This technique is still in the experimental stages but it has been demonstrated in the field. There are rumors of work along this line, but we know of only one published paper pertaining to this field aspect. It was reported in *Time,* 66(11) :65, 1955 (September 12 issue). R. H. Goetz "spiked" rifle bullets with curare and shot a giraffe in the hind quarters. It was paralyzed in 45 minutes. The original paper has not been obtained by us as yet.

The dart technique described in this paper requires workers skilled in both field methods and the application of general anesthesia. It may well have application to wildlife management and other biological endeavors.

It should be understood that the material presented in this paper is in no sense a final report of the research. This preliminary report is offered in the chronological order in which it has been necessary to approach the investigation. The authors are fully cognizant of the shortcomings of an informal presentation of this nature. Additional work is in progress and a more technical paper is being prepared.

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STATISTICAL GAME KILL SURVEYS—SOME OBSERVATIONS ON FIVE YEARS OF OPERATION

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I. PURPOSE OF REPORT

The purpose of this report is to set forth the observations of one state on five years of statistical game kill survey. It is not our purpose to expound the virtues of one system over another since it is felt that there has not yet been devised the perfect or fool-proof tchnique of collecting reliable kill data. It is our intent, rather, to discuss this type and the reliability of data here collected, and to set forth some observations in regard to desired improvements of the technique. It is hoped that this effort may be of some assistance to those who are in a position to further improve upon and refine this valuable tool of game management.

II. PURPOSE AND FUNCTION OF KILL SURVEYS

Game kill surveys of varying types have been conducted by state and other conservation agencies for many years. Although specific objectives and techniques for obtaining the desired information have varied, the primary purpose has been to obtain basic data upon which improved management practices can be based. These management practices generally fall into two major categories:

(1) The formulation of hunting regulations which provide for a wise and equitable annual harvest of surplus populations which, in turn, are coordinated

with the available supply of game and with the type and amount of interest and/or hunting demand.

(2) The formulation of restoration programs as are needed to perpetuate or increase the needed supply or harvestable surplus.

The functions of the game survey that supply these basic data are:

(1) The determination of the relative importance of individual game species as reflected by the amount of hunter-effort and the annual kill.

(2) The determination of hunter-success which is, to some degree, an index to availability and relative abundance.

(3) The correlation of annual trends in kills, hunter-success, and hunter-effort with annual variations in natural factors, such as weather and food supplies.

(4) In a similar manner, an evaluation and correlation of the effects of natural catastrophes, such as floods, fires, and hurricanes.

(5) Correlations between kills and annual changes in hunting seasons and bag limits.

III. SURVEY PROCEDURES

Each year for the past five years, a sample of approximately 4 per cent of the resident hunting license holders was selected systematically from the previous year's hunting license stubs. An initial sending of an all-species questionnaire was made to these persons at the close of the hunting season. Non-respondents were sent a second questionnaire. A subsample of approximately 10 per cent of the non-respondents to both the first and second mail sendings was taken, and as many of these people as possible were interviewed by field personnel. A 35 to 40 per cent return was received from the two mail sendings.

Useable returns were tabulated by the local IBM agency. The average seasonal kill and the average number of trips made, by species, were calculated for those persons responding and for those persons interviewed. These averages were then weighted according to the size of the respondent group and the size of the non-respondent group and projected to determine the total statewide kill and hunter-trips for the current hunting season. In this final tabulation the current season's total license-sales figure was used, after a proportionate reduction was made to account for persons who had died or moved away or did not hunt for other reasons.

Annual expenditures for the survey have ranged between $2,500.00 and $3,000.00. This includes materials, postage, clerical help, and IBM services, but not salaries and travel of field personnel conducting the interviews. This amounted to about 200 man days of labor which was integrated with other routine duties.

The number of resident hunting licenses sold annually in North Carolina is between 300,000 and 350,000; the size of the survey sample was approximately 14,000.

IV. RESULTS OF SURVEY AND OBSERVATIONS ON DATA

In the interest of brevity, the kill data for the five annual surveys have been tabulated and graphed and are presented in the appendix.

Upon examination of these data, certain observations and conclusions may be made:

1. *Hunting pressure.* The data reflect but slight variation in relative hunting pressure from one year to the next. For example, rabbits and squirrels consistently ranked at the top of the list in regard to total hunting effort. Quail ranked next. These three species accounted for an average of 68.0 per cent of the hunting effort during the four years surveyed. Raccoon and opossum hunting made up 13.4 per cent of the hunting effort; deer, 4.2 per cent; fox, 4.9 per cent; ducks and geese together, 3.4 per cent; doves, 2.8 per cent; and the remaining 2.0 per cent of total effort was apportioned to grouse, woodcock, turkey, and bear hunting.

