ECOLOGY, POPULATION DYNAMICS AND MANAGEMENT OF THE BOBWHITE QUAIL, *Colinus virginianus marilandicus* (L.), IN MASSACHUSETTS

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Thesis submitted to the Graduate Faculty of the

Virginia Polytechnic Institute

in candidacy for the degree of

DOCTOR OF PHILOSOPHY

in

BIOLOGY

APPROVED:

Chairman, Advisory Committee

May, 1958

Blacksburg, Virginia

TABLE OF CONTENTS

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

Since its beginning, the Quail Study in Massachusetts has depended on support and assistance of many groups and individuals. Without their unselfish help this manuscript could not have been prepared.

Especial acknowledgement is due the sportsmen and sportsmen's clubs of southeastern Massachusetts for their contributions of wings, crops, bands and related information.

Personnel of the Massachusetts Division of Fisheries and Game, particularly of the Southeast and Northeast Wildlife Districts and the Game Propagation Section, deserve much credit for their assistance in many phases of the Project.

Appreciation is expressed for the cooperation given by the Conservation Officers of the Massachusetts Department of Natural Resources for their assistance in quail stocking experiments and in the return of wings, bands and crops.

To the landowners, upon whose property field studies were carried out, appreciation is given. Particular acknowledgement is due the property owners of the Barnstable Study Area, and Great Island, West Yarmouth.

To Dr. Alexander C. Martin, Mr. Fred H. McLaughlin and Dr. Lawrence M. Bartlett, sincere thanks are given for their identifications of crop materials.

Credit is given to Dr. Sargent Russell for his assistance and advice in sampling design and statistical analysis of several important phases of the Study.

Acknowledgement is given to Mr. Jack Woolner for taking the aerial photographs used in this manuscript.

The writer wishes to express his appreciation for the unselfish help and interest given him by his fellow students and professors at the Virginia Polytechnic Institute.

The author is especially grateful to Mr. Russell A. Cookingham, Dr. William G. Sheldon, Dr. Ruben E. Trippensee, Mr. Charles L. McLaughlin, Dr. Henry S. Mosby, Dr. James S. Lindzey, Dr. Arthur B. Massey, Dr. Perry C. Holt, and Prof. John J. Aulbach for their technical assistance and suggestions in various phases of the study, and for their advice in the preparation of this manuscript.

INTRODUCTION

Quail are presently abundant in the southeastern counties of Massachusetts. This game bird, once distributed throughout the State, has declined rapidly during the past 50 years. The bobwhite is still an important game species and provides much sport in areas where it is abundant.

The Massachusetts Division of Fisheries and Game has been concerned with the well-being of the bobwhite for many years. Various programs of the Division have been directed toward the preservation and restoration of the resource. Until recently, however, no singular or intensive effort had been made to determine the past and present status of the species in Massachusetts.

In 1951, by mutual cooperation between the Massachusetts Cooperative Wildlife Research Unit and the Massachusetts Division of Fisheries and Game, a two-year research project was initiated. The basic objectives were to examine the past and present status of the species and determine its recreational utilization and management needs. The findings of this project answered many questions (Ripley, 1954), but other problems needed much more study than the two-year program provided.

The project was extended and expanded in 1953, and was administered by the Massachusetts Division of Fisheries and Game, Bureau of Wildlife Research and Management, as Federal Aid Project W-25-R. Since 1953 the Virginia Cooperative Wildlife Research Unit, Virginia Polytechnic Institute, Blacksburg, Virginia, has provided valuable technical assistance to the Study.

Throughout, the efforts of this investigation have been directed toward a better understanding of the ecology; the distribution, density, and dynamics of populations; and the nature and magnitude of recreational utilization. The common goal of these studies has been two-fold: (1) a contribution to the knowledge of the species, and (2) effective and practical management of the resource.

LITERATURE REVIEW

Quite probably few, if any, of the native game birds in the United States have received greater attention by research biologists than the several forms of the bobwhite quail, Colinus virginianus spp. Anyone working with this species may find this both a handicap and an advantage. Certainly, the voluminous published material is extremely helpful; on the other hand, it demands a laborious and critical review if the literature search is to be adequate.

The purpose of this section is to review pertinent, significant material, both published and unpublished, that has a bearing on the subject material of this dissertation. No attempt is made, however, to compile a complete bibliography.

Three pioneer workers whose publications are both numerous and undoubtedly basic to much of the later research work are Herbert L. Stoddard, Aldo Leopold and Paul L. Errington. Each has contributed classical material to a better understanding of the ecology of the species. Essentially, all of the material published before 1930 has dealt either with taxonomy or natural history.

Stoddard (1931) published what probably stands as the most complete and penetrating monograph of a gallinaceous species in North America. Although Errington published his extremely valuable contributions to the basic knowledge of the species much later (1945), this paper actually summarized a staggering list of lesser publications on various phases of his work which had contributed to the field for more than a decade and a half. His papers (1933 and 1936 with Hamerstrom), which dealt largely with population phenomena, have likewise served an invaluable measure of understanding of the ecology of the species. Leopold's (1931) game survey of the north central states was published at a time when both Errington and Stoddard were actively engaged in their research activities. Leopold's report presented original evidence, raised and parleyed questions, and projected sound theories which have paved the way for two generations of research.

The author has drawn heavily, not only on the study techniques of Stoddard, Errington and Hamerstrom, and Leopold, but he has also relied on the data collected by these outstanding workers.

The taxonomic material published by Phillips (1915), Aldrich (1946), and Aldrich and Duvall (1955), and to a lesser extent Bent (1923) and Forbush (1927), has been utilized largely with specific reference to systematics in Massachusetts.

Phillips (1915, 1928, and 1933), Bent (1923), Forbush (1927), Adams (1931), Aldrich (1946), Goodrum (1949), Bump (1936), and Leopold (1931) have published historical material on quail populations, local and general, that has been used in this paper.

Bennitt's (1951) excellent paper on the indirect, whistle-count census technique, which was previewed by Dalke (1943) and supported by the population composition research of Leopold (1945), has served as a basis for many population density and distribution studies (Reeves, 1954; Rosene, 1957; Ripley and Garvin, 1955; Elder, 1956; and Wingard, 1952).

The direct census methods for total population counts employed by Stoddard (1931), Errington and Hamerstrom (1936), Wight (1938), Mosby and Overton (1950) and numerous other workers provide valuable technique references for local study areas. Again, with trapping and banding techniques, the work of Stoddard and Errington and Hamerstrom has served as a basic point of reference for these techniques. Some later modifications have been valuable (i.e., Reeves, 1952).

Nearly every state with a substantial quail population has sponsored research and published life history material on the species. Some of the more recent reports of this type have been published by Murray and Frye (1957), Stanford (1952), Baerg and Warren (1949), Lay (1954), and Latham and Studholm (1952). The latter publication and the work by Wilson and Vaughn (1944) probably have greater application to New England populations than do the other cited reports.

Foods and bobwhite nutrition have been investigated both extensively and intensively. Food habits work by Wright (1941) and Wilson and Vaughn (1944) have been most helpful in the Massachusetts Study. Nestler (1949) published summary findings of his nutritional studies which were conducted, largely, at the Patuxent Research Station. Many of his contributions have appeared as separate papers, mainly in the Journal of Wildlife Management over a period of several years. Other, more general, work on foods and nutrition have been published by Martin (1935), and Martin, Zim and Nelson (1951).

Age determination and subsequent studies of population composition of gallinaceous species have resulted in a foundation for basic studies in population dynamics. Outstanding among the publications reporting the development and refinements of the quail aging techniques are the papers by Leopold (1939), Petrides and Nestler (1943), Petrides (1952) and Haugen

(1957). Leopold's work made adult-juvenile separation a reliable procedure which has been recently strengthened by Haugen. Petrides and Nestler were concerned with developing aging tables for juveniles on the basis of the moulting sequence of the primaries. These findings were utilized by Thompson and Taber (1948) to date nesting and hatching events. Collectively, these developments have led to notable contributions regarding quail age composition and hatching phenomena (Bennitt, 1951; Thompson and Kabat, 1949; Stanford, 1952; and Leopold, 1945). Petrides (1949) crystalized much of the recent thinking on the analysis of sex and age composition data, which for quail, depends on the aging techniques.

Studies of quail movements have been critically analyzed and reported by Stoddard (1931), Errington and Hamerstrom (1936), Mosby and Overton (1950), Agee (1957), Murphy and Baskett (1952), Lewis (1954), and Duck (1943).

Both parasites and predators have been the object of considerable investigation. In general, wild quail populations are apparently little affected by parasitism. Although many accounts of specific parasitic organisms have been reported (largely in journals of parasitology), the report by Cram and her co-workers (Stoddard, 1931:229-338) appears to be the most complete contribution on the subject. Errington (1933 and 1934) and Errington and Stoddard (1938), to cite perhaps the more important contributors to the subject of predation, have conducted extremely valuable investigations. These, and other papers (particularly by Errington) have been based on exceptionally fine ecological research concerning the relationships between prey, buffer, and predatory species.

Hunting and its influence on quail populations has been investigated by numerous workers. Errington and Hamerstrom (1935), Baumgartner (1944), Mangold (1951), Kozicky and Hendrickson (1952), and Thompson (1952) are in essential agreement regarding the advisability of a reasonable harvest.

Investigations concerned with a critical evaluation of restocking with pen-reared birds have been abundant. Buechner (1950) has summarized all of the important findings prior to his publication. Steen (1950), however, published the results of his Missouri studies the same year; and a year later Pierce (1951) completed a final federal aid report which substantiates earlier documents and outlines the specific problems in Kentucky. Frye (1942) delivered a paper on the results of a well-controlled Florida study. His findings are opposed to those of other workers, and stand as an interesting challenge to the majority. Goodrum (1949) and Nestler and Studholm (1945) suggest that, as a nationwide trend, stocking is declining in popularity.

Finally, Robinson (1957) has published what is perhaps the best contribution to the knowledge of the ecology of the species in recent years. Much that he reports for quail in Kansas has a direct bearing on the Massachusetts data.

PROCEDURES AND TECHNIQUES

Selection and Description of Study Areas

With the needs of the Massachusetts Study in view, and drawing on the experience and suggestions of other workers (i.e., Errington and Hamerstrom, 1936), two areas were selected and utilized for intensive, local population studies. The first, called the Barnstable Study Area, consisting of 1790 acres of typical cover contiguous with the surrounding countryside, was established in June, 1953. The second, Great Island (containing 383 acres), was established in January, 1954, and used for investigations of an insular population.

Cover and grid maps, and oblique aerial photographs of the two areas are shown in Figures 1,2,3, and 4. The cover maps were prepared in connection with the Statewide, cover-mapping program (MacConnell and Garvin, 1956). A key to the cover symbols is given in Table A of the Appendix.

In the following paragraphs, each of the study areas is described in considerable detail in order that the reader may visualize the conditions under which the local population studies were carried out.

Barnstable Study Area

Located in the approximate center of Cape Cod (Nauset Beach to the Cape Cod Canal, east and west, and Cape Cod Bay to the Vineyard Sound, north and south) in the Township of Barnstable, the 1790 acres of the Barnstable Study Area typifies vegetative conditions in the coastal region. Land area under active cultivation constitutes slightly less than 20 per cent (18.0) of the total acreage. Recently abandoned land, which is

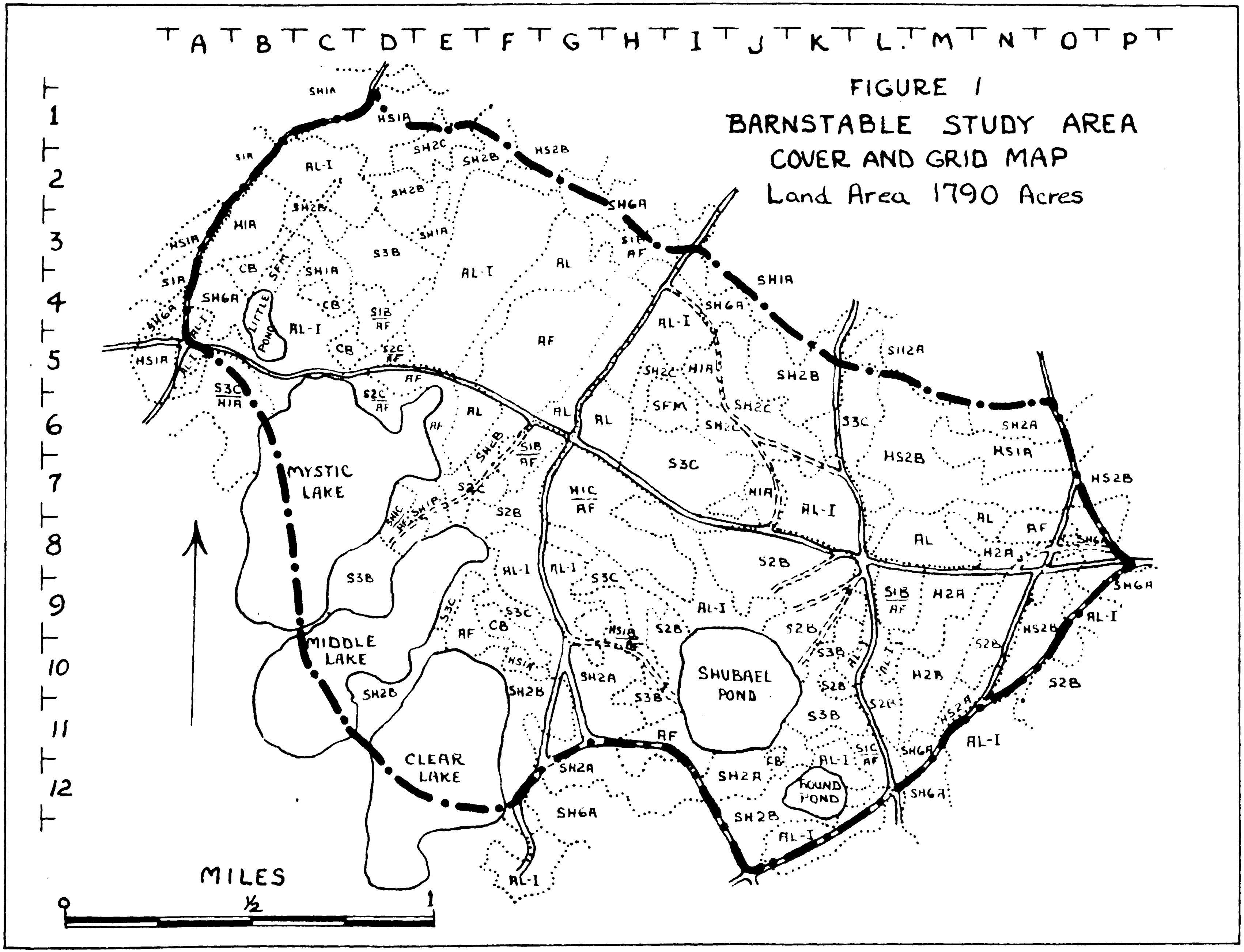

FIGURE 1
BARNSTABLE STUDY AREA
COVER AND GRID MAP
Land Area 1790 Acres

Figure 2. Oblique, aerial photograph of the Barnstable Study Area, looking northwest across the area, September, 1957.

reverting for the most part to densely stocked stands of pitch pine (Pinus rigida), comprises less than 15 per cent of the area. Mixed farming associated with moderately intensive dairying, home-consumption gardening, horticultural nursery enterprise, and a limited cranberry production (approximately 25 acres of bogs) constitute the essentially permanent agricultural activity in the area. Approximately half of the area classified as agricultural land is periodically stripped for top-soil which is sold in a local, active and lucrative market. Following the abominable practice of stripping, the area is usually fertilized and planted with an annual grain. Normally, these cover crops are plowed under in late summer or early fall and afford little, if any, benefit to resident game populations. Two or three such operations usually remove all salable top-soil and reduce the sub-soil to a virtually sterile condition. Thereafter, the fields are abandoned to natural succession. Almost without exception these sites eventually become stocked with dense stands of pitch pine; the successional stages following stripping are of limited value to quail. Figure 1 shows the distribution of this forest type. In all cases the softwood designation refers to pitch pine as the dominant coniferous species except for SH2B in grid C-2 and 3, and S2B in grid N-10 in which cases white pine (Pinus strobus) is the dominant species. In all instances the hardwood designation refers to stands that are predominantly mixed oak (Quercus spp.).

Except for a substantial wooded barrier along the north boundary and three lakes that constitute the southwestern boundary, the area is contiguous with cover that normally supports (or is frequented by) quail.

Maximum elevation is slightly more than 150 feet, and the minimum is 42 (based on U.S.G.S. topographical data). The soil is glacial in origin, grading in particle size from sand to sandy loam. Normally, it is moderately acidic, and the few nutrient elements that may escape leaching are "tied-up". The northern boundary is located along a row of low forested hills which constitute the end moraine of the last ice sheet. The lakes in the area likewise owe their origin to glacial action and presumably occupy kettles that were formed as the ice sheet retreated. Most of the suitable bog areas have been drained and are utilized for cranberry production.

The average winter temperature during December, January, and February is 31 degrees Fahrenheit, and the average annual snowfall is about 35 inches. The annual precipitation of 35 to 40 inches is well-distributed, seasonally. The area has a frost free period of approximately 190 days. The wind seldom abates and has an average hourly velocity of 10 miles prevailing from the southwest, except during mid-winter when it usually shifts to northwest.

In general, the vegetation is typical of the pitch pine-mixed oak disclimax of the southeastern part of the State. The low and dwarfed flora is harassed periodically by severe fires, and is drenched by the driven spume of hurricane winds that may affect the vegetation up to 20 miles inland.

The area supports a normal compliment of resident, and (during certain seasons) migratory predators: foxes, skunks, feral housecats, roving dogs, weasels, buteo, harrier and accipiter hawks, and great-horned owls. Buffer and prey species populations appear to occur in normal densities for the region. Quail, likewise, appear to manifest normal densities, and are subjected to seemingly typical gunning pressure.

Great Island

The center of the Great Island Area is located approximately six aerial miles southeast of the center of the Barnstable Study Area in the Township of Yarmouth. In many respects the areas are similar; for this reason, only the important differences will be discussed in the following paragraphs.

Great Island is actually a peninsula extending approximately two miles out from the mainland into Nantucket Sound (Figures 3 and 4). The only claim the area may have to the title "island" is by virtue of the fact that a small tidal creek separates the Island from the extended bar that connects it to the mainland. This sand bar is approximately one and a half miles long and is bordered on the west by a rather extensive salt marsh. A single-track asphalt road is maintained (privately) in a fair state of repair between the Island and the mainland.

The area is essentially an exclusive, summer-resident colony that is controlled by the interests of a corporation. In January, 1954, the writer obtained written permission to carry out population studies in connection with the Massachusetts Quail Project.

In contrast to the Barnstable Study Area, the vegetation on Great Island is largely woodland. Forest species are, however, the same as those described for the Barnstable Area. Except for small garden plots (usually only two or three) there is virtually no agricultural activity on the Island. A small air-strip, a golf course, and the salt marsh and sand dune borders constitute the balance of the open land on the area.

Prior to and during the course of the investigations, the fauna of

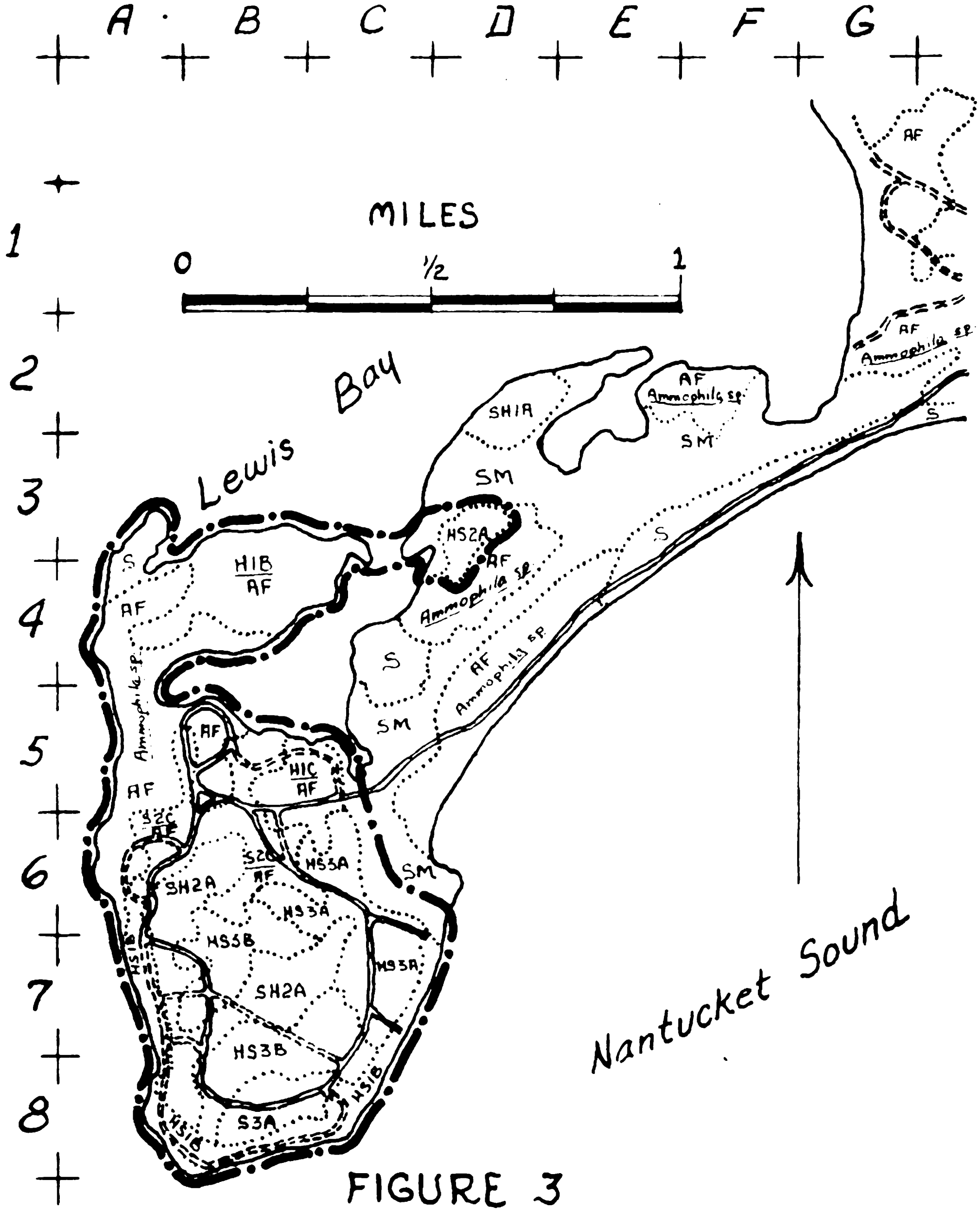

FIGURE 3
GREAT ISLAND
COVER AND GRID MAP
Land Area 383 Acres

Figure 4. Oblique, aerial photograph of Great Island, looking southeast across the area, September, 1957.

the Island appeared to be essentially the same as that found in the Barnstable Area. Soil, topography, climate, fresh water, and the pattern of fire and hurricane (salting) events appeared to contribute essentially parallel factors.

