A review of the transect method by comparing it with three other counting methods to estimate rabbit (*Oryctolagus cuniculus*) density

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Abstract: In dune areas in the Netherlands, the standard method for estimating rabbit (*Oryctolagus cuniculus*) populations is by counting the number of rabbits that can be seen in the headlights of a car along standard transects. This paper evaluates whether estimated rabbit densities derived from this method represent the density of rabbits in the hinterland. Three alternative methods were employed: the pellet count, the spotlight count and the burrow count. While the transect method could only be used on the transects, the others were used on both the transects and in the hinterland and these results were compared with those from the transect counts. The burrow count did not reveal any difference in the number of rabbits on the transects and in the hinterland. While the spotlight count and the pellet count showed a significant difference with more rabbits being estimated in the hinterland. The results of the pellet count are the most reliable since the results are not influenced by disturbance or weather circumstances. The number of rabbits estimated on the transects with this method was more or less similar to the density estimates of the transect method. The pellet count showed that there were 30% more rabbits in the hinterland than along the transect. Hence extrapolation of data of the transect method to the hinterland underestimates the number of rabbits in this area. It should be noted that these conclusions are based on a situation with a very low population density and it is possible that other results will be found in situations where the population density is much higher.

Keywords: Oryctolagus cuniculus, rabbit, dunes, Meijendel, density estimation, transect method, spotlight count, pellet count, burrow count.

Introduction

Rabbits (*Oryctolagus cuniculus*) are thought to play an important role in dynamic processes in the sand dune systems both by grazing and digging. Grazing will influence the diversity of rare plant species and digging will restart succession (Olff & Boersma 1998). Therefore information about rabbit density is important for the management of a dune area. In 1984 dune managers in the Netherlands started to count rabbits using a transect method to monitor populations. This method is performed twice a year along the whole western coast. There are several standard routes, which consist of transects with a length of approximately one kilometre each. A transect is a road with verges on both sides. Two dune managers drive in a car at 20 km/h along these transects and count the rabbits they see in the headlights of the car. This is done just after sunset on eight evenings in spring and eight evenings in autumn (Kivit 1987).

In the past ten years the number of rabbits counted in this way has decreased progressively. In this period the vegetation also changed dramatically. More and more sea buckthorn (*Hippophae rhamnoides*) appeared in the dune area and grasses became very tall. The decrease in the rabbit population is probably due to two factors. First, diseases such as myxomatosis and, more recently, Viral Haemorrhagic Syndrome (VHS) have reduced the rabbit population (Olff & Boersma 1998). Secondly, the population of red foxes (*Vulpes vulpes*) has increased in the past decade. In Meijendel the diet of a fox consists of more than 80% of rabbits (Mulder 2000).

Although there is an indication that the number of rabbits has declined in the past ten years, still there remain many uncertainties concerning the number of rabbits counted. It is possible that dune managers see less rabbits due to the higher and denser vegetation. Two metres away from the road the vegetation becomes so tall that probably not all rabbits can be seen. Another possibility is that the fox has changed the behaviour of the rabbit, making them behave more cautiously (Mulder 2000). Finally it is possible that dune managers overestimate the number of rabbits present in the dune area, as verges might be attractive to the rabbits because of the low vegetation. Clarity concerning the number of rabbits in dune areas is important for the management of these areas.

In this paper we investigate whether the number of rabbits counted with the transect method is representative for the number of rabbits in areas where the transect method cannot be executed. Therefore we compared the transect method with three other methods to estimate rabbit densities.

