STATUS AND MANAGEMENT OF BLACK SWANS *CYGNUS ATRATUS*, LATHAM AT LAKE ELLESMERE SINCE THE 'WAHINE' STORM, APRIL 1968

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SUMMARY: The "Wahine" Storm in April 1968 destroyed the beds of aquatic macrophytes in Lake Ellesmere, South Island, New Zealand and the resident population of black swans *(Cygnus atratus)* has since declined by at least 75%. Extensive breeding failure, poor cygnet survival, increased adult mortality, and permanent emigration, all responses to the diminished food supply, and intensive hunting, have contributed to this decline. The population in January 1978 was estimated to be 9500, only one-third of which was less than 10 years of age. It is predicted that over the next four years the breeding component of the population will decline by about 50%. The methods by which the North Canterbury Acclimatisation Society has managed the swan population before and since the storm are discussed and suggestions for future management made.

INTRODUCTION

Between 9 and 11 April 1968, a cyclone of tropical origin which affected most of New Zealand produced, in the Wellington area, the most severe weather conditions that have ever been recorded by instrument in New Zealand (Jamieson, 1968) and along most of the country's east coast, the most severe storm in living memory. Its devastating effect on human property was widely reported by the news media, together with the tragic foundering of the inter-island ferry, t.e.v. *Wahine,* in Wellington Harbour. Because of this latter event, the storm is commonly referred to as the "Wahine" Storm.

Damage to biological communities was not so widely reported. In the mountains, large areas of protection forests were damaged and Poole (1969) referred to massive wind throw in lowland *Pinus radiata* forests, particularly in the Wellington, Nelson and Canterbury districts; over 14 million cubic feet of timber were lost in Nelson forests alone where up to 32 % of some age classes were destroyed (Irvine, 1970). Kinsky (1968) reported the recovery of 588 specimens of 30 species of pelagic seabirds (including 110 royal albatross, *Diomedea epomophora* and 26 wandering albatross, D. *exulans)* from southern coasts of Wellington province, while Imber and Crockett (1970) suggested that similar seabird mortality occurred elsewhere along New Zealand's east coast, particularly in Canterbury.

Of the coastal wetlands, only Lake Ellesmere, 40 km south of Christchurch, obviously suffered. Adams (1971), Bucknell (1969) and Hughes, McColl and Rawlence (1974) all referred to the destruction of beds of aquatic plants there, while Adams (1971) commented also on the subsequent poor breeding of black swans *(Cygnus atratus).* In an earlier paper (Williams, 1977a), I showed that the pattern of dispersion of the swans had altered since the storm and I attributed this to the diminished food supply at the lake. In this paper I record the immediate and long-term effects of the "Wahine" Storm on the

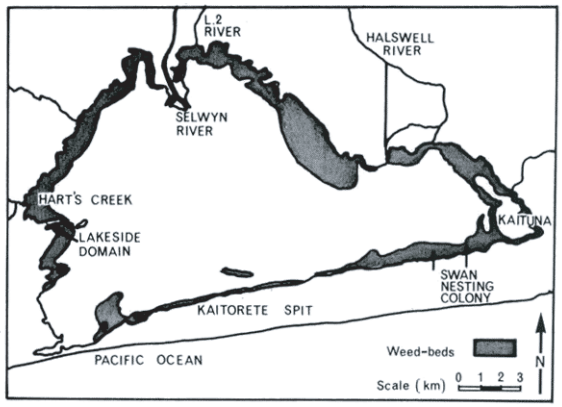

FIGURE 1. *Lake Ellesmere showing the distribution of weed-beds in 1960 and place names mentioned in the text. (Redrawn from Miers and Williams,* 1969).

population dynamics of black swans at Lake Eilesmere and discuss the methods by which they have been managed there before and since.

