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PIKE WHIN BOG - DECLINE IN WATER LEVELS

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1. INTRODUCTION

Mire ecosystems are subject to the impacts of both natural and artificial changes in their water regimes. It is perhaps tempting for conservationists to assume impacts of the latter kind, especially where (as in the case of East Durham) development pressures surround the sites in question. Many wetlands in the UK are now effectively "islands", completely surrounded by land uses which require drier conditions for success, e.g. arable farming and mineral extraction.

Nevertheless, the climate of the United Kingdom, whilst broadly supportive to wetland development and survival for 10,000 years, is inherently variable, especially east of the Pennines. Drought conditions impact on wetlands in a number of ways (Appendix A). Recent decades have been noted for droughts of varying duration and fortunately hydrological data (particularly rainfall data) are available for the region, dating back into the last century. **Unfortunately, numerical data relating to water levels in wetlands are very scarce and whilst Site Integrity Monitoring has improved the collection of routine observations at SSSI's it is not carried out in relation to quantifiable points in the climatic history and sensitivity of each site.**

This study was carried out during winter 1992-93, a relatively wet period; the working hypothesis must be that, since the site appeared healthily wet during field inspections (allowing water samples to be taken) the drought conditions prevailing in eastern England during 1988-92 must be at least partly the explanation for the subjective impression by EN staff of hydrological change over that period. However, a secondary hypothesis must be that drought stress has potentially compounded an existing human impact, promoting a threshold change, from which recovery may or may not be possible and in which management of both human and drought impacts may play a role.

2. FIELD OBSERVATIONS AND WATER SAMPLING ON SITE

Pike Whin Bog has already received considerable management manipulation in relation to perceived problems of both water quantity and quality. Its conservation interest is held in the face of progressive agriculture over its entire catchment area; it is a perfect example of the failure to conserve ***natural systems*** as opposed to valuable ***habitats***, i.e. of wetlands and their catchments.

Climatological maps reveal that the site can expect ca. 690mm of precipitation in an average year, balanced by an evaporative loss of 490mm, giving a considerable, if seasonal drainage surplus. At the time of visit on 11.12.92

there was considerable inflow, outflow and standing open water on Pike Whin. Nine snipe were put up during the visit. There was also a steady flow in the pipe drainage system around the southern margin of the mire; to the north the drainage system has no inspection chamber. These flows appeared undiminished on a second visit on 30.12.92, after two weeks without further rainfall. The Pike Whin drainage systems (Figure 1) were installed after a considerable problem over threatened agricultural improvements to allow the "arablisation" of the surrounding farmland in 1986. This scheme also threatened to open the ditch through the site. Whilst such overt hydrological damage was avoided, a lingering threat came from nutrient inputs supplied by under-drainage from the intensification of land use (which could not be prevented). At the advice of ADAS, NCC financed cut-off drainage systems around an enlarged SSSI (extended by 10m buffer zones, north and south) to deliver nutrient-rich drainage waters to the outfall from Pike Whin, rather than to the Bog itself - see Figure 1.

Water quality samples taken at the inflow and outflow (Table 1) illustrate fairly typical quality for Magnesian Limestone waters; differences between the two sites probably reflect the higher (calcareous) silt content of the inflow waters. Erosion of the area around a damaged inflow point should be curtailed to reduce the risk of sedimentation of the Bog. On the 30.12.92 visit the major drain inflow to the inspection chamber (i.e. that entering from the south) was sampled and both samples were given crude tests for nitrate and phosphate. In neither case was the nutrient concentration significant; since the flow of the two drains now bypassing the site was approximately equal to the outflow of Pike Whin on the day it could be that the Bog may be deprived of half its normal winter recharge without chemical justification.

3. EXPLANATIONS OF THE PERCEIVED DRYING OF PIKE WHIN BOG

3.1 General hydrological conditions, 1988-92

The 1991 Yearbook entitled "Hydrological Data UK" (IH/BGS, 1992) makes some salient points in relation to our region. After remarking that the 22-month period ending in December 1991 was the second driest for the whole of England and Wales since records began in 1767, the Yearbook concentrates a lot of attention on eastern England (extending well north - to Northumberland). It concludes that, "long term rainfall deficiencies across a large proportion of eastern Britain - already substantial at the end of 1990 - increased over 1991 as a whole".