From this it would appear that the ranking of species in regard to hunter favor may be accomplished with a single year's survey. Thus, it is relatively

simple to identify those species for which the greatest public interest is shown for purposes of formulating overall programs of restoration and management. In practice, such data must, of course, be tempered somewhat by the pressures exerted by various interest groups.

2. *Fluctuation of kill.* As might be expected, the data revealed fluctuations in kill for each species from year to year. These fluctuations varied from an average of 8 per cent for bear to an average of over 100 per cent for raccoon, woodcock, and turkey. In some cases, the kills remained relatively steady with wide fluctuations at erratic intervals; in other cases, rather wide fluctuations were the rule.

These fluctuations in kill from one year to the next should be the primary concern of the kill analysis since, theoretically at least, they reflect population levels which, again theoretically, should be considered in changes in regulations aimed at perpetuating or increasing problem populations. It is, therefore, very important that the nature and cause of these fluctuations be carefully analyzed. Two questions deserving particular attention in this connection are:

a. Does the indicated kill fluctuation accurately reflect a fluctuation in the population level or is it largely a function of other factors, such as weather or seasonal availability, or hunting pressure influenced by some outside force; or is it caused by the survey technique?

b. If the fluctuation in kill does accurately represent a change in the population level, is this change significant? This point must, of course, be related to the reproductive potential of the species being considered. For example, a drop of 50 per cent in the kill of a species with a low reproductive potential, such as the bear, could be much more significant than a similar drop in the kill of a species with a high reproductive potential, such as the rabbit. It would, therefore, be well to develop standards of significance for each species so as to gauge the importance of fluctuations.

3. *Annual fluctuation vs. confidence limit.* In many cases, the indicated fluctuation in kill from one year to the next was observed to be less than the total range of the confidence interval of the kill. For example, the 1952-53 grouse kill was computed to be $25{,}612 \mp 12{,}407$, or nearly 50 per cent of the kill. The next year the computed kill dropped about 3,000, or about 12 per cent. Furthermore, the total spread of computed kills over the five survey years ranged from about 9,000 to about 25,000. This spread of 16,500 is well within the limits of the possible spread of $\mp 12{,}407$ of the confidence limits for one year. Similar examples can be drawn from other species.

This situation raises important questions in regard to the accuracy of the method and the significance of the data. It may be redundant to point out, but yet very important to note, that much greater reliance could be placed on these figures if confidence limits could be held to a much lower level, say 10 per cent of the computed total kill. This poses an important problem for the statistician. It is possible that recently developed theories and formulas of a regression type may reduce the confidence spread of such data.

4. *Parallel fluctuations.* One could reasonably expect parallel fluctuations among species with similar food habits or habitat preferences. The data presented, however, do not bear out this generality. While it is true that some parallels exist, they are not always where one would expect them. Whether this situation serves to invalidate the data is open to question.

Woodcock and grouse show parallel fluctuations over four survey years but a contrasting fluctuation in the fifth. Turkey and deer kills show a similar parallelism.

Raccoon and opossum are parallel for the first two and last two years but conflict in the third year of the five survey years. Ducks and geese are generally parallel for all five years. Rabbits and squirrels are parallel for three out of five years. Bear kills exhibit very little fluctuation from year to year.

It is obvious that there is no sembance of uniform parallelism among the 14 species, and the reasons for such parallels as exist are not clear. From the standpoint of food and cover, grouse and deer kill fluctuations should be

parallel and different from turkey; but this is not the case. From the standpoint of habitat, quail should parallel rabbit; but, actually it parallels squirrel much more closely.

5. *Statewide fluctuations v. local fluctuations.* The data indicate that the annual statewide kill fluctuations do not necessarily reflect individual local fluctuations. The statewide squirrel kill from 1953 to 1954 showed a *drop* of about 13 per cent. On the other hand, the squirrel kill on the Pisgah game preserve during the same period showed an *increase* of 46 per cent. The previous year showed a statewide increase of about 4 per cent while the Pisgah showed a much greater increase of 217 per cent.

Obviously, the statewide fluctuations represent an average of opposing local fluctuations, some paralleling and others conflicting with the overall average. This suggests that it might be appropriate to regionalize the statewide analysis into geographic, physiographic, or ecological provinces. How detailed such a regionalization should be remains a question for the biological statistician to resolve. If at all practical, it should be related to administrative ease of application in regard to regulation and restoration.

