Interaction between wildfowl and recreation at Llangorse Lake and Talybont Reservoir, South Wales

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Introduction

General

This paper describes part of a three-year study into the effects of water-based recreation on wildfowl populations (Tuite 1981). The other two parts involved an extensive examination of wildfowl numbers and distribution on British inland waters in relation to recreation in winter (Tuite *et al.*, in press) and in summer (Owen & Tuite, in press). Whereas it is well known that water-borne activities are disturbing to wildfowl (e.g. Cooke 1975, Batten 1977), the exact way in which this affects the welfare or movements of the birds is unknown. Effects may vary from gross distributional changes, in which sites are totally abandoned, to much more localised small-scale alterations in ranging, feeding or roosting behaviour. This field study aimed to examine some of the latter.

The main study site was at Llangorse Lake, near Brecon, Powys, but the nearby Talybont Reservoir was also monitored during the study winter of 1980-81. Both waters are within the boundaries of the Brecon Beacons National Park, are close to one another (about 6.5 km apart), and have a reasonable number and diversity of waterfowl. Talybont supports little recreation, whereas Llangorse is heavily used for recreation throughout the year, with sailing, windsurfing, coarse fishing, power-boating, water-skiing, rowing and canoeing, as well as informal recreation (walking, picnicking, etc). In recent years there has been growing concern about the influence of eutrophication and recreation on the diversity and welfare of the lake's fauna and flora (Cundale 1980). Talybont was considered the control site, at which wildfowl use was largely determined by natural factors, such as migration, overall population levels in the region, weather and ecological carrying capacity. Comparative summaries of their morphometric features and trophic status are given in Table 1 and outline maps in Fig. 1.

Llangorse

Llangorse is the largest natural lake in south Wales, a typical lowland eutrophic lake. There are fairly extensive areas of reedbed, especially along the south and western shores (Fig. 1a), in which the commonest species are the common reed *Phragmites australis*, reedmace *Typha latifolia* and yellow water lily *Nuphar lutea*, while the only submerged macrophyte present in 1982 was milfoil *Myriophyllum spicatum* – the only remnant of the formerly abundant and diverse community (Cragg *et al.* 1980; R. Haycock pers. com.). Palaeological analysis of the diatom flora of sediment cores suggests that eutrophication started in Roman times with building of roads into the area and the introduction of settled agriculture (Jones *et al.* 1979). The rate of eutrophication has probably increased

Table 1. Comparative morphometric features and eutrophic status of Llangorse and Talybont.

Feature	Llangorse	Talybont
OS reference	SO 1019	SO 1326
Altitude (m)	155	200
Surface area (ha)	153	131
Mean depth (m)	1.8	9.0
Banks	Shelving	Steep
Maximum length (km)	2.0	3.3
Trophic status	Eutrophic	Oligotrophic
Surroundings	Mixed farmland	Largely forested

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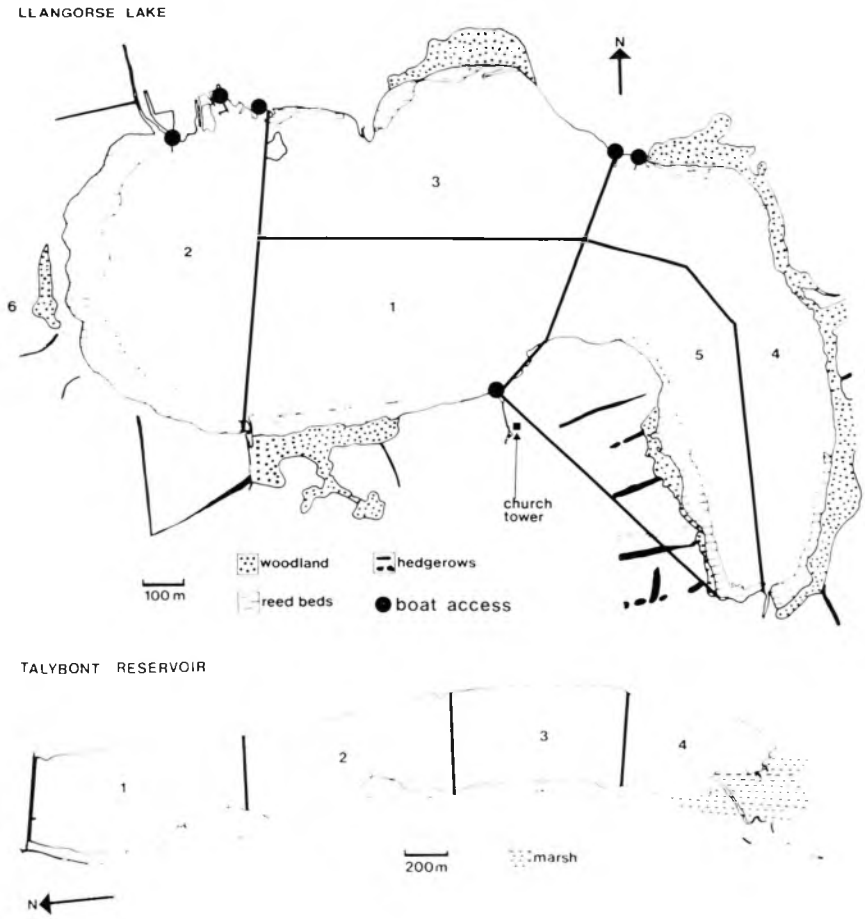

Figure 1. Outline maps of Llangorse Lake and Talybont Reservoir showing the vegetation zones.

recently, due to rapid growth in the application of agriculture fertilisers in the catchment area, and, until a new sewage treatment works was completed in 1981, to the sewage effluent from Llangorse village. A sequence of algal blooms occurs from spring to autumn (Tai & Benson-Evans 1977). Llangorse was declared a Site of Special Scientific Interest by the Nature Conservancy Council in 1954 and was listed as a Grade 1 site in the Nature Conservation Review (Ratcliffe 1977).