Study area and methods

The dune area of Meijendel is situated on the coast of the Netherlands between Scheveningen and Wassenaar. This research was carried out in five sections within Meijendel between October 2001 and February 2002. These sections were replicates, each one consisting of two test areas: a transect and an adjacent hinterland (figure 1). The transect was a small part of the monitoring route on which rabbits are counted by the dune managers. The hinterland was a roadless area where rabbits are normally not counted. The vegetation of all five sections was more or less the same: exposed dune with sea buckthorn. Because the fieldwork was done dur-

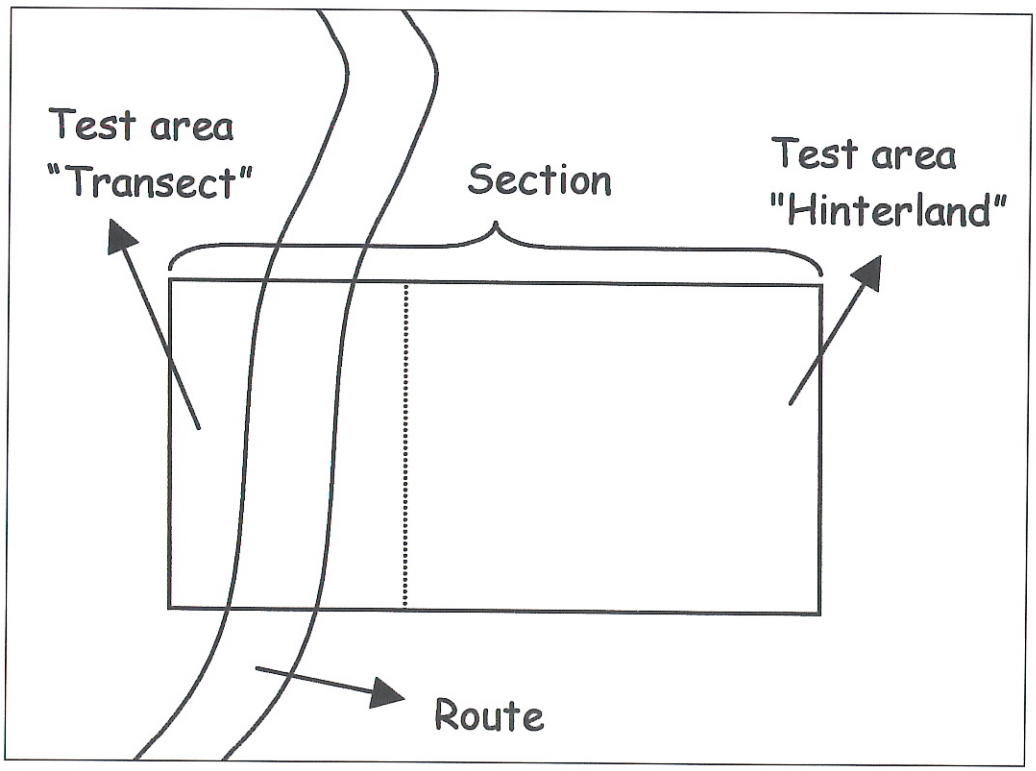

Figure 1. A visual description of a section consisting of two test areas.

ing wintertime the population could only decrease, due to predation, disease and natural mortality.

Four different methods for counting rabbits were applied in the test areas. These areas were not equal in size. Therefore each test area was surveyed with a Global Positioning System to estimate the total size in order to calculate the number of rabbits per ha.

In October, dune managers carried out the transect method (as described in the introduction) immediately after dark. This was performed again in January.

The spotlight count was carried out in the morning and in the evening during sessions lasting for one and a half-hour. Once every fifteen minutes the number of rabbits present in both test areas of one section was counted. Per section observations were performed from two fixed survey sites, one for the hinterland and one for the transect. These sessions were carried out 68 times, divided over the five sections. The spotlight count was done with a red spotlight because the retina of a rabbit is insensitive to red light (Nuboer 1971 in Wallage-Drees 1988).

For the pellet count pellets were counted and removed once a week from permanent circular plots of 3.14 m^2. Because of differences in size of the test areas ten such plots were counted in each hinterland and five plots on each transect. Plots were visited once a week, so that no pellets would decompose between counts. However, pellets could disappear because of other factors, particularly weather circumstances such as wind and rain. To determine whether pellets disappeared due to these reasons, six fenced plots were used in the same vegetation as the permanent plots. All but twenty pellets were removed and every week the remaining pellets were counted.