Disturbance from human activity was probably less than the Barnstable Area, and during the summer, nesting quail may have enjoyed somewhat greater protection because of an element of interested care by the landowners. General hunting was not permitted on the Island, and except for one isolated instance (one bird shot) the birds were not subjected to hunting pressure.

Great Island had one striking and extremely important feature insofar as these investigations are concerned. Certainly in January, 1954, and quite probably for at least five years prior to this date there had been no quail in the area*.

Between February 3 and 13, 1954, two coveys of native quail (10 and 7) were trapped on the mainland in grid area G-2 (Figure 3). These were liberated on the Island in two locations: (1) The covey of 10 birds was liberated in grid B-8. (2) The covey of 7 birds was liberated in grid B-5. Strict care was taken to maintain the covey units. Sex and age data were recorded on individual history cards, together with band numbers, date

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*Mr. Joseph Walker, caretaker-in-charge of Great Island for 10 years, described the absence of quail with an obviously keen awareness of conditions in the area in his charge. The writer made several intensive searches of the area using a well-trained standing dog, these plus a careful search for any quail sign confirmed Mr. Walker's observations.

taken and location of capture and release. Concurrently with the release, bucket-type feeding stations were established and maintained in the release areas.

Population Inventories

Direct Counts

Many of the findings in this study are based on data obtained from direct counts in local study areas. Wight (1938), Stoddard (1931:343), Errington and Hamerstrom (1936:317-326), Mosby and Overton (1950), and Robinson (1957:35) have used various methods of direct census in their investigations. The techniques described by these workers (to cite a representative number) have been employed essentially without modification to conduct total counts by tracking in sand, mud, and snow and by flushing counts using well-trained standing dogs. Particularly helpful reference was found in the technique descriptions by Errington and Hamerstrom.

Total counts of coveys and birds were taken during three census periods between early fall and late spring in the local areas. Approximately four weeks were needed during each period in the Barnstable Area, and two weeks on Great Island. In every case the total counts were taken and completed between September 20 and October 20, December 15 and January 15, and March 15 and April 15. For reporting purposes, the single dates October 1, January 1, and April 1 were used in summarizing the data in both areas. It should not be implied, however, that field observations were taken only during these periods. Local populations were maintained under almost constant, year-round surveillance.

Specific observations were recorded by numbered covey territories in the Barnstable Study Area. Changes in covey size, occupancy or abandonment of territories, ranging characteristics, and probable explanations for all of the population changes were noted for each territory. Particular care was taken to record evidence of mortality, daily movements, feeding, loafing, dusting and roosting habits, and general behavior.

Detailed information on individual coveys and covey territories was not determined for Great Island. Population counts were taken and reduced to total coveys and birds for each census period. High fall populations and the artificial feeding situation introduced complexity that made more detailed observations extremely difficult.

Extreme care was taken throughout the entire investigation to prevent disruption of normal conditions, insofar as possible. Repeated flushing of coveys was avoided where possible, and track counts were utilized by preference whenever they could be obtained. The writer and all project assistants took care (often in the face of rebuff) not to molest either the quail, or their predators, or other game and buffer species. The only instance contrary to this policy was the unavoidable destruction of a Cooper's hawk taken in a quail trap in the mainland trapping area adjacent to Great Island.

Indirect Counts

Roadside whistle-counts: The whistle-count census technique developed, critically evaluated, and used by Bennitt (1951) was employed, essentially without modification, throughout southeastern Massachusetts to determine annual variation in the density and distribution of quail populations.

The desirability of the three-minute listening period was confirmed by Elder (1956), and was used in Massachusetts. Bennitt's work in Missouri indicated the need for corrections due to temperature variation, but suggests this should be computed for the area involved. Ripley (1956) and Cookingham (1957) developed temperature correction factors for the Massachusetts census area, outlined specific census procedure (including a list of permanent census routes) and the method of statistically analyzing the counts.

The first census data were collected on Martha's Vineyard in 1952 (Ripley, 1954). Since 1952 data have been collected throughout the southeastern part of the State.

Call-index (C.I.), as the term is used in this paper, refers to the average number of birds heard for a series of listening stops. This may be applied to a single census route (normally 10-15 stops), several routes, a county or a state. If the term (call-index or C.I.) is prefixed by the word "uncorrected", a temperature correction factor has not been applied - if no prefix is used, the data have been corrected, and in some instances the term "corrected" has been used to avoid confusion.

Whenever annual figures for counties are presented they have been "corrected" for temperature variance and summarized by averages, weighted on the basis of the length of the routes, since the number of stops varies, and few counts are taken at the same temperature.

The term "comparative call-counts" refers to counts that can be compared directly since the same routes (sample areas) are involved between and among specified years. Statistical analysis for change in any area has been computed using the indices for "paired" routes as the units of measurement. These have been calculated using a "t" test for "paired observations" (Snedecor, 1946).

<u>Hunter opinion reports</u>: Some method of checking the reliability of the whistle-count census in terms of observed abundance was considered advisable. It was decided that an accurate determination of hunting success could not be obtained in terms of birds killed per hours hunted (Bennitt, 1951). The bobwhite is hunted mainly in connection with other upland birds (pheasant, grouse and woodcock) and the assignment of appropriate time among species would vary greatly and yield inconsistent and erroneous results. As a result, some technique for measuring annual change in abundance was thought to be a desirable approach.

All sportsmen who had contributed quail wings during the 1954 season were contacted by mail, given a questionnaire post card, and requested to supply a single opinion on the abundance of quail during the current as compared to the previous year. One of five choices - (1) much less abundant, (2) slightly less abundant, (3) no change, (4) slightly more abundant and (5) much more abundant - was to be checked. Each class (in effect each opinion) was assigned a numerical value: 5 to 1 ranging downward from maximum abundance. The returned cards were sorted by the five opinion classes and the frequency in each class was multiplied by the arbitrarily assigned value, then divided by the total number of reports to yield the average numerical opinion. The same procedure was repeated following the 1955 open season. Care was exercised to use the same interval between the hunting season and the request for opinion.

By comparing one year with another, the sportsmen were restricted in opinion. Since their decisions on the status of the bird would be relative, the chances of extreme and unrealistic reports should be reduced. The most striking limitations of the survey were its inabilities to deal with one year as an entity, or to provide data for a series of years with each year as an independent item. Notwithstanding these problems, some useful and interesting data were obtained.

Whistle-count triangulation: Twelve observation or listening stations were selected so that most, if not all, of the quail that called in the Barnstable Area could be heard from at least two stations. On either June 29 or 30, depending on the weather, twelve observers were stationed at the listening posts before dawn in 1954, 1955, 1956, and 1957. All participants were thoroughly briefed on the procedure and recognized the calling notes of males. Each observer was equipped with a table, a map showing his observation point, an alidade, pencils, draftsman's tape, and a flashlight. Four crews of three men were assigned to cover three points. One man in each crew had an accurate compass and a suitable vehicle. It was the latter's responsibility to place the men in his crew at the designated locations and carefully orient the maps on the plane tables. All observers waited quietly until sunrise noting general conditions of weather, temperature, predator activity, etc. Starting at sunrise and continuing for one hour, the direction and relative distance to each calling male was determined as carefully as possible (distance estimated) and radiating lines to all birds were drawn on the map from each point of observation. The relative distance was recorded on each line. Care was exercised to avoid duplication, since the whistling birds moved at least slightly during the period. Using these plotted observations, the approximate location of each whistling male was determined on a large map of the area by the intersection of lines from the several observation stations.

In addition to the total counts of calling males, timed counts were taken. Each year the hour of observation was divided into 12, five-minute periods (three minutes for listening, two minutes between). Each observer recorded the total number of birds heard calling during three, three-minute intervals. The listening time for each station was assigned so that the 12 observers made their timed counts at 20-minute intervals. The resulting observations were then comparable (in timing at least) to three, 12-stop, roadside counts, with each listening station contributing three counts or stops, one to each route. The data for the three resulting series of 12 counts were then reduced to three call indices. These were corrected, using the temperature factors already mentioned, averaged, and reported as a single index for the area each year.

Trapping and Banding

Equipment

Traps used in all phases of the Massachusetts Quail Study were the same as those described and used by Stoddard (1931:442-445) as the "standard quail trap". The only modifications were: (1) a permanently "laced-in" netting of seine material and (2) a funnel entrance fabricated from piano wire (approximately 20 gauge). The funnels had the same basic dimensions as those used by Stoddard (op. cit.) but the longitudinal or "feeler" wires were made of the highly resilient piano wire. These were held in place by soft-iron wire cross-strands and attached to the traps with "bull-rings". A "jig" for soldering the materials together reduced the construction time to about one hour per funnel. The finished funnels were sprayed with a flat black lacquer to reduce rusting and dull the metal surfaces. The distinct advantage of these funnels was the little care that they required. Also, the high resiliency of the feelers was thought to reduce the escape of imprisoned birds.

The 12 x 18 x 9 inch "catching boxes" were equipped with double sliding doors, and tops made of a heavy cotton broadcloth to prevent injury to birds. These were found to be extremely satisfactory.

This basic equipment was used for all of the trapping activities. Special "cock and hen" traps described by Stoddard (1931:446-448) were not used for summer trapping.

The hardware cloth cages for holding decoy hens for summer trapping of cocks were circular (about 10 inches in diameter and 8 inches high), the tops were made of netting material, and the bottoms of hardware cloth with a wire door. Small cans for water and food were wired to the inside of the cages.

Bait Sets

The procedures used for baiting and capturing quail from early fall until spring in these investigations were essentially the same as those described by Stoddard (1931:444-445). Quail using black locust stands as feeding areas presented some baiting difficulties, however, and were lured to grain supplies using seed-bearing limbs of locust (Ripley and Cookingham, 1958). The writer found that "chick-scratch" proved to be the most satisfactory baiting material. Traps were dropped in the morning, checked at noon, and again just before dark and propped open during the night. Bait was maintained at a trapping site only a few days. If longer periods were needed, the baiting was used intermittently.

Hen Decoy Sets

Game farm (decoy) hens were kept in holding pens during the summer trapping period of July and August for use in the cock and hen traps. Again, as with bait sets, Stoddard's work served as the most complete reference for the techniques employed (1931:446-450). It was found that frequent changing of hens from the holding pens to the traps, produced the most satisfactory results. It is doubtful if all of the calls of the hens were mating calls, but some were probably covey "scatter" calls for regrouping.

Decoys were normally placed in the traps in the morning. Usually if they were calling they were left in the trap until all captures at a site were repeats. The traps were normally checked morning and night. If predation, or a threat of predation, existed, trapping was suspended immediately.

Handling and Banding

Birds were removed from the traps using the catching box already described. During the winter trapping period, quail were then driven into a burlap sack for individual handling. This procedure was found to reduce activity and, hence, injury to the birds. Frequently, 15 to 20 birds were handled at one time. In the summer, however, normally only one bird was involved, and the birds were handled directly from the catching box.

Serially-numbered, aluminum leg bands (number 4) were used to band all quail handled during the course of these investigations. Each new bird that was captured was banded (numbers were double checked when attached), sexed, aged, and the information was recorded on a field sheet giving the area, grid location, date and miscellaneous remarks. Except for banding and sexing, repeats and recaptures were handled in the same way. The data were later transferred from the field sheets to individual cards which provided a complete history for each bird handled.

It appears advisable, at this point, to define the terminology used in connection with trapping and banding data. A "new", "initial", or "original" capture is a self-explanatory term, and construes the precise meaning it implies. The term "repeat" refers to the capture of a bird that has already been handled at least once during the same trapping period. A "recapture" or "return" denotes the first handling (during a given trapping period) of a bird that was banded or handled during at least one previous trapping period.

Weights

Collection of Data

During the winter trapping period 1955-1956 each quail that was trapped was carefully weighed on a triple beam balance by placing the bird in a dark stocking from which the toe had been removed. Birds rarely struggled when confined in this manner. The age, sex, date of capture, band number, location, and weight to the nearest tenth-gram were recorded and later transferred to large data sheets.

Effort was made to recapture a series of quail, first captured in early January, at regular intervals throughout the winter. Particular care was taken to use bait sparingly and only at times and in quantities that were absolutely necessary. Individual weights were sorted for two-week periods by age and sex for the entire series and on the basis of capture, whether new or repeat. Accumulated snowfall and minimum daily temperatures were recorded throughout the period of weight collection and summarized by two-week periods.

In addition to the weight records from this study, an old shooting diary* provided information on quail weights taken in 1865, 1866, and 1868. These were reduced to gram units and compared with live weights taken at a comparable time-of-year from Great Island trapping returns.

Movements

Covey Territories

In connection with the direct counts, detailed records of individual covey movements were mapped for the Barnstable Study Area for the three census periods in 1953-54, 1954-55, and 1955-56. These resulted in the

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*G. H. Peabody of Essex County, Massachusetts. Weight records of 49 quail taken in Massachusetts and Connecticut.

plotted covey territories for each census period which were summarized for the three-year period of study. These data provided a means of depicting the characteristics of total spacial movements for individual coveys.

Linear Movements

Linear movements reported in this paper are based on the banding and subsequent recapture or return of individual birds. Murphy and Baskett (1952), Lewis (1954), and Agee (1957) used similar methods and describe the techniques involved. Linear movement of individual birds was measured by scaled map distances (in miles) between the centers of two grid locations (at last capture) for two trapping periods. The data were stratified by sex for summer to winter, winter to summer, and winter to winter movements.

Influx and Egress

As they apply here, the terms influx and egress refer specifically to movement either into or out of, respectively, a given area. Unless otherwise specified, the areas of reference will be either an entire study area or specific covey territories.

Estimates of seasonal and annual egress were calculated for the Barnstable Study Area in an attempt to describe the nature and magnitude of these movements with respect to a local, contiguous population. This was done on the basis of initial capture and recapture data from the winter and summer trapping periods of 1955-1956, 1956-1957*, and 1957-1958*.

*Data from R. A. Cookingham (1957).

Seasonal egress was calculated using the male segment and annual egress used data for both sexes.

The following formula was developed to estimate the percentage of egress in this study.

$$\text{Percentage of Egress } (E) = \frac{n_{2e} - n_{2o}}{n_{2e}}$$

Where $n_{2e} = (n_1)(S)(N/P_2)$

and, where n_1 = number animals marked in pre-census period

S = estimated per cent survival between pre-census and census periods

N = total number of animals captured during census period

P_2 = estimated population during census period

n_{2e} = expected number of marked animals recaptured during census period

n_{2o} = observed number of marked animals recaptured during census period.

Kill Data

The information that may be obtained from an open shooting season is well-known (Petrides, 1949), and has been utilized by many workers. Leopold (1945), Thompson and Kabat (1949), Bennitt (1951), Stanford (1952), and Murray and Frye (1957) have made various analyses of open season returns, and describe treatments of data that were similar to those used in this study.

Terminology and Methods of Collection

"Population segment", as used in this paper, indicates a population sample based on either age or sex stratification. Sex ratios were computed and reported as the number of males per 100 females (i.e., 121:100). Age composition is reported as the percentage of juveniles in a total sample. Juveniles in this respect are synomous with "birds-of-the-year", e.g., from hatching until the following breeding season.

Prior to the opening of the shooting seasons (1953, 1954, and 1955), intensive publicity was employed to facilitate the collection of quail wings, attending information, and crops (the latter during 1953). Approximately 5,000 postage-paid envelopes with printed instructions were distributed each year; many were given directly to individual hunters. Space was provided for recording the date and town in which taken, sex, band number (if banded), and the sender. Sportsmen were instructed to send only materials from one bird per envelope. In 1953 coin envelopes were enclosed for collecting crops.

Manipulation of Data

Leopold (1939), Petrides and Nestler (1943), Petrides (1952), and Haugen (1957), working with the characteristics of the juvenile plumage and the post-juvenile moult of quail, developed criteria and methods for separating adults from juveniles, and determining the age (in days) for juveniles less than 150 days old. Thompson and Taber (1948) developed a table, and Reeves (1952) a "slide-rule" for dating the nesting and hatching events of gallinaceous birds, including the bobwhite. The techniques developed by these workers were used in the analysis of age composition and hatching characteristics in this study. Age composition was determined and reported on an annual basis. Likewise, a frequency distribution (two-week intervals) of hatching dates was developed for all juveniles (150 days of age and younger), for each nesting season. These distributions were summarized for the three years of study. Sex ratios were computed and reported on an annual basis.

The daily distribution of the open-season kill of both native and pen-reared quail was tabulated by direct enumeration of the individual dates of harvest. For purposes of annual reporting, this information was presented together with daily synopses of weather conditions. Because of the limited value of annual data the writer has averaged the three, annual distributions of daily kill for (a) the first three days, and (b) subsequent five-day periods of the open season (30 days). These data were then calculated and presented as periodic percentages of the total open-season kill.

Food Habits

Crop Samples

Crops collected during the 1953 open season were dried, and contents were analyzed. Since the general cover of Plymouth and Bristol Counties differs from that found in Barnstable, Dukes (Martha's Vineyard), and Nantucket Counties, the crops were separated on the basis of these two general areas of collection. The materials from each crop were separated, measured volumetrically, and identified. The frequency of occurrence of each material in the total sample of crops, and the collective volume in cubic centimeters of each food was tabulated for the two regions of collection and for the total sample.

The percentages of total occurrence and volume were tabulated for each item of food. In order to rank the materials in a single listing, the percentages of totals (frequency and volume) were multiplied, and the resulting products were numerically ranked, both for the two general areas of collection and for the total sample. The ten most important foods for each area of collection were tabulated for this paper.

Covey Feeding Habits

During the study of local populations in the Barnstable Area, records of the coverts and foods utilized by individual coveys were maintained. These data, while observational in nature, provide useful information on the feeding habits of various coveys on a seasonal basis. In the sections that follow, frequent reference is made to these observations.

Specific Quail-Cover Relationships

The techniques described in this section deal with the relationships which were found between quail call-counts and measurable characteristics of various cover types including: area, type frequency of occurrence, and linear edge. These analyses were carried out to provide an understanding of the ecological factors that may determine the distribution and density of quail populations. Although the methods used in this section have been published (Ripley and Garvin, 1955), the uniqueness, importance, and frequent reference to both techniques and results suggest that a limited treatment of methods should be included. Greater detail can be found in the paper just cited.

Call-counts taken at 103 stations during the summer of 1954 on Cape Cod were used as individual indices for local densities in quail populations. These were taken in connection with the regular whistle-count census activities, following the methods suggested by Bennitt (1951).

Bennitt reported that the average distance of audibility of calling quail was one-half mile under normal conditions during the census period. This value was accepted as a unit of measurement for determining the size of sample areas.

Each counting station was located on U.S.G.S. maps of the area upon which detailed cover mapping had been superimposed (MacConnell and Garvin, 1956). Circles with .5 mile radii were then plotted using the counting stations as centers. The total area of each cover type occurring in the plotted circles was measured and tabulated using a dot grid overlay. In addition, the frequency of occurrence of each cover type was recorded. The edge of all abandoned farm land, other open-land and wetland was measured in inches with a "map measurer".

Approximately 4,500 numerical values for area, occurrence of type, and edge were sorted and averaged by call-count into six classes (0, 1, 2, 3, 4, and 5 plus). The class 5 plus observations was selected, arbitrarily, since only 14 stations had 5 or more calling quail, and an observer might find it difficult to count more than 5 birds without confusion in a three-minute period. An average call of 5.57 was taken for this class.

Cursory inspections of average cover values indicated that several of these independent variables might be used to demonstrate a relationship between specific environmental factors and calling activity. The more promising environmental characteristics were selected as independent variables for analysis using simple and multiple correlations. The measurable cover values selected for analysis included: area of hardwood forests (H), of agricultural land interspersed with a variety of cover (AL-I), of all abandoned fields (AF), and edge of abandoned fields together with edge of interspersed agricultural land.

Survival and Contribution of Pen-Reared Quail

Fall Releases and Analysis of Shot Returns

Usable data concerning the exact date, location, and band number were obtained for approximately 9,000 juvenile quail stocked in general liberations prior to the shooting seasons in 1953, 1954, and 1955. All of these birds were leg-banded with number 4 aluminum bands. Each band carried a number and the request to "Notify F & G, Upton".

Fall liberations were made by releasing approximately 12-week old birds in boxed lots of 10 or 20 quail, in areas open to public shooting. In connection with the wing collections already described, intensive publicity was employed to insure as large a return as possible from the fall releases.

Two methods of analyzing the band returns from fall-stocked quail were employed: (1) contribution to the total open-season kill as it relates to time lapse between stocking and shooting, and (2) the distribution of the total harvest of pen-reared quail taken during the open season.

Fall liberations, during the three years of investigation, were made with varying periods of time between stocking and the beginning shooting. For ease of presentation, the time intervals between release and the open season were reduced to three weighted average dates of stocking: 28, 13, and 3 days prior to shooting. The percentages of the total return were then calculated for each stocking date.

In connection with the wing collections already described, the percentage of pen-reared quail in the daily kill was determined and summarized for three periods during the open season (first week, second and third weeks, and the fourth and fifth weeks). These periods were then compared as separate percentages of the total contributions of pen-reared birds to the open-season kill. All birds used in this analysis were stocked within three days of the opening of the shooting seasons.

Short-Term Survival

A method of direct count of birds tagged with plastic markers was used to determine characteristics and rates of survival of fall-stocked, juvenile quail. For three years (1952, 1953, and 1954) test series of 80, 100, and 81 birds, respectively, were stocked and observed for one month preceding the opening of the hunting season (October 20).

To assure enough birds for test release each year, approximately 130 juvenile quail were taken from game farm holding pens and tagged with plastic (bow-tie) markers during mid-August using the methods described by Wint (1951). In addition to the "bow-ties", leg bands were used to check the durability of the plastic tags.

