

IMPACTS OF OUTDOOR RECREATION UPON NEST-SITE CHOICE AND BREEDING SUCCESS OF THE KESTREL

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CONTENTS

1. Introduction	90
2. The mail questionnaire	91
3. Results	91
4. Discussion	95
4.1. The study design	95
4.2. The influence of food abundance	96
5. Acknowledgements	97
6. Summary	97
7. References	98
8. Samenvatting	98

1. INTRODUCTION

As a result of increasing welfare after the Second World War outdoor recreation has become an important feature in modern society. Many recreation activities were driven more and more to places outside the cities and industrialized areas as a result of a decreasing amenity value of these areas. Since all kinds of financial restrictions gradually disappeared in that period, individual mobility increased and also the interest in nature and environment developed rapidly. This process took place in a period in which nature became a scarce commodity.

The friction between these two developments has only but quite recently attracted the attention of ecologists (Wall 1977). They noticed that certain plant and animal species vanished from frequently visited areas. Furthermore differences between plant communities tend to disappear as a consequence of dominance of trampling-resistant species (Van der Werf 1972).

Watson *et al.* (1970) introduced two categories of recreation impacts upon fauna. The first is the category of impacts caused by the loss or alteration of habitats (*e.g.* marsh birds will disappear when marshes are drained for tourism development). Second is the category of impacts caused by the mere presence of tourists in an environment, so called disturbance.

In many disturbance studies raptors are cho-

sen as research objects, such as: *Haliaeetus leucocephalus* (Mathisen 1968), *Falco peregrinus* (Ratcliffe 1962), *Falco tinnunculus* (Versluis & Verhoeven 1978), *Buteo buteo* (Waardenburg 1976), *Accipiter gentilis* (Waardenburg 1977) and *Buteo jamaicensis* and *Buteo pineatus* (Wiley 1975). Significant negative impacts and also non-significant impact relations have been found between recreation intensity and bird density or breeding success. Several hypotheses have been put forward to explain these disparities:

- the time in the season in which the species settles and breeds compared with the time that recreation intensities reach a maximum level (Mathisen 1968);
- the kind of behavioural response of a species to human presence during the breeding cycle (Olsen & Olsen 1980);
- the possible enhanced chance of predation of the eggs or nestlings (Waardenburg 1976, 1977).

Because the existence and importance of disturbance is still often questioned (*e.g.* Newton 1979) it is essential to study disturbance to establish dose and effect relationships. In 1978, 1979 and 1980 we examined the influence of recreation upon the Kestrel *Falco tinnunculus* (Van der Zande & Ter Keurs 1981) using 150 nest-boxes. Though we choose this species because of its abundance, the sample of occupied nest-boxes was too small to draw reliable conclusions.

However, the results provided some indications that the Kestrel avoided nest-boxes within 30 m from footpaths. The only other indication we had of possible susceptibility to disturbance was the research done by Versluis & Verhoeven (1978). They found that the Kestrel preferred nesting places more than 100 m from urban set-

lements, which may be interpreted as a disturbance effect.

Our present study was intended to provide more definitive answers to the following two questions:

- does recreation intensity have a significant impact upon the nest site-choice and the breeding success of the Kestrel?
- over what distances does such an effect operate?

A mail questionnaire was designed to obtain data about the occupation and breeding success in nest-boxes by Kestrels in the years 1975—1980 in several areas in The Netherlands.

2. THE MAIL QUESTIONNAIRE

The mail questionnaire contained questions about three groups of variables. These variables are summarized in Table 1 and are discussed below.

The first three variables are estimates of recreation intensity. Accessibility was used as estimator in order to be able to determine whether the mere presence of people in the area where the box is placed influences the nest-site choice and breeding success. Since not only the mere presence of people may be important, details were also asked about the distance of the nest-box from the nearest disturbance source and about the visibility of the nest-box.