The mean number of pellets found can be converted to rabbit density according to the following equation (Forys & Humphrey 1997):

$$\delta = \frac{\mu}{\rho\, TA}\ 10.000$$

Where:

δ = density of rabbits (rabbits / ha)
μ = mean number of pellets / plot
ρ = defecation rate (pellets / rabbit / day)
T = time between consecutive countings (days)
A = area of each plot (m^2)
and 10.000 is expressed in m^2/ha.

To determine the defecation rate (ρ) the following experiment was performed. For five days two wild rabbits were kept within an enclosure (150 m^2) in which a burrow was situated. The fence was 1.2 m high and dug 0.4 m into the ground. There also was a wire netting on the upper side so no rabbit could escape and no fox could enter the enclosure. Every day pellets were counted and removed. Pellets were also dried and weighed to determine whether this would give a better indication of the defecation rate.

The fourth method used in this investigation is the burrow count. All burrows in the test areas, and 15 m around them, were counted. It was also noted which of those burrows showed evidence of rabbits regularly entering the burrow, and thus inhabiting them. To give a more exact indication of the number of rabbits present in each test area, two ferrets were sent into the burrows on two occasions, once in December and once in January.

Results

The transect method showed a significant decrease in the number of rabbits counted per day between October and January (Mann Whitney U-test; n=16, α=0.05, z=-3.260, P=0.00) (figure 2). On the first four count-days in January the temperature was below zero degrees Celsius and significantly fewer rabbits were counted on these days compared to eight other, warmer days in January (Wilcoxon-signed-rank test; n=10, α=0.05, z=-2.403, P=0.016) (figure 3). The results which were influenced by frost were removed from any further analysis.

With the spotlight count significantly more rabbits were counted in the hinterland compared to the transect (Wilcoxon signed-rank test; n=68, α=0.05, z=-2.483, P=0.013). This is only signif-

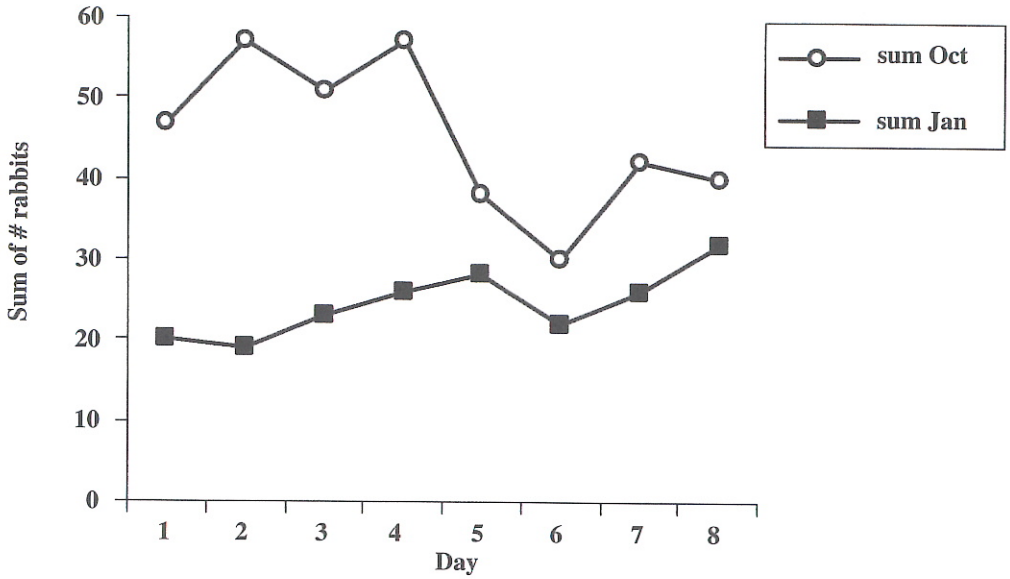

Figure 2. Total number of rabbits from ten transects counted with the transect method during eight counting days in October 2001 respectively January 2002. These eight counting days were divided over three weeks.

