H. N. van Lier

Institute for Land and Water Management Research (ICW), Wageningen

Determination of planning capacity and layout criteria of outdoor recreation projects

pudoc

Centre for Agricultural Publishing and Documentation

Wageningen – 1973

UDC 379.841.6:379.841.212:65.012.2:379.841.6.004.17:301.196.5:379.841.61.006

ISBN 90 220 0445 7

The author graduated as Doctor in de Landbouwwetenschappen on 27 June 1973 at the Agricultural University in Wageningen on a thesis with the same title and contents.

Abstract

LIER, H. N. VAN (1973) Determination of planning capacity and layout criteria of outdoor recreation projects. Agric. Res. Rep. (Versl. landbouwk. Onderz.) 795, ISBN 90 220 0445 7, (xii) + 156 p., 38 tbs, 28 figs, 167 refs, Eng. and Dutch summaries.
Also: Doctoral thesis, Wageningen.

When meeting the increasing demand for outdoor recreation projects, problems arise concerning location, planning capacity and layout. A system has been developed to solve the two last mentioned problems. Special attention is paid to inland beaches in the Netherlands. To apply the system two types of models are needed: use models and weather models. In the evolved use models the visits per origin appeared to depend for inland beach recreation in the Netherlands on road distance between origin and site, inhabitants and incoming and outgoing vacationists per origin and capacity of alternative sites. Two types of weather models were constructed: statistical ones in which temperature, sunshine and wind velocity were used, and physical (heat exchange) models based in addition upon global radiation and relative humidity. The system to determine the planning capacity is based upon the curve of exceedance of visits per day for a normative year, choosing a normative day and application of the maximum momentary visit on this day. The level of this curve is calculated with use models, while the frequency of a certain number of visits per day is determined with weather models. For the normative day it is reasoned that the third most crowded day is to be used for inland beaches in the Netherlands. The maximum momentary visit on the normative day gives the planning capacity of the outdoor recreation project. A study of the behaviour of recreationists on existing projects gives insight in the border effect, the relationship between walking distances and crowdedness of elements and the distribution of visitors over the elements. Based upon these data formulae are evolved with which the area needed for the different elements, once knowing the planning capacity, can be determined. An application is given of the determination of planning capacity and areas of elements for a specific inland beach in the Netherlands.

Preface

The research on outdoor recreation sites in non-urban areas as described in this study was aided by the cooperation received from many persons.

I am most grateful to Prof. Dr R. H. A. van Duin for his clear remarks on the subject and the fruitful discussions with regard to the crucial problems of the investigation.

I express my gratitude to Dr C. van den Berg, Director of the Institute for Land and Water Management Research, for the privilege to work freely on the here presented research.

Gratefully remembered is the way in which Prof. Ir C. Bijkerk, Head Division of Land Layout, introduced this kind of research on outdoor recreation in the mentioned Institute and his encouragements during the study.

I am greatly indebted to Ir E. W. Schierbeek MSF, for his critical review of the contents of the manuscript and the thorough correction of the English text. While congratulating him with 'his' tenth dissertation, I propose to introduce the verb 'to Schierbeek' to describe the high art in technical editing.

Thanks are due to Ing. J. G. van Keulen for carrying out the field surveys in the early stages of the research and to the late Ing. H. Bergman for collecting and compiling the first data on the variables of the use models, which system was taken over in the research. I express my special gratitude to Ing. J. G. Bakker for the way he took over the field surveys and the collecting of data, for his aid with the calculations of the different models, for our fruitful discussions and his support while finishing this study.

I greatly appreciate the remarks on weather relations of Mr J. F. den Tonkelaar of the Royal Netherlands Meteorological Institute, as well as our many discussions on climatology and outdoor recreation and his aid with regard to the frequency analyses of weather values.

I am very grateful to Dr P. E. Rijtema for our discussions on weather relations and for initiating the heat exchange model and to Dr R. A. Feddes for his aid when calculating the final heat exchange models. I am also thankful to Dr M. W. A. Verstegen of the Department of Animal Husbandry, Agricultural University, Wageningen, for his remarks on the first manuscript and the heat exchange model.

I am indebted to Ir A. A. M. Janssen of the Institute TNO for Mathematics, Information Processing and Statistics, Wageningen, for the aid with and discussions on the regression analyses and the setting up of the different models, as also to Mr M. C. Huisman of the same Institute for programming and processing the calculations on the computer.

I appreciate the remarks made by Drs L. J. Locht on the economics mentioned in

this study as well as those by Ir Ph. Th. Stol on the subject of mathematics and statistics.

I express my gratitude to Miss M. G. van Steenbergen, assisted by Mrs G. van den Berg-Buitenhuis and Mr J. R. Maassen, for their calculations with regard to this study.

The accuracy and patience with which Mrs M. J. van Dijk-Janssen typed the several drafts and the final manuscript are very much appreciated. Special thanks go to Mr M. Jansen, who under supervision of Mr T. Klaassen, made the drawings.

This study would not have been possible without the cooperation of both owners and supervisors of the inland beaches investigated in the Netherlands, and neither without the field surveys executed by many students of the Agricultural University at Wageningen.

I wish to thank the Centre for Agricultural Publishing and Documentation for publishing the manuscript in its series 'Agricultural Research Reports' and Mr R. J. P. Aalpol for supervising this.

The encouragement by and patience of my wife Elly, as also her contribution to the field surveys and the drafting of the manuscript were an invaluable aid to this study.

Contents

1 Introduction

1.1 General

The demand for outdoor recreation projects in non-urban areas of highly industrialized countries is rapidly growing, in response to the change in living pattern resulting from an increase in income, leisure time, mobility, etc. This growing demand is in most of such countries, as in the Netherlands, tried to be met by the development of new recreation projects. In the Netherlands they are often created as part of multipurpose land reallocation plans in which especially inland beaches play an important role (cf. de Koning, 1965). When planning such projects, problems concerned with the determination of location, design capacity and layout of the site will have to be solved.

The determination of the right location of a new outdoor recreation project has to be based on both the physical-geographical properties of the area and the regional distribution of the demand. The design capacity of a project deals with the carrying capacity as well as the prediction of the number of visitors in the future, while the layout is concerned with the determination of number, size and combination of the different elements of the project (see for example van Lier et al., 1971).

The three above mentioned problems cannot be solved independently as they are interrelated. The layout of the project determines among other things the attractiveness of the project, which in its turn directly influences the number of visitors. In the same way the location, especially with regard to area properties and climate, will have a considerable impact on the number of people using the project.

The design capacity of an outdoor recreation project depends either on the carrying capacity of the project (what number of people with what frequency can make use of the area without destroying its natural properties) or on the planning capacity, being the calculated number of visits to the project assuming enough provisions are made (see also van Lier, 1972). In this study the calculation of the planning capacity of a new outdoor recreation project in non-urban areas will be studied. Use has been made of data gathered on existing projects, i.c. inland beaches, where interrelations of location and capacity as well as layout and capacity were constant. The projects taken were limited to those which provide facilities for day recreation only. The system evolved can be considered as a general approach for the calculation of the planning capacity of outdoor day-recreation facilities with a fluctuating number of visitors per day. In addition research was made to determine some layout criteria for inland beaches in the Netherlands.

housing and industry and 5% for woods and outdoor recreation. In the SF, a polder which will be under construction from 1970 till approximately 1985, 50% will be agricultural land, 8% housing and industrial space, while 25% of the area will consist of woods and outdoor recreation facilities.

Such an increase in outdoor recreation facilities in non-urban areas in the Netherlands can also be illustrated by the course of investment in outdoor recreation by three Governmental Services (table 1).

Table 1. Investment (in 10^3 guilders) in outdoor recreation facilities by three Governmental Services in the Netherlands from 1960 through 1970.

Year	CRM*	CD**	RIJP***	Total
1960	600			600
1961	1500		42	1542
1962	2250		88	2338
1963	3750	1000	131	4881
1964	6000	800	329	7129
1965	9000	1200	149	10349
1966	18000	1600	303	19903
1967	15400	1600	1688	18688
1968	8700	2200	3199	14099
1969	15000	3600	6114	24714
1970	21730	2100	5600	29430

* Ministry of Cultural Affairs, Recreation and Social Welfare (CRM, 1971).

** Government Service for Land and Water Use (Cultuurtechnische Dienst, 1970).

*** IJsselmeer Polders Development Authority (Van Dord, pers. comm. 1972).

Many of the non-urban outdoor recreation facilities constructed in the Netherlands are part of multi-purpose reconstruction programs of rural regions (varying in size from 5000 to 25000 ha) in which as regards recreation, scenic roads (with simultaneous agricultural or forestry use), inland beaches (primary use sand pits), picknick sites, playing fields, camp sites, facilities for sport fishing, etc. are created. In such rural reconstruction programs outdoor recreation facilities play an increasingly important role. Van Duin & Loos (1969) stated that this may go to the point where it changes from a secondary to the main purpose of a project.

In the light of this increasing demand for and construction of outdoor recreation projects in non-urban regions, the present study was carried out.

1.3 Scope of this study

1.3.1 The problem

The term recreation in the modern sense is very young. Almost all efforts to define it have been made after the Second World War, to cover the activities of people during their leisure time. As Clawson & Knetsch (1966) emphasize there is no sharp line between recreation and all other activities. The same activity may be work during some periods and recreation during other ones. This aspect is also expressed by de Bruyn (1966) who states that recreation starts when work stops. From this time budget approach arises the definition of free time of Wippler (1968) as being the total period of time which is not used for regular professional employment or other regular daily occupations, going to and returning from work, sleeping, eating and care of the person. From this he concludes that outdoor recreation is that part of the total spending of free time that is taking place outdoors.

Another way of looking at recreation is the fun character of it. This leads Clawson & Knetsch (1966) to the definition: 'recreation means activity (or planned inactivity) undertaken because one wants to do it' and Douglass (1969) to: 'recreation is the wholesome activity that is engaged in for pleasure, therefore it is play' and: 'any action that refreshes the mental attitude of an individual is recreation'. From this he concludes that 'outdoor recreation is that [wholesome] recreation that is done without the confines of a building'.

The present study covers only that part of total recreation that is taking place in non-urban areas by people who are leaving their homes, their home grounds and their towns for recreational purposes.

In this study the following terms are used:

- *recreation* is any activity a person carries out during his periods of free time (free time as defined by Wippler, 1968);
- *outdoor recreation* is that part of recreation that is carried out in the open air in non-urban areas, away from the recreationist's main dwelling.

When speaking of outdoor recreation the word 'need' is often used to express a situation in which there is a deficit in provisions and a willingness to react, apart from the fact whether this willingness leads to a particular behaviour or not (Wippler, 1966). The latter could be called a latent willingness. De Jonge (1968) expresses this as latent recreation propensities. Wippler (1966) describes need as a for completion asking deficit, seen from the point of view of the total society on the one hand and of individual persons on the other hand. It might be possible therefore that as regards total society, the 'need' for outdoor recreation provisions confronted with the already existing ones is in equilibrium or even that the sum of the capacities of the existing projects exceeds this total need, but that the individual need remains unanswered.

In this study the following definition of 'need' is used: the *need* for outdoor recreation facilities is the reaction of people to these facilities when they would be amply available. In this way defined, need is closely correlated with 'demand' in the economic sense. This makes it possible to distinguish between the demand for total outdoor recreation in a general sense or for specific recreational activities and the demand for particular provisions or projects offering recreational possibilities. In the first case the total number of actual and potential recreationists has to be determined, while in the second case the actual and potential visits to a certain project have to be considered.

Since the aim of this study is to determine the planning capacity of new outdoor recreation projects in non-urban areas, only the *demand* for a specific project will be taken into account. The demand for an outdoor recreation project with a given location and layout, is then defined as the future number of persons showing their need by using the project. In this definition need is correlated with demand by means of the *use* to be made of the project.

The term outdoor recreation project is often used to describe a facility at a specific location which creates possibilities to perform outdoor recreation. Such a project is limited either in the offered forms, or in area, or in both (see Bijkerk, 1969a and Segers, 1970). Mostly such projects do offer one main form in combination with one or more other ones. In this study the following definition is used: an *outdoor recreation project* is area-limited, located in non-urban areas and has a layout which enables visitors to carry out one or more forms of outdoor recreation.

In this context the following definition of planning capacity has been used: *planning capacity* of an outdoor recreation project is the maximum number of visits which it should be able to accommodate at any given moment, and which is used as norm to dimension the different elements of the project.

Once given the description of the terms recreation, outdoor recreation, need, demand, use, outdoor recreation project and planning capacity, the general problem dealt with in this study can be given as: with what system can the planning capacity and layout be calculated for a future outdoor recreation project for day recreationists in non-urban areas. Such a system has been evolved and it has been applied to inland beach projects in the Netherlands.

1.3.2 Solution approach

The number of visits to an outdoor recreation project is influenced by several factors. Apart from physically measurable ones, psychological factors (as experience, mentality and conformation to group attitudes) have an impact on outdoor recreation participation rates, but such psychological factors have not been included in the present research.

The physically measurable factors are partly socio-economic variables as age, sex, amount of free time, income, mobility, etc. (demand part of the problem). Some are dependent on geographical properties, as type and number of facilities, accessibility, attractivity, etc. (supply part of the problem). Two other factors, physically measurable but of a different kind, are also of considerable importance. These are the day in the week and its place in or relative to the recreational season, and the weather conditions.

The demand for outdoor recreation can be estimated by means of a mathematical model which gives the relation between a measured behaviour (expressed as activity days, occasions, etc.) of people in relation to a certain form of outdoor recreation and one or more human properties (as age, income, etc.). The outcome is also determined, however, by the possibilities to participate in outdoor recreation, which means, as said before, that behaviour in outdoor recreation is a state of equilibrium between demand and supply.

The relationship of measured behaviour with both demand as well as supply factors will be studied in Chapter 3, which leads to the construction of use models (Chapter 5).

Once having a use model, which makes it possible to estimate the future number of visits, the next step is to predict the number of times that a certain number of visits will be reached or exceeded. For given projects, regions and numbers of inhabitants, the fluctuation in day visits is caused by the kind of day and the weather. The weather cannot be predicted for a certain day, but the frequency of certain types of weather (caused by certain climatologic factors) can be determined over a period of several years and for several situations if the relation between visit and weather is known. This relation is studied in Chapter 4, while a weather model will be given in Chapter 5. Using this weather model, the frequency of number of day-visits can be predicted over an average (=normative) year. A comprehensive scheme is given in fig. 2.

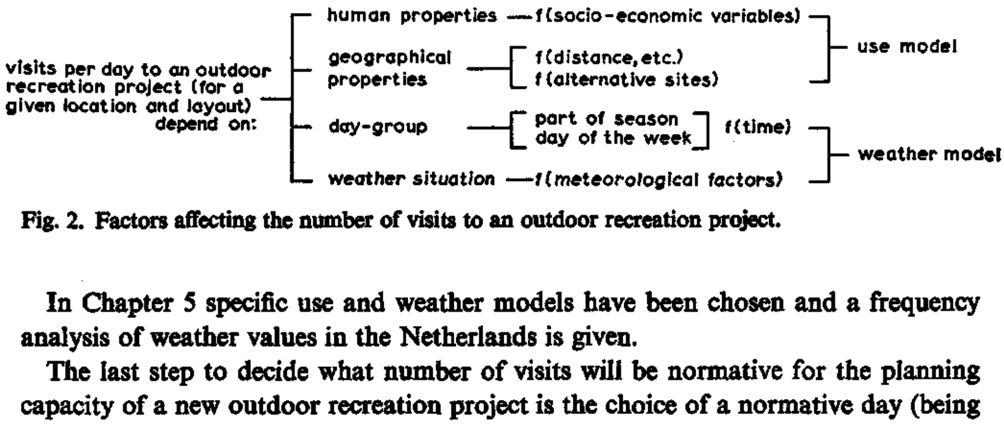

Fig. 2. Factors affecting the number of visits to an outdoor recreation project.