The second group of 6 variables was chosen as indicators of nest-site choice and breeding success: effect variables. The percentage of nest-boxes occupied (in a dose parameter class) was primarily chosen to measure nest-site choice. The percentage with nestlings, average clutch size, average number of nestlings, percentage failures and average breeding success are five different estimates of breeding success. This group is also called effect parameters (and sometimes dependent variables).

The third group of 4 variables was chosen as estimates of all other factors that might influence the nest-site choice and breeding success of the Kestrel: factors that most probably differ between the several areas with nest-boxes. This group is called "possible influencing parameters" to indicate that they might influence the dose-effect relations. It falls into two categories of parameters. One is concerned with the nest-box itself and includes nest-box type, height of the nest-box and fastening type. The other group deals with the environment of the nest-box and includes habitat type.

Table 1 not only shows these parameters but also shows how each parameter is specified. The respondents were asked to specify each variable for each nest-box in the period 1975—1980. In addition to the variables, some general questions were asked concerning the intensity of nest-box checks, the owner and manager of the nest-box area and the exact location of the nest-box area.

In all, 94 questionnaires were mailed to bird societies that had been selected from a yearly report of the Koninklijke Nederlandse Natuurhistorische Vereniging (1976). On the deadline date (January 1st, 1981) 27 questionnaires were returned with useful information about 160 nest-boxes in The Netherlands.

3. RESULTS

In Fig. 1 the geographical location of the nest-box areas from which we received usable information is shown, as well as the percentages of the total number of nest-boxes per area. Almost all data are from the central areas of The Netherlands.

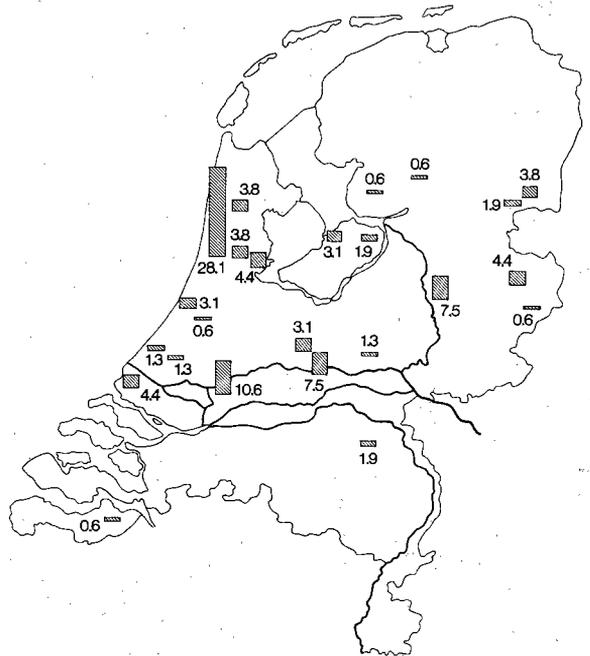


Fig. 1. Location of the nest-box areas from which data were obtained by the mail questionnaire. The bar graphs show the percentages of the total number of nest-boxes.

Fig. 2 shows some graphs with the values of the effect parameters in the 6 years. The years 1976 and 1980 were top years in breeding success while in 1976 the occupation of nest-boxes also showed a peak. The year 1978 was a relatively good year in breeding success and percentage occupation. For both effect parameters 1975, 1977 and 1979 were non-peak years. The average clutch size and average number of nestlings do not differ greatly between the years and only show an obvious peak in 1980. The percentage failures is extremely low in 1976 and 1980 and peaks in 1975 and 1978. The differences between the years imply that the data for the various years should not be amalgamated.