3.2 Local hydrological conditions

Whilst the drought period in question (1988-92) has received more media attention in the <u>south</u>-east through its affect on groundwater supplies and surface streams fed from groundwater it has been no less severe in the north-east; public attention in this region has been diverted from the topic because rainfall totals have increased during this period over the Northern Pennines, whence come our public water supplies from surface reservoirs, e.g. Kielder. For example the Yearbook's map of rainfall in 1991 shows 75-85% of normal for the coastal strip of the north-east but 110-120% over the Pennines (Figure 2). Figure 3 shows the soil moisture deficits developed under grass covers in north Northumberland for the years 1987-91, bringing out the joint impacts of both reduced rainfall and increased potential evaporation towards the end of this period.

Wheeler (1990a) quantifies the effect of the "rain shadow" to the east of the Pennines in this region, suggesting that it is independent of altitude, that moisture deficits in the airstream are not made up by evaporation from the surface and that the "shadow" is at a maximum in autumn (minimum in spring and summer when convective activity can compensate).

Wheeler (1990b) analyses the very dry year of 1989 in the north-east; assigning the Sunderland rainfall total a rarity of once in 700 years he suggests that it was a return to strong south-westerly and westerly winds (a possible feature of the enhanced "Greenhouse Effect") which brought into play the rain "shadow", resulting in drought. The point must be addressed, therefore, that north-east wetlands may now be entering an era of prolonged climatic threat; ameliorative management is therefore essential.

Table 2 shows a more local breakdown of annual rainfall data for the last four to five years.

TABLE 2
ANNUAL RAINFALL FIGURES FOR NEWCASTLE AND DURHAM UNIVERSITIES, 1988-91 (and including up to November 1992)

Year	Newcastle	%long term	Durham	%long term
1988	651mm	97	655mm	101
1989	362	54	353	54
1990	513	77	508	78
1991	462	69	460	71
1992 (part)	598	98	464	96

In order to put the recent dry spell into a longer term perspective, Figure 4 uses the University of Durham's very long record of observations and a calculation of both mean and standard deviation to show that 14 of the last 22 years have been drier than average, with 1989 and 1991 beyond the standard deviation of the data. 1989 was the driest year on record in both Durham and Sunderland (Wheeler, 1992); the decade 1980-89 was the driest in a record which dates back to 1859.

Figure 3 also separates out the spring season (March-May inclusive) because dry springs are particularly harsh on wetland plant communities needing a competitive advantage over invasive species; surface water is especially useful to wetlands during spring when transpiration may not be at the potential rate. Whilst the three recent drought years have also had dry springs there is no indication from this graph that spring rainfall has had a particular impact; it is more likely to be a sequence of "good", dry, sunny summers which has exacerbated to impact of the three dry years.

The recovery shown in 1992 is remarkable; for the Newcastle record (Figure 5) the sequence of four wetter-than-average months (August-November 1992) has not been repeated since the period February-May 1983.

4. ALTERNATIVE EXPLANATIONS FOR THE DRYING OF PIKE WHIN BOG

The ADAS drainage survey of the site (ADAS, 1086) did not locate existing drains; these were mapped on the advice of the landowner. In fact the existing drainage network in the neighbourhood is well shown in aerial photographs taken in 1968 and 1971. These impinge close to the north but not, apparently to the south.

ADAS estimates the catchment area to the lower end of Pike Whin SSSI (area 1.25ha.) as being 30 ha, on the basis of contours.

It was suggested that the new main drains should intercept the discharge of existing systems and surface runoff (via a permeable backfill) where appropriate. The latter strategy is only apparent on the north side where the surface slope is steeper.

Whilst it is difficult to have confidence about catchment definition (as ADAS admit) it is clear that the protective drainage system has reduced the potential for inflow to the SSSI from its natural catchment. To the north both surface and subsurface runoff from approximately 3.4 ha (11% of the total catchment) has been diverted and to the south subsurface drainage only has been diverted from 9.7ha (32% of the catchment). The aerial photographs suggest, however, that these circumstances were not new to the 1986 scheme (completed in 1988)- pre-existing drainage did essentially the same job, though perhaps not in repsect of surface flows from the northern portion.