V. SURVEY DEFICIENCIES AND DESIRED IMPROVEMENTS

There appear to be three basic deficiencies of the current survey technique which are serious enough to warrant further research. The first of these deficiencies has to do with biases. As in most statistical work, it is inevitable that biases exist which warp the data and conclusions derived. It is felt that such biases are more serious and more difficult to isolate and correct in the field of game kill surveys than in some other types of surveys.

Some of the more obvious causes for bias may be listed as: (1) The inability of the hunter to remember his kill accurately and the tendency to exaggerate or minimize. This may be partially corrected by conducting the survey as soon after the season as possible. (2) Another possible bias is caused by the failure of about 60 per cent of the hunters to respond. (3) Using the previous year's license list results in using names of those who may not have hunted while not using names of those who did. (4) Incomplete addresses on license stubs, especially in urban areas result in the absence of a part of the population in the survey sample.

These are but a few of the more serious biases affecting surveys of this type. Others may, no doubt, be found. Isolating them, determining their net effect, and compensating for them remains a problem for the biological statistician.

The second major deficiency has to do with confidence limits. As indicated above, the confidence spread appears to be excessive in regard to most species. Narrowing this spread would enable one to place more reliance on the data derived. In those cases where fluctuations consistently fall within confidence limits, it would appear that the data are more accurate than the formula would indicate. Serious consideration should be given to further research in testing and evaluating confidence limits as they apply to this type of survey. Recently developed theories of a regression type analysis may improve this situation.

More information is needed on the relationship between annual kill fluctuations and total populations. How accurately does the one reflect the level of the other? What percent of a population may be harvested? How large an increase in kill is required to reflect a serious decrease in the population? To what extent can the various populations be drained by hunting? These and similar problems seriously affect the interpretation and usefulness of kill data. Their solution poses important problems for future analysis. In many cases, these problems can probably be best resolved at the research station level rather than by state wildlife regulatory agencies.

VI. CONCLUSION

In conclusion it may be stated that although this technique shows much promise as a valuable game management tool, much work still needs to be done in the way of refining the technique. This refinement should be aimed

at evaluating and compensating for biases and improving the confidence limits which, in turn, may be expected to produce more accurate data on kill fluctuations and population levels.

TABLE I

COMPARISON OF STATEWIDE GAME KILLS
1949-50, 1951-52, 1952-53, 1953-54, and 1954-55

Species	*Statewide Kill*				
	*1949–50**	*1951–52*	*1952–53*	*1953–54*	*1954–55*
Bear	873	927	1,047	1,100	1,200
Deer	14,616	17,739	15,572	18,598	20,084
Dove	101,351	395,829	315,041	416,117	484,248
Duck	99,781	110,168	141,461	145,046	148,527
Fox	92,562	74,144	102,226	90,567	47,102
Goose	24,592	25,466	55,373	49,279	46,766
Grouse	9,169	16,736	25,612	21,803	17,181
Opossum	195,432	331,840	364,895	331,139	252,436
Quail	1,775,471	1,358,579	1,414,048	1,554,359	1,147,242
Rabbit	2,149,048	2,237,473	2,624,918	2,436,118	1,666,766
Raccoon	83,306	311,871	231,418	254,450	162,995
Squirrel	2,486,696	2,225,724	2,696,669	2,819,193	2,439,837
Turkey	914	4,203	2,656	4,301	3,294
Woodcock	1,530	4,696	8,342	4,497	8,252

* Figures taken from "The Value of North Carolina's Game and Fish" by Stains and Barkalow, 1951.

TABLE II

COMPARISONS OF STATEWIDE HUNTER-TRIPS
1951-52, 1952-53, 1953-54, 1954-55

Species	*Statewide Hunter-Trips*			
	1951–52	*1952–53*	*1953–54*	*1954–55*
Bear	11,298	19,620	18,040	15,073
Deer	238,934	256,147	266,096	286,227
Dove	151,560	119,084	144,319	145,634
Duck	87,497	115,700	116,671	120,712
Fox	229,373	296,767	288,335	169,622
Goose	38,249	87,794	51,667	65,781
Grouse	32,863	44,150	42,328	32,482
Opossum	248,367	292,407	262,501	808,908
Quail	574,805	675,418	698,749	589,792
Rabbit	1,323,259	1,619,782	1,570,568	1,143,158
Raccoon	272,819	301,086	311,548	179,213
Squirrel	1,182,151	1,539,676	1,518,435	1,295,512
Turkey	32,768	46,914	48,879	36,916
Woodcock	4,187	7,840	2,990	5,600
TOTAL	4,428,130	5,422,385	5,349,126	4,894,630

TABLE III

ANNUAL CHANGES IN STATEWIDE GAME KILLS, EXPRESSED AS PERCENTAGE OF INCREASE OR DECREASE OVER PREVIOUS YEAR'S KILL FIGURE

(See Table I for Actual Figures)