In Chapter 5 specific use and weather models have been chosen and a frequency analysis of weather values in the Netherlands is given.

The last step to decide what number of visits will be normative for the planning capacity of a new outdoor recreation project is the choice of a normative day (being a certain day in the sequence of decreasingly crowded days). The maximum momentary visit (the maximum number of visits at a certain moment) of the normative day is the normative number of visits. Chapter 6 deals with this, as also with data on the use of several elements of inland beaches by recreationists. An application of the determination of the planning capacity as well as the layout of a projected inland beach in the Netherlands is given in Chapter 7.

2 Model studies

2.1 General

Before choosing a model to describe outdoor recreation participation it is necessary to have an insight into the various aspects of models in general and specifically into existing prediction models with respect to outdoor recreation.

The function of models is to solve problems by simplifying intricate real situations, starting from a number of initial assumptions. According to Lambooy (1971) in physical planning sciences the task of a model is to act as a medium in forming a theory, as well as being an operational instrument to design or predict.

Models can be classified from different points of view. In economy an often used distinction is that between models describing steady state situations and those describing non-steady state situations (static and dynamic models, cf. Heertje, 1969). As most processes are dynamic it is better, when possible, to use a dynamic model. Static models are specifically important to describe the background of the process at a certain moment and place, and as such they are often used as a basis for the construction of dynamic models.

Another classification is based upon the construction-type of the model. In this context physical and mathematical models are to be distinguished. The first mentioned ones are for example scale-models (static models), electric analogue models (dynamic ones), etc. As example of mathematical models growth rate models can serve. Carson (1969) distinguishes between simulation models, analogue models, stochastic models and inductive or statistical models. An example of the analogue model in outdoor recreation is the gravity model. In this study a stochastic and physical model will be used as basis of the weather model, while the use model is a statistical one. Other classifications have been based upon the situation or subject described or upon the function or purpose of the model.

In physical planning sciences one is often dealing with quantitative models. In most cases and especially in model studies concerning outdoor recreation they are of an analogue type, derived from a general physical process or even law. The most outspoken example of this is the gravitation model for recreational travel which is based on Newton's gravitation law.

Model parameters can be derived empirically by measuring the variables assumed to be of value in the description of the process, by stating a hypothetical model and then using mathematical methods (as for example regression analysis).

In this study a use-model is evolved for inland beaches from which, in combination with a weather model the planning capacity for a new project can be derived. The weather model can then also be considered to be a prediction model, a model which is constructed in such a way that it is possible to predict the magnitude of the dependent variable as a function of the known changes in the independent variables.

2.2 Prediction models

2.2.1 Various model types

The prediction models in outdoor recreation have in common that they are designed to predict the participation in outdoor recreation activities. When constructing such models some assumptions have to be made. For example, that the assumed negligable influence of a not included independent variable remains true in the future and that the given statistical relationship is of a cause-effect type (which can be a hazardous assumption).

Qualitative models give the relationship between a certain outdoor recreation activity and the factors influencing it. If a set of independent factors has a known statistical relationship with, for instance, the number of occasions people are driving for pleasure and a prediction of a future change (whether they will increase, stay constant or decrease) in these factors can be given, a prediction of the participation in this specific type of outdoor recreation can be made in a qualitative way. The amount of the predicted increase can hardly be given if a model does not fit too well (e.g. if the coefficient of determination is less than 0.6 to 0.7). This often happens when a prediction model is built for clusters of recreation activities as passive versus active ones. In this way Wippler (1968) found that in his best cases just 47.4% of the variancy in recreational behaviour could be explained by a combination of 29 variables and 44.8% by the most important 6.

For quantitative models more data are required, which for outdoor recreation is relatively easy if only a small sector of the phenomenon is taken into consideration. This can be done by studying one single activity (e.g. camping, sport fishing, walking or driving for pleasure), or by studying a limited combination of recreation activities on a given area-limited project. A model for one single activity is built to predict the number of participants in that activity and is therefore a demand model. A model built to predict the number of visits on a specific project is a use model. A special model is the gravity model dealing with the relationship (mostly called interaction) between poles: people demanding outdoor recreation facilities on the one hand and recreational areas or projects on the other hand. Such a model is constructed to predict the future recreation traffic from urbanized areas to projects (see also Studiegroep Behoefteprognosen, 1971 and van Lier, 1970).

Two limitations are always met when constructing prediction models for outdoor recreation. The first is the dealing with statistical data, which means that the model is giving a statistical rather than a descriptive relationship and therefore does not give real knowledge of the process (see Carson, 1969). The relationship is not necessarily of a cause-effect order and generally it is not known what the real cause of a certain measured behaviour is. Since human characteristics are in play it is extremely difficult to isolate the real variables which control the process.

The second limitation is the situation-bound character of the measured data. When measuring the occasions or activity-days in outdoor recreation or the number of visits to a certain project, the data are area and time limited. Therefore they are only valid for a rather small region as well as a short period of time. The area-limited character of the data is a problem particularly connected with use and gravity models. The time-limited character of the data is a limitation of all prediction models and that makes it necessary to isolate and include many variables when the model should be valid for a longer period of time.

2.2.2 Demand models

In literature the meaning of the word demand with regard to outdoor recreation is often discussed (e.g. Clawson, 1959; Ciriacy-Wantrup, 1959; Clawson & Knetsch, 1966; Daiute, 1966; Seckler, 1966; Taylor, 1969; Klaassen, 1968 and 1971 and Burton, 1971). Demand as term is used by sociologists, economists and planners (see also Locht, 1970). It is not always clear what the meaning exactly is. The different uses of the term demand can be divided into:

- demand in the meaning of potential or latent behaviour;
- demand in the meaning of actual or existing behaviour.

This difference between actual and potential demand is stipulated by several authors. Ciriacy-Wantrup (1959) states that 'use projections for land and water do not separate demand and supply conceptually or statistically'. Taylor et al. (1969) say that 'the commonly measure of park demand, visitation, is not demand at all but is, in fact, consumption'. Clawson & Knetsch (1966) mention that 'the word demand stems from its incorrect application as a description of use or consumption', in this context demand should be called 'gross attendance at facilities'. Daiute (1966) points out that for economic analyses 'usually greater technical precision in distinguishing between supply and demand' is required. Klaassen (1971) distinguishes between need and demand. In his presentation need is equal to demand at the highest point on the demand curve. At this point one can get the facility for price zero. When only travel costs are involved this demand occurs at a distance of 0 km. In the conception of Burton (1971) consumption is called demand for laymen and others, while for economists it is just a part of the real demand, called the economic demand. He makes a difference between existing demand and latent demand. Existing demand then is 'a demand which currently exists', while latent demand is 'one which, for some reason, is not effective, but which would be so in other circumstances; it is a demand which is frustrated by such factors as the non-existence of facilities'.

This last approach points to the problem of need for facilities, and shift in and or substitution of the demand. If market supply is limiting, demand defined as actual behaviour can be raised by providing new facilities. This part of the demand Burton (1971) calls the induced demand. Shifting to other identical recreation facilities is described by the same author as a diverted demand 'a demand for a certain kind of facility which is diverted from one source of supply to another as a result of the provision of a new supply', while the shift to other forms of outdoor recreation is called the substitute demand to 'completely different recreation facilities'. Summarizing, the scheme of fig. 3 can be given.

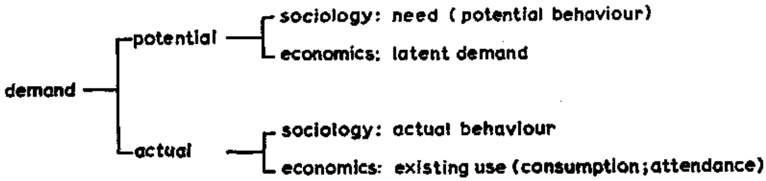

Fig. 3. Various meanings of the term 'demand' as used in outdoor recreation studies.

In the present study the term demand is taken to mean: outdoor recreational behaviour as a total or with regard to a specific form of outdoor recreation, while with the term use is meant: the behaviour of people with regard to a certain type of outdoor recreation project or to one particular project.

Since several factors are causing the demand, different levels can be distinguished, as given in fig. 4. Level I concerns the existing situation for a certain region at a certain time. It deals with human behaviour with regard to outdoor recreation at that time

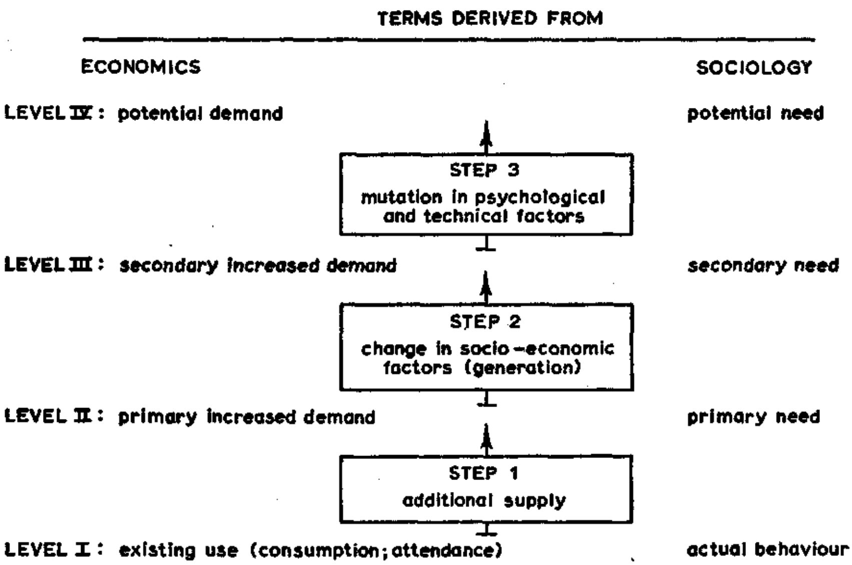

Fig. 4. Levels of demand for outdoor recreation participation.

and for that region. In the figs. 3 and 4 various terms as behaviour, demand or consumption are mentioned. In an economic sense level I would regard the effective demand (Klaassen, 1971), the consumption (Taylor, 1969) or the use (Ciriacy-Wantrup, 1959). With all these terms is meant the result of real demand and real supply which is in a state of equilibrium. In a sociological sense one is dealing with actual behaviour which is to a large extent determined by the supply. This means that the existing level of the number of participants can be raised by creating new facilities, by opening up natural areas or improving existing recreational areas and facilities; in other words by raising the supply. This is shown in fig. 4 where step 1 stands for the improvement of the supply by adding facilities. This can be done until further improvement does not influence the participation rate anymore. The new level of participation is called in this study the primary increased demand. In this approach the problem of substitution of the demand is not taken into account. The difference between level I and II can, according to Burton (1971), be called the induced demand. Level II itself can in an economic sense be called the demand, the economic demand or the real demand. In a sociological sense it can be named the existing need of people for outdoor recreation facilities, and in this study is called the primary need.

Socio-economic factors as age, income, mobility, housing, work, amount of free time, in some way, influence the participation in outdoor recreation. A change in each of these factors causes changes in participation and therefore in the demand for outdoor recreation facilities. This shift of socio-economic factors is indicated in step 2 of fig. 4, leading to the secondary increased demand. In economics this level represents the future demand, while in sociology it often is called the future need (e.g. Wippler, 1968), and here the secondary need. Level III will be reached after a change in socio-economic factors if the availability of provisions has not (again) become the limiting factor.

Step 3 stands for factors of a more psychological or technical character as changing of traditions, sudden mutations in behaviour, increased popularity of existing or appearance of new forms of outdoor recreation and technological not foreseeable changes. Some of these factors are influenceable, others not at all. It is hardly known to what extent they might influence outdoor recreation. After step 3, however, the highest or potential level is reached. Speaking in terms of economics this level is here called the potential demand, while in a sociological sense it was given the name of potential need. As shown in fig. 4 the height of level IV is the result of the three steps, namely: improvement of supply, change in socio-economic factors and change in psychological and technical factors. It is clear from these steps that the existence of facilities (supply) predominates behaviour. This supply has two major aspects:

- the accessibility of the projects or areas (travel distance, road quality, traffic congestions, etc.);
- the type of the projects or areas (their properties, accommodations, relative attractiveness, etc.).

Both aspects are of a similar importance to the supply as a whole, but attention will first be paid to the distance people have to travel from their place of residence to the recreational site or area. According to Clawson & Knetsch (1966) to use travel cost (and with that the distance) for estimating demand curves for recreation areas was probably first suggested by Hotelling (1949). Prewitt (1949) expresses this formulation while assuming that all people have identical preferences with respect to visiting a given recreation area. The decisive factor to what number of people are visiting a park is then the distance. Clawson (1959), Clawson & Knetsch (1966), Seckler (1966), Knetsch (1963, 1967 and 1970), Cesario & Knetsch (1970) and Klaassen (1971) are using the cost people have to make to get to a certain facility or area. Travel cost is considered to be a function of distance and time needed to travel from origin to destination. So in many studies factors as travel time (Clawson, 1959; Knetsch, 1967) and congestion in traffic (Sinden, 1967) are also taken into account.

In model studies distance and travel time are used as the independent variables. In these models the number of people visiting a project or area is given at different distance zones from the recreation site. The transformation of distance to time can be done by using the mean travel speed of all visitors to a site or, as is done in more refined methods, by using different mean speeds both for various types of roads (road size, type pavement, urban or rural) and for the period of travelling (working day or weekend, traffic congestions). A special problem arises if the distance is a lesser resistance factor, which can happen if the road to the project is a scenic road, giving the opportunity for people to combine both driving for pleasure and visiting a recreation site. For economic evaluations this combination of activities should be taken into account as was suggested by Clawson (1959).

In most demand studies specific properties of the site are not taken into account. In demand studies for visits to national parks in the USA the measured attendance was not related to the attractivity of the site in an absolute or relative way nor to the attractivity of competing sites. Sinden (1967) suggests to incorporate not only distance, travel time and traffic congestion, but also site attractiveness or the relative desirability of alternative sites. Clawson & Knetsch (1966) are giving five factors related to the recreation site itself. It might be expected to get a better result in explaining attendance figures if properties of the site itself as well as number and properties of alternative possibilities are used in the models. In models giving the participation rate for forms of outdoor recreation often only socio-economic variables are used as explaining factors (ORRRC, 1962a; Wippler, 1968).

Many studies have been carried out to investigate what kind of generation factors can be used to explain behaviour in outdoor recreation. It has also been tried to give an answer to the question which of these factors are most important and to what amount they are explaining the phenomenon. In ORRRC (1962a) some 18 factors are used, of which were found to be important: income, education, age, family-phase (child impedance), health, occupation, urbanization and race. For the explanation of the participation of American adults in outdoor recreation ORRRC (1962b) uses 9 factors: income, education, occupation, paid vacation, place of residence, region, sex, age (life cycle) and race. In a prospective demand for outdoor recreation ORRRC

(1962c) uses factors as income, mobility and leisure time for projecting demand through a time series. Projection of demand for selected activities is mostly based upon such factors as income, education, occupation, place of residence, age, sex and region. Wippler (1968) found the following factors to be of any use for explanation of free time behaviour in the province of Groningen (Netherlands): age, education, occupation, marital status, religion, urbanization, social status, place of residence, sex, family-size, political interest and free time. In forecasting future free time behaviour Wippler (1968) worked only with changes in educational level, urbanization, religion, amount of free time and life attitude.

