The flora of the marl-pits (ponds) in one Cheshire parish

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ABSTRACT

All the 153 ponds present in the 13 km^2 area of Christleton parish (Cheshire) were assessed for various physical characteristics and for age. Positive associations were established between degree of shading and age of pond, alkalinity and age, and alkalinity and percentage of open water. The herbaceous, macrophyte species were recorded for each pond. High numbers of species were associated with large, unshaded ponds with a moderate amount of open water. Some of the common individual species showed positive associations with certain physical characteristics of the ponds. 41% of the ponds in the parish have been lost since 1844. A simulation of the effect of pond loss on the numbers of plant species indicated that from 1844 to the present only seven species may have been lost, but if ponds continue to disappear this will have a much more drastic effect on the pond flora in the future.

INTRODUCTION

This study was carried out in 1971–72 as a part of a general parish natural history survey which involved recording the land use of the fields and all trees, hedges, etc. in the parish of Christleton, 3 km from Chester. It became apparent during the study that in this parish, as in the rest of this part of the Cheshire plain with its intensive farming, rigorously trimmed hedges and shortage of woods, the old marl-pits (now ponds) were much the richest areas for wild life. Indeed, the Cheshire marl-pits have been noted for this for many years.

The origin of marl and the history of marl digging have been covered by Day *et al.* (1982) and many of his comments apply to Christleton parish. Ponds in this part of Cheshire, as in Lancashire, betray their origin by being known locally as 'pits' rather than 'ponds' and one exceptionally large one of 8400 m^2 in the village of Christleton itself is called 'The Pitt'. However in this paper the word pond is used throughout.

There have been a number of studies of the flora of flooded marl-pits (e.g. Edmondson 1967) and in most of these the study area has been extensive and only certain ponds within the area have been selected for study. For example, in the Fylde of Lancashire 62 ponds out of about 4000 were selected to study flora distribution by tetrads, in the Lower Dee Valley about 400 ponds in five study areas were selected to assess the flora and determine a method of evaluating conservation interest and in the Wirral 52 ponds, likely to be of conservation interest, were selected (Day 1981; Day *et al.* 1982).

In contrast the Christleton study covered only a small area but every pond site found on any map from the tithe map of 1844 onwards was visited and if the pond still existed the flora was recorded. The two methods of study, sample ponds chosen from a large area and the examination of every pond within a small area, were thus complementary and a comparison of results obtained by the two methods may prove helpful in planning future surveys of this type.