STATUS AND MANAGEMENT PRIOR TO 1968

During the 1950s and 1960s, 40000-80000 swans were present on Lake Ellesmere (various estimates in Internal Affairs Department files). It was the largest breeding population of swans in New Zealand and from there many birds (principally juveniles) dispersed widely throughout the South Island and southern parts of the North Island (Williams, 1977a). Swan numbers were controlled annually by the North Canterbury Acclimatisation Society (N.C.A.S.), an organisation of freshwater fishermen and game-bird hunters which, under the Wildlife Act (1953), is statutorily responsible for the management and conservation of wildlife both at the lake and elsewhere in the northern part of Canterbury province. In response to complaints from lakeside farmers that, at certain times of the year, swans ate, fouled and damaged pastures, the Society endeavoured to restrict each year's hatch of cygnets to about 25 000. This they did by allowing successful nesting to occur only within a confined area (the Colony) on Kaitorete Spit (Fig. 1). All other nests were visited .regularly and fresh eggs collected. Because swans are indeterminate layers many were induced to lay 15 eggs or more and the average annual collection during the early 19608 was about 40000 (N.C.A.S. files). Eventually these persecuted swans ceased laying and abandoned their nests and it was the Society's contention that some or all of them attempted to r~nest within the safety of the Colony. However, satisfactory evidence that this was so is lacking. When the allowed hatch of cygnets had occurred in nests on the Colony, fresh eggs were collected and nests everywhere were then destroyed. Thus, throughout the 1950s and 1960s in particular, a similar number of cygnets hatched each year and only those swans which nested early on the Colony were successful (Miers and Williams, 1969). In each year intensive and unlimited hunting was allowed for three months (May to July), two months longer than for other waterfowl. In addition, special "swan drives" were conducted to reduce numbers further. On these occasions, hunters were stationed at intervals across the lake and the swans herded toward them. These drives were usually very successful and in most years more than one took place. In 1965, 3026 swans were shot during drives, in 1966, 1781 and in 1967, 1 866.

Throughout the 1960s the lake was apparently a highly favourable feeding and breeding area for swans. Luxuriant stands of the aquatic macrophytes *Ruppia megacarpa* and *Potamogeton pectinatus,* the main swan foods, occurred permanently around most of the shoreline (Fig. 1) and in places were almost 1 km wide. So dense were these stands that any kind of boating through them was virtually impossible, and the water within the beds was continuously calm and still even during strong winds. It was within these weed-beds that cygnets were reared. No data are available on their survival in any year prior to the "Wahine" Storm but, given the permanency of the weed-beds and the protection they afforded, probably a similar proportion of the total hatch survived each year.

Management throughout at least the 15 years prior to 1968 was mainly negative, being designed to restrict production and keep numbers low enough to prevent swans from becoming a major problem to local farmers. Probably the only positive management undertaken was to preserve the Colony as an undisturbed nesting area. Although N.C.A.S. had neither title to nor control over the area of the Colony, it obtained the co-operation of farmers to ensure that stock, particularly cattle, were not present during the peak of nesting. The level of Lake Ellesmere, probably the single most important factor affecting the swans' ecology, was not under the control of N.C.A.S. This was, and remains, the responsibility of the North Canterbury Catchment Board and its policy, of maintaining the lake at a constant level of about 1 m above mean sea level, is achieved by periodically cutting an opening to the sea at the south-western end of Kaitorete Spit.
In some years, especially 1959 and 1965, high lake levels persisted into early summer, so flooding the nesting area and substantially lowering cygnet production.

IMMEDIATE EFFECTS OF THE STORM

At the height of the storm on 10 and 11 April 1968, south to south~westerly winds up to 134 kph lashed the lake and gale-force winds continued over a period of 36 hours. The immediate effect of this was to push the water toward the north and north-eastern end. There, at Kaituna, the lake level rose 2-2.3 m (Christchurch Press, 13 April 1968). Within the lake, the weed-beds were unable to calm the extreme water turbulence; instead they were simply ripped apart and swept away. Much of this vast tonnage of weed was tossed over the old Kaituna railway embankment and deposited in windrows up to 1.5 m high. Annihilation of the weed-beds was total. Swans also were caught in the fury of the wind. Eye witnesses have told me of swans being bowled across the water, a tangle of neck, legs and wings. They saw flying swans and ducks being

driven backwards to crash onto hillsides and paddocks far from the lake edge.