The most used factor in demand studies is income (e.g. Clawson & Knetsch, 1966; Klaassen, 1968; Seckler, 1966; Gillespie & Brewer, 1968; Taylor, 1969; Douglass, 1969; Kunze, 1970; Wright & Bondurant, 1970; Burton, 1971; Duffell & Peters, 1971; Locht et al., 1971 and Tatham & Dornhoff, 1971). Other important factors are leisure time, age, sex, education, occupation and population. Aside from these factors many others were introduced. Clawson & Knetsch (1966) and Knetsch (1967) are paying attention to factors as family size, family composition, educational status and race. Incidentally used factors are mobility and urbanization (Knetsch, 1963; Kunze, 1970), experiences, tastes for outdoor recreation and place of residence (Clawson & Knetsch, 1966), social motivations (Klaassen, 1968), personality (Knetsch, 1967), communications (Douglass, 1969), opportunities (Burton, 1971), car ownership (Duffell & Peters, 1971) and travel time to work (Tatham & Dornhoff, 1971). Instead of using many factors in a prediction model it is also possible to use only one or two factors, considered to have a great influence on the dependent variables, together with a time factor which is then considered to be an 'omnibus' for the not included factors (see for instance the trend models of Almon, 1966 and Locht et al., 1971).

In U.S. Dept. of Commerce (1967) all factors influencing outdoor recreation participation are divided into three groups: physical factors (time or distance, activity-possibilities and traffic congestions), socio-economic factors (income, education, occupation, residence, age, religion, sex, life cycle, health, race and paid vacation), and other factors. With the 'other factors' step 3 of fig. 4 is introduced. They are factors directly related to the people themselves (psychological factors) as well as factors which are dependent on changes in techniques that improve or develop outdoor recreation appliances (technical factors).

Although almost nothing is known about the influence of psychological factors they are regarded to be of importance to recreational behaviour of individuals and groups. Moss et al. (1968) analyzed the relationship between recreation and personality by comparing traditionalism (with IQ as a covariate), and dogmatism and rigidity of participants and non-participants in some outdoor recreation activities (as camping, hunting, fishing, golf, basketball, etc.). The technical factors in step 3, fig. 4 also include changes in technology which have a large impact on society and with this on outdoor recreation (as for instance has been the development of the automobile and mass-motorization, the airplane and cheap charter flights).

The similarity of psychological and technical factors is that nothing is known about their possible influence on outdoor recreation. One of the differences is, however, that research might be able to give answers with regard to the relationship between psychological factors and outdoor recreation. This will be impossible for not yet known technical factors as it is not possible to predict what influence new appliances will have on participation rates of outdoor recreation. No demand model can be equipped with such technical factors. This implies that mutations caused by changes in techniques and appliances can at the most be taken into account in a qualitative way.

Summarizing, it can be said that the demand for outdoor recreation is caused by many factors which can be divided in three groups: supply factors, generation factors, and psychological and technical factors. In demand model studies up to now only the first two groups are measured in a quantitative way.

A demand model can be defined as a model which gives the statistical relationship between the participation in one outdoor recreation activity (or a cluster of activities) as the dependent variable and factors influencing this participation as the independent variables:

$$\pi = f(a_1 \dots a_k; b_1 \dots b_n; c_1 \dots c_m) \quad (1)$$

where

π = participation in one outdoor recreation activity (or a cluster of activities)
$a_1 \dots a_k$ = supply factors in the area
$b_1 \dots b_n$ = socio-economic factors of the population in the origin
$c_1 \dots c_m$ = psychological and technical factors

In demand studies the socio-economic factors have been found to give a significant improvement in the description of the measured behaviour of a certain population and most demand models are built on generation factors as income, age, sex, education, occupation, etc. A combination of supply and socio-economic factors or socio-economic and psychological and technical factors is not often taken into account when constructing demand models.

2.2.3 Use models

With use is meant in this study the number of visits to (an) existing outdoor recreation project(s) of a certain type during a certain period of time.

Use in this meaning is caused by the same three groups of factors as demand:

- supply factors;
- generation factors;
- psychological and technical factors.

As in demand there is a difference between the actual and potential use caused by limitations in the magnitude of one or more causal factors such as the accessibility and capacity of the project, lack of mobility, income and free time and others. The actual use as a total, being the sum of the actual uses of all existing recreation projects of a certain type, will therefore in most cases be limited by one or more factors. So in terms of total use there is a gap between the actual measured use and the potential use (see fig. 5, a transformation of fig. 4).

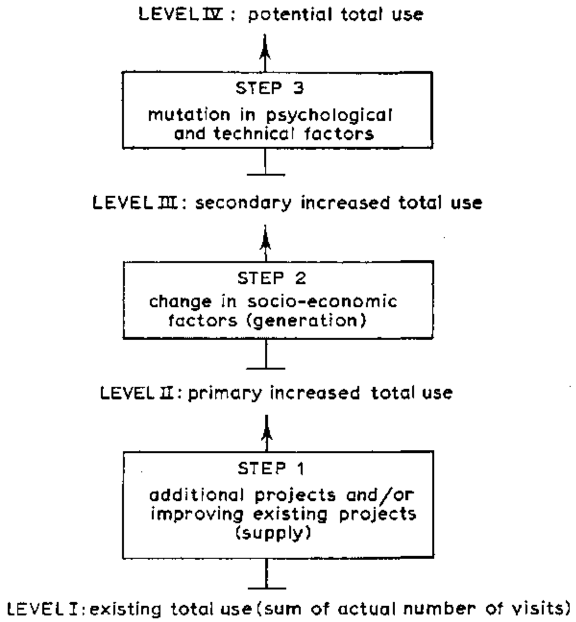

Fig. 5. Total use levels for a particular type of outdoor recreation projects.

Level I in this figure stands for the total number of visits to all outdoor recreation facilities of a certain type in a certain region and at a certain time.

Step 1 gives the addition in supply by improving existing projects and/or creating new projects of the same type. In step 2 the total use is increased by a change in socio-economic factors as income, mobility, free time, etc. The third step stands for unforeseeable psychological and technical factors.

When planning a new project, use figures taken from a similar project are required. The dependent variable is then the number of visits to that similar site during a certain period of time (e.g. one day, a week, a month, a year). In that case the scheme of fig. 5 changes into that of fig. 6.

Step 1 is dealing with the supply which can supposed to be the most important set of variables as is shown in many studies (e.g. Ullmann & Volk, 1962; Tiedemann, 1965; Merewitz, 1966; Stevens, 1966; van Doren, 1967; U.S. Dept of Commerce, 1967; Johnston & Pankey, 1968; Mutch, 1968; Bangs & Mahler, 1970; Cesario & Knetsch, 1970; Chueng, 1970; Burby III, 1971; Draijer, 1971 and Duffell & Peters, 1971). This supply is dependent on:

- the properties of the project and of the competing projects;
- the accessibility of the project and of the competing projects.

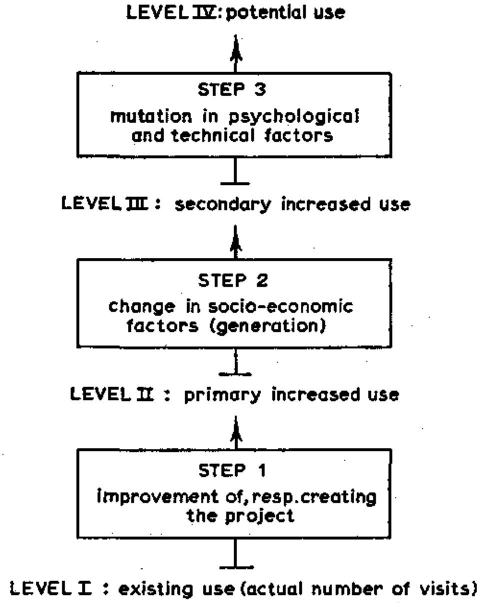

Fig. 6. Use levels of a particular outdoor recreation project.

For a given road system and population the number of visits to a certain project entirely depends on its properties and of those of the competing projects. Site attractivity is taken into consideration by Ullmann & Volk (1962), Tiedemann (1965), Stevens (1966), U.S. Dept. of Commerce (1967), Burby III (1971) and Duffell & Peters (1971). Ullmann & Volk (1962), Stevens (1966) and Mutch (1968) take into account the way in which the use of a site is affected by improvement of the attractivity.

A negative influence on the number of visits to the project will be noticed if a competitive project is made more attractive or better accessible and/or a new project is constructed within the area (substitute supply). For model studies the properties of alternative sites as well as of the project itself should therefore be taken into account. This relative attractivity of a project is more important than the absolute attractivity. Alternative projects have also been used furthermore by Ullmann & Volk (1962), Merewitz (1966), Johnston & Pankey (1968), Bangs & Mahler (1970), Chueng (1970) and Milam & Pasour (1970).

The second part of the supply is the accessibility of projects, which is dependent on distance, road quality, traffic congestion, etc. The accessibility can be considered in an absolute or in relative way by comparing it with the accessibility of alternative sites. Variables closely related with accessibility are taken into account in many studies concerning the use of an outdoor recreation project. U.S. Dept. of Commerce (1967) pays attention to distance and travel time as well as traffic congestions. Cesario & Knetsch (1970) are giving figures on the influence of distance and time. Distance as the only resistance variable is used by Ullmann & Volk (1962), Boyet & Tolley (1966), Johnston & Pankey (1968), Bangs & Mahler (1970), Chueng (1970), Draijer (1971) and Klaassen (1971). Different measurements of distance, as road and air distances, are used by Merewitz (1966) and by Burby III (1971). Other variables are also used, as for example a combination of mean travel time and distance (Duffell & Peters, 1971), travel or transportation cost (Tiedemann, 1965; Milam & Pasour, 1970); a combination of distance and transfer cost (Stevens, 1966) and travel cost, distance and a measure of access (Mutch, 1968). The effect of an improvement of the accessibility has not often been studied, although a wanted improvement of the accessibility of certain outdoor recreation areas was studied by Mutch (1968).

Summarizing the mentioned studies, a considerable part of the variation in number of visits to a certain outdoor recreation project is caused by supply factors, of which travel time and travel cost are the most important ones.

In step 2 of fig. 6 the socio-economic variables are introduced. Including some of these variables in use studies, gives a significant improvement of the use model. Population is considered to be the most important factor of this group. It is used by Boyet & Tolley (1966), Merewitz (1966) and Chueng (1970). Of the other socio-economic factors a wide selection is used as for instance income, leisure time, mobility, education, occupation, place of residence, sex, age, urbanisation level, population density, race and political interest. Not all of these factors have proved to be useful, except income for several kinds of outdoor recreation (e.g. Ullmann & Volk, 1962; Boyet & Tolley, 1966; Stevens, 1966; Milam & Pasour, 1970).

U.S. Dept. of Commerce (1967) considers leisure time and mobility as being causal factors for outdoor recreation participation. Bangs & Mahler (1970) investigated the influence of factors as education and occupation, place of residence, sex and age. Duffell & Peters (1971) saw car ownership as a decisive factor and Ullmann & Volk (1962) took urbanisation level also into account. This last factor is also used by Boyet & Tolley (1966) together with race, education and age. Merewitz (1966) found population density a useful and significant factor, later also used by Johnston & Pankey (1968). Nixon (1970) supposes education level and age to be important socio-economic factors.

Step 3 in fig. 6 gives the changes in number of visits caused by mutations in psychological and technical factors. In use studies almost no attention has been given to psychological factors, which is probably caused in the first place by the difficulty or impossibility to measure them and the fact that data on a community basis are not available. Moreover a combination of supply and socio-economic factors as the independent variables gives in many cases such a high goodness of fit (with a R^2 of 0.80 or higher) that it is almost impossible to get any improvement by taking into account psychological factors. The technical factors meant cannot be taken into account since nothing is known about the effect of technical mutations on outdoor recreation, nor what kind of technical developments will take place.

Summarizing, it can be said that in use studies the use of (number of visits to) an outdoor recreation project almost completely depends on two groups of factors: supply and socio-economic variables. In several studies the most important factors proved to be distance, (relative) attractivity and some socio-economic factors as population, income and mobility. Combination of these factors leads to the construction of use models which give the statistical relationship of the number of visits per origin for a given day to a certain outdoor recreation project with a combination of supply factors of the region and the socio-economic variables of the population in the same origin. In formula-form this can be given as follows:

$$V = f(a_1 \dots a_k; b_1 \dots b_n) \qquad (2)$$

where
V = number of visits to an outdoor recreation project for a given day per origin
$a_1 \dots a_k$ = supply factors in the area
$b_1 \dots b_n$ = socio-economic factors of the population in the origin

For improving existing projects or planning new ones, it is important to know the number of visits that might be expected at a specific future time. In this study use models for inland beaches will be derived and applied (Chapters 3, 5 and 7).

2.2.4 'Gravity' models

A method to predict recreational travel from a certain origin to a recreational site is to use simulation models similar to those applied in traffic studies. For recreation a commonly used model is the 'gravity' model. This model is based on the gravity law of Newton, saying that two bodies attract each other according:

$$K = g\frac{m_1 m_2}{D^2} \qquad (3)$$

where
K = attraction power
m_1 and m_2 = mass of bodies
D = mutual distance
g = accelleration due to gravity

The application of Newton's law for recreational travel is very recent. Van Doren (1967) constructed travel models to project attendance of campers at Michigan State parks. It was also used by Ellis (1966a and b), Ellis & van Doren (1966), Chubb (1967), Wennergren & Nielsen (1968), Niedercorn & Bechdolt (1969), van Lier & van Keulen (1970) and PPD Groningen (1970).

The suitability of the gravity model for simulation of measured flows or for projecting them has been studied by Howe (1963) and Hamerslag & Hupkes (1967). The latter ones did not find a reasonable degree of accuracy in the simulation of movement patterns. On the other hand Hartman (1968) reported examples of a successful use of gravity models.

The gravity model used as a function for description or prediction of number of visits from one origin to one destination can be written as follows (see also Ellis &

van Doren, 1966 and Niedercorn & Bechdolt, 1969):

$$V_{ij} = c\frac{P_i A_j}{D_{ij}^b} \tag{4}$$

where

V_{ij} = number of visitors from origin i to site j

P_i = population of origin i

A_j = attraction index of site j

D_{ij} = distance from origin i to site j

b = distance coefficient

c = constant (less than 1 in the following formulae)

In a certain region there will be more origins and more recreational sites, however. This means that the total number of visits from an origin to a site is strongly influenced by both the other origins (by the visits from these origins to the same site) as well as the other sites competitive to the site taken into account. This situation is analogous to a complex gravity field and the formula can be revised accordingly:

$$V_{ij} = c\frac{P_i A_j D_{ij}^{-b}}{\sum\limits_{j=1}^{J} A_j D_{ij}^{-b}} \tag{5}$$

where

J = total number of competitive sites

The gravity model can be used for the description or prediction of the total number of visits to one certain outdoor recreation project j by means of the following formula:

$$V_j = \sum_{i=1}^{I} V_{ij} = \sum_{i=1}^{I} c\frac{P_i A_j D_{ij}^{-b}}{\sum\limits_{j=1}^{J} A_j D_{ij}^{-b}} \tag{6}$$

where I = total number of pertinent origins

In this system the number of visits from each origin to the site is calculated as depending on population of the origin, attraction index of the site, distance from origin to site and attraction indices and distances to alternative sites. The total number of visits is finally obtained by summing the visits from each origin to the site.

