture, NVC community (Rodwell, 1991) found in the marshy fields just north of Glaslyn Marsh Reserve (Stevens & Turner, unpublished). This community finally merges into alder carr on the landward extremity of the marsh, but in the south eastern sector a species-rich grassland (Table 4) has developed, providing habitat for the uncommon *Carum verticillatum* (whorled caraway) and *Dactylorhiza majalis* subsp. *cambrensis* (Welsh marsh-orchid). This again appears to be similar to a community found in the marshy fields north of the Reserve which was described by Stevens & Turner (unpublished) as having some floristic affinities with a *Cynosurus cristatus—Caltha palustris* (crested dog's-tail—marsh-marigold community) flood pasture, NVC community (Rodwell, 1992).

BRACKISH SALTMARSH COMMUNITIES

Eleocharis parvula *(Dwarf spike-rush) saltmarsh (Table 1)*

Rodwell (in prep.) describes the *E. parvula* NVC community as a short open sward which usually occurs at the limit of tidal influence in southern England but may extend

TABLE 3. Juncus maritimus *saltmarsh*

Species	Quadrat Number 6	10	15	16	Frequency
	Domin Values				
Juncus maritimus	6	8	6	6	V
Agrostis stolonifera	8	5	9	8	V
Festuca rubra	4	6	4	4	V
Leontodon autumnalis	4	3	3	4	V
Carex nigra	1	4	2	1	V
Galium palustre	3	3	3	3	V
Lychnis flos-cuculi	2	2	1	2	V
Oenanthe lachenalii	4	4	4	4	V
Plantago lanceolata	4	8	4	4	V
Potentilla anserina	3	4	1	3	V
Ranunculus flammula	1	1	1	1	V
Trifolium repens	4	4	2	4	V
Aster novi-belgii	5	5	5	5	V
Eleocharis uniglumis	5		4	5	IV
Juncus gerardi	3		1	2	IV
Poa pratensis	1	3		1	IV
Ranunculus acris	1	5		1	IV
Triglochin maritimum	4	1	3		IV
Cardamine pratensis	1			1	III
Lythrum salicaria		2	1		III
Amblystegium riparium	1			1	III
Achillea ptarmica		4			II
Agrostis capillaris		3			II
Carex flacca		1			II
Eleocharis palustris		3			II
Filipendula ulmaria		4			II
Glaux maritima			1		II
Holcus lanatus		1			II
Hydrocotyle vulgaris		4			II
Juncus articulatus		2			II
Lotus uliginosus		4			II
Mentha aquatica		3			II
Poa trivialis			1		II
Rumex crispus			1		II
Sagina procumbens		1			II
Senecio aquaticus		4			II
Calliergon cuspidatum		7			II
Number of species per sample	20	30	20	19	

further downshore in Ireland. However, a floristic table for the community is still in preparation. In Britain, it is restricted to north and central Wales and the south coast of England (Byfield, 1992). Several of the species listed in Table 1, including *Schoenoplectus tabernaemontani, Eleocharis uniglumis, Spergularia marina* (lesser sea-spurry), *Agrostis stolonifera* (creeping bent), *Bolboschoenus maritimus* and *Juncus gerardi* (saltmarsh rush) are common to both the English and Welsh communities. On the other hand, Byfield found regional differences in species composition in England and there are a number of obvious differences between the English and Welsh communities. For example, *Limosella australis* is unique to the Welsh community, whereas other species such as *Limosella aquatica* and *Juncus foliosus* have only been recorded for the English community.

TABLE 4. *Mesotrophic Inundation Community*

Species	Quadrat Number 7	8	9	Frequency
	Domin Values			
Agrostis stolonifera	4	3	9	V
Cardamine pratensis	1	3	5	V
Galium palustre	3	3	4	V
Leontodon autumnalis	4	3	2	V
Plantago lanceolata	5	4	1	V
Ranunculus flammula	2	3	3	V
Trifolium repens	5	4	2	V
Calliergon cuspidatum	7	8	7	V
Anthoxanthum odoratum	3	3		IV
Carex echinata	2	5		IV
Carex flacca	2	2		IV
Carex nigra		2	7	IV
Carex panicea	6	6		IV
Carum verticillatum	3	3		IV
Cerastium fontanum	2	2		IV
Cynosurus cristatus	2	3		IV
Eleocharis palustris		4	5	IV
Equisetum palustre		1	2	IV
Festuca rubra	4	4		IV
Filipendula ulmaria	1	1		IV
Holcus lanatus	4	5		IV
Hydrocotyle vulgaris	4	4		IV
Lotus corniculatus	3	3		IV
Lychnis flos-cuculi		1	2	IV
Lythrum salicaria		2	3	IV
Potentilla reptans	4	1		IV
Prunella vulgaris	3	4		IV
Ranunculus acris	3	4		IV
Sagina apetala erecta	1	2		IV
Isolepis setacea	1	2		IV
Senecio aquaticus		2	2	IV
Juncus cf. articulata * *acutiflora*	5	6		IV
Caltha palustris		3		II
Juncus acutiflorus			5	II
Luzula campestris	2			II
Mentha aquatica			3	II
Myosotis laxa caespitosa			4	II
Oenanthe lachenalii			2	II
Phragmites australis			4	II
Potentilla anserina			3	II
Ranunculus repens		2		II
Succisa pratensis		2		II
Trifolium pratense	2			II
Triglochin maritima			4	II
Triglochin palustris		3		II
Rhytidiadelphus squarrosus	4			II
Aster novi-belgii			3	II
Number of species per sample	29	36	22	

