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Ecology Land and People

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ECOLOGICAL IMPACTS OF GROUNDWATER ABSTRACTION ON CATFIELD FEN

SOME INITIAL CONSIDERATIONS

Prepared for Mrs and Mrs Harris, Catfield Hall, Norfolk.

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1. Introduction

Concern has been expressed at the ecological impact of the groundwater abstractions less than 1km east of the margin of Catfield Fen. Hydrological work has apparently identified a drawdown beneath the fen arising from these abstractions.

The gross geology demonstrates hydraulic continuity between the chalk and crag aquifers and with the overlying peat. There are inter-leaving layers of marine clay (derived from the Romano-British marine transgression) between the crag and peat, and within the peat. However, at least along the eastern margins of Catfield Fen, these clay layers are thin and discontinuous. In addition, a number of the dykes have apparently been deepened, breaching the clay. Hence a drawdown in either of the two major aquifers is likely to translate to a drawdown at the peat surface.

Consequently, ELP were asked to provide comment on the sensitivity of fens such as Catfield to small drawdowns in groundwater. This short report provides a summary of this advice.

2. Ecological Interest of Catfield Fen

The eastern part of Catfield Fen has been intensively surveyed by Alec Bull and others in the publication 'A Natural History Of the Catfield Hall Estate' Norfolk and Norwich Naturalists Society occaisional publication no 11. The fen areas to the west and south were surveyed by ELP on behalf of the Broads Authority in 2007. It was also studied intensively by Bryan Wheeler in the 1970's as part of his studies of Catfield and Irstead Fens.

Catfield is one of the most important sites for fen conservation in Broadland and in the UK. It contains a range of very wet fen communities, often associated with the most exacting hydrological and substrate conditions. It is a fen associated with low fertility, base-rich and calcareous water tables. It supports wet fen communities, shallow fen pools and *Dryopteris-Sphagnum* communities which unusually is a more acid bog type and has been studied in detail at this site by Bryan Wheeler. He also identified a unique plant community characteristic of recolonising turf ponds at Catfield and other fens in the Ant. It is very species rich and includes some very rare species.

The ways in which these types of fen are vulnerable to changes in hydrological regime are described below. It is emphasised that such vulnerability could be to changes in water level regime consequent upon drawdowns of only centimetres, although detailed hydrological and ecological data are required to be more precise.

According to Peter Riches, Land Agent for Mr and Mrs Harris (*in litt.*, 2010), Alec Bull[1] has reported concerns that the site is drying out . Bull has apparently suggested that there is an increase in woody species especially downy birch, along with a marked reduction in cotton grass. Heath spotted orchid has not appeared in middle marsh for two years and there has in his view been a reduction in milk parsley, bladderwort and crested buckler fern as well as an increase in nettle, while the *Sphagnum* is also deteriorating. These observations are based on ten years of regular visits and careful recording.

[1] Alec Bull is chairman of the Norfolk and Norwich Naturalists Trust research committee and co-author of the Natural History of the Catfield Hall Estate

3. Ways In Which Drawdowns Affect Fens

There are a number of ways that groundwater abstractions can affect Fens. These include:

Reduction in water tables. Some plant species are obligated to high water tables. That is they cannot survive in dry conditions. They include particularly shallow-rooted species that rely on high water tables for their water requirements, or semi- or fully aquatic species which grow in the sometimes very shallow fen pools or hollows between tussocks. Bryophytes, stoneworts and small herbs which root into the moss layer, are especially vulnerable. Clearly, if water levels drop below the tolerance levels of these species, they cannot survive. This factor may operate quite subtlety; a well established perennials may be able to hang on in sub-optimal conditions for many years, but seedlings and young plants which are more intolerant of stress might not. Hence it may take some time before the impacts of reduced water tables are expressed in the flora.

Fens which typically have a very high water table with shallow fen pools may have a relatively high proportion of obligate species. Because these conditions are uncommon, these plant species are also uncommon, and hence the ecological interest of very wet fens is both fragile and high-value.

Reduced groundwater tables can affect "perched" surface water layers. For instance, mixed mires occur where a rain water driven water table overlies the typical ground water table. In a mixed mire, the calcareous tall fen species may be rooted through the shallow rainwater table and into the minerotrophic water table below, where as the surface bryophyte and shallow-rooted herbs may be supported by the perched rainwater table. Because the two water tables have different hydrochemistries, it produces an acid bog vegetation characterised by *Sphagnum* underneath a layer of rich-fen tall herbs. These are the prevailing conditions in the *Dryopteris cristata-Sphagnum* fen well known in the Broads and for which Catfield is the type locality. Their hydrochemistry is complex and is likely to be very fragile, susceptible to reductions in the level of the underlying ground water. The response of these mixed mires to small changes in water tables are not clearly understood.