The period of calm which followed the storm revealed the extent of the carnage. Dead or dying swans, all with one or both wings smashed, were littered amongst huge windrows of *Ruppia* and *Potamogeton*. Wildlife Service and N .CA.S. Officers searched only a small portion of these heaps and found 600 swans. A Kaituna farmer reported to N.CA.S. that on his land adjacent to the lake more than 1500 lay dead (N.C.A.S. files, 14 April 1968). Bucknell (1969) reported "at least 5000" dead amongst the weed, a figure which he and others involved in inspection consider to be a minimum (E. S. Bucknell, G. Webb, D. Maindonald, *pers. comm.)*. The devastation was not restricted to the Kaituna area. At Lakeside Domain, almost tOO dead swans were found, 30 of them tangled in the branches of tall *Pinus radiata* trees (D. Maindonald, *pers. comm.)*. For some time after the storm N.CA.S. received numerous reports from lakeside farmers of dead swans on their properties and elsewhere. Unless dead on public land, their bodies were not collected.

Of the 600 swans removed from the weed heaps at Kaituna, 58 carried bands; 47 (81 %) of them had only just fledged and seven (12%) had fledged the previous year. If these constitute a representative sample, then most of the swans killed were less than two years old.

EVENTS SINCE THE STORM

Recovery of aquatic macrophytes

In the last to years the beds of aquatic macrophytes have only partially recovered. Although small *Ruppia* plants are now present along much of the shore-line from the Halswell River to Kaituna and from the Selwyn River to Hart's Creek (Fig. 1), their density is obviously much less than prior to the storm and nowhere does the former luxuriant growth occur. Slow though the recovery has been, it seems similar to that which followed the weeds' disappearance about 1940 (Mason, 1946, 1951). Then, as now, the continuous removal of the finer bottom sediments by wave action has probably been an important factor preventing or slowing re-establishment. In addition, Lake Ellesmere now supports a continuous phytoplankton bloom which alone may prevent any further macrophyte establishment.

Decline of the swan population

Destruction of the weed-beds caused mass starvation of swans. Local residents have told me of "thousands" of birds dying in the first six months following the storm, but unfortunately no surveys were made and, since few bands were removed from dead birds and forwarded to the Wildlife Service Banding Office, there is no indirect method of assessment.

Deaths resulting from the storm itself and subsequent starvation initiated a continuing population decline. Bucknell (1969) counted from the air the swans on Lake Ellesmere one year after the storm and saw 22400. Subsequent aerial counts in January 1973, 1975, 1976 and 1978 were 18000, 13 000, 12300 and 9500 respectively. Four factors have contributed to this decline; extensive breeding failure, poor cygnet survival, increased adult mortality and/ or permanent emigration, all natural responses to an impoverished food supply, and intensive hunting.

l. Extensive breeding failure

In each year only a small percentage of the adult birds present have attempted to breed. Although, in September 1968, the population probably exceeded 25 000, only 1 200 nests were constructed from which few cygnets hatched. Most nests were abandoned during incubation, presumably because the adults were in poor condition. In 1969, there was a total breeding failure. N.C.A.S. Officers found only four nests around the entire margin of the lake. In 1970, 2500 nests were found and in a sample of these (number unknown) N.C.A.S. recorded an average of 3.5 eggs (compared with 5.4 recorded by Miers and Williams (1969) in 1960 and 1961). In the following year there were 3100 nests (Adams, 1971). Since then, the numbers attempting to nest have fluctuated (Table 1), but only in 1976 and 1977 have 50% or more of the estimated breeding population attempted to nest.

2. Poor cygnet survival

In almost every year few of the cygnets hatched have fledged (Table 1). None fledged in 1968 or 1969 and fewer than 100 in 1970. In 1972 only one cygnet was found on the lake three months after nesting ceased. Only in 1971 did more than 1500 cygnets survive to independence.

In some years, growth of the young has been retarded. In 1976, for example, 2000 newly-hatched cygnets were fitted with web-tags before leaving their nests. Those caught later for banding were weighed: 21 cygnets 125-130 days old weighed on average 3.7 :t 0.4 kg; 48 cygnets 95-105 days old weighed on average 3.2 :t 0.4 kg. However, 60 days later many were still incapable of flight although fully feathered and 30 birds caught all weighed less than 4.0 kg. For comparison, 108 almost-fledged cygnets (130-140 days old) caught on Lake Whangape near

TABLE 1. *Breeding success of black swans at Lake Ellesmere since the "Wahine" Storm.*

Year	Estimated number of nests		Estimated number of cygnets fledging	
1968	1200	(1,2)	nil	(2)
1969	4	(1,2)	nil	(2)
1970	2500	(1,2)	100	(1,2)
1971	3100	(3)	3200	(2)
1972	83	(1)	nil	(2)
1973	296	(2)	450	(2)
1974	900	(2)	1500	(2)
1975	1300	(1)	1500	(4)
1976	2200	(1)	1500	(4)
1977	1600	(4)	200	(4)

Notes: (1) Data from files of North Canterbury Acclimatisation Society.
(2) Data from files of Internal Affairs Department.
(3) Adams (1971).
(4) M. J. Williams unpublished data.