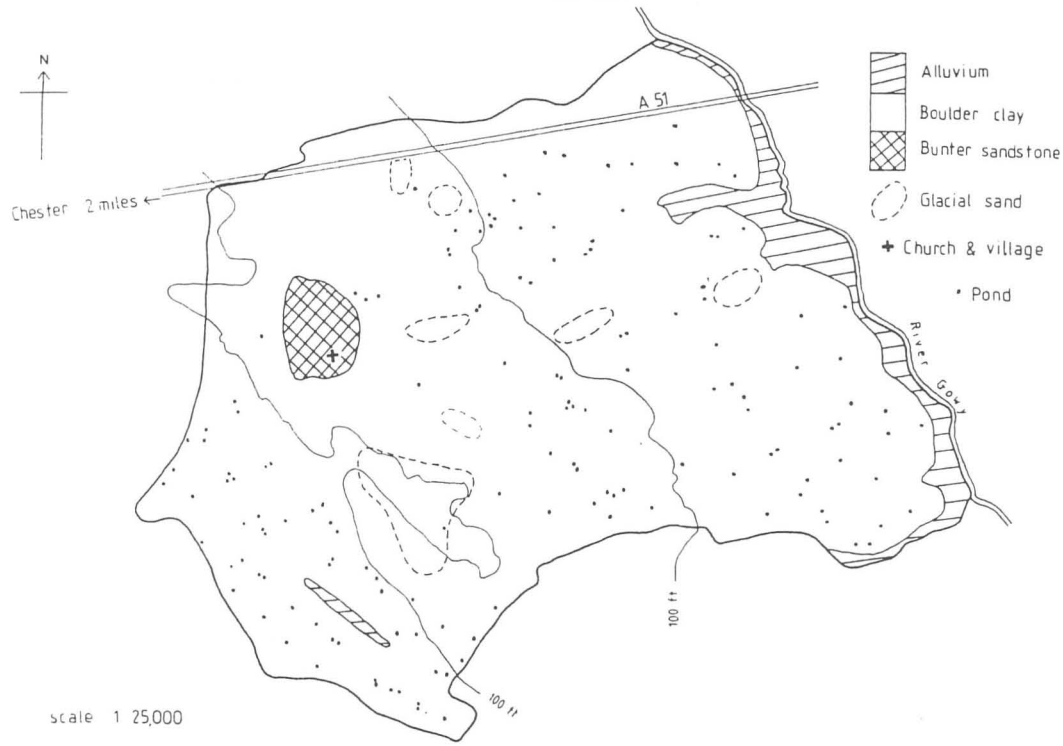

FIGURE 1. The distribution of ponds in the parish of Christleton, Cheshire.

METHODS

The study area (12.8 km^2) comprised the whole of Christleton parish, GR 33/45.66, excluding a small part with four ponds north of the A51, GR 33/465.675. The parish is low lying and slopes to the River Gowy on the east and towards the River Dee on the west. Most of the area is covered by boulder clay but there is a band of New Red Sandstone across the parish on which the church and village are built. The marl-pits were dug in the boulder clay areas (Fig. 1). Details from the five ponds in the parish that were not marl-pits in origin have not been included in this paper.

During 1971 and 1972 every field in the parish was examined thus ensuring that every existing pond was found, including a few which, while giving every indication of being as old as the other ponds, were not marked on any map. Each of the 153 ponds found was given a reference number within each tetrad thus conforming with other plant recording projects in the county. Five characteristics were recorded in the field for each pond and a sixth, age, was estimated from maps. A list was made of all herbaceous macrophyte species associated with aquatic habitats that were present but their abundance was not recorded (Table 1). Trees were also recorded but have not been included in the analysis except in so far as they may have cast shade on the ponds.

Brief notes were made on animals seen and factors of conservation interest, extent of dumping, if any, and use of the pond for angling or shooting. Some of the ponds were surveyed more than once within the growing season but the differences found on successive visits were not large enough to warrant second visits to all ponds. All the information has been deposited at the Cheshire County Record Office, Chester, together with the other data from the Christleton Parish Survey.

The methods used to record and categorize each of the six pond characteristics are described below and listed in Table 2.

Degree of shading. This was estimated by eye in the field to the nearest 10%, taking into account the height of any trees, how close they were to the water and their position relative to the pond and

TABLE 1. NUMBER AND PERCENTAGE OF PONDS IN WHICH THE DIFFERENT SPECIES OCCURRED

Species	Occurence in ponds Number	%
Alisma plantago-aquatica	109	71
Angelica sylvestris	2	1
Apium inundatum	3	2
A. nodiflorum	15	10
Berula erecta	43	28
Bidens cernua	41	27
B. tripartita	6	4
Butomus umbellatus	1	1
Callitriche spp.	40	26
Caltha palustris	5	3
Cardamine pratensis	32	21
Carex acutiformis	1	1
C. pseudocyperus	24	16
C. otrubae	3	2
C. riparia	1	1
Cicuta virosa	8	5
Eleocharis palustris	11	7
Elodea canadensis	17	11
Epilobium hirsutum	64	42
E. parviflorum	7	5
Eriophorum angustifolium	1	1
Filipendula ulmaria	5	3
Galium palustre	52	34
Glyceria fluitans	2	1
G. maxima	1	1
Hottonia palustris	4	3
Hydrocharis morsus-ranae	22	14
Hydrocotyle vulgaris	8	5
Hypericum tetrapterum	4	3
Iris pseudacorus	25	16
Juncus acutiflorus	24	16
J. bufonius	5	3
J. effusus	91	60
J. inflexus	70	46
Lemna gibba	2	1
L. minor	104	68
L. polyrhiza	4	3
L. trisulca	18	12
Lotus uliginosus	25	16
Lychnis flos-cuculi	7	5
Lycopus europaeus	15	10
Lythrum salicaria	5	3
Mentha spp.	7	5
Menyanthes trifoliata	3	2
Myosotis laxa subsp. *caespitosa*	8	5
M. scorpioides	38	25
Nasturtium officinale	19	12
Nymphaea alba	2	1
Oenanthe fistulosa	41	27
Polygonum amphibium	4	3
P. hydropiper	1	1
Potamogeton berchtoldii	1	1
P. obtusifolius	1	1
P. natans	61	43
Potamogeton sp.	2	1