Species	*1951–52*	*1952–53*	*1953–54*	*1954–55*	*Arithmetic Average*
Bear	+ 6	+ 12	+ 5	+ 8	8
Deer	+ 21	− 12	+ 19	+ 12	16
Dove	+290	− 20	+ 32	+ 16	89
Duck	+ 10	+ 28	+ 2	+ 2	10
Fox	− 20	+ 38	− 11	− 49	29
Goose	+ 3	+117	− 11	+ 5	34
Grouse	+ 82	+ 53	− 14	− 17	42
Opossum	+ 70	+ 10	− 9	− 24	28
Quail	− 20	+ 4	+ 10	− 26	15
Rabbit	+ 4	+ 17	− 7	− 31	15
Raccoon	+274	− 26	+ 10	− 36	101
Squirrel	− 10	+ 21	+ 4	− 13	14
Turkey	+360	+ 37	+ 62	− 23	120
Woodcock	+207	+ 78	− 46	+ 83	103

TABLE IV

RELATIVE HUNTING PRESSURE OR PREFERENCE, EXPRESSED IN PER CENT OF TOTAL HUNTING EFFORT

Species	*Year*					*Four-Year Average*	*Rank According to Average Hunting Pressure*
	1949–50 *	*1951–52*	*1952–53*	*1953–54*	*1954–55*		
Bear	.87	.26	.36	.34	.31	.32	13
Deer	5.73	5.40	4.72	4.97	5.85	4.19	7
Dove	.14	3.42	2.20	2.70	2.97	2.82	8
Duck	1.46	1.98	2.13	2.18	2.47	2.19	9
Fox	3.86	5.18	5.47	5.39	3.46	4.88	6
Goose	1.45	.86	1.62	.97	1.34	1.20	10
Grouse	.15	.74	.81	.79	.66	.75	12
Opossum	1.52	5.61	5.39	4.91	16.50	8.10	4
Quail	16.46	12.98	12.46	13.06	12.00	12.63	3
Rabbit	33.77	29.88	29.87	29.51	23.30	27.87	1
Raccoon	.72	6.16	5.55	5.82	3.70	5.31	5
Squirrel	24.48	26.70	28.39	28.39	26.50	27.50	2
Turkey	.21	.74	.87	.91	.75	.82	11
Woodcock	.00	.09	.14	.06	.11	.10	14
TOTAL	90.82†	100.00	99.98	100.00	99.92	98.68	..

* Figures from "The Value of North Carolina's Game and Fish" by Stains and Barkalow, 1951. (Figures not included in average.)
† 8.08 per cent indicated no preference.