After neck-tagging and banding, the birds were returned to the pens, and held until mid-September. No injurious or irritating effects were observed from the neck tags. No more than 10 tags were lost from approximately 400 quail marked during the three years. All tag losses occurred during the first few days after marking. Subsequently, no tags were known to have been lost either in the pens or after release.

In 1952 the liberations were made on Martha's Vineyard using 80 birds in four lots of 20 birds; each lot was liberated at a separate site (Ripley, 1954).

In 1953 and 1954 all of the liberations were made on Cape Cod. In 1953, five lots of 20 birds were used, and in 1954, seven lots varying in size from 8 to 19 birds were released. In this latter case, original pen units were maintained.

All of the test series were released without incident. The birds were allowed to walk freely from the shipping boxes, and in all cases they moved as units into dense cover.

Following a three-day period, when the birds were left unmolested, the birds were located and counted as frequently as time permitted. Normally the groups or remanents of groups were located at least twice a week using well-trained standing dogs until the season opened. The data collected from direct observations were summarized and reported as average percentages of survival by five-day periods for the three years of study.

Peripheral Stockings

Insofar as this phase of stocking evaluation was concerned, perpherial areas are taken to be (collectively) land that supported few, if any, bobwhites, but was contiguous with occupied habitat.

Three adjacent areas (A, B, and C) of approximately 3,000 acres each were selected in Norfolk County for experimental restocking using spring and fall released quail. These areas supported few, if any, quail prior to stocking, and census data taken in Norfolk County during the summer showed a very low population density (see Table 6). Evaluation of the effectiveness of the several restocking techniques was based on the increase or decrease in populations as reflected by whistle-count census observations.

During September and October of 1953 and 1954, Area A was stocked with 600 juvenile quail, annually, in a 100:100 sex ratio. Area B was stocked during May and June of 1954 and 1955 with 225 mature quail at a 125:100 sex ratio. Area C, which actually lies between the other areas, was not stocked. Stocking densities and sex ratios were selected on the basis of (1) normal population characteristics in the high (relatively speaking) density areas of Cape Cod, and (2) from open season findings for sex ratios.

The three whistle-count routes were taken using the standard procedures outlined in earlier sections. Call indices for each stocking area and the control were determined and summarized for 1954, 1955, 1956, and 1957.

Supplemental Feeding

In this investigation, two general types of supplemental feeding were evaluated: food patches and the use of automatic or bucket-type feeders. Both annual and perennial food patches have been used by the Massachusetts Game Division in its habitat restoration programs. Annual plantings have consisted, mainly, of 1/4 to 1-acre strips of small grains (rye, oats, and buckwheat). Perennial food patches have been established using species of bush clover (Lespedeza spp.) in 10 to 50-foot strips.

Frye (1954) describes the uses and values of the "bucket-type" feeders. Although these were not used by the Game Division they were employed by interested individuals. Since they might have large-scale management application they were included in this study.

Annual Plantings

Studies of population response to habitat manipulation using patches of annual grains were carried out in the Barnstable Study Area. During the spring and summer of 1956, the Area was placed under intensive management, and a total of 33, 1/4 to 1-acre annual food patches were established (Figure 5). Although the author's field studies were intermittent at this time, he cooperated with Mr. R. A. Cookingham, District Wildlife Manager for the Game Division, to obtain census and banding data from the Area. The Game Division and Mr. Cookingham have generously permitted the use of these data, and they serve as a basis for the preliminary evaluation of population response.

Perennial Plantings

Fifteen perennial food patches of bush clovers (Lespedeza spp.) in

Figure 5. Preparation of a typical annual food patch in the Barnstable Study Area, April, 1956.

Barnstable County were examined during March, 1954. These constituted nearly all of the perennial patches in the County that were at least two years old. The ages of the patches ranged from 2 to 11 years. General observations on the site, species planted, age, seed retention, available ground supplies of seed, growth, plant survival and game bird usage were noted for each food patch. These observations were examined in the light of findings of other workers for presentation in later sections.

Automatic Feeders

The evaluation of automatic quail feeders was restricted to the Great Island Study Area, where wintering coveys were presumably maintained largely as a result of food available from the bucket feeders (Figure 6).

Statistical Terminology

Frequent reference is made, throughout the sections that follow, to the results of statistical analyses. The reported symbols should be interpreted as follows:

S.D. = one standard deviation from the mean

r = coefficient of correlation

R = multiple correlation coefficient

X^2 = Chi square, index of dispersion

t = Student's "t", test of the null hypothesis

n = sample size

d.f. = degrees of freedom

All statements of significance are based on a 95 per cent confidence level, unless otherwise stated.

Figure 6. One of the bucket feeders used on Great Island, April, 1956.

RESULTS AND DISCUSSION

Systematic Status of Massachusetts Quail

Aldrich (1946) and Aldrich and Duvall (1955) suggested that the bobwhite inhabiting Massachusetts belongs to a distinct northeastern coastal race or subspecies, which they chose, by earlier authority, to call the New England bob-white, *Colinus virginianus marilandicus* (L.). Aldrich, in so doing, confirmed Phillip's (1915) earlier contention that the New England subspecies is a brighter, more reddish and larger bird. Although not officially recognized by the American Ornithologist's Union as of 1956 (1931 AOU check-list and numbers of the *Auk*) or by Ridgeway and Freedman (1946), the writer agrees with Aldrich in the validity of the separation, and contributes what he believes may be important supporting evidence based on the weight data collected in connection with this study. Further, since the writer uses the subspecific separation as a basis for other discussions, the inclusion of detailed comparisons appears advisable at this point if valid conclusions are to be drawn.

From January 2 to May 6, 1956, 282 quail were trapped and weighed. These observations serve as the basis for comparison with other reported findings. Nineteen adults and 49 juveniles, trapped between January 2 and 15 (the period of greatest weight), had average weights of 241.7 grams (S.D. = 13.1) and 228.6 grams (S.D. = 12.6) for the respective ages. The maximum weight observed in this series was 265.4 grams for an adult male captured on January 5 in the Barnstable Study Area.

Nelson and Martin (1953) combined the several subspecies of quail and reported an average weight of approximately 174 grams for 899 individuals. They did not distinguish subspecies, sex, age or time of observation. The maximum weight reported by these workers is approximately 14.6 grams less than the maximum cited above.

Leopold (1945), who worked with C. v. mexicanus in Missouri, showed that average adult and juvenile weights were about 192 and 185 grams, respectively. Reeves (1954) found similar weights for the same subspecies in Indiana. From 234 birds trapped between January 22 and March 3, 1947-1950, he obtained an average of 192 grams and a maximum of 235 grams. The comparable mean and maximum for the author's marilandicus data, based on 128 observations, were 208.5 and 251.1 grams, respectively. Again, with C. v. mexicanus, Hood (1955) found an average and maximum weight of 165 and 200 grams for 535 Mississippi birds. Bailey (1947) found that 31 birds of this subspecies trapped in February in West Virginia averaged 186 grams. Mattison's data, (1948) from the extremity of C. v. mexicanus range (Wisconsin), based on over-winter observations on 1,229 birds, gave an average of 202 and a range of 133 to 260 grams. The writer's marilandicus data, comparable to the latter, yielded an average and a range of 210.1 and 131.4 to 265.4 grams, respectively. Stoddard (1931:75) reported 176 and 213 grams (average and maximum) for a 244-bird shot sample of C. v. virginianus during December, January, and February from South Carolina. These are probably representative of the subspecies, but might be as much as 12.4 grams lighter than comparable trap samples (Robinson, 1957:49).

Robinson's data (1957:49), by this writer's interpolation, indicated that 19 fully mature *C. v. taylori* individuals from Kansas averaged 207 grams in January.

The writer's weights of Massachusetts quail serve to substantiate the thesis that the species increases in size northward, and offers additional evidence that *C. v. marilandicus* may be the heaviest subspecies of *Colinus virginianus*.

Life History

A full discussion of the general life history of the New England bobwhite seems inappropriate. So much has been reported on this subject by other workers that may be applied to the Massachusetts situation, that it seems advisable merely to cite the more applicable references.

Stoddard's (1931) full treatment of life history material, so far as the writer can detect, differs only slightly from general life history observations in Massachusetts. Wilson and Vaughn (1944) have included much in their paper on Maryland studies that is parallel to the more northeastern situation. Ripley (1956 and 1957) has published life history accounts noting particularly the differences he observed in Massachusetts.

History of Quail in Massachusetts

Distribution of Former Populations

The bobwhite is a native of the Bay State. Records of the presence of the species date to the time of early settlers (Forbush, 1927). Limited numbers of quail apparently thrived in natural openings, burnings, and under mature hardwood stands (Latham and Studholm, 1952). As colonization progressed westward through Massachusetts, the clearing of land provided better habitat for quail. The bobwhite found the conditions of diversified farming particularly desirable, and became well-established in nearly all sections of the State. The only areas that probably were never invaded by the species were the higher Berkshire Hills.

Before the twentieth century, quail were found in the lower valleys of Vermont as far north as Londonderry. They were also well-distributed in the southern New Hampshire lowlands, and extended into southern Maine (Aldrich, 1946; Bent, 1923; and Phillips, 1915).

The repopulation of lost territories following severe winter conditions was apparently commonplace prior to the late 1800's. After an extremely hard winter in 1903-04 the recovery of former quail range was, at best, incomplete. Again, in 1920, severe winter weather caused further reduction of range and population densities. Despite relatively mild conditions during the following decade, quail increased only locally. Severe winters in the early thirties reduced straggling populations in the central and western sections of the State. By 1933 the range had been limited to the southeastern counties with only a few scattered coveys occurring elsewhere in Massachusetts.

From 1933 until the present time, local extensions in range have occurred, but these were cut back during periods of adverse weather to positions embracing less and less area. The present range appears to be stabilized, and the bobwhite may be considered as a permanent resident in Nantucket, Dukes, Barnstable, Plymouth, and Bristol Counties. Figure 7 shows the distribution of quail in Massachusetts in 1902, 1933, and 1952.

Climate and Weather

It is doubtful if any adverse change in climate has occurred during the past 50 to 60 years. Hence, it is unlikely that this factor was responsible for widespread reductions in ranges and populations. Undoubtedly, there were many severe winters prior to 1903, but until that time quail were able to regain their previous distribution.

Weather may have been responsible for temporary range losses. Severe winters are known to have annihilated the species over wide areas (Errington, 1933; Errington, 1939; and Gerstell, 1937) in the past. However, if quail once managed to repopulate territory lost in adverse weather it seems logical that they would continue to do so, all other things being equal. Since the quail were not able to do this in Massachusetts after 1903, all other things were not equal. Weather was undoubtedly the agent of actual destruction, but at least one other factor must have been detrimental.

Figure 8 shows the mean winter temperature and average annual snowfall in Massachusetts*. It is interesting to note that prior to 1900 quail were distributed throughout the State except in the approximate

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*Taken from the 1936 progress report of the Massachusetts State Planning Board.

Figure 7. Former limits of quail distribution in Massachusetts, 1902, 1933 and 1952.

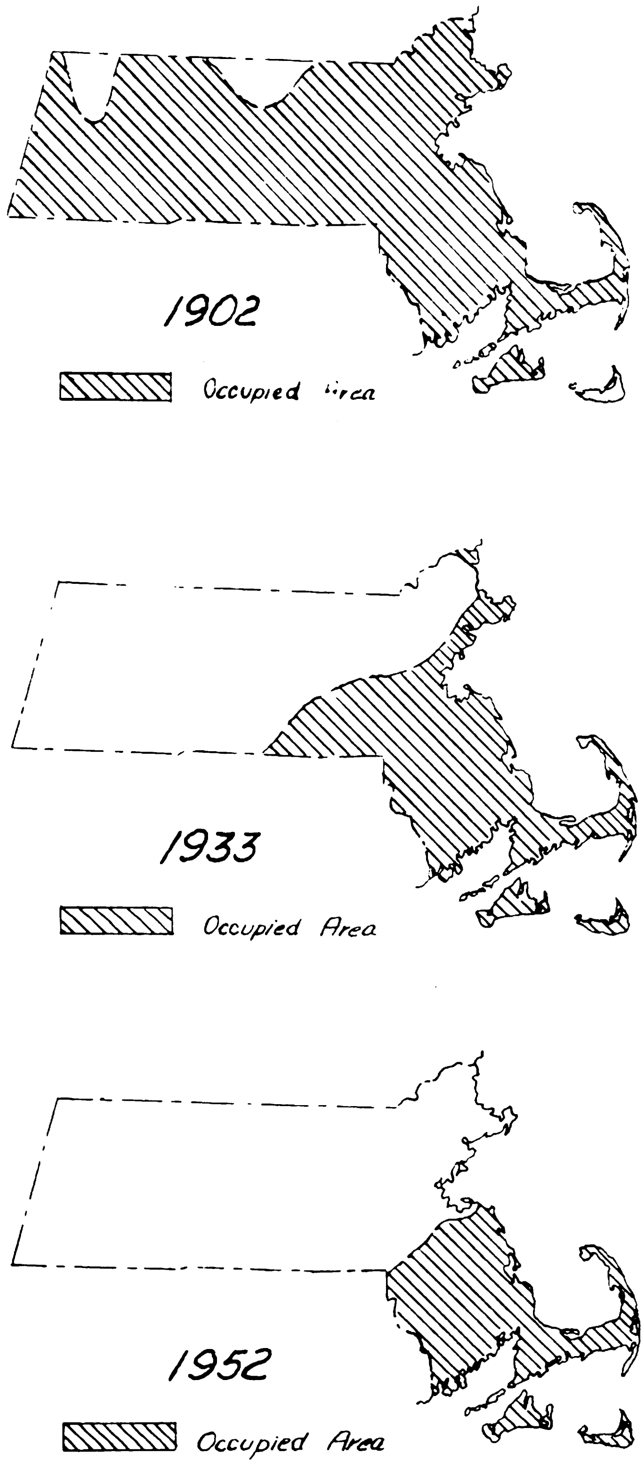
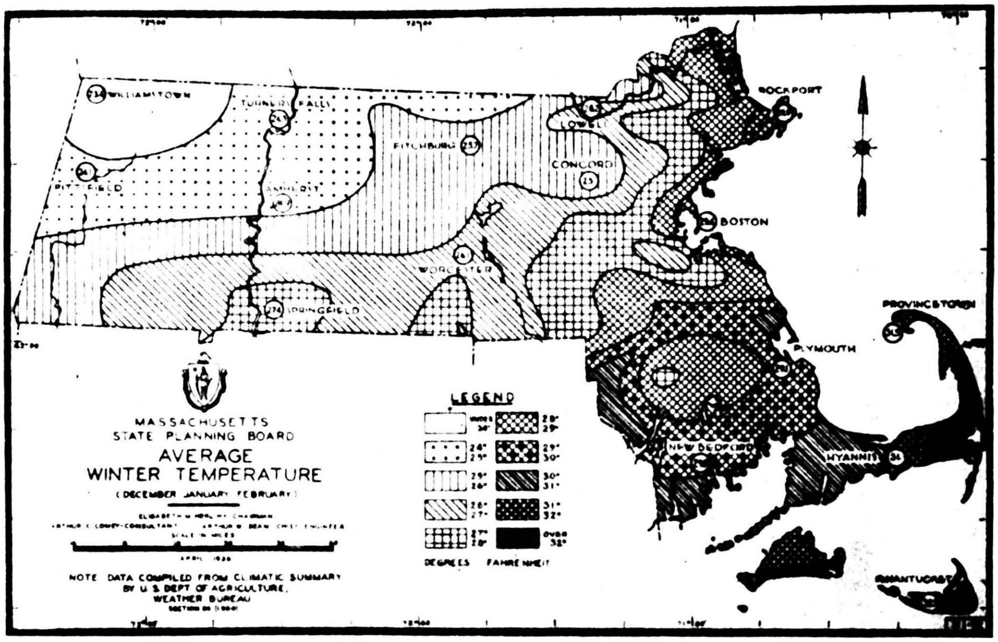
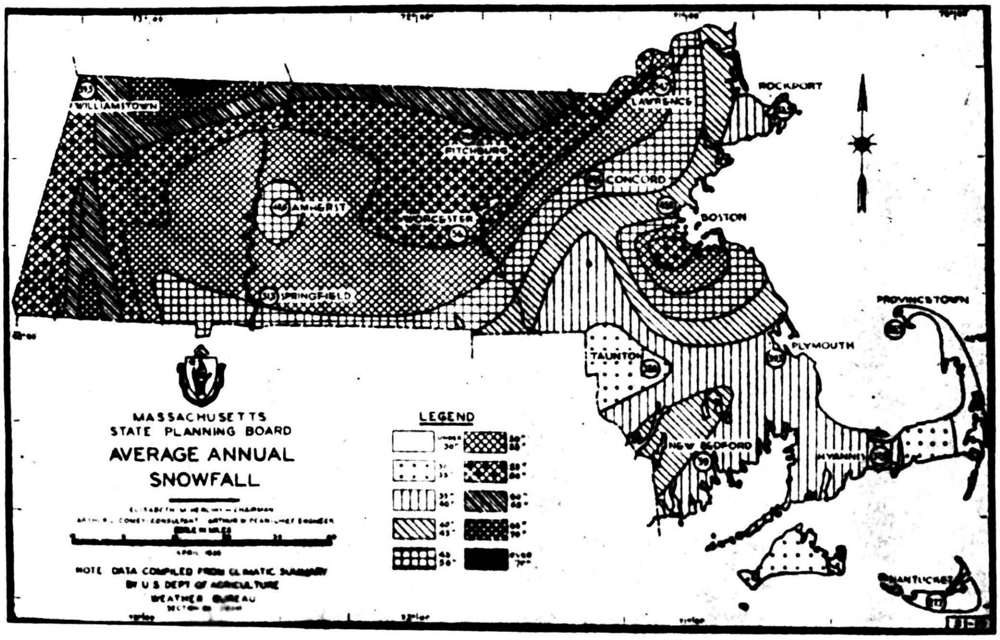


Figure 8. Average annual winter temperature and snowfall in Massachusetts.





area having less than 24° average winter temperature. Since 1903 quail have failed to become re-established north and west of a line designating a winter mean of 26° to 27° F. The present distribution is confined, except for isolated coveys, to the general north and west boundary of the 29° to 30° area. Before 1903 quail were found in all areas where average annual snowfall was less than 60 inches. At the present time, distribution of the species is confined to areas having 40, or less, inches of snowfall.

Cover Changes

Leopold (1931) summarized the land use changes of the north central states as they influenced the distribution and abundance of quail. In essence, they seem parallel to the Massachusetts situation.

One hundred years ago, approximately 75 per cent of Massachusetts was farmed. Today, agricultural acreage has dropped to about 25 per cent of the total land area.

Most of the agricultural land that was abandoned has reverted to native vegetation, and much is well-stocked with timber of ultimate crop value. This marked reduction in farm land has often affected great acreages in a relatively short space of time. The resulting cover has provided little suitable habitat for the maintenance of quail.

Of equally great importance are the changes which have occurred in the types of crops produced, and the decreasing varieties of crops on individual farms. During the last 75 years, the production of grain has dropped approximately 80 per cent*.

*Progress report, Massachusetts State Planning Board, 1936.

Clean farming also had an adverse effect on quail numbers (Goodrum, 1949). This trend can be characterized by the following practices: (1) fall plowing; (2) the use of temporary fences with fewer hedgerows and thickets; (3) the complete removal of crops including fodder and straw; and (4) a reduction in the amount of weed growth in idle corners and borders.

The decline in agricultural acreage and wide acceptance of clean farming practices probably have been the principal factors responsible for reduction of quail distribution and abundance.

Legislative Measures

The first legislation relating to quail was passed in 1818 when it became unlawful to take quail between March 1 and September 1 (Adams, 1931). In 1865 it became illegal to take quail except during October, November, and December. No open season was permitted between April 1, 1869, and November, 1872. In 1872, birds could be taken in November and December, and in 1886 this was extended to include October. The sale of bobwhites was made illegal in 1906, and the open season was established between October 29 and November 20.

Scarcity of quail between 1904 and 1932 prompted legislation which gradually limited the open season to the southeastern counties. Essex County was closed in 1914, Hampden and Middlesex in 1917. By 1925, Hampshire, Worcester, and Norfolk were closed. Berkshire and Franklin were closed in 1932*.

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*Acts and Resolves of Massachusetts.

Bag limits of 4 a day and 20 a season were set in 1912, and remained in effect until they were increased to 5 a day and 25 a season in 1955.

Between 1915 and 1920, quail apparently became quite scarce on Martha's Vineyard. This condition prompted a continuous closed season that was maintained until 1925. Quail were stocked on the Vineyard during the early twenties, and these birds may have contributed to an increase in that area.

At the present time both Islands (Nantucket and Martha's Vineyard) and Barnstable, Plymouth, and Bristol Counties are open to quail shooting, between October 20 and November 20, with bag limits of 5 a day, and 25 a season.

There is some reason to believe that hunting in the past may have been detrimental to quail populations. Market hunting, particularly, may have been instrumental in reducing bobwhite numbers. By and large, however, hunting restrictions since 1906 (when market gunning was stopped) have apparently done little to increase the resource or even to check the decline in closed areas.

Artificial Propagation and Restocking

The information reported below was taken from Adams (1931), and from annual reports of the Massachusetts Division of Fisheries and Game, unless otherwise cited.

The stocking of quail was undoubtedly carried on before the Civil War. Many of the early liberations were made quietly to avoid attracting the attention of market gunners (Phillips, 1928). Subsequent stockings have been made during the past 80 years by individuals and groups throughout the State. The birds used in these liberations were shipped from all sections of the range (Phillips, 1915; 1928; and 1933). Earliest attempts to propagate quail by the Commission of Inland Fish and Game (as the present Division was then called) were in 1894. This work was carried on for about 15 years by Commissioner Brackett of Winchester at his private establishment. From 1906 to 1918, quail were propagated at the Sutton Fish Hatchery. While complete records of stockings are not available, it is known that at least 182 birds were distributed prior to 1918.

The first game farm was established in 1913 at East Sandwich. Quail for breeding stock were trapped from native populations. Between 1915 and 1920, when quail production was suspended, 1,336 birds and 642 eggs were distributed.

Wild breeding stock was trapped again in the winter of 1926-27 and the quail rearing program was reactivated at the East Sandwich Game Farm. In 1930, 65 pairs of native stock-on-hand were increased by 10 pairs of birds from Virginia. The same year, quail production was started at three more farms with shipments of Virginia birds to the Ayer, Wilbraham and Marshfield Game Farms.

