Translocated vegetation establishment on new artificial wet fen areas in Hoveton Great Broad.

Hoveton Great Broad Restoration Project

Bure Marshes National Nature Reserve, Norfolk, UK

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Contents

1. Summary

- A wet fen translocation was trialled in the Norfolk Broads in 2019 to seed three artificial geotextile bags, which were installed to create new wet fen habitat.
- This survey was completed in 2022 to assess the vegetation growing on the artificial geotextile tube. The survey consisted of three belt transects along the centre of each geotextile tube.
- The survey identified the National Vegetation Classification community, as *Phagmites australis—Peucedanum palustre* (S24), which matches the donor site. This fen community is a nationally rare community which is largely restricted to the Broadland fens.

- The success of this trial has implications for future habitat restoration and creation, especially in response to changing conditions due to the climate crisis.

Keywords

Wet fen, translocation, wetland, habitat, NVC community

2. Introduction

2.1 Construction of new wet fen area

Part of the restoration of Hoveton Great Broad and Hudson's Bay (Bure Marshes NNR) involved the removal of 54,000 m^3 of soft sediment from the waterbodies. The sediment was disposed of within the site as this was considered the most economically and environmentally responsible option. This involved the creation of three disposal areas (north, east and south) at the eastern end of the Broad. Barriers of sediment-filled geotextile tubes (geo-bags) created bunded areas which were then infilled with the remaining majority of the sediment, occupying a total area of 3.7 ha. The disposal areas were filled to a suitable level to produce a winter-wet/summer-dry water regime. This is necessary for local native fen vegetation to colonise the sediment surface.

2.2 Fen turf translocation

In September 2019 the exposed surfaces of the geo-bags were covered with translocated fen material, sourced from compartments 13 and 14 of Woodbastwick Marshes. This utilised diggings which were already planned under the NNR Management Plan as a succession management project, creating nine shallow turf ponds, a total area of 0.7 hectares. The fen material was transported in barges approximately 2.5 kilometres along the river Bure to the receiving site in Hoveton Broad. It was then spread on the geo-bags, held in place by netting and protected from grazing by goose barriers on the inner and outer edges. To facilitate a successful translocation, the water regime and season were considered. The water regime at the donor site corresponded to the recipient site on the geo-bags and the translocation occurred in September when the plants were actively growing. Covering the geo-bags in fen material was essential for preventing deterioration of the geo-bag material by ultra-violet exposure. Additionally, it functioned as a restoration technique by providing a source area from which fen vegetation could colonise the disposal areas and added a littoral fringe to the Broad.

2.3 Donor site NVC classification

The donor site at Hoveton Marshes was recorded as *Phragmites australis—Peucedanum palustre* (S24) in 2014. This classification of wet fen habitat is regionally restricted to the fen peats of Broadland. S24 fen is formed of a community of herbaceous fen vegetation. The tall herb structure typically grows to between one and two meters. Several species are interspersed in this larger canopy, such as *Eupatorium cannabinum* (Hemp-agrimony) and *Peucedanum palustre* (milk parsley)[1]. *P. palustre* is a biennial plant which grows in wetlands and other shallow-water environments. Sedges and rushes grow to a lesser height of between 60 and 80 cm, and the smaller species are variable, and dependant on the water regime and the heterogeneity of the taller species. Climbers and sprawlers may also form part of the community. This habitat contains rare species such as *Cicuta virosa* (the cowbane) and *Peucedanum palustre* (milk parsley),[1] and some important species such as *Cladium spp* (saw sedge) and *Juncas subnodulosus* (a rush)[1].