Huntly in 1975 weighed on average 4.8 ± 0.3 kg (unpubl. data).

3. Permanent emigration and increased adult mortality

In an earlier publication (Williams, 1977a) I showed that since 1968 the pattern of swan dispersion has altered. Prior to the storm many juveniles dispersed from the lake before shooting commenced in May and they appeared to remain away from the lake, if not throughout their second to fourth years, then at least during the shooting season in those years. Since almost all banded birds older than five years that were shot were taken on Lake Ellesmere, I postulated that birds returned there once they became mature. After the storm, however, proportionately fewer of these older birds were shot at Lake Ellesmere which suggests that fewer were returning, possibly because they were being recruited into breeding populations elsewhere.

Mortality of birds resident at Ellesmere may now be higher than that recorded prior to the storm. I have previously calculated the mortality rates for the period 1956 to 1970 (Williams, 1973). Using the same method of life-table analysis (Seber, 1971), I have reworked these data and some more recent returns in two ways-firstly, for the period 1956 to 1967 inclusive (prior to the storm) and secondly, for 1956 to 1974 (after which shooting ceased). The results (Table 2) show that when returns for 1968 to 1974 inclusive are added to the life-table, the average mortality rate of adults increased by 4.3%. This indicates a higher rate of adult death subsequent to the storm but it is not possible by this method to suggest its magnitude. Nor, from the return of bands, can I determine mortalil rates applying since 1974 as few bands have been returned since shooting ceased.

4. Continued hunting and control

With food no longer available from the lake after the storm, lake-side pastures were invaded. Thousands of swans congregated on paddocks, principally at Kaituna, and caused severe damage. So serious were these depredations that local farmers endeavoured to have t:le black swan declared a pest of local importance under the Agricultural Pests Destruction Act 1967, a move which, had it been successful, would probably have resulted in the slaughter of at least half of the Ellesmere population. The response of N.C.A.S. to this serious problem was to undertake control operations themselves and to encourage hunting by allowing organised swan drives and a three-month hunting period without a daily limit. Control operations, especially throughout the winter of 1968, involved shooting and scaring birds from pastures. How many were killed is not known, but on one operation 300 birds were shot (E. S. Bucknell, *pers. comm.).*

Organised drives were held in 1968, 1969 and 1970. In 1968 there were six; at five attended by N.C.A.S. Officers, a total of 677 hunters participated, shooting 3814 swans. After one drive in 1970 in which 250 hunters participated, 935 swans were recovered. Hunting occurred each year after the storm up to and including 1974. In each year the season was three months long. There was no daily bag limit in 1968, 1969 or 1970 but in the subsequent four years it was two, two, five and one respectively.

Normally, newly-fledged swans are more likely to be shot than those of other age classes: of the banded birds shot on Lake Ellesmere from 1956 to 1968, almost half were young of the year and only one swan in seven was five years of age or older

TABLE 2. *Mortality rates of black swans banded as cygnets at Lake Ellesmere 1956 to 1968.*

Years after banding	0-1	1-2	2-3	3-4	Adult (1)
Mortality rate (%) 1956 to 1967	31.3	34.0	20.5	23.5	12.1
Mortality rate (%) 1956 to 1974	33.8	33.9	21.6	23.6	16.4

Note:(1) The adult figure is the mean of mortality rates for years 4-5 to 9-10 inclusive.

TABLE 3. *Percentage age composition of black swans shot by hunters at Lake Ellesmere before and after the "Wahine" Storm.*

Age (yrs)	1956-68		1969-74	
1	48.4		19.3	
2	21.2		7.9	
3	8.0		11.7	
4	7.2		5.3	
5	2.9		4.3	
6	2.9		7.7	
7	2.0		8.1	
8	2.2	15.2	5.8	55.8
9	1.0		8.8	
10	1.1		3.8	
11+	3.1		17.8	
Sample size	3274		583	

(Table 3). The contrast with the age composition of the hunters' kill since the storm is self-explanatory. Not only were the adults more heavily shot, but almost the entire sample of one-year-olds was shot in 1972, the production of the only breeding season of consequence since the storm.