Talybont

Talybont is a direct supply reservoir managed by the Welsh Water Authority, is deeper and less productive than Llangorse, and is surrounded by fairly steep hillsides rising to over 400 m. The lower slopes are mainly forested with upland sheep grazing above. The most important feature for wildfowl is the marsh area at the south end (Fig. 1b), where the Caerfanell river enters the reservoir. This provides the only feeding habitat for most wildfowl species and this part has been designated a Local Nature Reserve, managed jointly by the Brecon Naturalists Trust and the Water Authority.

The region is not an important one for wildfowl; the sites are not on a major flyway nor are there any other substantial concentrations of wintering wildfowl in the vicinity.

Methods

Waterfowl population monitoring

Total waterfowl counts were carried out at both sites on Wednesday and Sunday of each week from September to March. Each water was divided into zones as shown in Fig. 1. The numbers of birds in each zone were recorded separately. Zones 1-5 of Llangorse, which include open water, were observed from the top of the Llangasty Tallylyn church tower on the southern shore, using a telescope and binoculars. Zone 6, an area of flooded fields to the west of the lake, was counted from a vanatge point on the road from Bwlch to Pennorth. Talybont was counted from suitable points on the road running along its west shore.

Recreation and waterfowl monitoring at Llangorse

Detailed monitoring of recreational activity and of waterfowl numbers and distribution was carried out. At the half hour of each daylight hour the numbers of birds in each zone were counted and recorded. The position of each boat was plotted, using different symbols for different types of craft. The position and number of people involved in lakeside activities were also mapped. Sampling days were randomly selected, dividing them between weekends and weekdays. Days of poor visibility were replaced, wherever possible, by the next appropriate day. A total of 63 all-day watches were kept, 31 at weekends and 32 on weekdays. Full details of days and amounts of recreation are given in Tuite (1981).

Results

Wildfowl counts

The twice-weekly censuses are summarized for the commoner species in Fig. 2 in terms of the mean monthly numbers at each site. The monthly means for all except vagrant species are presented in Table 2. A comparision of these means with the 12-year regular mean (the average of the three highest counts in each season) from the National Wildfowl Counts indicates that 1980-81 was not atypical in the use of either site.

For Mallard *Anas platyrhynchos*, Tufted Duck *Aythya fuligula*, and Pochard *A. ferina*, numbers at Talybont were substantially higher than at Llangorse in all months. It would be expected that the latter would hold many more ducks of all these species, since it is larger, contains a much greater area of suitable habitat, and has a mixed farmland in the vicinity. Talybont is, in all these respects, less suitable for wildfowl. There seems, therefore, to be some factor restricting the carrying capacity of Llangorse for these species, and recreation is a likely candidate.

Goldeneye *Bucephala clangula*, while more capable of exploiting deeper waters than the above three species, are also generally more abundant on productive areas. Their numbers are, nevertheless, consistently higher at Talybont. This species was found to react to the presence of boats at great distances (Hume 1976), and is the most sensitive to recreational disturbance in winter (Tuite *et al.*, in press).

Teal *Anas crecca* and Wigeon *A. penelope* were present in similar numbers at both sites and showed very similar patterns of temporal change through the winter. However, if zone 6, which is outside the lake proper, were excluded, numbers of both species would be considerably lower than at Talybont. In contrast numbers of Coot *Fulica atra*, Great Crested Grebe *Podiceps cristatus* and Mute Swan *Cygnus olor* were higher for most or all of the winter months at Llangorse. All these species are commonly associated with more eutrophic waters. The stands of submerged macrophytes and emergents at Llangorse are likely to be particularly important for Coots and Mute Swans.

The total count showed that Bewick's *Cygnus columbianus* and Whooper Swans *C. cygnus* observed at the two sites were undoubtedly the same birds moving between the two. Talybont was used for feeding and roosting and Llangorse only as a daytime feeding site. The preference of Goosanders *Mergus merganser* for Talybont is almost certainly related to stocking with trout, and the existence of a breeding population of brown trout

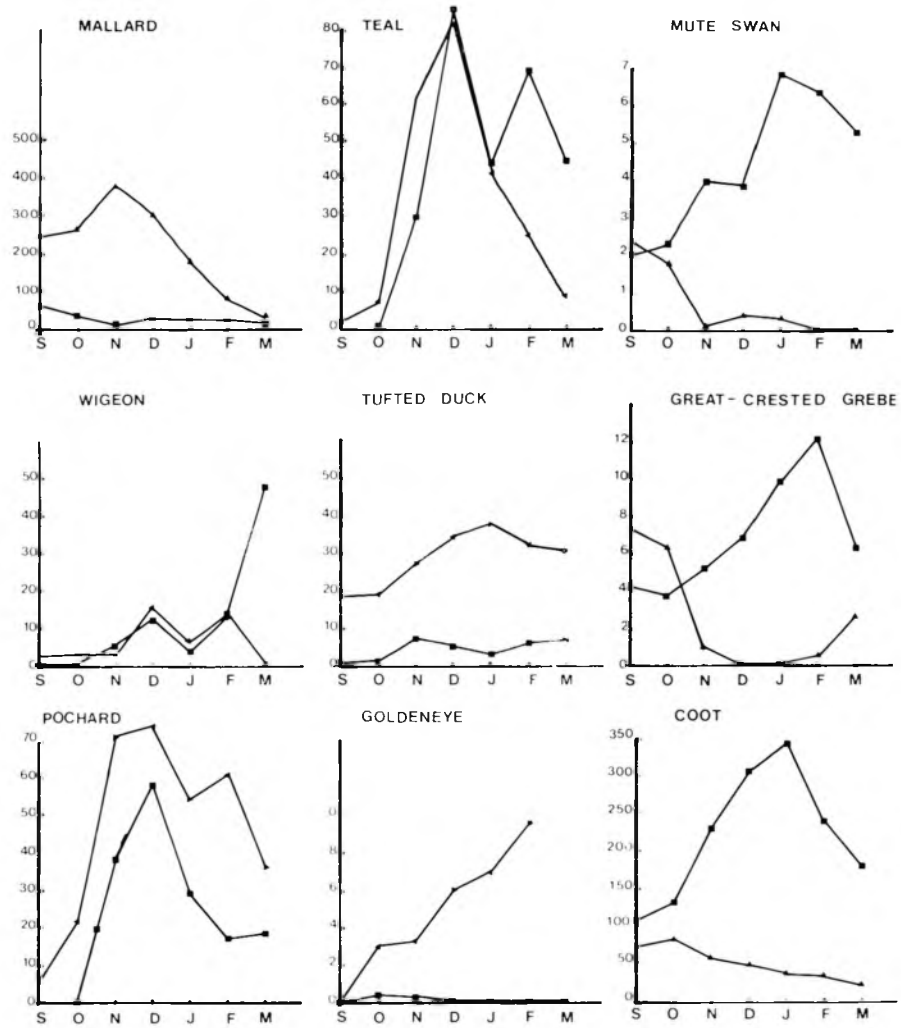

Figure 2. The seasonal pattern of numbers of the nine commonest wildfowl species at Llangorse (squares) and Talybont (triangles).

