

THE SELECTIVE ELIMINATION OF SILVER FOXES IN EASTERN CANADA

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Elton (1942) has published figures showing the decrease in the percentage of silver-fox skins among the total skins of 'coloured foxes', *Vulpes fulva*, taken in successive periods from 1834 to 1933 in a number of districts of the Quebec peninsula. About 1840 the percentage of silver-fox skins ranged from 11.46 ± 2.30 to 17.67 ± 1.18 % in different areas. About 1930 it ranged from 4.29 ± 0.30 to 6.38 ± 0.32 %. Standard errors are used here and throughout the paper. There was a similar but less regular decline in the percentage of cross-fox skins from about 32 % to about 21 % in the districts which furnished the best data.

Elton attributes the decline to selective killing. Silver-fox skins were worth about four times as much as red, and cross-fox skins about $2\frac{1}{2}$ times as much, throughout the century. The breeding of silver foxes in captivity began too recently to equalize prices during the periods considered. In consequence hunters took more trouble to secure silver, and perhaps cross, foxes than red. Elton puts the decline down to selective shooting, silver foxes being pursued when red foxes were not. He does not regard trapping as selective; however, it is conceivable that more traps were laid in a district where one or more silver foxes had been seen than elsewhere. In any case trapping must be less selective than shooting.

He points out that the statistics are interesting from two points of view. First, they show, or seem to show, the effect of selection on a natural population. Secondly, they demonstrate that the fraction of foxes killed per year 'though small, is not minute'. Since the number killed per year has on the whole been increasing, though with violent fluctuations, since about 1900, the fraction killed is too small to diminish the total numbers of the species, as has been the case with many other species of fur-bearing animals. On the other hand, since the number killed has apparently been large enough to influence the percentage composition of the species, it cannot be minute.

The data collected by Elton are of great interest to geneticists because they are the only quantitative records of changes within a natural population over a period of a century, and there is at least strong evidence for the selective agency at work. Haldane (1924, 1926, etc.), in a series of papers, developed a mathematical theory of the changes to be expected in a population under the influence of uniform selection; but in the absence of quantitative observational data these were often regarded as being of merely academic interest. It is of course true that Elton's data are biased. If there is selection against silver foxes, it is clear that the percentage of silver foxes among the wild population must be less than that among the skins. But we shall see later that this introduces a rather smaller bias than might have been expected.

According to Hijina (1934, 1935)* the relevant genetic facts are as follows. The red fox is *rr*, the silver *RR*, and the cross-fox *DD Rr* or *Dd Rr*, whilst *dd Rr* is a smoky red, probably classified with other reds for commercial purposes. Besides these two gene

* I have relied on the summaries given in *Animal Breeding Abstracts*, vols. 4 and 5.

pairs she recognizes another gene **B** found in Alaska. **BB** and **RR** foxes are blacks with varying amounts of silver hairs. According to her the amount of silvering depends on other genes, but according to Morgan & Simms (1940) it depends to some extent at least on a vitamin deficiency which induces silvering. **RR** blacks seem to give more valuable silvers than **BB** blacks. Since no black fox skins are recorded in the catches, and the gene **B** is absent or very rare in eastern Canada, I take it that all **RR** foxes were classed as silver, and that all silver foxes were **RR**. Iijina describes other genes for complete or partial albinism, white spotting, etc. These do not concern us. From the great irregularity of the percentages of cross foxes recorded, and of the deduced frequency of the dominance modifier **D**, it seems possible that the distinction between cross foxes and smoky, 'bastard' and other names given to **Rr** skins, may be rather uncertain. It also seems rather unfortunate that **B** and **R** are given capital, rather than small letters. Both the 'cross' and 'smoky' heterozygotes contain a good deal of yellow, which is almost or quite absent from good silver-fox furs, and they look a good deal more like reds than blacks or silvers. Thus **B** and **R** are more nearly recessive than dominant. To sum up, we assume that all the foxes caught in the Quebec peninsula are **bb**, that those classified as red are **rr** and **Rr dd**, those as cross, **Rr DD** and **Rr Dd**, those as silver **RR**.