icant when the results of all sections are combined. Individual sections showed very different results, despite the similar vegetation. No significant difference was found between the number of rabbits observed on rainy days and dry ones. There also was no discernible effect from wind on the number of rabbits observed. In one of the sections, observations were performed from an observation hut for the test area transect after nine sessions. No rabbits were observed until observations were done from the hut. Apparently, observers turned out to be a disturbing factor (figure 4).

The pellet count showed that, on a weekly basis, there were significantly more rabbits in the hinterland than on the transect (t-test; n=45, α=0.05, t=-2.383, P=0.04) (figure 5). A mean difference of 30% was found. During the survey period, the population density declined significantly by 42%, and this decline was especially notable during the first month of November (figure 5). Weekly counts appeared to be a good time interval, as the fenced plots showed that the number of pellets that disappeared were negligible. The mean defecation rate of a wild rabbit turned out to be 335 pellets per day, although daily numbers of pellets fluctuated enormously. On three consecutive days 483, 953 and 573 pellets were counted from two rabbits.

There was a linear relationship between the number of pellets and their weight (figure 6). Thus their appears to be no difference between the number of pellets or the total weight of these pellets as an indication of the defecation rate.

The results of the burrow count showed no significant difference in the number of rabbits on the transect and on the hinterland. The rabbits in the burrows were caught and this showed that only 20% of the burrows were inhabited. There was a large difference in numbers of regularly entered burrows, identified by footprints or fresh pellets, and inhabited burrows where rabbits were caught by the ferrets. Some burrows seemed to be inhabited but no rabbits were caught either in December or January.

Discussion

The methods used showed differences in the density estimates of rabbits living in the transect

and hinterland areas. During the spotlight count significantly more rabbits were counted in the hinterland. However, disturbance caused by the investigators seems to have lead to an underestimation of the rabbits on the transects (figure 4). These counting areas were smaller than the hinterland counting areas and therefore the disturbance had probably more impact on the transects. In retrospect, observations across all sample areas might better have been taken from huts or hides to undermine the possible effect of disturbance across all test areas in all sections. Wind and rain appeared to have no significant effect on the number of rabbits counted, although more rabbits were observed with a very strong wind (wind-force larger than 6 beaufort). Gibb et al. (1978) found an opposite effect: less rabbits were seen with a strong wind. This difference might be further evidence for the disturbance-effect. Strong wind makes it harder for rabbits to hear in the direction the wind is coming from and therefore the effect of disturbance is decreased. Twigg et al. (1998) also found no significant effect of wind and rain.

The pellet count method also showed more rabbits to be present in the hinterland. The pellet counts provide a basis for calculating the numbers of rabbits present. This calculation requires an assessment of the number of pellets produced in one day. We estimated a mean production of 335 pellets per day. Forys (1997) found a mean production of 171 pellets per day in February 1991, based on the production of a wild rabbit captured in a cage for 24 hours. It is unclear whether or not the defecation rate of a rabbit is changed by stress or different food due to capture and entrapment. It is also possible that normally, rabbits produce some pellets under the ground and these pellets are also counted when a rabbit is captured in a cage. Both these factors were minimised in this investigation by making use of a semi-natural situation: counts of pellets in an enclosure around a burrow with two rabbits.