2.4 Wet fen conservation techniques

Drainage[2], acidification[3] and eutrophication[4] have caused European fens to become some of the most threatened habitats in Europe, with 50 to 90 per cent of wetland ecosystems on organic soils being lost due to human activities[5,6]. This has far-reaching implications for biodiversity, carbon sequestration and hydrological and ecological services[7]. To address this issue, conservation techniques such as rewetting, seed transfer and topsoil removal have been proposed and tested, but with mixed results. Rewetting alone has been shown to have no measurable effect on restoration success[8]. Seed transfer has been achieved by harvesting and transferring hay from a desirable community and transferring it to a degraded site. Topsoil removal can lower the nutrient content of the degraded site and has been effective at increasing meadow diversity when combined with seed transfer[9]. Even with the successful application of these techniques, however, soil seed banks offer a relatively low possibility of re-establishing species-rich wetland habitats[10]. These techniques also only allow for the restoration of pre-existing sites, whereas habitat creation may be increasingly required to replace habitat lost to human activities and sea level rise[11]. Fen translocations offer the potential to transfer mature plants and to create new habitats to replace those lost elsewhere. Limited studies have documented translocations for a variety of wet meadow habitats but there is no evidence in the literature of local wet fen translocation studies or restoration of S24 community

[12-14]. Locally, wetland habitat creation has focussed on the less biodiverse reedbed habitat, an example being a small restoration project on Salhouse Broad.

2.5 Survey of translocated vegetation

Due to the sensitivity of the new fen and the logistical challenges of surveying this created habitat, this study was only able to survey the translocated fen community growing on the geo-bags. Visual observations of the new turf ponds show successful colonisation by fen vegetation. In the summer of 2022, observations of the new habitat show the successful colonisation of Charophytes alongside sightings of breeding species of Odonata and water voles.

This technical report aims to assess the National Vegetation Classification (NVC) community that has developed on the geo-bags. Data has been collected using a belt transect. This will provide quantitative data in these areas, allowing the NVC community at the three fen areas to be classified. This will allow comparison to the donor habitat and produce data showing the ecological importance of the artificial wet fen habitat. Understanding the efficacy of wet fen habitat translocation in maintaining species is imperative to inform a future conservation response to the changing climate.

3 Methods

Three belt transects were undertaken in August 2022, one along the centre of each geo-bag at the eastern end of Hoveton Great Broad (Figure 1). Eight by two-meter quadrats were surveyed at 25-meter intervals and the mid-way positions were recorded using GPS (Table 1). The eight-meter side of the quadrat was perpendicular to the geobag, covering the full exposed width of the geobag. The percentage cover was measured on a semi-quantitative 10-point scale (DOMIN), scoring the cover of each species from '<4% (few individuals)' to '91-100%' (Table 2)[15].

Modular Analysis of Vegetation Information System (MAVIS 1.04) was used to classify the best fit to National Vegetation Classification (NVC) community[16]. MAVIS assigns the data to multiple classification systems, such as programmes for NVC communities. This programme expresses the plant community in standard language to allow for comparative analysis. In addition, MARVIS analysis has been carried out for the vegetation at the donor habitat in 2005-2006. As no changes had taken place in this area prior to the removal of fen material, comparisons between the communities are considered appropriate.

4. Results

The survey identified 54 plant species across the three geo-bags (Table 3-5). MAVIS analysis expressed the vegetation from each geo-bag as a good fit for S24. The match to specific sub communities was weak, therefore there is a low confidence in the sub communities ascribed.

The results for the north disposal area gave a best fit to S24, with a typical sub-community. The east area was categorised as a best fit to S24 with a *Carex paniculata* sub-community. The south area was categorised as the best fit to S24 and *Phragmites australis-Eupatorium cannabinum* (S25).

The donor site gave a best fit to S24, with a typical sub-community and S24-S25. This is the commonest tall-herb fen community in Broad's fens.

5. Discussion

5.1 NVC community classification

The vegetation on the geo-bags was identified as a fit to the typical S24 *Peucedano-Phragmitetum* NVC community. The 54 species identified in the survey also contain species that are considered rare or important such as *P. palustre* and *J. subnodulosus*[1]. As the fen community is now locally endemic to the lowland peat fens in Broadland, the successful colonisation of this new area is important as it increases the overall habitat of this community[1]. This study was not able to further classify the vegetation to the level of sub-community, a difficulty which can be ascribed to the often-indeterminate boundaries between the categories at this scale. The fen turf was also mixed during translocation; therefore, the communities may become more distinct as the vegetation stabilises.

