Appendices

Appendix 1 Information held on the *Grazing Marsh GIS*

Attributes of Dargie polygons:

1. *Invertebrates (insects)*

Records for following groups:	*Orthoptera*, *Odonata*, *Noctuidae*, non-noctuid moths, *Carabidae*, *Syrphidae*, *Diptera* (non-Syrphid)
Attributes derived:	a) Species richness for each group and all combined (1km buffer) b) Density of spp. (km^{-2}) for each group & combined (1km buffer)

2. *Breeding waders*

Counts for these species:	lapwing, snipe, curlew, redshank, oystercatcher
Attributes derived:	a) Number of pairs for each species and all combined (5km buffer) b) Density of each species and all combined (5km buffer) c) % of UK population for each/all species (5km buffer)

3. *Wetland bird counts*

Counts for:	Wildfowl and waders (1km buffer – and for derived attributes)
Attributes derived:	a) Sum of regional/national/international importance scores b) Total count for all birds, wildfowl and waders

4. *Botany* **Botanical measures of site quality**

Various measures of grazing marsh quality were derived (Roy *et al.*, 1998):

A-SPP **Actual number of species** (based on 100m and 1km BRC data)
Number of species with 1km or 100m records within site.

A-QUAL **Actual quality**
Average quality of species with 1km or 100m records within site.

A-RARESPP **Actual number of rare or scarce species**
Number of nationally rare or nationally scarce species with 1km or 100m records within site.

P-SPP	**Potential number of species** (based on 2km/10km BRC data) Number of spp. with 100m, 1km, 2km or 10km records which intersect site.
P-QUAL	**Potential quality** Average quality of species with 100m, 1km, 2km or 10km records which intersect site.
PWGT-SPP	**Potential number of species - weighted** Number of species with 100m, 1km, 2km or 10km records which intersect site. For sites that intersect more than one 10km square, the contribution of each species is weighted by the proportion of the 10km squares of the site in which it is present.
PWGT-QUAL	**Potential quality - weighted** Average quality of species with 100m, 1km, 2km or 10km records which intersect site. For sites that intersect more than one 10km square, the contribution of each species is weighted by the proportion of the 10km squares of the site in which it is present.
P-RSPP-PRE	**Potential number of rare/scarce species before 1970** Number of nationally rare or scarce species with 100m, 1km, 2km or 10km records, dated before 1970, which intersect site.
P-RQAL-PRE	**Potential quality of rare/scarce species before 1970** Average quality of nationally rare or scarce species with 100m, 1km, 2km or 10km records, dated before 1970, which intersect site.
P-RSPP-POST	**Potential number of rare/scarce species after 1970** Number of nationally rare or scarce species with 100m, 1km, 2km or 10km records, dated 1970 or after, which intersect site.
P-RQAL-POST	**Potential quality of rare/scarce species after 1970** Average quality of nationally rare or scarce species with 100m, 1km, 2km or 10km records, dated 1970 or after, which intersect site.

Management, land-cover and flood data

1. *Management*

Take-up data for:	Field boundaries - ditches, hedges, mixed; old meadows and pastures; waterside land
Attributes derived:	Take-up in NA of each/all schemes as proportion of national value

2. *Land-cover, altitude and liability to flood*

Arc/info grid of England (25m resolution on the Great Britain National Grid) showing cells satisfying the potential wet grassland criteria. The attributes of this grid are:

Value:	Unique value for each LCM/Dargie presence/Natural Area combination (primary key)
Count:	Number of 25m cells in Value
Na_g:	Natural Area number
Lcm_class:	LCM class (6,7,8,18 or 19)
Dargie:	Dargie presence (INSIDE or OUTSIDE)
Na_name:	Natural Area name

Quality scores

Note: the quality scores for Natural Areas are in an Excel spreadsheet and can be ranked by whichever quality score is considered appropriate.

Dargie attributes selected:	Breeding wader density and UK proportion (see above) Wetland bird counts - total species richness and total bird density (see above) Botany - rare and potential species (see above) Marsh area
Attributes derived:	Mean and mean national rank of Dargie data in NA, weighted by area of Dargie in NA, for each selected attribute Marsh area in Natural Area

Appendix 2: Survey of existing and planned restoration schemes

Appendix 2A: Survey form distributed to EN staff *etc* to enumerate schemes

Please fill in the sections which are relevant to your projects; site location, area, time scale and the type of project are the most important.
Please continue overleaf if there is any additional information that might be useful.

Grazing Marsh creation and restoration projects

Site name:

Grid ref:

Area (ha):

Brief site description/history (most important features of this site *e.g.* existing species / proximity to other good habitat).

Type of project (*e.g.* creation, restoration, or improvement of existing marsh).

Requirements/Objectives (e.g. land purchase, raised water-levels).

Time scale (i.e. planned or in progress, short or long term).

Any Problems ?

How interested are landowners/farmers in this area?

Costs; Some money will be available to help reach BAP targets so for good projects in the planning stages or on your wish-list, an estimated budget would be helpful.

Appendix 2B: Offices of English Nature *etc* contacted within the ITE survey

Areas contacted			Information received					
				Other contacts followed up, usually after discussion with EN staff.				
Natural Area (Letters sent to EN offices for these areas)	NA Code No.	EN offices contacted by phone	EN	WT	EA	RSPB	CS	Other
Solway Basin	3	Yes	x				*	
Tees Lowlands	7	Yes	*				*	
Cumbria Fells and Dales	10	Yes	*				*	
West Cumbrian Coastal Plain	11	Yes	*				*	
Lancashire Plain and Valleys	13	Yes	*				*	
Vale of Pickering	18	Yes	x					*VPWP
Humberhead Levels	22	Yes	*				*	
Holderness	20	Yes	x				*	
Humber Estuary	21	Yes	x				*	
Mosses and Meres	27	Yes	*					
North Lincolnshire Coversands and Clay Vales	34	meeting	*		*			*FWAG
Lincolnshire Coast and Marshes	36	meeting	*		*			*FWAG
Trent Valley and Rises	33	meeting	*				*	
The Fens	37	meeting	*			*		
The Broads	48	Yes	*	*		*		*NT/IDB
North Norfolk	47	Yes	*					*IDB
Suffolk Coast and Heath	49	Yes	x					*EN project
West Anglian Plain	52	Yes	x			*		*Northants/ Beds. C.C. & EN project
Severn and Avon Vales	56	Yes	*					
Thames and Avon Vales	63	Yes	*					
London Basin	66	Yes	*					*LEU
Greater Thames Estuary	67	Yes	*					
North Kent Plain	68	Meeting	*	p			*	
Wealden Greensand	70	Yes	*			*		* AVP
Romney Marshes	71	Meeting	p				*	
Low Weald and Pevensey	73	Yes	x	*	*			
South Downs	74	Yes	*					
South Coast Plain and Hampshire Lowlands	75	meeting	p				*	* West Sussex CC
Isle of Wight	76	meeting	*					
New Forest	77	meeting	x				*	
Hampshire Downs	78	meeting	p				*	
South Wessex Downs	80	Yes	x	*				
Dorset Heaths	81	Yes	*				*	
Somerset Levels and Moors	85	Yes	*					
Devon Redlands	90	Yes	*					

