Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

SB – Project

NC-Pathfinder-GWSW-Modelling

Mapping topography & broad vegetation type to characterise the Boxford meadows SSSI (Unit 2)

C. Roberts[1], G. Old[1], O. Mountford[1], J. P. R. Sorensen[2] and P. J. Williams[2]

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Summary

Understanding the dynamic relationship between hydrology and ecology in a complex wetland setting should be considered integral to the sustainable management and conservation of wetland habitats and future water resource planning. Wetland hydrology can exhibit considerable spatial complexity as a result of sub surface and surface heterogeneity. The latter of which may be determined by the relationship between spatial topography variation and broad vegetation distribution. Any study to investigate such a relationship must be at a spatial resolution sufficient to identify patterns in surface topography and vegetation type.

In this study state of the art survey technology was used to collect and record for subsequent mapping the topographic and vegetation characteristics of the Boxford lowland chalk groundwater dependent terrestrial ecosystem (GDTE). The resultant survey dataset successfully unveiled distinct patterns in topography and vegetation type. The analysis of the data in a Geographical Information System (GIS) desk confirmed for the first time the presence of paleo-channels and a braided fluvial system within the meadows. In addition the combined survey method gives some indication that the type of vegetation present appears to coincide with some of the more distinctive topographical features.

The results demonstrate that combining the field survey campaign alongside desk based GIS analysis is an extremely useful and versatile tool and can provide valuable information to support the decision making process for both further scientific investigation and sustainable habitat management.

Introduction

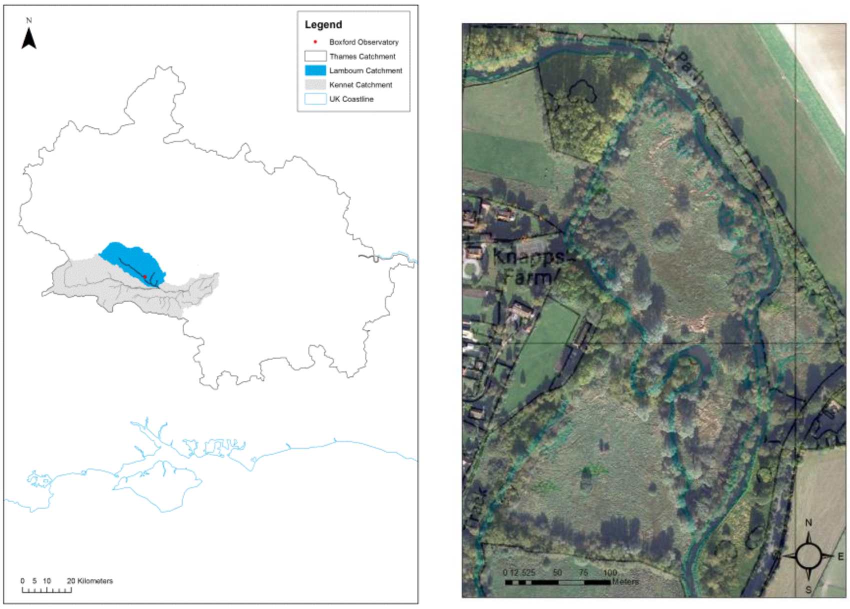
Groundwater dependent terrestrial ecosystems (GWDTE) are wetland habitats which critically depend on groundwater flows and /or chemistries (WG-C; Schutten et al, 2011). They can be

[1] Centre for Ecology and Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, OX10 8BB

[2] British Geological Survey, Maclean Building, Benson Lane, Crowmarsh Gifford Wallingford, OX10 8BB

described as groundwater dependent when whole or part of their water demand is supplied by groundwater and, in the absence of it, the ecosystem functions will be impaired, leading to fundamental alterations of the structure of the ecosystem itself. There are several variations of GDEs that have been recognised (Klove et al., 2011a). The Boxford meadows (NGR SU429722) (Figure 1) are an example of a Groundwater Dependent Terrestrial Ecosystem (GWTE). These meadows have a high biological productivity and are sensitive to environmental change. The Centre for Ecology and Hydrology (CEH) and the British Geological Survey (BGS) are engaged in collaborative research efforts to conceptualise and model the hydrological functioning of the site and relate this to its ecosystem characteristics. Ultimately this research will enable an assessment of future scenarios of climate change, regional groundwater resources and or catchment area management practices and planning strategies. Current research and management of the site requires detailed topographic and vegetation maps to be produced as they are deemed critical to developing targeted monitoring and implementing effective management practices.