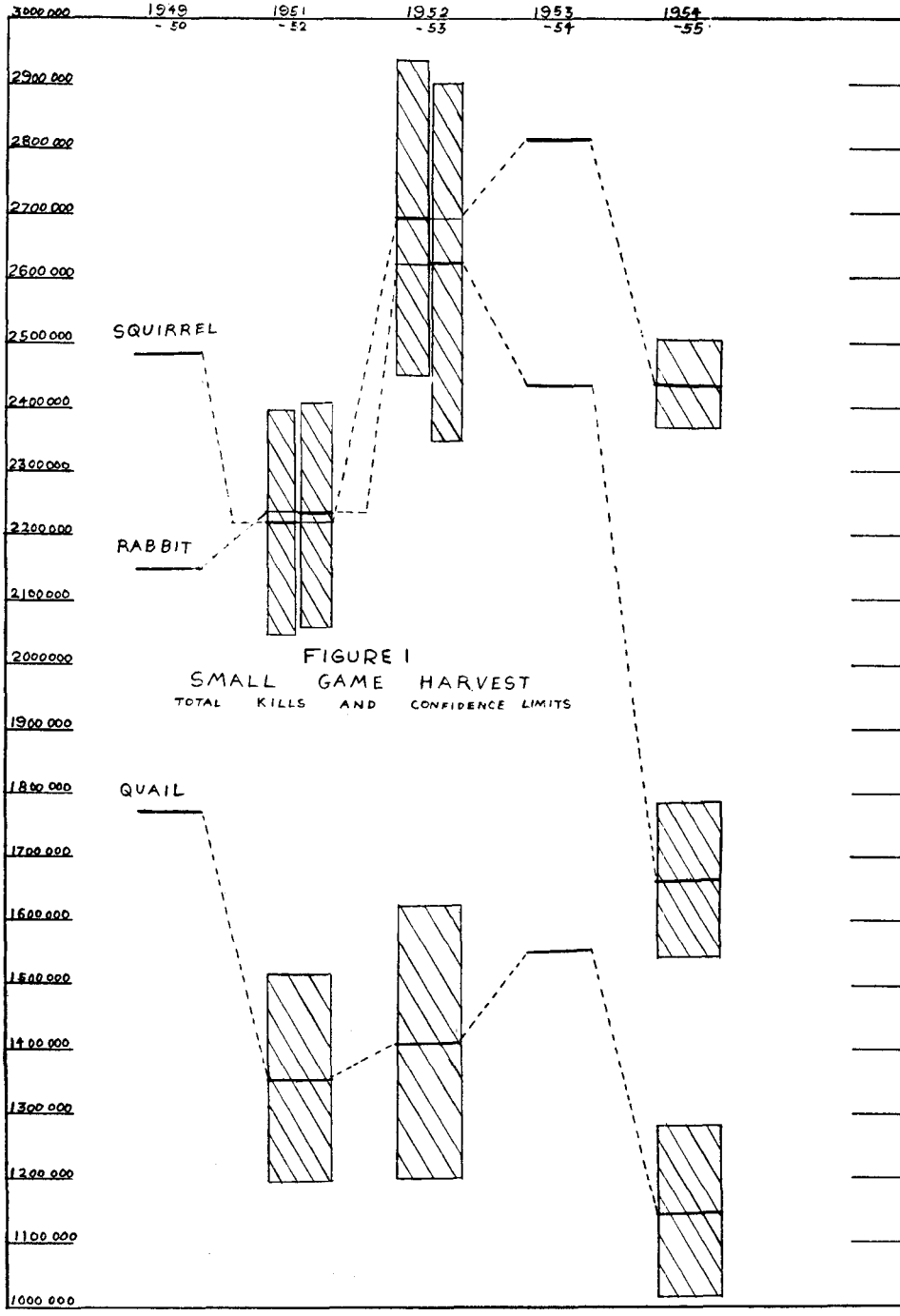


FIGURE 1

SMALL GAME HARVEST

TOTAL KILLS AND CONFIDENCE LIMITS