Additional contacts from EN and other organisations who contributed data

Name/organisation		Contacted	Data received
Tim Dixon	EN-York	Yes	*
Rick Keymer	EN- Grantham	meeting	see Natural.Area 33 34 36 above
Andy Gordon	EN - London	forms sent	*
Mike Wilkinson	EN - Hereford	Yes	*
Patrick Green	BASC Wrexham	meeting	*
Malcolm Ausden	RSPB Sandy	Yes – forms sent	*
Sam Alton	FRCA North Mercia	Yes– forms sent	p
Nicky Davis	FRCA Kent	Yes– forms sent	p
Stephanie Payne	FRCA Dorset/Wiltshire	Yes– forms sent	p
David Shaw	FRCA North	Yes– forms sent	No detailed information readily available
Mark Simmons	FRCA Hampshire	Yes– forms sent	*
Lajla White	FRCA East Riding/Humberside	Yes– forms sent	*

Legend:

* = data received
p = data promised
x = no data available

AVP: Arun Valley Project
BASC: British Association for Shooting and Conservation
CC: County Council
EN project: Restoring the Alde (Suffolk) and the Ouse (West Anglian Plain)
FRCA: Farming and Rural Conservation Agency
FWAG: Farming and Wildlife Advisory Group
IDB: Internal Drainage Board
LEU: London Ecology Unit
NT: National Trust
RSPB: Royal Society for the Protection of Birds
VPWP: Vale of Pickering Wetlands Project

Appendix 2C Form of information held in Annexe of grazing marsh restoration schemes (ongoing and planned)

Note: Schemes are generally listed in the numerical order of the EN Natural Areas within which they occur, groups of schemes being separated by a bold line. A few schemes co-ordinated nationally (by RSPB and BASC) are listed out of Natural Area order at the end of the table.

Legend:

Easting Reference from National Grid (if absent site cannot be localised or is too large to define simply by one Grid Reference)

Northing (as latter)

Name Name may refer to specific site or area within which site is located. In some instances the name is cross referenced to the original code from Dargie (1993, 1995) *e.g.* NE236 and SW116. Where no National Grid Reference is included, the Natural Area number (*e.g.* NA9) is given.

Area Given in hectares where known

Time scale Defined as follows:

1: In progress
2: Planned (advanced stage)
3: Planned (early stage, but likely to happen in a few years)
4: Proposal with some research on feasibility complete but remains on "wish list"
5: As yet merely on "wish-list"

Project type: Defined as follows:

1: Creation/re-creation
2: Restoration/rehabilitation.
3: Improvement/enhancement

Requirements: Summary of objectives of scheme, methods to be adopted, and/or problems faced in achieving these goals. CS: Countryside Stewardship; EA: Environment Agency; ESA: Environmentally Sensitive Area.

Contact: Individual providing this information. "Wet Fens" = Wet Fens for the Future" campaign (EN Cambridgeshire and RSPB)

Info.: Amount of information provided:

(no entry): basic info.
***:** additional info.
****:** detailed info.

Conf.: Where information is confidential, this is indicated by **Y** (*i.e.* Yes) – particularly sensitive data are denoted by **Y***

Office: Organisation/location which provided this information

Appendix 3 Proportional take-up of Countryside Stewardship management schemes in 95 Natural Areas

Natural Area	Area (ha)	Marsh area (ha)	Scheme					All schemes combined
			Field Boundaries			Old Meadows and Pasture	Waterside Land	
			Ditches	Hedges	Mixed			
The Culm	283072	899.94	0.0000	0.0323	0.0000	0.2648	0.0104	0.0684
East Anglian Plain	634387	4006.91	0.0000	0.0629	0.0000	0.0211	0.0952	0.0644
West Anglian Plain	350948	7202.19	0.0000	0.0401	0.0222	0.0079	0.0699	0.0436
Trent Valley and Rises	457119	6845.59	0.0000	0.0462	0.0444	0.0184	0.0424	0.0396
Mosses and Meres	388289	1915.44	0.0000	0.0295	0.0111	0.0343	0.0565	0.0391
Lancashire Plain and Valleys	167228	12209.54	0.0000	0.0445	0.0444	0.0026	0.0193	0.0281
Thames and Avon Vales	253285	6731.8	0.0000	0.0223	0.0000	0.0303	0.0320	0.0266
London Basin	521383	2673.51	0.0000	0.0200	0.0000	0.0211	0.0357	0.0251
Midlands Plateau	305019	920.08	0.0000	0.0206	0.0000	0.0487	0.0134	0.0230
High Weald	174885	566.21	0.0000	0.0128	0.0000	0.0171	0.0335	0.0203
Severn and Avon Vales	210326	13941.36	0.0000	0.0072	0.0111	0.0501	0.0208	0.0200
Forest of Bowland	111485	1313.6	0.0000	0.0373	0.0667	0.0013	0.0045	0.0200
Midland Clay Pastures	171738	824.47	0.0000	0.0250	0.0333	0.0119	0.0141	0.0190
Border Uplands	395080	0	0.0000	0.0234	0.0556	0.0013	0.0208	0.0190
Solway Basin	98350	9652.93	0.0000	0.0351	0.0333	0.0053	0.0030	0.0185
Coal Measures	248735	215.08	0.0000	0.0156	0.0222	0.0224	0.0156	0.0170
Wessex Vales	186189	1217.12	0.0000	0.0122	0.0222	0.0461	0.0060	0.0168
Low Weald and Pevensey	192058	4640.51	0.0000	0.0128	0.0111	0.0066	0.0260	0.0160
Cornish Killas and Granites	248375	317.68	0.0000	0.0200	0.0111	0.0053	0.0149	0.0153
Central Herefordshire	123315	212.17	0.0000	0.0111	0.0000	0.0435	0.0052	0.0150
North Norfolk	183071	1848.27	0.0000	0.0089	0.0000	0.0013	0.0305	0.0145
Cotswolds	288170	1227.91	0.0000	0.0206	0.0000	0.0092	0.0104	0.0145
Cumbria Fells and Dales	347753	8660.9	0.0000	0.0156	0.1111	0.0026	0.0089	0.0130
Humberhead Levels	171805	6023.18	0.0000	0.0189	0.0000	0.0013	0.0119	0.0128