The burrow count showed no difference in rabbit density between the transect and the hinterland. The ferrets twice searched the burrows but the total number of rabbits found by the ferrets per test area was less than the highest number of rabbits observed by the spotlight method. It was expected that the ferrets would catch more rabbits than there were observed by the spotlight

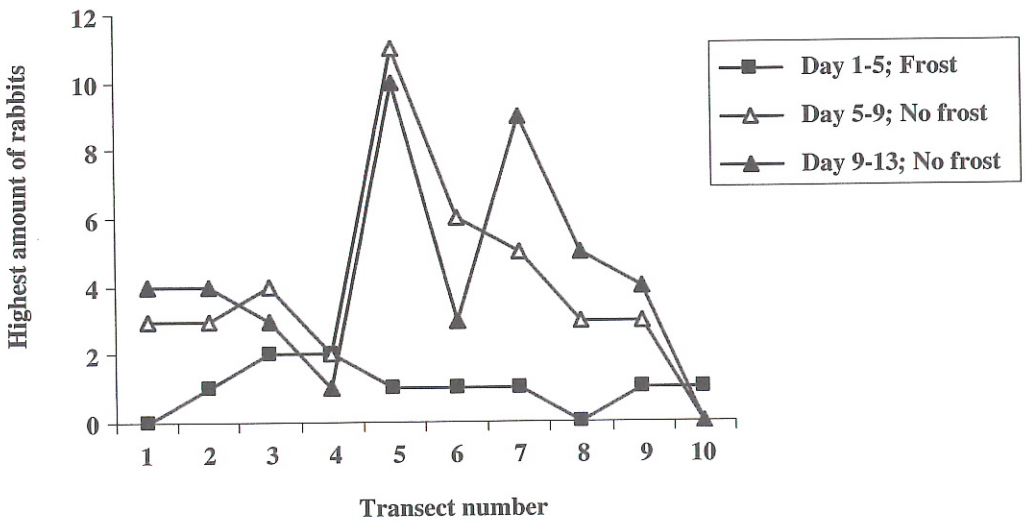

Figure 3. Highest number of rabbits observed per transect with the transect method during three time-periods in January 2002. The temperature during the first time-period "Day 1-5" was below zero. During two other time-periods the temperature was above zero.

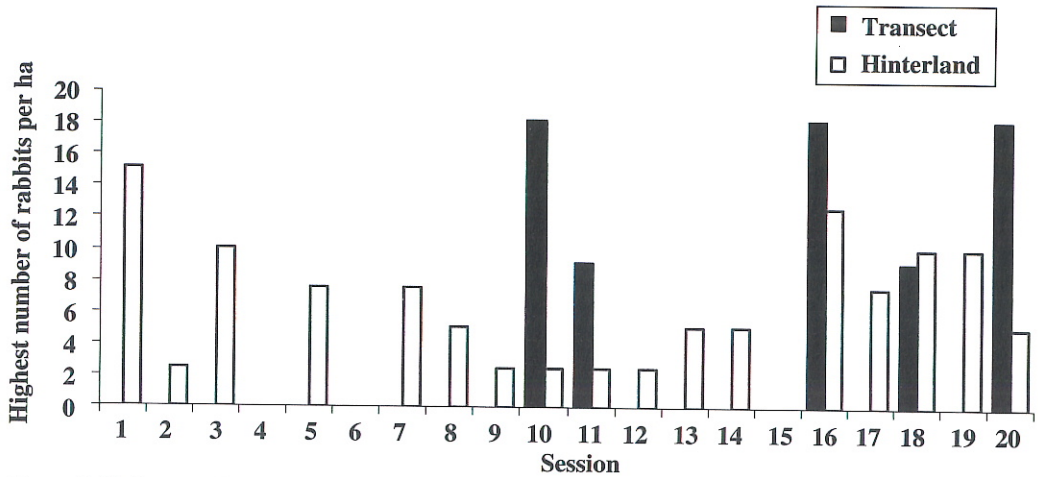

Figure 4. Highest number of rabbits per ha for sections 6A calculated according to the results of the spotlight count. After nine sessions observations on the test area transect were done from an observation hut.

method. During the spotlight count not all rabbits present in the test areas would probably be active at the same time, and thus would not all be counted. All rabbits were presumed to be inside their burrows at the time of performing the ferret method, for this reason it was expected that the ferrets would catch them all. However, the opposite was found. The number of burrows in which rabbits were caught was far less than the number of burrows which showed evidence of use. It is possible rabbits do not just use one burrow for living, but also enter other empty burrows. This was already described by Dunsmore (1974), who witnessed individual rabbits use more than one burrow. Further, not all rabbits may have been underground at the time of catching. Another