There is increasing evidence that the relationship between the composition of fen plant communities and water table is much more complex than simple mean summer water table, although this remains a useful if blunt guide to the sensitivity of different fen types. The hydrological profile of the site, describing the rise an fall of the water table through the year together with the balance between rising groundwater, rainfall and lateral flow, all determine the precise nature of the fen community and the presence of particular plant species. Two approaches which appear to have been successful in describing the hydrological regimes of wetlands are flow duration curves and sum exceedence values. The application of both approaches requires good quality vegetation and hydrological data.

Loss of surface wetland features. Shallow fen pools are often small in extent and vulnerable to changes in water levels. Larger features, such as dykes or turf ponds, are robust to water level change because of their initial water depth. However, shallow depressions, pits or inter-tussock pools may only be a few centimetres deep. They cannot therefore buffer small reductions in water level.

Shallow features may respond to reductions in water levels in two ways; firstly through loss of extent – the depressions become smaller as the water table reduces. Secondly, through reductions in botanical interest, as obligate species are lost as conditions move from aquatic to semi-aquatic and eventually to dry fen.

Changes to water quality. Groundwater is generally low in nutrients compared to river water, and its chemistry reflects the nature of the aquifer, with chalk providing calcareous water and sands producing base-poor and acid waters. The species composition of fens supplied by groundwater generally reflects the hydrochemistry of the source aquifer, hence chalk aquifers support calcareous base-rich fens, which sands give rise to poor-fen. Low nutrient groundwater is important in maintaining low fertility, one of the key determinands of species-richness in plant communities. Some of the most important fen communities are associated with calcareous, low nutrient water quality. If abstraction withdraws this component of groundwater, the chemistry of the fen can change which itself will cause ecological change. The plant communities at Catfield are strongly calcareous and base-rich. Withdrawal of groundwater could affect the water quality irrigating the peat. Although the chemistry of the peat could buffer the site against withdrawal of groundwater, change would still be expected in the long term.

A high groundwater table, and especially one with a significant calcareous element, prevents downward percolation and reduces penetration of the surface by base-poor rainwater. Reduced groundwater levels increases the degree of downward percolation of rainwater so that the near-surface soil water is dominated by base-poor rainwater. Downward percolation also increases leaching. In this way the fen surface can become acidified promoting a significant change in plant communities. The degree of effect clearly depends on many factors, principally the original balance between calcareous groundwater and rainwater in the surface water table, the degree of reduction in the water table, and the ability of the peat chemistry to buffer induced change. These relationships are not clearly understood and may not be linear.

Consequential Impacts. These include changes in fertility or changes in the competitive balance between fen species arising from some of the above processes. It is perhaps through consequential impacts that much of the damage and loss of species may accrue. The processes at work are often complex. Although they may be understood at a conceptual level, quantitative understanding and predictive models remain elusive because of the difficulty of making field measurements or of evaluating change.

Lowered water tables can reduce permanently water logged conditions in the rooting zone. This has two effects. The first is that peat and other organic matter is no longer rendered inert by the reducing conditions of the fen waters. The peat fibres break down and release nutrients. The fertility of the substrate is enhanced. Many of the most valuable fens persist in the lowest nutrient conditions. Increasing nutrient status leads to progressively less diverse fen types, with fewer rare species.

Reducing water table levels can change the competitive balance between plant species. Growing in waterlogged conditions is extremely challenging for most plants. The rooting environment is low in oxygen and nutrients can be difficult to absorb, even if present. Many fen species are not obligate to very wet conditions (they can grow reasonably well in drier conditions) but they persist in wet conditions because other more competitive species cannot. Reducing water tables allows less specialised species to dominate the plant community at the expense of the usually slower-growing species which are often the most valuable in conservation terms. There is subsequently a transition to more common fen communities with a greater representation of dryland plants. Overall, conservation value is reduced.

Water table lowering can provide synergy between these two processes. The increased nutrient levels associated peat wastage feeds the more competitive plants which have been released by more aerated soil substrates. The rate of change due to either or both processes together depends on the degree of water level change, the nature of the initial fen plant communities and the nature of the original fen substrate. Again, while these processes are understood reasonably well at a conceptual level, a quantitative understanding, especially regarding rates of change in relation to degree of groundwater lowering, is not available. However, we know that Catfield Fen is characterised by plant communities typically associated with infertile substrates and very high water tables. The condition and fertility of the peat at the fen surface is likely to be critical in maintaining the current plant assemblage. The site may show consequential impacts of even small changes in water levels.

4. Droughts and Average Years

While changes to hydrological regime should be considered for average years, the impact of groundwater lowering during droughts should be a particular focus. In droughts, water table lowering is much more marked and consequently, the range of species affected is greatly expanded to include deeper rooting species. The consequential impacts are much more marked.

