FORVISITS: modelling visitor flows at a regional level

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Abstract: The Netherlands Environmental Assessment Agency (MNP) is trying to develop a coherent set of indicators to monitor nature areas in the Netherlands. One of the proposed indicators is the recreational use of nature areas. Besides indicating the social value of a specific area, recreational use may be also be used as input for modelling habitat quality, another MNP-indicator. Recreational use itself is likely to depend on the attractiveness of the area, such as its scenic beauty. This attractiveness is yet another MNP-indicator. Because the MNP wants a national overview of the recreation use of all nature areas, on-site monitoring is not a feasible option. Therefore we have started to develop a model to predict the number of recreational visits to forests and nature areas: FORVISITS. Although the model is still in its early stages, a first nation-wide application has taken place and will be presented.

Background

The MNP indicator framework

To assist policy makers in their decision-making, the Netherlands Environmental Assessment Agency (MNP) is developing a framework of indicators to assess the quality of nature and landscape. These indicators have to provide easy understandable and objective scientific information on the state of the natural environment. For eleven themes indicators are under development. One of these themes is recreation. Indicators for recreation have been developed into two directions. The first and main indicator for recreation deals with recreation as a goal in itself: to provide the Dutch population with enough nearby opportunities for outdoor recreation in a natural environment (RLG 2004). The initial development of this indicator has already been reported elsewhere (De Vries & Goossen 2002a). The second indicator, and the topic of this paper, deals with the recreational use of natural areas. This is thought to be important for the ecological functioning of the area. The intention is that the indicator can be used as input for ecological models. In this sense this second indicator is more a part of another theme within the MNP-framework: conditions for bio-diversity.

The link between the 'recreational use'-indicator and the main recreation indicator is that, as much as possible, both will use the same data set and basic assumptions as input. Beyond that, they are developing in quite different directions. The main recreation indicator is quite normative in nature and leads to judgements on for which residential areas the local supply of outdoor-recreational opportunities is too small to accommodate the local demand. The present indicator, on the other hand, is intended to predict the actual usage of forests and nature areas as well as possible. Of course this intensity of recreational use also supplements the main recreation indicator, in that it signifies the social function of specific natural areas.

Besides the link with ecological models behind the 'conditions for bio-diversity' theme, the recreational use indicator also has a link with yet another MNP-theme: landscape appreciation. The indicator for landscape appreciation is intended to also function as input in the model behind the 'recreational use'-indicator. It is thought to be an important part of the recreational quality of a natural area, and thereby influence the usage of this area. At a more abstract level, it may be partly by way of visits to natural areas that people (learn to) appreciate nature. In this way the present indicator may also be relevant for a fourth theme within the MNP-framework: social support for nature and landscape. However, this latter relationship has not yet been formalised within the MNP-framework.

Scale of the model and other models

The fact that the FORVISITS-model is to be used at a national level has certain consequences. For one thing, given the information available in national GIS-databases, the model is relatively simple, as well as coarse. In this respect it clearly differs from other models that aim to describe/predict how visitors move about in a specific natural area (see e.g. Gimblett et al. 2000). Such a more detailed model is also under construction for the Netherlands, and has been given the name MASOOR: Multi-Agent Simulation Of Outdoor Recreation (Visschedijk & Jochem 2002). The FORVISITS- and the MASOOR-model can be combined, in that the first provides input for the latter. The FORVISITS-model generates numbers of visits for each access point of a natural area, at which point the MASOOR-model takes over and models how the visitors distribute themselves over the area during their visit.

The only other model for visits to natural areas that has been applied nationally is the one developed for Denmark by Skov-Petersen (2002). His model deals with car-born visits only, as does the FORVISITS-model, at least up till now. In the remainder of this paper we will point out some other similarities, but also differences with this Danish model.

The FORVISITS-model

In this paper a first attempt to develop a specific indicator for recreational usage of natural areas is presented. The Assessment Agency would like the indicator to be available for all natural areas within the Netherlands. It also desires the indicator to be suitable for monitoring purposes. These two requirements bring along certain conditions with respect to the way the indicator is operationalised. For example, the fact that the indicator should be available for all natural areas within the Netherlands makes field studies as a way to determine the number of visits infeasible, because the associated costs are prohibitively high. That is why it was decided to try to model the recreational use of natural areas. However, the two requirements with regard to the indicator also have consequences for the way the model may be developed. Because a nation-wide application of the model is desired, the data needed as input should be easy to collect, or preferably, already be available nation-wide. To be able to use the indicator for monitoring purposes, these input data should be updated regularly, always in the same, standardised way. Below we will show how these requirements have shaped the form that the model has taken thus far.