Correlations between the independent pa-

Table 1. Name, description and details or definition of the variables in the mail questionnaire

Dose variables	Description	Categories/classes
Accessibility	type of access of the area in which the nest-box is situated	0 = no access 1 = limited access 2 = free access
Distance	distance between the nest-box and the nearest disturbance source-/road	1 = 0— 25 m 2 = 26— 50 m 3 = 51— 100 m 4 = 101— 250 m 5 = 251—2,000 m
Visibility	can nest-box be seen from the nearest road or path	0 = not visible 1 = visible
Effect variables	Description	Definition
Percentage boxes occupied ¹	fraction of the total number of nest-boxes in a year (for which information was available) which contained a clutch	$\frac{\text{number of boxes with a clutch}}{\text{total number of boxes in that year}} \times 100\%$
Percentage with nestlings ¹	fraction of the total number of nest-boxes in a year (of which information was available) which contained nestlings	$\frac{\text{number of boxes with nestlings}}{\text{total number of boxes in that year}} \times 100\%$
Average clutch size	number of eggs per clutch	$\frac{\text{total number of eggs}}{\text{total number of clutches}}$
Average number of nestlings	number of nestlings in a box	$\frac{\text{total number of nestlings}}{\text{total number of boxes with nestlings}}$
Percentage failures	proportion of the number of nest-boxes which contained a clutch but from which no nestlings hatched	$\frac{\text{number of nest-boxes with n eggs but 0 nestlings}}{\text{total number of boxes with a clutch}} \times 100\%$
Average breeding success	number of nestlings per clutch	$\frac{\sum_{n=1}^n \text{number of nestlings}}{\text{total number of nest-boxes with a clutch}} \times 100\%$ n = nest-box with a clutch i = total number of nest-boxes with a clutch
Possible influencing parameters	Description	Categories
Nest-box type	type of nest-box which was used	0 = open (part of the front of the nest-box has been removed along the total length) 1 = closed (part of the front of the nest-box has been removed for only a part of the total length)
Fastening type	way the nest-box was fastened	0 = on a pole 1 = in a tree
Height of the nest-box	estimated height of the nest-box above the ground	1 = 3—4 m 2 = 5—6 m 3 = 7—8 m 4 = \geq 9 m
Habitat type	kind of habitat in which the nest-box is situated	1 = open field 2 = along a forest edge 3 = in a small woodlot or tree lane 4 = in a wood

¹ The mail questionnaire was designed to obtain data from all nest-boxes owned by the respondent, thus also data on nest-boxes, that were never occupied during the six years 1975—1980. Unfortunately, most respondents only sent data about nest-boxes, occupied at least once during this period. As a consequence the percentage nest-boxes occupied and percentage with nestlings are abnormally high. The real values of these two variables could only be calculated for Culemborg, Voorne and Alblasterwaard. The percentage nest-boxes occupied ranged from 16.7% to 60.0% (mean for the three areas over 1978, 1979 and 1980: 27.9%), the percentage with nestlings ranged from 10.3% to 60.0% (mean for the three areas over 1978, 1979 and 1980: 22.8%).

