Winter appraisals of annual productivity in geese and other water birds

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Summary

Every nesting season stamps a visible record of its success or failure on fall populations of geese, swans, and some other water birds. Thanks to the distinctive first winter colouration of young of some species, and the persistence of broods ('families') and other functional groupings in some of these and other species, comprehensive studies of annual reproductive success and mortality can be made by methodical field scanning of wintering flocks. Winter survey methods developed for Blue, Snow and White-fronted Geese are discussed here in great detail, not only because of their intrinsic importance, but because they may provide clues for probing the vital statistics of other birds. Winter appraisals of productivity have the special advantages of being quick, simple and economical, and of providing information that is timely rather than historical. Their efficacy hinges upon competence of field observers. So long as observers remain afield the appraisals can take cognizance of biological as well as arithmetical aspects of current welfare of populations. By themselves the data from some winter appraisals may be sufficient for routine management of the robust species; used in concert with other surveys they may help solve many intricate problems in those bird populations that require special attention.

Inquiries into the mechanics of bird populations sometimes encounter an informational 'partial vacuum', in which further progress seems to evoke laboured exercises in abstruse mathematics. It is therefore refreshing to learn that populations of many of the geese, swans, and other water birds can be examined directly, and if need be in minute detail, by expedients that are relatively uncomplicated and pleasant. A mildly-sophisticated form of winter bird-watching, that exploits familial and other groupings and/or distinctive coloration of first winter young, serves to monitor annual status, mortality and reproductive success among Blue and Snow Geese, White-fronted Geese, and the other species discussed in this report. With application of simple actuarial arithmetic, the historical record of these winter observations can be made to yield vital statistics for these populations.

History of Development

Information that is reliable and timely is essential to effective conservation of wildfowl. At a bare minimum, this information should afford some idea as to annual status of each species. Management of birds that are heavily hunted requires more precise records of current mortality, increment, and other factors that affect status, so that hunting regulations and other conservation measures can be evaluated and brought up to date. Heroic action may be required to save a rare or endangered species, and such action, to be efficacious, calls for detailed, up-to-the-minute knowledge of ecology of environments, and of biological as well as arithmetical aspects of biotic potential in the species. In the tribe Anserini,[1] almost every genus has species that are robust and some that are not; it is often difficult to get detailed data for those populations that require special attention, unless it be adduced from studies of their more prosperous relatives. Of the investigational techniques formerly in common use, no one method could produce all the information needed for this group of birds. All conventional methods used together have fallen short of providing for some species information that is timely as well as comprehensive.

The first substantive data on numerical standing of various species of waterfowl in North America came from a midwinter 'inventory' or census that was conducted in January each year (Bell, 1937). This inventory was intended to produce numerical indices that would reflect trends in abundance, although its data often invited further interpretation not all of which was warranted. When it registered an increase one winter for a species that previously had been low in numbers, one might infer that mortality in that species had been lessened during the past calendar year, perhaps by protective measures, although it was equally possible that the nesting season just past had produced more than enough young to compensate for annual mortality. When a species showed decrease in numbers one winter, the decline might be thought to reflect high mortality, or poor productivity, or both during the past year. Or the discrepancy may have represented only census error. So long as inventory figures had to stand alone, without benefit of corroborative information from productivity sur-

[1](of Delacour and Mayr, 1945)

veys or other sources, they gave no clue as to the nature of changes in population status, and often left some doubt whether changes had indeed occurred.

Supporting information as to annual status of birds might be adduced from band records (Lincoln, 1930), but the Arctic-nesting geese, swans and brants had not been banded in numbers when our inquiry started in 1937. More recently, large-scale banding programmes are contributing materially to knowledge of distribution of these birds, their survival, and other vital statistics. However, banding data used alone have shortcomings (Boyd, 1959), and are more historical than current. Few band returns can be expected from species whose hunting is greatly curtailed or forbidden.

Nesting ground surveys each summer produce timely information as to breeding population levels and reproductive success, but such surveys of the American Anserini would have to cover each year vast breeding ranges that include much of the topside of the North American mainland and the Arctic Archipelago, and some portions of Asia. Even after 1947, when routine summer surveys were expanded to take in most of the breeding grounds of the American game ducks (Williams, 1948), they did not unearth much data on 'annual arithmetic' of the geese, swans and brants, although their explorations have contributed materially to better understanding of the nesting geography of these birds (Lynch and Smith, 1959).

The prevalence of young of the year in the fall population of a species reflects its annual reproductive success. Fall age-ratio information is important to waterfowl management even if only in subjective or percentage form. When taken together with an estimate of total birds in the fall population, the two types of data become complementary. Census figures make possible the conversion of percentages to total numbers of young and older birds. This information, if obtained for two consecutive years, can serve as a quantitative expression of net annual increment of young and can be made to disclose calendar year mortality of older birds (see later discussion of Population Plot). This record serves in turn to monitor the credibility (if not the absolute accuracy) of census counts, and provides a means of interpreting the trends the latter seem to indicate. Most methods of determining age in waterfowl in fall and winter (Mosby *et al*, 1960) require in-hand examination of specimens furnished by hunters or trapped in the course of banding operations, and so could not be used for species that were difficult to trap in winter, or that were not subject to hunting. Fortunately many of these 'difficult species', especially of the genera *Cygnus* and *Anser*,[1] display external features that may be exploited in winter surveys of annual productivity. The young of many of these have characteristic first-winter plumage by which they can be distinguished from older birds at considerable distance.