In the Baltic, both *E. parvula* and *S. tabernaemontani* are described as pioneer species on emerging flats in areas of reduced salinity (Dijkema, 1984). Likewise, on the Glaslyn Marsh, *E. parvula* saltmarsh usually occurs on the seaward edge of the marsh but can also be found in shallow depressions in other areas. In Europe, vegetation dominated by *E. parvula* has been recorded from the Biscay coast of France and Spain, Northern Portugal and the Mediterranean and Black Seas (Rodwell, in prep.) and was regarded by Chapman (1978) as part of the natural succession between Zosteretum (eelgrass community) and Phragmitetum (reed community).

Eleocharis uniglumis *(slender spike-rush) saltmarsh (Table 2)*

Rodwell (in prep.) describes the *E. uniglumis* NVC community as a species-poor, upper marsh fringe community with an extensive under-carpet of *Agrostis stolonifera*, and having *Juncus gerardi*, *Glaux maritima* (sea-milkwort), *Festuca rubra* (red fescue), *Triglochin maritima*, *Potentilla anserina* (silverweed) and *Alopecurus geniculatus* (marsh foxtail) as frequent associates. According to Chapman (1978) it has much in common with *J. gerardi* saltmarsh which he regarded as representing the natural succession from *E. uniglumis* saltmarsh in brackish conditions. Saltmarsh vegetation dominated by *E. uniglumis* is a rare community in Britain occurring locally along the west coast from the Dyfi Estuary northwards and is mainly found in Scotland (Doody, 1984). On the Glaslyn Marsh, most of the species described by Rodwell as common associates of this community were recorded, but as a lower, rather than an upper marsh community. This again reflects the situation found in the Baltic, where *E. uniglumis* vegetation dominates most lower saltmarshes from southeast Sweden and Estonia northward (Dijkema, 1984).

Juncus maritimus *(sea rush) saltmarsh (Table 3)*

Rodwell (in prep.) describes the *J. maritimus* NVC community as an association dominated by tall dense clumps of *J. maritimus* with an understorey of *Agrostis stolonifera, Festuca rubra, Glaux maritima,* and *Juncus gerardi.* In Britain, the community extends as far north as Arran in Scotland and has been recorded in areas of low salinity in the southern Baltic (Dijkema, 1984). Vegetation dominated by *J. maritimus* also occurs in southern Europe and the Mediterranean (Gehu, 1984). Chapman (1978) regarded it as representing the regional climatic climax in European saltmarshes but, because further development was possible if the saline influence was eliminated, the community was termed a sere climax. In the Glaslyn Marsh, the *J. maritimus* vegetation is slightly anomalous, in that the introduced *Aster novi belgii* (Michaelmas-daisy) represents a major component of the community and it also occasionally includes *Juncus acutus.*

Schoenoplectus tabernaemontani *(grey club-rush) and* Bolboschoenus maritimus *(sea club-rush) swamp*

According to Rodwell (in prep.) both of these swamp communities tend to have a very sparse understorey of associated species. On the Glaslyn Marsh, this was particularly true for the *B. maritimus* community which was mainly composed of monospecific stands. The Glaslyn Marsh *S. tabernaemontani* vegetation was usually slightly more

species-rich but differed from the NVC community, as described by Rodwell, due to the presence of *Eleocharis parvula* and *Limosella australis*. In Britain, vegetation dominated by *S. tabernaemontani* is restricted to the coasts of England and Wales, but is comparatively rare in Wales (Burd, 1989), whereas the *B. maritimus* community has been recorded at suitable sites all around the British Isles as far north as Sutherland (Rodwell, in prep.). Both communities tend to occur in the upper saltmarsh zones in Britain (Burd, 1989), whereas in the brackish conditions in western Scandinavia and the Baltic they represent pioneer communities of emerging flats (Dijkema, 1984). Their pioneer status on the Glaslyn Marsh shows again how this unusual marsh appears to have more in common with the saltmarshes of the Baltic than those more typical of Britain.