The figures for fox skins taken at four Moravian mission stations in Labrador, namely, Hopedale, Nain, Okak, and Hebron, are given in Table 1, columns 2-4. They are taken from Elton's Table 29, p. 280. He also gives the figures for the four stations separately. The percentages barely differ significantly, but on the whole the percentage of silvers has fallen more in the north-westerly than the south-easterly part of this area. Tables 2 and 3 give comparable data for the Ungava district in the north of the Quebec peninsula, and the Eastmain district on its western, or Hudson Bay, shore. The standard error $100 \sqrt{\frac{s(1-s)}{N}}$, of the percentage of silvers 100s is also given, *N* being the number of foxes killed.

In our preliminary discussion we shall neglect the bias mentioned above, and treat these figures as if they dealt with true samples of the population. Let *c* and *s* be the frequencies of cross and silver foxes respectively. Thus in the first 10-year period of Table 1, *c* = 0.3205, *s* = 0.1584. Let *y* be the frequency of the gene **d**, *z* that of the gene **R**, among the gametes (or chromosomes) of the population. Then if mating is at random, the frequencies of the genotypes are:

rr ,	$(1-z)^2$	}	$(1-z)(1-z+2y^2z)$,	Red foxes
Rr dd ,	$2z(1-z)y^2$			
Rr Dd ,	$4z(1-z)y(1-y)$	}	$c=2(1-y^2)z(1-z)$,	Cross foxes
Rr DD ,	$2z(1-z)(1-y)^2$			
RR ,	z^2		$s=z^2$,	Silver foxes

It follows that $z = \sqrt{s}$, and $y = \sqrt{\left(1 - \frac{c}{2(z-s)}\right)}$. The calculated values of *y* and *z* are given in each table. While *z* falls fairly steadily, *y* fluctuates in an irregular manner, with no clear tendency either to rise or to fall. Now the elimination of silver foxes will account for the fall in *z*, and also the fall in *c*, or $2y^2z(1-z)$. If, however, there were any appreciable elimination of cross foxes as compared with reds, this would lead to an elimination of the gene **D**, and therefore an increase of *y*. Thus if selection were as intense

against cross foxes as against silvers, y would rise from 0.6 to 0.7 in 90 years. Since there is no evidence of an increase, we conclude that cross foxes as such are at a very slight disadvantage, if any, and have only diminished relatively to reds because they are heterozygous for silver. This is intelligible for the following reason. A silver fox can be distinguished from a red or cross at a great distance; but it would be much harder to tell a cross fox from a red, particularly a smoky red, except at close range. Thus cross foxes

Table 1. *Skins of different fox varieties collected at Hopedale, Nain, Okak, and Hebron (Labrador) in successive 10-year periods*

Period	No. killed	% cross	% silver	s.e. of % silver	Frequency of D	Frequency of R	% silver (calc.)
beginning	N	100c	100s		y	z	
1834	4243	32.05	15.84	0.560	0.5754	0.3980	16.00
1844	3145	28.55	14.53	0.628	0.6283	0.3812	13.70
1854	2879	24.70	11.80	0.601	0.7051	0.3435	11.78
1864	2759	24.86	8.63	0.535	0.6332	0.2938	10.19
1874	3526	21.84	8.11	0.460	0.6811	0.2848	8.86
1884	1813	22.95	5.95	0.556	0.6147	0.2439	7.74
1894	1939	21.45	7.48	0.597	0.6784	0.2735	6.82
1904	2191	22.09	7.35	0.558	0.6641	0.2711	6.02
1914	2855	25.22	5.18	0.415	0.5313	0.2276	5.34
1924	4316	21.16	5.07	0.334	0.6261	0.2252	4.76

Table 2. *Skins of different fox varieties collected in the Ungava district (Fort Chimo*)*

Period	n	No. killed	% cross	% silver	s.e. of % silver	Frequency of D	Frequency of R	% silver (calc.)
		N	100c	100s		y	z	
1837-39	-32.5	192	30.21	11.46	2.30	0.5705	0.3385	(21.62)
1868-73	0	1587	26.28	14.30	0.879	0.6653	0.3782	12.94
1874-83†	8.1	3103	25.33	10.89	0.559	0.6542	0.3300	11.47
1884-93	18	2303	26.14	12.20	0.682	0.6519	0.3493	9.95
1894-1903	28	2049	22.31	9.17	0.631	0.6867	0.3028	8.65
1904-13	38	1950	21.95	9.69	0.660	0.6986	0.3133	7.57
1914-23	48	1739	24.27	6.67	0.599	0.6055	0.2583	6.66
1924-33	58	3360	23.82	5.65	0.398	0.5851	0.2377	5.89

* Closed from 1842 to 1866.