Since the Blue Goose (*Anser c. coerulescens* (L.)) is a form whose dark first winter young are conspicuously different from white-headed older birds, the authors began studies in 1937 in an effort to determine its annual productivity via field observations in Louisiana. This work later was expanded to include Continental populations of the Snow Geese (the Lesser Snow or white phase of *A. c. coerulescens* and Greater Snow *A. c. atlanticus* (Kennard)), and the White-fronted Goose (*Anser albifrons*). Somewhat similar studies were undertaken on the Blue Goose by the Canadian Wildlife Service in 1946 at James Bay, Ontario (Hewitt, 1950), and series of observations of this general type have been made in England on the White-fronted Goose (Boyd, 1957) and the Brent Goose (*Branta bernicla* (Burton, 1958)). Greater Snow Goose (*A. c. atlanticus*) observations by Howard (1940), the Whooping Crane (*Grus americana* (L.)) surveys described by Stevenson (1943), and the Trumpeter Swan (*Cygnus cygnus buccinator* (Richardson)) counts reported by Banko (1960) can be considered examples of winter appraisals of productivity. Boyd (1959) summarizes the potentialities and the accomplishments of these surveys. Most of these early studies involved a field sorting of young and older birds on the basis of plumage; in only a few instances were family and other groups considered.

Of additional value in population studies would be annual records of average number of young per brood, the proportion of adults that produced broods, the percentage of broods that had lost parents, and similar details of annual productivity and mortality. All species of the tribe Anserini (and of the Gruidae and some other birds) have strong social organization wherein young remain with parents as families through their first winter of life. This offered the possibility that rather comprehensive 'nesting studies' might be conducted on the wintering grounds of these waterfowl. At first our winter appraisals did not seek to explore fully this possibility, although families were recorded by some observers as a matter of convenience in

[1]Including *Chen*. The nomenclature used in this paper is that of P. Scott *A Coloured Key to the Wildfowl of the World*. Scribner's, New York. 1961.

keeping field notes. Eventually the more experienced observers noted that certain 'non-family' groupings were as conspicuous as the families, not only in the wintering flocks but also in field records. After 1947, the recording of all groups, non-family as well as family, became a standard practice in winter surveys.

That we elected to follow this course of action was due not so much to astute planning, as to the circumstances attending field observations in the Gulf Coast marshes. Geese wintering in this region seldom congregate on open water, or along exposed shores or sand bars where they would offer the observer an unrestricted look at all birds in a flock. They are more apt to be found deep in the vast marshlands or in weedy pastures or rice stubble, where settled birds are screened at least partially by vegetation. Only when these birds take wing can the observer see them clearly, and even then he is apt to be overwhelmed when a great flock of many thousands of birds is suddenly flushed or passes overhead. So we made a practice of seeking out each individual wintering flock when it was 'working' to a feeding or roosting area in a normal undisturbed manner. Thus most of our observations were made of flying birds at times when functional groups would be most conspicuous. Eventually we learned how to exploit the family and other group records, as is explained subsequently in this paper (see 'Population Plot'). Derivation of vital statistics from winter data is illustrated by the Whooping Crane analyses of Allen (1952) and Lynch (1956).

These appraisals are now routine each winter for Blue-, Snow- and White-fronted Geese, but are still exploratory for other birds. Survey data are collated and analysed annually in the Branch of Wildlife Research, Bureau of Sport Fisheries and Wildlife. Annual reports that are prepared for the information of wildlife administrators and survey co-operators are on file at Patuxent Wildlife Research Center, Laurel, Maryland, and at its Lafayette, Louisiana field station; and also at the Wildfowl Trust, Slimbridge.

The present paper describes these winter appraisals as an adjunct to, not a substitute for, other waterfowl fact-finding techniques. Their principal value is that they can produce, quickly and economically, rather precise and timely information on annual productivity for species that are amenable to such survey. When employed in concert with other surveys, they may help develop for some species a whole spectrum of vital knowledge that can be kept up-to-date.

Field Procedure

These appraisals involve direct field observations of living birds. In this regard they differ from some biometry, wherein the investigator remains quite aloof from the birds he is studying and contents himself with maintaining a clearing house to which comes information furnished by hunters or other co-operators. Our appraisals take a more 'personal' approach to the subjects. It must be acknowledged that this requires of field workers a keen interest in and a certain familiarity with wintering birds and their habits. Observers must be able to locate all important segments of wintering populations each year, and to scan them methodically so as to detect and record evidence of productivity. Being thus afield and in intimate contact with birds, they are also able to keep aware of environmental and other factors affecting the welfare of species.

In its simplest form this productivity appraisal would amount only to a tally of all first winter young and all older birds in sample wintering flocks, without reference to groups. The young Blue Goose has a dark head and body during most of its first winter (Bent, 1925), whereas 'yearling' (sub-adult) and adult Blues have white heads. The head and body of young Snow Geese and swans are dull white suffused with slate or dun in the fall, in marked contrast to the gleaming white plumage of adults and sub-adults. Among some other birds that might be candidates for these winter appraisals, first-winter young can be discerned when lighting conditions are favourable. In the case of the White-fronted Goose, for example, the cross barring on lower breast and belly of sub-adults and adults, and the unmarked underparts of first-winter young (Bent, 1925), can be seen when the sun is at a low angle, as in morning or evening, or when the birds pass directly overhead. Burton (1958) uses the presence of white edgings to the wing-coverts to distinguish first-winter Brent Geese (*Branta b. bernicla*).

Young of many of these species have been caught alive during the fall months, and held captive at an aviary in Lafayette, Louisiana to learn the dates when first winter colours gave way to adult-appearing yearling plumage. It was found that most young Blue Geese remain conspicuously different from older Blues as late as March, although care must be exercised in field identification of Blue Geese after January because precocious youngsters show some whitening of cheeks at midwinter. Young Snows become progressively whiter as winter advances, but traces of darker colour persist on dorsal aspect until birds enter midsummer moult. Some young

Whitefronts show individual dark feathers on the underparts by the end of January, but these do not begin to resemble the conspicuous dark blotches of yearling plumage until the month of June.