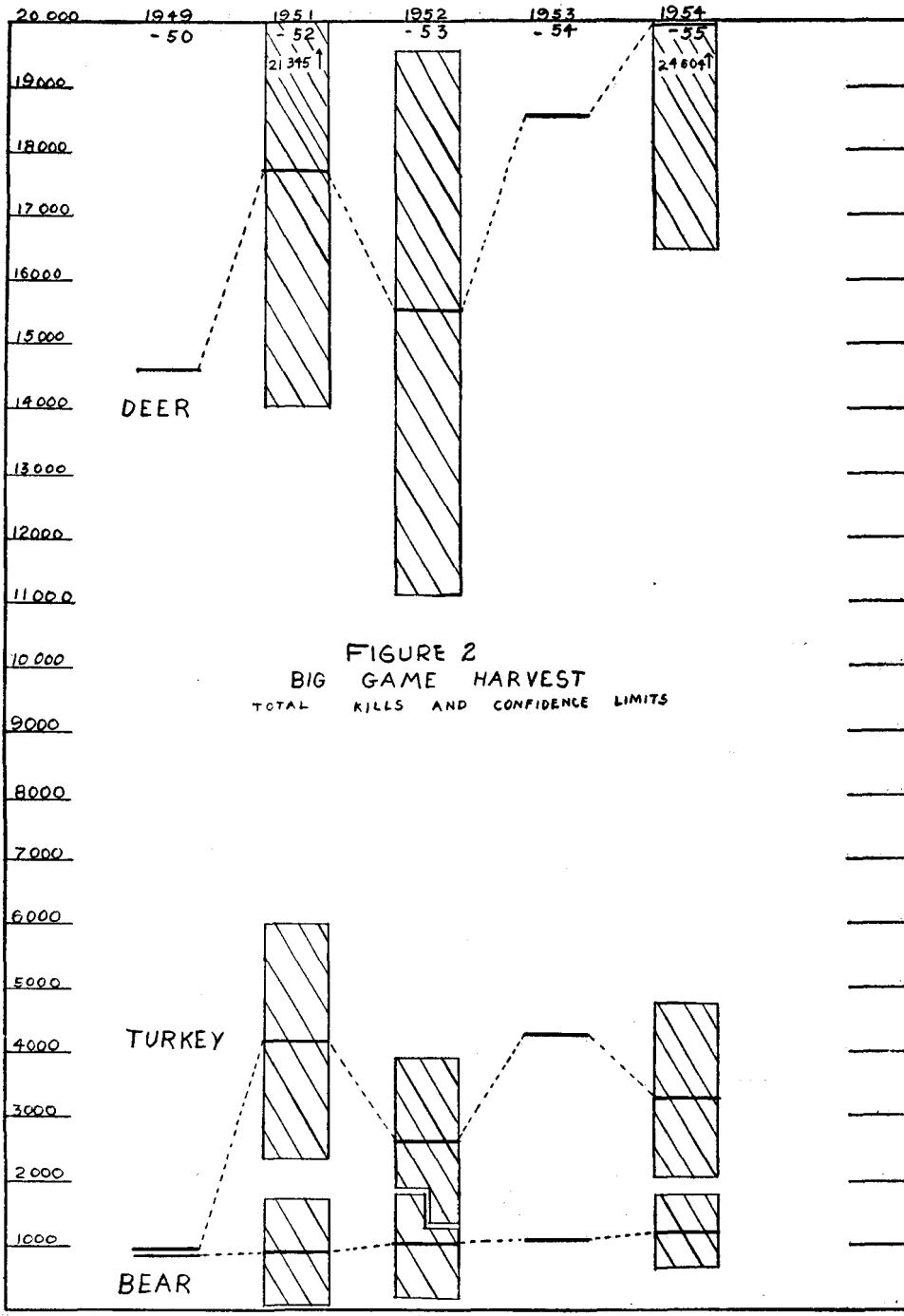
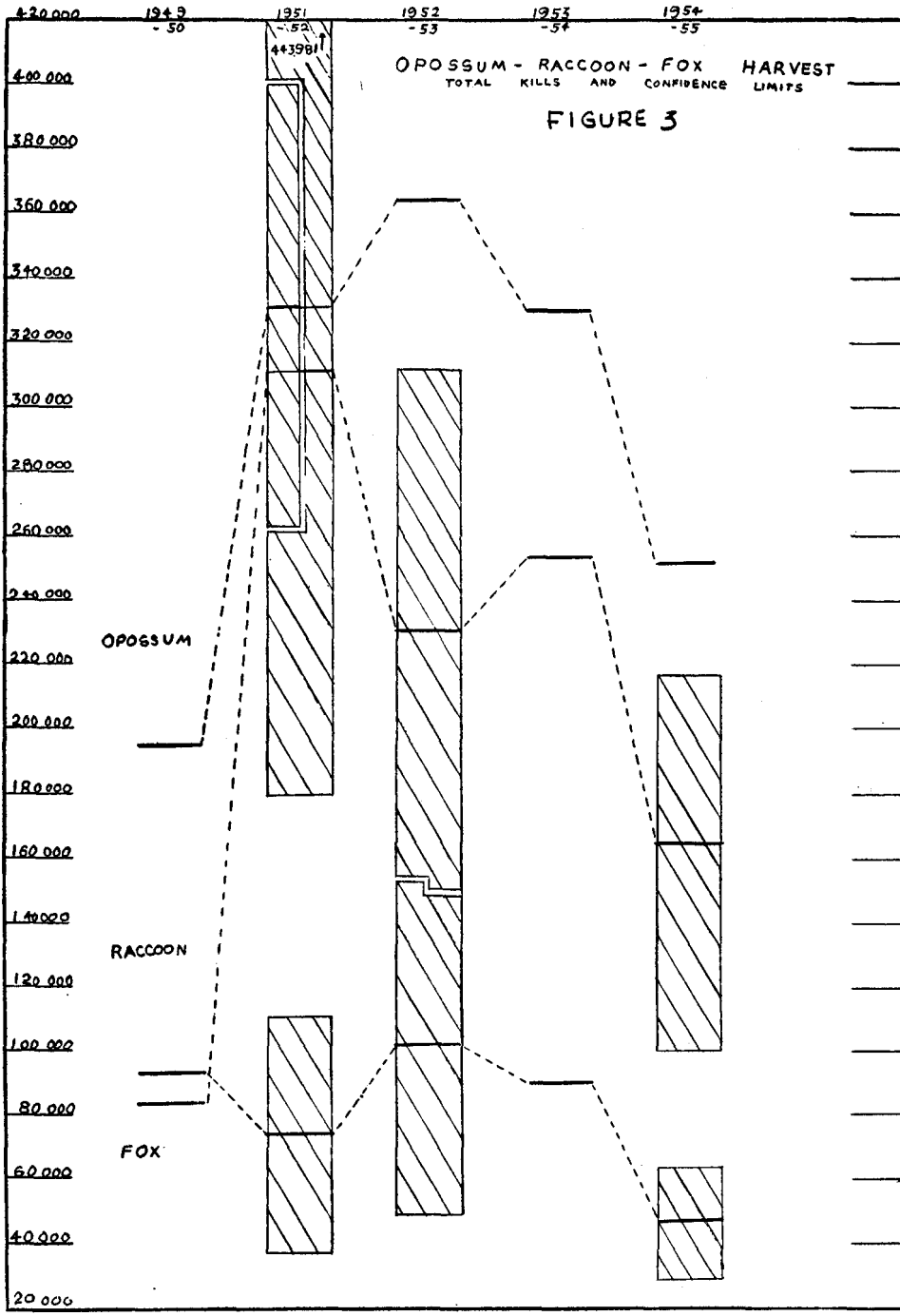