The Boxford meadows observatory is located in the lower half of the River Lambourn catchment at a distinctive bend in the valley base immediately upstream of the village of Boxford, Berkshire, UK. The River Lambourn is a designated Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) whilst the meadows also have independent SSSI status [3] predominantly as a result of the habitat they provide for the endangered *Vertigo moulinsiana* (Desmoulins snail)[4]. The Desmoulins snail thrives in calcareous wetlands and its preferred habitat is one of tall monocots such as Phalaris arundinacea (canary reed grass) and Glyceria maxima (sweet reed grass). The presence of this critically endangered species is one of the key drivers of the 'CEH Boxford Meadows Management Plan'.



(a) (b)

Figure 1. (a) Location of the Lambourn catchment and (b) the Boxford meadows observatory

[3] SSSI Citation statement notified in 1986, Section 28 of the Wildlife and Countryside Act 1981
[4] Killeen, I., Moorkens, E. & Seddon, M. 2012. Vertigo moulinsiana. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1.

CEH owns what Natural England under SSSI designation has classified as Unit 2 of the Boxford Water Meadows SSSI (Figure 2). The total area according to the SSSI unit information sheet is 8 ha. However, this covers the entirety of the site owned by CEH, including all boundary scrub and Carr, the river, the land to the east of the river and the middle area which was excluded from this survey for safety reasons. The site is physically divided into two main units of land acknowledged as the North and the South Meadows. The boundary segregating the two is defined by a carrier stream flowing from north to south.

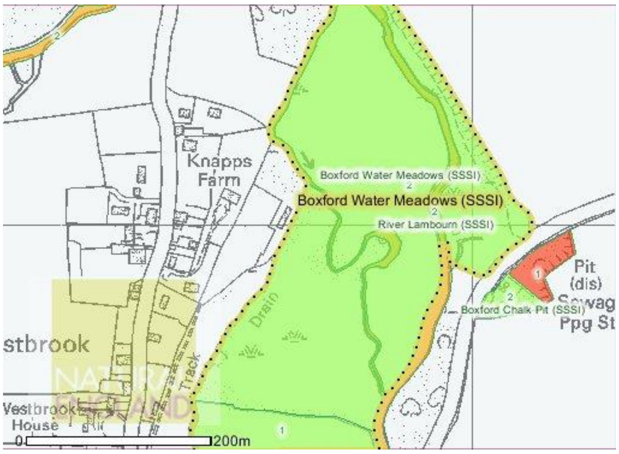


Figure 2. Natural England SSSI map of unit 2 at Boxford meadows

The aim of the survey campaign is to accurately and precisely map the surface topography and broad scale vegetation communities of the Boxford Meadows. This report will also present how the integrated use of fieldwork surveys and GIS in producing maps of the site will help in improving the understanding of the hydrological behaviour of the site.

Methodology

The Boxford Meadows Observatory site survey was undertaken over 4 days in May 2012 during a period of fair and dry weather. The preceding winter had been an unusually dry and cold one resulting in seasonally depressed patterns of river flow and groundwater levels across southern England[5]. This subsequently provided ideal firm ground conditions for the topographical survey but presented greater difficulty in identifying plant species as emergent vegetation had yet to appear. This meant that much of the visual identification of species was carried out on decaying plant material left over from the previous year.

An approximate 3m resolution grid was followed for topography and corresponding broad vegetation type alongside a simplified dichotomous key employed to identify plant species in line with the National Vegetation Classification System (NVC)[6].

To increase efficiency in survey observations a field survey identification code was employed of 7 abbreviations of the most probable vegetation type to be found at the site:

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[5] NRFA Hydrological Summary for the UK, Hannaford et al 2012

[6] Rodwell, J.S (ed) 1995. British Plant Communities. Volume 4. Aquatic communities, swamps and tall-herb fens, Cambridge University Press, Cambridge.

Vegetation type	Veg Abbreviation
Pond sedge	sed
Canary reed grass	can
Sweet reed grass	swt
Grass	grss
Blackthorn/willow scrub	srb
Tussock sedge	tus
mixture of sweet reed grass and pond sedge	swtsed
mixture of pond sedge and grass	grssed

To account for areas of the site where mixing of vegetation species was clearly abundant and thereby challenging to assess the most dominant one the best practice taken was to couple two code abbreviations together e.g. grssed. These areas represent the more heterogeneous parts of the site.