In the more detailed appraisal, the observer views a flock of wintering birds not as a casual aggregation of individuals, but rather as a congregation of families, mated pairs, 'yearling' (sub-adult) bands, and other meaningful groups of birds. These groups, and the diagnostic features of plumage, are most conspicuous when these birds are in flight and executing some manoeuver. A flock of feeding or roosting birds that is attracting newcomers provides an ideal situation for detailed observation. The settled birds serve as a decoy flock, and the observer can devote full attention to new arrivals. These arrivals first appear in the ragged V's or long strings that characterize the cross-country flight formation. As they approach the settled flock, their in-line formation will usually break up into families and other functional groups, and these often circle the decoys before landing. Groups should be identified and recorded in the interval between break up of formation and actual touch-down. With experience, the observer will learn the best time to identify these groups and their members. Groups may coalesce temporarily when flocks are excited or disturbed but, being the basic units of social organisation among the geese, they make themselves clearly evident when circumstances are favourable.

While incoming flight birds are the first choice for observation, groups that take wing and depart from the settled flock in a normal unexcited manner also are suitable. Complete appraisal counts can be made from birds passing overhead, provided they are moving such a short distance that functional groups do not tend to merge. Once the latter have coalesced into the larger flight formations, age-ratio counts may still be feasible but groups cannot be recorded. Birds that are settled on the ground or water are tallied only when they are not crowded, and when visibility is exceptionally favourable.

The experienced observer knows that sun angle, wind direction, and background (cloud masses and landscape) can influence his observations, and he learns to position himself so as to take advantage of these factors. As a general rule he will want the sun at his back. Birds land into the wind, so he may prefer to be located down wind from landing Snow Geese whose young have diagnostic markings on the back, upwind from species such as Blues (early winter) and Whitefronts, and across the wind from late-winter Blues and some other species.

Good field glasses are essential in this work. Most observers prefer glasses of 6- to 8-power. Greater magnification is advantageous for special studies, but reduces the field of vision, making the location and identification of fast-moving flying groups most difficult. 'Heat-shimmer' and other atmospheric distortion may be aggravated by great enlargement. When a team of two is available for the work, one man can serve as observer, calling out data to be recorded by the other. If one must work alone, he will find a battery-operated recording device most valuable.

We have adopted a standard field record sheet (Figure 1), and a routine method of calling out data. When only a simple age-ratio is desired from wintering birds, all obvious first winter young and all older birds all tallied (as in Item 1, Figure 1), without reference to groupings. If the average brood is to be determined, but no other data are wanted, counts would be confined to recognisable family groups.

In the complete appraisal of productivity, all groups are taken as they come, and there is no selectivity. As each group is identified, its members are entered in appropriate columns on this field sheet in the following manner (items are numbered as in Figure 1): (2) *A group having two adults and one or more young*, would be a normal family group (brood and parents) and is so entered in Figure 1; the number of

Figure 1. Productivity Appraisal: a Sample Field Record

Locality_____ Date_____ Size of Concentr._____ Obs._____

	(sp)		(Blue, snow, or other)	
	IN FAMILIES		NON-FAMILY	
	Adults	Young	Adults	Young
(Sample entries) Item (1)			5,3,4,2,etc.	2,2,3,etc.
(2)	2 —	— 3		
(3)	1 —	— 2		
(4)			2	
(5)				2
(6)	2 —	— 2 (and) —	1 (3 —	— 2)
(7)	(See #8-11)		(6 —	— 8)
(8)	2 —	— 1		
(9)	1 —	— 3		
(10)	0 —	— 2		
(11)	(See #1)		(Tot. Ads.	Tot. Young)
(12)	Ad. Blue	Ad. Snow	Young Blue	Young Snow
(13)	1 —	— 1	2 —	— 2
(14)	2 —	— 0	2 —	— 2
(15)	0 —	— 2	1 —	— 2
(16)	0 —	— 0	1 —	— 1
(17)	1 —	— 1	0 —	— 0

Figure 1. A sample Field Record of goose productivity.

young per fall or winter goose family usually ranges from one to five, occasionally to seven in the Blue and Snow and rarely to nine in the Whitefront. (3) *A family group with only one surviving adult* will appear now and then as hunting and other winter mortality make themselves felt on a concentration, and the prevalence of single-adult families enables us to monitor such mortality through the season. (4) *A group of two birds (or one to many)*, all in adult plumage and not accompanied by young, may represent full adults that have lost all young or failed to produce any, or they might be sub-adult yearlings (16 months of age in October and therefore not yet fully mature). Among Snows and Blues it is practically impossible to distinguish sub-adults from mature adults in the field. In the case of Whitefronts some yearling birds can be told from the more heavily marked adults and the unmarked young; while we do not attempt to make such differentiation in regular Whitefront surveys, separate yearling field records could be maintained in the course of special Whitefront appraisals. (5) *A group of two (or one to several) young birds*, not accompanied by older birds, probably represents 'orphans' that have lost both parents.

(6) *This group of three adult-plumaged and two young birds*, might show every evidence of being a family, but has an extra adult-plumaged bird. The frequency of such aberrations determines the method we employ in handling them. Where they are few (such as on the wintering grounds where our records show that the 'three-adult families' comprise less than 3% of all recorded families), we arbitrarily separate the group as has been done in Figure 1, to a family of two adults (with two young in this case), and non-family adults (one in this case). This odd grouping invites speculation that the 'ménage a trois' described in the Mute Swan (Dewar, 1936) may occur also in Blue and Snow Geese; in our captive flock there have been instances of a Blue gander 'pairing' with two females, although these arrangements did not progress to the nest-building stage. The important thing from the standpoint of surveys is that normal goose families should have only two parents; if odd groups are seen to be unusually common in study flocks, they are handled as described in Item 7.