5.2 Comparison between classification at donor and receiving sites

This classification is consistent for both the donor and receiving site, indicating that the assemblage was retained when the fen was translocated. This result demonstrates that it is possible to translocate a rare fen vegetation community to another site, along with its peat substrate, implying that soil flora and fauna also moved successfully. In addition, this project indicates that wet fen translocation is resilient to rough handling, as the translocated material was moved by excavator buckets at least three times during excavation and transportation.

5.3 Implications for future conservation practices

As sea level rise is adding to the anthropogenic threats to fen habitats, conservation of fens may have to include habitat creation at locations further inland and upstream[11]. The high retention of species recorded in this survey demonstrates that translocations can be an effective technique to conserve and restore fen habitats when combined with the correct water regime at the receiving site. If future translocations can also retain the NVC community, this technique may be more effective than seed transfer. This has positive implications for any future translocation of fen communities when creating new wetlands in the face of climate change and sea level rise. Finally, this technique is especially relevant when the management of fens already requires topsoil removal, either as part of a succession management plan or in response to high nutrient levels.

Acknowledgements

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7. Tables and Figures

Table 1. Grid references for the midpoint of each transect.

Transect	Grid reference		
	Disposal area		
	South	North	East
1	TG 32015 15951	TG 31974 16345	TG 32241 16127
2	TG 31998 15980	TG 31950 16310	TG 32238 16096
3	TG 31982 16018	TG 31955 16276	TG 32232 16038
4	TG 31950 16037	TG 31976 16247	TG 32218 16006
5	TG 31913 16059	TG 32009 16245	TG 32192 15970
6		TG 32045 16253	
7		TG 32085 16272	

Table 2. DOMIN conversion table and key for crust/meadow growth forms, edited from[15].

Percentage cover range brackets (%)	DOMIN Key
91-100	10
76-90	9
51-75	8
34-50	7

26-33	6
11-25	5
4-10	4
<4 (many individuals)	3
<4 (several individuals)	2
<4 (few individuals)	1

Table 3. Fen vegetation survey data for Hoveton Great Broad south disposal area, data collected on the 16/08/2022.

Identified species	Abundance/cover values on DOMIN scale				
	Transect				
	1	2	3	4	5
Alisma plantago-aquatica				5	5
Alnus glutinosa	5				
Angelica sylvestris			1		
Berula erecta			5	6	6
Bidens cernua					5
Calamagrostis canescens	4			5	
Calystegia sepium	3	3	5		
Carex acutiformis					
Carex paniculata		4			4
Carex pseudocyperus		3		3	4
Carex riparia	5	5		4	3
Circuta virosa					2
Cirsium arvense					
Cirsium palustre	2		1		
Cladium mariscus					3
Dryopteris dilatata	2	2			
Epilobium palustre					
Epilobium hirsutum	2		1		1
Eupatorium cannabinum	5		3	6	
Filipendula ulmaria					
Galium palustre	2		5	5	4
Humulus lupulus					
Hypericum tetratrapterum			5	2	
Juncus acutifloris					
Juncus effusus				2	5
Juncus subnodulosus	8		5	5	5
Lotus pedunculatus	2				
Lycopus europaeus	4	8	8	8	8
Lysimachia vulgaris	5				1
Lythrum salicaria					5
Mentha aquatica	5	8	8	6	6
Myrica gale				3	3
Myosotis caespitosa					
Peucedanum palustre					4

Phragmites australis	8				2
Phalaris arundinacea					2
Pulicaria dysenterica					1
Ranunculus flammula					
Rumex hydropathalum		2			
Salix alba					
Salix cinerea					1
Salix x fragilis			1		
Scrophularia auriculata					2
Scutellaria galericulata					
Solanum dulcamara					3
Sonchus palustris					
Sparganium erectum			5		4
Sparganium emersum	3				3
Stachys palustris	2	2			2
Thelypteris thelypteroides	2				3
Typha angustifolia					
Typha latifolia	6	6	6	6	6
Urtica dioica		5	5	4	
Veronica anagallis-aquatica				2	

Table 4. Fen vegetation survey data for Hoveton Great Broad north disposal area, data collected on the 16/08/2022.