Pike Whin is therefore deprived of almost half its potential inflows, apparently a highly damaging situation. However, one must consider the following points:

a. The pre-existing drainage (i.e. diverting water from the Bog) may have existed since the 19th Century and so any recent "drying" may be more due to either the efficiency of the new scheme or to climate,

b. The ratio of catchment area to mire area at Pike Whin is fairly generous, i.e. 24 to 1. Because of this it is highly likely that much of the former inflow volume under "natural" conditions was transmitted rapidly through the surface water storage of the site to the outflow stream (now drain). A decline to the ratio of 13.5 to 1 may not be seriously depleting to the wetness of the site, though this is for biologists to debate.

If the condition of Pike Whin in 1986 was sufficiently wet to appear to the landowner to be a drainage hazard I would assume that this impression, together with the good volume of winter recharge observed on 11.12.92, means that the long-term viability of a wet fen in this situation is not in doubt. However, there may well have been an alteration to the ***duration*** of saturation and surface standing water at the site as the result of peripheral drainage and this can be remedied by more purposeful use of the outfall sluice.

5 CONCLUSIONS AND RECOMMENDATIONS

By the prevailing political economy of conservation in the United Kingdom it has been impossible to gain control of the surface and subsurface hydrological catchment of Pike Whin Bog, despite this being the strategic judgement of English Nature and the specific recommendation of Dr Foyt for the site.

Nevertheless, a system of protecting the Bog from the undesirable water quality effects of runoff from arable agriculture appears to have been successful, without chemical checks being made of the original assumption of a eutrophication risk. The problem with the scheme is that it has coincided exactly with a dry period (1988-92) only recorded once before in 200 years.

Recommendations for the future management of the site are as follows:

a. Retain the aim of **acquiring catchment control**,

b. In the interim the existing drain diversions should be retained in the interests of water quality protection, though the **quality of water in the subsurface drains to the south should be checked** from time to time,

c. In the interim there is some flexibility in the management of open water and saturated conditions on Pike Whin. The outfall sluice does not, apparently control upstream water levels effectively because the bunds on either side of the central stream are not effective - that on the north side appears to allow bypassing of any sluice-locked water. Similarly, there are opportunities for careful schemes of water spreading from the existing core areas of open water towards the inflow end of the bog to "irrigate" other parts; first a regular record should be kept of the distribution of surface water (photography will suffice).

d. The inflow pipe should be repaired and reconstituted to avoid soil erosion in high flows and consequent deposition of silt within the site; the settling pond at the east end of the site does not remove much of the finest material as we observed on 11.12.92.

e. Some form of hydrological monitoring of water depths, as well as extents, is required. A transect of dip-wells north-south across the centre of the site would be useful and there are already gauge boards for standing water at the inflow and outflow (data are mentioned for Site Integrity Monitoring visits in 1988 but not since).

f. The timing of Site Integrity Monitoring should be organised with a view to obtaining observations during both very dry and very wet conditions (see Appendix B).

References

Wheeler D A 1990(a) Modelling long-term rainfall patterns in north-east England. Met. Mag., 119, 68-74.

Wheeler D A 1990(b) Climatic change in Sunderland? Weather, 45(6), 229-231.

APPENDIX A

Potential impacts of drought conditions on wetland flora

A drought is not a drought, is not a drought! The term covers a huge variety of dry conditions of varying intensities and durations, most of which are fairly specific in relation to elements of the wetland habitat and will vary in their impact according to the main water source (i.e. especially precipitation and seepage). We may roughly delimit the following classes:

a. A dry summer season - a "farming drought" or memorable holiday season. Reduced precipitation leading to soil dessication, exacerbated by increased potential evapotranspiration. Die-back of sensitive species, e.g. Sphagna. Surface dessication/oxidation of peat. Danger of fire. Less impact where groundwater is main supply and good recharge the previous winter,

b. A sequence of dry years - a "water-supply drought". Reduced groundwater seepage to fens and valley mires. Progressive and irreversible cracking of peats and clays and vegetative change as the result of changed competitive situation,

c. Dry spring seasons in which lack of surface water gives competitive advantage to drier-loving species whose taller canopy then increases evapotranspiration during the subsequent summer. This is a second-order effect,

d. Third-order effects brought about by increased access to wetland, visitor and grazing pressures and the danger of fires which may damage vegetation and, more seriously, peat.