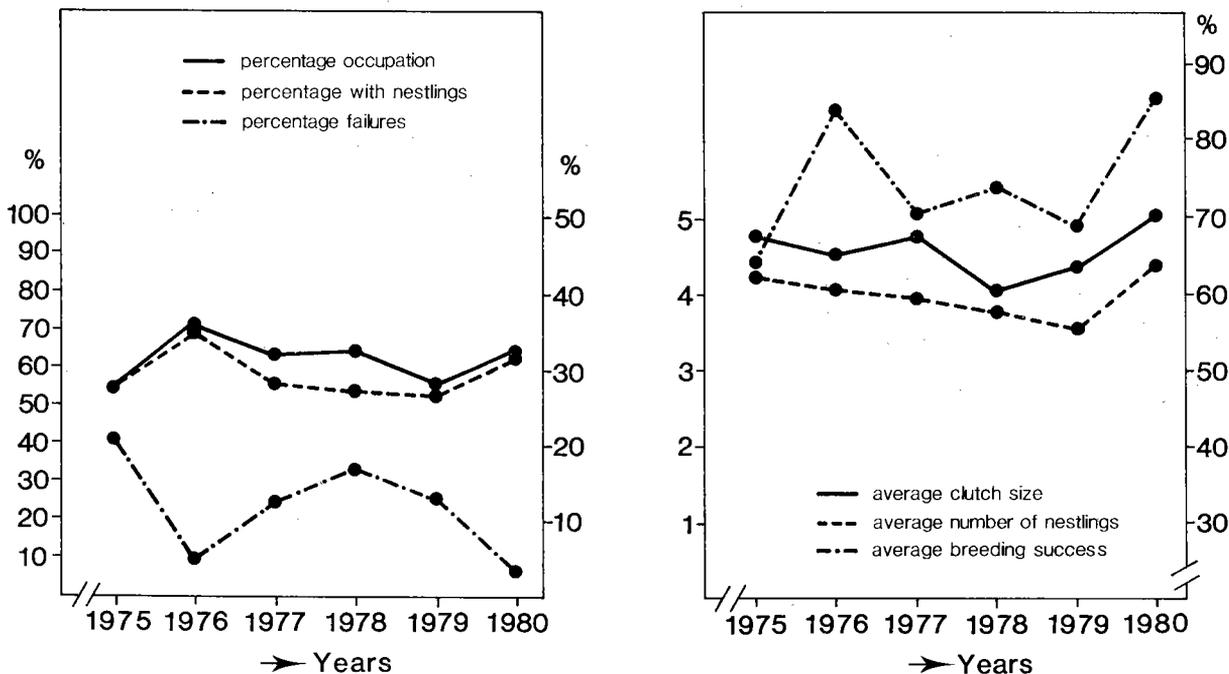


Fig. 2. Values of the six effect variables in the years 1975—1980. The left ordinates are to be used for the percentage nest-boxes occupied, the percentage with nestlings, the average clutch size and the average number of nestlings. The right ordinates are to be used for the percentage failures and the average breeding success.

rameters were calculated and it appeared that the parameters nest-box type, height of the nest-box, fastening type and habitat type are strongly correlated.

Cross tabulations have shown that 81—84% of the cases can be regarded as belonging to one of the following three categories:

- open boxes, in open fields or along woodland margins and hung below 6 m (30—35%);
- open type boxes in wooded lanes or woods, hanging at different heights (21—23%);
- closed type boxes in wooded lanes or woods, hanging above 5 m (25—28%).

We also found that the dose parameter "visibility" is correlated with accessibility and thus cannot be used as an independent dose parameter. The parameter "distance" and "accessibility" are independent of each other and can be used as separate dose parameters.

To test whether values of the effect variables differed between the three categories, the chi-squares for non-parametric variables and Students' *t*'s for parametric variables were calculated in 6 years. Because the values of almost all

effect variables did not differ significantly between the three categories there seemed to be no justification in retaining the categories. To test the effect of the dose parameters upon the effect parameters, the data from one year were thereafter used as a homogeneous population.

Subsequently, tests were run of the comparison between the values of the effect variables in the dose parameter classes. The differences between the distance intervals and accessibility classes were significant in only a few cases.

Because this might be a consequence of too low a sample per dose class the number of classes was reduced. Using information from or about the manager (or owner) of the nest-box area, we arbitrary reallocated the data of the 10 nest-boxes (29 cases) in accessibility class 1 between the classes 0 and 2: access and no access. The distance intervals were reduced to two classes: more or less than 50 m. Furthermore it seemed to be possible to amalgamate years that showed either high values or low values in most effect parameters. This distinction was believed to coincide with vole abundance (Jonkers pers. comm.). In that way vole peak years (1976,