In the models, as given in the formulae (4) through (6), three basic components can be distinguished (see also Niedercorn & Bechdolt, 1969): an origin factor, a destination factor and a linkage factor.

The origin factor is dealing with the influence of the origin on the number of visits. In most cases only the total population of the origin is used (Ellis & van Doren, 1966; Niedercorn & Bechdolt, 1969; van Lier & van Keulen, 1970). Other variables used are origin data on campers and camper days (van Doren, 1967) and the estimated maximum percentage of the total population participating in different forms of outdoor recreation (PPD Groningen, 1970). Probably the best method is to use a special model to ascertain the origin factor, in which socio-economic variables are taken into account. This is done by Wennergren & Nielsen (1968) by using data on income, leisure time, mobility and desire to participate. The gravity model can in this way be constructed by means of a special demand model standing for the origin factor in the gravity model.

The destination factor is a measure of the attractivity of the site. In an absolute way the attractivity index is based upon properties of the site itself such as the number and kind of accommodations and capacity figures or is based on, for instance, a factor analysis of properties (van Doren, 1967). In a more relative way the attraction index of a site as part of a number of projects in a certain area, is considered in connection with the attraction indices of the other projects in the area. This is done by van Lier & van Keulen (1970) where the attraction indices of six inland beaches are found as the result of the calibration of a gravity model on measured interactions. Wennergren & Nielsen (1968) use the suitability or utility of the alternative site and take, among other things, the size of the area and the expenditures of the visitors at the site into account. Van Doren (1967) is using attraction indices for State Parks in the USA based upon the presence of natural resources, outdoor activity opportunities and accommodations and services available. More or less the same properties were used by Ellis & van Doren (1966). Niedercorn & Bechdolt (1969) use the capacity of the recreational area, which is also done by PPD Groningen (1970). Probable a better method to find attraction indices is to calculate them as a relative value from interaction figures and to relate the in this way derived indices to the properties of the site.

The linkage factor in the gravity model stands for the resistance to be overcome by people in order to reach the project. This linkage factor is in most cases closely related to distance as already discussed for the use models. Other variables are minimum time distance (Ellis & van Doren, 1966) and travel time (Wennergren & Nielsen, 1968 and van Doren, 1967). The distance itself can be measured as road or air distance. Improvement of the linkage factor might be expected to occur if such factors as capacity and quality of the road, congestion, etc. are also taken into account.

Although gravity models are introduced in only a few studies on visit rates of outdoor recreation projects, or in prediction models or in regional studies, it is to be expected that this kind of approach will be helpful when planning outdoor recreation projects. A gravity model can be seen as a simulation model of traffic flows of outdoor recreation participants which makes it possible to calculate simultaneously changes in flows of participants from several origins to various sites.

2.2.5 Weather models

It is evident that tourism and outdoor recreation depends on human comfort and as such is highly influenced by weather conditions. Maunder (1970) states that the effect of weather conditions on outdoor recreation is probably the greatest and the most influential variable on the flux in numbers of participants and the cost of the various types of sites. Van Duin (1971) considers climate to be a supply factor, because the suitability of an area for outdoor recreation depends on the climate of the area itself as well as on location and surface properties, including plant growth and built-up of the area, which are climate dependent.

No confusion must exist between the terms weather and climate. Weather is to be defined as the actual meteorological situation, while climate is the meteorological situation over a long period as described by average and extreme values as well as frequencies of the meteorological parameters. Weather will be a decisive factor for a specific outdoor recreation activity on a specific day and at a specific time, while climate is to a large extent decisive for the forms of outdoor recreation that have developed in a particular area.

Climate is influencing outdoor recreation in two ways (cf. Clawson, 1966):

- directly, because it determines the probability of the desired weather conditions for specific forms of outdoor recreation;
- indirectly, as it is one of the factors which form the environment.

According to Clawson (1966): 'many forms of outdoor recreation are dependent upon a certain range of temperature, sunshine, humidity, wind velocity and other climatic factors, if they are to be tolerably enjoyable'. Not all types of outdoor recreation are dependent on weather to the same degree. Beach recreation and swimming, but also some types of winter outdoor recreation, demand specific weather conditions, but sport fishing, walking, driving for pleasure and sailing have a larger tolerance for weather (van Duin, 1971).

Maunder (1970) also mentions the double effect of meteorological factors and states that climate influences the properties of environment in which outdoor recreation takes place; the most obvious effects being upon water supply, vegetation, and the amount of snow.

Bates (1966) distinguishes three levels in the climatic environment surrounding life:

- the microclimate being the meteorological conditions closely surrounding a given individual organism;
- the ecoclimate as the climate of the habitat;
- the geoclimate as the geographical climatic conditions measured by means of standard meteorological methods (see also Maunder, 1970).

Many studies have been performed on the relation between human beings, especially as regards human comfort, and climate or weather. Various definitions, empirical functions and meteorological elements have been used. Houghton & Yagloglou (1923) have introduced the term effective temperature being an empirical function of air temperature and wind speed. Other functions have also been introduced as heat stress index (Belding & Hatch, 1955), thermal strain (Lee, 1958), the discomfort index (Thom, 1959), human climatic index (Maunder, 1970), physiological climates (Terjung, 1966a), bioclimatic classifications based on man (Terjung, 1966b) and bioclimates of the world (Gregorezuk, 1968).

For the relation between outdoor recreation and weather circumstances in the Netherlands studies have been done by Delver (1952–1955), Buwalda (1970), Bruning (1971), Smedema (1971) and den Tonkelaar (1972).

In constructing classifications of climate in relation to human comfort Maunder (1970) distinguishes 3 phases:

- the choice of the meteorological elements (variables);
- the classification or measuring of the chosen elements;
- the determination of the relative weight of these various elements.

Since there is a close relationship between human comfort and outdoor recreation, classifications both for human comfort and for outdoor recreation are based on the same meteorological elements. Temperature will influence the heat balance of man and other homeothermic animals because heat exchange by means of internal conduction, convection and radiation are determined by the temperature gradient between body and environment (see also Chapters 4 and 5). The temperature is expressed as:

- mean annual temperature (Maunder, 1970);
- dry and wet bulb temperature (Houghton & Yagloglou, 1923 and Thom, 1959);
- maximum day temperature (Buwalda, 1970);
- mean temperature in the daytime (Delver, 1952–1955; Bruning, 1971; Smedema, 1971 and den Tonkelaar, 1972).

Many meteorological elements are closely related, which means that in any empirical classification, function or model, a certain meteorological element can often be replaced by one or more other elements. Those, aside from temperature, that are mostly used are: sunshine or solar radiation, precipitation, wind, humidity and barometric pressure. In various studies both the used elements as well as the contributions of these elements are different, depending on correlation of elements, on insufficient or rough data, on non-availability of data or on the fact that only a few elements were taken into account. An important aspect in transferring a found relationship to other areas with different weather conditions is the breach in correlations and in time lag between meteorological elements. For general application the use of many elements is therefore often needed.

Moreover, there are a number of other meteorological aspects that are influencing physical and psychological well-being as, for instance, sequence of hot days, dust transport by wind, persistence of a certain type of weather, the fact that certain weather types generate a large number of insects and a high degree of air pollution, etc.

Van Wijk & de Vries (1952) think that temperature, relative humidity, radiation and a certain degree of change in weather are the most important in this aspect. Delver (1952–1955) determined the relationship between the value of beach weather figures given by visitors to North Sea beaches and the actual weather situation. This relationship is given in a diagram in which were used wind velocity, temperature and 'effective cloudiness' (a substitute parameter for sunshine). In the heat stress index of Belding & Hatch (1955) wall temperature, air temperature, wind speed and vapour pressure were incorporated. Lee (1958) makes a distinction in four groups of the different climatic influences on organisms, namely:

– factors affecting heat such as temperature, humidity, air movement and radiant energy;
– specific factors as photochemical effects of solar radiation, dust, precipitation, wind and barometric pressure;
– indirectly operating factors via plant growth, etc;
– the variability of these factors: time trends, interval conditions, psychological significance and weather patterns.

The discomfort index is defined by Thom (1959) as being dependent on the dry and wet bulb temperature, so only one element is introduced. In his human climatic index Maunder (1962) is using rainfall (in 3 ways), sunshine (2 ways), temperature (5 ways), humidity and wind (2 ways). Schmidt (1967) thinks that the most important elements of agreeability of weather for man are global radiation, temperature, humidity and wind velocity. The thermal balance of homeothermic animals is according to Hounam (1967) affected by global radiation, air temperature, humidity and air movement. Den Tonkelaar (1972) modified the Delver-diagram by relating weather values of 0 through 10 to cloudiness, wind velocity and temperature and made use of it to predict weather values for outdoor recreation on the North Sea beaches. According to Leyendeckers & van Duyse (1969) comfort of man depends on his heat balance as affected by his heat exchange with his environment. The most important factors in this process are air temperature, relative humidity, radiation, air velocity and air purity. Buwalda (1970) relates recreational traffic to three weather factors: daily maximum temperature, sunshine and rainfall. Smedema (1971) related the number of visitors on several inland beaches to rainfall days with a rainfall duration of less than half an hour, average temperature from 10 p.m. to 4 a.m. and sunshine percentage. Bruning (1971) quantified the relationship of the number of visitors on the beaches of the lakes bordering the newly reclaimed IJsselmeerpolders in the Netherlands with the average daily temperature, sunshine percentage, wind velocity and rainfall amount. Clawson (1966) describes the weather desired for outdoor recreation, without referring to a specific recreation type, by stating that 'from a purely outdoor recreation viewpoint, an ideal climate is one where it never rains, it is always pleasantly warm but not hot, always mildly sunny, never too humid, that has only gently breezes, etc.'. This is, of course, only true for a limited number of forms of outdoor recreation. The ideal weather conditions for human beings with regard to outdoor recreation in general can hardly be given since, for instance, winter sports ask for totally different weather situations than outdoor swimming.

Although it can be expected that there is a difference in the way various human beings react to weather, a range can be given for specific forms of outdoor recreation. This range of values of meteorological elements can be wide or narrow depending on the difference in weather tolerance of the forms of outdoor recreation considered. This does not imply that the optimum weather situation required is the same for all forms of outdoor recreation. The way in which man is reacting to weather can be determined in several ways, for instance:

- by asking what kind of weather one likes the best for a specific form of outdoor recreation;
- by asking recreationists how they value the actual weather;
- by counting the number of people carrying out a specific form of recreation under different weather conditions.

The weather model, as used in this study, can be defined as giving the relationship between the number of visits per day to an outdoor recreation project expressed in weather values and one (or a set of) meteorological element(s) for constant human (socio-economic) and area (geographical) properties. This definition can be written as:

$$W = f(V_t) = f(z_1 \dots z_n) \qquad (7)$$

where

W = weather value

V_t = daily number of visits to an outdoor recreation project

$z_1 \dots z_n$ = meteorological elements

2.2.6 Discussion

In 2.2 a conspectus was given of a number of models as used in studies concerning outdoor recreation, especially with regard to the planning of new facilities. The height and the fluctuation in number of visits to such projects depend, aside from the type of day, on properties of the region and weather conditions.

Keeping the weather conditions constant, the number of visits to an outdoor recreation project is then influenced by properties of the region as socio-economic factors of the population, supply factors, technical factors, etc. The way in which people react to these factors can be studied and described with models. Depending on the purpose of the model and the way in which the model is built, three model types were given: demand, use and gravity models. The first one is especially used when a prediction of the number of participants on a certain form of outdoor recreation is wanted. Use as well as gravity models are built to predict the number of visits to one (or more) specific project(s).

Keeping the area properties constant the fluctuation in the number of visits per day (for a certain type of day) is to a large degree caused by fluctuations in the weather. Weather models are particularly constructed to predict these fluctuations in day-visits for a special project.

Combination of a use and a weather model gives a basis for the normative number of visits to a new outdoor recreation project and for its planning capacity. In this study such models will be given for inland beaches in the Netherlands.

2.3 Construction of models

2.3.1 General

A model can be written in the most general way as:

$$y = f(x_1 \ldots x_n) \quad (8)$$

Lambooy (1971) calls this an 'empty' model since it does not have any 'content'. If the symbols have a meaning as, for instance, in:

$$V = f(P, D, I, A) \quad (9)$$

where
V = number of visits to a project
P = population
D = distance
I = income
A = properties of alternative sites

the model has a theoretical content, it is a projection of a theory. If (9) is written as:

$$V = \alpha_1 P + \alpha_2 D + \alpha_3 I + \alpha_4 A \quad (10)$$

an additive type has been chosen. Using now empirical data, the coefficients can be calculated, giving for instance

$$V = 0.25P - 1.52D + 0.18I - 4.5A \quad (11)$$

The construction of models often shows several phases. Bertels & Nauta (1969) distinguish models in connection with the sequence: collecting data, forming a hypothesis, forming theories and applicative stage.

The mathematical construction of models can be achieved in several ways. For gravity models an estimation procedure can be used with which, for instance, values of attraction indices and distance parameters are determined (van Lier & van Keulen, 1970). In this study use will mostly be made of regression analysis.

2.3.2 Regression analysis

According to Snedecor & Cochran (1968) the descriptive term regression is generally used in statistics 'to describe a relationship between one variable y and another variable x'. In mathematics such a relationship or dependency is often expressed as: y is a function of x. The function or regression equation might be based on one variable x although in most cases more variables ($x_1 \ldots x_n$) are taken into account.

Regression means shift towards a lower state and the term in a statistical sense originated from Galton (see Snedecor & Cochran, 1968) when stating the 'law of universal regression': 'each peculiarity in a man is shared by his kinsman, but on the average in a less degree'. In such cases one could say that 'there is a regression or going back' (Snedecor & Cochran, 1968).

In regression analysis two main types of variables can be distinguished: the independent and the dependent variables. The independent variables are the ones which can be either set at a desired value (in controlled experiments, etc.) or have a certain measurable value. Changes in the value of these independent variables, controlled or uncontrolled, have an effect on the value of the dependent variable. The dependent variable will change in two ways:

– if the independent variables are controllable in a sense that they can be set at any value at any time and place, the desired value of the dependent variable is obtained just by changing the individual values of the (set of) independent variable(s);
– if the independent variables are not controllable the value of the dependent variable is the result of the estimated or known changes in value of the independent variables.

The purpose of many models, for instance prediction models based on regression analysis, is not to obtain a certain desired value but to predict a mean value of the dependent variable. This is true for the use and the weather models in this study.

The regression equation can have different forms of which the linear type is often used. The general form of a linear regression equation can be written as

$$y = \alpha x_1 + \beta x_2 + \varepsilon \qquad (12)$$

where

y = mean of the population of values of y at a given x_1 and x_2
x_1 and x_2 = independent variables
α and β = to be estimated parameters
ε = random error

Estimation of α and β can be carried out with standard methods if the observations of y are independent of each other. Of these methods the least squares method is generally used. If necessary transformations of x are introduced in order to make the variancy of y constant for each x. If y can be assumed to have a normal distribution for each selected x, hypotheses can be tested and confidence limits can be calculated by standard methods (cf. Draper & Smith, 1967 and Snedecor & Cochran, 1968).