TABLE 1. *continued*

Species	Occurence in ponds Number	%
Potentilla palustris	14	9
Ranunculus aquatilis	7	5
R. sceleratus	58	38
Rorippa amphibia	1	1
R. islandica	1	1
Rumex hydrolapathum	2	1
Scrophularia auriculata	14	9
Scutellaria galericulata	1	1
Solanum dulcamara	84	55
Sparganium emersum	5	3
S. erectum	88	58
Stachys palustris	2	1
Stellaria alsine	2	1
Typha angustifolia	5	3
T. latifolia	34	22
Veronica beccabunga	21	14
V. catenata	2	1
V. scutellata	1	1
Azolla filiculoides	4	3
Equisetum fluviatile	28	18
Aulacomnium sp.*	3	2
*Calliergon cordifolium**	1	1
Fontinalis antipyretica	1	1
Polytrichum sp.*	3	2
Riccia fluitans	2	1
Ricciocarpus natans	4	3
Sphagnum spp.	4	3

* Bryophytes that were only recorded when very abundant.

TABLE 2. THE PHYSICAL CHARACTERISTICS OF THE PONDS AT THE TIME OF THE SURVEY

Characteristic	Category	Number of ponds	% of ponds
Shading	unshaded	87	57
	medium shade	40	26
	very shaded	26	17
% open water	91–100	33	22
	10–90	81	53
	0–9	39	25
pH*	below 6.0	7	5
	6.0–8.9	97	63
	over 9.0	27	18
Size in hectares	below 0.04	89	58
	0.04–0.08	46	30
	over 0.08	18	12
Age	dug before 1844	78	51
	dug after 1844	30	20
	'marsh ponds'**	45	29
Fence	present	40	26
	absent	113	74

* The pH was not recorded for 22 (14%) ponds.
** 'marsh ponds' are those that started as ponds but at some intermediate period of their existence have been marked on a map as marsh rather than open water.

especially whether any were on the south side. Ponds were finally classified as unshaded (0–9%), medium shade (10–90%) and very shaded (over 90%).

% of open water. This was estimated in the field by eye to the nearest 10% but for analysis the ponds were grouped into three categories: 0–9%, 10–90% and 91–100% open water. Most of the ponds were visited during the height of the growing season so that the results would be comparable.

pH. This was estimated in the field using Universal Indicator and for analysis the ponds were grouped into those with acidic (below pH 6.0), neutral (pH 6.0–8.9) and alkaline (over pH 9.0) water.

Size. The area of each pond was measured from the 1:10560 O.S. map, 1911 and 1913 editions, and the ponds were grouped into small (below 0.04 ha), medium (0.04–0.08 ha) and large (over 0.08 ha).

Age of pond. The presence or absence of each pond recorded in the 1971/72 survey was followed from the first map on which it appeared starting with the tithe map of 1844 and through five editions of O.S. maps. The majority of the ponds were present on the tithe map and, since these could have been dug very much earlier than this date, it was decided to divide ponds into two age groups only, those made before and after 1844. However, an interesting third group emerged from the map study. Some of the ponds were marked as open water on both an early map and on a later one but at some intermediate period were marked as marsh. 45 ponds fell into this category and are referred to subsequently as 'marsh ponds'. The cause of these changes is not known but it is unlikely to be associated with changes in the general level of the water table since this has been falling steadily over the period in question and the water level in the ponds represents a perched water table.

Presence or absence of a fence. Fences were found in various stages of decay. A pond was recorded as fenced if cattle were effectively excluded from the margin of the pond and grazing thus prevented.

RESULTS

RELATIONSHIPS BETWEEN THE VARIOUS PHYSICAL CHARACTERISTICS

Table 2 shows the various characteristics, their categories and the number and percentage of ponds found in each. Chi-squared tests were carried out for each of the possible pairs of variables to determine if they were associated. The results of these are shown in Table 3 and comments on the significant associations are given below.