To ensure the survey campaign was carried out as efficiently as possible three field scientists were employed to the task with one leading the technical aspect of the survey and the other two acting largely as survey assistants. In an independent but adjoining piece of work the survey assistants, simultaneously carried out an intrusive probe survey to measure the depth of peat and capture the elevation of the peat base[7]. The peat depth survey, although carried out in tandem with this exercise, is not reported here.

Where terrain permitted, survey points were observed at approximately 3m intervals as estimated by the surveyors. It was agreed that areas with problematic access such as scrub thickets, wet woodland Carr and open water, would be excluded for this exercise. In these areas, even where access is possible communication difficulties between survey instruments would have slowed progress of the survey. The start and finish of each survey transect were marked with ranging poles to provide a reference point. As each transect was completed the next transect line was marked out with a line approximately 3m parallel. The orientation of transects generally followed the orientation of the open ground i.e. SE in the northern meadow and SW in the southern meadow.

At each observation point several survey units were logged of Real Time Kinematic (RTK) Global Positioning System (GPS) data. These were the horizontal coordinates, vertical elevation, broad-vegetation type and peat depth. Horizontal units of Eastings and Northings were collected based on the Ordnance Survey National Grid coordinate reference system of Great Britain (OSGB36)

Equipment

The survey was undertaken using the Trimble Integrated Survey Setup, which included the following survey equipment:

- Trimble R8 GNSS roving satellite data receiver
- Trimble TSC2 survey controller complete with Trimble Access survey software installed
- Trimble S3 Optical Total Station

[7] Peat Depth Survey of Boxford Meadows, 2012, Sorensen et al

- Subscription Licence to the Trimble RTK VRS Now web based real time data correction service

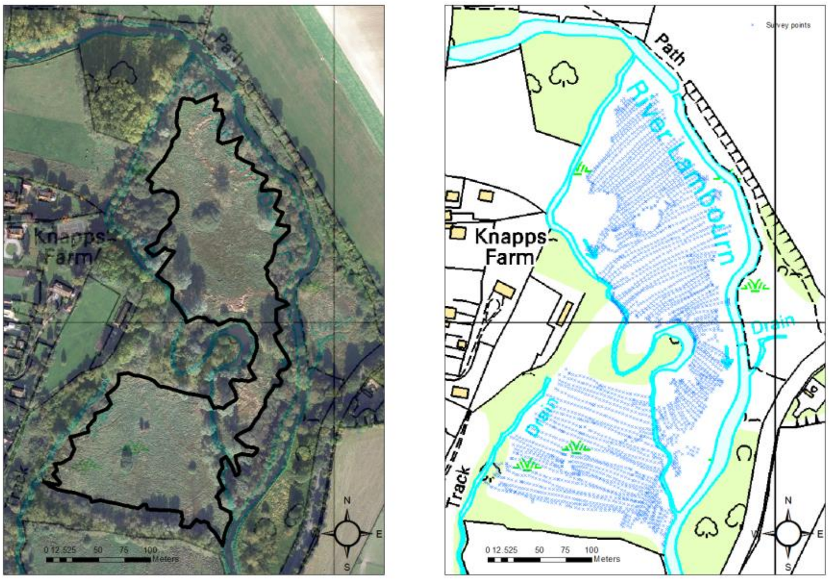
The most effective and quickest method for undertaking a topographical survey is using the GPS roving set up as an unaided independent survey instrument, which with a positional accuracy of >20mm will normally provide ample precision for a survey of this kind. However, prior experience of the communication problems associated with using this set-up unaided on this site meant there was a prerequisite to establish the TST EDM (Total Station Theodolite Electronic Distance Meter) as a temporary fixed base station in open space. The integrated set-up permits the uninterrupted transpondence of satellite and GSM signals (Global System for Mobile Communications network) to the fixed base station thereby allowing the roving set-up to be used as a mobile target in tandem with the optical line of sight method from the TST EDM to determine its position. As the survey progressed around the site the base station was relocated and repositioned as and when required to repeat the exercise.