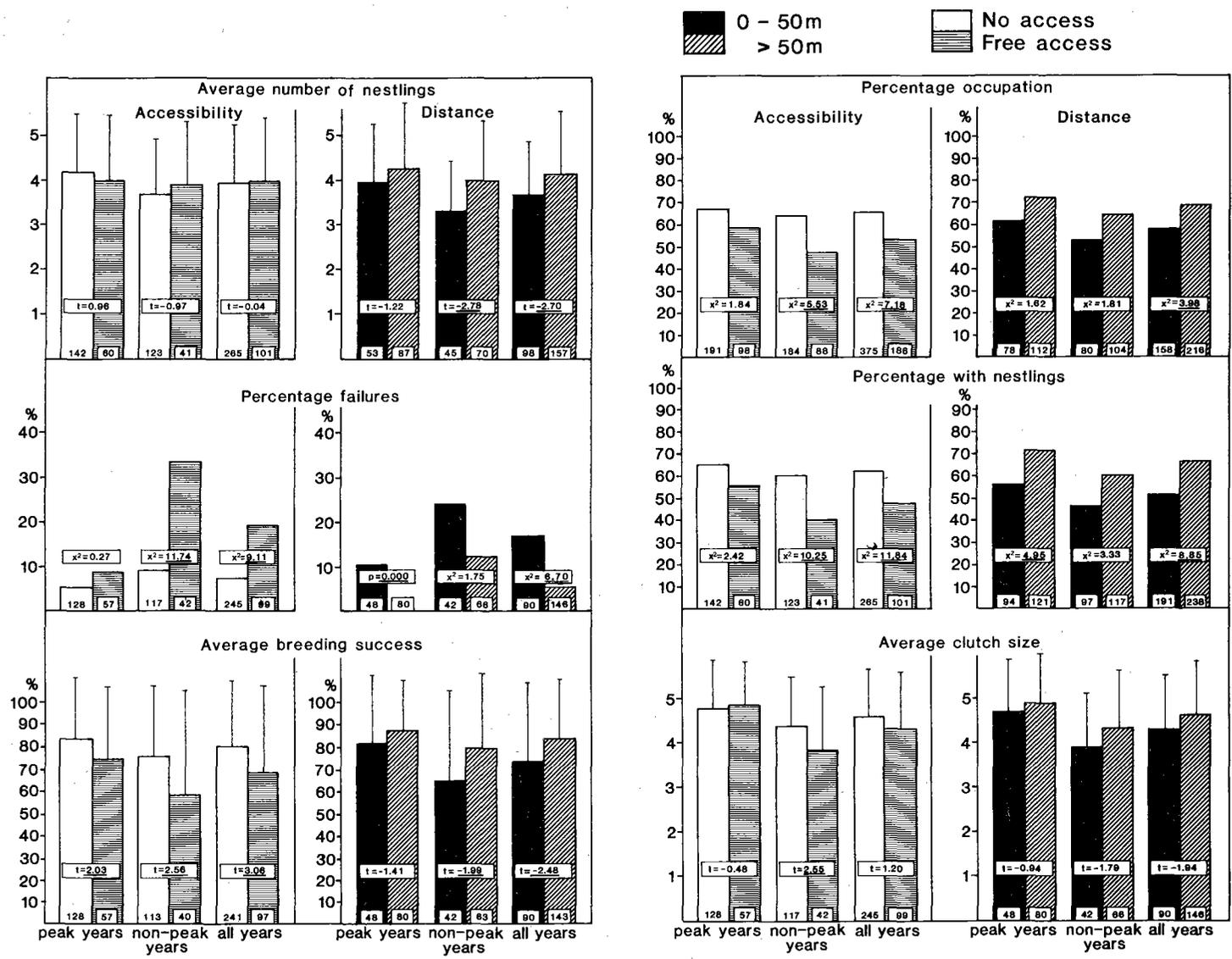


Fig. 3. The impact of accessibility and distance on the 6 effect variables in relation to vole abundance. The values of the effect parameters are presented as bar graphs for both vole peak and vole non-peak years. Significant test values are underlined ($p < 0.05$). The numbers in the bar graphs refer to the sample size.

1977 and 1980) and non-peak years (1975, 1978 and 1979) were combined.

The results of testing the differences between the values of the effect parameters in these classes are shown in Fig. 3. In this figure it can be seen that in non-peak years the differences between the "no access" class and "access" class are significant in the percentage nest-boxes occupied, percentage with nestlings, average clutch size, percentage failures and average breeding success. In vole peak years none of these differences, except in the average breeding success, nor the difference in average number of nestlings, were significant. Furthermore, the differences in the values of the effect parameters between peak and non-peak years are striking.