According to Draper & Smith (1967) in the case of prediction models 'one can often obtain a linear predictive model which, though it may be in some sense unrealistic, at least it reproduces the main features of the behaviour of the reponse under study. These predictive models are very useful and under certain conditions can lead to real insight into the process or problem. It is in the construction of this type of predictive model that multiple regression techniques have their greatest contribution to make. The problems are usually referred to as 'problems with messy data', that is data in which much inter-correlation exists. The predictive model is not necessarily functional and need not to be useful for control purposes. This, of course, does not make it useless, contrary to the opinion of some scientists. If nothing else, it can and does provide guide lines for further experimentation, it pinpoints important variables and it is a very useful variable screening device'.

In a prediction model a certain phenomenon is explained in a statistical way with one or more variables. Since this is a statistical explanation, this does not give an insight in the real processes, which are at the base of the phenomenon. Carson (1969) says that 'it is not, however, explanatory in that we still do not know the real processes involved that relate the variables ($x_1 \ldots x_n$) to the y variable'.

The application of such a model is based on the initial assumption that a phenomenon remains in the near future related in the same way to a set of explaining variables as it is at the moment. Only repeated research in time might be able to deny or confirm the reality of this assumption.

In outdoor recreation these limitations with regard to prediction models are severe because human beings are not reacting to measurable supply, socio-economic and weather variables only. It is to be expected that prediction models have to be fitted again with time. This follows from the fact that in most of these models variables are used which do not give the real cause-effect relationships. The result of this is that prediction models are useful only within a rather short period of time because other, not included, factors can become that important in the future that they also must be taken into account.

A problem when constructing prediction models is the selection of the variates. This problem arises if a choice between many available variables (many of them intercorrelated) has to be made and most of these variables may contribute little or nothing to the prediction. The best n out of N variables ($n \ll N$) is to be chosen (see Chapter 5). If it is not efficient to compute all possible regression equations, several procedures can be followed to limit the number of regressions (see Draper & Smith, 1967 and Snedecor & Cochran, 1968).

In this study a stepwise regression procedure was used (Draper & Smith, 1967). This method is derived from the forward selection procedure (Draper & Smith, 1967) or the step-up method (Snedecor & Cochran, 1968). In the forward selection procedure the calculations are started with all the single regressions of the dependent variable on each of the independent variables. The variable giving the greatest reduction in the sum of squares of deviations is selected. The next step is the calculation of all bivariate regressions of the selected variable and each of the still unused independent variables, as well as the selection of the variate with the greatest additional reduction in the sum of squares. This process is continued until the inclusion of new variables does not, according to some rule, give enough additional reduction in the sum of squares.

The stepwise regression procedure is an improvement of the forward selection procedure since now at every stage of the regression a re-examination of the variables incorporated in previous stages into the model is involved. The reason for this is that a variable at an early stage entered as the best variable in the regression may be superfluous at a later stage because of the relationship between it and other variables now in the regression. New variables are entered and, if necessary, old variables are withdrawn, which is continued until no further variables are admitted to the equation or rejected, both according to some rule (see Draper & Smith, 1967). This has been done to select the variables for the use model and for the statistical weather model.

3 Relationship of visits with supply and socio-economic factors

3.1 General

The construction of use models (as described in Section 2.2.3) for inland beaches is one of the purposes of this study, so the definition given earlier is transformed into: A use model for inland beaches gives the statistical relationship of the number of visits per origin for a given day to a certain inland beach with a combination of supply factors of the region and the socio-economic variables of the population in the same origin.

Inland beaches in the Netherlands can be described as outdoor recreation projects existing of sandy or grassland beaches and a fresh water lake, with a water area varying from approximately 1 to 100 ha, including furthermore playgrounds and other accommodations (varying from simple to high rate), mostly situated in rural areas.

Although use models can be constructed for beaches along the sea coast and along large salt and fresh water lakes, no attention has been paid to such projects since only data on inland beaches with rather small artificial lakes were collected. A use model, as defined above, can generally be written as follows:

$$y = f(x_1 \dots x_n) \qquad (13)$$

where

y = dependent variable = number of visits per origin to the inland beach at a certain day

$x_1 \dots x_n$ = independent variables = supply factors in the area and socio-economic variables of the people in the origin

The construction of the use models was carried out in two steps namely by a multiple regression analysis, in which the stepwise regression procedure (see Draper & Smith, 1967) was followed, and secondly by building various models based upon the results of the regression analysis and, after trying them out, a choice of the final models according to their goodness of fit. In this chapter the regression analysis is described, while in Chapter 5 the final models will be given.

3.2 Data requirements and sampling procedure

3.2.1 Required data

The regression analysis requires the following three groups of data:

– data on number of visits per origin, for a certain day and project;
– data on the socio-economic variables of the people in the several origins;
– supply data, consisting of one of two possible accommodation levels of the project and its accessibility as well as similar figures of competing outdoor recreational sites.

These data were gathered in two manners, namely by means of:

– field surveys: obtaining data on number of visits to inland beaches (with regard to their origins) during the years 1967 through 1970;
– desk work: rearranging existing data on socio-economic and supply factors for all origins inside the sphere of influence of the projects.

The data were divided in three main groups. Each of these main groups was subdivided in subgroups, while most of these subgroups were again subdivided in basic and derived variables, as shown in table 2. Of the variables in table 2 c.1 and c.3 through c.6 are socio-economic variables, while c.2 and c.7 are supply factors.

As the analysis procedure would consist of four steps namely:
step 1: calculation of the distance-decay function (see Section 3.3.2.1);
step 2: multiple regression analysis of all variables mentioned in table 2, for some days and some projects to test which of the basic and derived variables give a significant contribution in the explanation of the variancy of the dependent variable. The other variables were then excluded from the further procedure;
step 3: multiple regression analysis of the significant variables (see step 2) for all days and projects sampled;
step 4: setting and calibrating of the final use models (see Chapter 5).

The data needed for the calculations of the distance-decay functions and the multiple regression analyses were sampled and obtained as described in Section 3.2.2.

Table 2. Main and subgroups of variables used for regression analysis of visits per origin to inland beaches on socio-economic and supply factors.

Main group	Subgroup	Number of variables	
		basic	derived
a. Properties	a.1 day of research	1	
	a.2 number of project	1	
	a.3 number of origin	1	
b. Dependent variable	b.1 visits	1	3
c. Independent variables	c.1 population	5	7
	c.2 distance	4	16
	c.3 mobility	1	3
	c.4 number of households	1	3
	c.5 income	2	3
	c.6 cultural pattern	2	2
	c.7 alternative projects	4	26

The distance-decay functions (see step 1) were determined for all projects and all days studied. The results of these calculations are given in Section 3.3.2.1. In step 2 the variables to be used in the runs of data of 1968 through 1970 as well as of those of the remaining projects and days of 1967 were chosen. The results of the regression analyses (see step 2 and 3) are given in Section 3.3.2.2.

3.2.2 Data acquisition

As said before a distinction can be made in data obtained from field surveys and data obtained from already existing official and other statistics.

3.2.2.1 Field surveys

Data on visits to 12 inland beaches were gathered during 50 research-days. Since on certain research-days two or more projects were simultaneously under investigation, the number of project research-days (prd; 1 prd is a research during one day on one particular project) were 89.

Because of different reasons (among other things bad weather conditions) not all of these prd were used for further model studies. As will be shown later, the design capacity of new projects is based on a normative day chosen at a particular point of the curve of exceedance. This point is situated on the upper half of this curve, which refers to days with a high number of visits. Therefore such days are worthwhile for further study. For this reason data of 39 prd out of 89 prd for 12 inland beaches were used for regression analysis, while for 11 projects (37 prd) use models were constructed (see Chapter 5). In table 3 a conspectus is given of some of the properties of the 12 projects, while in fig. 7 the location is given of these 12 inland beaches (for which use

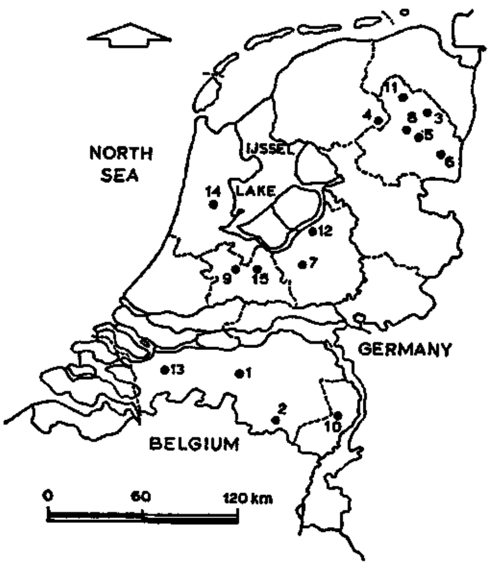

Fig. 7. Location of the investigated inland beaches in the Netherlands:
1. Beekse Bergen
2. Eurostrand
3. Hemelrijk
4. Hildenberg
5. Ieberenplas
6. Kibbelkoele
7. Loofles
8. Loomeer
9. Maarsseveense Plassen
10. Schatberg
11. Tijnaarlo
12. Zandenplas
13. Bosbad Hoeven
14. Natuurbad Wijde Wormer
15. Soester Natuurbad

Table 3. Conspectus of the inland beaches investigated during 1967 through 1970 (see also fig. 7).

Project	Municipality	Province	Area (ha)		Number of visits (×1000)		Specific properties
			water	total	peak day	year	
1. Beekse Bergen	Hilvarenbeek	N.Br.	80	190	20	400	gate fees high accommodation level part of large recreation project
2. Eurostrand	Westerhoven	N.Br.	18	30	15	300	gate fees high accommodation level 1 campground include, 1 adjacent
3. Hemelrijk	Gasselte	Dr.	2	3	3.5	35	no gate fees low accommodation level under construction
4. Hildenberg	Ooststellingwerf	Fr.	0.5	2	4	40	gate fees medium accommodation level concrete with sand beach
5. Ieberenplas	Westerbork	Dr.	1	2	3	30	no gate fees low accommodation level
6. Kibbelkoele	Sleen	Dr.	2.5	5	15	150	no gate fees no accommodation
7. Loofles	Barneveld	Gld.	2	5	15	150	no gate fees medium accommodation level
8. Loomeer	Rolde	Dr.	1.5	2.5	5	50	no gate fees low accommodation level
9. Maarsseveense Plassen	Maarssen	Utr.	130	150	15	200	gate fees high accommodation level
10. Schatberg	Sevenum	Limb.	18	63	10	150	gate fees high accommodation level campground included
11. Tijnaarlo	Vries	Dr.	3.5	25	12.5	100	gate fees high accommodation level
12. Zandenplas	Nunspeet	Gld.	1	3	7	100	no gate fees low accommodation level

models were made) as well as of 3 other inland beaches (for which only weather models were determined, see Chapter 4).

Table 3 shows many differences between the projects. The surface areas of water and of the total project together with the properties of the projects are closely related to the number of visits on peak days as well as during the year. The area of water ranges from 0.5 (project 4) to 130 ha (project 9). The total surface of the projects has a range of 2 (projects 4 and 5) to 190 ha (project 1). From the 12 projects 6 have gate fees while the remaining 6 have free entrance. The accommodation level is high at 5 projects, medium at 2 projects and low at 5 projects. Three of the inland beaches are part of a larger project with facilities for vacation recreation (camping, etc.). All these differences lead to large differences in the number of visits ranging for a peak day from 3000 to 20000 and for the year from 30000 to 400000. It will be clear that these differences will have to be taken into account when analyzing the results of the calculations. In table 4 a conspectus is given of the 39 prd for which a regression analysis was carried out.

Not all the investigations carried out on these projects and days were consistent with regard to the type and amount of the data collected. The most important investigations concerned the number of visitors and their density on different elements of the project, questionnaire research (among other things with regard to the origin of the visitors, means used for transportation, group size, length of stay, etc.), water quality research and measuring of weather conditions.

For the regression analysis and the construction of use models only field data on the number of people entering the project per period of time, their origin, the type of vehicle they used and their length of stay were required. The field data on weather conditions were needed to construct the weather model (Chapter 4 and 5). Additional data on the number of people leaving the project per period of time and of the visitor density on the different elements were necessary to determine normative number of visitors and layout criteria respectively (Chapter 6).

Data acquisition on the number of incoming people and their properties can be carried out with various sampling methods, as for example simple random sampling, systematic sampling, stratified sampling, sampling in two stages or by using ratio and regression estimates (Snedecor & Cochran, 1968). In this study a stratified random sampling method was followed.

The total population (total number of visits) was divided into 5 strata according to the type of vehicle used to visit the project (automobiles, motorbikes and scooters, mopeds, bicycles, public transport). From each stratum a random sample was drawn. This was done by the questioner taking the first group entering after having finished with an earlier group. The number of questioners was kept constant per stratum and as the number of visitors entering the project was fluctuating with time the percentage of people questioned differed per hour as well as per stratum (vehicle).

The sample size is to be based upon the wanted precision of the number of visits per origin, since these data are the most important ones when constructing use models.

Table 4. Project research-days (prd) and number of visits for 12 inland beaches (see table 3) under investigation during 1967 through 1970 and used for regression analysis.

Project	1st date	Visits	2nd date	Visits	3rd date	Visits	4th date	Visits	5th date	Visits	6th date	Visits	7th date	Visits
1	1-6-68	5232	2-6-68	14827	7-7-68	0766	31-7-68	11463	26-7-69	4036	27-7-69	17156	6-8-69	9429
2	3-6-68	11946	30-7-68	9585	24-8-68	6545	25-8-68	10463	26-7-69	3524	27-7-69	14833	6-8-69	6826
3	2-7-67	3698	20-7-67	1050										
4	2-7-67	2451	20-7-67	1150										
5	2-7-67	3115	20-7-67	1012										
6	2-7-67	8558	13-7-67	4960	20-7-67	2459								
7	23-7-69	13762	27-7-69	13647	9-8-69	4560								
8	2-7-67	4258	20-7-67	1608										
9	1-8-70	7989	2-8-70	14908										
10	2-8-70	9950												
11	14-5-67	1471	2-7-67	4979	12-7-67	3140	20-7-67	1369	29-7-67	1578				
12	19-7-69	3858	23-7-69	6015	27-7-69	7032								

With a confidence level of 0.95 the following equation (see also Crapo & Chubb, 1969) holds:

$$P\left[|\hat{p}V_t - pV_t| \leqslant x\right] \geqslant 0.95 \tag{14}$$

where

P = probability of occurrence
p = proportion of questioned visitors coming from a certain origin
$\hat{p}$ = an estimate of p
V_t = total number of visits to an inland beach on a certain day
x = absolute error in number of visits per origin

Equation (14) leads to:

$$2\sqrt{(\text{var}\,\hat{p}V_t)} \leqq x \tag{15}$$

For an infinite population:

$$\text{var}\,\hat{p}V_t = V_t^2\,\text{var}\,\hat{p} = \frac{V_t^2 p(1-p)}{n} \tag{16}$$

where n = sample size, the combination of (15) and (16) yields:

$$2\sqrt{\left[\frac{V_t^2 p(1-p)}{n}\right]} \leqq x \tag{17}$$

or

$$n \geqq \frac{4V_t^2 p(1-p)}{x^2} \tag{18}$$

For a finite population eq. (18) has to be transformed to:

$$n \geqq \frac{4V_t^2 p(1-p)\left(1-\frac{n}{V_t}\right)}{x^2} \tag{19}$$

or

$$n \geqq \frac{4V_t^2 p(1-p)}{x^2 + 4V_t p(1-p)} \tag{20}$$

The calculation of the sample size n can now be based on several kinds of origins as for instance the largest origin (either with regard to inhabitants or number of visits) or the origin with the highest number of visits per 100 inhabitants. An example of a wanted sample size is given for the origin giving the largest number of visits on project 2 (Eurostrand), calculated from the survey on June 3, 1968 (table 5).