Results

Initial desk based post processing and quality controlling of the origin survey dataset, mostly to remove erroneous and spurious values noted from field records, revealed that an overall 3177 survey points had been logged. A resultant total of 3101 survey points were evaluated for subsequent vegetation mapping in ARCGIS.   This dataset provided the baseline data for further spatial and statistical analyses.

Topography& surface interpolation

Spatial analysis of the extent of the survey revealed that an area of *ca* 9.6 acres (*ca* 3.9 hectares) had been covered under this survey campaign (Figure 3).



(a) (b)

Figure 3. (a) Outline of surveyed area and (b) coverage of survey points

The frequency distribution results of survey measurements show there is little variation in surface topography across the entire site (Figure 4). The upper and lower limits occupy a range of 1.443m with a minimum elevation of 89.809 and a maximum elevation of 91.252mAOD. The mean elevation is 90.492mAOD and the Standard Deviation has been calculated at 0.342m.

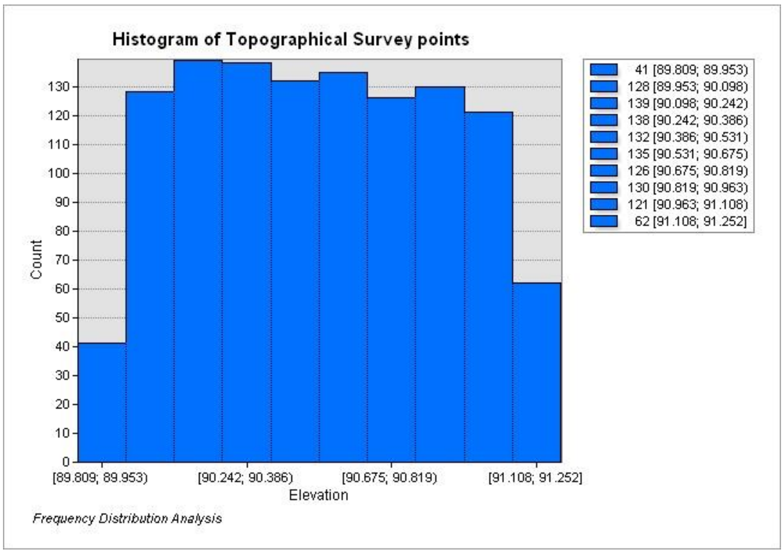
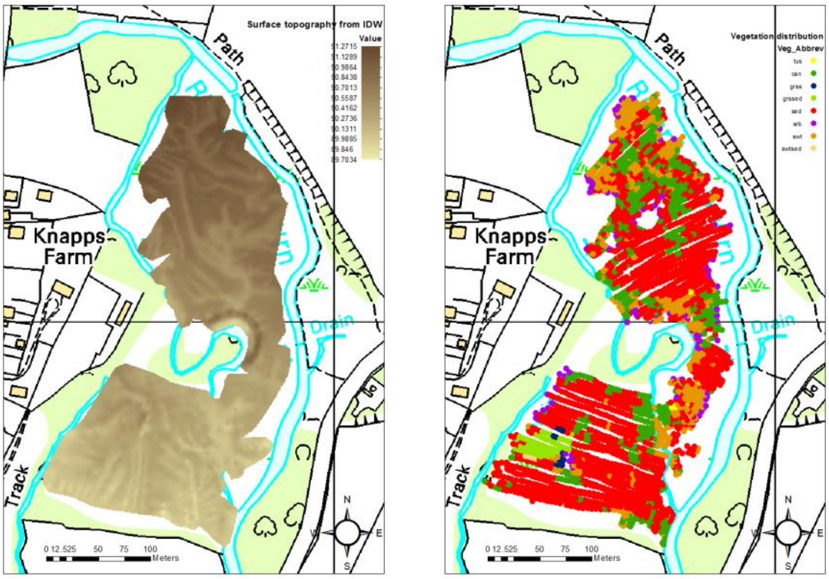


Figure 4. Distribution of surface elevation heights across the site

Interpolation of unknown values between measured locations within the surveyed area is a useful Geostatistical exercise employed in the accurate mapping of topography from a limited dataset. One method used in the spatial analyst tool in ArcGIS is the Inverse Distance Weighted (IDW) technique. IDW determines unknown cell values using a linear weighted combination set of neighbouring samples points to derive a predicted value for an unmeasured location between known points. The greater the distance between points the less influence the cell has on output value.