Natural Area	Area (ha)	Marsh area (ha)	Scheme					All schemes combined
			Field Boundaries			Old Meadows and Pasture	Waterside Land	
			Ditches	Hedges	Mixed			
Vale of York and Mowbray	162716	1709.96	0.0000	0.0150	0.0000	0.0013	0.0164	0.0125
Northumbria Coal Measures	156249	255.41	0.0000	0.0156	0.0333	0.0066	0.0104	0.0125
The Fens	382606	5046.33	0.0000	0.0033	0.0000	0.0026	0.0275	0.0113
Chilterns	164094	341.59	0.0000	0.0211	0.0000	0.0013	0.0045	0.0113
Eden Valley	80956	280.05	0.0000	0.0184	0.0444	0.0013	0.0045	0.0110
Urban Mersey Basin	213004	2442.48	0.0000	0.0156	0.0000	0.0053	0.0082	0.0108
Clun and North West Herefordshire Hills	62470	166.34	0.0000	0.0150	0.0000	0.0145	0.0030	0.0105
South Magnesian Limestone	136762	553.39	0.0000	0.0106	0.0000	0.0026	0.0141	0.0100
Wealden Greensand	145783	1302.27	0.5000	0.0067	0.0000	0.0000	0.0193	0.0098
North York Moors and Hills	189892	208.01	0.0000	0.0111	0.0444	0.0040	0.0089	0.0098
South Devon	121080	575.78	0.0000	0.0106	0.0000	0.0145	0.0060	0.0095
Pennine Dales Fringe	87303	95.34	0.0000	0.0095	0.0556	0.0066	0.0082	0.0095
Derbyshire Peak Fringe and Lower Derwent	37770	349.78	0.0000	0.0056	0.0111	0.0105	0.0134	0.0093
Shropshire Hills	107988	453.38	0.0000	0.0150	0.0000	0.0026	0.0052	0.0090
Holderness	87282	3110.04	0.0000	0.0095	0.0000	0.0026	0.0119	0.0088
Isle of Wight	38017	580.5	0.0000	0.0089	0.0000	0.0013	0.0134	0.0088
Dean Plateau and Wye Valley	82538	123.15	0.0000	0.0039	0.0000	0.0290	0.0045	0.0088
Lincolnshire Wolds	84486	0	0.0000	0.0089	0.0000	0.0053	0.0097	0.0083
Tees Lowlands	102194	789.21	0.0000	0.0139	0.0111	0.0040	0.0015	0.0078
Blackdowns	80807	885.26	0.0000	0.0050	0.0000	0.0224	0.0015	0.0070
Exmoor and the Quantocks	137990	534.92	0.0000	0.0078	0.0000	0.0092	0.0052	0.0070
Black Mountains and Golden Valley	25974	0	0.0000	0.0045	0.0000	0.0211	0.0030	0.0070
Needwood and South Derbyshire Claylands	81540	1679.85	0.0000	0.0089	0.0111	0.0053	0.0045	0.0068
East Anglian Chalk	83870	390.36	0.5000	0.0039	0.0111	0.0000	0.0126	0.0065
North Lincolnshire Coversands and Clay Vales	131955	27.72	0.0000	0.0072	0.0000	0.0040	0.0074	0.0065
Suffolk Coast and Heaths	82179	3215.95	0.0000	0.0050	0.0000	0.0026	0.0097	0.0060

Natural Area	Area (ha)	Marsh area (ha)	Scheme					All schemes combined
			Field Boundaries			Old Meadows and Pasture	Waterside Land	
			Ditches	Hedges	Mixed			
South Coast Plain and Hampshire Lowlands	90879	2902.54	0.0000	0.0011	0.0000	0.0013	0.0156	0.0060
Bristol, Avon Valleys and Ridges	84255	565.25	0.0000	0.0067	0.0111	0.0132	0.0007	0.0060
Somerset Levels and Moors	65797	43429.81	0.0000	0.0011	0.0000	0.0053	0.0126	0.0058
Yorkshire Wolds	111422	0	0.0000	0.0100	0.0000	0.0000	0.0037	0.0058
Devon Redlands	97404	3945.83	0.0000	0.0045	0.0000	0.0092	0.0052	0.0055
West Cumbria Coastal Plain	49293	3301.17	0.0000	0.0083	0.0111	0.0026	0.0030	0.0055
North Kent Plain	84832	1391.84	0.0000	0.0050	0.0000	0.0026	0.0082	0.0055
Midvale Ridge	44501	202.89	0.0000	0.0045	0.0000	0.0013	0.0089	0.0053
Lincolnshire and Rutland Limestone	126044	137.7	0.0000	0.0072	0.0000	0.0013	0.0052	0.0053
South Wessex Downs	239189	3931.91	0.0000	0.0017	0.0000	0.0066	0.0089	0.0050
Yorkshire Dales	239984	487.07	0.0000	0.0045	0.0444	0.0040	0.0037	0.0050
Potteries and Churnet Valley	53136	284.36	0.0000	0.0078	0.0000	0.0053	0.0015	0.0050
Romney Marshes	36681	4770.16	0.0000	0.0006	0.0111	0.0013	0.0119	0.0048
Lincolnshire Coast and Marshes	88201	172.47	0.0000	0.0061	0.0000	0.0013	0.0052	0.0048
Southern Pennines	119715	99.6	0.0000	0.0056	0.0333	0.0053	0.0000	0.0043
Hampshire Downs	148913	1544.58	0.0000	0.0050	0.0000	0.0000	0.0052	0.0040
North Pennines	214563	0	0.0000	0.0022	0.0333	0.0066	0.0030	0.0040
North Downs	137447	62.14	0.0000	0.0056	0.0000	0.0000	0.0037	0.0038
Durham Magnesian Limestone Plateau	45261	0	0.0000	0.0061	0.0000	0.0000	0.0022	0.0035
Berkshire and Marlborough Downs	110986	304.02	0.0000	0.0022	0.0000	0.0026	0.0052	0.0033
Yardley-Whittlewood Ridge	33776	199.13	0.0000	0.0045	0.0000	0.0000	0.0037	0.0033
Rockingham Forest	51001	140.06	0.0000	0.0017	0.0000	0.0040	0.0052	0.0033
White Peak	52860	0.17	0.0000	0.0006	0.0111	0.0132	0.0007	0.0033
Malvern Hills and Teme Valley	27623	0	0.0000	0.0033	0.0000	0.0092	0.0000	0.0033
Bedfordshire Greensand Ridge	27337	137.74	0.0000	0.0039	0.0000	0.0000	0.0030	0.0028
Bodmin Moor	28579	0	0.0000	0.0039	0.0000	0.0013	0.0022	0.0028