THEORETICAL AGE STRUCTURE OF THE PRESENT SWAN POPULATION

The years of poor or no breeding have resulted in some age classes no longer being represented in the population. In Figure 2 I present an approximation of the size and age structure of the population as at January 1978. In determining the size of each cohort 1 assumed that in all but two years prior to the storm 25 000 cygnets reached the lake and that 15000 of them fledged. (In 1959 and 1965 breeding was poor and in both years approximately 500 cygnets fledged). There are no data available on cygnet survival prior to 1968. My estimate is based on the calculated survival of marked cygnets on Lake Ellesmere in 1976 (Williams, 1977b), cygnet survival at Pukepuke Lagoon near Himitangi over the years 1970 to 1977 (T. A. Caithness, *pers. comm.)* and an analysis of swan brood counts made at Lake Whangape in 1975 and 1977 (unpubl. data).

To the calculated number fledged I applied the mortality rates shown in Table 2 for the 1956 to 1967 period. When these cohorts entered the year 1968 and subsequent years, I applied the increased mortality rates shown in Table 2 for the period 1956-74. The analysis of band returns indicated that after the 10th year, mortality increased to 24% for years 11 and 12, to 30% for the 13th and 15th years and maintained an average of 40% thereafter. No doubt band loss has contributed substantially to these higher mortality estimates, but the possibility that some real increase in mortality occurred cannot be ignored. However, in constructing the age histogram 1 have applied only the "adult" mortality rate shown in Table 2.

There are now no birds in their sixth, eighth, ninth or 10th years of life, and almost no fifth year birds. Swans now entering their fourth year were hatched in 1974, a "good" year, but mortality in the interim has reduced the size of this cohort to less than the number of 1976-born cygnets now alive.

Although it has not yet been confirmed in the field at Lake Ellesmere I suspect that, on average, swans do not commence breeding until their fifth year; at present there are few birds in the 5-10 year category, normally the largest breeding group. The last major input to the breeding population were the progeny of 1967, the cohort which probably suffered most during the "Wahine" Storm and which experienced considerable shooting pressure in subsequent years. The number of swans born since the storm and now of breeding age comprise less than 10% of the total adult population.

THEORETICAL AGE STRUCTURE FOUR YEARS HENCE

In four years' time, all birds alive at present and remaining alive will probably have entered the breeding population. If the mortality rates outlined in Table 2 continue to apply over the next four years, the number of breeding birds in the population will decline by approximately 50 % (Fig. 2). If

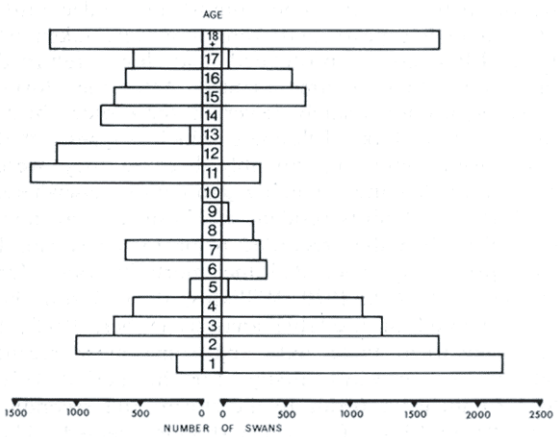

FIGURE 2. *Theoretical size and age structure of the Lake Ellesmere swan population in January 1978 (left) and four years later (right).*

mortality rates do increase after the 10th year, the older birds will die out even more rapidly and the rate of decline will be greater. There is no way of predicting beyond this period without making assumptions about future cygnet production. What may be predicted, however, is that for the decline to be arrested, and for the population to remain approximately stable thereafter, an average annual production slightly in excess of one fledged cygnet per pair of swans of breeding age is required (the projected number of one- to four-year-olds in Figure 2 assumes this production). Such production considerably exceeds anything that has occurred since the "Wahine" Storm. The prognosis for the future is not especially encouraging.

MANAGEMENT OR LAISSEZ-FAIRE?

It is obvious that this once splendid natural resource is in trouble and a further decline seems inevitable. What management practices, if any, should be implemented to effect a recovery? To answer this question we must first review recent management practices and their effects and pose more specific management questions.