APPENDIX B

Site Integrity Monitoring and hydrological change

Whilst there are clearly excellent biological reasons for choosing a particular date for Site Integrity Monitoring and even more pressing reasons of time management, access and convenience, it is suggested here that Monitoring could fairly easily be guided, for wetland sites in a hostile climatic environment, by hydrological sequences. The implications for Pike Whin Bog are shown in Figure 5.

As an initial proposal we might list four conditions under which Site Integrity Monitoring would be useful. Were it not possible to map standing water or measure dip-well levels monthly (as advised elsewhere in this report), these periods would also be appropriate for such measurements.

The conditions are:

a. After any three winter or summer months with less than 60% of average precipitation (autumn is less important unless it follows a dry summer),

b. After any six consecutive months with below average precipitation (no specified shortfall),

c. After any two spring months with less than 60% of average precipitation,

d. After any two consecutive months with greater than 150% of average precipitation.

The "surplus" criterion is deliberately set higher than the "deficit" because surpluses of this magnitude are approximately of the same probability over a two-month period. The two-month period is also chosen for spring because of the sensitivity of plant competitive stresses in this season.

The definition of seasons followed by hydrologists is as follows:
Winter: December, January, February,
Spring: March, April, May,
Summer: June, July, August,
Autumn: September, October, November

Figure 1: Pike Whin Bog and the diversion drains designed to protect it from agricultural chemicals.