Natural Area	Area (ha)	Marsh area (ha)	Scheme					All schemes combined
			Field Boundaries			Old Meadows and Pasture	Waterside Land	
			Ditches	Hedges	Mixed			
Mid Somerset Hills	42092	4213.29	0.0000	0.0028	0.0000	0.0066	0.0000	0.0025
South Downs	101855	1343.03	0.0000	0.0017	0.0000	0.0000	0.0052	0.0025
Breckland	101926	1024.62	0.0000	0.0006	0.0000	0.0026	0.0052	0.0025
Dark Peak	86605	269.05	0.0000	0.0000	0.0333	0.0079	0.0007	0.0025
South West Peak	42568	11.7	0.0000	0.0017	0.0000	0.0079	0.0007	0.0025
Greater Thames Estuary	83675	12786.88	0.0000	0.0006	0.0000	0.0000	0.0060	0.0023
Vale of Pickering	43085	3692.75	0.0000	0.0028	0.0000	0.0000	0.0030	0.0023
Dorset Heaths	61662	2712.44	0.0000	0.0006	0.0000	0.0000	0.0060	0.0023
Vale of Taunton and Quantock Fringes	48403	1533.9	0.0000	0.0022	0.0000	0.0026	0.0022	0.0023
New Forest	73767	2023.85	0.0000	0.0017	0.0000	0.0040	0.0015	0.0020
North Northumberland Coastal Plain	37670	205.53	0.0000	0.0028	0.0111	0.0000	0.0015	0.0020
Isles of Scilly	1639	0	0.0000	0.0011	0.0667	0.0000	0.0000	0.0020
The Broads	56290	11579.04	0.0000	0.0022	0.0000	0.0000	0.0022	0.0018
Dartmoor	87407	0	0.0000	0.0033	0.0000	0.0013	0.0000	0.0018
Sherwood	53457	167.01	0.0000	0.0017	0.0000	0.0040	0.0000	0.0015
Mendip Hills	30300	163.51	0.0000	0.0006	0.0000	0.0053	0.0007	0.0015
Oswestry Uplands	9981	0	0.0000	0.0017	0.0000	0.0026	0.0007	0.0015
Humber Estuary	27950	813.64	0.0000	0.0028	0.0000	0.0000	0.0000	0.0013
Charnwood	17464	0	0.0000	0.0006	0.0111	0.0026	0.0000	0.0010

Appendix 3 (Part 2)

Take-up of Countryside Stewardship management schemes (Proportion for each scheme by region)

Region	Scheme					All schemes combined
	Field Boundaries					
	Ditches	Hedges	Mixed	Old Meadows and Pasture	Waterside Land	
EMIDS	0.50	0.22	0.12	0.08	0.33	0.22
WMIDS	0.00	0.15	0.11	0.33	0.15	0.18
SW	0.00	0.11	0.11	0.41	0.07	0.15
NE	0.00	0.17	0.19	0.04	0.13	0.13
NW	0.00	0.19	0.44	0.04	0.06	0.13
SE	0.50	0.09	0.02	0.05	0.15	0.10
S	0.00	0.07	0.00	0.06	0.11	0.08
Total take-up	**2**	**1797**	**90**	**759**	**1344**	**3992**

Appendix 4. Detailed account of workshop at ITE Monks Wood on 7 December 1998. "Habitat restoration -setting objectives and evaluating success"

Setting objectives

I. Basic principles of objective setting

Why are objectives necessary?

A review of many case studies recording attempts at habitat restoration strongly suggests that a major cause of failure has been the lack of clearly stated objectives. Without clear objectives, it may be impossible to decide where restoration is meant to go and when one has reached the target. Objectives may be determined by some vision of a desired goal, and influenced by political or economic considerations. The objectives chosen may require the complete or partial restoration of a habitat that was previously present at a site, or the creation of an entirely new habitat. At the same time as the specific objectives, some quantitative measures that can be used to evaluate the success of a restoration project should be selected. Some objectives may be defined relatively simply, and include criteria that are economic, educational, recreational or related to broad environmental concerns. To these may be added three ecological objectives: the restoration of diversity, species composition and, critically, ecological processes.

A functioning ecosystem - the central objective of ecological restoration

The achievement of ecological objectives will depend on an ability to create the required physical and hydrological conditions, particularly in respect of the soil. The ultimate goal of ecological restoration is an ecosystem whose structure, functioning and sustainability are akin to those of a (semi-)natural community, with each element in place, and evolved to a level comparable to that of the target ecosystem. It follows that the success of ecological restoration depends upon detailed knowledge of processes and inter-relationships. Where knowledge is only partial for a particular ecosystem, attempts at restoration may be somewhat haphazard, or less likely to achieve their desired objectives. Indeed the level of knowledge may itself determine the objectives and the course of action. Is enough known about the desired ecosystem to decide whether

i. to allow natural processes to occur, taking no direct action;
ii. to attempt restoration of the original community through intervention; or
iii. alternatively, to create a new ecosystem as an alternative?