The table shows that with an error of 250 visits for the largest origin (which is less than 10% of the total number of visits) the sample size n has to be 1392 persons. It also gives the sample size per stratum and in total as realized. The real number of sampled people was 1622 persons or 14.9% of the total.

Table 5. Sample size n (per stratum and total) for 3 values of the absolute error in number of visits (x), a confidence level of 0.95 and a finite total population, as well as the realized sample size, both for Eurostrand (June 3, 1968).

Stratum	V_t	P	$(1-p)$	Value of n for x is			Real sample size	
				25	50	75	abs.	in % of V_t
1. automobiles	8276	0.23	0.77	7490	5829	4255	1411	17.0
2. motorbikes and scooters	1242	0.73	0.27	761	352	185	122	9.8
3. mopeds	815	0.16	0.84	289	98	47	64	7.9
4. bicycles	78	0.44	0.56	7	2	1	6	7.7
5. public transport	492	0.53	0.47	215	80	39	19	3.9
Total	10903	0.30	0.70	4020*	1392*	666*	1622*	14.9*

* For an x-value of 125, 250 and 375 visits per origin.

Since for this study only the total number of visits per origin is important it is obvious that, with regard to the chosen error and confidence level, the sample size was sufficiently large. The sample size n of the prd for which the regression analysis was carried out is given as percentage of visits per day in table 6. From this it can be seen that the sample size for almost all prd is over 15% except for two projects for which the sample size is low. For project 7 (Loofles) it is varying from 5.1 to 9.0%, while for project 12 (Zandenplas) the percentage ranges between 9.5 to 10.5. These low values were caused by the fact that the origin survey was part of an investigation with a different motive which did not need a higher sample size. The results of the model studies for these two projects therefore need to be handled with care.

For the calculation per project of the total number of visits per origin and the properties of the visitors from data obtained in the manner described above, a special procedure was developed. First, the total number of visits ($x_{i,j}$) per hour (i) and per stratum (j) was determined. Secondly the number of questioned people ($y_{i,j}$) for the same hours (i) and strata (j) was taken from the questionnaires. Thirdly the ratio ($g_{i,j}$) between the total number of visits per hour and stratum ($x_{i,j}$) and the number of questioned people ($y_{i,j}$) was calculated. This weight is:

$$g_{i,j} = \frac{x_{i,j}}{y_{i,j}} \; (i = 1 \ldots 9; j = 1 \ldots 5) \tag{21}$$

Now the absolute values of a certain property Z of the visitors to a project were determined.

– Per hour and stratum the sample value is taken from the questionnaires $z_{i,j}$ = sample value of property Z for hour i and stratum j.

– This value is weighted with the ratio g pertaining to the same hour and stratum:

Table 6. Sample size *n* given as percentage of number of visits per day for the selected project research-days.

Project	1st date	*n* %	2nd date	*n* %	3rd date	*n* %	4th date	*n* %	5th date	*n* %	6th date	*n* %	7th date	*n* %
1	1-6-68	31.8	2-6-68	16.3	7-7-68	20.3	31-7-68	28.9	26-7-69	31.6	27-7-69	13.3	6-8-69	24.9
2	3-6-68	14.9	30-7-68	34.7	24-8-68	39.1	25-8-68	33.6	26-7-69	42.6	27-7-69	16.1	6-8-69	28.8
3	2-7-67	37.8	20-7-67	94.9										
4	2-7-67	24.4	20-7-67	55.1										
5	2-7-67	55.5	20-7-67	68.3										
6	2-7-67	16.7	13-7-67	20.0	20-7-67	55.1								
7	23-7-69	5.9	27-7-69	5.1	9-8-69	9.0								
8	2-7-67	41.2	20-7-67	58.7										
9	1-8-70	25.6	2-8-70	17.1										
10	2-8-70	37.2												
11	14-5-67	61.1	2-7-67	26.6	12-7-67	37.6	20-7-67	44.4	29-7-67	43.4				
12	19-7-69	10.3	23-7-69	9.5	27-7-69	10.5								

$$Z_{i,j} = g_{i,j} z_{i,j} \tag{22}$$

– Summation of all $Z_{i,j}$ gives the absolute value of property Z of the visitors for the project research-day:

$$Z = \sum_{i=1}^{9} \sum_{j=1}^{5} Z_{i,j} \tag{23}$$

Substituting of eq. (22) in eq. (23) gives:

$$Z = \sum_{i=1}^{9} \sum_{j=1}^{5} g_{i,j} z_{i,j}$$

or

$$Z = \sum_{i=1}^{9} \sum_{j=1}^{5} \frac{x_{i,j}}{y_{i,j}} z_{i,j} \tag{24}$$

All properties of the visitors were calculated in this way from questionnaires.

3.2.2.2 Existing statistics

In this section a short description will be given of the acquisition of the independent variables c. 1 through c. 7 (see table 2). Most of the variables were taken from existing material, but in some cases additional data were used from own investigations.

P = number of inhabitants of origin. Data were taken from CBS, 1967a and 1969a, valid for January first of each year.

E = number of inhabitants or origin on vacation elsewhere. Obtained by means of a curve given in fig. 8 (see also CBS, 1969b and 1969c).

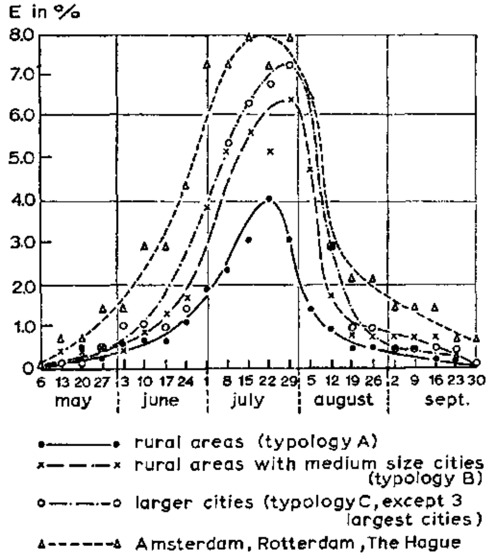

Fig. 8. Inhabitants of origin on vacation elsewhere in per cent of total number of inhabitants E during the summer season 1969 for four urbanization levels in the Netherlands (after CBS, 1969c).

B = number of vacationists incoming into origin. Based on known capacities of vacation homes and sites per origin as hotels, cabins, campings, etc. Data were taken from maps (NKR, 1971).

F = area of origin in km^2. The area (land inclusive water less than six meter wide) was obtained from CBS data (1967a and 1969a).

U = urbanisation level of origin. Based on CBS (1964). Since urbanisation values are given per nucleus of an origin a calculation procedure had to be followed for the determination of U:

$$U = \frac{p_1 u_1 + p_2 u_2 + \cdots + p_k u_k}{p_1 + p_2 + \cdots + p_k} \tag{25}$$

or

$$U = \frac{1}{100} \sum_{q=1}^{k} p_q u_q \tag{26}$$

where

U = urbanisation level of the total origin

p_q = percentage of inhabitants of origin in nucleus q

$u_q = f(P_q)$ = urbanisation level of nucleus q

k = number of nuclei in origin

The value of u_q depends on the inhabitants P_q in the nucleus. For this relation was chosen:

$$\log P_q = a + b u_q \,(\text{with } 2000 < P_q < 100000) \tag{27}$$

and $u_q = 1$ for $P_q \leqslant 2000$
$u_q = 10$ for $P_q \geqslant 100000$

Equation (27) then becomes:

$$\log P_q = 3.1 + 0.187 u_q \tag{28}$$

or

$$u_q = 5.3 (\log P_q - 3.1) \tag{29}$$

This relation is given in fig. 9. Fitting the separate u_q-values into eq. (26) gives the wanted U-value of the total origin.

D_r = road distance in km between origin and site. Measured from road maps over the most probable route from origin to site. If applicable, different roads were chosen for different vehicles (automobiles, bicycles, mopeds, etc.).

D_a = air distance in km between origin and site. Also measured from maps.

M = total number of automobiles in origin per August 1, 1966 (CBS, 1967b). The variancy in automobiles per inhabitant (MP^{-1}) was very small. This was the reason that the variable M did not appear significantly in the regression equations. Therefore mobility was omitted in the regression analyses of 1968 through 1970.

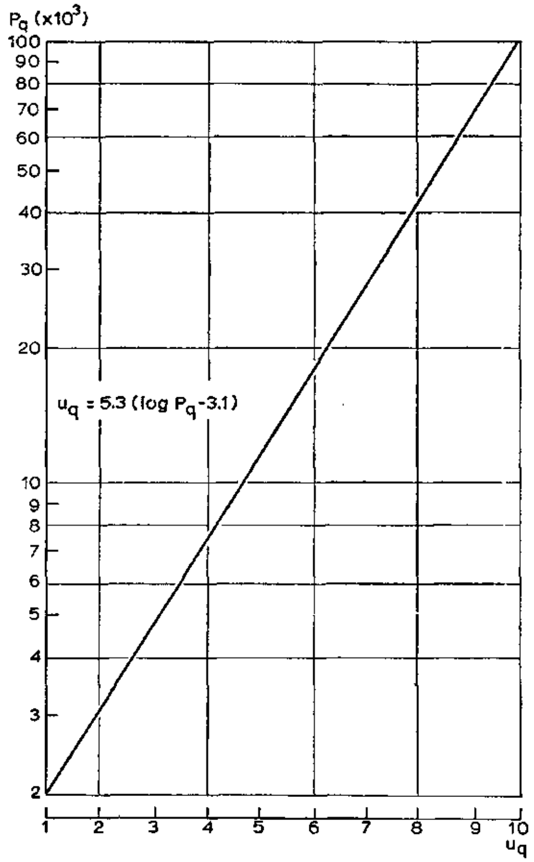

Fig. 9. Relationship assumed to exist between number of inhabitants of origin in a nucleus P_q and its urbanization level u_q.

H = number of households in origin. This is meant as a measure of the total number of families per origin and is based on CBS data (1964 and 1971/1972).

Y = income level of population in origin. The most recent data on income were those for the year 1965 (CBS, 1970). In order to calculate income per origin for 1967 through 1970, the incomes of 1965 were multiplied by a factor determined by using index figures from 'income from labour' (CBS, 1971b and 1971c). The multipliers were: 1.227, 1.290, 1.418 and 1.600 for 1967, 1968, 1969 and 1970 respectively. Checking the calculated values for some origins with already known new data showed that this procedure was sufficiently accurate.

n_t = number of tax payers in origin. Since this number was neither exactly known for the years after 1965 an estimate was made by calculating the total number of tax payers as a percentage of the total population of the Netherlands, being 43.63. For 1967 through 1970 the total number of tax payers per origin was calculated by multiplying the population P with the factor 0.44.

C_1 = educational level of population of origin. As a measure of education the percentage of the employed people having followed only primary school was taken

(CBS, 1971/1972). If more than one municipality is included in the origin an average weight according the total number of employed people has been used.

C_2 = religion of population of origin. This variable is a measure of the people who for religious reasons do not visit outdoor recreation projects on Sunday. Since Sundays are very important with regard to the upper part of the curve of exceedance of visits per day and with this for the determination of the planning capacity of a project, this might be an important variable. Since no official statistics on C_2 exist per municipality, a mail-questionnaire was sent to all origins of the 1967 investigations. It was evident from the received response that for most municipalities the estimate had a low rate of accuracy. For this reason, as well as because this variable plays a role in only a few parts of the Netherlands, as also that it can be assumed that the percentage of people who do not visit outdoor recreation projects on Sundays will decrease in the future, it was decided to exclude the variable C_2 for the investigations of 1968 through 1970.

A_{s1} = score of alternative outdoor recreation sites inside origin weighted according recreation type. For the determination of A_{s1}, which varies from 0 to 1, a special procedure was developed, as based on a score value s_{v1} (for an example of the determination of this value see table 7), by means of eq. (30):

$$A_{s1} = \frac{\sum_{n=1}^{5} g_n m_n}{2 \sum_{n=1}^{5} g_n} = \frac{1}{30} \sum_{n=1}^{5} g_n m_n \qquad (30)$$

The determination of both the availability as well as the properties of the sites is based on various sources:

Group 1 and 2: swimming pools and small shallow pools, etc. For each munici-

Table 7. Example of the determination of score value of alternative outdoor recreation sites inside the origin (s_{v1}).

Subdivision outdoor recreation sites	Weight g_n	Availability m_n*	$g_n m_n$
1. swimming pools, inland beaches, etc.	5	*2*	*10*
2. small shallow pools for children	4	*1*	*4*
3. open water for sailing, fishing, etc.	3	*0*	*0*
4. special sites	2	*2*	*4*
5. wood and waste lands	1	*1*	*1*
			$s_{v1} = \sum_{n=1}^{5} g_n m_n = 19$

* 0=not present; 1=present, low capacity; 2=present, high capacity.

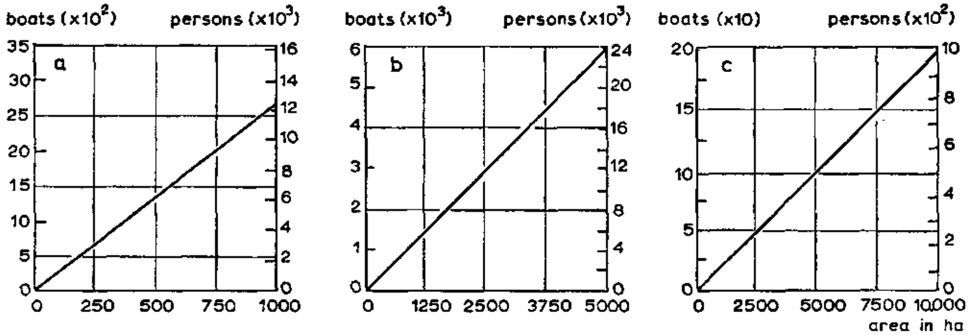

Fig. 10. Criteria for peak-day use of three types of open water by boaters in the Netherlands; a, pools and small lakes up to 1000 ha; b, rivers and large lakes up to 5000 ha; c, IJssel lake, Western and Eastern Scheldt estuaries, Grevelingen basin, etc.

pality the type and number of pools; the total number of visits on the peak day was taken from CBS (1971d) and from non-published data.

Group 3: open water. For water sports the criteria given in fig. 10 were used. They are based on many studies (for instance Koot, 1969; Hendriksen, 1970 and Hendriksen, pers. comm. 1972; Strobrand et al., 1970; ETI, 1971; Provinciale Raad voor de Recreatie in Zeeland, 1971 and van der Voet & Dijkstra, 1971). For fishing no data were available with regard to fishing water (location, capacity, water quality, etc.). As an indication for this variable the number of fishing licencies per municipality was chosen (data of the Ministry of Agriculture and Fisheries). A distance function as given in fig. 11, based on several investigations (Kamphorst, 1969; van Oostrum, 1971; Bakker, 1972 and ITS, 1972), was used to estimate the capacity of fishing waters within 10 and 20 km from center of origin.