The model developed to generate the 'recreational use'-indicator has been termed FORVISITS. At this time, the model only deals with visits made to a forest or nature area by car, with the intention to go for a walk in the area. Furthermore, up till now only visits originating from local residential areas are taken into account. In other words, the model covers only a part of the recreational usage. Other parts concern visits to natural areas made by other means of transport (by bicycle, by foot) and visits originating from holiday resorts (campgrounds, bungalow parks).

The FORVISITS-model is an adaptation of an earlier model developed for regional application (De Vries & Goossen, 2002b). The model distributes the visits to forests and nature areas originating from a residential area to destination areas in the local choice set. The local choice set is defined as all destinations within a given airline distance of the residential area. In the national application this action radius was set at 15 kilometres. Empirical data show that on average about 75% or more of the local visitors of a given forest live within this range (Segeren & Visschedijk 1997, Visschedijk 1997). For all destinations within the choice set of a residential area, the attraction value is calculated. This attraction value is based on three components:

– distance by road from residential area to destination area
– size of the destination area
– recreational quality of the destination area

We will discuss each of these components in more detail.

Distances between origins and destinations

Distance, or even better, travel time, is known to have a considerable influence on the probability and intensity of visitation (Brainard et al. 1999). Distance has already an important effect within the model, in that it determines the local choice set: destinations outside this set will be ignored (with regard to the residence at hand). But also within this choice set distance is assumed to play a role. Because we are dealing with rather short trip distances, the road network needs to be quite complete and have a high level of spatial detail. On the other hand, because the model has to be applied nation-wide, the road network also needs the cover the whole of the Netherlands.

The digital road network we used, was the National Road Database (NWB). This is a highly accurate spatial database (scale 1:10,000) that is updated several times a year. However, this network does not include the type of road for each segment, nor the average speed that can be travelled by road segment. The first is needed to ascertain that the road segment is accessible by car, the second to determine travel times. The first problem was solved to a large degree by transferring information on the type of road from another database, Top 10 Vector, to the NWB-database, although this involved a rather complex GIS-analysis. The latter problem was not solved, precluding the use of travel times within the model.

To determine the road distances from origins to destinations, the location of both need to be identified. For the origins the midpoints of neighbourhoods as distinguished by Statistics Netherlands (CBS) have been used. The Netherlands is divided into over 10,000 of such neighbourhoods, together covering the whole of the Dutch land area. The size of a neighbourhood is about 340 hectares on average, but tends to be smaller in towns and cities and larger in the countryside. This spatial unit is convenient because, besides being quite small, also information on the population is nationally available at this neighbourhood level. We will return to this when we describe how we arrived at the total number of visits originating from a given place of residence. For the distance analysis, the centroid of the neighbourhood is snapped to the nearest road in the network database.

Destinations and their access points

The identification of the access points of destination areas posed a more difficult problem. In the previous regional application (De Vries & Goossen 2002b) maintenance units were used as destination areas. For most of these maintenance units, e.g. the ones of the National Forest Service, information was available on where the parking lots were located. For the remaining units the access points were determined by hand. At a national level, this proved to be too laboriously. Therefore a different approach was used. To start with, destination areas were defined as all forests and/or nature areas within the spatial land use database of Statistics Netherlands, over 5 hectares in size. Sometimes natural areas are fragmented by roads etc. Areas that are located within 500 metres of each other are defined as one destination, with one exception. Motorways and highways were considered not to be crossed by visitors. If a motorway of highway ran through a destination area, it was split up using the road as a borderline. The whole operation resulted in a data set with over 1800 (concatenated) destination areas, with an average size of about 250 hectares.