Discussion

Fig. 2 shows the state of the Glaslyn Estuary in 1796, approximately 15 years before the building of the Porthmadog Cob. From the map, it seems likely that much of the area now occupied by the Glaslyn Marsh was then represented by sand flats with possibly some *Puccinellia maritima* (common saltmarsh-grass) dominated marsh along the landward edges. This is more or less the situation today in the area seaward of the Cob, except for the fact that *Spartina anglica* (common cord-grass) occupies some of the former sand flat areas, but since this species did not appear in Wales until about 1920 it would not have been present at that time. Much of the former estuary landward of the Cob has now been reclaimed for agriculture. However, apart from grazing by sheep and cattle the vegetation on the Glaslyn Marsh Reserve appears to represent the culmination of fairly unhindered natural succession. How the vegetation would have developed in the absence of grazing is difficult to say, but since grazing animals tend to actively avoid *Juncus maritimus* and preferentially feed on other vegetation types this community would probably have been far less extensive. On the other hand, poaching by grazing animals is thought to favour the growth of *Eleocharis parvula* (Jones, 1991a).

In its 182 year history, the Glaslyn Marsh vegetation has developed a complete sequence from pioneer saltmarsh communities through zones of mid and upper saltmarsh to glycophytic herb and woodland vegetation. The saltmarsh communities and their zonation patterns, however, appear to have much more in common with saltmarshes in the southern Baltic than those normally found in Britain. The semi-permeable barrage or cob has created brackish conditions comparable with those found in the Baltic, and this seems to be overriding any possible climatic differences. In the Baltic, salinity is usually below 10 parts per thousand, whereas in the open seas around the coast of Britain it can reach 35 parts per thousand. Both the *Eleocharis parvula* and *E. uniglumis* saltmarsh communities are widespread in the southern Baltic (Dijema, 1984) and the Glaslyn Marsh appears to have a Baltic type zonation pattern with both *Bolboschoenus maritimus* and *Schoenoplectus tabernaemontani* vegetation representing pioneer communities—in Britain these normally occur as an upper-marsh fringe. On the other hand, it is important to remember that the Glaslyn Marsh is a semi-natural system and has a number of features you would not expect to find in the Baltic. For example, *Juncus acutus* has a southern distributions and represents a common component of saltmarsh in the Mediterranean, whilst *Aster novi-belgii* and probably *Limosella australis* could be classed as American elements.

Barrage construction plans have been proposed for a variety of reasons in many estuaries in Britain, including barrages for tidal power generation, protection against