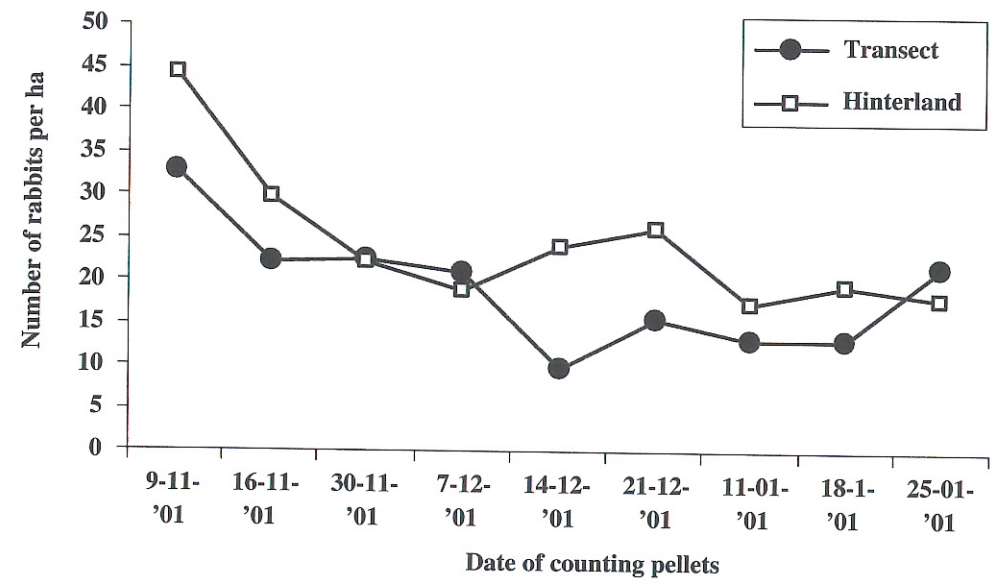

Figure 5. Number of rabbits per ha calculated with the results of the pellet count.

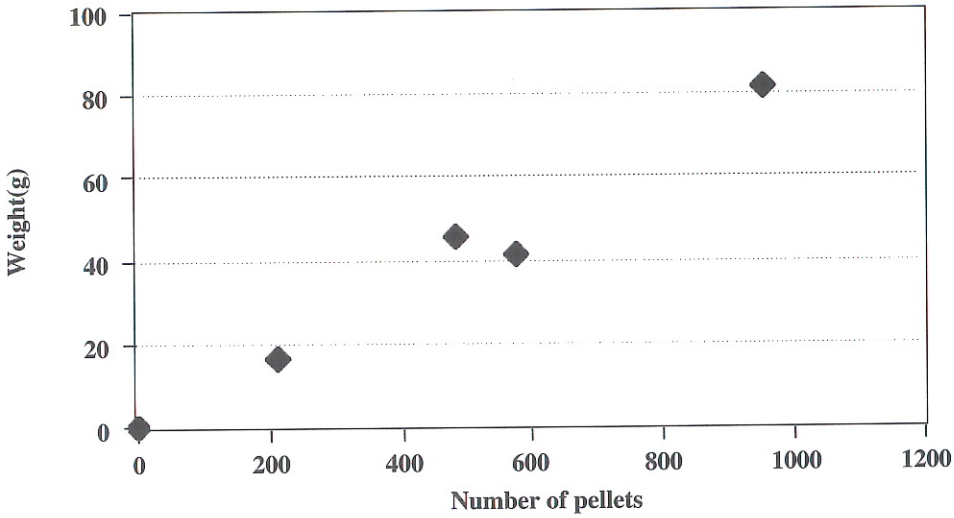

Figure 6. Relation between the number of pellets produced per day by two rabbits, and their dry weight.

possibility for the differences found is that the ferrets did not chase out all rabbits present in a burrow.