Since 1930, annual production for distribution from the four farms has ranged from 2,000 to nearly 20,000 quail. Until 1938, distribution was essentially State-wide. Since that time distribution has been limited to the southeastern counties. Propagation at Ayer and Wilbraham was discontinued in the late 30's and the present (1955) annual distribution from the East Sandwich and Marshfield farms totals about 5,000 birds.

Despite the liberation of thousands of quail, these measures apparently had little or no effect on native populations.

Restocking and Racial Hybridization

The effect of hybridization on indigenous forms of quail by the introduction of alien subspecies has been of considerable concern to several workers. Latham and Studholm (1952) and Phillips (1928) suggested that introductions in Pennsylvania and Massachusetts, over a long period of time, may have altered the characteristics of indigenous forms to such an extent that the capacity to cope with rigorous winter conditions was reduced. Latham and Studholm have assembled considerable data to support their theory in Pennsylvania. In the writer's opinion, however, the conclusions which they reached for Pennsylvania may be of questionable application in Massachusetts. Likewise, Phillips (1928) reports similar conclusions "...New England States...have received birds from so many different sources and for so long a time that the indigenous stock is probably now extinct." Aldrich (1946) does not agree. "The usual result is that the birds are so poorly adapted to the new environment as to die within a year or so, ..." He does, however, offer a definite note of caution regarding the probable detrimental influence of concentrated stockings, and cites Leopold's work with turkeys.

Stoddard (1931:485) discussing the influence of *C. v. texanus* introductions upon *C. v. virginianus* in the Florida-Georgia area found no detectable permanent change in indigenous stocks. Similarily, Robinson

(1957:50) reports "...little or no permanent effect on the size of bobwhites in south-central Kansas", as a result of restocking.

The writer was fortunate in locating the weight records of 49 quail shot in Massachusetts and Connecticut in 1865, 1866, and 1868*. Forty-five were shot between December 2 and 13 and four were shot between January 22 and 24. Unfortunately, these were weighed collectively, but the average weight of 203.9 grams is useful. Thirty-seven birds weighed between December 3 and 8, 1956, (normal, 81 per cent juvenile segment) averaged 210.7 grams. Live trapped weight might be heavier (7.2 grams) because of fuller crops, a larger proportion of adults in the sample, and no loss of blood or drying. In summary, however, the two series suggest that the weight of quail has remained essentially unchanged for nearly a century.

In all, it seems probable that the decline in the New England subspecies was due to a rapid and extensive reduction of habitable range, but that the agent of actual mortality was severe wintering conditions, felt most pressingly in the marginal habitat.

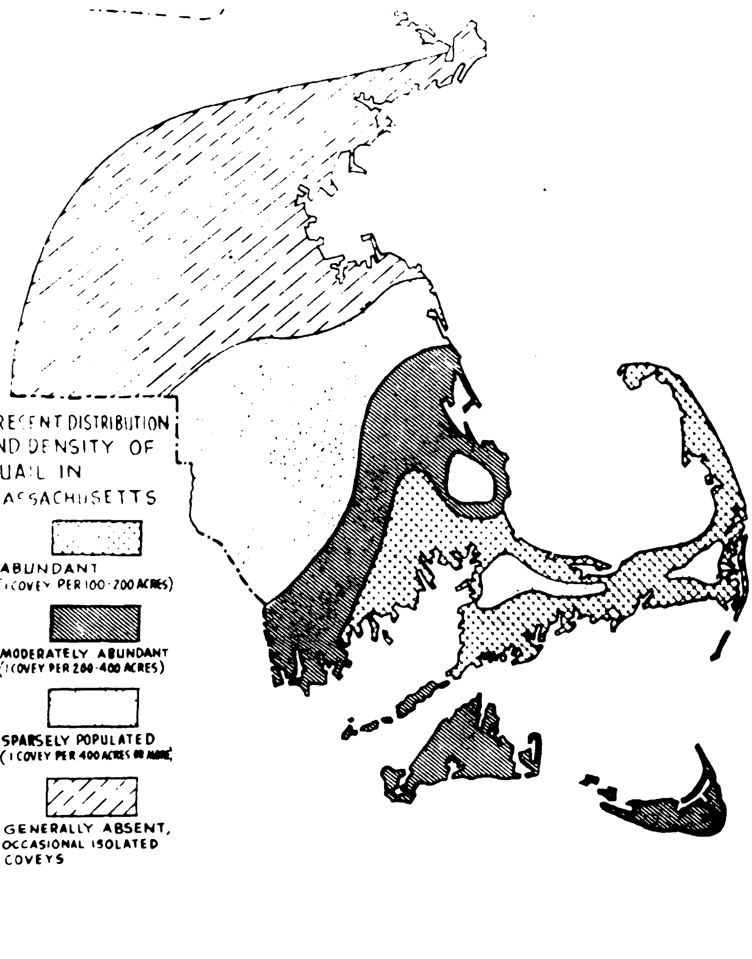
Present Status of Quail in Massachusetts

Distribution and Relative Abundance

Figure 9 depicts the present distribution and relative abundance of quail in southeastern Massachusetts. For convenience, the C.I. (Call

*Hunting diary of G. A. Peabody (deceased), Essex County, Mass. Courtesy of Mr. David Aylward, Mass. Wildlife Inc., Spruce Street, Boston.

Figure 9. Density and distribution of present quail populations (1956) in southeastern Massachusetts.



Index) data used to prepare this map were reduced to estimated density in terms of acres per covey.

The influence of certain climatic factors has already been discussed in connection with the previous section. Climate apparently limits the abundance of quail within the occupied habitat since the areas having abundant or moderately abundant populations are also characterized by having somewhat more moderate winter conditions (Figure 8). The two major islands, Nantucket and Martha's Vineyard are exceptions, however. Both apparently have fewer quail than the coastal mainland sections despite a somewhat milder climate. This is due, in all probability, to the general types of vegetative cover.

With the exception of Marth's Vineyard, Nantucket and a coastal portion of Plymouth County, the amount and intensity of agricultural activity is similar in the abundant and moderately abundant zones. The cover of the Islands, the Cape and a small portion of the coast north of the Cape (Plymouth County) is basically a pitch pine, mixed oak disclimax. The balance of the presently occupied habitat is white pine with mixed northern hardwoods. The associated shrub strata and herbaceous vegetation is different between these areas, and also may influence quail populations. The pitch pine-oak areas, with moderately active agricultural practices, apparently support the highest quail populations. Without agricultural activity they are essentially unused by quail. In these areas cranberry and strawberry production are foremost, and the latter (because of the grain rotation with strawberry production) is undoubtedly the more important (Figure 10). Figure 11 shows a general view of a productive, well-kept

Figure 10. Typical strawberry field, Falmouth, Massachusetts, September, 1957.

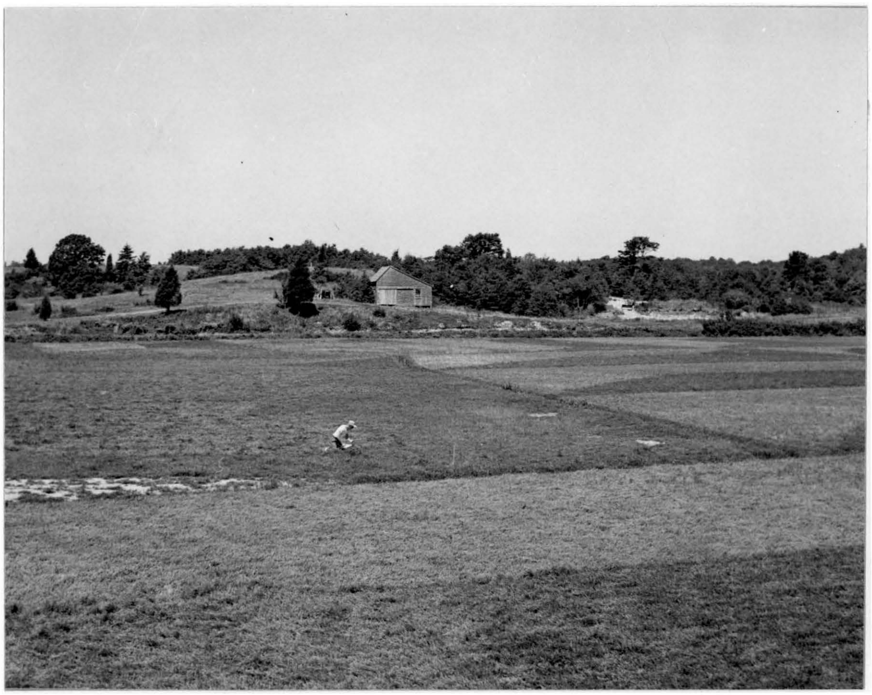


Figure 11. Typical cranberry bog (harvest in progress), Barnstable Study Area, September, 1957.

cranberry bog on Cape Cod at time of harvest (September). Cranberries are probably unimportant as a food for quail but the bog edges which are maintained by clipping and spraying appear to be used rather commonly by the species. Truck gardening and a limited dairy industry are also found in the area; truck gardening seems to be of considerable importance in quail production.

The oak woodland areas (Figure 12) apparently attract quail and serve importantly in supplying food during fall and early winter. These are characteristically very dense in younger stages with a shrub strata of scrub oak (*Quercus illicifolia*), black huckleberry (*Gaylussacia* spp.) and, to a lesser extent, catbriar (*Smilax* spp.) and sheep laurel (*Kalmia angustifolia*).

Figures 13 and 14 show characteristic development of essentially pure stands of pitch pine (*Pinus rigida*) in abandoned farm-land situations. With very few exceptions this species invades open situations and dominates the sites. Shrub and herbaceous strata are virtually non-existent, and as an ecological community these areas are essentially useless for quail.

Specific Cover Relationships

Table 1 gives the simple correlation coefficients between quail call counts and cover values of area and edge. Each of the independent variables was significantly related to call-count but the relationship was low for the area of three cover types. The relationship with hardwoods was negative indicating that call-count decreases as area of hardwood increases. The relationship between edge and call-count is considerably higher than for any of the other factors.

Figure 12. Typical mixed oak woodland, Barnstable Study Area, August, 1957.

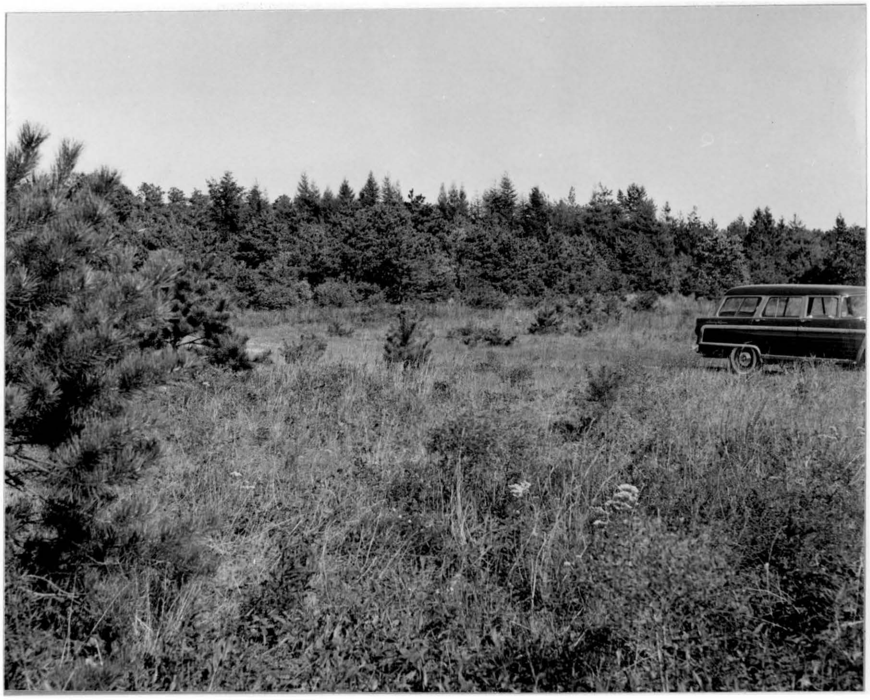


Figure 13. Typical pitch pine (Pinus rigida) succession in a field that had been stripped for topsoil in 1952, Barnstable Study Area, September, 1957.

Figure 14. Advancing pitch pine (Pinus rigida) succession in an abandoned field, Barnstable Study Area, September, 1957.

Table 1. Simple correlation coefficients (r) between call counts and cover values of area and edge

Cover factor	Correlation* coefficient
Hardwood (acreage)	-.2639
Agricultural Land Interspersed (acreage)	.2934
Abandoned Field (acreage)	.2130
Agricultural Land Interspersed and Abandoned Field (linear edge)	.4073

*102 degrees of freedom.

Using all four factors related simultaneously to call-counts (multiple correlation) the degree of relationship was not materially improved over that which existed between edge and call-count (R = .4302). The influence of edge on call-counts was by far the most important factor. If it were not for the limitations in the call-counts to measure populations in local areas, this relationship probably would have been much greater. In examining the values which indicate the independent effect of each variable on call-count, it was noted that the formerly significant, positive, relationship between the area of abandoned fields (AF) and call-count became negative in multiple analysis. This indicated clearly that the size of abandoned fields was relatively less important, and that the edge of these areas is the more important feature. Likewise, a sharp reduction in the relationship between agricultural land interspersed (AL-I) and call-count was seen in multiple analysis in comparison with the simple correlation. Similarly, edge of (AL-I) was more important than area. Forest hardwoods (H) showed a negative relationship to call counts throughout the analysis.

Obviously, the density of quail populations is directly related to the acreage and configuration of open land; of the influencing factors tested, edge appeared as the most important. The "edge effect" that is demonstrated by this analysis has valuable management implications whenever habitat manipulation is employed.

Food Habits

Table 2 is a listing of the fall foods found in crops of 149 quail taken during the 1953 and 1954 open shooting seasons in southeastern

Table 2. Fall foods found in 149 quail crops collected from two areas between October 20 and November 20, 1953, and 1954, in southeastern Massachusetts. Foods listed in order of importance by combined values of frequency and volume

BARNSTABLE-DUKES
(118 crops)

Animal Materials (mainly Orthoptera)
Ragweed, *Ambrosia artemisiifolia*
Oak, *Quercus* spp.
Bayberry, *Myrica pensylvanica*
Domestic Rye, *Secale cereale*
Poison Ivy, *Rhus toxicodendron*
Snapweed, *Impatiens pallida*
Leafy greens
Black Locust, *Robinia pseudoacacia*
Skunk Cabbage, *Symplocarpus foetidus*

PLYMOUTH-BRISTOL
(31 crops)

Ragweed, *Ambrosia artemisiifolia*
Domestic Rye, *Secale cereale*
Pigweed, *Chenopodium* spp.
Chickweed, *Stellaria media*
Animal Materials (mainly Orthoptera)
Bayberry, *Myrica pensylvanica*
Poison Ivy, *Rhus toxicodendron*
Bastard Pennyroyal, *Trichostema dichotemum*
Domestic Corn, *Zea mays*
Ash, *Fraxinus* spp.

TOTAL
(149 crops)

Ragweed, *Ambrosia artemisiifolia*
Domestic Rye, *Secale cereale*
Animal Materials (mainly Orthoptera)
Oak, *Quercus* spp.
Bayberry, *Myrica pensylvanica*
Poison Ivy, *Rhus toxicodendron*
Snapweed, *Impatiens pallida*
Leafy greens
Black Locust, *Robinia pseudoacacia*
Skunk Cabbage, *Symplocarpus foetidus*

Massachusetts. It may be seen that the food items of the Bristol-Plymouth subsample are more closely associated with strictly agricultural conditions than are the Barnstable-Dukes data. The Barnstable-Dukes subsample was taken from the pitch pine-mixed oak type. Conversely, the Plymouth-Bristol crops were collected largely from the white pine-northern hardwood type. The birds of this latter region are quite probably more directly dependent on cultivated land. Although the Cape and Island fall foods indicate similar relationship, the use of materials from trees and shrubs (particularly acorns) is apparent.

Wright (1941), investigating the food habits of Rhode Island quail, found conditions in that area similar to those found in the analysis of the Bristol-Plymouth crops. His listing of ragweed (Ambrosia artemisiifolia) parallels this and numerous other food habit analyses. Ragweed was found to rank first in Maryland (Wilson and Vaughn, 1944), Virginia (Baldwin and Handley, 1946), Wisconsin (Errington, 1939), Pennsylvania (Latham and Studholm, 1952), and Oklahoma (Baumgartner, et al., 1952). Native lespedezas, prominant in food lists from the southern and southeast states (Lay, 1954; Barbour, 1951; Stanford, 1952; Martin, 1935; Stoddard, 1931; and Laessle, 1944), are not found in the native flora of Massachusetts, and except for a trace of L. capitata were not found in the analysis. Cultivated lespedezas are rarely used in connection with agricultural activities in Massachusetts.

Observations on the feeding habits of wintering coveys in the Barnstable Study Area indicated certain seasonal shifts in food materials taken. The dwindling use of greens and insects during the fall presumably follows the patterns described by Massey (1938). Acorns were utilized heavily by some coveys until mid-winter, but these normally became scarce and coveys retreated to more open situations to feed on agricultural products or weeds. Some coveys utilized bayberry (Myrica pensylvanica) and poison ivy (Rhus toxicodendron). Ripley and Cookingham (1958) discuss the importance of black locust (Robinia pseudoacacia) for over-wintering coveys in Massachusetts. They report that this material may be extremely important to wintering populations.

Age and Sex Composition

Tables 3 and 4 give the age composition and sex ratios, respectively, for quail. The age composition figures reported in Table 3 appear to be normal for the species and are substantiated by the findings of other workers (i.e., Bennitt, 1951; and Leopold, 1945). The lower percentage (76.2) of 1954 compared to the three-year average, while highly suggestive of a shift in composition, is not significant, and may be due to sampling error ($X^2 = 2.859$, 1 d.f.). The writer feels, however, that a shift did occur.

Petrides (1949) suggested that the percentage of juveniles might produce misleading results if it were used as a measure of rearing success, unless sex ratios were known, and even then the results might be erroneous in the absence of knowledge concerning breeding hen mortality. With quail, however, and particularly with limited samples, reducing juvenile data to an adult hen ratio might be risky. Since the species is monagamous, and since cocks contribute to rearing the normally single brood (Stoddard, 1931; and Stanford, 1953), the rearing success of any

Table 3. Per cent of juvenile quail in total shot and trap samples in southeastern Massachusetts, 1953, 1954, and 1955

Year	Per cent juveniles Trap	 Shot	 Total
1953	—	81.2 n 340	81.2 n 340
1954	73.0 n 89	76.8 n 403	76.2 n 492
1955	79.0 n 271	81.5 n 362	80.5 n 633
Total 3-year	77.5 n 360	79.8 n 1105	79.3 n 1465

Table 4. Sex ratios of quail in southeastern Massachusetts from trap and shot samples, 1953, 1954, and 1955

Segment	1953	Year 1954	1955	3-year total
Adult Trap	—	140:100 n 24	159:100 n 57	153:100 n 81
Adult Shot	125:100 n 54	178:100 n 89	94:100 n 64	133:100 n 207
Adult Total	125:100 n 54	169:100 n 113	120:100 n 121	137:100 n 288
Juvenile Trap	—	110:100 n 65	93:100 n 214	96:100 n 279
Juvenile Shot	98:100 n 226	97:100 n 281	86:100 n 274	93:100 n 781
Juvenile Total	98:100 n 226	99:100 n 346	89:100 n 488	94:100 n 1060
Grand Total	103:100 n 280	112:100 n 459	95:100 n 609	102:100 n 1348

season is probably not dependent entirely on the adult hen segment since both parents participate. While it is true that a high proportion of young in a population might be indicative of heavy adult mortality rather than increased rearing success, it would appear to be more hazardous to use one, rather than both, adult sexes unless exact sex ratios and mortality rates were known. In the local areas, influx, egress, and limited samples would also tend to compound the dangers of using the adult hen-juvenile ratio.

The average sex ratios reported in Table 4 appear to be normal for both age segments (137:100 for adults and 102:100 for juveniles). Despite the sample variation between years in each segment, no significant differences were found. As with other studies (Bennitt, 1951; Stoddard, 1931; Stanford, 1952; Reeves, 1954; Leopold, 1945; and Frye and Murray, 1957) the marked disparity in sex ratios between the adult and juvenile segments was highly significant using average figures ($X^2 = 49.2$, 1 d.f.). Based on the average sex ratio of 112:100 reported by these workers, the average Massachusetts figure (Table 4) of 102:100 was not significantly lower ($X^2=4.552$, d.f. 5). These data show that except for differences between the sex ratios for adult and juvenile segments, extremely large samples are needed to detect differences that can be used with reliability. Certainly, sex ratio samples for local areas must be handled very cautiously.

Table 4 suggests that differential sex mortality may occur during the winter (based on a comparison of sex ratios between fall shot and winter trap samples), but by far the more important hen losses apparently occur during the breeding season.