The IDW technique of representing the spatial variation in elevation across the site has revealed the presence of a series of relict paleo-channels that have a greater definition across the northern meadow over the southern (Figure 5a). Lower sections of site, as indicated by the lighter tones of the colour graduation, can be clearly seen dominating the ground throughout the southern half of the site and representing the dendrite outline of the paleo-channels in the northern section.

Nearest neighbour weighted-average analysis was carried out on the topographical dataset to verify the distance between survey points as stipulated in the field campaign. The mean observed distance results estimated a value of 2.46m between points. This is approximately 0.5m shorter than as followed in the actual physical survey campaign. The difference between these two distances may be because of the clustering of survey points due to overlapping of the actual survey transects.



(a) (b)

Figure 5. (a) IDW interpolated map of the surface topography and (b) corresponding vegetation type alongside

Slope

The surface elevation of the land to the north of the site is higher with the gradient falling away to south of the site. This gradient has been calculated to be *ca* 1:360 which is roughly equivalent to the gradient of the river Lambourn flow reach through the eastern boundary of the site.

Board vegetation type

In the spatial mapping of the vegetation survey dataset each Vegetation type was assigned a numeric grid code from 0 -7.

Veg Abbrev	Veg code
sed	0
can	1
swt	2
srb	3
tus	4
grss	5
swtsed	6
grssed	7

Figure 6. Assigned vegetation numbers for distribution mapping

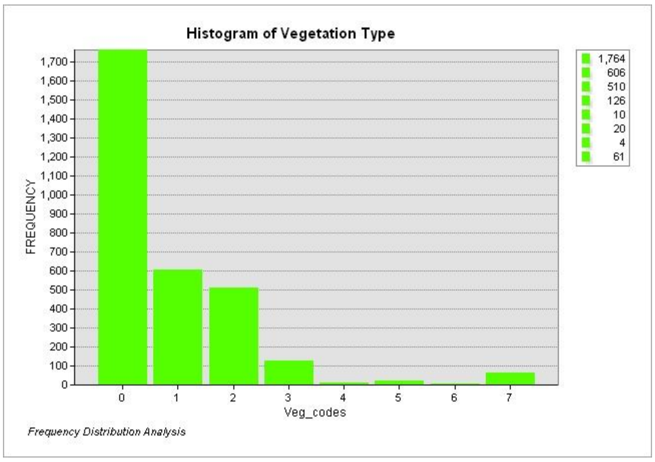
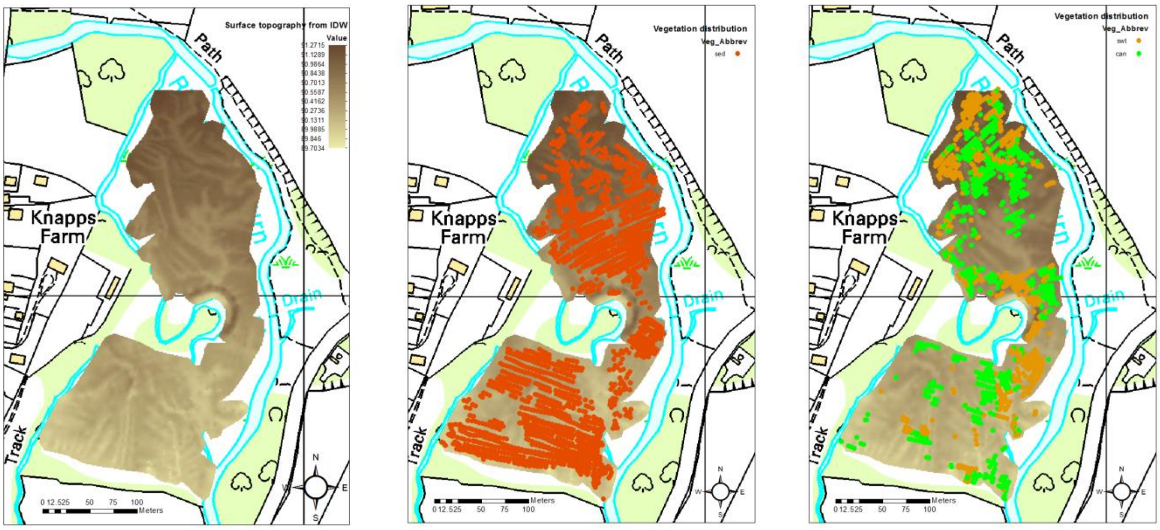