Salmo trutta.

The distribution of birds in the different zones, from the twice-weekly bird counts, is shown in Tables 3 and 4. At Talybont the vast majority of wildfowl were associated with the shallow water and marshland in zone 4, only the diving species spending significant amounts of time in other areas, with Goldeneye showing a preference for the zone nearest the dam. All the zones of Llangorse were used substantially by one species or another, reflecting the wider availability of usable habitat. The bottom is within reach of diving ducks in all zones. The vegetarian ducks and swans are most frequently found in the flooded marshland of zone 6, whereas of the open water areas, zone 5 holds most birds.

Recreation at Llangorse

Llangorse is privately owned and although there are water-ski and sailing clubs there is little control on the water and access is freely available. A group called PGL Holidays, which caters for children adventure holidays, has a camp on the

Table 2. Mean monthly numbers of waterfowl at Talybont and Llangorse in winter 1980-81 and the regular mean (average of the three highest counts in each season) from the National Wildfowl Counts for the 12 seasons 1970-71 to 1981-82.

	Sep		Oct		Nov		Dec		Jan		Feb		Mar		Regular	Mean
Species	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L
Mallard	243.8	63.4	268.8	34.6	385.6	11.4	308.9	31.1	184.0	27.9	88.1	30.1	24.8	19.5	293	52
Teal	2.0	0	17.6	0.6	61.4	30.0	82.1	86.4	41.9	44.3	25.1	69.8	9.2	45.0	62	58
Wigeon	2.4	0	3.4	1.0	3.4	6.3	16.0	13.0	7.3	4.3	14.4	12.9	1.2	48.5	18	24
Shoveler	0	0	0	0.1	1.7	0.9	0.3	0.6	0	0	0	0.9	1.0	1.0	5	5
Tufted Duck	18.4	1.4	19.5	1.9	27.9	7.4	34.9	5.6	38.3	3.7	32.6	6.6	31.0	7.3	89	44
Pochard	6.2	0	22.8	0.9	71.8	38.4	74.1	58.4	54.6	29.9	61.9	17.1	36.3	18.7	143	56
Goldeneye	0	0	0.5	0.4	3.0	0.3	3.3	0	6.1	0	7.0	0	9.5	0	6	1
Goosander	2.2	0	0.3	0	13.3	0	14.3	0	9.7	0	8.1	0	15.0	0	13	0
Canada Goose	0	1.8	0	11.1	0	5.9	0	0.3	0	9.1	0	15.5	0	17.8	0	5
Mute Swan	2.4	2.0	1.8	2.3	0.1	4.0	0.4	3.9	0.3	6.9	0	6.4	0	5.3	1	12
Bewick's Swan	0	0	0	0	1.6	0	11.4	0	15.7	0	15.1	6.0	0.8	6.3	1	1
Whooper Swan	0	0	0.4	0	3.2	0	1.1	3.4	1.1	3.6	3.4	2.3	0	1.5	4	2
Coot	73.8	108.2	84.8	133.4	56.0	233.1	49.1	307.8	36.7	345.4	34.4	240.4	22.7	174.3	–	–
G.C. Grebe	7.4	4.2	6.4	3.8	1.1	5.3	0	6.9	0	9.9	0.6	12.1	2.7	6.3	–	–

Table 5. The number and percentage of boat/people hours spent in the five open water zones of Llangorse Lake, September 1980 to March 1981.

	Zone										
	1		2		3		4		5		Total
	No	%	No	%	No	%	No	%	No	%	
Fishing	183	11.5	132	8.3	858	55.6	127	8.0	264	16.6	1591
Canoeing/Rowing	138	12.5	324	29.4	337	30.6	181	16.4	122	11.1	1102
Sailing/Windsurfing	195	20.7	243	25.8	344	36.5	68	7.2	93	9.9	943
Water-skiing/Power-boating	74	14.3	71	13.7	67	12.9	215	41.2	91	17.6	518
Informal	43	54.4	0	0.0	3	3.8	0	0.0	33	41.8	79
Shooting/Wildfowling	0	0.0	11	61.1	0	0.0	4	22.2	3	16.7	18
Motor Cruiser	0	0.0	0	0.0	0	0.0	1	50.0	1	50.0	2
Total	633	14.9	781	18.4	1636	38.5	596	14.0	607	14.3	4253

Table 3. Mean percentages of birds counted in each zone at Talybont.

Species	Zone 1	2	3	4
Mallard	6.4	7.6	7.4	78.6
Teal	0.1	0	11.2	88.8
Wigeon	3.9	0	7.0	89.1
Tufted Duck	19.9	12.9	19.5	47.6
Pochard	2.1	3.4	1.8	92.7
Goldeneye	54.0	10.8	4.6	30.6
Goosander	5.1	6.7	2.8	85.4
Mute Swan	20.0	0	3.3	76.7
Bewick's Swan	0.4	0	0	99.6
Whooper Swan	9.1	0	0	90.9
Coot	8.3	4.9	7.0	79.8
Great Crested Grebe	17.8	8.3	14.5	59.4

Table 4. Mean percentages of birds counted in each zone of Llangorse according to the twice-weekly counts.