(7) *Grouped adults and young, that fit none of the above categories* may be seen in some places, especially at migration stop-over points. When we encounter such in a wintering flock, we simply decide that the flock is too excited or disturbed for its groups to segregate properly that day, and re-schedule it for later appraisal at some time when it is more co-operative. Observers in the more northerly areas may not have this freedom of choice, for they are working with migrating flocks that could leave the area at any time. An alternative method of appraisal suitable for use under these circumstances involves a two-fold operation. One job is to determine the number of young and the number of parents in the 'average family'. Therefore, all families that can be identified as such (this includes all identifiable family remnants) are recorded as follows: (8) *An obvious family, two parents with young* (one in this case), (9) *An obvious single-adult family*, and (10) *A group of young, probably a brood remnant*, that has lost both parents. Along with family counts, *another separate record is maintained of all young birds and all older birds (as in Item 1)*, regardless of their groupings. This second operation provides us with an age-ratio for the concentration. Knowing the total number of birds in the latter (from aerial estimate or other total enumeration), we can estimate the total number of young in the concentration. Then, applying to the latter the ratio of family adults to young (average from Items 8, 9 and 10) we can estimate the total number of productive adults.

(12) *Mixed groups of blues and snows* are encountered whenever Blue Geese and Snow Geese are found in the same locality. To record these mixtures, we alter one of our field sheets as indicated in Figure 1, item 12, and tally the following: (13) *A family with one blue and one snow for parents*, having blues or snows or both among the young. Young snows can be distinguished from young blues without difficulty; we have seen cases where a very pale 'pearl-grey' young blue and a muddy or rust-discolored young snow might be confused, but these are extremely rare. As for adults and yearlings, all Blue Geese, whether the dark-bellied or white-bellied phase, are obviously 'blues'. We have never seen an adult Snow Goose that had traces of Blue Goose plumage such as could be detected at the distances these field observations are made. Other mixtures to be recorded are: (14) *A family having blue parents but some of its young are snows*, (15) *A family with snow parentage*, but some of its young are blue (this mixture is encountered too frequently on the Gulf Coast to be entirely accidental), (16) *An orphan group that includes both young blues and young snows*, and (17) *A pair of birds in adult plumage*, one of which is a blue and the other a snow; they may be recorded as indicated on Figure 1, or a separate record may be maintained for them at the bottom of the sheet.

There can be no substitute for experience and knowledge of the habits of these birds, although new observers seem able to master the techniques of appraisals in a remarkably short time. When the novice is able to work with an experienced observer, he will do well to start with the task of recording, meanwhile scanning the birds with field glasses as time permits. Then an hour or so of actual identification, under guidance, is usually ample to acquaint him with the rudiments of method. We have seen new observers attain a high degree of competence in this work after a few hours of practice. Many have become proficient without benefit of tutelage, although some made minor errors or omissions until they gained a better understanding of the social organisation among geese, and the purpose of the observations.

The data turned in by our corps of observers over the years assure us that accuracy can be developed and maintained in these appraisals. The work in Texas is launched each fall at Eagle Lake, where all observers, old and new, appraise productivity in selected flocks of Blue-, Snow- and White-fronted geese and compare results. At the start of the fall 1960 work in Texas, 8 observers turned in almost 5,000 snow goose records that averaged 49·0% young. The percent young among the individual sets of data from this locality ranged from 47·0% to 51·5%. An equally convincing picture may be seen in the fall 1959 productivity appraisal for continental Blue Geese (Lynch *et al.* 1959) wherein 14 observers turned in 17 sets of area records that totaled 30,861 birds, of which 51·4% were young; individual area records ranged from 48·0% to 56·9% young. Average brood, and ratio of productive adults to birds in adult plumage, can also be determined with consistency. In the course of a post-hunting season appraisal of a Louisiana flock of 45,000 Blue Geese in January 1961, 4 observers turned in 6 sets of records of over 6,600 birds, wherein the average brood figure ranged from 1·6 to 1·7, while the proportion of adult-plumaged birds that was productive ranged from 28·0% to 33·1%.

Productivity appraisals are usually made in late fall or early winter, when most birds have arrived on their wintering grounds but before hunting and other mortality have broken up families or otherwise distorted the picture of nest success. When possible they should be conducted during the same period that total counts are being made. Special appraisals to examine the effects of hunting or protection, as shown by the frequency of group remnants, may be started earlier in the fall, and repeated at intervals throughout the winter season. Special appraisals are also of value in critical banding studies, for they provide information as to the nature and composition of local populations at times of actual banding, and at times when banded birds are being recovered from those populations.

The Sampling Problem

Wintering Blue Geese are confined largely to Louisiana and Texas, and so it is possible for one or two observers to conduct a complete annual appraisal of productivity for this species. The Whitefront, the Lesser Snow and other candidates for these surveys are much more widely distributed in winter. Appraising their productivity calls for teamwork among several strategically located observers, and direction by a competent agency. Not all the birds of a wintering population will be tallied in the course of these surveys, so the problem of methodical sampling must be considered at all levels of the job. Fortunately the samples in these appraisals can be apportioned with direct reference to birds, and need not deal with populations through an intermediary such as the hunter or trapper. The matter of determining minimum adequate sample is seldom of concern in this work; once the observer is in proper position, his opportunity to get records is almost unlimited. Our fall 1960 regular and special appraisals amassed a grand total of 115,430 blue and snow goose records, and our 1959 records contained over 75,000 entries for the Blue Goose alone. But the matter of getting samples that are representative must be considered.

The responsibility for distribution of sample within any one flock and among the various flocks in one wintering region rests with individual observers. There is sometimes a tendency among new workers to focus too much attention on large families or certain other conspicuous groups in a flock. One way to avoid selectivity is to train the field glasses on a fixed spot in the path of incoming or passing small groups, recording every group that crosses the field of vision. Slow, methodical sweeping of the glasses across a wave of incoming birds, recording all groups, also helps assure proper sampling.