The network analysis used to calculate road distances requires points rather than polygons as input. Access points of the destination areas, or 'pseudo parking lots', were determined by an automated procedure based on the following rules:

– destination areas can only be accessed by local roads, not from a highway or motorway
– a local road has to penetrate the area at least 10 metres in order to create an access point
– if a road cuts the recreational area multiple times, only the two outer access point will remain
– access points have to be situated at least 500 metres Euclidean distance apart; if not, the access point closest to the centre of the area will be removed
– the size of the destination area divided by the number of access points should be above 25 hectares; if not, the access point closest to all other access points will be removed, until this criterion is met
– if no local road is accessing the destination area, then the centroid of the polygon representing this area is snapped to the nearest local road

The whole procedure was aimed at arriving at a minimum number of access points that still would give a good estimate of the distance by road to the destination area at hand. Too few access points are likely to lead to an overestimation of this distance, and too many access points to a underestimation. The total number of resulting access points was about 8000, which implies an average of about 60 hectares of destination area per access point.

The same problem was addressed in a different manner by Skov-Petersen (2002). He used the nodes of the road network as a sort of access points in his model. Natural areas within a certain distance of such a node (including end nodes) were uniquely assigned to this node. The main differences between the two approaches seem to be that we explicitly created new nodes to serve as access points, but on the other hand did not consider all nodes to be access points.

Other characteristics of destinations

In the model the size of a destination area is an important factor. The assumption is that, all things being equal, each *hectare* of destination area will draw the same number of visits, rather than each destination area. In the next phase of the analysis each access point will be considered a separate destination, competing with other destinations. Therefore it is necessary to determine the size of the part of the destination area that may be considered to 'belong' to the access point. In this first application it was decided to simply divide the size of the destination area equally over all its access points.

Besides road distance and size, the third factor determining the attraction value of a destination within the model, is its recreational quality. The quality figures were taken from a study by Goossen and Langers (2000). They developed a GIS-based model to assign quality scores to each 500x500 metres grid-cell of countryside within the Netherlands, per recreational activity. Obviously we used the figures for walking. Aspects included in this quality score are type of land use, density of recreational infrastructure (paths and quiet roads), relief, banks & shores, tranquillity, and distance to nearest city. The relative importance of these aspects was determined by a survey among walkers, using a conjoint measurement method. The quality score for a destination area was defined as the average score of all grid-cells covered by this area. So, each access point of a destination area got the same quality score. This completes the input for the destination side of the model.

Visits originating from residential areas

As already mentioned, neighbourhoods are used as the smallest unit of origin. For each neighbourhood the number of inhabitants is available. This is an important factor in estimating the number of forest and nature visits originating from each neighbourhood. The other element that is needed, is the number of these visits per person. At this time, this number is still independent of the local supply of destination areas. For simplicity's sake, we make the (unrealistic) assumption that an individual makes the same number of visits, regardless of whether there are many attractive destinations nearby or not.

In a previous, regional application the population was subdivided into five segments that differed in their average number of visits (De Vries & Goossen 2001). This segmentation was largely based on age, family-stage and socio-economic status. However, it appeared that the segmentation had little effect on the number of visits to different destinations. The reason for this is that local populations tend to be quite mixed in their composition according to these segments (see also De Vries 2000).

Combining data from different sources, we estimated that the actual number of visits to forests and nature areas (as opposed to retrospectively reported) is about 13 visits per year on average (De Vries & Goossen, 2002b). Based on the monitoring of visits to several forest areas (Segeren & Visschedijk 1997), it is further estimated that of these 13 visits, on average roughly 8 visits are made by car.

The distribution function

To start with, we already mentioned that the number of visits to a destination area is assumed to be directly proportion to the size of the area. Every else being equal, every hectare of natural area is assumed to draw the same number of visits. This leaves the two other factors to determine differences in the density of visits: recreational quality and road distance. As for recreational quality, we assume that the distribution of quality scores is more or less normal. This implies that a score of 10 out of 10 is much less common than a score of 7. To model this feature, we decided to make the attraction value of a destination proportional to the square of its quality score. This implies that the attraction value of a destination with a quality score of 10 is four times as high as that of a destination with a score of 5.