† Records for 1877, 1878, 1880 missing.

Table 3. *Skins of different fox varieties collected in the Eastmain district*

Period	n	No. killed	% cross	% silver	s.e. of % silver	Frequency of D	Frequency of R	% silver (calc.)
		N	100c	100s		y	z	
1854-62	0	3445	27.06	11.96	0.553	0.6340	0.3458	13.03
1865-73	11	3135	22.62	12.66	0.594	0.7130	0.3558	11.64
1874-75	16.5	785	23.95	11.34	1.13	0.6810	0.3367	11.02
1895-1900	39.5	1991	24.25	10.10	0.675	0.6639	0.3178	8.81
1915-23	61	2775	24.83	7.68	0.505	0.6166	0.2771	7.25
1924-33	70.5	5913	26.70	6.38	0.318	0.5394	0.2526	6.67

would rarely be pursued across country when reds were not, whilst silvers would frequently be so hunted.

The data also show that there is at least a good deal of interbreeding between different types. Taking the figures of 1834-43 from Table 1, if there were 15.84% of silver (RR) foxes, then if mating were at random there should have been 47.92% of Rr heterozygotes, and 36.24% of rr homozygotes. We see that the frequency of heterozygotes was at least 32.05%, though we do not know how much greater it was unless we know either the mating system or the frequency of the dominance modifier D. If, however, we take the

extreme hypothesis that the whole population was homozygous for **D**, the frequencies of the three types would have been:

Red rr	$(1-z)^2 - \alpha z(1-z)$	0.5211
Cross Rr	$2(1-\alpha)z(1-z)$	0.3205
Silver rr	$z^2 - \alpha z(1-z)$	0.1584

where α is the mean coefficient of inbreeding. Thus $z=0.31865$, $\alpha=0.2619$. Since α may have any value from 0 (random mating) to 1 (complete inbreeding), and the frequency of **d** is certainly not zero, we conclude that inbreeding is slight at most. If α does not exceed 0.1, the effects of inbreeding can be neglected in a rough calculation of the intensity of selection. It may be added that since the true frequency of silver foxes was less than 15.84%, the maximum possible amount of inbreeding was really less than calculated above.

It remains to account for the curious irregularity in the values of c and y . This must still be explained even if there are other dominance modifiers than **D**. It can hardly be explained by variations in the intensity with which cross foxes are hunted relatively to red, since we saw reason to doubt whether they were selectively hunted. It may depend on differences of classification. There are several kinds of yellowish fox with dark markings, and it is possible that at some times the criterion for describing a particular fur as a cross fox was more rigid than at others. If furs are now included under this category which would not have been included a century ago, it may be that the frequency of cross foxes has fallen more than appears, and that they have been selectively eliminated.

Let us now see whether the observed rate of decrease of silvers is compatible with the hypothesis that selection of uniform intensity was directed against them. Suppose, therefore, that the effective fitness of a silver fox is to that of the other types as $1-k:1$, where k is a small constant. That is to say on an average 100 silver foxes leave $1-k$ times as many offspring as 100 non-silvers. Since the population is not diminishing it follows of course that the latter must, on the average, rather more than reproduce their own numbers.

Haldane (1924) showed that in this case, if u is the gene ratio $r/R = \frac{1-x}{x}$, then if u_0 is the initial value of u , and u_n its value after n generations,

$$u_n - u_0 + \log_c u_n - \log_c u_0 = kn. \quad (1)$$

If, however, the number n refers to years, not generations, then if g be the average length of a generation, k/g must be substituted for k in the above equation. Haldane (1926) showed how g could be calculated when generations overlap, provided the survival and fertility of different types at varying ages were known, which of course they are not in the case in question.

Since $s = \frac{1}{(u+1)^2}$, the values of u can be calculated. Putting $u_0 = 1.5$ and $k = 0.0328$ in the equation (1), we obtain the calculated values for the frequency s of silver foxes which are given in column 8 of Table I. The calculated values are as often above those found as below them, so the fit is fairly good, though it could doubtless be slightly bettered. One calculated value exceeds the observed by 3.2 times its standard error, and two differ by over twice the standard error. So the differences are probably not due to sampling errors alone. However, it is clear that the hypothesis of a constant intensity of selection fits

the facts fairly well, and we can, for example, use the equation to extrapolate. Thus unless the domestication of silver foxes has markedly affected the relative prices, we may expect to find $u=3.84$, $x=0.2066$, and the percentage 100s. of silver foxes 4.27% approximately in the decennial period ending in 1943.