Choosing appropriate objectives

How are objectives formulated, when an opportunity for ecological restoration is presented? A number of factors should be taken into account, when defining ecological objectives for restoration schemes, or in selecting appropriate sites. Each site is unique, needing objectives that are specific to that site. However, the selection and effectiveness of such site-specific objectives can be improved if implemented in a regional (or national) context, and adapted accordingly. This context should take account of broad environmental aims and the natural distribution of species and communities.

Objectives must therefore be defined in relation to:

- The *overall aims* of ecological restoration in the area, region, nation *etc.*
- *Economic* factors: time and resources available for restoration.
- The '*target*' for restoration - a particular species, a specific plant community, or a fully functioning ecosystem.
- *Feasibility* (technical and scientific) of proposed restoration site, determined by:

    1. Physical character (topography, geology, soil, hydrology, climate, size);
    2. "Locational attributes" (*e.g.* position in relation to distribution of desired species; location in relation to other landscape features; *etc*).
    3. Management history.

** On the basis of 1-3, using ecological knowledge, define what is ***possible***, what is ***appropriate***, and what is ***realistic***.

Table A1: General Objectives for Ecological Restoration

I.	DEFINITION OF OVERALL AIMS	
II.	IDENTIFICATION OF TARGET HABITATS, COMMUNITIES AND SPECIES	
	1.	Definition of habitat types and associated species
	2.	Identification of those which are rare, declining and threatened i.e. "in need of restoration".
III.	REDEFINITION OF TARGETS TO TAKE ACCOUNT OF REGIONAL VARIATION	
	1.	Assessment of current range/distribution of target habitats and species.
	2.	Definition of physical circumstances in which target habitats and species naturally occur.
IV.	IDENTIFICATION OF HABITAT REQUIREMENTS	
	1.	Identification of habitat requirements of target species.
	2.	Definition of actions necessary to satisfy those requirements.
V.	IMPLEMENTATION OF RESTORATION STRATEGY	
	1.	Formulation of restoration prescriptions
	2.	Definition of criteria for assessing achievement of management objectives
	3.	Definition of time-scales within which objectives are to be achieved
	4.	Implementation of restoration programme

Bearing in mind these factors, an approach to the definition of ecological objectives may be proposed (Table A1). Implicit within such an approach is a properly designed monitoring programme, where results are rapidly processed so as to allow feedback to the management of the restoration scheme. Such an approach requires detailed knowledge of the status and distributions of the target species and communities, the habitat requirements of key species, and the technical expertise required to provide them on appropriate sites. A programme of ecological restoration might have two overall aims. Taking into account regional variation, the first aim could be to achieve a representative range of viable and sustainable ecosystems by the:

i. conservation and rehabilitation of existing ecosystems;
ii. re-creation of degraded ecosystems; and
iii. creation of new ecosystems.

The second aim might then be to achieve a full representation of the species of the target ecosystem throughout their range, maintaining viable populations, arresting any decline and then promoting the spread of target species. It is unlikely that a single restoration scheme can meet all the aims and objectives that are desired for a region - hence the need for integrated programmes of restoration and careful evaluation of priorities.

Describing the target of restoration

Targets for restoration may be defined from prior knowledge of the site where restoration is proposed, or from a knowledge of what communities are typical of that region and those environmental conditions, paying particular attention to those which are threatened. Targets may be described simply in numerical terms *e.g.* "100 plants of Fen Violet within 10 years", or in complex terms *e.g.* "a *Molinia caerulea-Cirsium dissectum* fen meadow with its associated invertebrate fauna". Targets may have a temporal aspect *e.g.* "wintering wildfowl, and both breeding waders and a species-rich hay meadow in summer". More complex targets are less likely is it to be realised "perfectly". However, restoration attempts may be judged successful if ecological processes, critically that of soil development, have been re-established in a self-sustaining direction. As knowledge grows, original objectives and described targets may be adjusted, and any assumption that there is only one correct target, with an absolutely rigid composition, should be avoided.

Choosing measurable objectives

Due to lack of experience with some communities, the ability to define clear objectives for the restoration of appropriate habitats and species, and also to establish quantifiable criteria by which to assess the effectiveness of strategies to meet these objectives, is somewhat limited. However, wherever possible the objectives chosen should be quantifiable. Even where a complex community structure is the desired target, direct comparison of the composition achieved with that intended should be attempted. Nevertheless, it can be asserted that for an attempt at ecological restoration to be judged successful, the restored community should achieve the following objectives:

- have a net productivity similar to that of the target community;
- be effective in nutrient retention, showing fluxes that do not exceed those of the target community;

- be functionally entire, having not only the plant species that define the community, but also the full range of associated animals and microbes, with inter-relationships and processes in place that closely approximate those of the target community;

- be capable of perpetuating itself, or (if modelled on a semi-natural community) requiring only the traditional management under which such communities evolved;

- be resistant to invasion by exotic species, once the desired composition is achieved.

II. Comparing experience in setting objectives and targeting restoration

In the wide countryside, such principles have influenced the design of agri-environment schemes aimed at habitat restoration and enhancement. In Countryside Stewardship, targets are identified in terms of landscape, wildlife, access and history/archaeology. However, a problem frequently encountered with specific schemes is their generality, with individual species and directly measurable targets not mentioned. Different projects with different objectives often have the same management plan, and there is a pressing need for more detailed management plans which are clearly tailored to specific objectives. Such restoration plans require assessments of the baseline situation and the desired end point, so that deliverables may be defined and measured. Management and restoration plans are often most detailed where birds are the target group, but schemes to encourage wet grassland and ditch species are often rather summary in nature.

Indicator species and communities as targets for restoration

Attempts have been made to define those species which the restoration of grazing marsh aims to conserve. Mountford and Newbold (Appendix in Mountford *et al.* 1998c) devised a botanical method for ranking the indicator value of individual plant species. However, the use of such an approach in grazing marshes must be used with caution since this landscape comprises a mosaic of different habitats, where a mixed set of objectives may be appropriate. For example, high-quality grazing marsh may contain wet mesotrophic grassland (*e.g.* **MG8** *Cynosurus cristatus-Caltha palustris*) or fen meadows (**M22-25** *etc*), as well as species-rich ditch communities (**A4**, **A5**, **A13** *etc*). Some of these communities are the subject of other costed Habitat Action Plans. In botanical terms, restoration priority (and hence selection of objectives) might be given to **MG8**, but a balanced strategy for the restoration of grazing marsh must also include other objectives (ornithological, entomological *etc*). For this reason the present project has ranked sites on the basis of a range of criteria, using varied biological groupings and distributional information.