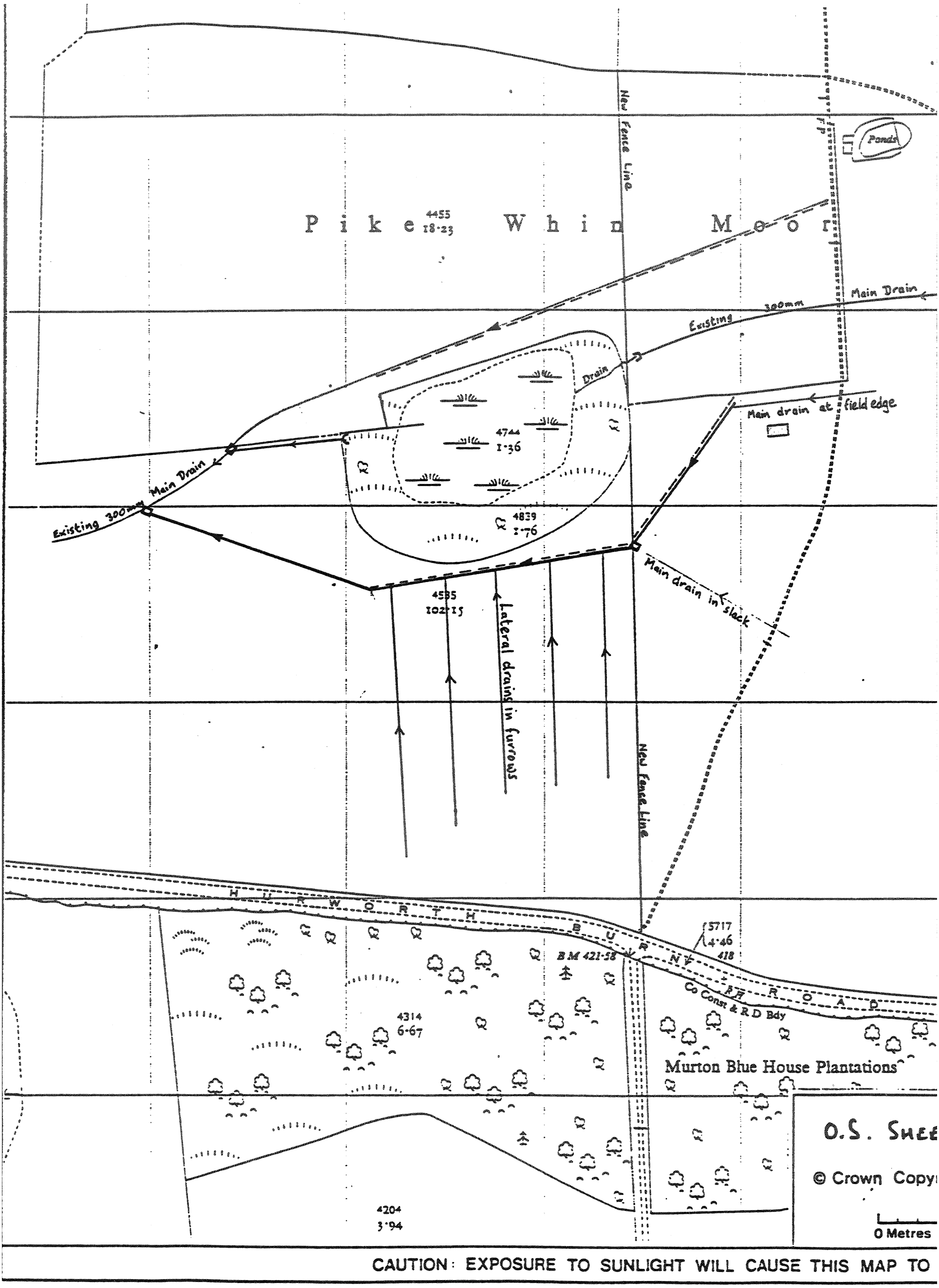
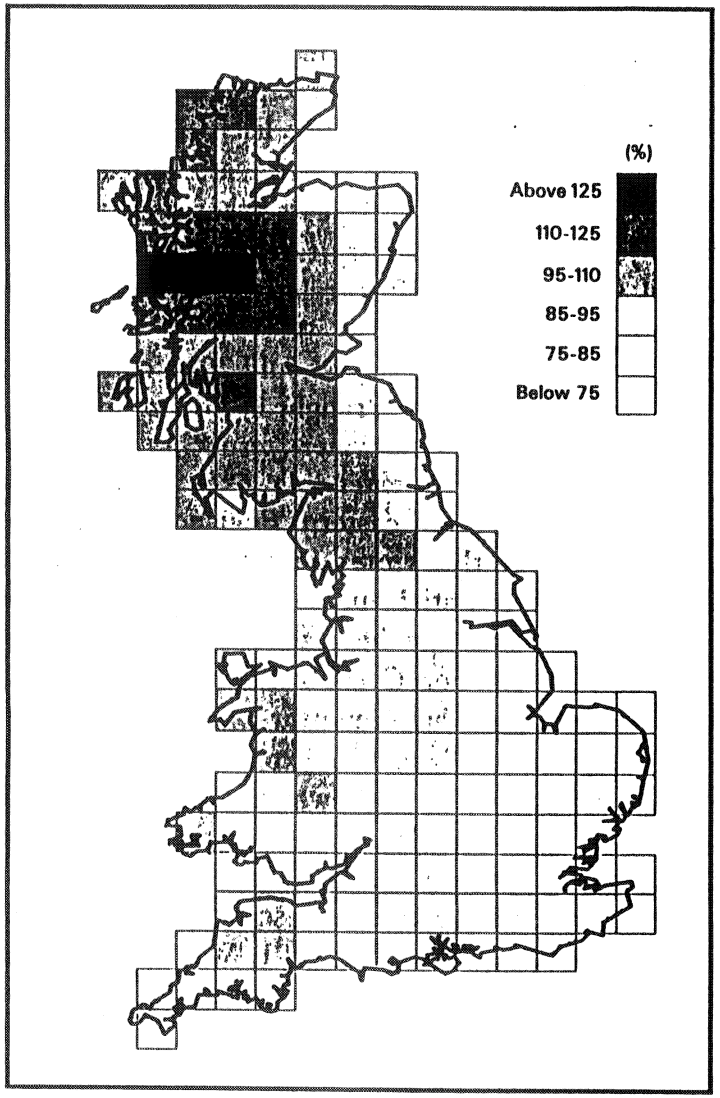