This last result generally also holds true for the analysis using the dose parameter distance, while here the most significant differences in the values of the effect-parameters can also be found in the vole non-peak years (Fig. 3). The percentage with nestlings, the average number of nestlings and the average breeding success in these years are in the distance class 0—50 m significantly lower than in the class > 50 m. The average clutch size tended to be higher far from a disturbance source in vole non-peak years ($0.05 < p < 0.1$).

On the other hand, it appeared that in vole peak years the percentage with nestlings and the percentage failures differed significantly in the first 50 m from a disturbance source compared with in the distance class more than 50 m.

Some results of an analysis of variance (ANOVA; Nie *et al.* 1975) are shown in Table 2. The F-values and the percentage variance explained within the effect variable are given for several factorial designs and for several subsamples of years. Eleven out of twenty seven F-values are significant, indicating that the dose variables contribute significantly in explaining the variance in the effect variables. The influence of vole non-peak years and vole peak years on the F-values for the clutch size and the number of nestlings is striking, while the general results of the analysis with the breeding success do not change when the years are split into two subsamples.

4. DISCUSSION

4.1. THE STUDY DESIGN

In interpreting the effect parameters it has to be taken into account that only data are provided from nest-boxes that had been occupied at least once during the period 1975—1980. This could imply that only the breeding results in nest-boxes which were relatively uninfluenced by disturbance were analysed.

It might be that factors which were not measured have caused the differences now ascribed to recreation intensity. Two important criteria determine the breeding density of Kestrels (Glutz von Blotzheim *et al.* 1971): an open vegetation structure in which food is abundant and available nest-sites. As far as the latter is concerned, Kestrels accept a wide range of nest-sites, from old or abandoned nests in trees to all kinds of cavities in trees and buildings, cliffs and nest-boxes at almost any height (Piechocki 1979). Habitat type was measured roughly or incomplete (by the choice of habitat types in the questions and by "measurement" of the respondents). Still, we have no reason to expect that both factors differ in value systematically between the various recreation intensity classes.

An exception must be made, however, for the abundance of food in the different nest-box areas. Some areas may differ from the general trend in food abundance probably as a result of vegetation succession or severe human influences. The results could have been biased if accessibility classes or distance intervals in certain nest-box areas were overrepresented compared with other areas. When food abundance also differs between these areas, significant differences in effect variables cannot be attributed to recreation intensity alone. Since no quantitative data were available on food abundance per area, it was not possible to correct directly for this possible bias.

Using an indirekt approach we divided the sample in two subsamples: the 5 largest areas and the others. Indeed we found significant differences between these subsamples in the access and no access frequencies. In both large and small areas, however, the differences between these subsamples in accessibility classes in per-

centage failures was significant (χ^2 values respectively 4.07, $p < 0.05$ and 4.17, $p < 0.05$), while only in large areas the average clutch sizes and the average breeding success were significantly higher in the no access class than in the access class (t-values respectively 2.72, $p < 0.05$ and 2.96, $p < 0.05$).

The results of the ANOVA analysis (Table 2) show that the percentages of variance explained in the effect parameters are low (at most 8.4—8.8%). It is well-known that the breeding density and breeding success of Kestrels can be greatly affected by vole abundance (Cavé 1968, Rockenbauch 1968, Snow 1968, Hagen 1969), which may be the most relevant cause of the variance. The 6 years can be looked upon as indirect parameters of vole abundance and the independent variable year has been introduced in the analysis of variance. Although the percentages explained variance increased somewhat as a result of this, they remained low. The variable

year had a significant effect on all effect parameters, while the conclusions, based on Table 2, were not affected.

Incorporating one of the possible influencing parameters in the analysis of variance did not produce a rise in the percentages of variances explained. Therefore it must be concluded that the most relevant factors of influence upon the Kestrel's nest-site choice and breeding success were not included, or that the scale of the dose parameters was too inaccurate to yield a high percentage of variance explained.

4.2. THE INFLUENCE OF FOOD ABUNDANCE

From Fig. 2 it is clear that the values of the effect parameters fluctuate greatly from year to year. The presence and magnitude of an effect of recreation intensity differs between years too.