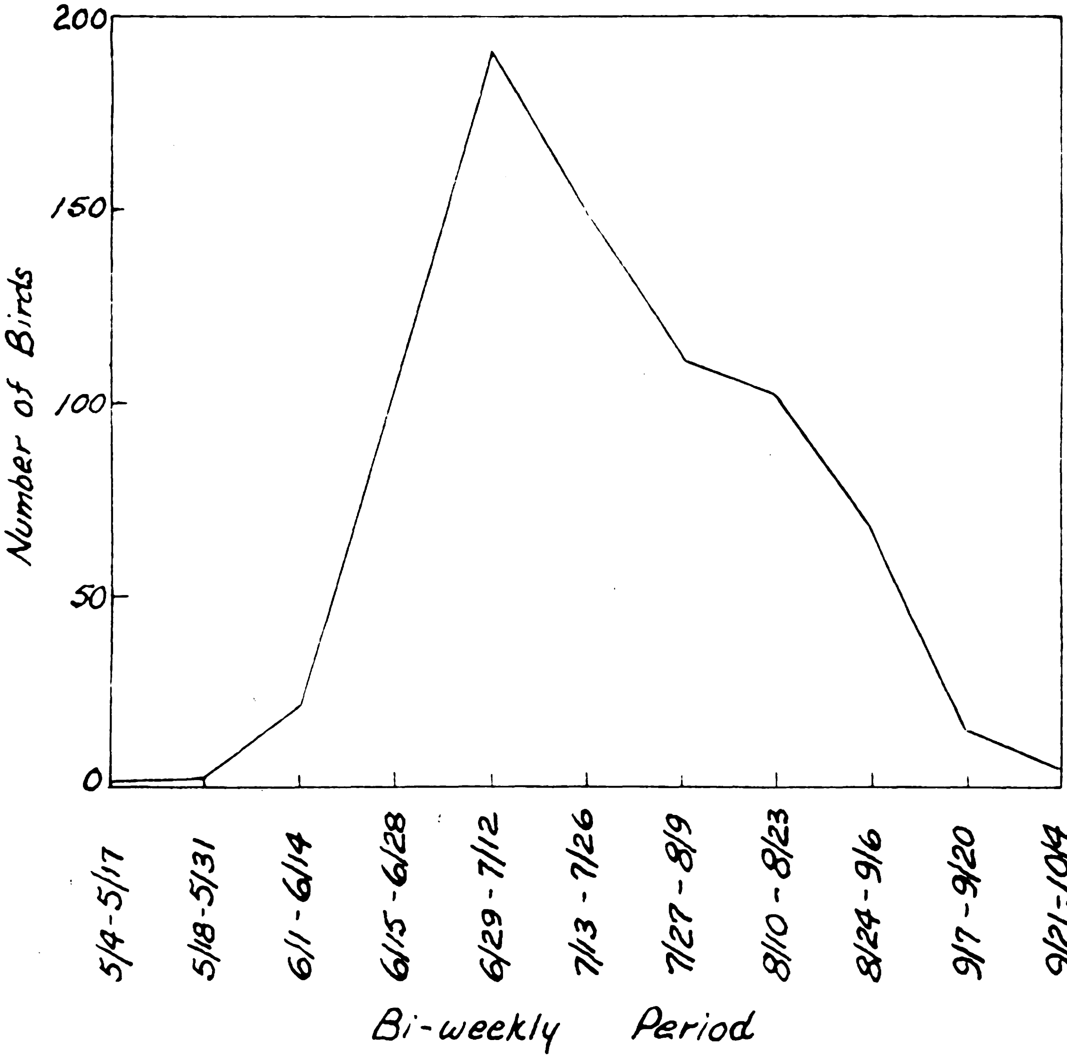
<u>Hatching Characteristics</u>

Figure 15 shows the frequency distribution of 772 hatching dates as determined from shot samples of juvenile quail collected during the course of the investigation. Data were plotted on the mid-points of two-week intervals. In general, the shape of the line graph follows the data presented by Thompson and Kabat (1949), Reeves (1954), and Stanford (1952). Thompson and Kabat found two distinct peaks of hatching in Wisconsin which coincided well with the early July peak in the Massachusetts data and the hint of re-nesting in mid-August. Reeves found a peak of hatching in early July. Stanford's data suggest a delayed hatching peak in Missouri (mid to late July or early August). The later hatching in more southern Missouri is rather difficult to explain, except as it may be the culmination of both nesting and re-nesting activity. The early, highly pronounced peak in Massachusetts appears to be suggestive of highly favorable nesting and hatching conditions with reduced re-nesting. Because of the nature of the cover, disruption of nests by mowing would probably be somewhat less; other, perhaps more obscure, factors might also contribute.

Klimstra (1950) found an average nesting period of 130 days in southern Iowa. The Massachusetts hatching data suggest 178 days, by back-dating 38 days from hatching to first egg (Thompson and Taber, 1948). For all practical purposes, however, the period of nesting is about 135 days, from early May to early September.

The age of quail at the time of hunting is often an important consideration for the administrator. Normally, 12-week old birds are nearly mature, physically, and produce satisfactory shooting. On this basis,

Figure 15. Frequency distribution of the hatching dates of 772 quail from shot samples in southeastern Massachusetts, 1953, 1954 and 1955.



only about 26 per cent of the juveniles would be less than 12 weeks old when shooting started (October 20), and less than 12 per cent would be 10 weeks-of-age. Assuming that juveniles constitute at least 75 per cent of the total population in late October, less than 20 per cent of the total population would be younger than 12 weeks on October 20 in a normal year. This percentage would hardly justify delaying the open season, particularly in view of other factors which will be discussed later.

Weight and Weight Change

Between January 2 and May 6, 1956, 624 initial, recapture, and repeat observations on body weights were obtained from 244 quail. The data were first examined for variation between sex and age segments by two-week periods. Weight differences between sexes for each age segment were not significant, but were remarkably similar (males 210.9 and females 209.4 grams). Data from other investigations showed the same results (i.e., Leopold, 1945; and Robinson, 1957). The writer feels that this fact may have received too little attention insofar as differential mortality between sexes is concerned. If the females were physiologically weaker, it might follow that a weight difference during periods of adversity would become apparent, but none could be detected. Again, the nesting season appears to be the period of accelerated loss among females.

Table 5 gives a bi-weekly summary of weights from all captures between January 2 and May 6, on the basis of age. Apparently, the average weights of adults is not only higher at the onset of winter but remains relatively higher than juveniles until mid-spring ($t = 3.13$, 8 d.f.).

Table 5. A comparison of average weights of adult and juvenile quail from bi-weekly trapping samples taken during January, February, March, April, and May, 1956, Cape Cod, Massachusetts

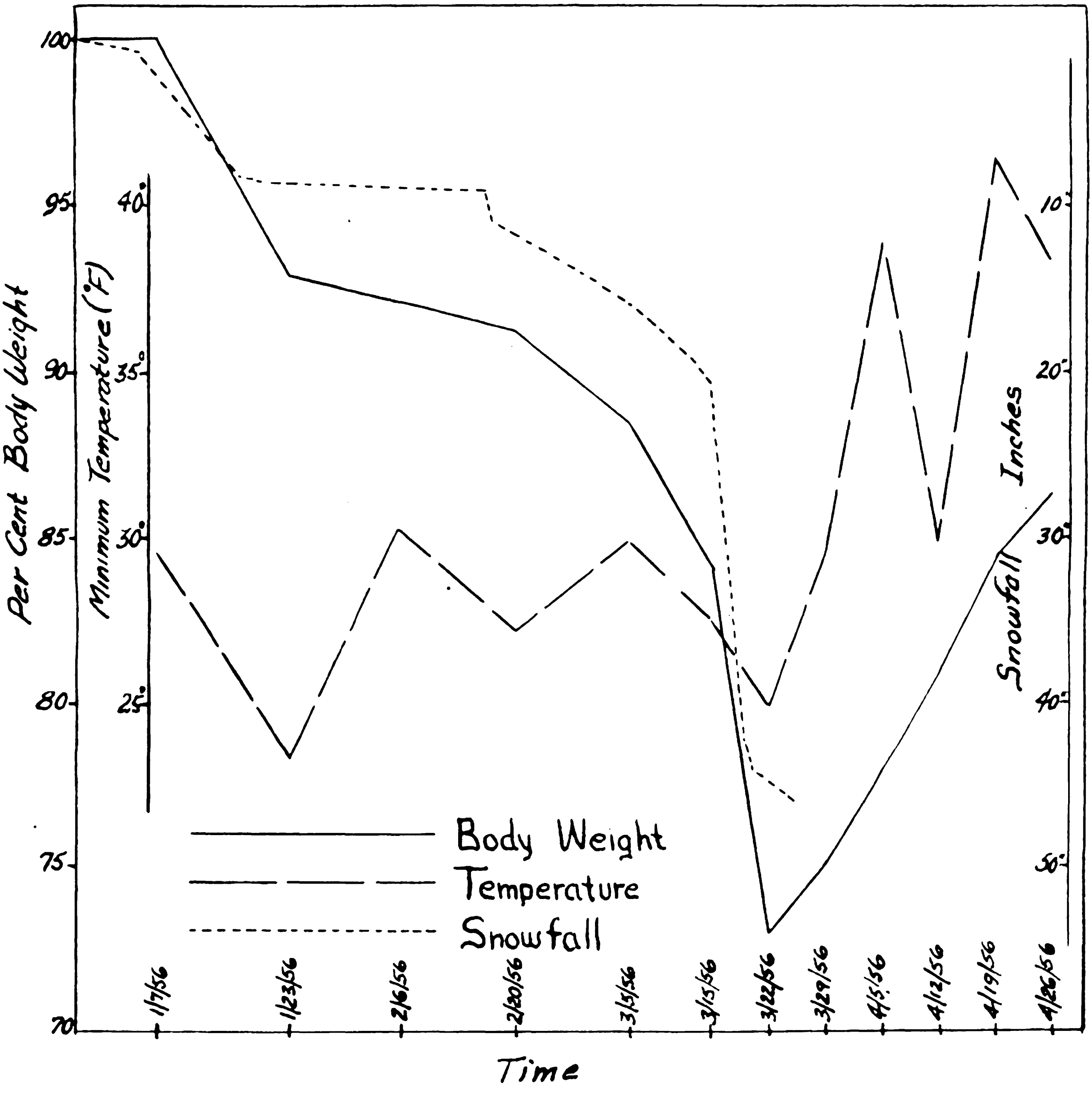
Bi-weekly period	Average weight (grams) Adult	Juvenile
1/2 - 1/15	239.6 n 27	228.2 n 63
1/16 - 1/29	220.8 n 9	209.2 n 33
1/30 - 2/12	210.6 n 12	211.5 n 96
2/13 - 2/26	210.7 n 17	200.7 n 48
2/27 - 3/11	203.1 n 20	200.7 n 58
3/12 - 3/25	199.3 n 18	183.7 n 64
3/26 - 4/8	180.4 n 7	176.1 n 61
4/9 - 4/22	187.8 n 10	188.4 n 44
4/23 - 5/6	200.3 n 2	197.6 n 35
Average	205.8	199.6

At this latter time, however, the weights are essentially equal. These data agree with those of Leopold (1945). Robinson, however, (1957) found no difference in his Kansas series. Mattison (1948) reports that adults averaged 6 to 7 grams heavier than juveniles, and Reeves (1954) found about a 7 gram disparity favoring adults (interpolated from his table).

Table 5 shows (3/26 - 4/8) that during the period of lowest weight adults may maintain higher total weight than juveniles. Based on data taken between December 3 and 8 on Great Island, in which 8 adults and 29 juveniles averaged 223.7 and 207.1 grams, respectively, it may be construed that the early January weights are the highest. Robinson (1957), on the basis of his own data and that of other workers, indicates that quail weigh less during the breeding season and relates body weight (inversely) to length of photoperiod. The writer, however, found that the period of lowest weight coincided most closely with the vernal equinox (Figure 16). Lack (1954:132-140) summarizes much of the available information on weight build-up. He suggests that weight frequently increases prior to periods of stress, and cites several examples to substantiate his remarks. Wolfson's work with white-throated sparrows (1954) substantiates Lack's observations. Hanson and Kossack (1957) did not find a relationship between fat storage, age, and migratory habits of doves.

From Figure 16, it may be seen that a close inverse relationship exists between accumulated snowfall and average body weight ($r = .997$, 6 d.f.). Temperature showed no clear relationship to body weight. Nestler and Langenback (1946) found that even severe cold had little effect on

Figure 16. Curves of total accumulated snowfall, periodic means of minimum daily temperature and periodic means of body weight change among 54 quail (based on 100 per cent body weight on January 7) for January, February, March and April, 1956, Cape Cod, Massachusetts.



well-fed quail. Likewise, Mosby and Overton (1950) found in Virginia that over-wintering survival was inversely related to accumulated snowfall. The data in Figure 16 tend to substantiate the findings of both of the latter investigations. Quite probably snow, as it effects the availability of food supplies and impedes normal feeding activities, contributes to this situation.

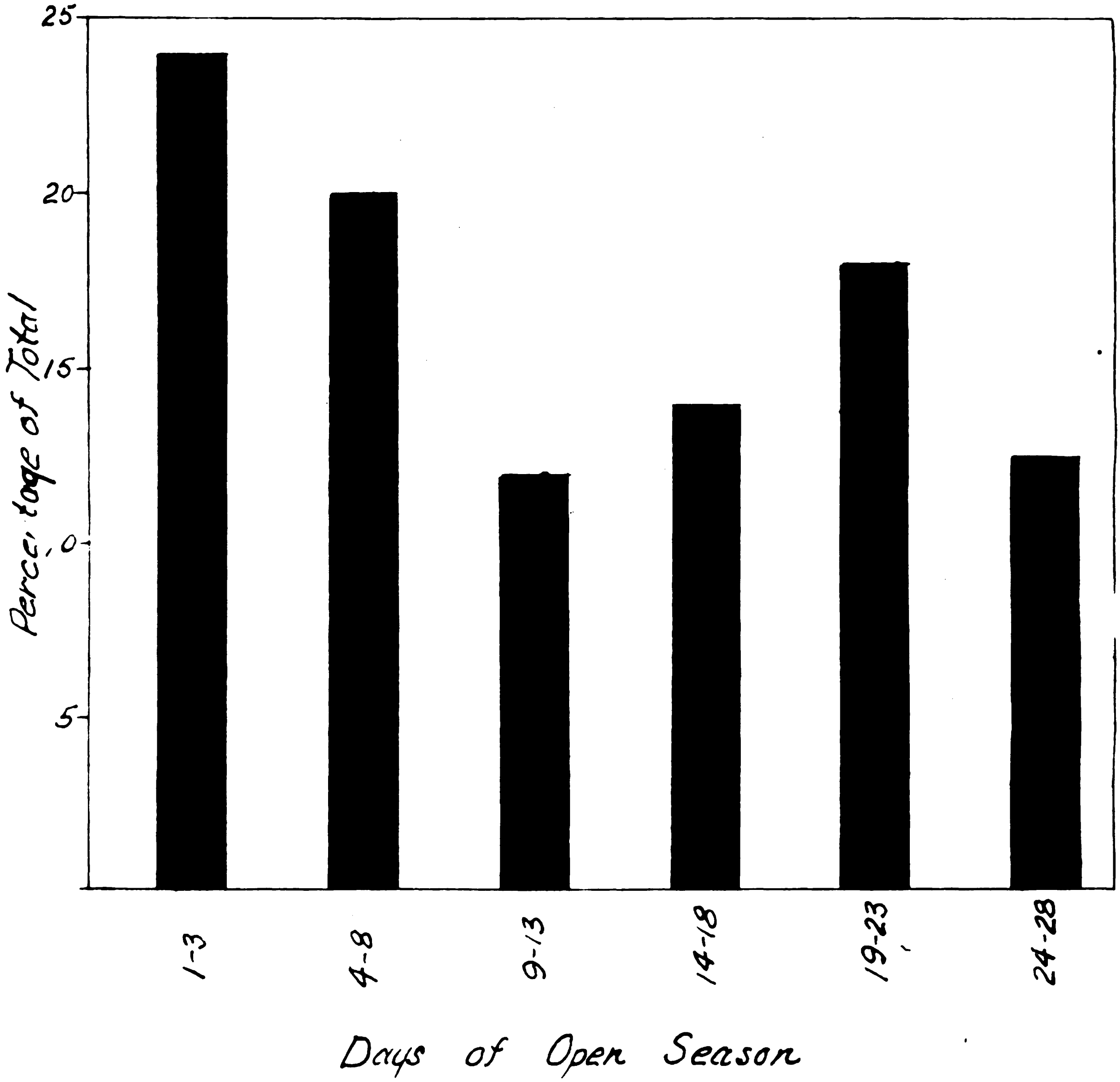
Hunting Pressure and Kill

Couture (1954) reports that only 6.7 per cent of the Massachusetts sportsmen hunt quail as compared to 35.2 per cent for pheasants. Quail probably rank below other major game birds because of the limited distribution of the species.

Inventory and observation in the Barnstable Study Area, which is presumably comparable to much of the open shooting area, indicate that the harvest of quail during the open season is between 10 and 15 per cent. This is a modest harvest, and in view of a 75 to 80 per cent annual turnover (based on age composition), the writer, as well as many other workers, feels that hunting pressure could be substantially increased without detriment to over-wintering populations (Murray and Frye, 1957; Kozicky and Henderson, 1952; Errington and Hamerstrom, 1935; Baumgartner, 1944; Mangold, 1951; and Thompson, 1952).

Figure 17 shows the open-season distribution of the kill. These data indicate that about 44 per cent of the total kill is taken during the first eight days of the season. Thereafter, the kill is distributed so that about 12 per cent is taken each five days open to shooting. The

Figure 17. Mean distribution of the in-season harvest of native quail, per cent of total for first 3 days and subsequent 5-day periods 1953, 1954 and 1955, southeastern Massachusetts.



upsurge in the harvest (Figure 17) between 19 and 23 days is probably due to increased hunting pressure during the Thanksgiving holidays.

Inventory

Whistle-Count Census and Hunter Opinion

Table 6 gives the whistle-count census results expressed as corrected call indices for southeastern Massachusetts. All indices were tested for significance with the preceding year and average years using a "t test" for paired county routes. No significant differences were found. The Dukes data (Martha's Vineyard) were highly suggestive of decline. Since the results are based on only two routes, significant differences would be difficult to demonstrate. The writer observed what he considers to be a deterioration of quail habitat on the Island during the period of study, and feels that the census data reflect this condition.

Bennitt (1951) showed that hunting success was higher during years of high calling activity. He also noted that a high breeding population was associated with high call counts and lower percentages of young in shot samples. The Massachusetts data suggest the same relationships. The 1954 average of 1.28 (Table 6) corresponds with the lower percentage of young already reported in Table 3.

Table 7 gives the average numerical opinion of sportsmen on the relative abundance of quail. The data indicate (although the series is short) that the call index and average opinions are parallel. Reeves (1954:26) found essentially the same condition in Indiana.

Table 6. Results of annual whistle-count census (comparative call indices), 1952 through 1956, southeastern Massachusetts

County	Call indices (comparative) 1952	1953	1954	1955	1956
Norfolk	—	0.00	0.08	0.07	0.05
Bristol	—	0.63	0.24	0.16	0.24
Plymouth	—	0.84	1.03	1.09	1.53
Barnstable	—	2.39	2.44	2.37	2.74
Dukes	2.30	1.88	2.39	1.19	0.65
Area-wide	—	1.14	1.28	1.15	1.27

Table 7. Sportsman opinion of the relative change in abundance of quail in southeastern Massachusetts between 1953 and 1954, and 1954 and 1955

Degree of abundance	Value	1953-1954 Number reports	1953-1954 Value x reports	1954-1955 Number reports	1954-1955 Value x reports
Much more abundant	5	20	100	17	85
Slightly more abundant	4	44	176	41	164
No change	3	27	81	19	57
Slightly less abundant	2	14	28	10	20
Much less abundant	1	2	2	5	5
TOTALS		107	387	92	331
Average sportsman opinion		3.62		3.60	

All evidence gathered in the course of these investigations suggests that the whistle-count census is a reliable inventory technique. There is little question that its continued use in Massachusetts will be valuable in ascertaining the relative status of quail populations.

Population Dynamics

Influence of Study on Local Populations

As far as the writer can determine, the total census counts and associated investigations in the study areas had no influence on the populations under observation.

The influence of trapping and baiting, on the other hand, might raise certain questions. Since the discussions that follow concern an extremely important phase of the investigations, it appears appropriate to question the influence of the use of these techniques on the local populations.

Despite the great care that was exercised in trapping and handling, 7 trap mortalities occurred in the Barnstable Area with 702 captures during the course of the study. No trap losses occurred on Great Island, proper, but 6 mortalities were suffered trapping the mainland adjacent to the Island. Of the 13, 2 were by a weasel, 4 by dogs, 1 by a rabbit, 3 by a Cooper's hawk and 2 by quail (males fighting). In addition, 1 quail was inadvertently lost when it escaped from the weighing sock and flew into a windshield (inside a station wagon). While regretable, it is very doubtful that these losses would greatly influence local populations.

Although food was probably only rarely critical to over-wintering birds, it is conceivable that baiting might affect local populations. Bait was always used sparingly and intermittently, and the writer seriously doubts that it appreciably influenced the inter- and intra-territorial activities of coveys or subjected them to either greater or lesser vulnerability to predation.

Supplemental feeding, by baiting, and its subsequent physiological influence on survival was also thought to be negligible. If birds were obtaining any continued benefit from baiting it might be demonstrable in a weight difference between new and repeat captures. It may be construed from the data in Table 8 that this did not occur, since there was no significant difference between the average weight series (adults: $t = .450$, 7 d.f. and juveniles: $t = .032$, 8 d.f.).

Barnstable Study Area

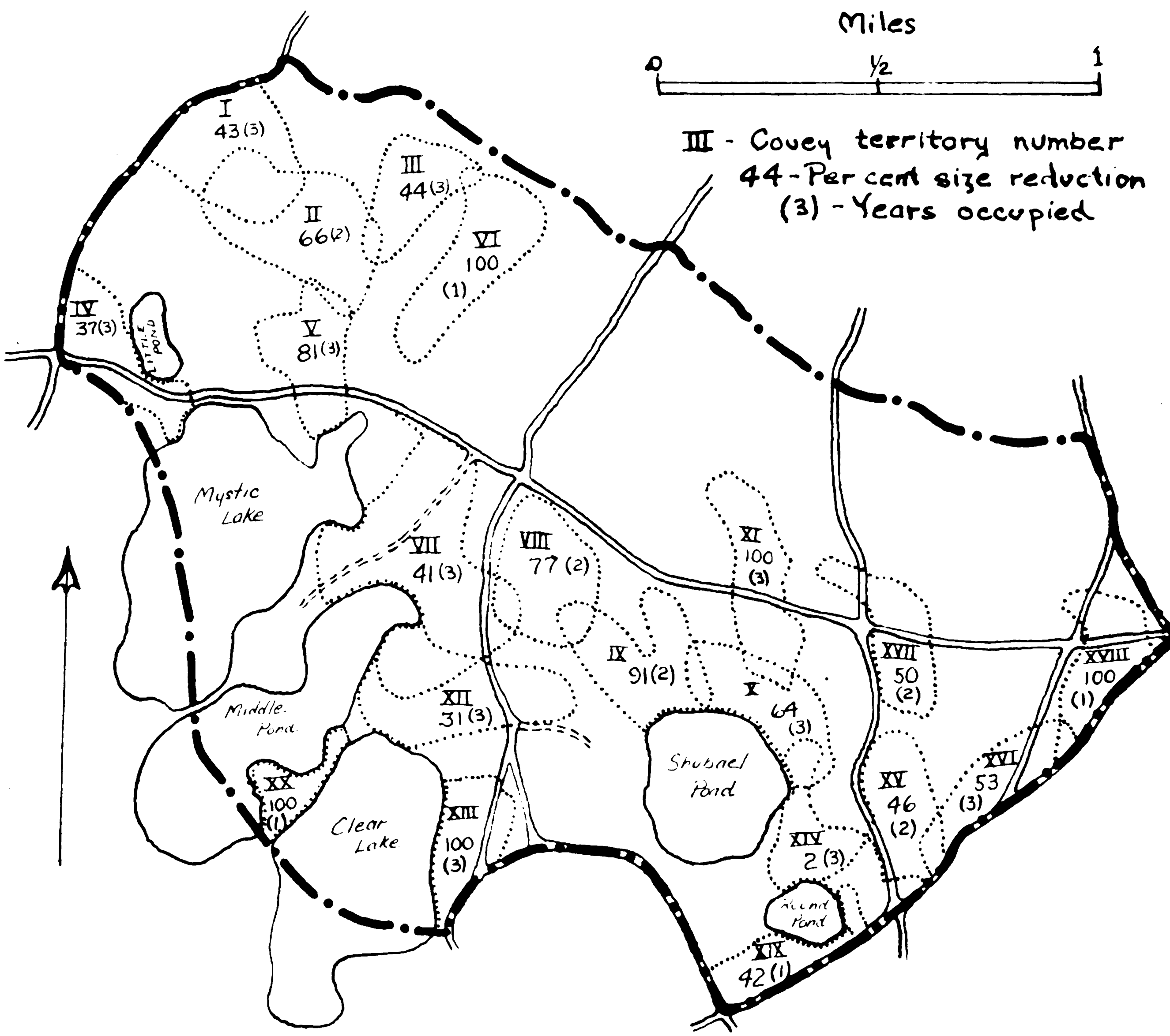
Covey territories: Figure 18 delineates the maximum covey territories of over-wintering quail in the Barnstable Study Area during the period of investigation. Each plotted territory was known to have been occupied at least once during one fall census period. Individual territories are identified by Roman numerals. The average percentage of over-wintering loss for each territory (during the years it was occupied) is reported, and the number of years (during the three-year period) that the territory was occupied is shown in parentheses.