Landscape objectives - spatial variation in biodiversity

Objectives based upon species co-occurrence or communities may be most appropriately set at a local scale. In contrast, national objectives for restoration may require the use of landscape criteria. The intact grazing marsh landscape is flat, with a (dense) network of surface drainage-channels, and is associated with groundwater gley and loamy peat soils. Nationally, there may be conflict between giving priority to those areas where restoration may be expected to have the greatest likelihood of success, and those areas where it would achieve the greatest increase in biodiversity:

- Restoration success may be most likely where extensive areas of high quality grazing marsh still occur; but

- Restoration (specifically re-creation) may be most necessary where grazing marsh has largely disappeared, but in such situations both appropriate colonising species may be rare or unavailable, and the land-drainage infra-structure may require severe modification.

In the present project, all Natural Areas were considered, though successful meeting of the BAP targets required particular attention being paid to areas of extant quality and high propagule availability. It is clear that alongside such an approach, a restoration strategy must have regard to those areas (*e.g.* Lincolnshire) where grazing marsh may have largely been eliminated, but where efforts to radically increase the area are strongly advocated by local conservationists. Such local efforts may be justifiable in a national context in order to reverse fragmentation of the grazing marsh resource. However in the short and medium term, there must be some doubt as to how sustainable such blocks of grazing-marsh are where they occur away from the remaining main areas.

Refining objectives on grazing marshes

Five different elements of biological interest may be distinguished: a) within the drainage channels: botanical and invertebrates; and b) in the grass fields: botanical, invertebrates and both over-wintering and breeding wetland birds. In many grazing-marsh situations, the main biodiversity value is contained within the interstitial habitat rather than in the marsh-fields themselves, and targets might best be set in terms of the interstices. Changes in field-size following intensification may have a marked impact on biodiversity through elimination of drainage channels. Working in the Humberhead levels, Mountford and Sheail (1985) found that the length of the drainage network had been reduced by *ca.* 25% since 1950. In grazing marshes where intensification had been less marked, the network remains largely intact, though within-field grips may no longer be linked hydrologically to main channels. Reinstatement of the ditch network as part of restoration will result in some reduction of field size.

Socio-economic considerations

It may be desirable to define the minimum size of grazing marsh which it is feasible or economical to manage in the present situation for farm businesses. However, as well as practical and economic factors, the interest and commitment of the local people to habitat restoration may influence the feasibility. As very intensively managed areas are proposed for restoration, vital human skills required to manage grazing marsh may have been lost to the local community. Stock required to implement the management of restored or re-created grazing marsh may be limited, and in some areas BAP targets may consequently seem unrealistic.

However, not only do farmers' representatives involved in habitat restoration believe current targets to be achievable, but changing agri-economic circumstances may make them relatively conservative. In late 1998, the Country Landowners' Association advocated transfer of large amounts of money from production to the environment through reform of the Common Agricultural Policy.

Feasibility of large-scale restoration

Provided lower quality targets are set, it is currently practical to restore large areas of certain grazing-marsh communities *e.g.* **MG13** *Agrostis stolonifera- Alopecurus geniculatus*, **S5** *Glyceria* washlands and **MG6**-type grasslands (with reseeding, followed by enhancement to more desirable types). However, at a large-scale (indeed any scale) the fundamental problem in achieving grazing marsh restoration is the large quantity and high quality of water required. Should such hydrological aims be met over a large area, BAP targets may be achievable, though producing relatively low quality habitat in the short term. Restoration of larger land-areas may be possible where flood defence is a priority, and where significant blocks of farmland may be sacrificed to protect housing and highly-productive farm. In addition, where lower quality grazing marsh landscape is the goal, moderately eutrophic water may be suitable, provided it is available in sufficient quantities.

Water quality

The influence of water quality on restoration partly depends upon those taxonomic groups selected for promotion *e.g.* plant and invertebrate species of drainage channels my be sensitive, whilst some birds are less demanding. The relationship between plant and invertebrate species and trophy status has been described in ranking systems (Ellenberg, 1988; Newbold and Palmer, 1979). It is known that waders and waterfowl do not always use areas of unpolluted water, and indeed that the presence of many birds can further degrade water-quality. The needs and tolerances of individual bird species to water-quality appear less well known Targets relating to water quality may need to be divided into winter inundation water and summer ditch water. Extant water quality may influence the choice of objectives for grazing marsh, determining which goals are attainable.

Finalising objectives for grazing marsh

Birds may be less useful as both an objective and a measure of success (see below) since their numbers are prone to large temporal fluctuations. Their value as indicators cannot be discounted altogether, however, and the rankings derived in the present work are informed by *inter alia* botanical, botanical/invertebrate, or invertebrate/bird criteria. Selection of objectives should be on the basis of those attributes and species which are:

- core,
- desirable,
- neutral; and
- detrimental

The grazing marsh plant species ranking of Mountford and Newbold set out with this underlying philosophy. Targets may then be set in terms of what is undesirable as well as desirable (Mountford *et al.*, 1997). The derivation of generic prescriptions for habitat types by Wye College also used this approach, indicating those features which habitat restoration would not want to promote.

There is concern that restoration objectives may be finally determined by policy and economic imperatives. Ecological objectives should not be cash-dependent when originally coined, and indeed the present shift in agri-environment funding may render previously impractical restoration as realisable. There is a clear need to look at priorities nationally and regionally, so that funds to meet objectives are not simply divided up area by area, without regard to those areas where several priority habitats co-exist. Selection of objectives must be followed by a process of review, to ascertain their continued applicability and appropriateness. Are the critical issues still being addressed? Objectives which are very species orientated should be combined with those that take account of general habitat and physical condition. A pragmatic solution to conflicts between large-scale restoration goals, and the needs of individual species, may be to design broad habitat objectives which realise benefits for widespread mobile species, and then to design supplementary objectives for more sedentary species.