Degree of shading and age. A highly significant positive association shows that the older ponds dug before 1844 were more shaded than those dug later. This result was to be expected since the longer a pond had been present the more chance there would have been for colonization of the banks and tree growth. It also implies that although the date chosen to divide the ponds into two age groups was arbitrary it has real meaning and the older ponds must have been dug well before 1844 since even the younger ones were mainly dug soon after that date.

Degree of shading and presence of a fence. This positive association was also to be expected since a fence, by preventing cattle grazing, gives trees a chance to become established. Shaded ponds now unfenced may well have been fenced at some earlier date.

% of open water and pH. A positive association was found between % of open water and pH; open water tended to be alkaline whilst ponds with little open water tended to be acidic. Certainly the most acidic ponds found were those where the centre was covered with *Sphagnum*. These ponds formed a very distinct group and would seem to represent very small floating bogs (*Schwingmoor*). Day (1981) found only two ponds with *Sphagnum* spp. whereas in the much smaller area of this survey there were four. Sinker (1962) reported a "miniature example" of a *Schwingmoor* in Shropshire where the surface had been completely overgrown by *Sphagnum* in the course of 50 years. These ponds may have misled the O.S. surveyors and one at least, although quite deep at the time of the survey, was marked on a recent map as a marsh.

Age and pH. The older ponds were significantly more alkaline than the post-1844 ponds. An explanation of this might be that marl was first dug in areas of the parish known to be the most lime-rich and that the practice spread to the less lime-rich areas at a later date until over half the fields came to have their own marl pit.

TABLE 3. RELATIONSHIPS BETWEEN THE PHYSICAL CHARACTERISTICS OF THE PONDS AND THE TOTAL NUMBER OF SPECIES PER POND

Chi-squared values are given in the top, right section of the Table and their probabilities, where significant, in the bottom, left section.

	Shade	% open water	pH	Size	Age	Fence	Number of species
Shade	—	1.37	1.70	1.84	15.36	6.50	13.80
% open water	NS	—	6.83	3.61	2.61	0.88	12.22
pH	NS	<0.01	—	0.18	8.04	3.41	0.20
Size	NS	NS	NS	—	11.58* 0.74	4.44	15.70
Age	<0.001	NS	<0.01	<0.01* NS	—	0.01	0.75
Fence	<0.02	NS	NS	NS	NS	—	0.54
Number of species	<0.001	<0.001	NS	<0.001	NS	NS	—

* The top figure shows the relationship between size and 'marsh' or 'non-marsh' ponds, the lower figure the relationship between size and pre- or post-1844 ponds.
NS Not significant.

The size of marsh ponds. The size of ponds was not associated with any of the other physical characteristics measured, except that those ponds that at some stage in their history had been marshes were significantly smaller than ponds that had always been open water. Probably smaller ponds would also have been shallower and thus more likely to turn into marshes than larger ponds if the water supply was in some way restricted.

RELATIONSHIPS BETWEEN THE NUMBER OF PLANT SPECIES IN A POND AND ITS PHYSICAL CHARACTERISTICS

There is general agreement that the more species there are present in an area the more valuable that area is likely to be for conservation. Consequently the relationships between the total number of herbaceous macrophyte species in a pond and each of the physical characteristics listed above was also determined. To obtain numbers suitable for analysis the ponds were divided into only two, roughly equal, groups, those with 0–9 species and those with 10–24 species. The results are included in Table 3.

Shading. There was a highly significant association between the number of species and the degree of shading, the unshaded ponds having more species. This was to be expected and agreed with the findings of Day (1981). It was for this reason that Day *et al.* (1982) decided not to survey shaded ponds.

% of open water. There was a highly significant association between the total number of species and the % of open water but in this case most species were found in the intermediate category of 10–90% open water. The explanation of this perhaps lies in the fact that these ponds are at an intermediate stage of the hydrosere and so have the largest range of water plants. Ponds with over 90% of open water lacked emergent water plants around the edge and ponds with under 10% lacked submerged and floating plants.

Size. There was a highly significant association between total number of species and size, the larger ponds having the most species. This agreed with Day's (1981) study in Clwyd and is a relationship found in other types of habitat.