Territories number VI, XI, XIII, XVIII, XX, were never occupied by an over-wintering covey. In each instance they were abandoned before the spring counts were taken. Coveys in territories XIII, XVIII, and XX

Table 8. A comparison between initial-trap and retrap weights of adult and juvenile quail by two-week periods, winter 1956, Cape Cod, Massachusetts

	Average weight (grams)			
	Adult		Juvenile	
Period	New	Repeat	New	Repeat
1/2-1/15	241.7 n 19	234.6 n 8	228.6 n 49	227.1 n 14
1/16-1/29	214.5 n 4	225.7 n 5	207.3 n 10	210.0 n 23
1/30-2/12	210.0 n 7	211.3 n 5	212.4 n 58	210.1 n 38
2/13-2/26	215.4 n 5	208.7 n 12	200.8 n 17	200.7 n 31
2/27-3/11	205.3 n 6	202.2 n 14	202.4 n 21	199.7 n 37
3/12-3/25	189.4 n 5	203.1 n 13	182.4 n 23	184.4 n 41
3/26-4/8	178.2 n 2	181.3 n 5	171.5 n 6	176.6 n 55
4/9-4/22	183.1 n 3	189.8 n 7	192.3 n 5	187.9 n 39
4/23-5/6	—	200.3 n 2	196.0 n 4	197.8 n 31

Figure 18. Barnstable Study Area, covey territories mean, percentage reduction in over-wintering covey size, and years of territory occupancy for 1953-54, 1954-55 and 1955-56.

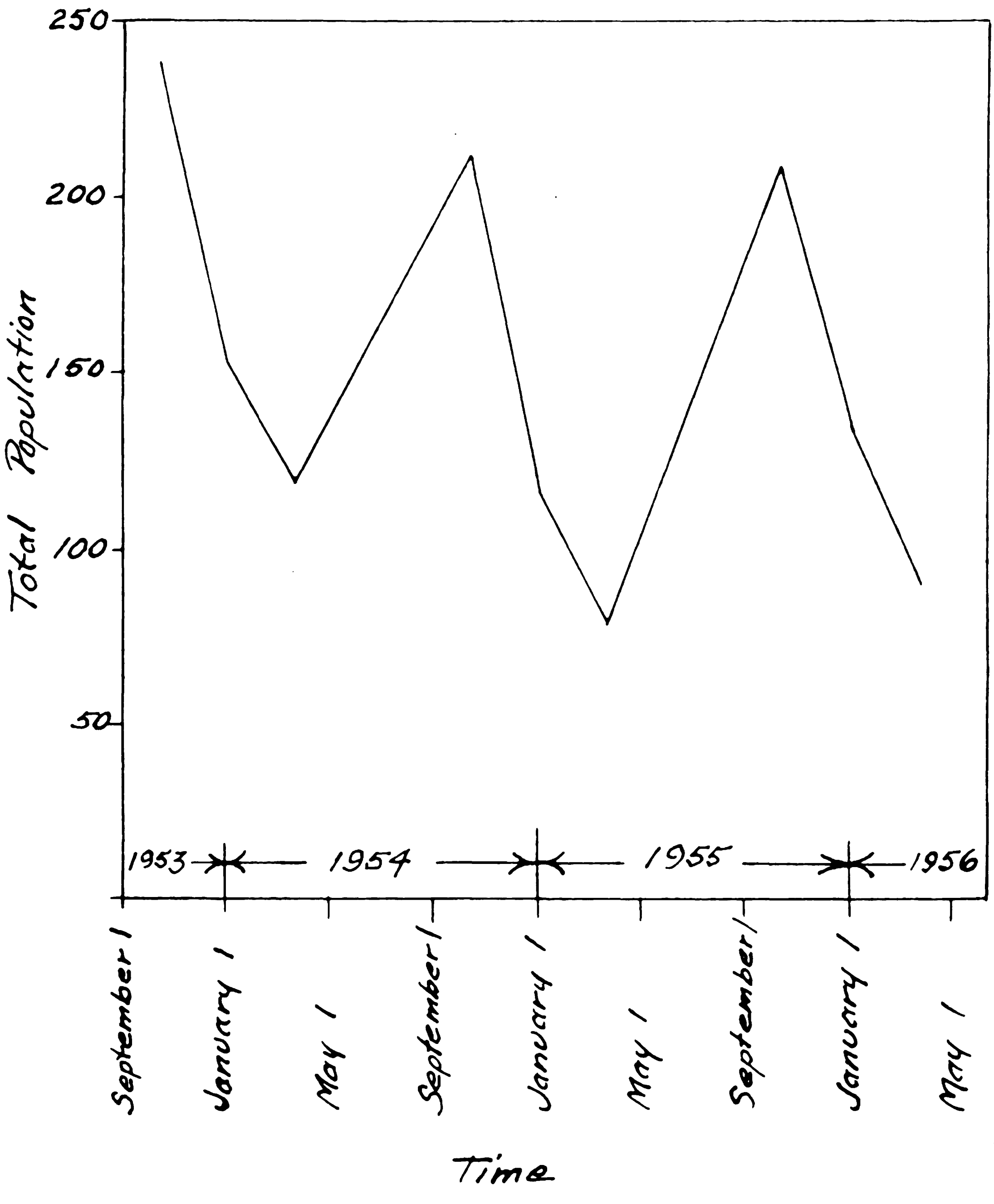


egressed from the area. Birds occupying territories VI and XI normally suffered heavy loss and joined the coveys occupying territories II and III or X, respectively. Higher over-wintering loss was suffered by coveys utilizing the more open agricultural territories: i.e., II, V, VIII, IX, X, and XVI. (See Figure 1 for cover details). Territories IV, XII, and XIV apparently were the best suited for over-wintering survival. These areas had several, apparently highly desirable, features in common: (1) a greater diversification of good cover, (2) a greater variety of fall foods, and (3) supplies of winter foods that were nearly always available (i.e., black locust, bayberry, and poison ivy).

Seasonal population densities: Figure 19 shows the seasonal population densities in the Barnstable Study Area based on direct counts. From the beginning of the period of observation (fall, 1953) until the spring of 1956 the data suggest a declining population. The reduced build-up and subsequently lower fall populations in 1954 and 1955 probably indicate a deterioration in habitable fall and winter range resulting in higher juvenile mortality and excessive egress during the post-nesting season. The same conditions may have prevailed during the late summer and early fall of 1953. The writer suspects that this condition was somewhat modified by a temporary decline in habitat deterioration during 1955 and that the 1955 and 1956 populations may have been more stable (Figure 19).

Unfortunately, the author's field studies were limited after the summer of 1956, and the three annual census periods could not be continued. In May, 1956, the Barnstable Area was subjected to intensive management. These operations apparently had a substantial effect on the local

Figure 19. Progressive seasonal population density, Barnstable Study Area (1790 Acres), Cape Cod, Massachusetts, October, 1953 - April, 1956.



populations, but are not shown in Figure 19 because fall and spring census data are lacking. Based on a single, direct census count, however, an over-wintering increase of about 30 per cent was observed during the 1956-57 period.

Sex and age composition: Table 9 gives the sex and age composition of Barnstable Study Area populations during the period of study. The reasons for reporting percentages of juveniles has already been discussed. It appears pertinent to call attention to the inconsistencies that would result if a ratio between adult hens and juveniles were used in discussing production, and juvenile survival (e.g., sample size and sex ratio of 1956-57 adult segment).

The apparent increase in the sex ratios (both segments) can only be attributed to sampling error. If a trend were present, it was not reflected elsewhere (Table 4).

Recalling that intensive management was applied in 1956, it is extremely interesting to note in Table 9 the marked shift in age composition during 1956-57. This condition, with 88 per cent juveniles as compared to an average of 70.5 for the two previous years is significant ($X^2 = 14.72$, 1 d.f.) and probably indicates an increase in juvenile survival. It is conjectured that the timing of the management applications resulted in conditions that may have been extremely favorable for the survival of young quail. It is also possible that an influx favoring juveniles may have occurred which contributed to both the total expansion and the increased percentage of young.

Table 9. Sex and age composition of quail in the Barnstable Study Area based on trapping data collected during the winters of 1954-55, 1955-56, and 1956-57, Cape Cod, Massachusetts

	Year			
Segment	1954-55	1955-56	1956-57	Total
Adult	175:100 n 11	238:100 n 27	367:100 n 14	246:100 n 52
Juvenile	85:100 n 24	94:100 n 70	120:100 n 99	105:100 n 193
Total	106:100 n 35	120:100 n 97	135:100 n 113	125:100 n 245
Per cent juveniles	69	72	88	79

Throughout the period covered by these discussions there were no abnormally severe winters that might have influenced the total populations or the sex and age composition. The winter of 1955-56 was probably the most rigorous, but at no time during this period did the birds appear to be faced with emergency conditions nor were excessive losses observed (Figure 19). Weight loss, already discussed, apparently did not approach the dangerously low levels of 50 per cent normal weight (Errington and Hamerstrom, 1946; and Leopold, 1933).

Likewise, predation was not thought to be a factor of importance. Based on general observations, the only change in predator populations that may have occurred was a slight increase in foxes. Errington (1933 and 1934) and Errington and Stoddard (1938) contend, in essence, that such predation would probably be minor in total effect.

Movements: Table 10 summarizes the seasonal and annual linear movement obtained from banding data in the Barnstable Study Area. Although recapture data are meager, they suggest that: (1) spring movement probably exceeds that of the fall, (2) males generally move more than females, (3) annual movement may be less than spring movement, and (4) annual movement may have been considerably less in 1956-57 than in 1955-56.

Table 11 shows the calculated percentage of egress for the Barnstable Area on the basis of trap and recapture data. As with linear movement, spring and annual egress (the latter for both sexes) appears to be about equal. Spring egress apparently exceeds that of fall.

The influence of intensive management on the Area during 1956 is also seemingly demonstrated by reduced annual movement (Table 10) and spring

Table 10. Seasonal and annual movement of quail banded and recaptured in the Barnstable Study Area, 1954 through 1957, Cape Cod, Massachusetts

Year	Linear movement (miles)			
	Summer to winter (males)	Winter to summer (males)	Winter to winter (males)	Winter to winter (females)
1954-1955	.59 n 2	.73 n 3	—	—
1955-1956	.42 n 4	.77 n 10	1.30 n 2	0.00 n 1
1956-1957	.52 n 2	.72 n 5	.22 n 7	0.00 n 1
Means	.49 n 8	.75 n 18	.46 n 9	0.00 n 2

Table 11. Estimated seasonal and annual egress of quail in the Barnstable Study Area. Reported as per cent of total population based on trap-retrap data for 1955, 1956, and 1957, Cape Cod, Massachusetts

Period (years)	Egress, Percentage of total population March to August (males)	August to March (males)	March to March (both sexes)
1955-1956	54	27	57
1956-1957	38	37	53
1957-1958	57	—	—
Average	50	32	55

egress (Table 11). It may be recalled, however, that during the fall and winter of 1956-57 a higher than usual percentage of young was observed. It appears that the fall movement of adult males was not affected by the management operations, and that counteracting influx may have involved a higher percentage of young birds; thereby contributing to (1) a higher percentage of young in the sample, and (2) a normal, or perhaps higher loss of adult males through egress.

Studies of seasonal and annual movements have interested several workers (Duck, 1943; Murphy and Basket, 1952; Mosby and Overton, 1950; Lewis, 1954; and Agee, 1957). Lehmann (1946) and Duck (1943) found that fall movements of quail may be considerable. The papers of these and other workers may have created an impression that movement, with the species in general, is more pronounced during the fall-of-the-year. The so-called "fall-shuffle" has been refuted by Murphy and Basket (1952), Lewis (1954), and Agee (1947). In essence, the Massachusetts data appears to support the thesis that spring movement is much greater than that of the fall, and that movement during the breeding season is greater than that during the so-called "fall-shuffle".

Whistling activity and local populations: Table 12 summarizes the results of four years of investigation regarding the relationship between the total number of calling males, call index and total captures for the Barnstable Study Area. It should be pointed out that trapping activities during the summer were intensive, and presumably most of the males that were captured were unmated. The writer feels that the intensity of trapping effort was comparable throughout the experiment and did not introduce further variation.

Table 12. Total calling males, call indices, and total captures of males in the Barnstable Study Area, summer of 1954, 1955, 1956, and 1957, Cape Cod, Massachusetts

Year (summer)	Total calling males	Call index	Total captures males
1954	20	2.02	11
1955	43	5.48	19
1956	42	6.33	13
1957	23	4.13	11
4-year average	32	4.49	14

As one might expect, there was a significant relationship between the total number of calling males and call index ($r = .904$, 3 d.f.). In addition, a significant relationship was observed ($r = .914$, 3 d.f.) between calling males and total captures. The relationship between call indices and captures was not significant ($r = .705$, 3 d.f.) although it suggested a similar pattern. If the total number of calling males actually constituted a representative portion of the Barnstable Area population, it should follow that the call index could be used to measure relatively small changes in local population density. This was not suspected to be the case, however, since the numbers of calling males and the call indices did not follow population density levels (see Figure 19). It appears that call index and total captures are related, in general, to the total numbers of calling males; hence, these may be related to the unmated male segment of the population. It seems that a large proportion, if not all, of the males call whether mated or not, but that the calling activity of mated birds is reduced in frequency and may be of lesser importance in determining call indices.

Why the number of calling males, call index, and the number of trapped birds should be lower in both 1954 and 1957 is not known. The difference may be due to temporary shifts in sex ratios during the census period because of influx and egress, to sampling error in age and sex data, or to unexplainable variation in calling activity. The latter is probably the cause, and indicates the impropriety of using whistle-counts to determine local population densities, unless substantial variation or error of measurement is acceptable. This should not imply, however, that the whistle-count census technique used over wide areas (i.e., counties) is not an acceptable index of relative population density and change.

Bennitt (1951) and Stoddard (1931:97-99) are in essential agreement that the unmated males do most of the whistling. The writer's data and Elder's investigations (1956) agree that the whistling of these males constitutes a very important part of the three-minute timed counts.

Rosene (1957) found a close relationship between the average number of calling males and the average number of coveys in the fall in a series of local areas. He found, however, (using eight-minute listening periods) that fall populations could only be predicted if a series of areas totaling at least 12,000 acres were used.

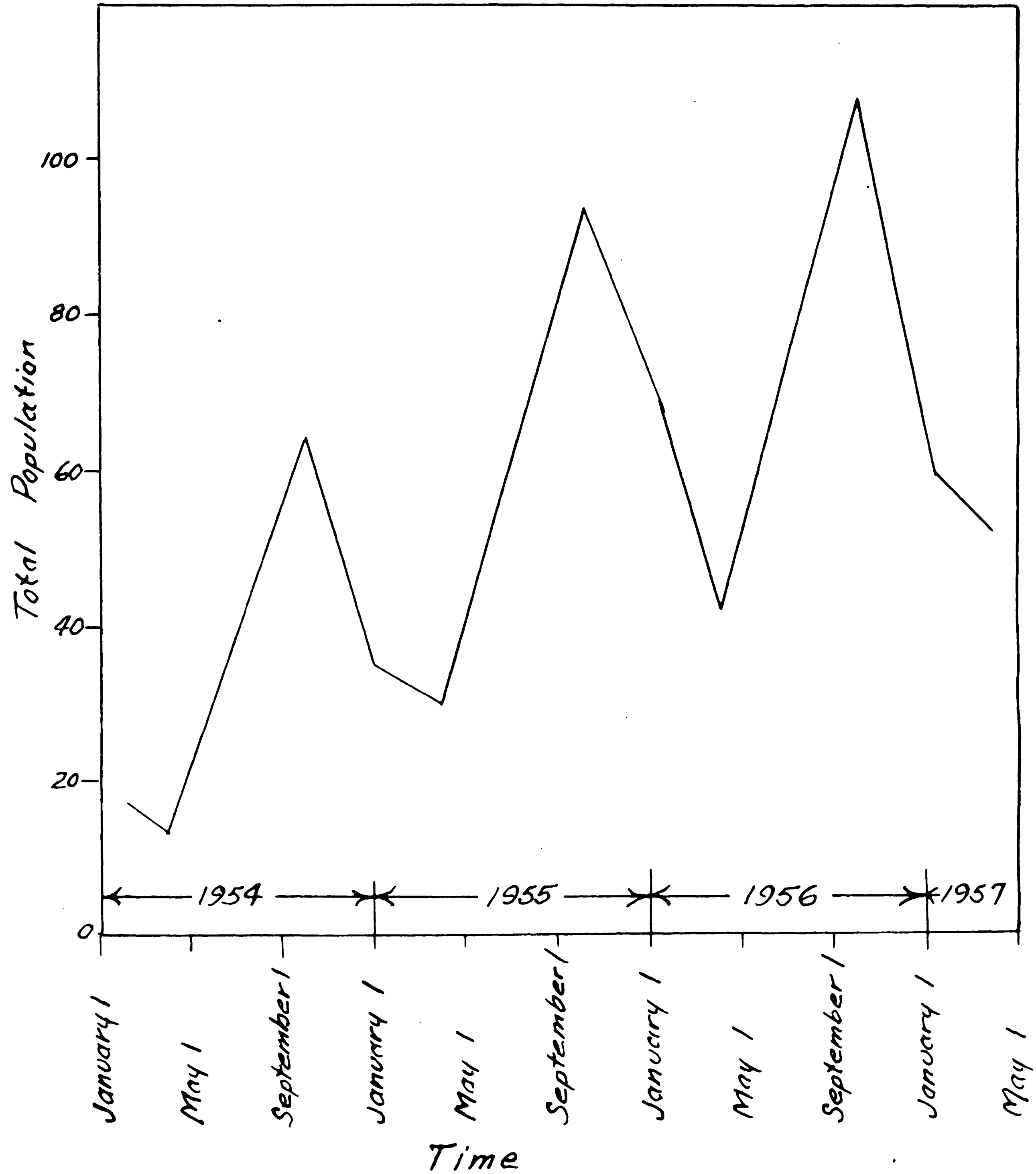
Great Island

In contrast to the data concerning a local contiguous population in the Barnstable Study Area, the Great Island population was insular and hence offered interesting information to an understanding of population dynamics.

Seasonal population densities: Following the release of the two wild-trapped coveys (total of 17 birds) during the winter of 1954, the insular population was censused at regular intervals. In the writer's opinion, this was a well-controlled field study. Only one bird was known to have left the Island, and no instance of influx was observed.

Figure 20 shows the seasonal population densities for Great Island from February, 1954, to April, 1957. During the summer of 1954, 1955, and 1956 the annual increase decreased smoothly and progressively: 492, 313,

Figure 20. Progressive, seasonal population density, Great Island (383 Acres), Cape Cod, Massachusetts, February, 1954 - April 1957.



and 257 per cent, respectively. At the same time, the percentage of over-wintering mortality was virtually constant: 53, 55, and 52 per cent for 1954-55, 1955-56, and 1956-57. Total spring populations followed a curvilinear increase (13, 30, 42, and 52 birds) for the four years. Likewise, fall populations showed the same trend 64, 94, and 108 for 1954, 1955, and 1956, respectively.

One thing that is interesting is the relatively constant percentage of over-wintering loss of about 53 per cent. The declining population of the Barnstable Area averaged only slightly more (57 per cent) over-wintering loss. It seems that under normal conditions, even in a rapidly expanding population, the over-wintering loss is (on-the-average) relatively constant. It may also be seen that the size of fall populations is probably dependent on two factors: (1) the size of the spring breeding population, and (2) the rate of summer gain.

Sex and age composition: Table 13 gives the sex and age composition of the Great Island population during the period of study based on late fall and winter trapping results. During 1955-56 and 1956-57 most, if not all, of the birds that wintered-through in the area were banded. Such was not the case in 1954-55; at least four birds in the over-wintering population were not banded. Since all of the unbanded birds that were trapped later were found to have been juveniles during the 1954-55 trapping period, the percentage of young in Table 13 (for that period) was undoubtedly low. The writer suspects that had the entire population been captured in 1954-55, the percentage of juveniles would have been about 88 per cent. If this were true, it appears that the per cent of juveniles

Table 13. Sex and age composition of quail on Great Island based upon trapping data collected during the winters of 1954-55, 1955-56, and 1956-57, Cape Cod, Massachusetts

Segment	1954-55	1955-56	1956-57	Total
Adult	150:100 n 5	233:100 n 10	117:100 n 13	155:100 n 28
Juvenile	62:100 n 21	109:100 n 46	108:100 n 52	98:100 n 119
Total	73:100 n 26	124:100 n 56	110:100 n 65	107:100 n 147
Per cent juveniles	81	82	80	81

probably dropped rather sharply for the three-year period.