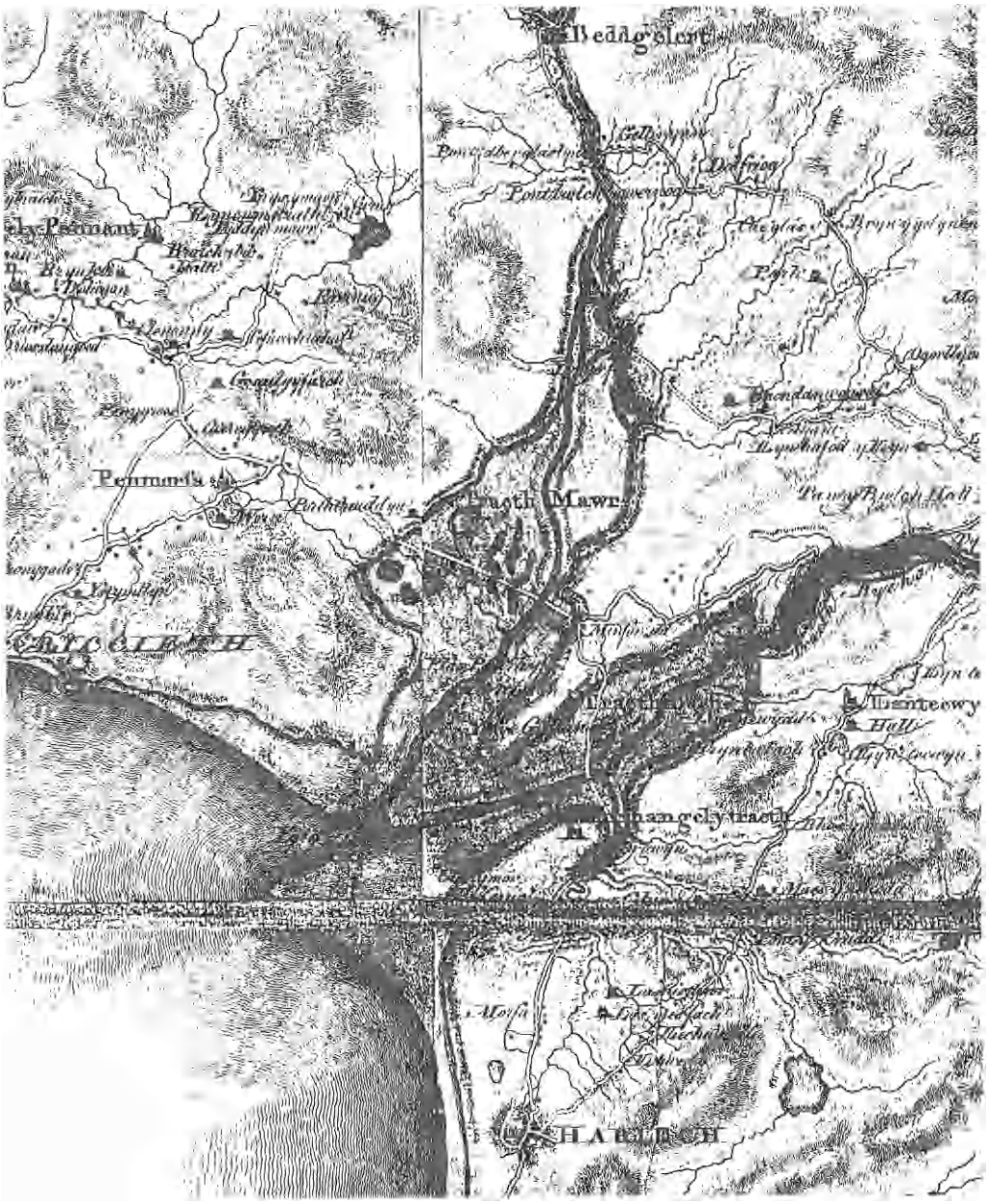

FIG. 2
John Evans' map (1796) showing the Afon Glaslyn—Afon Dwyryd Estuary prior to the building of the Porthmadog Cob in 1811. (Map supplied by Gwynedd Archive Services, Caernarfon)

storm surges, transport links, recreation and freshwater storage (Gray, 1992). With this ever increasing demand for these structures, it is important that the nature conservation implications are fully considered. One important factor, in the case of barrages built for recreation, reclamation, or as transport links, is whether they should be permeable to seawater or not. The distinctive ecology of Glaslyn Marsh would not have developed if, like some modern barrages, the Porthmadog Cob had been impermeable to seawater. It therefore provides a useful example of the long term possibilities of constructing barrages which allow some landward movement of seawater, and since most brackish water habitats, such as coastal lagoons and brackish saltmarsh, are rare in Britain, these constructions could be designed to create habitats of major conservation value.

The Glaslyn Marsh, however, provides no indication of the more immediate ecological changes that would take place in recently created post barrage environments, and these will vary according to a variety of factors. Gray (1970; 1977), for example, found that initially, there was a tendency towards the development of large monospecific stands of comparatively few individual plant species, and depending on local variation in soil factors, the successful pioneer plant species may be those generally found on saltmarsh (e.g. the wind dispersed *Aster tripolium* (sea aster), on drying lakeside mud (e.g. the water dispersed *Ranunculus sceleratus* (celery-leaved buttercup), or as farmland weeds (e.g. the wind dispersed *Tussilago farfara* (coltsfoot). Nevertheless, this initial phase can also provide an important, albeit temporary, habitat for a number of uncommon species including *Chenopodium rubrum* (red goosefoot), *Atriplex littoralis* (grass-leaved orache) *Bidens tripartita* (trifid bur-marigold), *B. cernua* (nodding bur-marigold) (Gray, 1970 and personal observation).