Defining terms

In writing a set of objectives it is necessary to adequately define certain basic terms and to set objectives for each *e.g.* from *Shorter Oxford English Dictionary* (Brown, 1993):

- ***Restoration***: "…the act of restoring to a former state or position … or to an unimpaired or perfect condition"
- ***Rehabilitation***: "the action of restoring a thing to a previous condition or status." This definition is close to that of restoration, but there is little (or no) implication that the end result will be perfection.
- ***Enhancement***: "the action or process … of increasing in value, importance *etc*, … or improving in quality or utility".
- ***Re-creation***: "The action of creating something over again".
- ***Creation***: "The action of making, forming, producing, or constituting for the first time, or afresh; invention, causation, production."
- ***Maintenance***: "The action of upholding or preserving a … state of affairs. The action of keeping something in working order, in repair *etc*."

A final set of objectives for the restoration of grazing marsh may be derived using the approach outlined in Table A1. This approach arrives at broad categories of objective within which specific objectives may be defined. Table A2 outlines the kinds of objective that might be employed in the restoration of grazing marsh:

Table A2   Types of objective in the restoration of grazing marsh

Landscape (both aesthetic and landscape ecology issues)
fragmentation/connectivity
extent, present and past
aesthetic, appearance and composition
Physical/chemical
water supply, quality, timing and duration
soil types, previous inputs
flood defence
floodplain dynamics and functional connectivity
hydrological budgets
Biological/ecological
migration distances
local ecotypes
core/desirable/neutral/detrimental species
management objectives
Socio-economic
tenure
time-scale
sustainability of management
availability of regional skills appropriate to i.e. management
Historical/archaeological:
maintenance/protection
avoiding of conflicts

Measuring success

I. Introduction – basic principles

There are four underlying, and somewhat overlapping, reasons for attempting to evaluate the success of a restoration scheme:

- To assess how effective the restoration has been
- To measure the progress toward the objectives set
- To permit adjustment of current management in order to achieve the goals set
- To inform and influence future schemes

The measures of success available differ in scale, complexity and the ease with which each one may be measured or evaluated. Those attributes which are most readily measured include:

1. species complement and diversity *i.e.* what fauna/flora is present and how much?
2. species interactions *i.e.* communities, predation *etc*; and to a lesser extent
3. habitat structure and connectivity *i.e.* shape and distribution of a community.

However, in terms of the long-term success of a restoration scheme, the more complex and large-scale attributes of ecosystem stability and resilience, of process and function, are clearly most important, though far more difficult to quantify. In practice, therefore, success may often have to be evaluated using an approach which is at best a fair approximation to a true measure of the sustainability of a restoration scheme.

In practice several simple measures have been applied to measuring the success of attempts at ecological restoration:

1. **Use of indicator species and species associations** – are key taxa present, what is their number and distribution?

2. **Similarity** – does the community present correspond well to a "target" community, the latter defined either in terms of some local "blueprint" or using some national system *e.g.* the *National Vegetation Classification – NVC* (Rodwell, 1991).

3. **Environmental and biotic indices** – measures of species diversity, environmental quality (*e.g.* nutrient level), assessment of habitat condition.

4. **Compliance** – have the managers/owners of the site met criteria set under a political or socio-economic framework such as the agri-environment schemes (ESA, CSS *etc*).

The most important measure of ecosystem processes (as reflected in energy flow, nutrient cycling, productivity, trophic levels, food webs, succession, niche resource and partitioning) is usually far less amenable to simple evaluation.

Fundamental criteria for selection of measures
Those measures which are adopted for evaluating success (or for schemes of monitoring) must be **a**) ecologically appropriate; **b**) practical (and also cost-effective); **c**) accurate; **d**) repeatable; and **e**) standardised between restoration schemes.

II. Applying the principles to grazing marshes

Most actual restoration projects do not actually attempt to monitor movement toward all possible objectives, though some monitoring (for SSSI and agri-environment) does address multiple objectives. Limits on the scope of evaluation may be set both by monetary constraints, and by the staff available to undertake the work. To be sustainable, any monitoring required should be sufficiently simple that it can be undertaken by the land manager, rather than it being a task that needs specialist skills. Many attributes of a restoration scheme are relatively easy to measure *e.g.* ditch interval and management.

A context for assessing restoration success

There is a need to assess the changes observed following a restoration scheme in a wider context *e.g.* the long-term monitoring provided by the ITE Countryside Survey and the Environmental Change Network (ECN). Such an approach allows longer-term questions of stability and resilience to be answered. Unfortunately, few if any suitable long-term data-sets exist within grazing marsh National Nature Reserves, and it is for this reason that the NERC

Centre for Ecology and Hydrology (including the ITE and Institute of Hydrology) has proposed a wetland site network with standard monitoring methodology, allowing a condition assessment to be made in terms of functioning *etc*. There is a particular need to examine trends in water-quality in a range of semi-natural and restored wetlands. Existing dipwell and piezometer networks should be used not only to examine water-regime, but to monitor nutrients and assess the influence of water-quality on restoration success. Agri-environment schemes may also provide some context, particularly Countryside Stewardship. Finally, some grazing-marsh species display huge year-to-year variation in abundance, and the community within which they occur may also appear to vary. It is therefore important to use a local reference community against which to measure success, and compare changes in species-abundance within the restoration scheme and those "natural" changes in the reference site.

Indicator species

The present project has used botanical indicator species widely in arriving at rankings of sites and schemes *e.g.* Ellenberg (1988) and Mountford and Newbold (*op. cit*). This approach is less well developed for invertebrates, and those species which are most amenable to assessment by non-specialists (*e.g. Odonata*) are less precise indicators than other groups (*e.g.* aquatic *Coleoptera*). *Coleoptera* have the advantage of being numerous, with the many taxa reflecting variation in water-quality, temperature regime and ditch structure, and they are the subject of a good recording scheme. However, only a limited number of people are competent to identify water-beetles, and it is probably more appropriate to select aquatic plant species with similar range and requirements. Snails provide an alternative indicator group, but though shells persist, and might therefore be assumed helpful in reconstructing site history, the impact of ditch-cleaning may render them less useful in this regard. There remains a clear need to cross-compare the requirements of plant and invertebrate species in order to assess the extent to which one taxonomic group could act as a general indicator of restoration success and site quality.