A discussion of sex ratios will be omitted since no relationships of the types discussed for the Barnstable Study Area are pertinent.

Since a progressive decrease in the percentage of juveniles may have occurred during the three years of study, and since populations showed a curvilinear increase with a curvilinear decline in summer gain, it may be indicated that: either (1) progressively fewer young were hatched and reared per breeding pair, (2) fewer birds mated and nested, or (3) juvenile survival declined.

Errington (1945) demonstrates very clearly that fall populations have a density-dependent relationship to spring populations. He implies that this may result from associated change in the reproductive rate of the species. Bennitt (1951) confirms Errington's work but does not refer to the cause. Both workers term this condition as "inversity"; wherein a high breeding population produces a correspondingly lower summer gain.

Lack (1954:115-117) thinks, however, that the inverse density-dependent relationships are due to changes in post-nesting survival of juveniles. On the basis of the Great Island data, and the observed increase in the percentage of juveniles in the Barnstable Area immediately after intensive management, the writer thinks that Lack's theory of juvenile survival explains the Great Island phenomena. The possibilities of reduction in mating, nesting, clutch size or fertility are not evident to the writer in these data.

Management Evaluations

Stocking

Short-term survival: Figure 21 shows the rate of survival for 261 tagged birds that were liberated approximately one month before the season opened. Thirty days following the liberation of the test quail an average of 33 per cent had survived (all series). Mortality was accelerated at the onset, but leveled-off substantially within 10 days. Loss during the first five days was found to be 38 per cent.

From Figure 22, which represents the percentage of total return from three stocking periods, it may be seen that the relationship between the return and the time of stocking is similar to (if not a function of) the rate of survival described in Figure 21. Birds stocked three days before the opening of the season yielded approximately 600 per cent higher return than those stocked 28 days before the season opened.

Figure 23 shows the percentage distribution of the open-season harvest of pen-reared quail that were stocked immediately before the season opened. Of the total returns from birds stocked in this period, it can be seen that the contribution of the pen-reared birds dropped sharply during the first 15 days of the 30-day season, and that 65 per cent of the pen-reared birds was taken during the first five days of the season.

Figure 24 depicts the relationship that exists between the rate of mortality and time of stocking as the latter influences the open-season take of pen-reared birds. The closeness with which these curves follow one another suggests that the rate of harvest of pen-reared birds (as

Figure 21. Mean, regressive rate of survival of 261 tagged, pen-reared quail. Releases made in southeastern Massachusetts, three series, 1952, 1953 and 1954.

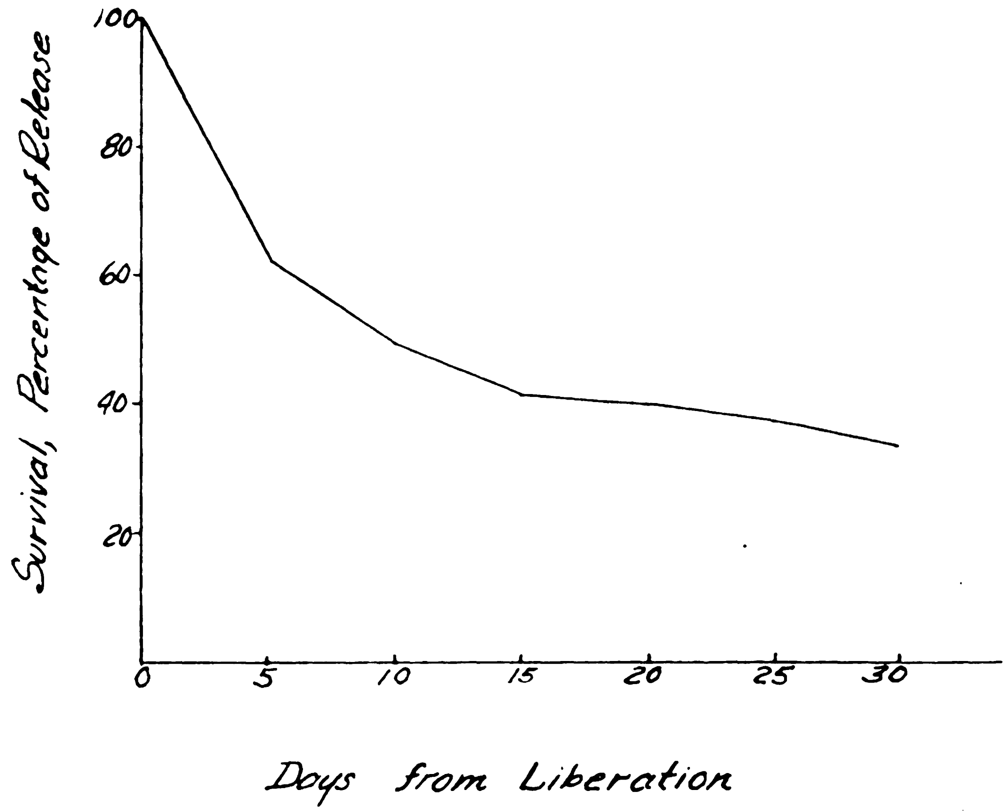


Figure 22. Contribution of three stocking periods to the total in-season take of pen-reared quail, southeastern Massachusetts, 1954 and 1955.

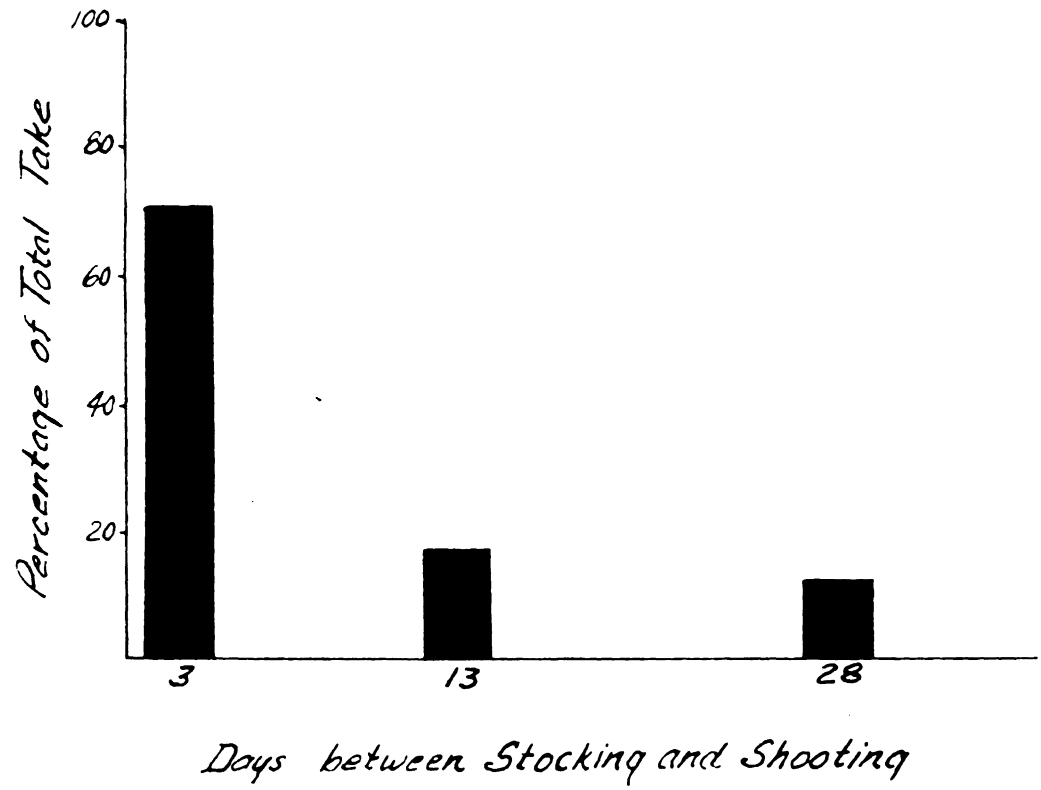


Figure 23. The in-season distribution of the harvest of pen-reared quail stocked two days before shooting, southeastern Massachusetts, 1954 and 1955.

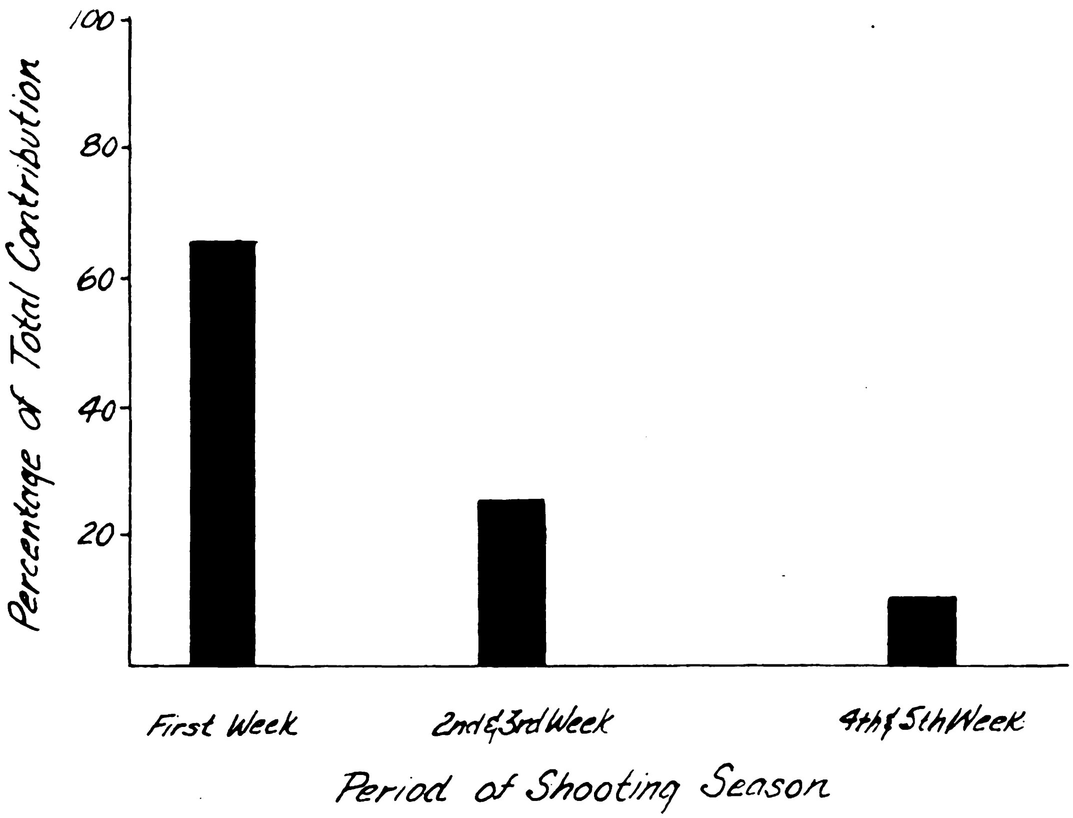
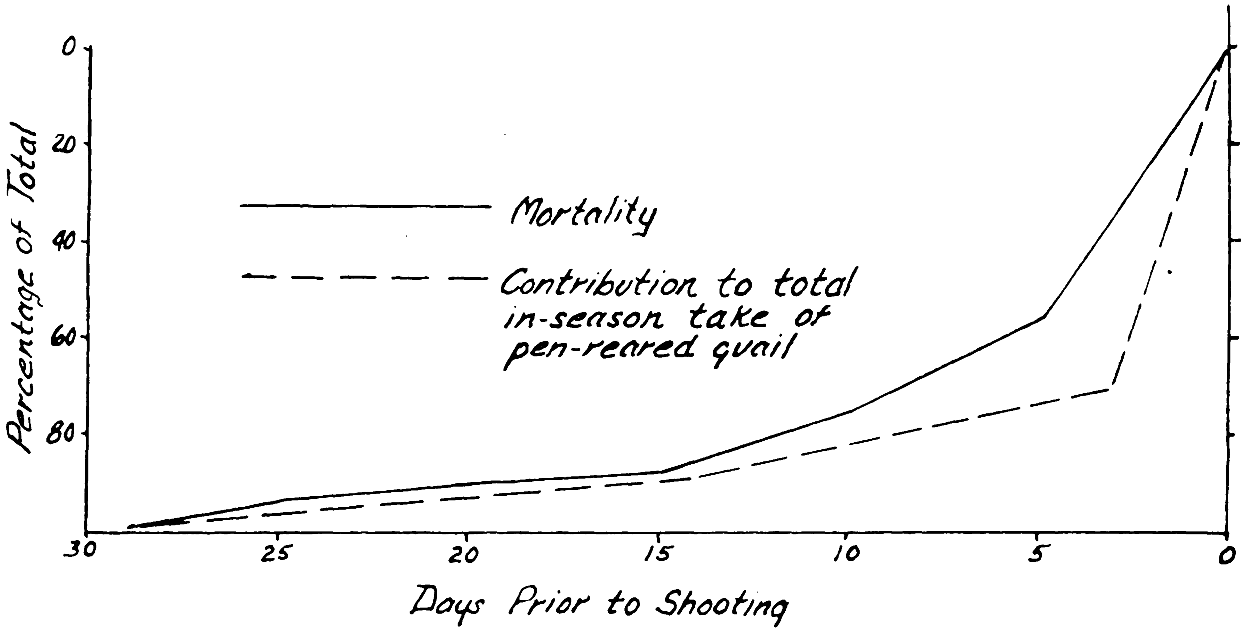


Figure 24. Mortality and the contribution of pre season stockings to the total in-season take of pen-reared quail by interval between stocking and shooting.



influenced by the time of stocking) is a function of survival. The author believes this to be the case.

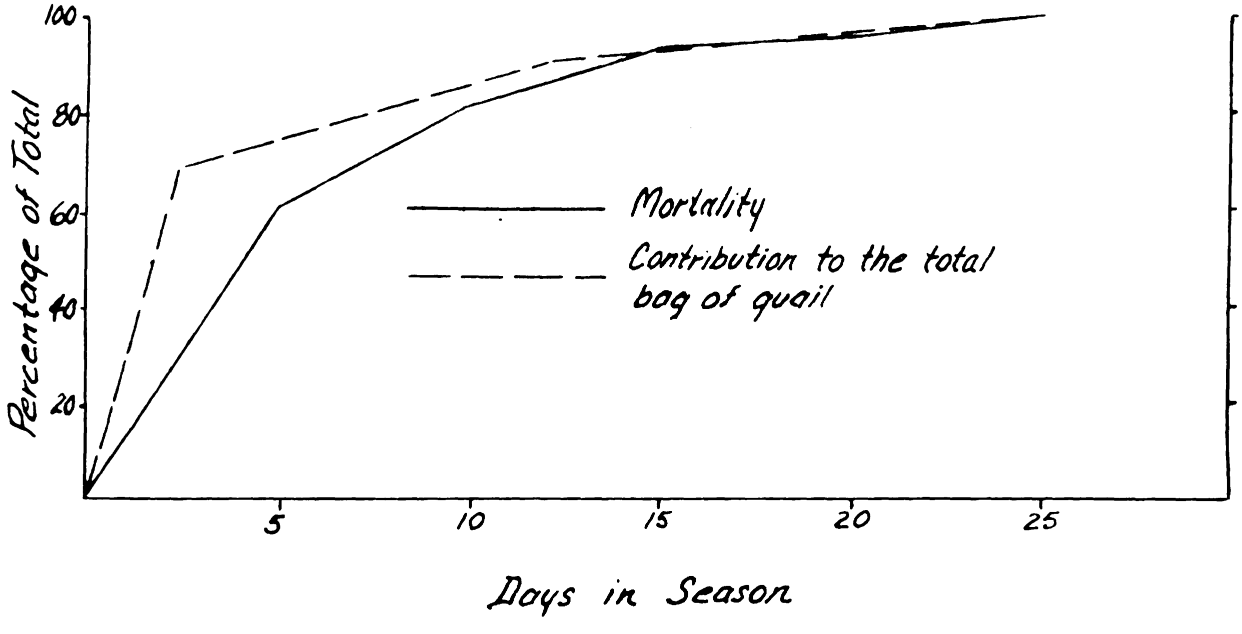
Likewise, Figure 25 shows the influence of mortality on the contribution of pen-reared birds in the hunter's bag. Progressive mortality, again, apparently controls the contribution of stocked birds throughout the open season. The curve of contribution (Figure 25) is somewhat higher than that for mortality during the first few days of the season. This may be explained by the fact that the mortality curve was developed from data collected on the tagged series that were not subjected to the additional hazards of gunning pressure. If survival had been determined from birds that were hunted, initial mortality would, undoubtedly, have been accelerated.

There is little question that normal stocks of pen-reared quail suffer substantial and immediate losses after release. All facets of these data indicate that survival, and hence availability of pen-reared birds is reduced to approximately one-third of the original stocking in a period of one month from the time of release.

Pierce (1951) found essentially the same rate of mortality in his studies in Kentucky. In 1946 he observed a 72 per cent mortality within two months, and 1947 a 71 per cent mortality within 28 to 50 days after liberation. Latham and Studholm (1952) conducted studies in Pennsylvania which suggested a similar rate of mortality in fall-stocked birds.

Peripheral stockings: In addition to fall-stocked juveniles, about 10 per cent of the production of the Massachusetts quail farms is held-over and released in the spring. In order to appraise the contribution of

Figure 25. Mortality and the contribution of pen-reared quail to the total bag (native and stocked) during the open season.



both types of stockings in terms of carry-over and repopulation, liberations were made in the peripheral range in Norfolk County and evaluated using the whistle-count census.

Table 14 shows the call-indices obtained for four years in the stocked and control areas. Obviously, the release of these quail had, at best, only a temporary and extremely minor influence, and the attempt to bolster peripheral quail populations was a failure.

Carry-over: During the course of the banding studies only one band in about 300 returns was from a fall-stocked juvenile that survived through one winter. Based on a normal 80 per cent turnover in native populations one might expect (assuming comparable releases between years) that approximately 20 per cent of the quail bands that were returned (60 returns) would be from "carry-over stock". Obviously, survival and carry-over in pen-reared birds are not comparable to native-reared quail.

Hunting returns: Analysis of the reported bag of hunters for three years (1954, 1955, and 1956) showed that, with an average annual stocking of about 5,000 birds, only 9.6 per cent of the total kill came from pen-reared stocks. In view of the limited hunting pressure on native populations, and the relatively small contribution of pen-reared birds in maintaining or increasing native populations, the writer can only surmise that the stocking of quail has no place in the usual management program.

The only possible justification for stocking would be strictly on a "put and take" basis in extremely heavily hunted areas, such as public shooting grounds. Under such circumstances, the birds should be liberated as close to the opening of the season as possible, and in quantities no

Table 14. Whistle-count census indices for three experimental stocking areas in Norfolk County, Massachusetts, during 1954, 1955, 1956, and 1957

Year	Call index		
	Area A Fall stocked	Area B Spring stocked	Area C Control
1954	.00	.30	.00
1955	.25	.00	.08
1956	.00	.00	.00
1957	.00	.00	.00
4-year average	.06	.08	.02

greater than can be immediately and fully harvested by sportsmen. Such measures should be employed only if it is demonstrated that native populations are incapable of producing enough birds to supply pressing recreational demands. The criterion of judgment should (in the writer's opinion) be based on recreational benefit and not on total kill, although the two may, unfortunately, be inseparable.

Buechner (1950) published an account summarizing virtually all of the stocking evaluation work done up to 1949. His findings are directly parallel to those discussed here. Likewise, these findings substantiate the data published by Steen (1950) and Pierce (1951).

The only contradictory note in stocking evaluation studies was published by Frye (1942). He found, by releasing pen-reared birds with native quail that he trapped, that survival for the two groups (native and pen-reared) was essentially equal. There is little question that Frye's study was well-controlled and that his observations are accurate. The writer can only conclude that these data stand as an interesting exception to other findings. His techniques, however desirable in terms of survival, would be impractical as a management tool. In this latter respect, he presumably agrees (based on discussions following the presentation of his (1942) paper).

Habitat Manipulation

Except for some of the more intensively farmed areas in Bristol County, the writer believes that a lack of cover is not a limiting factor in the range occupied by quail in Massachusetts. In the writer's opinion the most important single factor limiting quail populations probably is food, particularly as it may be associated with open areas. Therefore, habitat manipulation will be treated largely in this respect.

Perennials: No detailed evaluation of plantings of perennial shrub lespedezas (*Lespedeza* spp.) was conducted. However, a reconnaissance of 15 bush lespedeza plantings was made and the results of this appraisal are given:

1. Survival of planted seedlings appeared to be high in all species and varieties examined. Growth and form, in general, were good and most plants were thrifty.
2. Plantings made in exposed situations retained only a small quantity of seed, and apparently provided little available food during periods of deep snow. Plots in sheltered locations were only moderately better in seed retention.
3. Only two of the food patches examined by the writer were apparently being used by game birds (one by pheasants, the other presumably by a grouse). None appeared to be used by quail.

Since it appeared that seed crops were small and that the limited seed produced would normally be unavailable during severe periods, the value of shrub lespedezas in a quail management program in Massachusetts is questionable.

Davison (1948 and 1949) has advocated the use of shrub lespedezas in farm game habitat restoration activities, largely in the southeastern states. Mainly through the efforts of the Soil Conservation Service, shrub lespedeza plantings came into widespread usage. Rosene (1956), in his appraisal of bicolor plantings in quail management, found that L. bicolor was not important to quail where native foods were plentiful. He did, however, suggest that it might be valuable in areas of native food scarcity. Marshall (1953) suggested that wildlife plantings were badly in need of critical appraisal, insofar as they might contribute to habitat restoration programs. Finally, Gehrken (1956) found "...no noticeable effect on quail populations..." following recommended practices using bicolor lespedeza. The trend with the shrub lespedezas has been one of enthusiasm and optimism, followed by concern that the shrubs might not be a panacea, and lastly by serious questioning of the value of the plantings for quail populations.

Since about 1953 few perennial bush-clovers have been planted in southeastern Massachusetts. Although habitat restoration has been intensified, the use of annuals has gradually supplanted the use of perennials in this work.