The subsequent development or natural succession of vegetation in a post barrage environment will again be highly dependent on local conditions. It will also dependent on the local availability of suitable species, as exemplified by the fact that *Limosella australis* is restricted to North Wales. Gray (1970) found that saltmarsh and paramaritime plant species can persist for long periods in grazed reclaimed land, with saltmarsh plants persisting for up to 30 years or more, and paramaritime plants probably for centuries, but could disappear very quickly after cessation of grazing. In other words, grazing was preventing the spread of more dominant, glycophytic species. Trampling by grazing animals will also tend to maintain bare and disturbed areas which are essential for the long term survival of certain saltmarsh species. So grazing is an important factor, but if brackish water communities are to be maintained indefinitely, periodic inundation by saltwater or brackish water will obviously be necessary. The frequency of inundation will determine the types of plant communities that develop. On the Glaslyn Marsh, for example, seawater incursion only occurs on the highest spring tides, and actually penetrates the porous wall of the Cob. Tidal flood doors prevent seawater flooding the marsh via the river channel. It is unlikely that modern barrages would be purposely built to be porous to seawater. Sluice gates would be far more convenient and provide much more control. However, the important point is that the facilities to allow some seawater incursion onto what would otherwise be reclaimed land in a post barrage environment would have to catered for, and designed, at the planning stage.

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REFERENCES

ADAM, P., (1981). The vegetation of British saltmarshes. *New Phytologist.* **88**, 143-196.

ANDREWS, C. H., (1934). New County and Other Records. *The Botanical Society and the Exchange Club of the British Isles.* Report for 1934 p.887.

BENOIT, P. M., (1959). Two interesting botanical discoveries in Merionethshire. *Nature in Wales* **5** (1), 725-728.

BYFIELD, A., (1992). *The status and ecology of* Eleocharis parvula *in Britain.* Report for English Nature—South Region.

BURD, F., (1989). The saltmarsh survey of Great Britain. *Research and survey in nature conservation* **17.** Nature Conservancy Council.

CHAPMAN, V. J., (1978). *Coastal Vegetation.* Pergamon Press.

DAHL, E. and HADAC, E. (1941). Strandgesellschaften der Insel Ostoy im Oslofjord. Eine pflanzensoziologische Studie.

DIJKEMA, K. S., (1984). Description of saltmarsh ecosystems in Europe. Western Scandinavia and the Baltic. In: *Saltmarshes in Europe.* ed. K. S. Dijkema. Council of Europe. Nature and the Environment Series No. 30.

DOODY, J. P., LANGSLOW, D. A. and STUBBS, A. E., (1984). Description of saltmarsh ecosystems in Europe. Great Britain and Ireland. In: *Saltmarshes in Europe.* ed. K. S. Dijkema. Council of Europe. Nature and the Environment Series No. 30.

GEHU, J. M., (1984). Description of saltmarsh ecosystems in Europe. Mediterranean saltmarsh and salt steppes. In: *Saltmarshes in Europe.* ed. K. S. Dijkema. Council of Europe. Nature and the Environment Series No. 30.

GRAY, A. J., (1970). The colonisation of estuaries following barrage building. In: *The Flora of Changing Britain.* ed. F. Perring., Classey, Hampton PP 63-72.

GRAY, A. J., (1977). Reclaimed Land. In: *The Coastline.* ed. R. S. K. Barns. John Wiley and Sons.

GRAY, A. J., (ed.) (1992). *The Ecological Impact of Estuarine Barrages.* Ecological Issues No.3. Published for the British Ecological Society by the Field Studies Council.

JONES, A., (1991a). *Rare species monitoring in Wales, 1991.* Wales Survey and Monitoring Report CCW 91/2/-6 (confidential).

JONES, A., (1991b). Welsh Mudwort ?. *Welsh Bulletin of the Botanical Society of the British Isles.* No. 52: 6-8.

JONES, D. A., (1921). New County and other Records. *The Botanical Society and the Exchange Club of the British Isles.* Report for 1921. p.270.

MALLOCH, A. J. C., (1988). *VESPAN II. A computer package to handle and analyse multivariate species data and handle and display species distribution data.* University of Lancaster.

RODWELL, J. S., (ed.) (1991). *British Plant Communities. Volume 2. Mires and heaths.* Cambridge University Press.

RODWELL, J. S., (ed.) (1992). *British Plant Communities. Volume 3. Grasslands and montane communities.* Cambridge University Press.

RODWELL, J. S., (in preparation). *British Plant Communities. Volume ? Saltmarshes.*

PACKHAM, J. R. & LIDDLE, M. J., (1970). The Cefni Saltmarsh, Anglesey, and its recent development. *Field Studies,* **3,** 331-356.

STEVENS, D. P. & TURNER, J. C. E., (unpublished). *Glaslyn Marshes (North-West): Site Description.* An unpublished report by the Wales Field Unit of the Nature Conservancy Council.

YAPP, R. H., JOHNS, D. and JONES, O. T., (1917). The saltmarsh of the Dovey Estuary. *Journal of Ecology,* **5,** 65-103.