Identifed species	**Abundance/cover values on DOMIN scale**						
	Transect						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Alisma plantago-aquatica		1					
Alnus glutinosa	1	5	2	1	1	2	1
Angelica sylvestris							
Berula erecta	5	5	4	4	4	3	3
Bidens cernua		2	1				
Calamagrostis canescens	3	3	3	4			3
Calystegia sepium	5	4	3	2	2	3	1
Carex acutiformis			2	2			5
Carex paniculata	1	1		1		1	1
Carex pseudocyperus		1	2	2		1	1
Carex riparia	2		6	4	4	6	6
Circuta virosa			2		1	1	
Cirsium arvense	2	1		2		1	
Cirsium palustre	1	2		1			
Cladium mariscus							
Dryopteris dilatata							
Epilobium palustre							
Epilobium hirsutum			1				
Eupatorium cannabinum	5	5	5	5	5	5	5
Filipendula ulmaria					2		
Galium palustre				2	3	3	2
Humulus lupulus					1		
Hypericum tetratrapterum	1	1			1		1
Juncus acutifloris					1		

Juncus effusus		5	4	2		2	
Juncus subnodulosus	5	5	3	5	3		5
Lotus pedunculatus	2	2	2				
Lycopus europaeus	5	5	5	5	5	3	3
Lysimachia vulgaris						2	
Lythrum salicaria	2						
Mentha aquatica	5	6	5	5	5	5	5
Myrica gale							
Myosotis caespitosa		2					
Peucedanum palustre	1				2	1	
Phragmites australis		3		3		3	3
Phalaris arundinacea	8	7	8	8	7	7	7
Pulicaria dysenterica							
Ranunculus flammula							
Rumex hydropathalum	2			1		1	1
Salix alba							
Salix cinerea			1				
Salix x fragilis							
Scrophularia auriculata							
Scutellaria galericulata							
Solanum dulcamara	2	2	2			2	2
Sonchus palustris				1			
Sparganium erectum		5			3		
Sparganium emersum							
Stachys palustris	2	2					2
Thelypteris thelypteroides	4	4	4	4	4	5	5
Typha angustifolia					5		3
Typha latifolia	5	5	4	4	4	4	5
Urtica dioica	5		4	4	4	5	4
Veronica anagallis-aquatica							

Table 5. Fen vegetation survey data for Hoveton Great Broad east disposal area, data collected on the 16/08/2022.

Identified species	**Abundance/cover values on DOMIN scale**				
	Transect				
	1	**2**	**3**	**4**	**5**
Alisma plantago-aquatica		2		2	
Alnus glutinosa		6	5		3
Angelica sylvestris					
Berula erecta	2	5		5	4
Bidens cernua		5	5	3	5
Calamagrostis canescens	5	5			5
Calystegia sepium	2	2	2	2	2
Carex acutiformis					
Carex paniculata		3	3		2
Carex pseudocyperus	2			3	2
Carex riparia				2	
Circuta virosa					
Cirsium arvense					
Cirsium palustre					
Cladium mariscus					

Dryopteris dilatata					
Epilobium palustre	1				
Epilobium hirsutum	1		1		
Eupatorium cannabinum	5	5	4	3	
Filipendula ulmaria					
Galium palustre	6		2	2	2
Humulus lupulus					
Hypericum tetratrapterum			2	2	
Juncus acutifloris					
Juncus effusus	2	5	5		
Juncus subnodulosus	6	6		8	6
Lotus pedunculatus					
Lycopus europaeus	5	4	5	5	5
Lysimachia vulgaris			2		
Lythrum salicaria	2	2		2	
Mentha aquatica	5	5	5	4	2
Myrica gale	1				
Myosotis caespitosa					
Peucedanum palustre					
Phragmites australis	2	5	8	8	8
Phalaris arundinacea			2	2	2
Pulicaria dysenterica					
Ranunculus flammula		1			
Rumex hydropathalum				1	2
Salix alba	1				
Salix cinerea			1		
Salix x fragilis					
Scrophularia auriculata			1		
Scutellaria galericulata		2			
Solanum dulcamara				3	
Sonchus palustris					
Sparganium erectum					
Sparganium emersum					
Stachys palustris					
Thelypteris thelypteroides	2	5	4	4	2
Typha angustifolia			3	6	3
Typha latifolia	6	6	5		
Urtica dioica	5		3	3	2
Veronica anagallis-aquatica					