As for distance, functions with very high distance decay are quite common in the literature (see Sen & Smith 1995, p. 93). However, in some models competing destinations are not explicitly taken into account (see e.g. Brainard et al. 1999). This means that the distance function has to take care of intervening opportunities also. The number of such opportunities may be expected to be more or less linearly related to the size of the area that is within the reach defined by the distance to the destination under consideration. This makes a quadratic function quite reasonable in those cases. However, in our case the competing destinations are explicitly taken into account. Furthermore distance already has a quite strong effect in the sense that the local choice set for an origin only includes only the destinations within a range of, in this application, 15 kilometres.

A study by Ploeger et al (2000) suggests that once people get in their car, they seem to be quite willing to drive somewhat further to go to a more attractive destination. There is also other evidence that Dutch people are quite willing to travel a considerable distance to visit a forest area (De Vries 2000). Therefore we decided to make the attraction value of a destination inversely proportional to the square root of the road distance between origin and destination. So, within the 15-km radius people are expected to be quite sensitive to the quality of an area. Together the proposed relations lead to the following function for the attraction value of a single destination:

$$A_{ij} = (S_i * Q_i^2) / \sqrt{(D_{ij})} \qquad \text{Equation (1)}$$

with:
- A_{ij} - attraction value of destination access point i for origin j
- S_i - size of destination area assigned to access point i
- Q_i - quality score of destination area assigned to access point i
- D_{ij} - distance by road from origin j to destination access point i

Within the model, the number of visits from a given origin to this destination is proportional to the size of this attraction value:

$$V_{ij} = V_j * (A_{ij} / A_j) \qquad \text{Equation (2)}$$

with:
- V_{ij} - annual number of visits to access point i originating from origin j
- V_j - total number of visits per annum originating from origin j
- A_{ij} - attraction value of destination access point i for origin j
- A_j - sum of attraction values of all access points in the local choice set of origin j

Because an access point may receive visits from several origins, the final step is to sum the number of visits for all origins that have this destination access point within their choice set.

$$V_i = \Sigma_j (V_{ij}) \qquad \text{Equation (3)}$$

with:
- V_i - annual number of visits to access point i
- V_{ij} - annual number of visits to access point i originating from origin j

The model is kept quite simple in the sense that calculations can be made for each origin separately: there is no interaction between origins. The number of visits to a destination is not limited in any way, nor is the attraction value of a destination influenced by the number of visits it has already received.

Skov-Petersen (2002) used more detailed information on the number of visits per origin. He divided the total number of visits over four (travel) time bands, and within these time bands over type of natural area (forest, beach, etc.). This distribution was sensitive to the local supply situation, in that if a type of natural area was not available within a certain time band, the number of visits was set to zero. At the same time, the average number of visits to this type of area within the time band was increased for the people that did have the resource available, in keeping with the national total number of visits. As a consequence of this approach individuals are assumed not to compensate for the lack of a certain type of natural area within a time band, neither with visits to another type of natural area, nor with more visits in other time bands to this type of area. This seems a clear difference with the present model, in which different types of natural area at different distances all compete with each other, as long as they are included in the local choice set.

Results of national application

At first instance the model generates results for each destination access point. Since these access points, or pseudo parking lots, do not really exist, the results are converted to annual visiting densities for the 'original' destination areas. The number of visits assigned to each access point of a destination area is summed, and then divided by the size of the total destination area. This gives the annual number of visits per hectare. Results for the Randstad region are shown in figure 1.

The density figures range from 0 to 19,100 per hectare per annum. Clusters of high densities can be found in the natural areas situated closely to or in between the very densely populated cities of the Randstad, a conurbantion in the west of the Netherlands. But densities are also high in the most southern part of the Netherlands. By and large this is a logical outcome, because these areas are densely populated and, certainly in the case of the Randstad, there are not many opportunities to go for a walk in a natural area (except for urban parks).