Group 4: special sites as recreation parks, zoos, playgrounds, children farms, special attraction points, etc. From ANWB (1969, 1970 and 1971) data on special sites were collected with regard to location, type and capacity for each municipality.

Group 5: wood and waste lands. Special maps of CBS (1971a) with data on wood and waste lands were used as a basis for the calculation of the number of ha within 10 and 20 km from center of origin. This calculation was carried out by means of a 'Quantimet', an electronic device to measure small surfaces. The criteria, used to translate these surfaces into capacities, were based on several investigations (for instance Heytze, 1965 and 1968; Berthery & Riquois, 1970; BOR, 1967b): 2 to 10 persons per ha for woods depending on the type of wood for the variables A_{s1} and A_{c1} and 4 persons per ha for the variables A_{s2} and A_{c2}, while for waste land 1 person per ha was taken.

The value of m_n, needed for the determination of A_{s1}, is based upon the capacity of the projects for which the classes given in table 8 were used.

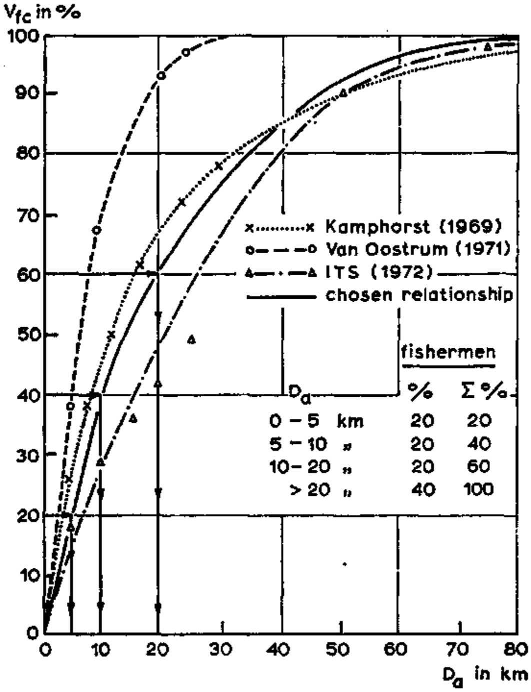

Fig. 11. Relationship of cumulative percentage of sports fishermen V_{fc} and air distance from center of origin to fishing waters D_a.

Table 8. Value of the availability of alternative outdoor recreation sites (m_n) in dependency of type and capacity (c_n).

Subdivision outdoor recreation sites		c_n	m_n
1 and 2.	swimming pools, inland beaches; small shallow pools for children, etc.	<2000	0
		2000–6000	1
		>6000	2
3.	open water for sailing, fishing, etc.	< 500	0
		500–4000	1
		>4000	2
4 and 5.	special sites, wood and waste lands	<1000	0
		1000–3000	1
		>3000	2

A_{c1} = capacity of alternative outdoor recreation sites inside origin weighted according recreation type. Determined, as based on a capacity value c_{v1} (for an example see table 9), by means of eq. (31):

$$A_{c1} = \frac{\sum_{n=1}^{5} g_n c_n}{g_1} = \tfrac{1}{5} \sum_{n=1}^{5} g_n c_n \tag{31}$$

Table 9. Example of the determination of the capacity value of alternative outdoor recreation sites inside the origin (c_{v1}).

Subdivision outdoor recreation sites	c_n	g_n	$g_n c_n$
1. swimming pools, inland beaches, etc.	*8000*	5	*40000*
2. small shallow pools for children	*500*	4	*2000*
3. open water for sailing, fishing, etc.	*1500*	3	*4500*
4. special sites	*6000*	2	*12000*
5. wood and waste lands	*200*	1	200
			$c_{v1} = \sum_{n}^{5} g_n c_n = 58700$

A_{s2} = score of alternative outdoor recreation sites outside origin weighted according recreation type and distance between origin and site. Since not all projects can be taken into account, a sphere of influence has to be chosen. Based on literature (e.g. RNP, 1961 and 1966; Maas, 1968) two distance zones were taken (0 to 10 km and 10 to 20 km). The score value s_{v2} can now be determined (see table 10). The value of A_{s2} for distance zone a is:

$$A_{s2.a} = \frac{\sum_{n=1}^{5} g_n w_n}{2 \sum_{n=1}^{5} g_n} = \tfrac{1}{30} \sum g_n w_n \tag{32}$$

The total value of A_{s2} now is:

$$A_{s2} = \tfrac{1}{2}(A_{s2.a} + A_{s2.b}) \tag{33}$$

Table 10. Example of the determination of the score value of alternative outdoor recreation sites outside origin (s_{v2}) in dependence of distance zones.

Subdivision outdoor recreation sites	w_n (value of alternative project)						g_n	$g_n w_n$
	large project			small project		no project		
	0–10	10–20	>20	0–10	>10 km			
1. swimming pools, inland beaches, etc.							5	$5 \times 2 = 10$
2. small shallow pools for children							4	$4 \times 1 = 4$
3. open water for sailing, fishing, etc.	2	1	0	1	0	0	3	$3 \times 2 = 6$
4. special sites							2	$2 \times 2 = 4$
5. wood and waste lands							1	$1 \times 1 = 1$
								$s_{v2} = \sum_{n=1}^{5} g_n w_n = 25$

A_{c2} = capacity of alternative outdoor recreation sites outside origin weighted according recreation type and distance between origin and site. Determined with the aid of the scheme given in table 11 and the eqs. (34) and (35). The capacity of alternative sites for distance zone a is:

$$A_{c2.a} = \frac{\sum_{n=1}^{k} g_n r_n c_n}{g_1} = \tfrac{1}{5} \sum_{n=1}^{k} g_n r_n c_n \qquad (34)$$

while the value of A_{c2} is:

$$A_{c2} = A_{c2.a} + A_{c2.b} \qquad (35)$$

Table 11. Example of the determination of the capacity value of alternative outdoor recreation sites outside the origin (c_{v2}) in dependency of distance zones.

Subdivision outdoor recreation sites	c_n	r_n (reduction factor)			g_n	$g_n r_n c_n$
		0–10	10–20	>20 km		
1. swimming pools, inland beaches, etc.	*15000*				5	$5 \times \frac{1}{2} \times 16000 = 40000$
2. small shallow pools for children	*2000*				4	$4 \times 1 \times 2000 = 8000$
3. open water for sailing, fishing, etc.	*8000*	1	½	0	3	$\left.\begin{matrix} 3 \times 1 \times 5000 \\ 3 \times \frac{1}{2} \times 3000 \end{matrix}\right\} = 19500$
4. special sites	*2000*				2	$2 \times \frac{1}{2} \times 2000 = 2000$
5. wood and waste lands	*4000*				1	$1 \times 1 \times 4000 = 4000$
						$c_{v2} = \sum_{n=1}^{k} g_n r_n c_n = 73500$

3.3 Distance-decay functions and regression equations

3.3.1 *Method and criteria for goodness of fit*

In Chapter 2 a description was given of the multiple regression analysis which is used in this study. This analysis, however, was not carried out for all origins on a project research-day (prd). It was limited to the sphere of influence, which is defined as all origins from which in total 90% of the visitors come (90%-boundary). The percentages of people coming from the different distance zones are summed and the relation between the cumulative percentual visits and the distance is given by a

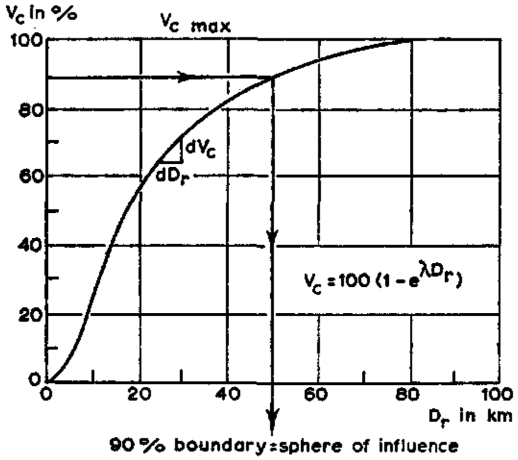

Fig. 12. Schematic relationship of the cumulative percentual visits V_c with the road distance from origin to site D_r, as well as the determination of the sphere of influence, based on the 90%-boundary (after van Lier, 1969/70).

Mitscherlich-equation (fig. 12; van Lier, 1969/70):

$$\frac{dV_c}{dD_r} = \lambda (V_{c.max} - V_c) \tag{36}$$

where

V_c = cumulative percentage of recreationists on inland beaches per road distance zone from origin

D_r = road distance in km between origin or zone and site

λ = to be estimated parameter

$V_{c.max}$ = highest value of V_c (= 100%)

This formula can be written as:

$$V_c = 100(1 - e^{-\lambda D_r}) \tag{37}$$

For each prd the parameter λ and then the 90%-boundary were calculated. All origins inside of this boundary were used for the calculations of the distance-decay functions, for the regression analyses and for the construction of the use models.

For the goodness of fit several criteria can be used as multiple correlation coefficient, standard error of estimate, mean error, average absolute error, range of errors and inequality coefficient (Merewitz, 1966).

The aim of the distance-decay functions and use models is to estimate the total number of visits to a new outdoor recreation project. Therefore functions and models have to be constructed in such a way that they fit as good as possible the measured numbers of visits. Since the total number of visits is equal to the sum of the visits from all origins this is rephrased as to construct functions and models in such a way that the (by means of the function or model) estimated number of visits per origin fits as good as possible the measured number of visits of the same origins.

All origins produce a number of visits that can vary from 0 to the maximum number of visits of the most important origin (the origin with the highest number of visits).

It will be clear that the total number of visits to the project is determined to a high degree by these most important origins. So the function or model has to be constructed in a way in which especially the important origins get the best fit. For this reason the multiple correlation coefficient (R^2) is used, both as a measure for the goodness of fit of the distance decay functions, the regression analyses and the use-models.

3.3.2 Results

3.3.2.1 Distance-decay functions

This distance-decay function is taken to be an e-function with which the number of visits per origin is related to two independent variables expected to be the most important ones, i.e. inhabitants and distance. The general formula reads:

$$100\ V/P = \alpha\, e^{-\beta D_r} + \gamma \qquad (38)$$

or

$$V = \tfrac{1}{100}\alpha P\, e^{-\beta D_r} + \frac{\gamma P}{100} \qquad (39)$$

where

V = total number of visits to an inland beach per origin on a certain day
P = number of inhabitants of origin
e = base of natural logarithms
D_r = road distance between origin and site in km
α, β and γ = to be estimated parameters

The formulae (38) and (39) were calculated for 54 project research-days. The most important results are given in table 12.

Several conclusions can be drawn. First it appears that the sphere of influence is fluctuating to a large extent (from as low as 15 km on project 4 to as high as 96 km on project 2). This is one of the reasons of the large differences in number of origins per project (from 12 to 384).

As regards the estimations of the parameters, the β's differ the least. It is not clear what the reason is of the great fluctuations in α, since high and low values are found as well as within the projects as between them. Differences in α between projects would possibly indicate a difference in attractivity. The large differences in values of γ are mostly the result of two severely low values for project 4. If these two values are not taken into account the fluctuation of γ is moderate and low values around 0 are found.

The values of β are important since this value gives an idea of the impact of the travel distance on visitors to an outdoor recreation project. Higher values mean a higher sensibility of the project for distances, in other words people are not willing to travel large distances to visit such a project. The reason for this is not quite clear, but the differences in willingness to travel are probably caused by such factors as accommodation level of the project, accessibility, alternative sites and distribution of resi-

Table 12. Estimated values of the parameters in the distance-decay function (eq. 14) for 54 project research-days of 12 inland beaches in the Netherlands.

Inland beach	Date	Sphere of influence (km)	Number of origins	Parameters α	β	γ	Goodness of fit R^2	Standard deviation
1. Beekse Bergen	1-6-68	43	93	26.00	0.49	0.16	0.84	0.055
	2-6-68	43	93	13.90	0.28	0.32	0.42	0.401
	7-7-68	43	93	30.76	0.53	0.27	0.12	0.934
	18-7-68	43	93	1287.70	1.20	0.42	0.28	0.801
	31-7-68	43	93	3.65	0.03	−0.96	0.28	0.891
	26-7-69	43	93	2.87	0.20	0.13	0.23	0.353
	27-7-69	43	93	4.32	0.02	−1.83	0.26	0.904
	6-8-69	43	93	3079.90	1.42	0.54	0.15	0.952
2. Eurostrand	3-6-68	96	275	8.73	0.20	0.08	0.54	0.327
	2-7-68	96	275	13.44	0.18	0.05	0.65	0.473
	28-7-68	96	275	28.35	0.77	0.09	0.13	0.230
	30-7-68	96	275	11.45	0.19	0.10	0.52	0.466
	24-8-68	96	275	6.75	0.21	0.05	0.64	0.193
	25-8-68	96	275	9.33	0.34	0.15	0.22	0.354
	26-7-69	96	384	0.27	0.02	−0.06	0.05	0.260
	27-7-69	96	384	1.57	0.003	−1.08	0.05	0.573
	6-8-69	96	384	1.77	0.11	0.13	0.10	0.422
3. Hemelrijk	2-7-67	49	52	889.17	0.78	0.29	0.53	1.590
	20-7-67	49	52	33.00	0.40	0.08	0.66	0.470
4. Hildenberg	2-7-67	15	12	100.23	0.01	−83.80	0.15	12.0
	20-7-67	15	12	38.26	0.02	−29.93	0.15	5.9
5. Ieberenplas	2-7-67	51	60	8.56	0.10	−0.12	0.32	1.285
	20-7-67	51	60	4.21	0.14	0.03	0.52	0.276
6. Kibbelkoele	2-7-67	82	103	5.64	0.07	0.04	0.57	0.588
	13-7-67	82	103	7.50	0.13	0.13	0.53	0.505
	20-7-67	82	103	1.86	0.07	0.03	0.63	0.178
	1-8-70	59	115	12.68	0.18	0.04	0.87	0.226

Table 12 (continued)

Inland beach	Date	Sphere of influence (km)	Number of origins	Parameters			Goodness of fit R^2	Standard deviation
				α	β	γ		
	2-8-70	59	115	27.08	0.22	0.15	0.91	0.100
7. Loofles	20-7-69	42	60	13.19	0.17	0.07	0.58	0.404
	23-7-69	42	60	48.21	0.19	−0.01	0.89	0.514
	27-7-69	42	60	46.33	0.19	0.07	0.81	0.669
	5-8-69	42	60	1.18	0.02	−0.34	0.02	0.910
	9-8-69	42	60	37.77	0.28	0.04	0.86	0.224
	10-8-69	42	60	42.35	0.30	0.30	0.25	0.906
8. Loomeer	2-7-67	72	100	4.43	0.08	−0.003	0.52	0.416
	20-7-67	72	100	2.57	0.10	0.005	0.60	0.164
9. Maarsseveense Plassen	1-8-70	26	38	15.68	0.36	0.42	0.52	0.878
	2-8-70	26	38	12.07	0.21	0.39	0.50	1.250
	29-8-70	26	45	8.79	0.37	0.05	0.76	0.317
	30-8-70	26	45	28.62	0.49	0.45	0.69	0.782
10. Schatberg	1-8-70	72	82	18.63	0.33	0.14	0.74	0.303
	2-8-70	72	82	1609.70	1.15	0.51	0.55	0.557
	30-8-70	72	82	3.76	0.25	0.14	0.28	0.257
11. Tijnaarlo	14-5-67	51	62	5808.80	1.47	0.06	0.92	0.156
	2-7-67	51	62	4569.70	1.35	0.32	0.59	0.566
	12-7-67	51	62	1911.00	0.28	0.13	0.92	0.710
	20-7-67	51	62	347.45	0.91	0.18	0.92	0.148
	29-7-67	51	62	2321.50	1.25	0.10	0.86	0.244
	1-8-70	48	67	2016.00	1.29	0.11	0.82	0.191
	2-8-70	48	67	2444.40	1.28	0.15	0.71	0.331
12. Zandenplas	18-7-69	64	106	1406.90	0.80	0.004	0.87	0.222
	19-7-69	64	106	2447.30	0.88	0.10	0.69	0.374
	23-7-69	64	106	3870.20	0.88	0.16	0.60	0.757
	27-7-69	64	106	495.02	0.65	0.09	0.75	0.338

dences over the region. High values are found for the projects 1, 10 and 11 and low values for the projects 4, 5, 6, 7 and 8, but this picture is not consistent since for instance projects 1 and 2 have both high values as well as low ones.