The various major flocks in a wintering region should all receive equivalent attention. These geese tend to be colonial both in their nesting habits and on the wintering grounds. Nesting failure one season may affect some colonies but not others, so the wintering flocks may show important disparity in their numbers of families and young. Great numbers of young produced

in one season may show up the following year (when 16 to 20 months old) in largely independent flocks of adult-appearing yearlings instead of mingling with productive adults and young. For these reasons we strive to sample every major flock in a region, and after a sample of about 5% of birds in any one flock is achieved, we move on to another.

Sometimes several major winter flocks will move into an area while one unit of observation is in progress. In some regions, almost all of the major wintering flocks may move into a single refuge area. If productivity should vary greatly among these flocks, the sampling must be adjusted accordingly. We use a simple expedient to detect variability. As soon as any one column on a field sheet (Figure 1) is filled, we immediately start an entire new sheet, instead of trying to fill all columns on one sheet. Thus each record sheet becomes a miniature sample, valid for the time it was taken. Quick perusal of completed sheets will show whether new flights differ from earlier records to any important degree. Reconciliation of area or regional samples that are disproportionate is discussed under 'Computations'.

Aerial observers can discern first-winter young while flying over Blue and Snow Geese, swans and some other birds. Scouting by plane is therefore helpful in detecting variability, and in deciding whether flocks wintering in remote areas are so atypical as to warrant the special effort that would be required to reach them by boat or car for more detailed appraisal. Simple age-ratio may be ascertained from aircraft, either by visual counts or colour photography, but the meaningful groupings of geese are seldom apparent to the aerial observer.

Computations

When the appraisal seeks to determine only a simple age-ratio, all first-winter young and all older birds in the records (item 1, Figure 1) are totalled; this ratio is often expressed in terms of young to all older birds, although in winter work with geese it would be more realistic if expressed as a 3-way ratio (as in Table III), involving first-winter young (6 months old in December), yearlings (18 months), and mature adults. When complete appraisal has been made (items 2-6, Figure 1), all columns would be totalled, and grand totals of first-winter young, older birds, and all birds set forth. It then becomes possible to determine the percentage of adult-plumaged birds accompanied by broods, the average number of young per recognisable brood, and the average number of parents and young for all families or identifiable remnants thereof. These are indications of the magnitude of productivity, although some items are subject to further interpretation (see Population Plot).

Summaries can be made by simply adding the data from the field sheets if about the same percentage of birds is counted from each flock, area and region. Sometimes, however, it is difficult to sample each flock or area proportionately. The sample may be 15% or more of total birds in one area, and only 2 or 3% in another. If the flocks in these areas differ in proportion of young, a direct total will be biased. So it usually is better to weight the data before combining it. The weighting procedure is basically simple, and is done as shown in Table I. The percentage of birds counted in each category is multiplied by the total number of birds in the flock that was sampled. Instead of doing this flock by flock, we combine data from these flocks that have about the same proportion of young in them. Table II shows the weighted estimates for the group of data used as an example in Table I. The figures are rounded for final use, for they are not accurate to the digits shown in the tables.

Even carefully collected data may be interpreted incorrectly if gathered from only a part of the winter range of a species. For example, productivity appraisals of Snow Geese made in the Pacific Flyway in 1958 suggested that the birds wintering in California had a less successful nesting that year than the birds that came down the Central and Mississippi Flyways to the Gulf Coast. Yet the total California population was about 27% greater than it was the previous year. The reverse was true in the Gulf Coast, where productivity estim-

Table I. Method for weighting estimates in combining flock samples

	field data	*% of geese observed*	*weighted estimate*[1] *(tot. pop. 230,000)*
ADULTS			
In families	1,105	16·40	37,729
Not in families	4,567	67·80	155,940
Total adults	5,672	84·20	193,669
YOUNG			
In families	1,003	14·89	34,247
Not in families	61	0·91	2,084
Total young	1,064	15·80	36,331
TOTAL GEESE	6,736	100·00	230,000

[1] The figures are rounded for final use, for they are not accurate to the digits shown.

Table II. Weighted estimates for Blue Goose Stratum 2, South-west Louisiana 1958

locality	*Sabine*	*Crowley*	*Iota*	*Marsh Island*	*sub-total field data*	*weighted estimates*
TOTAL FAMILIES	147	28	222	203	600	20,486
FAMILY						
Adults	280	55	401	369	1,105	37,729
Young	248	50	327	378	1,003	34,247
NON-FAMILY						
Adults	1,275	170	1,754	1,368	4,567	155,940
Young	1	0	25	35	61	2,084
Total Ads.	1,555	225	2,155	1,737	5,672	193,669
Total Young	249	50	352	413	1,064	36,331
Total Birds	1,804	275	2,507	2,150	6,736	230,000
% Young	13·8	18·2	14·0	19·2	15·8	**
% Prod.*	18·0	24·4	18·6	21·2	19·5	**
Average Brood	1·7	1·7	1·5	1·8	1·6	**

* of birds in adult plumage
** to be recomputed when all strata combined

Table III. Comparison of annual productivity of the Blue Goose, 1949-59 (from winter appraisals)

year (fall of:)	*per cent imm.*	*ad:subad:imm ratio (in thous.)*	*aver. brood (fall)*	*field* % prod.*	*true** % prod.*
1949	47·6	90:108:180	2·1	46·4	100·0
1950	35·5	111:101:117	2·1	37·3	71·2
1951	11·2	177: 97: 35	1·6	13·2	16·0
1952	48·5	179: 23:190	2·4	66·7	75·0
1953	38·9	157:148:195	2·2	51·0	99·0
1954	1·8	200:134: 6	1·6	1·6	2·7
1955	54·9	200: 4:247	2·7	75·7	77·0
1956	31·8	117:143:121	2·1	30·7	68·0
1957	46·1	156: 73:196	2·3	62·5	91·6
1958	16·3	154:129: 55	1·6	19·7	36·0
1959	51·4	202: 39:255	2·5	75·0	89·6

* % of geese in adult plumage (including sub-adults) that brought young to the wintering-grounds.
** Probable % of mature adults (24 months of age or older) accompanied by broods in fall.

ates were higher but the population was lower. This anomaly, which was resolved when regional data were weighted and combined (Lynch and Singleton, 1958), could have been produced by some of the yearlings and non-productive adults shifting to the Pacific Flyway in 1958. Such a shift would tend to inflate productivity estimates for the Gulf Coast and depress estimates for California.