The figures calculated on the hypothesis (which we saw to be false) that foxes of different colours do not interbreed, diminish in geometrical progression. They are distinctly higher than those of column 8 in the middle of the century if they fit at the ends. Thus the calculated value for 1884-93 is 8.15% , which differs from 5.95% by 4.0 times the standard error. The false hypothesis that silver is dominant over the other colour types gives intermediate figures, but nearer to the geometrical progression than to those given in the table. Thus the observed trend of the figures on the whole supports the account of the genetics and mating system given above. If we had accurate figures in a similar case ranging over frequencies between 10 and 90%, they would by themselves go far to determine both the genetics of the polymorphism concerned and the mating system.

Similar calculations have been made in Tables 2 and 3. As the data are incomplete the mean date in each period has been calculated, and the values of n in column 2 refer to this. In Table 2 I have taken $u_0=1.78$, $k=0.0328$. The latter is the same as in Table 1. Perhaps a slightly better fit would have been obtained if k had been taken about 0.0332, but the intensity of selection seems to be nearly the same in the two areas. The bracketed value in the last column is of course in complete disagreement with the observed value. This is as it should be, for during 24 of the $32\frac{1}{2}$ years between the two data no furs were collected by the Hudson Bay Company in this district, and in consequence there was very little selection against silver foxes. In fact their numbers did not diminish.

For Table 3 I have taken $u_0=1.77$, $k=0.0225$. That is to say the intensity of selection seems to have been only about 70% of that in the other two districts. It would seem that the number of foxes killed per year per 100 square miles was a good deal less in the Eastmain district than in the two more easterly areas, and the selection may also have been less intense, though doubtless migration between the different regions tended to equalize the rates of fall of z .

The mean length of a generation is unknown. It certainly exceeds 1 year, for silver foxes can live for several years, and some at least must breed in several seasons. On the other hand, it is almost certainly less than 4 years, for the following reason. Elton has shown that the number of fox furs taken per year fluctuates very violently and rather irregularly. The average interval between maxima is 4 years, though it ranges from 2 to 7. The greatest fluctuations recorded by the Moravian mission stations is between 2226 fox skins taken in 1934 and only one in 1919. The geometrical mean of 22 maximum catches recorded in Elton's Table 17 is 8.99 times the geometrical mean of the corresponding minima. Before a year of minimum catch it seems sure that a majority of the foxes die through famine, due to shortage of rodents which they eat, and disease. It is not so certain that their numbers are reduced in proportion to the catch, since they may find food more readily when their numbers are reduced, and therefore be less likely to approach traps. But there seems little doubt that most of the fox population dies in the periodic disaster. If so most foxes live for less than 4 years, even if we only begin to count them at the end of infancy, and thus do not consider infantile deaths.

The survivors of a disaster probably breed freely. If the number of foxes increases roughly in geometrical progression till the next disaster, when most of them die, it

follows that most foxes have only one year of breeding, and the average length of a generation is between 1 and 2 years. It cannot well be as much as 4 years. Probably we shall not be far out in taking it at 2 years. If so the value of k per generation is about 0.06, that is to say, a silver fox, on an average, leaves about 94 % as many offspring as a red or cross fox.

A little further information may be gained, particularly as to the bias, by treating the matter on the lines of Haldane's (1926) paper. His hypothesis can be considerably simplified. We suppose the death-rate at a given age to be the same in both sexes, and apart from human killing, the same in all varieties of fox. We also suppose the fertility at a given age to be the same for both sexes and all genotypes. Instead of actual fertility we consider net fertility; that is to say, instead of supposing the offspring to be counted at birth, we suppose them to be counted at the end of infancy, so that the effect of infantile mortality is to diminish the net birth-rate. We further suppose that the probability of being killed and skinned within a given time is constant throughout the life of a fox after infancy. All these assumptions are doubtful. For example, a very young fox is perhaps less likely to be shot than an adult, but more likely to be trapped through its inexperience; while a very old fox, which is too feeble to hunt efficiently, may be more likely to be trapped than a healthy adult. Nevertheless, the order of magnitude of numbers found on such assumptions is probably correct.