The pellet count seems to be the most reliable method in this investigation for calculating rabbit density in different test areas. Calculations of the number of rabbits along the transects, based on the pellet counts, were similar to the number of rabbits counted with the transect method. Both methods show a decline in rabbit density during the four months of fieldwork. The pellet count showed a decline of 42% and the transect method a decline of 55%.

According to the pellet count there seemed to be 30% more rabbits in the hinterland than along the transect. When we compare these results with the transect method we can conclude that, although the transect method seems to give a good indication about the number ofrabbits present on the transect, extrapolation of such data to the hinterland underestimates the number of rabbits in this area. The transect method is suitable for providing information about population trends (Olff & Boersma 1998) but is less suitable for giving an indication of the total number of rabbits present in an area. Pellet counts appear to be more appropriate for this purpose. Other methods such as the capture-mark-recapture or capture-mark-resight methods may also be appropriate. It should be noted that these conclusions are based on a situation with a very low population density and it is possible that other results will be found in situations where the population density is much higher.

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Samenvatting

Een beschouwing van de transect-methode door vergelijking met drie andere telmethoden voor het bepalen van konijnendichtheden

Het konijn (*Oryctolagus cuniculus*) speelt een belangrijke rol in het dynamische duinmilieu. Door haar begrazing en graafactiviteiten wordt verruiging van het terrein tegengegaan en krijgen plantensoorten van vroege, open successiestadia een kans om voor te komen. Dit verhoogt de diversiteit. Om het duin zo goed mogelijk te kunnen beheren zijn duinbeheerders in 1984 langs de hele Nederlandse vastelandskust begonnen met monitoring van de konijnenpopulatie. Dit gebeurt door middel van de transect-methode. Hierbij worden acht avonden in het voorjaar en acht in het najaar vaste transecten afgereden met een auto. Het aantal konijnen wordt genoteerd dat in het groot licht van de koplampen van de auto gezien wordt. De laatste jaren nemen deze aantallen steeds verder af. Tegelijkertijd neemt de verruiging van het terrein toe. Hiervoor zijn in 1990 grote grazers ingezet die het duin open moeten houden.

Onduidelijk is welke konijnen er precies geteld worden met deze transect-methode. Beheerders vragen zich af of de getelde aantallen representatief zijn voor de aantallen die zich in het achterland bevinden, het aangrenzende gedeelte van het duin waar niet geteld wordt vanuit de auto. Getracht is met dit onderzoek een antwoord te vinden op deze vraag. Hiervoor zijn in het duingebied Meijendel, gelegen tussen Wassenaar en Scheveningen, vijf secties geselecteerd, bestaande uit een proefvlak op het transect en een proefvlak in het direct aansluitende achterland. Op deze delen zijn de volgende vier telmethoden toegepast: transectmethode, keuteltelling, zichttelling en burchtentelling. Omdat het achterland onbegaanbaar is met de auto is de transectmethode alleen op de transecten uitgevoerd. De andere drie methoden zijn zowel op het transect als in het achterland tegelijkertijd uitgevoerd zodat een vergelijking kan worden gemaakt tussen deze twee proefvlakken.

De verschillende methoden laten geen eenduidig beeld zien van een mogelijk verschil in aantal tussen transect en achterland. Daarom is gekeken naar de methode die het minst gevoelig is voor verstoring en dus de meest betrouwbare resultaten geeft. Dit is de keuteltelling en uit deze methode blijkt dat er zich 30% meer konijnen in het achterland bevinden. Hieruit blijkt dat extrapolatie van data van de transectmethode naar het achterland tot een onderschatting van de konijnendichtheid zal leiden. De konijnenaantallen zijn momenteel zeer laag en er zouden andere resultaten gevonden kunnen worden bij hogere dichtheden.

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