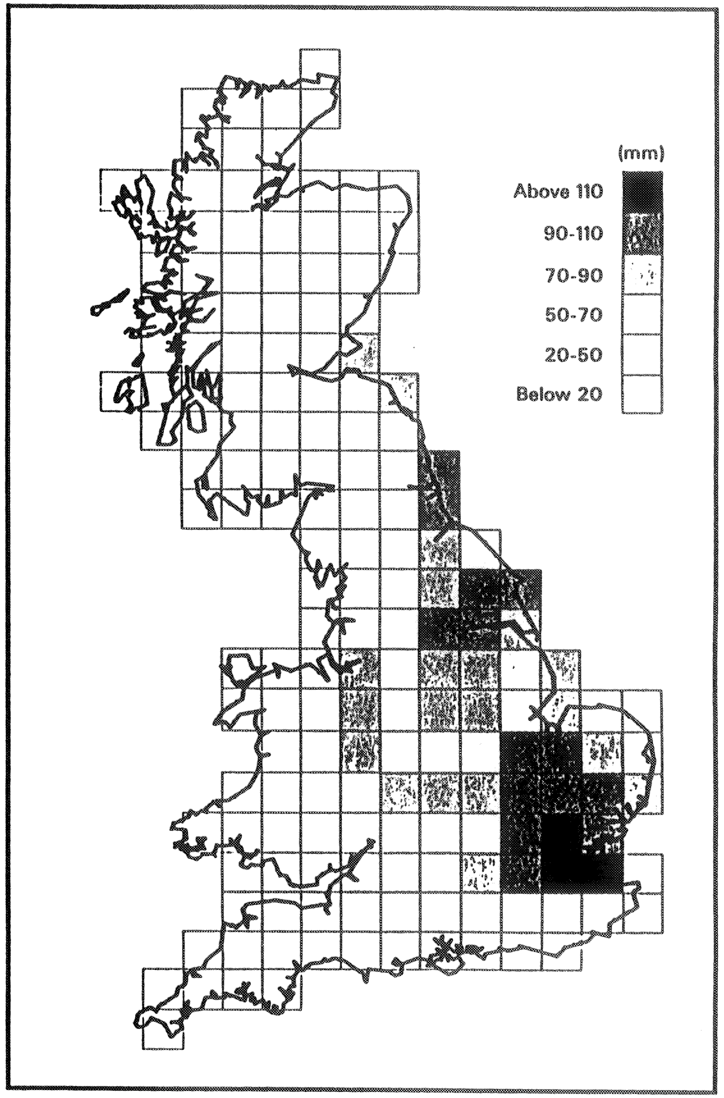
TABLE 1
CHEMICAL ANALYSES OF WATER SAMPLES FROM PIKE WHIN BOG

11.12.92	pH	Con	Ca	Mg	Na	K	Pb	Zn	Cu	Mn	Fe
Pike Whin Inflow	7.8	700	70	16	21	2.8	0.16	0.067	0.49	0.22	1.33
Pike Whin Outflow	7.3	400	40.9	11.8	12.9	3.9	0.1	0.082	0.58	0.21	2.84

30.12.92	pH	Con	Ca	Mg	Na	K	NO_3^-	P	Pb	Zn	Cu	Mn	Fe
Drain Inflow Pike Whin	7.5	660	68.9	22.4	20.53	0.95	<10	<15	0.1	0.11	0.19	0.1	0.89
Outflow Pike Whin	6.9	600	57.6	19.2	20.58	4.27	<10	<15	0.1	0.13	0.24	0.1	0.75