Recent management policy

To N.C.A.S., an organisation apparently required to reflect in its management policies the views of its diverse membership, the Ellesmere swan popula-t:on is a traditional and highly prized hunting resource. Now (1978) the Society members see 9500 swans on the lake but are not permitted to hunt them. Using funds derived from the sale of hunting licences (probably none of which was purchased for the sole purpose of hunting swans) the Society employs full-time field staff to manage the waterfowl resource of its district and Ellesmere swans are a costly management exercise. In fact, this is probably the first time in the Society's 110 year history that its funds have been spent so liberally on a species for which there is no obvious immediate or short-term recompense. Its primary and continuing aim has been to retain swans as a game-bird (Table 4), and for some years after the storm the Minister of Internal Affairs, acting on the advice of his departmental officials, acceded to its requests.

Management policies have, by and large, remained unchanged. It is still considered necessary for all nesting to be confined to the Colony. In each year up to and including 1976 nests outside the Colony were destroyed and fresh eggs collected, an activity conducted under permit from the Minister of Internal Affairs. The rationale for this was no longer that cygnet production should be severely restricted, but that by so confining all nesting the cost of law enforcement would be reduced and nesting birds more easily protected. It was also advocated that late nesting attempts both on the Colony and elsewhere should be destroyed so that no late-hatched cygnets competed for food with those hatched earlier. Just how many nests were destroyed each year is not known, but the examples of 1976 and 1977 show that, even at the Colony, breeding birds were not ensured a successful nesting. In 1976 nests were deserted when cattle were turned into part of the Colony. The land on which this happened is leasehold and one of the terms of the lease is that officers of the Department of Internal Affairs may, in consultation with the lessee, erect a fence to protect nesting swans. As local Departmental Officers were changed, this clause became forgotten and has never been invoked, despite the

TABLE 4. *Annual requests by the North Canterbury Acclimatisation Society for swans to be included on the waterfowl hunting licence and the approval granted by the Minister of Internal Affairs.*

Year	Daily limit requested	Season length requested	Daily limit approved	Season length approved
1969	no limit	3 months	no limit	3 months
1970	no limit	3 months	no limit	3 months
1971	3	3 months	2	3 months
1972	5	3 months	2	3 months
1973	5	3 months	5	3 months
1974	5	3 months	1	3 months
1975	3	1 month	Nil	
1976	Nil		Nil	
1977	2	6 weeks	Nil	
1978	10	2 months	Nil	

fact that stock have caused desertions in most years since 1971. In 1976 when 2200 nests were built about Lake Ellesmere, 800 beyond the confines of the Colony were destroyed and 400 on the Colony were deserted because of cattle; thus 55 % of the nests were lost directly or indirectly from man's activities. Miers and Williams (1969) reported that on the Colony, 22% of the nests they studied were deserted or failed to produce cygnets. Again in 1977, birds nesting at the Colony were molested. Cattle were once more released into part of it when hatching had just commenced. Almost all of the 600 nests in that area were deserted. Over the remainder, what was obviously a highly organised egg-stealing operation destroyed between 500 and 600 clutches. Re-nesting did not occur. Although about 1 600 nests were established in 1977, cygnets hatched in fewer than 200.

Should hunting be allowed?

There can surely be no dispute that hunting this year, next year or in the near future will do nothing other than accelerate the population decline by removing more of the breeding adults (hunting mortality is probably partly additional to natural mortality) as well as a proportion of the newly-fledged cygnets and other pre-breeders, a group whose welfare is imperative if a recovery is to occur. Hunting should not even be considered until the decline in the breeding population has been arrested.

Should cygnet production be restricted?

The decline of the breeding population can be arrested only by the recruitment of juveniles. Given that the sole immediate aim is to ensure the maximum recruitment of new breeding stock to replace the ageing adults, there seems to be no case whatever for restricting cygnet production. The concern that late-hatched cygnets may compete for food with those hatched earlier is best left for the forces of natural selection to resolve.

Should nesting be confined to the Colony?