Both food abundance and the availability of nesting places are known to be important fac-

Table 2. Results of the analysis of variance using several factorial designs with dose parameters as factors and effect parameters as dependent variables. F-values are given for the analysis with both factors combined, together with the percentage explained of the total variance in the effect variable, and for each factor separately corrected for the other. Significant F-values are marked with an asterisk (significance level $p \leq 0.05$)

Factorial design Accessibility and distance in 2 classes (df = 1)	Period	Factors	F-values	% explained variance
Clutch size	all years (1975—1980)	accessibility + distance	3.441*	2.9
		– accessibility	3.049	
		– distance	2.378	
	vole non-peak years (1975, 1978, 1979)	accessibility + distance	4.777*	8.4
		– accessibility	6.070*	
		– distance	1.516	
	vole peak years (1976, 1977, 1980)	accessibility + distance	0.406	0.6
		– accessibility	0.006	
		– distance	0.747	
Number of nestlings	all years (1975—1980)	accessibility + distance	2.713	2.1
		– accessibility	0.216	
		– distance	4.872*	
	vole non-peak years (1975, 1978, 1979)	accessibility + distance	3.134*	5.3
		– accessibility	0.287	
		– distance	6.128*	
	vole peak years (1976, 1977, 1980)	accessibility + distance	1.103	1.6
		– accessibility	0.968	
		– distance	0.881	
Breeding success	all years (1975—1980)	accessibility + distance	7.337*	6.0
		– accessibility	9.328*	
		– distance	2.501	
	vole non-peak years (1975, 1978, 1979)	accessibility + distance	4.991*	8.8
		– accessibility	5.590*	
		– distance	1.970	
	vole peak years (1976, 1977, 1980)	accessibility + distance	2.483	3.8
		– accessibility	3.880*	
		– distance	0.393	

tors (Cavé 1968, Glutz von Blotzheim *et al.* 1971). Since the availability of nesting places is a constant factor (a constant surplus of nest-boxes) an explanation of the results has to be searched for in food abundance, which gives rise to the following questions:

1. how can the impact of recreation upon nest-site choice be influenced by food abundance when the latter differs from year to year?
2. how can the impact of recreation upon the breeding success be influenced by food abundance, when the latter differs from year to year?

For Dutch Kestrels food abundance is synonymous with vole abundance, because their main prey is the Common Vole *Microtus arvalis* (Cavé 1968, Glutz von Blotzheim *et al.* 1971, Cramp & Simmons 1980). In this species a 3—4 year cycle in population density can be seen in the optimal habitat (Van Wijngaarden 1957). In peak years the population density can increase dramatically in little grazed and manured grasslands (their optimal habitat (Stein, 1958)) to such a level that, towards the end of the cycle they spread into suboptimal and marginal habitats (Jonkers & Van Wijngaarden 1975). At the end of the 3 or 4 years the population crashes and the next spring voles can again only be found in their optimal habitats. These cycling fluctuations are synchronous in different parts of the country.

Optimal vole habitats are difficult to find in The Netherlands nowadays (De Bruijn 1979) but a new kind of vole habitat has evolved recently: Jonkers & Van Wijngaarden (1975) state that road verges appear to be good vole habitats.

The mechanism which is likely to be active is that disturbance results in lost foraging time for which hardly any compensation can be obtained, especially in non-peak years of the vole-cycle or in suboptimal habitats.

As a result of disturbance during foraging in the period prior to the potential breeding the foraging efficiency may be so bad that the female Kestrel may decide to leave the area or not to breed at all. Both processes will result in lower percentages occupation. The disturbance effect on breeding success may be a direct consequence of poorer feeding conditions with, as a

result smaller clutches (Cavé 1968).

The effect of disturbance on the average clutch size contradicts the finding of Snow (1968) but is in agreement with the results obtained by Hagen (1969), Versluis & Verhoeven (1978) and Dijkstra *et al.* (1982).