Let $D(x)$ be the intensity of mortality from natural causes at age x . That is to say, let $D(x) \delta x$ be the probability that a fox aged x will die before reaching the age $x + \delta x$. It is to be noted that $D(x)$ is not independent of trapping, which probably keeps the population low enough to reduce the risk of death from starvation, and perhaps disease. Let K be the intensity of mortality of red and cross foxes from the human killing, defined in the same way, and $(1+q)K$ be the same for silver foxes. Let $F(x)$ be the fertility at age x , that is to say, let $F(x) \delta x$ be the probability that a female fox will have a female offspring between the ages x and $x + \delta x$. $F(x)$ is assumed to be the same for males and females, silvers and others. Let $L(x)$ be the probability that a non-silver fox will live to age x , $L(x) - l(x)$ the same probability for a silver fox. Let the time t be measured in years.

Then
$$\frac{L(x + \delta x)}{L(x)} = 1 - [D(x) + K] \delta t.$$

So
$$L(x) = \exp \left[- \int_0^x D(u) du - Kx \right],$$

$$\begin{aligned} L(x) - l(x) &= \exp \left[- \int_0^x D(u) du - Kx - qKx \right] \\ &= L(x) e^{-qKx} \end{aligned}$$

Therefore $l(x) = qKxL(x)$ approximately, if qK is small.

Further, the fraction of all red and cross foxes killed and skinned is KL , where $L = \int_0^\infty L(x) dx =$ mean lifetime, and the corresponding fraction of all silver foxes is $(1+q)K(L-l)$, $L-l$ being the mean lifetime of silver foxes. Their ratio is $(1+q) \left(1 - \frac{l}{L} \right)$, or slightly less than $1+q$.

If $u(t)$ is the gene ratio as defined above, then by Haldane's (1926) equation (2.5),

$$\begin{aligned} \frac{d}{dt} u(t) &= \frac{\int_0^{\infty} l(x) F(x) dx}{\int_0^{\infty} xL(x) F(x) dx} \frac{u(t)}{1+u(t)} \text{ approximately} \\ &= \frac{qKu(t)}{1+u(t)}. \end{aligned} \quad (2)$$

This is equivalent to equation (1), so that $qK = k = 0.033$ approximately for the Labrador population. The error involved in equating e^{-qKx} to $-qKx$ is not more than about 3%.

We have no such definite information as to the values of q or of K , but we can see what meaning is to be attached to the statement that $qK = 0.03$. If $K = 0.2$, this would mean that red and cross foxes were killed off at a rate of 20% per annum, silvers at a rate of 23%; if $K = 0.1$, the corresponding figures would be 10 and 13%. Already the frequency of silvers would be overestimated by nearly 30%, which would involve a certain increase in the above value of k . If K were 0.04, this would mean that red and cross foxes would be killed off at a rate of 4% per annum, and silver foxes at double this rate, since when allowance is made for the bias, qK rises to 0.04. We shall see later on that so low a killing rate for red and cross foxes is unlikely.

Let us now see what would be the effect on k , or qK , of a large bias, measured by q . Suppose that $q = 1$, so that the rate of killing of silver foxes is twice that of red and cross foxes, or in other words, the true frequency s' of silver foxes in the population is related to the frequency s among the skins by the equation $s = \frac{2s'}{1+s'}$. Then $s' = \frac{s}{2-s}$. So s' in Labrador was reduced from about 8.70 to 2.44% in 90 years. That is to say, u rose from 2.390 to 5.407, whence $qK = 0.0426$. In other words, red foxes were killed at a rate of 4.3% per annum, silver foxes at 8.5%. If $q = 2$ the rates would be 2.5 and 7.5%. If, on the other hand, q is small the corrected value of k is

$$\begin{aligned} k' &= k + \frac{q}{n} (u_n - u_0) \left(\frac{1}{2} - \frac{1}{u_n u_0} \right) + O(q^2) \\ &= 0.0328 + 0.0073q + O(q^2). \end{aligned}$$

An argument given later makes it quite improbable that q is as large as unity, that is to say, that the annual rate of killing of silver foxes is twice as great as that of other types. If this were the case the ratio among the skins would be about 30% greater than that in the living population. This value is likely to be too small rather than too large.