Age of pond. No association was found here. This was in disagreement with the results of Godwin (1923) who found a steady increase of species with age. However all his ponds had been dug more recently than the Christleton ponds, the oldest being less than 100 years old. In contrast, all the Christleton ponds would have had time to reach a stable number of species. In addition, any changes in water level, for which there is some evidence, would mean that the stage in the hydrosere reached by any one pond would not be related to the age of the pond. Periods of changed water level have been shown to alter the plant community elsewhere in Cheshire (Willis &

Young 1983) and in Czechoslovakia (Dykyjová & Květ 1978). In the woodland habitat too it has been reported that there is no evidence for an increase in plant diversity with woodland age (Reed & Grove 1981).

To summarize, in general, the ponds with the most diverse flora were those of a good size with only a moderate amount of open water and unshaded, with trees, if present, on the north side.

RELATIONSHIPS BETWEEN INDIVIDUAL PLANT SPECIES AND THE PHYSICAL CHARACTERISTICS OF THE PONDS

The relationship between each of the individual plant species and each of the six physical characteristics of the ponds was determined by chi-squared tests. Only five species were found to be positively associated with individual physical characteristics, all at the $P<0.05$ level.

Alisma plantago-aquatica, *Lemna minor* and *Potamogeton natans* were all positively associated with 10–90% open water. *Oenanthe fistulosa* and *Typha latifolia* were positively associated with large ponds. Thus many of the commoner species apparently had no preferences. There were indications that many of the less common species favoured certain physical characteristics of the ponds but they occurred in too few ponds for analysis. There was therefore every indication that further work of a similar sort on a larger area with more ponds would yield worthwhile results.

THE LOSS OF PONDS AND THE LOSS OF POND FLORA

There is a good deal of information on the loss of ponds in recent years and this has been summarized in Day *et al.* (1982) for different parts of the country. In Christleton parish the figures for total number of ponds at different dates are as follows: 1844 – 263 ponds; 1908 – 237 ponds; 1972 – 156 ponds (Latham 1979). From these figures it is apparent that the rate of loss has increased considerably. In the 64 years from 1844–1908, 26 ponds disappeared while in the same period from 1908–1972, 81 ponds disappeared. If the trend were to continue in the future there would be few ponds left by the year 2250 unless new ponds were made. Of the 81 lost ponds, 57 have reverted to pasture, some naturally, some after deliberate infilling, 13 are rubbish dumps and eleven have been replaced by buildings.

From the results of the survey it is possible to estimate the effect of future loss of ponds on the total pond flora by using the data for each pond. The effect of the loss of varying numbers of ponds on the total pond flora of the parish was simulated by removing different numbers of ponds, taken at random from the data set, and recording the total number of species remaining. Each simulation was repeated four times and the average number of species 'lost' was recorded. The results are shown in Fig. 2 where an empirical curve has been fitted to the points.

These results show that the number of species remaining declines more rapidly as more ponds are lost since the gradient of the curve becomes greater as the number of ponds decreases. In 1844, 263 ponds were marked on the tithe map and it is estimated that these would have contained 97 species, while in 1908, when there were 237 ponds marked on the map, there would have been an estimated 95 species. Since the curve flattens out very considerably, even had there been a much larger number of ponds in the more distant past, this might not have meant very many more species in total. Presumably there is a limit to the number of species that would grow under the prevailing physical and climatic conditions.

Because of differences in the methods of recording it has only been possible to find where the results of one other comparable survey of marl-pits would fall relative to the curve in Fig. 2. Day (1981) recorded the total number of species from 405 ponds in Clwyd. When some species are omitted from his list because, even if present, they would not have been recorded in the Christleton survey (e.g. *Salix* spp.), his survey area falls quite close to the extrapolated curve.

On the other hand, Godwin's Derbyshire ponds (1923) had a much richer flora while the ponds surveyed by Jones (1971) in Leicestershire had a much poorer flora. Points for both these are shown on Fig. 2. Neither of these sets of ponds owed their origin to marl digging.

If it is assumed that the extrapolated curve gives a reasonable estimate of the situation in the past then between 1844 and the time of the survey in 1971 only about seven species may have been lost in the parish although over 100 ponds have gone. In contrast the loss of a further 100 ponds might mean the loss of nearly 30 species. Although these figures have been derived from a simulated exercise they do show the urgency of preserving as many as possible of the ponds that still remain. If action is taken now it is probably not too late to preserve the bulk of the flora of the ponds.