Species	Zone 1	2	3	4	5	6
Mallard	2.2	1.9	22.6	31.8	21.6	19.8
Teal	0	2.4	0	0.1	44.8	52.7
Wigeon	0.1	1.2	0.7	7.0	42.9	49.1
Tufted Duck	17.8	39.8	30.4	9.1	3.0	0
Pochard	29.7	23.9	32.9	10.5	2.7	0.3
Mute Swan	13.0	5.6	18.3	4.2	21.4	37.4
Bewick's Swan	0	3.9	0	0	0	96.1
Whooper Swan	0	0	0	0	0	100
Coot	3.9	4.4	7.6	1.8	63.2	19.1
G.C. Grebe	11.5	12.5	30.8	32.6	12.5	0

north shore, which has numerous jetties and is the main launching point for boats, but PGL ceases operations in mid-September. There is no zoning of activities and no temporal restriction of access within the water area, and canoes often encroach into the shallows and among the reedbeds. There are, however, no moorings on the water. An associated tourist industry has developed, involving accommodation, camping and caravan sites. The recreational use of the lake has been the subject of a case study (Dartington Amenity Research Trust 1972).

Seasonal pattern of recreation

The monthly pattern of different recreational activities are shown in Fig. 3. Sailing, fishing from boats (there was none from the banks), water-skiing/power boating, and canoeing/rowing are plotted as the mean number of boat hours recorded during the all-day observations, with weekday and weekend data shown separately. Informal recreation was recorded as the number of people involved.

The most striking feature is the marked concentration in September and October, with a rise again in March. Pleasure and sport boating virtually cease in midwinter, whereas fishing continues in all months. Informal recreation is slight and sporadic. There is also an obvious concentration of recreation, as might be expected, at weekends, with an average of nearly 20 boat hours fishing even in midwinter. This is equivalent to 2.5 boats on the water throughout the day.

Diurnal pattern

The pattern of recreation during the day is shown in Fig. 4, as the total number

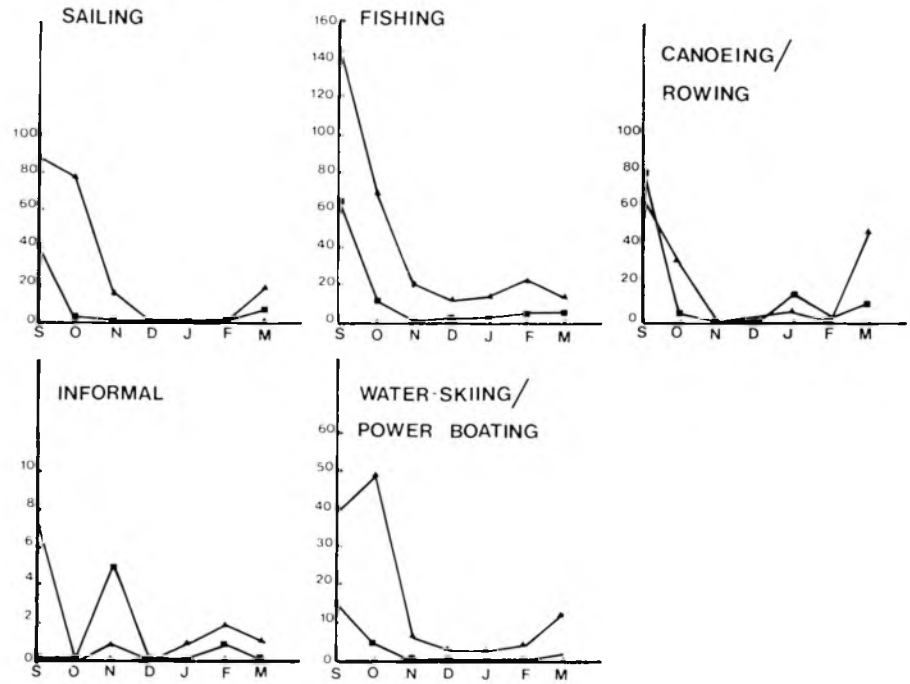

Figure 3. The seasonal pattern of recreational activities at Llangorse on weekdays (squares) and at weekends (triangles), in 1980-81.

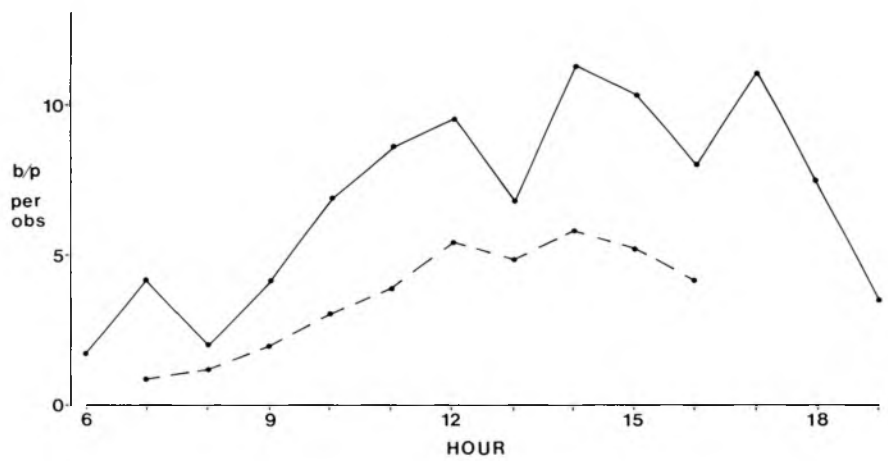

Figure 4. The diurnal pattern of recreational activity expressed as the total number of boat/people hours at Llangorse from September to March (solid line) and October-March (dashed line).

of boat/people per observation. There is a clear rise in activity during the morning, with a pronounced drop at lunchtime, and a high level through most of the afternoon. The lunchtime drop is less marked when September is excluded because much of the recreation in that month is organised from the PGL camp, which closes in October. The early morning activity is also overemphasised, since observations at 6.30 and 7.30 were only made in September, the month of the highest activity. The influence of September recreation on overall winter levels is also clearly shown.