I think that such a high value of q is most improbable, for the following reason. The percentage of silver foxes among the skins fluctuates very moderately, and the same is true for other stations. The ratio of silver foxes among the skins to those in the wild population must therefore have remained fairly steady. It cannot have fluctuated by more than about 30% from its mean value. If it was always fairly near unity, this is quite intelligible. If, on the other hand, this ratio always remained about 2, this implies economic determinism of human actions more extreme than seems to me at all probable. The frequency of silver foxes must, for example, be higher among the skins shot than those trapped. The proportion shot must vary from year to year. If the frequencies were very different, we should get larger fluctuations. I therefore conclude that the true frequency

of silver foxes was considerably more than half that among the skins, and that the excess annual killing rate of silver foxes was between 3 and 4%.

If we take $q=0.3$ as a reasonable value this would give an annual killing rate of 11.7% for red and cross foxes, and 15.2% for silver foxes. The fractions of all foxes which were ultimately skinned would be two or three times these values. These figures are suggested for Labrador and Ungava. For Eastmain they should be somewhat lower. Elton's account of fox ecology suggests why the killing of so large a fraction has not reduced the population. As the population is very drastically reduced by natural causes every 4 years or so, human killing may merely diminish the numbers destroyed in the catastrophes, whereas in a species not subject to crises, and more nearly in equilibrium, it might have a serious effect.

It might be possible, by further examination of the records of the fur trade, to discover whether the frequency of silver-fox skins fluctuates with the total catch. Thus it might well be that in a year where only a score or so of pelts was taken over a large area, a hunter would pursue a red fox as eagerly as a silver, so that q would be zero, while q increased in the years of plenty. This would perhaps enable us to set an upper limit to q , and hence a lower limit to the percentage of all foxes killed per year. A full solution of the problems involved probably requires the following action. As Elton suggests, a number of trapped foxes should be marked and released, thus determining both the fraction killed per year and the amount of migration. Secondly, the classification of colours should be brought more into line with genetical findings by listing smoky yellows, 'bastard' cross foxes, and so on. Thirdly, the frequency of silver and cross foxes should be compared among the skins secured by trapping and shooting respectively.

Finally, we must face the question whether the observed decline is after all due to human agency or to natural causes. I think that the first line of Table 2 answers it. Here the fox population was left alone, and the percentage of silvers increased, though not significantly. In any case it seems most unlikely that so rapid a change in a population as that recorded in the table would occur except as the result of a drastic change in the environment. At a selection rate measured by $k=0.0328$ it would need just 500 years to reduce the percentage of silver foxes from 99 to 1%. It would be most surprising had Europeans arrived in Canada just in the middle of this process. There is strong reason to believe that Elton's interpretation is correct.

The only other data known to me with a bearing on this question are those of Cowan (1938) and Cross (1941). Cowan gives figures for the frequencies of the colour phases in eight regions of British Columbia, Washington, Oregon, and Idaho, in 1827-56. The percentage of silvers varied from 25 ± 0.72 to 0.9 ± 0.19 . It fell off from north to south and from east to west. The differences can hardly have been due in the main to selective hunting, but it seems more reasonable to attribute the cline to natural selection. These figures are not quite comparable with Elton's, since the gene **B** was probably responsible for some of the silvers. They support the theory that cross foxes are heterozygotes, but unfortunately give no information on the rate of change of the colour frequencies. It is, however, clear that geographical (probably climatic) as well as human agencies will have to be considered before this fascinating problem is completely solved.

Cross (1941) found that in Ontario the fall in silver foxes between 1916 and 1938 had been very marked. In 1916-1920, 4.4% of the skins taken at 21 posts were silver; in 1934-1938 only 2.2% were silver. The corresponding values of u are 3.77 and 5.47,

giving $k=0.12$. Thus the intensity of selection would seem to be over 3 times as great as in Quebec. This high figure may be correct. When silver foxes are rare they may be hunted more persistently. But as Cross does not give absolute numbers of skins, it may be that the above figure has a considerable standard error. And some of the figures for short intervals in other districts would give high values of k . Thus the apparent value of k in Labrador from 1874 to 1884 is 0.9. On the whole the percentage of silver and cross foxes was higher in the north than the south, but the cline is much less marked than that detected by Cowan.

SUMMARY

Elton's collected data on the frequency of silver and cross foxes killed in several districts of the Quebec peninsula are discussed. The fall in the percentage of silver-fox skins can be explained if the annual rate of killing of silver foxes exceeds that of red and cross foxes by 3-4% in Labrador and Ungava, by 2-3% in the Eastmain district. There is no evidence that cross foxes are killed in greater proportions than red foxes. The annual rate of killing of red foxes is probably of the order of 10% or even more. The different colour varieties cross fairly freely.

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