A remarkable difference in the effects of disturbance between vole peak years and vole non-peak years can be seen in Fig. 3. In contrast to the influence of accessibility upon the percentage failures, which is largest in non-peak years, the influence of distance to road is largest in peak years. The latter phenomenon might be a result of the suboptimal habitat character of the areas further than 50 m from a road.

In non-peak years voles are only potentially abundant along the verges of roads (an optimal habitat (Stein, 1958)) but because of a high disturbance level the breeding conditions for Kestrels are also unfavourable close to the road. Far from the road disturbance is less, but the Kestrel feeding conditions are poor there which results in even poorer breeding conditions for the Kestrel, thus explaining the absence of a significant difference between both distance intervals. In vole peak years, however, voles spread from their optimal habitat and because of this the feeding conditions for Kestrels at a large distance from the road are favourable, as is illustrated by the low percentage of failures in the nest-boxes. This results in a maximum difference in percentage of failures in both distance intervals in peak years.

5. ACKNOWLEDGEMENTS

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6. SUMMARY

In 1980 a mail questionnaire was designed to investigate the impacts of outdoor recreation upon the density and breeding success of the Kestrel breeding in nest-boxes. The returned questionnaires yielded data about 160 nest-boxes in The Netherlands over the period 1975—1980. The nest-boxes could be classified according to distance from human activities, accessibility, and visibility. Nest-site choice and breeding success parameters were analysed in the various recreation intensity classes: this analysis took into account

the effects of other variables such as the characteristics of the nest-boxes and the characteristics of the nest-box area. Significant effects were found between different years, apparently closely related to vole abundance.

Summarizing the results and discussion we conclude that:

1. recreation may cause the Kestrel to avoid areas freely accessible to humans and areas approximately 50 m from sources of disturbance;
2. recreation may also influence the breeding success of the Kestrel in areas with free access to humans and in areas near sources of human disturbance;
3. the effect of accessibility is strongest in years with a low food supply for the Kestrel and is especially important during the settlement and incubating stage of the breeding cycle;
4. the effect of the distance from a source of disturbance (road) can be strong in both vole non-peak and vole peak years and is of special influence in the incubating and young-raising stage of the breeding cycle.

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8. SAMENVATTING

In 1980 is een enquête samengesteld om de effecten van openluchtrecreatie op de dichtheid en het broedsucces van in nestkasten broedende Torenvalken te onderzoeken. Van de 94 verstuurde enquêtes werden er 27 teruggestuurd met bruikbare informatie van 160 nestkasten in de periode 1975—1980. Als schatters voor de recreatie-intensiteit waren in de enquête vragen opgenomen over de toegankelijkheid van de gebieden, de afstand van de nestkast tot wegen en de zichtbaarheid van de nestkast. In de hieruit samengestelde recreatieklassen zijn de nestplaatskeuze en het broedsucces onderzocht waarbij rekening is gehouden met de effecten van relevante toestandsparameters.

Tussen de 6 jaren bleken aanzienlijke verschillen te bestaan in zowel bezetting als broedsucces, die op basis van literatuurgegevens konden worden toegeschreven aan verschillen in abundantie van veldmuizen.

De resultaten en discussie samenvattend concluderen wij dat:

1. openluchtrecreatie er toe kan leiden dat de Torenvalk vrij toegankelijke gebieden en gebieden dichter dan 50 m van een verstoringsbron mijdt;
2. openluchtrecreatie er ook toe kan leiden dat het broedsucces van de Torenvalk in vrij toegankelijke gebieden en gebieden dichter dan 50 m van een verstoringsbron negatief wordt beïnvloed;
3. het effect van de toegankelijkheid voor publiek het grootst is in jaren met een gering voedselaanbod voor de Torenvalk en vooral van belang is in de fase van territoriumvestiging en de broedfase;
4. het effect van de nabijheid van een verstoringsbron (autoweg) zowel in muizenrijke als in muizenarme jaren sterk kan optreden en vooral van belang is in de broedfase en de voederfase van de broedcyclus.