Figure 7. Distribution count of vegetation type

The survey count of species identified that Pond sedge is the dominant broad vegetation type throughout the site by a factor of almost 3 to Canary reed grass the second most frequently observed (Figure 7). The spatial mapping of vegetation distribution shows Pond sedge (red markers) appears to dominant the lower areas of surface topography, in particular along the dendritic lines of the relict paleo-channels (Figure 8b). This relationship appears stronger in the northern meadow than the southern where the magnitude of elevation variation is less pronounced and Pond sedge is more abundantly spread. This may suggest that the depth to water table from ground surface in the lower areas is shallower for longer periods of time throughout the year as Pond sedge particularly thrives in high groundwater regime conditions.



(a) (b) (c)

Figure 8. (a) Interploated mapping of surface topography, (b) distribution of sedge and (c) distribution of canary grass and sweet grass

The Canary reed grass (green markers) appears to be marginalised to pockets of ground surrounding the relict channels that have slightly higher elevations (Figure 8c). As with the pond sedge this is more apparent in the northern meadow than the south. One feasible explanation for the apparent marginalisation of the Canary reed grass is that the pond sedge simply dominants any competition for spatial succession despite the likeliness of the water table regime being indistinguishable between the two.

Constraints and limitations of survey campaign

The broad vegetation community maps produced here should be viewed in the context of a general description of the vegetation characteristics of this site. This is because several species were spread abundantly across large areas of the site and judgement by the surveyor as to which is the dominant species is challenging. This will affect precision in the boundary zones of mapped vegetation.

Preferably the survey would have been undertaken during the summer months when the vegetation has fully grown and is easier to identify. However, prior knowledge of the behaviour of this site from previous fieldwork campaigns is that it experiences a period of rapid growth in vegetation from early summer onwards. Thus the ensuing tall herbaceous vegetation coverage and density occurring in the summer makes it highly impractical to undertake a survey of this kind.

Another important factor that must considered when determining the most appropriate time of the hydrological year to undertake such a survey is the behaviour of the peat layer in response to wetness. In fact Price and Schlotzhauer (1999)[8] have shown that the total storativity in compressible peat substrates should be taken as the sum of the specific yield and storativity due to peat compression. However, they also note that where compressibility is low, total storativity can be adequately represented using only specific yield, and suggest that shallow (<0.5 m) peat generally possesses low compressibility. Regular survey measurements by scientists of the surface elevation in the immediate vicinity of a select number of the boreholes at the site has so far determined there is little or no vertical expansion in the peat layer at Boxford.

Conclusion

This survey has encapsulated, for the first time, a high resolution (horizontal <3m) high quality topographic and broad vegetation community dataset of the Boxford Meadows GWDTE Observatory site.

The resultant maps of the topography and vegetation have revealed the presence of extensive palaeo-channels and a braided fluvial network throughout the site. There appears to be some evidence that points towards specific vegetation species, particularly Pond sedge, preferring to colonise the lower areas of ground, maybe as a result of having a shallower depth to water table. Others such as the Canary reed grass and sweet grass whilst abundantly present throughout the site are marginalised to higher ground possibly as a result of the dominance and competitive nature of pond sedge to colonise.

The use of spatial analyses and GIS functionalities to interpolate the surface elevation of the site has proven to be a key technique in representing spatial variations of surface elevation and board vegetation type coverage. Integrating the results of the two surveys has made a valuable contribution to developing a greater understanding of the hydrological behaviour of the site and a more clearly defined conceptualisation of the environmental drivers behind vegetation succession.

[8] Price, J.S., & Schlotzhauer, S.M., (1999) Importance of shrinkage and compression in determining water storage changes in peat: the case of a mired peatland. Hydrological Processes 13: 2591 – 2601.

High resolution topographical ground surveys of habitats such as the Boxford Meadows SSSI are proven here to be a valuable exercise to undertake in helping to characterise, conceptualise and instrument a GWDTE habitat. The maps will also provide a valuable resource in determining the decision making process for any restoration and management intervention in the future.

References

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Schutten, Verweij, Hall & Scheidleder, 2011. Common Implementation strategy for the Water Framework Directive (2000/60/EC). Technical report No. 6. Technical report on Groundwater Dependent terrestrial Ecosystems. ISBN: 978-92-79-21692-3

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