Of course, agriculture has the greatest demand for abstracted water during droughts and this greatly exacerbates the impact of abstractions. Consequently, any modelling of impacts of abstraction should consider drought conditions in tandem with maximum abstraction rates.

Finally, the impacts of climate change need to be factored in. Natural England[2] has forecast that climate change will bring hotter, drier summers which will have the following consequences in Broadland:

- A reduction in the area of freshwater habitats.
- Reduced available water resources.
- Damage to wetland habitats due to increased drought stress.
- Loss of some species currently present in the Broads, along with the arrival of others, the latter including non-native or invasive species.

Clearly, sites such as Catfield with the most ecologically sensitive fen communities could potentially be hardest hit by climate change. All considerations of the impacts of abstraction need to factor in the additional water required by the Fen to accommodate climate change.

[2] Neale, A. (2009) *Responding to the impacts of climate change on the natural environment; The Broads.* Natural England Report NE114R.

5. Timescales for Change

The rate at which plant communities change in response to hydrological change varies according to the composition of the plant community and the degree of drawdown. Communities principally composed of deep-rooted, long lived perennials may take many years of drawdown to express the change induced by an abstraction. Such vegetation has great inertia.

Vegetation with a significant component of bryophytes and shallow rooted herbs or with a high component of shallow semi-aquatic fen pools may respond more quickly to the change. Catfield has a significant component of this type of vegetation.

Detecting significant change can be very difficult because of other confounding factors such as how the site has been managed during the period of abstraction. Detailed vegetation monitoring and analysis of the data is required, along with experienced interpretation of the results.

Short-term time limited licenses of 5 years are rarely adequate to detect this kind of change. In addition, once the change is expressed in the vegetation it is effectively damaged. Much of this damage, such as changes to the peat, may be impossible to reverse. While time-limited licenses with monitoring have frequently been adopted where there are unresolved concerns, it is a flawed approach. By the time you know the practise is damaging, the damage has been done.

6. Invertebrate Communities

Recent work undertaken on behalf of the Broads Authority[3] has shown that invertebrates may be as sensitive to water level change as are fen plants. Researchers found that the overriding influence on the diversity and quality of fen invertebrate communities was hydrology. The best invertebrate communities, with the rarest species and many of the true fen species, were associated with very wet mires with stable water table regimes. Drying of the fen surface caused a change of invertebrate assemblages towards damp meadow and marsh species. These communities had many fewer rare invertebrates.

Clearly the impact of abstraction may be felt in species groups other than invertebrates. If the impact is severe such that consequential change is brought to bear and there is significant shift in the nature and physical structure of plant communities, then there will consequent shift in all of the fen fauna including birds.

[3]Lott, DA, Drake, CM and Lee, P. (2010a) *Broads Fen Invertebrate Survey: Project 2: Assemblage Responses to Salinity.* Report to Broads Authority and Natural England, Norwich.
Lott, DA, Drake, CM and Lee, P. (2010b) *Broads Fen Invertebrate Survey: Project 1: Assemblage Responses To Local Factors. Project 4: Evaluation of Invertebrate Assemblages.* Combined Report to Broads Authority and Natural England, Norwich.
Telfer, MG (2010) *Broads Invertebrate Survey. Project 3 : Monitoring Invertebrate Assemblages Responses To Climate Change in the Broads.* Report to Broads Authority and Natural England, Norwich.

7. Conclusion

Catfield Fen is characterised by a series of wet fen plant communities with a range of uncommon or rare species. A suite of these species are obligate to high water tables, particularly bryophytes, stoneworts and shallow-rooted herbs. The fen is also characterised by shallow surface pools, and by lenses of acid *Sphagnum* mixed mire. Other than the *Sphagnum* communities, the fen is characterised by communities which are indicative of calcareous, low nutrient and base-rich conditions, and very high water tables.

The ways in which abstraction may affect this kind of wet fen has been broadly reviewed. It is clear that fens such as Catfield are very sensitive to even small changes in hydrological regime, a term which includes the behaviour of the water table throughout the year, the mixes of water sources feeding the fen and water quality. It is the species and features of Catfield Fen which are rarest and most valued in conservation terms that are the most vulnerable, because their habitat requirements are the most stringent and the least commonly encountered. They are generally also the most fragile. As a result, these species and communities are highly vulnerable to even the smallest reductions in water levels on Catfield Fen, and the direct and consequential impacts that may attend such changes. The precise degree of impact resulting from a specific water level change is more difficult to assess. Monitoring is only effective at demonstrating when damage has occurred and therefore is not a useful method in determining whether or not a particular proposal is acceptable. Hence with fens such as Catfield, a precautionary approach should be applied when considering potential hydrological change.

This is particularly so as the site's sensitivity may extend to water level reductions of only a few centimetres,although detailed hydrological and ecological data would be required to be more preciseabout potential impacts of changes to the hydrological regime.