Zonal pattern

The recreational observations were made only on the 5 zones of the lake itself (Table 5). Zone 6 was difficult of access and little disturbed. In general it can be assumed that birds displaced from the lake could use this zone. The number of boat/people hours in each zone of the lake was also analysed separately for each month. Where sample size was sufficient, however, there was no consistent variation between months.

Overall, fishing is the most common activity, followed by rowing and sailing. Bankside activities (informal, shooting), contribute little to the total. Zones 2 and 3, close to the main launching area for boats, are the most intensively used for rowing and sailing. Fishing is also concentrated close to the island in zone 3. The fast-moving water sports, particularly water-skiing, are most practised in zone 4. There is no effective zoning, but these activities are hampered by the presence of other boats. Overall, Zone 3 is the most intensively used area.

Recreation at Talybont

The only recreation allowed at the reservoir is game fishing from the banks. The shore most favoured by fishermen was close to the mouth of the river in zone 4, adjacent to the area of highest waterfowl concentration (Table 2). The game fishing season ends on October 15, however, so there is little overlap with the main wildfowl season. The road on the south side of the lake is shielded by trees over much of its length and there are only two stopping places for cars, one close to the dam and one opposite the marsh at zone 4. The road at this latter point is some 200 m from the lake (Fig. 1) and the birds soon habituate to the presence of cars and people. From the recreational point of view, therefore, Talybont is truly a control area having little disturbance.

The interaction between recreation and the numbers and distribution of wildfowl at Llangorse.

Water-based recreation could deprive wintering wildfowl of roosting or feeding habitat by driving them away from Llangorse altogether, or reducing its carrying capacity. It is impossible in a one-season study and without the ability to control recreation to test this. However, by examining the interaction between recreation and wildfowl within the lake we can investigate whether such effects are likely.

The total number of boat + people hours may not be the best measure of recreational intensity available, for the presence of a single boat might be just as disturbing as that of many. Again, the different types of recreation are not equally disturbing to birds. The intensity patterns of recreartion on the five zones of the lake are shown in Fig. 5 using four different (though related) measures of intensity. Total recreation is the number of boat/people hours, whereas incidence disregards the number of boats/people involved in any type of activity. The total and incidence were weighted to give the other two measures, the weighting being based on the probable disturbing influence of that recreation on birds, as follows:

activities on water involving:	
noise and movement (power boats)	4
movement but no noise (sailing, rowing)	3
noise but no movement (shooting from banks)	3
neither noise nor movement (fishing)	2
activities on the banks (informal)	1

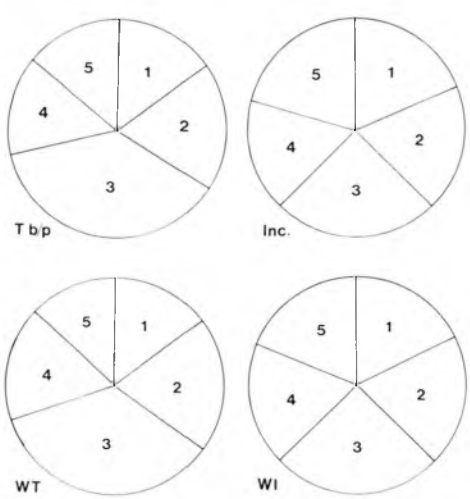

Figure 5. The intensity of recreation in zones 1-5 at Llangorse expressed by four related measures. The top two diagrams are total boat/people hours (left) and incidence, disregarding the number of boats/people involved (right). The bottom two measures are weighted total and incidence weighted for disturbance (for explanation of weighting see text).

This gives two further measures of recreational activity.

There is a clear difference between the incidence of activity and total activity measures, the former showing a high concentration of activity in zone 3 and the latter almost equal density in all zones. The zones are quite large areas and it is likely that the number of boats will have an effect on the birds. In fact, since the boats are well dispersed, the amount of water area available to ducks is inversely proportional to the number of boats. For this reason the total rather than incidence is the intensity preferred measure. Weighting made no appreciable differences to the results. If the weightings truly reflect disturbance, then the disturbance impact per recreation unit is almost exactly similar on all zones, despite the clear differences in zone use shown in Table 5. Because weighting introduces a degree of subjectivity, we therefore conclude that the total number of boat/people hours is the most meaningful and most objective measure of recreational intensity.

Another important factor how the activity is concentrated at any one time. It could be, for example, that zones were used at different times so that there wa always an unused zone for the birds. The number of zones in use for recreation at any one time is shown in Fig. 6 for each month of the winter. This does indicate a very dispersed pattern of recreation. In September all zones are occupied for more than two-fifths of the time. Even in midwinter, when overall boat density is low, there are times when all zones are being used. This result is not unexpected since many water sports are liable to interfere with one another and boats tend to keep out of each other's way. It does mean, however, that the spatial pattern of recreation on Llangorse Lake is the worst possible as far as wildfowl are concerned.

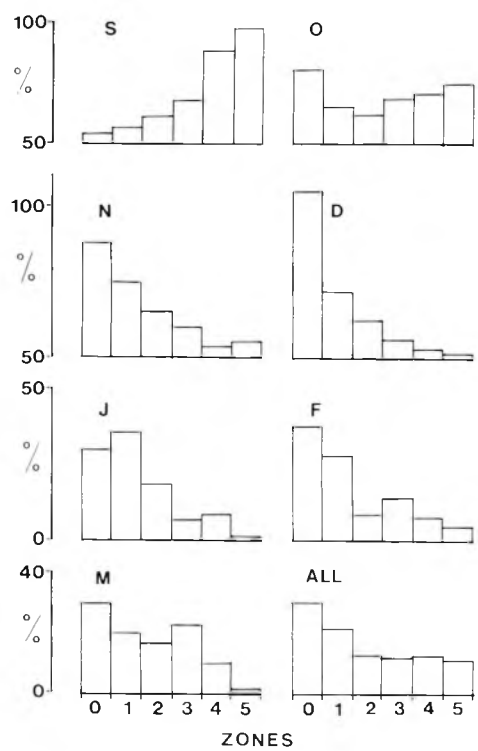

Figure 6. The number of zones occupied by recreation at Llangorse Lake in each month of the winter 1980-81.