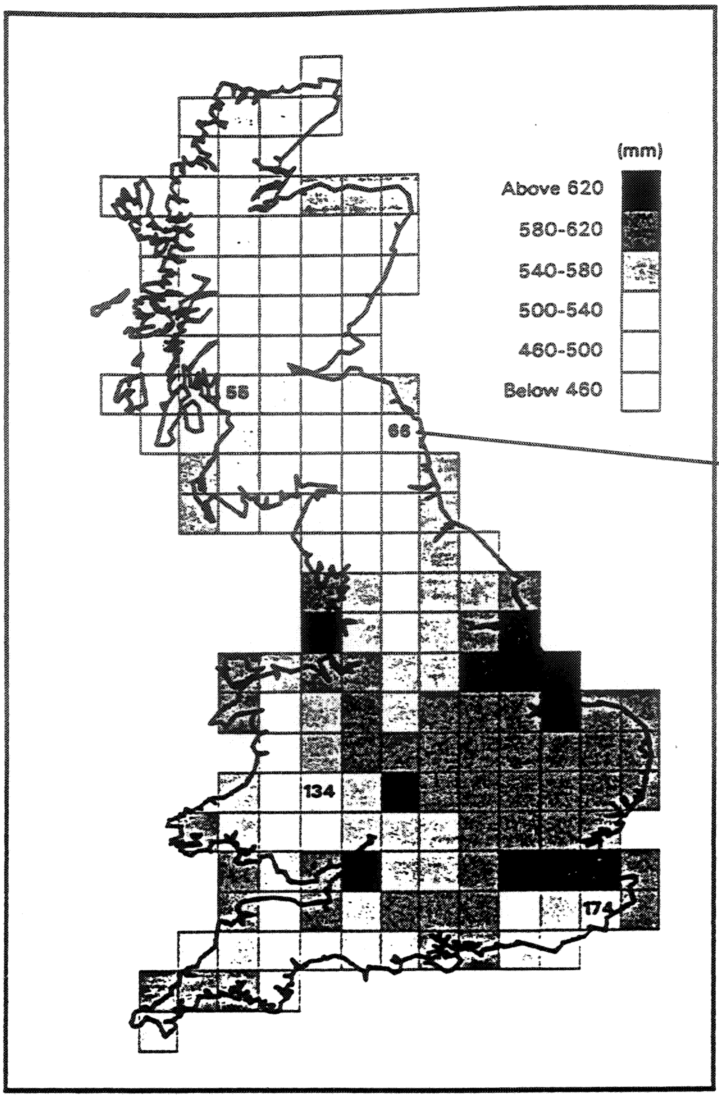


August 1988 to December 1991 rainfall as a percentage of the 1961–90 average

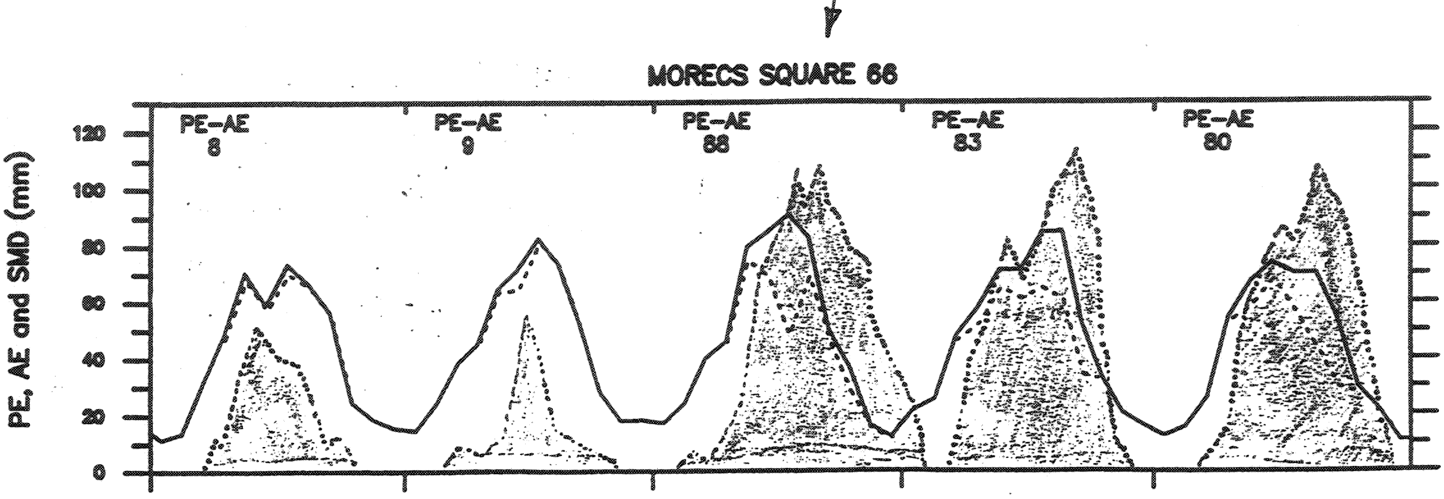


Soil moisture deficits (for a grass cover) at the end of October 1991 Data source: MORECS

Figure 2: The 1988-91 drought - rainfall and soil moisture deficits (maps from the Surface Water Archive, Institute of Hydrology, Wallingford).



Potential evaporation (for a grass cover) in 1991
Data source: MORECS



Solid line: potential evapotranspiration
Dashed line: actual evapotranspiration (as modified by deficit in soil)
Shaded area: Soil Moisture Deficit

Figure 3: Drought in north Northumberland as seen by potential and actual evaporation rates and soil moisture deficit (data from the Surface Water Archive, Institute of Hydrology, Wallingford).