FIGURE 2

BIG GAME HARVEST

TOTAL KILLS AND CONFIDENCE LIMITS


OPOSSUM - RACCOON - FOX HARVEST
TOTAL KILLS AND CONFIDENCE LIMITS
FIGURE 3
1949 -50
1951 -52
1952 -53
1953 -54
1954 -55
443981
420 000
400 000
380 000
360 000
340 000
320 000
300 000
280 000
260 000
240 000
220 000
200 000
180 000
160 000
140 000
120 000
100 000
80 000
60 000
40 000
20 000
OPOSSUM
RACCOON
FOX

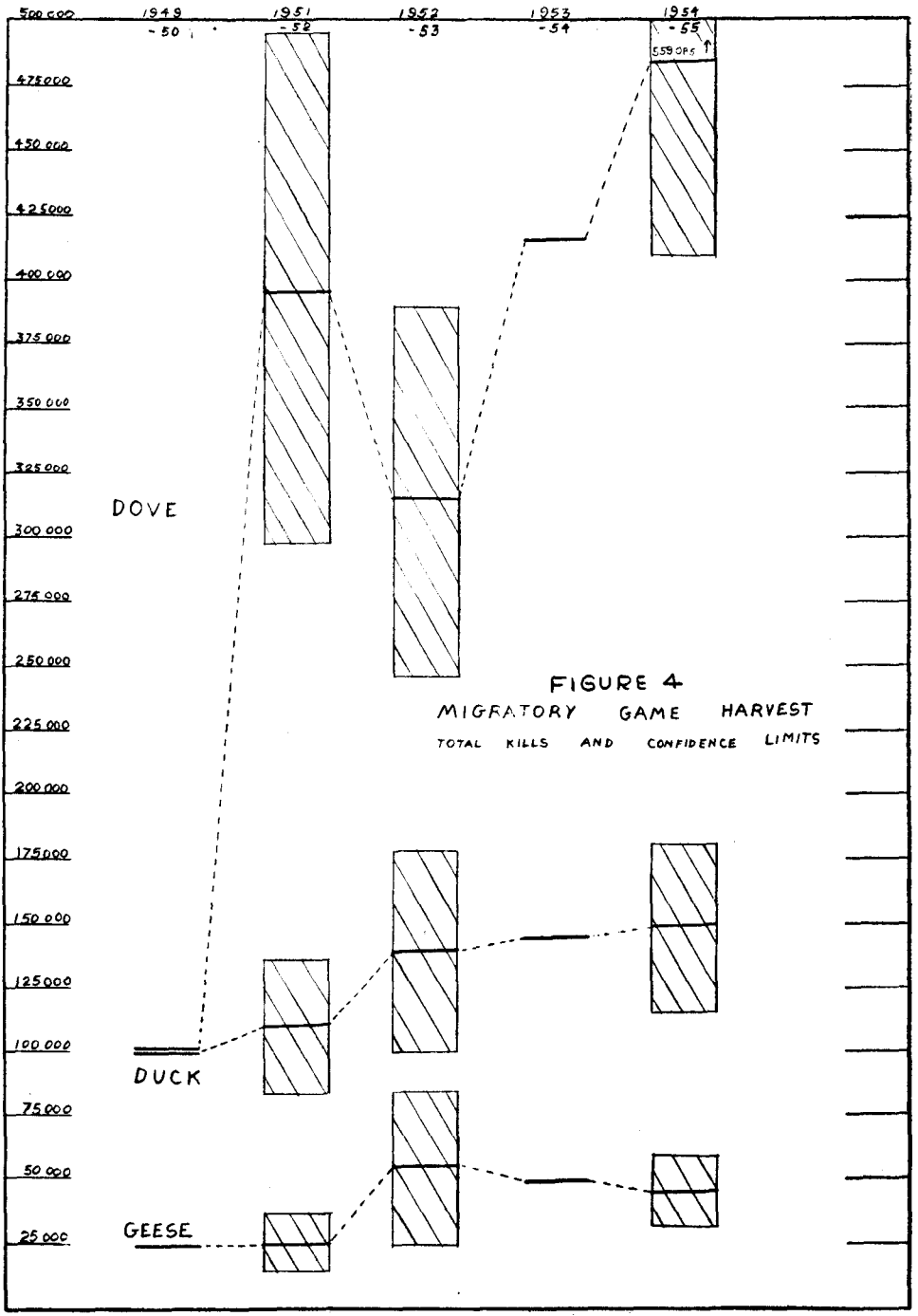


FIGURE 4

MIGRATORY GAME HARVEST

TOTAL KILLS AND CONFIDENCE LIMITS

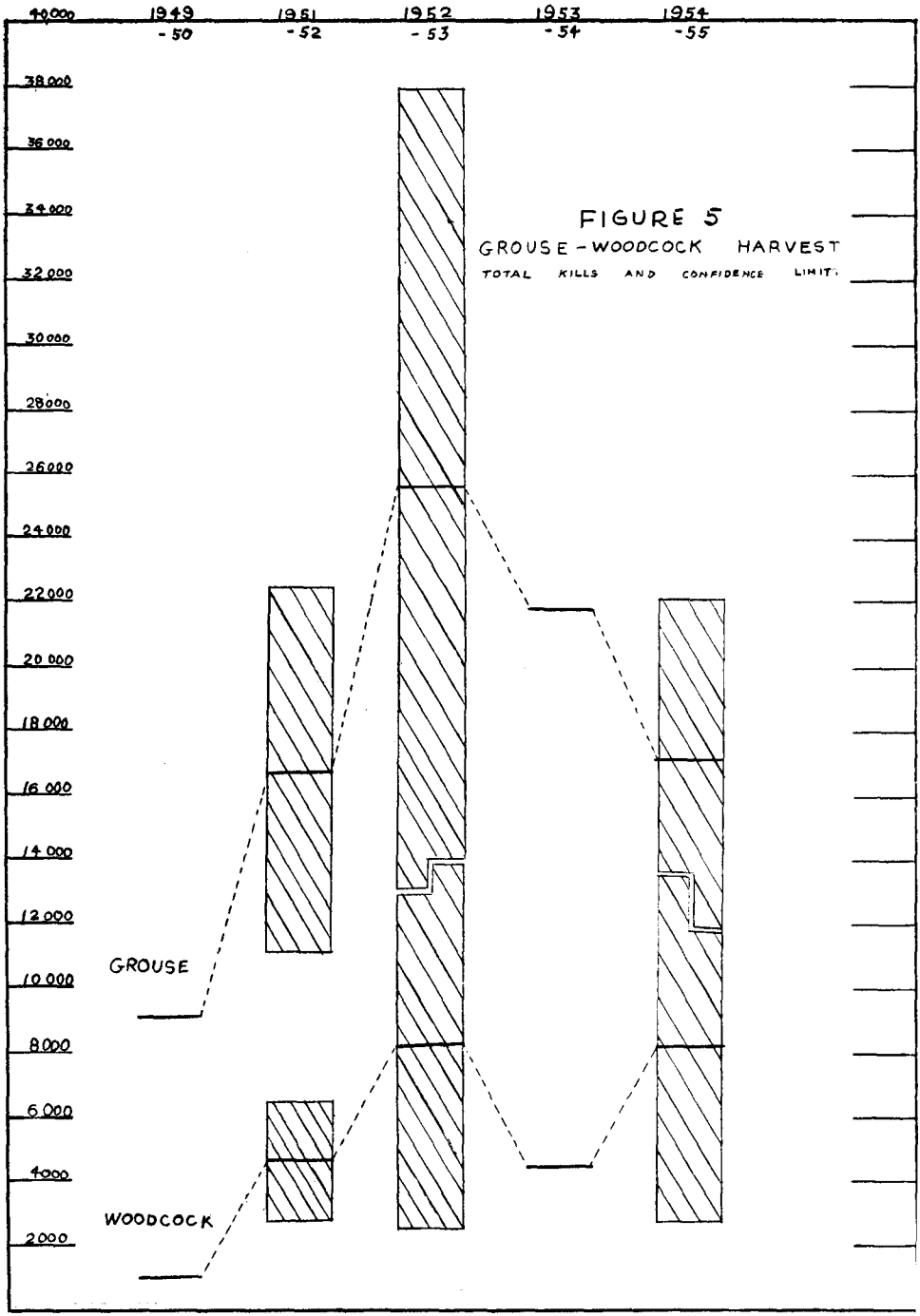


FIGURE 5

GROUSE - WOODCOCK HARVEST

TOTAL KILLS AND CONFIDENCE LIMITS