The problem of protecting nesting swans is very real. Swan eggs are a delicacy to poachers and, as a result of sales by N.C.A.S. in the late 1960s and early 1970s, there is a ready market for eggs as supplementary food for local race-horses. Nesting around most of the shore-line-as occurred prior to the storm-certainly presented an expensive and difficult law-enforcement problem, although its cost was offset by egg sales. Since 1976, however, swans have nested in compact colonies at few localities-on two small islands at Kaituna, on Gray's Spit (a region of high ground situated midway between Kaituna and the Halswell River mouth), near the mouth of the L.2 River, on the Colony itself and in fields immediately alongside. The law-enforcement task is now less onerous and seems to provide little justification for the destruction of nests established outside the Colony, the locations where in 1976, 1977 and 1978 an average of 25% of all nests were built.

No research has been undertaken at Ellesmere to determine the wisdom of crowding nesting swans onto a confined area like the Colony. The species is mainly a colonial nester but there is probably an optimum nesting density at which maximum success is achieved. Miers and Williams (1969) indicated this when they showed that the proportion of unsuccessful nests was significantly greater amongst those spaced up to five feet (1.6 m) apart than amongst those more widely spaced. Research on this topic is obviously required.

Should the nesting area be re-developed?

As nesting habitat, the Colony has deteriorated rapidly since the storm. Formerly, the large quantity of wind-driven *Ruppia* and other debris deposited along its shore-line was used extensively by early breeders to build nests and the numerous clumps of rushes *(Juncus* spp.), especially those near the shore-line, became the focal point for one or more nests (Miers and Williams, 1969). Since the storm, however, the now unprotected shore-line has been heavily eroded and many of the *Juncus* clumps lost. In addition, the farmers have endeavoured to improve their pastures by cutting, burning and heavily grazing the rushes. Now, nesting material is scarce and the few remaining rushes are the almost exclusive location of nests. On 29 September 1978, all but seven of 175 nests built on the eastern half of the Colony, were amongst the *Juncus* clumps, many of them 150-200 m from the lake-edge. This contrasts with the findings of Miers and Williams (1969) that most early nests were established close to the shore. Much of the Colony, therefore, may no longer be an attractive nesting area and perhaps only large-scale planting of *Juncus* along the shore will prevent more swans from nesting elsewhere. If research confirms the wisdom of confining nesting to the Colony and as a result rehabilitation of the Colony is undertaken, there will be an opportunity to create nest sites at spacings which may ensure maximum nesting success.

What of the pasture damage problem?

The years of poor breeding and poor cygnet survival are mainly a reflection of the impoverished state of the swans' habitat-the Ellesmere population has had to adjust to the reduced carrying capacity of the lake and now relies heavily on lake-side

pastures for food. Denied access to those pastures, the population would probably be even lower, and it is very likely that pastures will remain a major source of its food in future. The serious problem of depredation occurs mainly in winter when high lake levels and minimal growth of aquatic macrophytes combine to make food in the lake scarce. The present control measures of shooting birds or scaring them from pastures will continue to be ineffective so long as swans have no alternative source of food. The provision of specific pastures for swans, a common practice in the management of geese in Britain and Europe (Owen, 1973), would seem to be an obvious remedy.

Management options

A further decline at Lake Ellesmere appears inevitable. For how long it will continue and at what rate depends on the rate of juvenile recruitment into the breeding population. The wildlife managers can do little within. the bounds of economic reality to improve the quality of Lake Ellesmere and in so doing enhance cygnet survival, but they can ensure optimum circumstances for nesting and cygnet production. This must now be seen as a priority. Management policies based on expediency-the destruction of nests because they are a law-enforcement problem-are totally inconsistent with this aim. The choice for the managers is clear. They can adopt a positive approach and:

1. leave the swans to nest wherever and whenever they wish and so accept that laissez-faire in this regard is also a benign form of the managers' art;
2. improve the Colony as nesting habitat with the aim of enticing swans to nest there under optimum conditions if research shows this is wise;
3. accept that the lake-side pasture will remain an important source of food and so provide it; and
4. refrain from hunting.

Conversely, they may continue the present negative approach and:

1. destroy all nests built outside the deteriorating Colony;
2. continue the policy of scaring and shooting birds from pastures without providing alternative food, and when it does not work seek to have swans hunted again; and
3. ignore the fact that in managing the Lake Ellesmere swans they are managing not just a local but a South Island resource.

Under the pretence of management, man interferes with the natural processes of many species. Perhaps in the present example the difference between malign and benign management is in an understanding of the animal's biology and the processes which affect its numbers.

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