Changes in numbers within the season

Since recreation is so heavily seasonally biased we might expect that this would influence the seasonality of wildfowl numbers. Bird numbers increase nationally as autumn progresses, whereas recreation is decreasing. It might be, for example, that once recreation had declined to a low intensity at Llangorse, birds would move there from Talybont. Examination of the wintering patterns in Fig. 2 reveals that of the eight species occurring at both sites (Goldeneyes being excluded because of its scarcity at Llangorse), Coot, Great-crested Grebe and Mute Swan do indeed decrease at Talybont and markedly increase at Llangorse after the peak recreation months of September and October. Teal and Pochard are absent from Llangorse in these two months, but present at Talybont. Of the remaining species, Wigeon and Tufted Duck show similar patterns in the two areas, and Mallard shows no clear trend at Llangorse, apart perhaps from a slight dispersal in September and October and a recolonization in midwinter.

This does not suggest that the high levels of recreation in the autumn do delay the arrival of most of Llangorse's wintering birds. It must also be emphasised that these counts include the undisturbed zone 6 which can be used as a refuge, so the effect on the lake itself is even more marked.

The effects of recreation at weekends was examined by comparing the mean number of individuals of each species on weekdays with the weekend totals in each of the seven months in both waters. Of 61 tests at Talybont, 37 were higher at weekdays though not significantly so. No single species showed a significant preponderence of differences in one direction (sign test). At Llangorse only 27 of 62 tests showed higher numbers on weekdays. Again no single species showed a significant consistency. Thus there is no evidence that birds displaced from Llangorse at weekends go to Talybont. At Llangorse Pochard and Tufted Duck loaf during the day at the edge of the reedbed in zone 2, and when disturbed by boats they moved to the open water of zones 3 or 4, where they were easier to see. Thus higher numbers of these species were recorded when recreation levels were high and the temporal pattern of their numbers was distorted. However, since Talybont is very easy to count and there is no such bias there, it can be said that the birds do not consistently use the reservoir as a refuge when disturbed from Llangorse on high recreation days. Flocks were frequently put to flight by boats at Llangorse and disappeared in the direction of the reservoir, but they probably sought refuge on the river Usk, which lies between the two sites, rather than made the 6 km journey.

The coefficient of variation of counts within a month (indicating how much numbers fluctuate from day to day) would be higher at Llangorse than at Talybont if recreation caused significant disturbance. The coefficients were compared for the commoner species and indeed in 31 of 46 tests there was a higher coefficient at Llangorse, a significantly higher proportion than expected (sign test $P = 0.014$, one-tailed). Of the 15 negative results, 6 were contributed by Coot and the relative stability of their numbers at Llangorse may indiacte that they are better able to cope with disturbance. If Coot are excluded from the test the probability decreases to $P = 0.0096$.

Changes with time of day

The very marked pattern of recreation intensity through the day shown in Fig. 4 ought, if recreation does displace birds from the lake, be reflected in bird numbers at different times of day. This possibility is examined in Fig. 7, which compares the pattern of bird numbers at very low intensity recreation with that at high intensity. When there are a few boats there is no overall trend in bird numbers. Indeed, the numbers tend to be higher in the middle of the day, probably because more are roosting on open water or because they return to the lake from zone 6 to drink and preen, or are disturbed from there. In contrast, at high levels of recreation there is a decline in numbers through the morning. From 11.30 onwards the lake holds only 70% of the initial numbers. This decrease matches well the increase of recreation up to midday on the same high intensity

days, also shown in Fig. 7. One problem in the interpretation of this result is that 11 of the 12 high intensity days are in September, October and in March, whereas 14 of the low intensity days were in January and February. The difference in pattern could, therefore, be a seasonal difference in the habits of the birds. There was, however, no evidence that at any time during the day were birds flighting to and from the lake to feed. Feeding on farmland normally occurs around dawn and dusk and more birds should be roosting on the lake at midday. Neither is there any seasonal variation in zone use by ducks which could account for this difference in daily pattern. We must conclude, therefore, that it is the high level of recreation that displaces up to 30% of the wildfowl at Llangorse in the middle of the day.

Effects of recreation on spatial distribution of birds

To examine the use of different lake zones under different conditions of recreation eleven classed of recreation were distinguished, as follows:

	Intensity	No. days in sample
1	No recreation	7
2	1-10 boat/people hours	13
3	11-20 hours	11
4	21-30 hours	5
5	31-50 hours	6
6	50-75 hours	7
7	76-100 hours	2
8	101-150 hours	1
9	151-200 hours	4
10	201-300 hours	4
11	more than 300 hours	3

The number of each species of wildfowl on each of the five zones was calculated at each recreation intensity and a series of Chi-squared tests run to test for differences in overall pattern of zone use from one intensity level to the next. This test makes no assumptions as to the preference for zones, but only tests for differences in use pattern. Each species was treated separately where the sample was sufficiently large and a total of 98 tests were carried out. No fewer than 93 of these (95%) showed a signif-

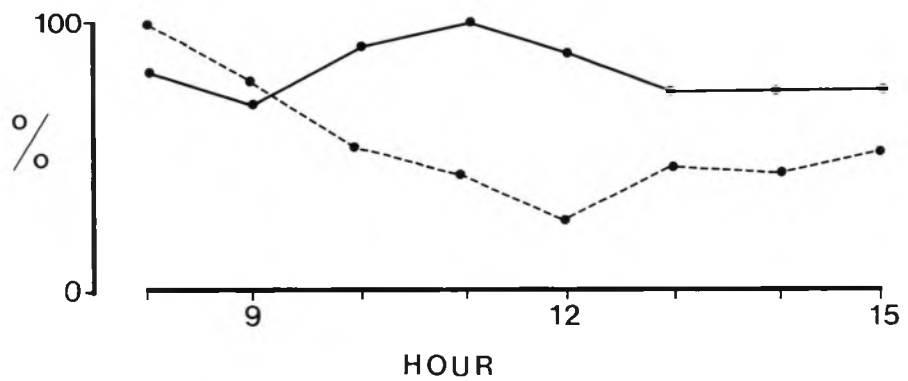

Figure 7. The diurnal pattern of bird numbers at Llangorse at low (solid line) and high (dashed line) recreation intensity.

icant relationship between recreational intensity and bird distribution 87 (89%) at the 0.1% level.

