picture, in the years to which they are common, as the much larger samples available in more recent years.

Five samples of comparative counts have been assembled, varying in size and length from one of 165 waters for the six years, 1950–51 to 1955–56, to one of 601 waters for the single season 1955–56. The patterns of the seasonal fluctuations in the numbers of Tufted Ducks (*Aythya fuligula*) presented by the five samples are first compared and shown to be similar in the years for which they are all available. From this it is inferred that the smaller samples are as reliable as the larger ones.

The trends in population are also examined by this method with the larger samples being used to confirm the results of the longer but smaller ones. During the period 1950–51 to 1955–56 wide variations in the numbers present in October, November, February and March may be detected, with increases in the level of population in these months in 1955–56 and to a lesser extent in 1954–55. In January, however, which is the month in which the population of Tufted is most likely to be stable, no variation between the levels in the six years is detectable. From this it is inferred that although early and late in the season the British wintering population of Tufted may be augmented by varying numbers of immigrants, the basic population in January, after the arrival of the autumn immigrants and prior to the hard-weather influxes, has been constant throughout the six years under review.

Examination of relative numbers of Tufted Duck counted in different areas and on different habitats reveals a variety of population patterns. In particular, reservoirs appear to be of great importance, as although they comprise only 20% of the waters counted, they carry up to 60% of the birds recorded throughout most of the winter. As a great deal of information on the size and depth of reservoirs is already available, it is intended that the behaviour of the populations of Tufted on them shall be the subject of a further, more detailed, paper.

THE PLACE OF AERIAL SURVEYS IN BRITISH WILDFOWL RESEARCH

The Alternative Methods of Population Study

A BASIC requirement for programmes of conservation is a knowledge of the size and distribution of the animal populations concerned. The capture/recapture technique can estimate population size, but a general knowledge of distribution is implicit in the sampling process. Moreover, it is necessary to use traps which are mobile (or used in large numbers throughout the country) and which do not result in trap-shyness developing. Neither of the usual duck-catching devices, decoys and cage-traps, meet these requirements. Only Shelducks congregate in suitable numbers to be driven into stake-nets when flightless in the moult. Most ducks only form dense flocks on water or mud banks, where rocket-propelled nets cannot be used.

The majority of duck populations and some of the geese can therefore only be studied by direct survey methods. In some cases where the population is relatively small and restricted, a complete census can be the aim. Generally, only the population found in sample areas can be surveyed. But if this sample

is representative, changes in its size and composition can be taken as reflecting those in the population as a whole. Further, if the habitat range of these species is limited and the proportions of the different habitats covered by the survey can be determined, then appropriate extrapolation of the census figures will give an estimate of total population. The larger the sample the greater will be the accuracy of the final estimates.

Ground Survey of Wintering Flocks in Britain

The Wildfowl Trust has taken over (from the former Wildfowl Inquiry Committee) and expanded the Wildfowl Count Scheme of surveys from the ground in Britain. Under this organisation some 700 volunteers count the number of ducks and geese present on selected inland and coastal waters. This is done at monthly intervals throughout most of the year, on fixed dates. Regular information over a number of years is now available for more than 500 waters and partial information for a further 500. Even so, probably less than 1% of the inland waters alone are being surveyed, and there are great tracts of important duck country too far from the large towns to be covered by watchers living there. Attempts are being made to expand the survey, but a limit is imposed by the distribution and numbers of competent ornithologists willing to undertake this arduous task. If the present corps of observers did not give their time free and pay their own travelling expenses, the present limited survey would cost considerably more than ten times the modest sum now provided by the Nature Conservancy for running expenses. It is clear that little could be done by the employment of professionals to supplement the amateur effort.

Even if a small number of professionals were made available, each man could, on the ground, cover only a limited number of the more isolated waters or a limited stretch of coast on a count day. Moreover, they, like the present observers, would be unable to count birds lying well off-shore. This part of the population is of particular interest, since many wildfowlers opine that it contains three times as many birds as can be seen from the shore—a point which it is clearly desirable to check. A species which is of especial conservation interest, the Brent Goose, spends almost the whole winter below high-tide mark and may easily be missed from the shore.

Aerial Survey of Wintering Flocks in America

In North America, with its much greater expanses of sparsely populated country, the problem has been tackled for more than twenty years by the use of aerial survey methods. These have not been restricted to wildfowl alone—Bison, Elk, Wild Sheep, Sea Lions and deer having been counted in this way. The cost per square mile has, by some estimates, been less than one two-hundredth part of the cost of a ground search by professionals. Moreover, extensive areas could be searched that were quite beyond the scope of ground crews—nine man-weeks were spent in counting the deer on 746 square miles; a ground survey of the area would have taken more than three man-centuries!

The American winter flocks of wildfowl have been subjected for many years to an extensive sample census regularly towards the close of the shooting season. In January 1957, 150 aircraft were used, flying a total of 85,615 miles. All the indications are that estimates of numbers in flocks of wildfowl made by skilled observers from aircraft are as accurate as those made from the ground. When visual observation is supplemented by high oblique or vertical photographs as a permanent record, the final accuracy will be greater.