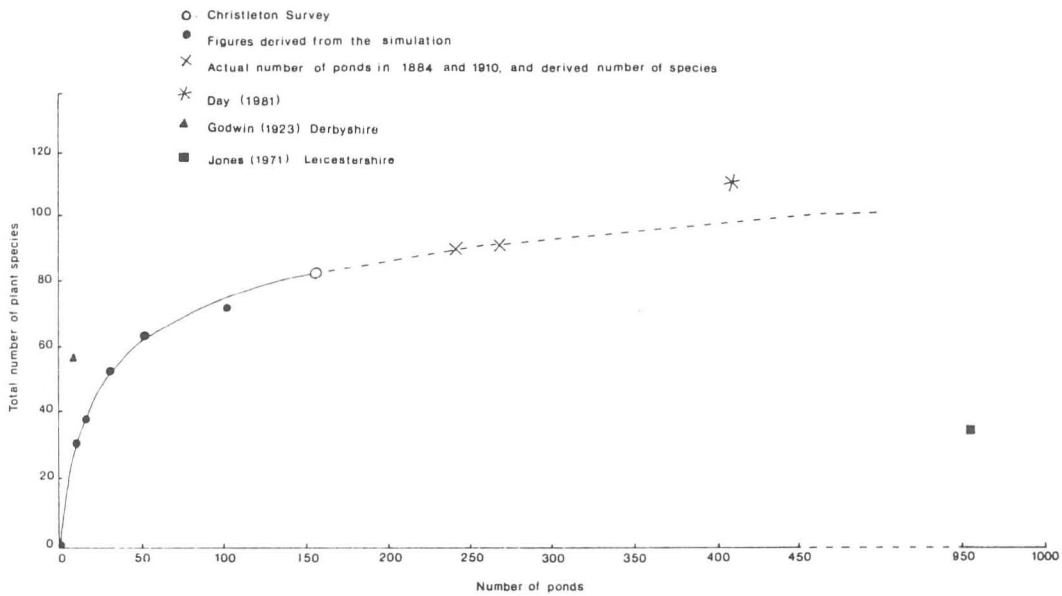

FIGURE 2. Relationship, derived from a simulation, between the number of ponds and the total pond flora of the parish.

DISCUSSION

THE SPATIAL DISTRIBUTION OF THE POND FLORA

One of the most striking features of the flora of the Christleton ponds was the great variation in species between different ponds. Only five species occurred in over 50% of the ponds while 54 species occurred in less than 10%. One of the original aims of the survey was to try to find some of the underlying reasons for this distribution pattern. Some of the possible contributory factors are discussed below.

The flora available locally. This must have been an important factor in the initial colonization of the ponds as pointed out by Day (1981). These plants would have been growing in the marshes and ditches before the days of intensive agriculture. One such area is still present in the parish, a wet meadow beside the River Gowy, now a nature reserve managed by the Cheshire Conservation Trust. A comparison of the plant list for the reserve with that for the ponds showed that the two areas had 38 wetland species in common while 37 species occurred in the ponds only and ten species in the meadow only. Obviously the old marl-pits have indeed provided a refuge for many of the wetland plants.

The age of the ponds. The length of time that a pond has been available for colonization might be expected to affect the composition of the flora and Godwin (1923) has shown that for newly dug ponds there was a steady increase of species up to 70 years. Most of the Christleton ponds are older than this and no connection between age and flora was detected.

The rate of dispersal of water plants. A comparison was made between the number of species in each pond and the distance of each pond from other neighbouring ponds. No association was found, isolated ponds being often just as species-rich as ponds that had others near them. When individual species were considered there was again little evidence that any one species occurred mainly in neighbouring ponds and in most cases a species appeared to be scattered over the area. The three commonest species in Christleton, *Alisma plantago-aquatica*, *Lemna minor* and *Juncus effusus*, were also the three commonest in the Fylde, Wirral and Clwyd (Day *et al.* 1982). Similarly, species rare in Christleton, like *Lemna polyrhiza* and *Hydrocharis morsus-ranae*, were also rare in

the other surveys. These differences must be due in part to differences in the efficiency of their dispersal mechanisms over land and Godwin (1923) came to the conclusion that the distribution of the species in his seven ponds was initially a matter of chance and that the early distribution pattern persisted because "land barriers are very effective in slowing down the rate of dispersal of water plants".