To test whether recreation is keeping birds away from areas where they would prefer to be for feeding and roosting, the proportion of their time spent in the preferred zone at different intensities of recreation (1-11) was examined. The preferred zone was defined as that used most when there was no recreation on the lake. The trend was analysed for the seven commonest species and for total wildfowl using the Spearman rank correlation analysis. A summary of the result is given in Table 6, and Fig. 8 shows the relationship for the 8 tests.

All the relationships are inverse (i.e. birds are allowed to spend less time in the preferred zones as recreation intensity increases), and 7 of the 8 are significant. In the case of the Mallard, Mute Swan, Wigeon and Pochard, the highest levels of intensity keep the birds out of their preferred zone altogether. The effect is less marked, though still significant in Coot, Great Crested Grebe, and for total birds (which is largely governed by the effect on Coot – the most numerous species). Only in Tufted Duck is the relationship not significant, and, as mentioned earlier, the presence of boats does tend to move them from their loafing sites around the margins to open water.

These results provide conclusive evidence that the intensity of recreation

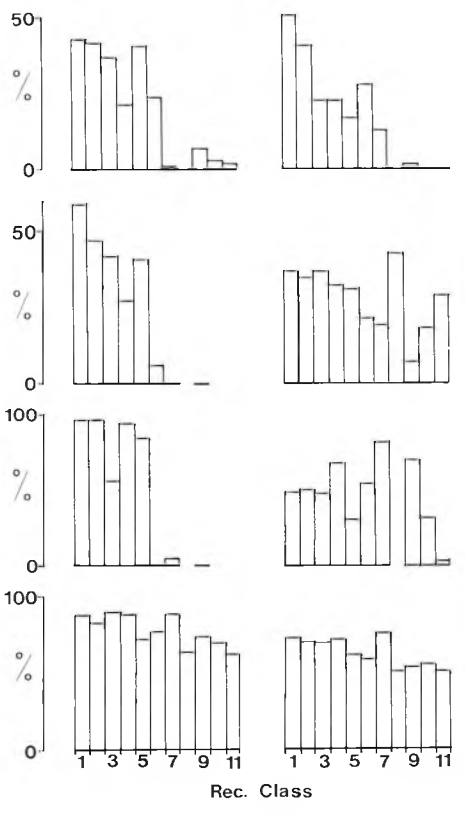

Figure 8. The percentage of time spent by various species in their preferred zone at Llangorse (defined as that used most when there was no recreation) at eleven different recreational intensities. For explanation of recreation intensity classes, see text.

Table 6. The effect of recreational intensity on the proportion of their time spent by different species in their preferred zone (that most used when there was no recreation), using the Spearman rank correlation analysis

	Pref zone	% in pref zone when no rec	Degrees of* freedom	Spearman coeff	Significance (P less than)
Mallard	5	51	9	–0.915	0.001
Wigeon	5	96	6	–0.880	0.01
Pochard	3	58	6	–0.970	0.001
Tufted Duck	2	49	8	–0.127	Not sign.
Mute Swan	1	43	9	–0.818	0.01
Coot	5	88	9	–0.715	0.02
G.C. Grebe	4	37	9	–0.612	0.05
Total Wildfowl	5	73	9	–0.731	0.01

* the number of intensity classes included was restricted in some species because there was no or very few birds on the lake at those intensities.

existing at Llangorse has a deleterious influence on bird distribution. Four species make very little use of their preferred areas at levels above 75 boat/people hours (an average of 8-10 boats on the lake at any one time).

Discussion

To investigate fully the effects of human activities on wintering birds requires a long-term and controlled study. Many other factors which are difficult to quantify also influence the numbers and movements of birds. Knowledge of wildfowl behaviour and feeding habits as well as historical data do, however, help us to interpret the findings of this short-term but intensive study.

In a review of wildfowl and recreation Atkinson-Willes (1969) took a rather gloomy view of the future, and said that in particular sailing caused 'a degree of disturbance which most species of duck cannot tolerate'. In a more recent review, however, Tanner (1979) emphasises the complexity of the problem of assessing the long-term impact on birds (as opposed to short-term disturbance or displacement), and describes several examples of reservoirs where recreation is managed so that wildfowl can coexist with it. There are few detailed field studies, and those of Cooke (1975) and Batten (1977) have already been quoted as evidence of the disturbing effect of reaction. Parr (1974) concluded that sailing had caused a reduction in the numbers of wildfowl at Island Barn Reservoir, Surrey, but gave little supporting evidence. On the other hand Summers-Smith (1977) concluded that the opening up of Scaling Dam Reservoir to recreation had no effect on wildfowl numbers, but part of the area had been set aside as a wildfowl reserve. Russel (1982) came to the same conclusion at Dinton Pastures Country Park, Berkshire, but again there were effective refuges for the birds. So much depends on the details of the local situation that it is difficult to come to general conclusions except, perhaps, that where refuges are available to the birds the deleterious impact is not serious.

Unfortunately historical information on wildfowl numbers at Llangorse is sparse. The lake was heavily used for recreation, particularly shooting and boating, in the early 1960s. Atkinson-Willes (1963) wrote 'with commercialisation and the advent of motor boats and a sailing club, the place has become almost untenable'. Before then there is little information but there were as many as 200 Goosanders on the lake at times and the usual number of Tufted Ducks probably exceeded 100. In the 1960s numbers of Pochard were sometimes as high as 450 while those of Tufted Ducks had declined. Nationally the populations of all three species have increased dramatically in the last two decades (Owen & Atkinson-Willes, in press), so their decline at Llangorse is probably due to local factors. There is much circumstantial and direct evidence that recreation affected the habitat with consequences for birds (Cundale 1980). The tendency for numbers to increase at Llangorse and decrease at Talybont as the season progresses had been demonstarted and attributed to the high level of recreational disturbance at Llangorse by Massey (1976).