In addition to exotic perennials, certain native and naturalized taxa may have value in a habitat restoration program. Cook and Edminster (1944) suggested that bayberry (Myrica pensylvanica) could be easily cultured. The writer's observations on covey feeding habits, plus the fall food habits analyses already reported, indicate that this plant might be useful. Ripley and Cookingham (1958) suggested that black locust (Robinia pseudoacacia), particularly if it were used with tartarian honeysuckle (Lonicera tatarica), may be valuable in a management program.

Annuals: In earlier sections it was shown that over-wintering quail populations in the 1790-acre Barnstable Study Area increased about 30 per cent within six months after the establishment of 33 annual plantings of various grains. Data on the sustained effect of these plantings may be reported later.

Cost and production data for 20 annual grain plantings made by the Falmouth Sportsmen's Club (Cape Cod) were available to the writer. Several direct counts of quail using bird dogs were taken in these food patches during the late winter of 1956. These counts indicated (on-the-average) that each food patch was used consistently by a covey of eight birds. These plantings were located in areas that were reverting to habitat that probably could not support quail, and it may be presumed that the birds were the result of habitat manipulation. Since the average annual cost of establishing and maintaining the plantings (prorated for 10 years) was about $20.00, it may be reasoned that this type of habitat restoration produced additional quail at $2.50 per bird.

Other workers have substantially increased quail with annual plantings in habitat similar to much of southeastern Massachusetts. Bump (1936) reported costs for a large increase in a Long Island, New York, quail population by establishing annual food patches in land reverting to pitch pine and scrub oak. He estimated that the cost per additional bird produced was $1.27. Wilson and Vaughn (1944) found approximately a 300 per cent increase in quail populations on intensively managed areas in coastal Maryland. They reported costs that ranged from 9 to 63 cents for each additional bird, depending on the type of area used.

The writer's observations and the findings of other workers (i.e., Wilson and Vaughn, 1944) indicate that annual plantings are most effective when located in areas that are reverting to cover that is incapable of supporting wintering coveys. Furthermore, except where quail may have aesthetic value, it would seem uneconomical to engage in intensive management in any area that is supporting a high native population. This is particularly true since the hunting harvest removes only 10 to 15 per cent of the fall population. Peripheral, low-density areas probably should receive first attention, especially if they are heavily hunted. In addition, food plantings might serve a useful purpose by luring birds into open situations where a more effective harvest could be exacted. Since edge is apparently very important, narrow food patches located near forest-open land edges probably would be more effective.

Feeding Stations

Concurrently with the liberation of wild-trapped quail on Great Island, commercial bucket-type feeders were established and maintained. The ten-quart feeders were filled once a week with fine "scratch" for about 30 weeks each year. Total labor per winter per feeder averaged about five hours. Total grain consumption per feeder per winter was approximately 200 pounds. On the average, each feeder supported five quail during the winter at a cost not exceeding $4.00 per bird (including the cost of equipment). From Lack (1954:131) it may be estimated that each bird probably did not use more than 10 to 15 pounds of "scratch" during the feeding period, even if no other food were used. Other animals, of course, took substantial quantities of feed, but care was taken to assure a constant supply of grain in the feeders.

Frye (1954), using automatic feeders in Florida, found that quail could be increased up to 180 per cent at the end of two years. He calculated that the cost averaged $1.91 per bird increased. Lay (1954) suggested that feeders might be dangerous because of the increased incident of predation. Frye (1954), however, did not believe that the hazards of predation were increased.

Insofar as southeastern Massachusetts is concerned, the writer thinks that the Great Island populations presented ideal conditions for artificial feeding due to the limited supply of native foods. It is doubtful if bucket feeders employed elsewhere in the quail range of Massachusetts could duplicate the apparent success of this insular area. As a result, cost might rise accordingly. In certain situations where habitat manipulation could not be carried out or where temporary measures were desirable, the use of bucket feeders might be valuable.

A number of interested people, many of whom are quail hunters, supply food and feed quail during periods of severe weather. Properly handled, this undoubtedly has merit. To be fully effective, its proper use demands a knowledge of the feeding habits and territories of individual coveys. Quite probably feeding should be continued if the birds become dependent on the emergency rations. Actually, emergency feeding is a "stop-gap" measure, and although it is highly commendable in purpose, it probably has no place in the Game Division's management program. Unlike the use of food patches and bucket feeders, this method would be incapable of increasing the carrying capacity of any environment.

Legislative Measures

No evidence was secured in this investigation to indicate that harvest had any deliterious effect on native quail populations. Several references have been cited in earlier sections to strengthen this thesis. Undoubtedly, the harvest of 10 to 15 per cent could be doubled and still remain considerably below the present loss from normal, over-wintering mortality.

Liberalization of bag limits should be encouraged, although the writer doubts that such measures would have any important effect in increased kill. An increase in the length of the season probably would not be directly proportional to the kill, but would show a pattern of diminishing harvest return. This might be overcome by closing and then reopening the season in order to effect a resurge of pressure. On the other hand, with the season closed on other species, an extended quail season might shift greater pressure on the species. Certainly, if maximum safe utilization of the resource is desirable, both the season and the bag limits should be increased.

Summer whistle-count census data collected immediately before the open season might be used to govern the degree of extension, from year to year. Legislative process is slow, at best, and no attempt to manipulate the length of the season appears advisable unless it could be handled directly by the Game Division. Knowledge of the harvest, including the magnitude and daily distribution during an extended season, could be obtained from a bag sample of the type used in this study. This procedure would be advisable in order to determine the relative effect of manipulation.

Refuges

Occasionally, the suggestion is made that a refuge system should be employed. Even if all of the present quail habitat were open to shooting, refuges would probably do little, if anything, to increase quail populations. Many good quail areas are closed to hunting for various reasons, and the writer thinks that these probably support no more quail than those that are hunted. This condition has been clearly established elsewhere (i.e., Errington and Hamerstrom, 1935; and Mosby and Overton, 1950).

Predator Control

There are few aspects of quail management that have received more attention, often heated dispute, than the control of predators. Too frequently, misunderstanding of predator-prey relationships has prompted the conclusion that practically any hungry carnivorous bird or mammal is an arch enemy of quail. The distinction between threat and actual destruction is often completely overlooked.

At no time during the course of these investigations did the writer observe what he considered excessive predation (removal of more birds than could be carried in a given environment). Errington (1933) and Errington and Stoddard (1938) reported that predation is largely restricted to fall surpluses in the quail population. Further, Errington and Stoddard suggest that because of the greater number of "buffer" species in the northern part of the quail range, shifts to predation of quail are less likely to occur even during periodsof heavy predator densities.

No evidence was found in this study to suggest that predators were limiting quail populations in Massachusetts. It is very doubtful if a predator control program would have any beneficial effect on quail. Probably such measures would cause the needless destruction of essentially harmless raptors, and waste both time and energy that could be well-spent for positive management.

SUMMARY AND CONCLUSIONS

A comparison of the weights of Massachusetts quail with those from other areas indicates that the New England form was, and probably still is, the heaviest. There may be further justification, on this basis, for a definite taxonomic separation as proposed by Aldrich (1946).

An examination of the factors that may have caused the marked reduction of the quail range in Massachusetts suggested that a decrease in agricultural acreage and the widespread practice of clean farming were probably the most important. It was indicated that adverse weather was the agent of actual destruction during particularly severe winters. It is doubtful that hunting, racial hybridization, or a change in climate were important factors. Likewise, artificial restocking and legislative restriction apparently did little, if anything, to check the decline or to increase the species.

Present quail populations are associated with areas characterized by milder winters. Higher densities are associated with actively farmed or recently abandoned areas. The amount of edge between "interspersed" farm land and other open-land types demonstrated a direct, measurable relationship to population densities on Cape Cod. These relationships clearly supported the thesis that declines were largely the result of reduction and deterioration of agricultural-type habitat.

A study of the fall food habits, likewise, confirmed the relationship found between agricultural lands and the distribution of the species. This was less pronounced, however, in the pitch pine-mixed oak disclimax, and native shrubs and trees (i.e. bayberry and black locust) appeared to be important food sources in this area. The use of these plants in habitat restoration programs, in conjunction with annual plantings, appears to be worthy of further testing.

A sample of the hunter harvest of quail permitted the collection of open-season sex, age, and hatching data. Sex ratios showed a normal, significant disparity (favoring males) between the adult and juvenile segments. Annual sex ratio variations and differences between findings of other workers were not statistically significant, and were thought to be normal manifestations of sampling error. It was concluded that the interpretation of sex ratio samples demands extreme caution. Age composition also was normal for the species. During 1954 a drop in the percentage of juveniles may have reflected an increase in populations for that year. Although the shift in the adult-juvenile ratio was not significant, the whistle-count census also indicated an increase in the breeding population. The distribution of 772 hatching dates showed a high, early peak of frequencies, and probably indicated excellent nesting conditions. Further, these data indicated that no more than 20 per cent of the total fall population was less than 12 weeks old by the time the shooting season opened. This percentage of juveniles would hardly justify delaying the open season.

Kill data from open-season returns and local area observations indicated a light harvest that was fairly evenly distributed after the first week of shooting. The total take of available fall populations was estimated to be between 10 and 15 per cent. On the basis of normal population turn-over (80 per cent), the open-season kill probably has little effect on native populations.

Weights taken from 624 quail trapped during the winter of 1956 showed no differences between sexes. Adults, however, were found to be heavier, but the difference between age segments decreased as winter progressed. These data showed that both adults and juveniles attain their maximum weight in early January prior to the period of greatest food shortage. The decrease in weight from January to April was apparently due to food shortage or unavailability. Weight loss was closely associated with accumulated snowfall, but probably was not related to temperature change.

Whistle-count census data did not indicate any significant change in populations between 1953 and 1956. Populations on Martha's Vineyard apparently declined because of habitat deterioration during the period of study.

A close, although inconclusive, relationship was indicated (two-year series) between sportsman opinion of change in quail abundance and the whistle-count census results. It was concluded that the whistle-count census is a useful inventory procedure for securing information on quail population density and distribution from large areas. This technique was not capable of accurately measuring population density and change in small areas (2,000 acres).

The influence of direct census counts, baiting, trapping, and banding in local areas did not appear to affect the normal characteristics of populations under observation. Comparison between new and repeat captures suggested that baiting did not influence the weight or survival of trapped quail. Trapping mortalities suffered in connection with intensive activities probably did not have an appreciable effect on the local populations.

A study of individual covey activities in a 1790-acre local area suggested that the diversification of cover, the variety of fall foods, and the availability of winter foods were factors that governed variation in survival and occupancy of wintering territories. Intensive habitat manipulation using annual grain plantings in this local area produced an initial expansion of 30 per cent in six months. A significant increase in the percentage of juveniles, and a reduction in spring egress and linear movement were simultaneously observed immediately after management.

Comparisons of spring and fall movements in the same 1790-acre area indicated that the "fall-shuffle" involved much less movement, in general, than that found in the spring.

Analyses of total calling males, call indices, and summer captures of males indicated that a larger proportion, if not nearly all, of the males in the area called. The calling of mated birds was probably less frequent and of lesser importance, however, than the un-mated males in timed whistle-counts used for general census.

The establishment and subsequent expansion of an insular population showed spring-to-fall gains of 492, 313, and 257 per cent annually, for the first three years. Over-wintering mortality, however, was essentially constant: 53, 55, and 52 per cent. The decline in summer gains that followed total population increase was probably due to reduced juvenile survival.

Data collected from short-term survival studies of pen-reared birds showed a survival of about one-third within a month. Studies of the effect of concentrated spring and fall stockings on populations in peripheral areas indicated very poor survival and virtually no carry-over. Banding data analyses substantiated both of these findings. Except for strictly "put and take" release in areas of extremely heavy gunning pressure, the stocking of pen-reared quail appears to be unwise.

Evaluations of habitat manipulation practices indicated that perennial lespedezas were of limited or questionable value. Cover plantings (as such) were probably not necessary. Plantings of annual grains, however, produced positive responses in quail populations at a cost of about $2.50 per bird. Annual plantings of grain for habitat restoration work appeared to produce better results than other methods.

The use of bucket feeders probably was very important in the maintenance and expansion of the local, insular population on Great Island. Although more costly than food patches (about $4.00 per bird), the method might have limited application, and produce measurable population increases under special circumstances.

The feeding of grains during emergency periods, while commendable in purpose, is not suitable for large areas of application, since emergency feeding of quail is a "stop-gap" measure, and probably could not appreciably influence the carrying capacity of the environment.

Based on all available evidence regarding the influence of hunting pressure and kill on native populations, a liberalization of hunting restrictions is indicated if full recreational utilization of this resource is to be realized.

General observations by the writer and results obtained by other workers clearly indicate the impropriety of establishing refuges, or engaging in predator control programs. Neither, it is concluded, would be of any important or lasting benefit to quail in Massachusetts.

MANAGEMENT RECOMMENDATIONS

1. The whistle-count census should be made each year as a means of determining annual variation in the density and distribution of quail populations in Massachusetts.

2. Present regulations governing the harvest of quail should be liberalized by: (1) increasing the length of the open season (possibly by a split-season), (2) increasing the daily bag limit, and (3) by removing the seasonal bag limit.

3. If regulations are liberalized, bag samples of the harvest should be taken as a means of determining the effectiveness of manipulatory measures.

4. Habitat restoration should be stressed as a useful management technique in areas where an agricultural type is reverting to a less productive habitat, particularly in areas of heavy gunning pressure.

5. The use of annual grain plantings (usually fall-sown rye) should be employed as the basic habitat restoration practice. All such food patches should be planned and located to provide as much edge as possible.

6. The use of certain native and naturalized trees and shrubs should be considered and tested as an adjunct to current habitat restoration practices.

7. Until or unless critical evaluation indicates to the contrary, the planting of shrub lespedezas should be discouraged.

8. The use of automatic feeders should be considered as a management technique in areas that cannot, for various reasons, be successfully manipulated by habitat restoration.

9. The use of plantings to provide cover should be discouraged, except in local areas that are clearly deficient in this requirement.

10. Except in public shooting areas that are subjected to extremely heavy hunting pressure, the stocking of pen-reared quail should be discontinued.

11. No program of refuge establishment or maintenance should be initiated or sanctioned for quail by the public game agency.

12. The control of predators should not be undertaken except in intensively managed public shooting areas.

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APPENDIX

Appendix Table A. Cover mapping classification*

Forest Land

Species classes

S - softwoods constitute at least 80% of the stand.
H - hardwoods constitute at least 80% of the stand.
HS - a mixture of hardwoods and softwoods with the former predominating.
SH - a mixture of softwoods and hardwoods with the former predominating.

Height classes

1. 1 - 20
2. 21 - 40
3. 41 - 60
4. 61 - 80
5. 81 - 100
6. Uneven heights (three or more height classes represented)

Density classes

A. good stocking (81-100% crown closure)
B. fair stocking (51-80% crown closure)
C. poor stocking (30-50% crown closure)

This code method of vegetational separation or typing lists species, heights, then density in that order as in the following examples:

H2A = a hardwood stand 21 to 40 feet in height with good stocking.

HS5A = a mixture of hardwoods and softwoods with hardwoods predominating. This stand is 81 to 100 feet tall with good stocking.

S3B = a softwood stand 41 to 60 feet in height with fair stocking.

$\frac{H3C}{H1B}$ = a hardwood stand 41 to 60 feet in height with poor stocking in the overstory and hardwood 1 to 20 feet in height with fair stocking in the understory. Such types usually occur after logging or blowdown.

* From Ripley and Garvin (1955)

A two-storied classification is also used on abandoned fields in later stages of succession; i.e., abandonment 15 or more years ago. These areas can be recognized as having definite past abandoned field affinities and the woody vegetation has reached the point where crown closure is 30 to 80 per cent. The forest land symbols are placed in the numerator while the abandoned field symbol (AF) is represented in the denominator.

For example: $\frac{S1B}{AF}$ = softwoods, less than 20 feet tall with a crown closure of 51 to 80 per cent in an abandoned field or pasture.

<u>Open land</u>

The open land classification contains the following eight types:

1. AL is agricultural land intensively farmed. This type consists of nearly all open, continuous fields with no stonewalls, hedgerows, small patches of abandoned land, small forested areas (1-2 acres), or wet land.

2. Al-I is agricultural land interspersed with stonewalls, hedgerows, small forested areas or patches of abandoned land.

3. AL-M is agricultural land with a small, fresh-water meadow present. If the meadow were ten acres or larger, it would be placed in the wet land classification to be described. The darker green of the reeds gives a lower spectral reflectance than the surrounding grasses and sedges, distinctively revealing the field drainage pattern.

4. AF are former fields or pastures reverting to forest land where the woody vegetation has a crown closure of less than 30 per cent.

5. O indicates a productive fruit orchard of any kind for no distinction can be made between the various fruit tree species.

6. AO designates abandoned orchard. There is a sharp contrast on the photo between the orchard in use and the abandoned orchard.

7. CB designates the cranberry bog which is restricted to the southeast portion of the State.

8. U indicates an urban area.

Wet land

The wet land classification follows closely the types defined by the Office of River Basins of the Fish and Wildlife Service (Martin, et al., 1953. Classification of wet lands of the United States. U. S. Fish and Wildlife Service, Special Scientific Report: Wildlife No. 20).

The limiting factor that prevents full utility of that system stems from the fact that vegetation was their main criterion for type separation. The photographs used in the Massachusetts study reveal only limited tonal contrast between the various aquatic plant species. Since it was impossible to recognize on the aerial photographs all the various species used in the Fish and Wildlife Service Wet Land Classification, it was, therefore, necessary to depend on gross physical features that could be recognized in the third dimension, and correlate these characteristics with those used by the Fish and Wildlife Service. The final result was a modification of the wet land classifications as described below.

Inland Fresh Areas

1. FM designates the fresh meadow. The principal means of identifying this type is through the decreased spectral reflectance of a reed (Juncus spp.) which produces a tonal contrast between the reed and the surrounding grasses and sedges. Juncus species commonly grow in the wetter parts of meadows. The type is often found in pastured agricultural land.

2. SFM designates the shallow fresh marsh. In the third dimension, there is little evidence of open water or woody vegetation. Numerous field checks revealed the predominant vegetation to be cattails, and the soil either completely waterlogged or covered with water up to several inches in depth.

3. DFM designates the deep fresh marsh. On the photo, it is characterized by various amounts of open water with interspersion of splotchy patches of vegetation. The water may range from 6 inches to 3 feet deep with the vegetation being a scattered floating type.

4. SS signifies the shrub swamp. There are two characteristics which serve to distinguish the type: (1) location, and (2) vegetation height.

5. The vegetation in wooded swamps is designated by forest type symbols. After the forest land has been classified, U.S.G.S. sheets are used to determine the extent of the swamp.

Coastal Saline Areas

A cursory survey of the five types described in the Fish and Wildlife Service wet land classification would show them as follows: (1) Salt Flats, (2) Salt Meadows, (3) Irregularly Flooded Salt Matshes, (4) Regularly Flooded Salt Marshes, and (5) Sounds and Bays. Irregularly flooded Salt Marshes (3) do not exist along the Massachusetts coast. It is impossible to consistently separate (1) Salt Flats, (2) Salt Meadows, (4) Regularly Flooded Salt Marshes for the following reasons: The photos were taken during portions of three seasons, under various light conditions and while the tides were at varying levels. For these reasons, it was necessary to combine Salt Flats, Salt Meadows, and Regularly Flooded Salt Marshes into one type designated by the letters SM. Sounds and bays were not classified.

Appendix Table B. Data used in the calculation of seasonal and annual estimated egress for the Barnstable Study Area, 1955 to 1957.

Period	n_1	S	N	P_2	n_{2o}	Sex Segment
March 1955 to August 1955	18	90	19	47	3	male
August 1955 to March 1956	19	30	97	98	4	male
March 1955 to March 1956	35	20	97	98	3	both sexes
March 1956 to August 1956	53	90	13	47	8	male
August 1956 to March 1957	12	30	113	130	2	male
March 1956 to March 1957	97	20	113	130	8	both sexes
March 1957 to August 1957	65	90	11	55	5	male

n_1 = number of animals marked in pre-census period

S = estimated per cent survival between pre-census and census periods

N = total number of animals captured during census period

P_2 = estimated total population or segment during census period

n_{2o} = observed number of marked animals recaptured during census period

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ABSTRACT

of

ECOLOGY, POPULATION DYNAMICS AND MANAGEMENT OF THE BOBWHITE QUAIL,

Colinus virginianus marilandicus (L.), IN MASSACHUSETTS

Thomas Huntington Ripley, B.S., M.S.

Thesis submitted to the Graduate Faculty of the

Virginia Polytechnic Institute

in candidacy for the degree of

DOCTOR OF PHILOSOPHY

in

BIOLOGY

This investigation was conducted to determine the ecology and dynamics of Massachusetts quail populations, and to interpret the findings in terms of practical management of the resource.

Weight data collected during the course of the study support the thesis that the northeastern coastal quail population may be separated, subspecifically.

Declines in quail populations in Massachusetts during the past century probably resulted from a deterioration in habitable range. Present populations are apparently limited to areas of farming activity. Coastal populations are probably less dependent on a strictly agricultural environment than inland populations. No statistically significant change in quail populations was observed between 1952 and 1956, based on whistle-count census data. A probable increase in 1954 was detected, however, in both the whistle-count census and in age composition data.

An analysis of 772 hatching dates for three years indicated that early and successful nesting occurred in Massachusetts quail populations.

Weight studies showed that all sex and age segments of the quail population were heaviest during early January, and lightest in April. No weight difference between sexes was observed. Adults were significantly heavier than juveniles throughout the winter, but weight differences between the age segments decreased as winter progressed.

Comparisons of spring and fall movement among individual quail indicated that spring movement was greater than in the fall.

A 30 per cent increase in six months was observed for the total population of a 1790-acre area that was intensively managed using annual grains. A significant increase occurred simultaneously in the percentage of juveniles in the same population.

Data collected from an expanding insular quail population indicated that summer gains were inversely related to spring population densities, and that a decrease in the percentage of juveniles might be attributed to post-nesting mortality. The insular population was maintained using "bucket-type" feeders at a cost of $4.00 per additional bird.

Plantings of perennial shrub lespedezas apparently were of limited value to quail. Likewise, predator control and refuge establishment were thought to be ineffective techniques. The use of narrow-strip annual grain plantings with maximum edge in areas reverting to non-productive habitat apparently provides the most economical ($2.50 per bird) and practical means of increasing quail populations.

Except in very special cases, the artificial propagation and release of quail was found to be unwise.

Studies of hunting pressure and total kill suggest that effort should be directed to liberalize hunting restrictions if greater utilization of the resource is to be realized.