The 'field percentage of productive adults' (Table III) refers only to the ratio of productive adults to birds in adult plumage in fall, and determination of 'true' percentage of productive adults is discussed in the next section. The 'average brood' figure is derived from intact families that have at least one surviving parent, since orphan young probably have a much greater vulnerability (average of only 1·4 survivors per 'stray' young group in the fall of 1957) than would young with 1 or 2 parents (2·28 young per group at that time).

The data from 'mixed groups' of Blue and Snow Geese (items 12-17 in Figure 1) are for special study of the blue-snow complex (Cooch and Beardmore, 1959); while the method of gathering these data is described here, their analysis is beyond the scope of the present paper.

The geese discussed here are not known to nest in their first year of life. In analysing data from productivity appraisals, it is assumed that most if not all Blue, Snow and White-fronted Geese will attain sexual maturity at approximately 22 months of age, and may nest at age 24 months unless prevented from doing so by unfavourable breeding conditions. This determination is largely inferential, but is based on a wealth of data such as is presented in Table III. The high productivity among Blue Geese in the 1949, 1953, 1957, and 1959 nestings (Table III) could scarcely have been accomplished without considerable assistance from birds that nested successfully when only 24 months of age. Hanson and Smith (1950) present evidence that Canada Geese reach sexual maturity at a similar age. The present authors carefully refrain from citing breeding age of geese in 'years', for a female goose that reached sexual maturity and mated at age 22 months may lay eggs at age 24 months, while still '2 years old', but these eggs would not hatch until the parent was 25 months of age and therefore 'in her third year'. To avoid confusion, ages in geese are given in months from hatching.

It is recognised that some productive pairs may have lost all their young on the nesting grounds or en route south, and therefore will appear in our fall appraisal records as 'non-productive'. Various other components of goose populations will undergo some changes in the interval between the nesting season and the time we conduct our appraisals. These changes seem not to be of consequence in our analysis of data, for such analysis is largely on a calendar-year basis (see Population Plot), and is concerned primarily with net gains and losses. There are some obvious advantages in appraising the success of a waterfowl nesting season after, rather than during, the tumultuous period of hatching and rearing.

The Population Plot

The population plot is a graphic layout of data obtained from productivity appraisals and total inventories. It gives a picture of the history of the population that is helpful in following the progress of mortality and recruitment from year to year. It is especially useful when constructed for a period of several years. For simplicity, the method of making the plot will be explained on the basis of data collected during two successive annual surveys.

Figure 2 shows the population plot we constructed for calendar year 1957 Blue Geese from the data of 1956-57 and 1957-58. The total populations for each year are taken from the data of the midwinter aerial surveys. The numbers of young birds, adult-plumaged birds, and adult birds accompanied by young are from the productivity appraisals. Our working data for the period are:

winter of:	*1956-57*	*1957-58*
Total population (midwinter)	380,000	425,000
Per cent young (winter)	31·8	46·1
Per cent productive, of birds in adult plumage (winter)		62·5
Average brood (winter)		2·3
Average August brood (estimated)		3·3

First, the total figures (from January surveys) are plotted for calendar year 1957 and 1958 at points 'B' and 'C' respectively. We know from the 1956 productivity appraisal that 31·8% of the January 1957 population were young birds, so point 'a' can be located (reading from 'B' to 'A'). Point 'b' also can be plotted since our fall 1957 appraisal showed that 46·1% of Blue Geese at the end of 1957 were young. Then the line from the base point 'A' to 'a' represents the 259,200 adults and advanced sub-adults, and line 'a-B' represents the 120,800 young (from 1956 hatch) that are becoming yearlings at the start of 1957. Line 'D-b' represents the number of adults and advanced sub-adults, and line 'b-C' the number of new young surviving at the end of calendar year 1957.

Mortality can be expected to be somewhat disproportionate between adults and sub-adults, but banding returns (personal communications, F. G. Cooch, Canadian Wildlife Service) offer assurance that it is not greatly so. Therefore, we assume that the ratio of adults to sub-adults at the start of 1957 was still the same at the end of the year. This enables us to locate point 'c' (31·8% of line 'b-D'), and line 'D-c' then represents the approximate number of breeding-age adults at the end of the year. Line 'c-b' represents the 72,800 birds from the 1956 hatch that now are advanced yearlings. Productivity appraisals showed that 62·5% of birds in adult plumage at the end of 1957 were accompanied by young. When computed, 62·5% of the 229,100 birds in adult plumage (line 'D-b') amounts to 143,200 productive adults, shown as point 'd'. Since the total number of mature adults (line 'D-c') was 156,300 at the end of 1957, the 143,200 productive adults (line 'D-d') would represent a nesting success of 91·6% among eligible breeders. This is the 'true' percentage of productive adults (Table III) rather than the 'field' percentage of adult-plumaged birds (full adults and sub-adults).