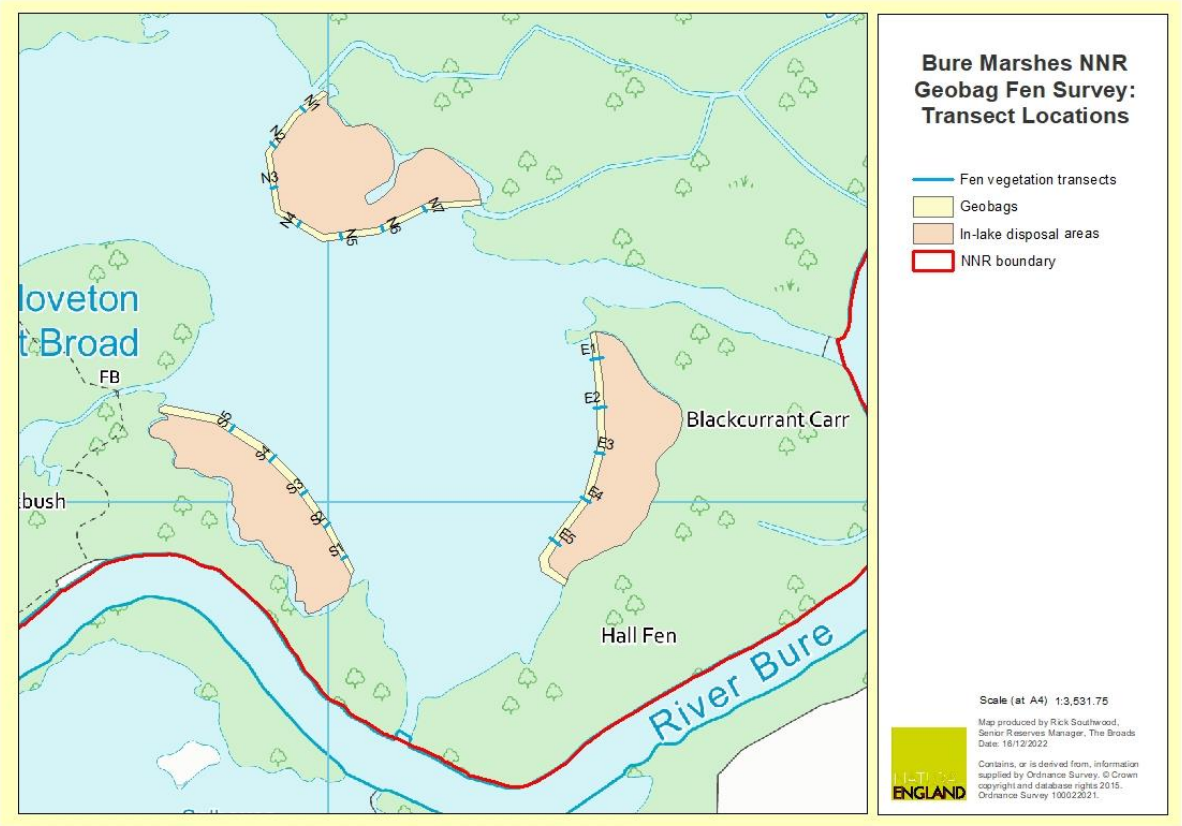

Figure 1. New wet fen area locations (beige polygons), located in the eastern end of Hoveton Great Broad, Norfolk, UK. North, east, and south geobags are depicted in yellow (labelled N, E, and S respectively). Fen vegetation transects are depicted with a green line, perpendicular to the geobags (labelled with the transect number).