To get a better idea on what constitutes a high density of visits, we will take a look at an urban forest, the "Amsterdamse Bos", directly south of the city of Amsterdam. This area of about 900 hectares includes recreational water surfaces and many recreational facilities. Given the location of this area and its special features, it is likely to be one of the most densely visited areas in the whole of the Netherlands. The "Amsterdamse Bos" is reported draw about 9 million visits per year. This is a density of 5000 visits per hectare per year. Higher densities are unlikely to occur in natural areas outside the city limits. The model estimate for this area is about 3700 visits per hectare per year. Since the additional features of this area are not completely accounted for in the model, this too low estimate does not seem unreasonable, also given the fact that other than car-born visits by residents are not yet included in this

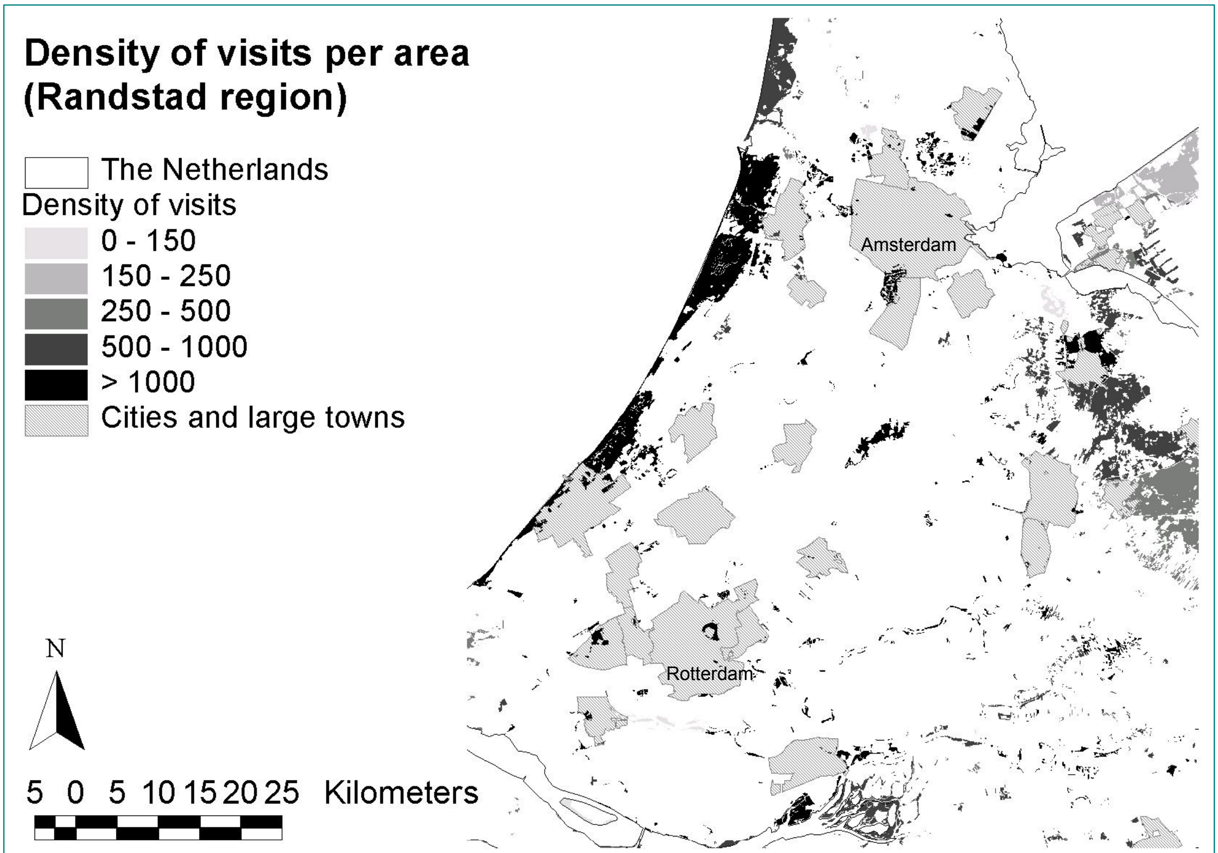

Figure 1. Density map for the Randstad region.

estimate. Given this reference, the estimates for some destination areas are clearly way too high.

The Dutch National Forest Service (SBB) has assigned recreational targets to their areas. Visschedijk (1995) estimates that the areas with the highest recreational target realise a visiting density of about 1300 visits per hectare per year on average. Based on this estimate, we concluded that certainly areas with an estimated density of over 1600 visits for car-born visits by residents only, should be areas that are well known for their recreational function. Using this density as a criterion it appeared that about 12% of the destination areas had intensities above 1600 visits per hectare per year. Of these 210 areas about 50 areas even had densities above 5000 visits. All 50 areas were located near the Randstad. And only in a few cases these areas were well known for their recreational function, e.g. the "Kralingse Bos" in Rotterdam, with an estimated density of about 13,600 visits. When looking closer at the areas with high visitation densities, it appears that they mainly are small areas within the 15-km reach of one or more cities. In fact, 62% of the 210 destination areas with visiting densities above 1600 per year are smaller than 15 hectares. From the other 1590 destination areas, with lower densities, only 44% are smaller than 15 hectares.