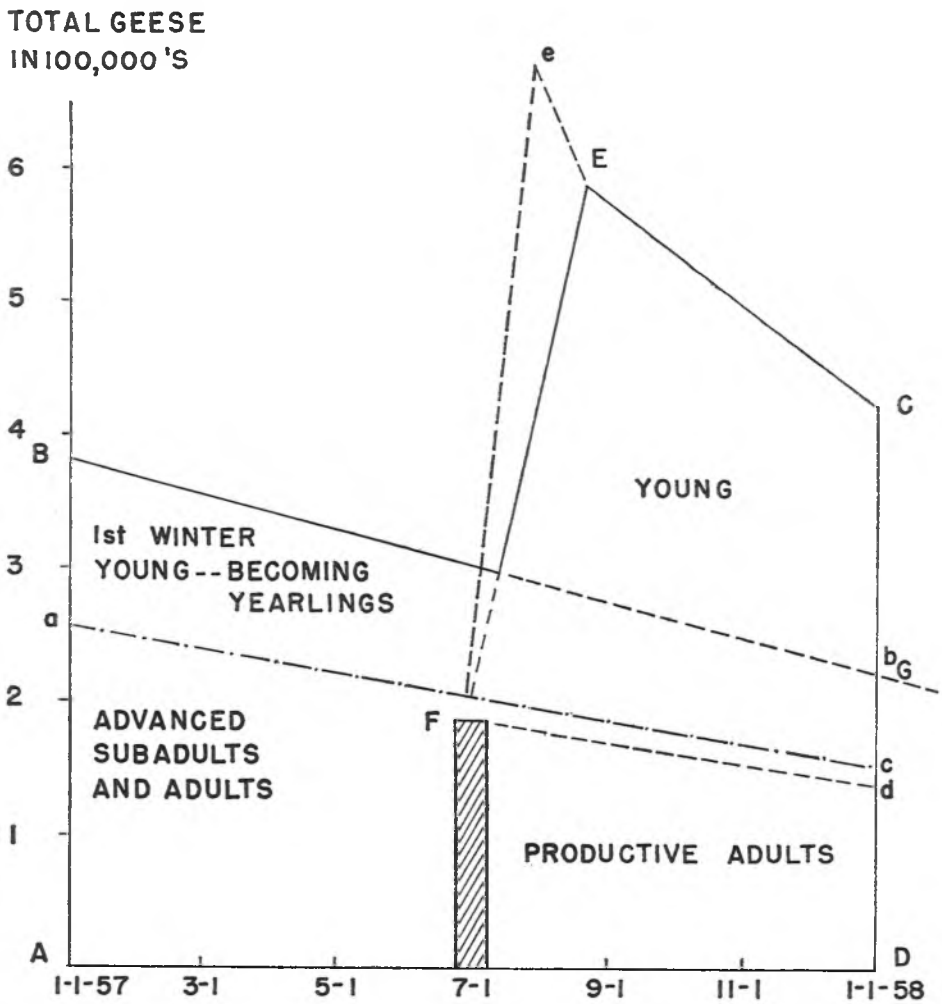

Figure 2. A sample population plot, from the 1957 Blue Goose surveys.

An average annual mortality rate can be estimated here since we know the total number of birds the first year and the number of these surviving to the second year (points 'B' and 'b' on Figure 2). Assuming constant rates, we may then approximate the number living either at an intermediate time like July or at some later time such as the following spring. The graphical method depicted by the population plot seems adequate for present purposes even though using a straight line plotted on an arithmetic scale, as in Figure 2, implies literally that the proportional rate of mortality is continuously increasing.

A rough approximation of mortality of young of the year can be made by using brood figures from nesting-ground studies in combination with our data as follows. The July point on line 'B-b' suggests that there were about 300,000 adult-plumaged birds present then. We found in the fall that about 62·5% of the adult-plumaged birds were accompanied by young. If we assume that this same percentage were successful breeders in July, then we can estimate their number at 187,500 (62·5% of the 300,000 adult-plumaged birds presumably present in July). This number is shown at point 'F'. If broods averaged 3·3 goslings at Class III stage (fledged but not flying), this would mean that the 93,750 pairs (assuming an even sex ratio) contributed 309,400 advanced goslings to the population. This number is plotted at point 'E'. If we knew from breeding-grounds observations the average number of goslings per Class I (downy) brood, we could locate point 'e' as an approximation of the total number of goslings produced for the

season. Mortality is shown by the line 'E-C' or 'e-E-C'.

When accurate population plots are available for several consecutive years, the histories of each year's population can be traced. Turnover rates and rates of population replacement may be examined. Life expectancies and other vital statistics also can be calculated by methods described by Petrides (1949) and Farner (1955). Survival curves we calculated for Blue Geese were very similar to those calculated from band returns (personal communication, F. G. Cooch). Longevity figures produced by both methods also were similar.

Estimates of Total Numbers

Since a knowledge of total numbers of birds in populations is of great value in organising productivity appraisals and in exploiting the data they produce, we report here certain refinements that improve the accuracy of visual estimates of waterfowl numbers. Continental goose populations are enumerated during the midwinter waterfowl surveys described by Bell (1937). Other counts of area and regional flocks may be made during each fall and winter for the guidance of productivity appraisals and for special purposes. These 'counts' are actually visual estimates, usually made from aircraft, of total numbers of birds in each concentration. Goose counts present fewer problems and can attain greater accuracy than census of some other waterfowl. Most geese frequent open terrain during the winter period, and usually all birds take wing simultaneously when a goose flock is approached by an aircraft. Unlike some ducks of the wooded swamps or large open waters, all wintering geese can be found with adequate search, and since they can be seen, they can be enumerated. Furthermore the application of productivity data to total population figures over a period of years provides a means of monitoring the credibility (if not the absolute accuracy) of the historical record of numerical estimates for a species.

Census work among the geese is not without problems. The task of locating all the important flocks in some far-flung wintering regions is somewhat formidable, and calls for experienced survey teams that have intimate knowledge of the birds and their ranges. Many of these winter ranges were almost inaccessible at one time, but now are flown at frequent intervals by private and business aircraft as well as by pilots of conservation agencies. Most major goose concentrations are therefore under almost constant surveillance throughout the winter period. Exchange of information among these many observers simplifies the task of locating concentrations.