Aerial Survey of Breeding Populations in America

For the past nine seasons the Americans have, in addition, been making censuses of the breeding population in the summer quarters, as these are considered to give a better indication of the subsequent autumn population, which is the basis used for adjusting shooting regulations each year. Under these conditions the birds are much more scattered and are liable to be hidden by vegetation. They therefore form the most stringent test of the efficiency of aerial survey, and a number of reports on this score have been issued.

It is not claimed that aerial survey will, in these conditions, reveal the same number of birds as the ground coverage. In general, fewer birds will be recorded. But since we are only attempting to sample the population, it is only required that the method should produce consistent results.

From several detailed comparative investigations the American Fish and Wildlife Service workers have concluded that aerial survey of breeding populations is an efficient as well as economic method of making a sample census. The reliability of aerial survey of winter flocks is unquestioned.

Aerial Survey in Europe

Nearer home, the survey of moulting Shelduck on the Grosser Knechtsand in north-west Germany in August 1955 has pointed out the value of the aerial method using both visual observation and photographic records. The report of the commission indicated that without air cover the duck concentrations could hardly be located, let alone counted.

Since January 1955 Dr L. Hoffmann has made frequent aerial censuses of the ducks wintering in the Camargue area of southern France (see pp. 154–156 of this Report, and L. Hoffmann et J. Penot: 'Premier recensement des canards hivernant en Camargue' in *La Terre et la Vie*, 1955, pp. 315–320).

On 21 January 1956 a photographic flight was carried out by Dr J. K. S. St Joseph, Curator of Aerial Photography, Cambridge University, on behalf of the Nature Conservancy. In less than two and a half hours the entire coast of the Wash was surveyed for two distinct species—Brent Geese and Oystercatchers. Mr I. C. T. Nisbet, who made counts visually and from the oblique photographs, has estimated that in the latter case the standard error was between ½% and 1%.

Clearly aerial survey is a technique that must be introduced into British wildfowl research, particularly to fill in the inevitable gaps in the coverage provided by amateur ground observers of wintering flocks. Many of our birds come from Russia, Iceland or Scandinavia, and so are difficult or impossible to count on their breeding-grounds. But Britain holds an important breeding population of Mallard whose status could easily be investigated by this method.

Methods of Operation

For preliminary work, more flights such as those made by Dr St Joseph, using aircraft and men provided by the R.A.F., could certainly be used. They would have the advantage of being able to use Service airfields, weather forecasting and other facilities. But this is not a satisfactory solution for making regular surveys. The flights would have to fit in with Service requirements, and the same pilot would seldom be available. Moreover, Service training today is such that few pilots are adept at map-reading, an essential proficiency in this type of work.

American work has stressed the importance of the training of individual pilots and observers for aerial survey work, and shown how much more efficient is coverage by an experienced man. If a wide range of inexperienced aircrews had to be used, no reliance could be placed on apparent fluctuations in wildfowl numbers. Because of the much wider sample covered by the aerial observer, individual errors would loom larger in the overall sample, and would not be corrected by cancelling out of tendencies to overestimate or underestimate as is the case when hundreds of ground observers are used. Moreover, the Service pilot (or commercial pilot) would simply be driving the aircraft, and other crew members would be required to tell him where to go, to map read, to identify the birds and do the counting and/or the photography. The obvious solution is for the pilot to be a biologist himself, making aerial survey one of his main researches.

Dr S. K. Eltringham has been appointed to the staff in this capacity. As he was not available until October 1957, a preliminary programme during the winter of 1956–57 was undertaken by members of the existing staff, in a light aircraft provided and flown by Mr J. D. H. Radford. The Trust is very much indebted to Mr Radford for his enthusiastic co-operation. This first season's work was exploratory, with two principal aims: first, to discover what it is reasonable to expect from aerial observations in the conditions of a British winter, and second, to familiarise several observers with the appearance of wildfowl from the air and with the problems of approach and counting.

A total of 82 hours' flying-time was divided between four assignments. First, the aircraft was used in support of the rocket-netting team in October 1956 to locate flocks of Pinkfooted Geese in the Solway, Humber and Wash areas. Second, a short trip in December 1956 was devoted to counting ducks in Somerset. Some experience of conditions on inland reservoirs, on flooded marshes and on the coast was gained, but the weather was bad for flying, and complementary counts from the ground were hampered by the shortage of petrol at that time. Third, between 3 and 12 January 1957, a search was made of the south and east coasts of England from the Exe estuary to Skegness, with particular attention to the numbers of Brent Geese and Mute Swans. A repeat count of Brent Geese on the coast between Skegness and Southend was made on 2 March 1957. The fourth task, taking almost exactly half the total flying-time, was a search of the Hebrides and the west coast of Scotland, chiefly for Barnacle Geese. The results of this search are reported on pp. 42–46.

The expenses of the aerial survey are being met by part of the annual grant made to the Trust by the Nature Conservancy, whose support for the venture is gratefully acknowledged.