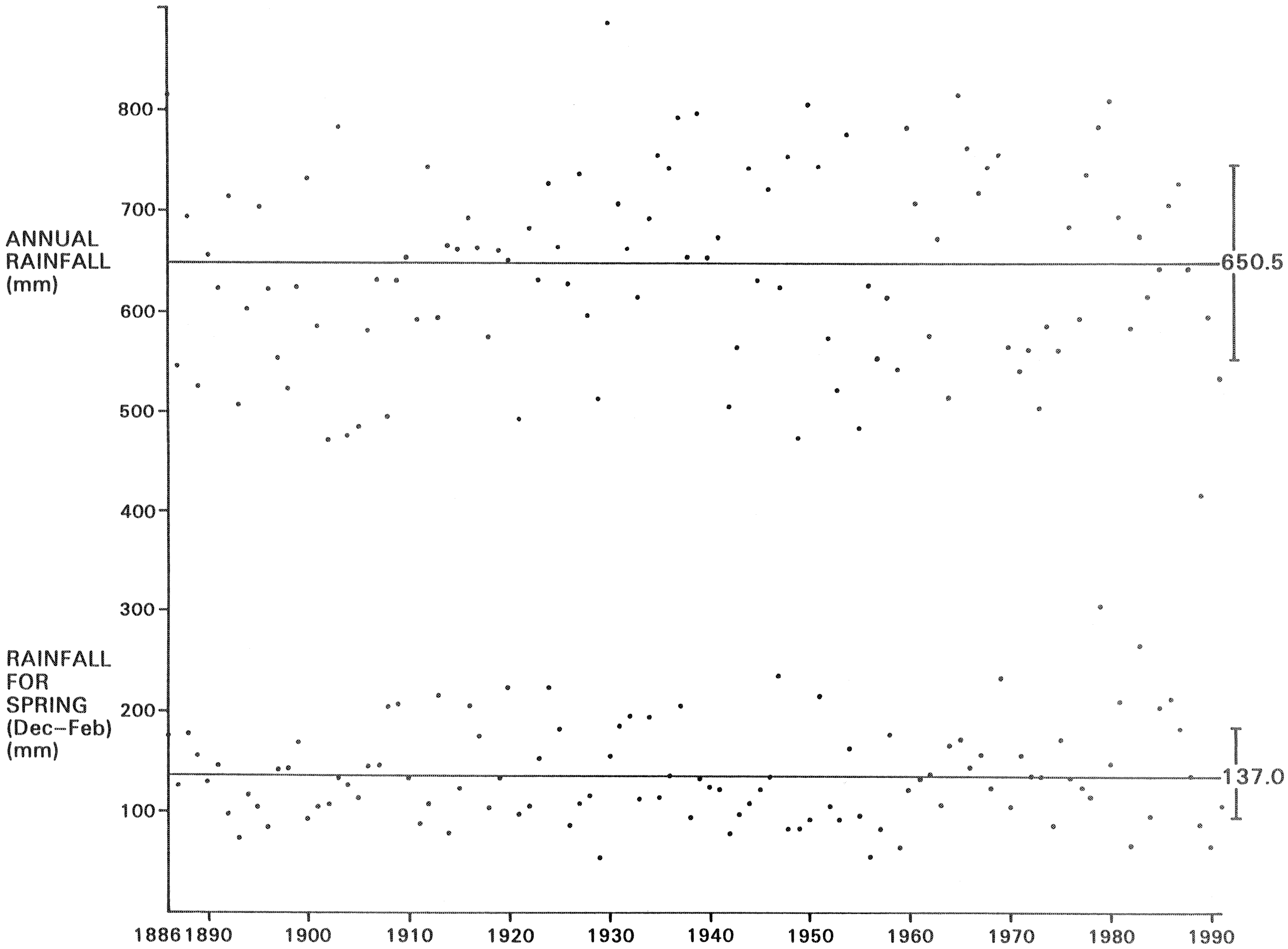


Figure 4: Rainfall totals (annual and spring season) for Durham Observatory, 1886-1990. The bars at the r.h.s. show mean and standard deviation.

Figure 5: Newcastle University monthly rainfall figures 1988-1992, showing actual Site Integrity Monitoring visits and those suggested by a hydrological prompt scheme.