The reliability of visual estimates of numbers in large flocks of birds is an aspect of census work that evokes more critical than constructive comment. Perhaps some are prone to think that an ability to estimate numbers is a faculty with which a few gifted individuals are endowed at birth. In reality, such ability is nothing more than a skill that can be developed by anyone given normal eyesight and appropriate training. But development of such skill is of little avail if proficiency in the skill is not maintained and brought up to its highest possible level at the instant counts are to be made.

To improve accuracy of the estimates we employ a series of transparent plastic sheets, marked with crayon or 'glass-marking' pencil to represent flocks of various numbers in various formations. Cellulose-acetate or -nitrate sheets were first used in open-cockpit aircraft, but the development of the vinyl, polyethylene and other plastics of 6- and 8-mil thickness gave us pliable sheets that proved much more convenient for use in modern aircraft. All observers, regardless of their prior experience, seem to profit from a concentrated scanning of these training devices before making any aerial counts. These sheets with their known numbers of 'birds' can be held up to the aircraft windshield during census flights, for comparison with actual flocks of geese against any background. Materials for these sheets may be found at upholstery and stationery counters in any dry-goods store, and their preparation requires no special equipment. In emergencies, we have used for this purpose standard plastic 'freezer bags' that were marked with ballpoint pen, and have even resorted to marking model 'flocks' on the windshield of the aircraft. Other training devices are described by Spinner (1953). Any type of training device will serve the purpose, so long as it is used conscientiously to develop and maintain skills, and affords a standard for ready reference.

A portion of a sheet deliberately folded back upon itself several times serves to illustrate some facets of the problem of estimating numbers. Ground observers who approach a large flock of geese may see only a veritable maelstrom of objects, moving in many directions and on many planes, and have no way of determining the dimensions of this confused mass. To the aerial observer, the same flock is seen moving in one direction on a single plane. The advantages of aerial estimates in this instance are quite obvious. When very large concentrations of geese (as

great as 50,000 birds or more) are encountered by aerial observers, the pilot may split them up into more convenient units by judicious herding. Aerial photography is also of value in estimating numbers, provided that weather and background are favourable and the subjects are reasonably 'photogenic'.

Appraising Productivity in Other Species

The methods we describe for Blue, Snow and White-fronted Geese can be used with only minor changes for other birds whose first winter young are identifiable in the field and who stay in family groups. This 'Category 1' of candidates for winter appraisal of productivity would include all American geese except the Canada and its races, and would encompass the Whistling Swan (*Cygnus c. columbianus* (Ord)) and Trumpeter Swan, Atlantic Brent, Black Brant (*Branta bernicla orientalis* Tougarinov), Whooping Crane and Sandhill Crane (*Grus canadensis* L.), and perhaps some Old World waterfowl and wading birds.

Modifications of method for birds of other categories are now in various stages of development. Category 2 birds would include waders such as the Little Blue Heron (*Florida caerulea* (L.)) and sea birds like the Herring Gull (*Larus argentatus*) whose young have distinctive first winter plumage but whose broods soon lose their identity. Category 3 comprises certain Arctic-nesting ducks such as Eiders (*Somateria* spp.) and Goldeneyes (*Bucephala* spp.) whose first winter young resemble in plumage the adult female but not the adult male. Much remains to be learned about sequence of plumages in some of these candidates, although study of captive specimens is helping to shed light on this subject.

In Category 4 are birds such as the Canada Goose (*Branta canadensis* and subspp.) whose first-winter young cannot readily be distinguished from adults and sub-adults in the field, but whose families, sub-adults and mated pairs have distinctive flocking patterns. Elder and Elder (1949) and Hanson and Smith (1950) suggested that fall average group counts of Canada Geese might reflect prevalence of families and could therefore be used to determine annual productivity. This thesis was challenged by Lebret (1956), who pointed out that some groups of family size in the Whitefront might be bands of yearlings.

Since our appraisals of Blue and Snow Geese and other Category 1 species recorded all groupings as well as ages of birds, their data could be analysed as though representative of species of Category 4. Such study showed (Lynch *et al.*, 1959) that the size of the average group in fall populations of these species varied directly with their percentage of young, under our conditions of observation (which, as previously stipulated, would tend to favour recognition of basic groups). This analysis also disclosed that the bands of yearlings designated as 'pseudo-families' by Lebret (*op. cit.*) and generally thought to number several to many birds per group, actually averaged two birds per group in our observations (Lynch *et al.*, 1960). Even in winters such as 1949-50, 1953-54, and 1957-58, when most fully adult Blue Geese had young and therefore appeared in our records (Table III) as larger 'family groups', the small bands of adult-appearing Blues not accompanied by young (undoubtedly yearlings) still averaged two birds per group. It would perhaps be mere rationalisation to suggest that an old brood bond that had persisted more than a year, or a newly-forming mating bond, either of which would tend to be of two birds or thereabouts, would be stronger than the bond that held together any larger, more casual aggregation of unrelated birds. Yet it is pure speculation to suggest that the latter would invariably override the former.

In any event, we now use fall average-group counts to determine whether distant flocks of Blues, Snows, and Whitefronts are worthy of closer inspection, having learned from special appraisals that this procedure gives acceptable results and saves much field travel. There is every reason to hope that similar group counts can be made to reflect fall *per cent* young in the Canada Geese, provided observations are carried on at times when basic groups would be most conspicuous.

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Charles D. Evans and C. E. Addy have pioneered the use of these appraisals on geese of the Pacific and Atlantic coasts and have contributed refinements in method. M. C. Hammond achieved important advances in developing appraisals for whitefronts and swans. As the appraisals expanded further to become continental in scope, many co-operators joined in to help; we here acknowledge the competence and enthusiasm of all these workers, and their individual contributions are set forth in our various annual reports. We have been particularly fortunate in having the wholehearted co-operation of F. Graham Cooch, Alexander Dzubin, and other biologists of the Canadian Wildlife Service who have been working in recent years on the nesting grounds of the species we have been studying. To C. R. Lynch go thanks for avicultural services and plumage observations of captive birds at Lafayette.

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