Assessment against a target community

Attempts have been made by the ITE (Manchester *et al*., 1999) and the University of Cranfield to use goodness-of-fit values to the *NVC* derived from MATCH (Malloch,1991) and TABLEFIT (Hill, 1991) as a means of assessing restoration success and within-site variation. Though such an approach has the merit of being national and standard, it is also artificial, and thus not necessarily regionally appropriate. The information contained is heavily influenced by the original sampling strategy. Some community descriptions were based on very few releves, omitted major variants and distribution maps (*e.g.* **MG8**). Use of the *NVC* in measuring success of grazing marsh restoration may be particularly compromised by the poor coverage that aquatic communities received in such areas.

It should be borne in mind that simply because restored communities appear "new", this does not necessarily imply they have no conservation value, rather that they are simply different. In the Netherlands, it has been demonstrated that under restoration management, previously degraded habitats do not generally revert to their original (pre-degraded) state. The advantage of using a local reference community against which to assess variation in the composition of the restored habitat has been discussed above.

Feedback to alter site management

Measurement of success must be able to influence the post-restoration management of the site. However, the early dynamic changes observed in restored vegetation mean that it may be premature to alter the regime after a very few year's data. There is a tendency to react rapidly to perceived failure, and there may yet be insufficient information on the long-term results of restoration schemes to be sure which are destined to fail. Land-drainage continued until the mid-1980s, and experience of wetting sites to achieve ecological restoration is relatively short-term.

Species change and mobility

More research is required on species movement between sites, and more use needs to be made of extant knowledge. Should suitable conditions be created, one can be confident that certain species will arrive at restored sites, particularly mobile species like wetland birds and widespread plants. If arable land is flooded, *Agrostis stolonifera* may well increase markedly, since it is a common species of arable margins, as well as a dominant of inundation grasslands (**MG13**). However presently rare or scarce species may require some intervention, and indeed their very rarity may stem from an inability to move between sites once a small barrier is created.

Practical measures

Attempts to monitor success must be economical enough to be maintained by the conservation agencies. Although detailed species-composition studies may be desirable, they may be too expensive (requiring specialist knowledge) to sustain. The monitoring may also have to be sufficiently frequent to satisfy the needs of those bodies auditing the use of other public funds (agri-environment schemes *etc.*). In this context, other measurables may have to be employed.

Even simple targets such as the visual impact of "wild-flowers" (*e.g. Ranunculus* species) providing a measure of the aesthetic value might be appropriate, although the selection of any such measure would be moderated by other issues (*e.g.* toxicity to stock). Public perception clearly wants "less grass and more flowers", but such a target may be measurable only in terms of very broad proportions of grasses: forbs: sedges *etc.* Other broad measures available still require taxonomic skills which may be absent among the farmers who will have to undertake such work *e.g.* mean Ellenberg indicator values for moisture and fertility (mF, mN *etc*). Although the present restoration prescription for grazing marsh does not focus on those species listed in the BAP, it is clear that such species are high in the mind of government. Simple methods like monitoring of the management regime and basic structural measures may be all that is practical.

The work of Wye College has produced a series of uncomplicated prescriptions for monitoring the success of restoring coastal grazing marsh from pasture. Monitoring uses a walk-through approach, following a standard route, augmented by point samples. The method is complemented by rigorous validation monitoring on a subset of sites. The simplicity of the method allows for very frequent survey by the land-manager, and thus goes some way to overcoming the problem of each survey being merely a "snapshot in time". The approach identifies broad changes successfully, but would not be appropriate for detecting single individuals of a rare plant. The monitoring must be timed carefully when all the target features are visible.

The preferred method may be to employ this type of widespread survey, coupled to detailed scientific monitoring on a subset of sites. Such sites would be selected to be representative of each region on the basis of soils *etc*, using a rationale similar to that used in the MAFF assessment of raised water-level schemes (Mountford *et al.*, 1998b).

Socio-economic evaluation

There are a variety of socio-economic measures for judging the success of a restoration scheme. Compliance is predominantly used within Countryside Stewardship, and there is a marked correspondence between those who enter a scheme and those who wish it to continue (McNally *et al.*, 1998). However, compliance may not be an adequate measure from an ecological perspective. There is a clear need for whole-farm studies within grazing marsh to examine the viability and sustainability of such enterprises. Research on the agronomic impacts of Tier 3 raised water-levels at Tadham Moor has gone some way to providing such information (Mountford *et al.*, 1998a). In grazing marsh areas like the Somerset Levels and Moors ESA, land tenure often straddles uplands and levels, whereas within the Fenland basin individual farms would be confined to the flatlands. The economic viability of a farm is not solely dependent on the level of subsidy available, but on how much of the land holding is on a particular landscape and management. For example, on a farm with restored grazing marsh, stock may need to be held on the upland longer (or under cover) and require supplementary feed.

Commitment to habitat restoration schemes may depend partly on the level of subsidy, and whether the scheme lasts for an appropriate time. In Lincolnshire, amongst other areas, there is concern about entering land into a 10-year scheme, especially where the land is tenanted. There is generally much higher uptake in the lower tiers of ESA agreements, reflecting the perceived inflexibility of prescriptions, loss of control over business and low payment rates at the higher tiers (ADAS, 1996). Such socio-economic factors may strongly influence the success of conservation and restoration. Thus, grazing marsh Tier 1 (to preserve extant grassland acreage) may be successful, but may need to have its full potential realised. However, those habitats that depend on a regime of regular flooding may not be favoured by the poor take-up of Tier 3. Much of the higher Tier grazing marsh in the ESAs is owned by bodies such as the RSPB, National Trust and English Nature.

Summary

Although selection of methods for evaluating success may requires simplicity and realism, it is desirable not to be too hidebound by what appears feasible in the present agricultural climate. Issues such as cross-compliance are likely to become more prominent in the future, and there is a strong move toward environmental benefits in the CAP. In 1980, very few people would have conceived of the content of the 1986 Agriculture Act. Present trends in agri-environment issues suggest that the range of policy options for realising ecological restoration in the near future may be very great. In that light, it is important not to couch the discussion always in terms of problems, but to address what can be done for wildlife, landscape, and both history and archaeology. There are two levels of objective:

- realistic and achievable schemes/monitoring, and
- holistic, desirable objectives – thinking at the whole wetland level.