Also destination areas with densities below 400 visits per hectare per year were examined in more detail. About 970 of the 1800 natural areas (54%) fall into this category. By and large these areas are located in the east and south of the Netherlands, especially on sandy soils. This part of the Netherlands is more forested. Notable exceptions, with higher densities, are the southern part of the province of Limburg (most southern part of the Netherlands) and the area around the conurbation of the cities of Enschede, Hengelo and Almelo in the east. Clearly this has to do with the concentration of demand in these areas.

Also remarkable is that the well-known national park "De Hoge Veluwe" falls within this low-density category. Partly, this may be due to the visits originating from holiday resorts and campground not being included in the model yet. On the other hand, it is also likely that only a small part of this national park is subject to high visiting densities: other parts have little or no recreational infrastructure. Precisely because all visitors have to follow the (few) paths within the park, they are likely to experience the park as being heavily visited. On a per hectare basis, however, the density may not be that high at all. The estimated density is 136 visits per hectare per year. Given the size of the park, about 5000 hectares, the estimated number of car-born visits by residents is 680,000. According to the official web-site of the park, the actual total yearly number of visits is 'only' 600,000. So, the present estimate is already on the high side. It may be that the very low density of paths within the park is not sufficiently reflected by the quality score.

Conclusions and discussion

Given that up till now the model is limited to car-born visits by local residents, it is difficult to compare the estimated visiting densities with observed densities. Nevertheless, there clearly are destinations for which the predicted density is (much) too high. Since this seems to be the major flaw in the model thus far, we will briefly discuss a number of reasons for these over-estimations.

The model forces every inhabitant to make a certain number of visits. No distinction is made between different segments of the population. In an earlier, regional analysis such a distinction was made, but proved to have little effect on the outcomes (De Vries & Goossen 2001). The reason was that the composition of local population according to this segmentation was quite heterogeneously. However, there may be another segmentation that is not only relevant with regard to the number of visits made, but also spatially more segregated: autochthonous inhabitants versus inhabitants from ethnic minorities. The latter segment appears to visit natural areas outside the city limits less often (with a possible exception of beaches) and lives concentrated in the larger cities (De Vries et al. 2003). In the reported analysis this segment was assumed to make the same number of visits as the autochthonous population.

Another issue is that the local choice set may have been defined too narrowly. Fifteen kilometres is a relatively small distance and people are known to travel further. If the small choice set offers no attractive, large destination areas, people are 'forced' to visit small areas, even though they may be not very attractive. This brings us to the issue of the recreational quality of the destination areas. The method used to determine this quality, is one that has been developed for the countryside as a whole. As a consequence natural areas tend to score rather high, compared to agricultural areas. Since the FORVISITS-model focuses on natural areas, the level of discrimination may be too small. However, for more discrimination at the upper end of the scale additional information is likely to be required, e.g. on the type of forest. Perhaps also the information that already is available can be used more fully, e.g. that on the density of the recreational infrastructure.

Another issue, also having to do with discrimination between destination areas, is the fact that originally separate areas have been concatenated when not too far apart. In some cases this has led to quite extended areas. Furthermore, in this first national application each access point was given an equal share of the total size of the destination areas, as well ass the same, overall quality score. In a future application it may prove worthwhile to divide the destination area by means of Thiessen polygons, and calculate separate quality scores for each part of the destination area.

Finally the FORVISITS-model also needs to be extended to visits from residents made by bicycle or by foot, and to visits originating from holiday resorts. In some areas the latter are responsible for more than half of the total number of visits. Extending the model in this direction is important, because of the intended use of its outcomes as input for ecological models, estimating the effects of visitor density on habitat quality. What is needed, are good estimates of the absolute number of visits to specific natural areas. Clearly, we still have a long way to go, but the journey has been worthwhile thus far.

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