The physical characteristics of a pond. The position of a pond, the type of soil where it was dug and its original size must also have had some effect on the flora. Many of the earlier pond flora studies commented that larger ponds had a richer flora and this study has shown also that individual species were affected by the size of the pond. The original depth and steepness of the banks must also have had their effect on the flora.

The history of the pond post-construction. The management of the area around a pond affects the flora by producing different conditions which favour different species. The effect of a fence has already been described. Absence of a fence leads to trampling by cattle and a shallow edge to a pond.

Deliberate introductions. These have probably taken place in the past, especially of attractive plants like the white water-lily, *Nymphaea alba*, which was said to have been introduced by a past land-owner into one pond near his house.

Obviously with so many different potential factors at work it would seem inevitable that there should be large differences in the flora of the different ponds. This variation between adjacent sites of similar habitat type is a general phenomenon and a very similar distribution of woodland species has, for example, been found recently in a woodland survey in Herefordshire (Barfield *et al.* 1984).

A COMPARISON BETWEEN THE INTENSIVE CHRISTLETON SURVEY AND THE EXTENSIVE CLWYD SURVEY

The Clwyd pond survey is the only one of those described in Day *et al.* (1982) which gives sufficiently detailed results for a meaningful comparison to be made with the Christleton survey. Because of the different methods used for selecting the ponds for survey in the two areas, a comparison of the results may prove useful in the planning of future surveys and these results are set out in Table 4.

The Christleton ponds appear to be rather larger than those in Clwyd though this could be caused by the different methods used to assess the areas. The number of species recorded was fewer in Christleton, partly perhaps because fewer ponds were visited but also possibly because of a bias in the Clwyd survey towards ponds known to be of interest. On the whole however it is apparent that the two sets of ponds have very similar characteristics and flora and that the different methods used to select the ponds for survey have not affected the results significantly. There is now enough information on the physical characteristics and flora of the old marl-pits of the Cheshire plain and surrounding areas to show that there is overall uniformity combined with a good deal of variation in flora from pond to pond.

CONSERVATION

The importance of old flooded marl-pits as refuges for wildlife in intensively farmed areas has been discussed by Day *et al.* (1982) and the Christleton survey results reinforce their conclusions.

At the time of the Christleton survey a scheme for evaluating the ponds in the parish was prepared (Brian *et al.* 1975; Latham 1979). A rather broader list of criteria was used than that of Day (1981) since, in addition to number of species per pond and rarity of species, the final pond score was weighted by aesthetic factors, potential for educational use, accessibility and the likelihood that for some time at least the pond would remain undisturbed. This evaluation was more in line with that given in Spellerberg (1981) but nevertheless produced a similar proportion (5%), of what might be called 'first class' ponds, to that estimated by Day (1981) in Clwyd.

In view of the variation demonstrated between different ponds there is no doubt that the general flora, and probably the fauna as well, would be much impoverished if only the 'first class' ponds survived even if transplantation was carried out. Nearly every pond has some value and discrimination between 'first class' and 'other' ponds might hasten the loss of the 'other ponds'. Even if a pond has little of interest or variety from the point of view of its flora it very often functions as a small nature reserve in an otherwise intensively managed field. Many ponds have mature trees and patches of scrub valuable for non-aquatic birds and insects, and the banks harbour meadow plants now eliminated from the fields around.

TABLE 4. A COMPARISON OF THE CHRISTLETON AND CLWYD SURVEYS

	Christleton	Clwyd (Day 1981)
Date of survey	1971/72	1979
Number of ponds surveyed	153	406
Number of ponds per km^2, mean (range)	12.0 (3–34)	11.2 (0–443)
Position of ponds in field		
(i) away from hedge	57%	35%
(ii) edge of field	43%	60%
Size of ponds, mean (range), m^2	490 (40–1800)	242 (23–1472)
pH mean (range)	7.6 (5–10)	7.1 (5.7–8.6)
% of ponds unshaded (0–9% shade)	57	49
% of ponds fenced	27	14
Total number of plant species	84	112*
Number of species per pond, mean (range)	9 (0–23)	15.6 (0–30)
Number of species common to both areas	73	73
Number of species not found in the other area	10	39
% of ponds with rubbish dumping	25	46
Loss of ponds	34% in last 64 years	32%

*Excluding those species that would not have been recorded in the Christleton survey even if present.

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(*Accepted May 1986*)