Our results have shown that the intensity of recreation on the lake causes substantial movements from the lake during the day and, even in midwinter, cause substantial movements within the lake. Is this displacement likely to be having an effect on the birds? In goose studies it is well known that the level of disturbance is the chief factor in governing the use of a habitat in winter (Owen 1973; Owens 1977), and this is likely to be true for ducks. Most ducks are capable of feeding at night and some birds have been seen to return to feed at Llangorse at dusk, having found another daytime refuge (Cundale 1980). In midwinter, however, especially during cold weather, some daytime feeding is essential to cope with high metabolic demands. Where food supplies are spatially concentrated, restriction of feeding time inevitably means a higher feeding density and increased competition, with a consequent reduction of carrying capacity. Teal, Wigeon and the migratory swans, which often feed in very shallow floodland or on dry land, have to spend some daytime feeding to assure safety from predators.

Compared with the basal metabolic rate (BMR), the energy required for flying in birds is extremely high, about

12 x BMR (Tucker 1971), whereas resting requires only about 1.5 x BMR and swimming only 2.3 x BMR (Wooley & Owen 1978). Potential disturbance also increases stress and energy demands and lessens feeding time by increasing alert behaviour.

Wildfowl are highly traditional, returning to the same wintering areas year after year. Many species still come to Llangorse, but there is little doubt that the consequence of the high level of recreation there has been a reduction in the carrying capacity of the site. Wigeon, for example, are rapidly colonizing inland habitats, making use of lakes and reservoirs for roosting and feeding on surrounding pastures (Owen & Williams 1976). Llangorse and its surroundings seem highly suitable for this species but only a handful winter there. Tufted Ducks have increased three-fold as a breeding species in Britain since 1960 and two-fold as a wintering bird (Owen & Atkinson-Willes, in press), and the number at Llangorse should be considerably higher. There have been suggestions that boating disrupts the breeding of the Great Crested Grebe (Cundale 1980), and there is no doubt that its numbers in winter are low for such a large and productive water.

This, on the face of it, seems a depressing picture, suggesting that wildfowl and recreation cannot survive together. However, in Britain as a whole, both bird populations and recreational intensity on inland waters have increased substantially. This has been made possible largely by sensitive management of waters to accommodate both interests, with spatial or temporal zoning of activities on the larger sites (Tuite *et al.*, in press).

Referring to wintering populations, Atkinson-Willes (1963) explained the objectives of wildfowl conservation as:

a) To safegaurd the species of wildfowl.
b) To maintain existing stocks in at least their present strength and in their present distribution.

In the two decades since then for the majority of species this has been achieved or exceeded. Nowadays, however, wetland habitat is more than ever under threat and the number of natural sites such as Llangorse are fast diminishing and there is a greater need for their carrying capacity to be increased. In the past the emphasis has been placed on wintering wildfowl. However, British-bred birds form a very important part of the Mallard and Tufted Duck populations, and all the Great Crested Grebes and Mute Swans. The maintenance of the numbers and diversity of our breeding wildfowl is also an essential aim.

Neither must we forget that wildfowl conservation is also beneficial for recreation. The number of people involved in birdwatching must now number well over a million. In the extensive survey of inland waters, bitdwatching was the most common form of recreation both in summer, occurring on 66% of sites (Owen & Tuite, in press) and in winter, occurring on 59% (Tuite *et al.*, in press). In addition an increasing number of people have a general interest in wildlife. Each year more than 500,000 people visit the Wildfowl Trust's seven reserves, and only a small proportion of these are keen bird watchers. The educational impact of such centres is also well recognised.

Given that the level of recreation is significantly affecting wildfowl at Llangorse at present, what measures would produce a compromise acceptable to both sides? In summer there is a high density of boats and most or all the water area needs to be occupied. The exclusion of boats from the areas favoured by birds would achieve some desirable effects, but a decrease in the overall intensity of recreation would be necessary.

In winter the intensity of use is much lower. At least from October to March, recreation could be excluded from one or more zones without causing any appreciable change in the quality of that recreation. The quantity and diversity of birds would increase and the quality of birdwatching and informal recreation would also be improved. The most important zone of wildfowl is zone 5, occupying about one eigth of the water surface but holding nearly three-quarters of the birds when there is no recreation. However, there would be much disturbance if zone 4 remained open to recreation, so we suggest that the most effective measure would be to prohibit boats from zones 4 and 5, at least between October and March. This would still take away only a quarter of the lake area from boating recreation.

Finding a balance between the de-

mands of conservation and water-borne recreation at such important sites as Llangorse lake is vital, not only to the welfare of the birds but to those humans whose recreation is to watch them or those who, perhaps even unconciously, regard wildlife as a valuable component of their surroundings.

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Summary

A field study related wildfowl numbers and distribution to the pattern and intensity of recreation at Llangorse Lake, Powys. The nearby Talybont Reservoir, which is almost free of recreation in winter, was used as a control. Most species of wildfowl occurred in higher numbers at Talybont than at Llangorse. However, in view of the habitat requirements of wildfowl the reverse would be expected.

Recreation intensity (number of boat/people hours) decreased during the autumn and increased again in March. The total number of boat/people hours was the most relevant and objective measure of recreational intensity. Boats were very dispersed among different parts of the lake – the worst distribution as far as the birds are concerned.

The arrival of wintering birds was later at Llangorse than at Talybont and there was some indication of movement from the reservoir to the lake in late autumn when recreational intensity had decreased. Day to day fluctuations in numbers were also greater at Llangorse, suggesting greater disturbance there. Wildfowl were disturbed from the lake during the morning as the intensity of recreation increased. There was significant changes in bird distribution within Llangorse with increases in recreation. It was concluded that recreation was responsible for significantly limiting the carrying capacity of Llangorse for wintering wildfowl.

Prohibiting recreation in certain key areas would probably increase wildfowl numbers and diversity but would, in summer, require an overall decrease in recreation. In winter, however, exclusion of boats from about a quarter of the lake area would be effective in encouraging birds, without substantially affecting the quality of recreation. Bird-watching is the most widespread single form of recreation on British inland waters both in summer and winter. Some compromise should ceratinly be reached at such sites as Llangorse Lake, so important both for recreational and wildlife interests.

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