All these results have to be seen in relation with the goodness of fit, which is also fluctuating to a large extent (from 0.02 for project 7 to 0.92 for project 11). The R^2 mostly differs from project to project although some projects also show a great difference from day to day. Projects 3, 6, 8, 9, 11 and 12, so half of the projects tend to have a goodness of fit. On the other hand it is evident that the fluctuation in number of visits per origin can never be fully explained by the number of inhabitants and the distance, as in all cases there must be more influencing factors. The results of the multiple regression analysis will show this.

3.3.2.2 Regression equations

In the regression analysis a stepwise regression procedure (Draper & Smith, 1967) was followed by means of an adapted computer program. This resulted in regression equations for the 39 project research-days. In the regression analyses three forms of the independent variable either V_t or one of two functions of V_t, i.e. $\log 100(V_t+1)(P+B)^{-1}$ respectively $\log 100(V_t+1)(P+B-E)^{-1}$ were used, each for some of the 39 prd. From this it appeared that the equation with the $(P+B)$-form gave a R^2 of 0.59, the equation with the $(P+B-E)$-form a R^2 of 0.60, while the direct V_t-form gave a R^2 of 0.80. This last equation reads (between brackets the standard deviations of the regression coefficients; Standard deviation = 117; R^2 = 0.80):

$$
\begin{aligned}
V_t = 8070 &+ \underset{(0.0007)}{0.006P} - \underset{(0.02)}{0.17A_{c1}} - \underset{(23.79)}{152.21 \ln D_r} + \underset{(128.25)}{400.98 \ln C_1} - \underset{(414.40)}{2284.48\, e^{A_{c1}10^{-4}}} + \\
&- \underset{(13.32)}{3930 \ln (A_{c1}+1)} - \underset{(68.61)}{675.19 \ln (21 \times 10^3 - A_{c1})} + \varepsilon \qquad (40)
\end{aligned}
$$

where

V_t = total number of visits to an inland beach per origin on a certain day

P = number of inhabitants of origin

A_{c1} = capacity of alternative outdoor recreation sites inside origin, weighted according recreation type

D_r = road distance between origin and site in km

C_1 = education level of population of origin

The most important independent variables in the three equations were found to be: P (inhabitants), D_r and D_a (distance), M (mobility), C_1 (education) and A_{c1} and A_{c2} (alternative sites).

The variables giving a significant improvement in the explanation of the variancy in the measured number of visits per origin in the different regression equations are given in table 13. This table shows that although many variables are included in the different equations, the variables based on number of inhabitants, distance and alternative sites appear to be the most important ones.

Table 13. Used independent variables, multiple regression coefficient and standard deviation of the regr
Netherlands.

Project	Date	Sphere of influence (km)	Used variables			
Non-free entrance						
1. Beekse Bergen	1-6-68	22	U	$\ln P$	D_a^{-2}	PH^{-1}
	2-6-68	43	H	$\ln D_r$	$\ln D_a$	D_a^{-1}
	7-7-68	54	D_r	H	$\ln D_r$	D_a^{-1}
	31-7-68	37	D_r	$\ln D_r$	$D_r^{-1.5}$	$D_a^{-1.5}$
	26-7-69	43	H	$\ln D_r$	$\ln D_a$	D_a^{-1}
	27-7-69	59	D_r	P	$\ln D_r$	$D_r^{-1.5}$
	6-8-69	89	D_r	$D_r^{2.5}$	$\ln D_r$	$D_r^{-1.5}$
2. Eurostrand	3-6-68	96	P	U	$\ln(P-E+B)$	$(P-E+B$
	30-7-68	96	P	U	$\ln U$	$\ln D_r$
	24-8-68	77	P	F	U	$\ln U$
	25-8-68	96	E	F	U	$\ln U$
	26-7-68	96	P	F	U	$\ln U$
	27-7-68	96	P	F	U	$\ln U$
	6-8-68	96	P	U	$\ln(P-E+B)$	$\ln U$
9. Maarseveense Plassen	1-8-70	18	E	P	PF^{-1}	D_a^{-1}
	2-8-70	19	E	U	PF^{-1}	$\ln(PF^{-1})$
10. Schatberg	2-8-70	20	F	H	$e^{-10^{-2}D_a}$	D_r^{-2}
11. Tijnaarlo	14-5-67	51	P	A_{c1}	$\ln P$	$\ln U$
	2-7-67	51	P	$\ln P$	$\ln D_r$	$e^{-A_{s1}}$
	12-7-67	51	P	D_r^{-2}	$\ln(1.1\times10^5-A_{c1}$	$\ln(A_{s2}+0.$
	20-7-67	51	$D_r^{-1.5}$	D_r^{-2}	$(A_{s2}+0.01)^{-1}$	$e^{-10^{-5}A_{s2}}$
	29-7-67	51	P	$\ln P$	$\ln U$	$D_r^{-1.5}$
Free entrance						
3. Hemelrijk	2-7-67	49	U	D_r^{-2}		
	20-7-67	49	A_{s1}	$\ln D_r$	$D_r^{-1.5}$	D_r^{-2}
4. Hildenberg	2-7-67	15	P	A_{c1}	A_{s2}	$e^{-10^{-4}\cdot A_{c1}}$
	20-7-67	15	D_r	$\ln D_r$	$\ln y$	$(A_{s1}+0.01$
5. Ieberenplas	2-7-67	48	P	U	$\ln P$	D_r^{-2}
	20-7-67	48	A_{s2}	$\ln P$	$\ln U$	$\ln D_r$
6. Kibbelkoele	2-7-57	82	P	A_{c1}	$\ln D_r$	$\ln(A_{c1}+1)$
	13-7-67	78	A_{c1}	$\ln P$	$\ln D_r$	$\ln(1.01-$
	20-7-67	78	P	U	A_{c1}	$\ln D_r$
7. Loofles	23-7-69	42	F	$\ln D_r$	D_r^{-2}	$\ln(1.01-$
	27-7-69	42	F	U	A_{c1}	$\ln P$
	9-8-69	47	H	$D_a^{2.5}$	$D_r^{-1.5}$	D_r^{-2}
8. Loomeer	2-7-67	72	P	A_{s1}	$e^{-10^{-2}Dr}$	$e^{-A_{s1}}$
	20-7-67	72	D_r	P	$\ln(1.01-A_{s1})$	
12. Zandenplas	19-7-69	28	H	I	D_a^{-2}	PH^{-1}
	23-7-69	28	H	I	P/F	$\ln U$
	27-7-69	64	I	$P-E+I$	$D_r^{2.5}$	D_r^{-1}

tions of 39 project research-days for 5 non-free entrance and 7 free entrance inland beaches in the

variables			R^2	Standard deviation
$+1)^{-1}$	$(A_{c2}+1)^{-1}$	$P(A_{c2}+1)^{-1}$	0.99	20
.5	$D_a^{-1.5}$	D_r^{-2}	0.92	222
.5	$D_a^{-1.5}$	D_r^{-2}	0.89	126
	PH^{-1}	$\ln(1.01-A_{s1})$	0.94	167
.5	$D_a^{1.5}$	D_r^{-2}	0.94	71
.5	D_r^{-2}	D_a^{-2}	0.92	145
.5	D_r^{-2}	$P(A_{c1}+A_{c2}+1)^{-1}$	0.85	41
	D_r^{-2}	D_a^{-2}	0.48	145
$^{2}D_r$	D_r^{-2}	D_a^{-2}	0.61	67
	D_a^{-2}		0.62	89
	D_{r-2}	D_a^{-2}	0.52	98
	D_r^{-2}	D_a^{-2}	0.58	23
	D_r^{-2}	D_a^{-2}	0.50	143
	D_{r-2}	D_a^{-2}	0.57	38
$+A_{c2}+1)^{-1}$	$\ln[4.6\times10^5-(A_{c1}+A_{c2})]$	$P(A_{c1}+A_{c2}+1)^{-1}$	0.99	111
	$D_r^{-1.5}$	$P(A_{c2}+1)^{-1}$	0.98	227
$_{c1}+1)$	$(A_{c2}+1)^{-1}$	$(P-E+B)(A_{c1}+A_{c2}+1)^{-1}$	0.78	42
.5	$\ln(1.1\times10^5-A_{c1})$		0.83	38
$1\times10^5-A_{c1})$	$(A_{s2}+0.01)^{-1}$	$P(A_{c2}+1)^{-1}$	0.91	78
$+A_{c2}+1)^{-1}$			0.94	28
$_{c2}+1)$	$P(A_{c2}+1)^{-1}$	$P(A_{c1}+A_{c2}+1)^{-1}$	0.85	21
	$\ln(1.1\times10-A_{c1})$		0.81	37
			0.93	131
$01-A_{s1})$	$P(A_{c2}+1)^{-1}$	$P(A_{c1}+A_{c2}+1)^{-1}$	0.99	18
$1\times10^5-A_{c1})$	$\ln(1.01-A_{s2})$	$P(A_{c1}+A_{c2}+1)^{-1}$	0.53	93
$+1)^{-1}$	$P(A_{c2}+1)^{-1}$		0.85	19
$+1)^{-1}$	$(A_{c2}+1)^{-1}$	$\ln(1.1\times10^5-A_{c1})$	0.85	47
	D_r^{-2}	$\ln(1.1\times10^5-A_{c1})$	0.79	20
$^{-4}A_{c1}$	$\ln(A_{c1}+1)$	$\ln(1.1\times10^5-A_{c1})$	0.80	117
$^{-4}A_{c1}$	$\ln(A_{c1}+1)$	$\ln(1.1\times10^5-A_{c1})$	0.82	74
$^{-4}A_{c1}$	$\ln(A_{c1}+1)$		0.84	26
		$\ln(1.01-A_{s2})$	0.74	331
	$\ln(1.1\times10^5-A_{c1})$	$P(A_{c1}+A_{c2}+1)^{-1}$	0.79	327
$H^{-1})$	$(A_{c1}+A_{c2}+1)^{-1}$		0.78	108
$01-A_{s1})$			0.66	78
			0.35	35
$+1)^{-1}$	$P(A_{c2}+1)^{-1}$	$P(A_{c2}+1)^{-1}$	0.99	49
$+1)^{-1}$			0.98	194
$+0.01)^{-1}$	$P(A_{c2}+1)^{-1}$	$P(A_{c2}+1)^{-1}$	0.69	129

3.4 Discussion

The regression equations as given in the previous section show that three groups of factors are important in explaining the variancy in number of visits per origin, namely:

- number of inhabitants or variables derived from it;
- distance between origin and site (of which in the equations the road distance or variables derived from this were used in most cases);
- properties of alternative sites (both scores and capacities of the sites were used) or the from this derived variables.

In Chapter 5 use models will be constructed based upon those variables which appear frequently in the regression equations. The type of the models will be based on the way in which these variables occur in the different equations.

Comparing the regression equations with functions found in other studies a similarity is found. Merewitz (1966) constructed use models in which population, distance and population density gave a significant explanation. The form of his equation is similar with, for instance, a ln-form for the inhabitants variable and the distance variable as an e-power. Stevens (1966) constructed use models for fishing waters and he found as most important variables distance, travel cost and income. So one socio-economic variable appeared in the equations, but the distance (and the with this closely related travel cost) appeared to be the most important one.

All in all it can be stated that from the socio-economic variables inhabitants and from the region distance and properties of alternative sites give a good explanation of measured behaviour. The advantage of this is that use models can probably be constructed in a rather simple way and then will be easy to use for prediction. On the long term, however, there is a reasonable doubt about their power for prediction. This results from neglecting factors which can be expected to change with time (as for instance income, mobility, education, etc.). That they do not appear in the short term models is probably caused by the fact that their variancy is rather small compared with other factors as inhabitants, distance and properties of alternative sites. On the other hand it might be that other socio-economic factors do not have a significant impact on visits to inland beaches. According to Kerstens (1971b) swimming for instance is classless. In terms of use models this would mean that socio-economic factors as income, free time, occupation, etc. do not fit in the equations. It would also be possible that the measured behaviour of people with regard to visits to inland beaches is on a level at (and in a range in) which the socio-economic variables do not have any influence. From the results of the present analysis it is not clear which of these alternatives is the case. When socio-economic variables could be omitted, this would mean that the use models can be used as a prediction model on the short as well as on the long term. If not, they will only have a short term validity.

For this reason use models have to be applied with care, particularly when using them for long-term predictions (see also Chapter 5).

4 Relationship of visits with meteorological factors

4.1 General

As regards weather models for inland beaches the following definition will be used: A weather model for inland beaches gives the relationship between the number of visits per day to an inland beach expressed in weather values and one (or a set of) meteorological factors at constant human (socio-economic) and area (geographical) properties.

As already mentioned (Chapter 2) the relationship between visits to inland beaches in the Netherlands and weather can be studied in two ways, namely statistically by relating separate (or combinations of) meteorological factors to visits or physically by expressing the heat exchange of man with the atmosphere in meteorological factors and relating this formulation to measured data on visits. In this study both systems will be followed. In the present Chapter, however, only the statistical relationship will be studied by means of multiple regression analysis of which the results will lead to the statistical weather model of Chapter 5.

For the construction of weather models data on visits per day and weather are required. The number of visits on a specific day to an inland beach is easily known if the project is a non-free entrance one. The number of tickets sold is a rather accurate estimate of the number of people visiting the project. For the Netherlands there is a limited number of inland beaches with known figures on visits per day over many years, of which four projects were chosen to determine the relationship between weather and number of visits.

Weather data were obtained in two ways namely by own investigations with small temporary weather stations at four inland beaches and by using data of official climatogical stations of the Royal Netherlands Meteorological Institute. These latter stations were chosen as close as possible to the projects, but in some cases not all required weather data were available.

The relationship between visits and meteorological factors was studied in four steps:
step 1: regression analysis of visits per day and all basic and derived meteorological variables for the inland beach Tijnaarlo. Based on the results of these analyses the significant variables were chosen for further analysis;
step 2: regression analysis of visits per day and the meteorological factors for the projects Hoeven, Wijde Wormer and Soest;
step 3: setting and calibrating a statistical weather model, based on the regression analysis of step 2 for all four projects and 12 day-groups according part of season and

type of day (Chapter 5);
step 4: setting and calibrating a heat exchange weather model (Chapter 5).

4.2 Data requirements and sampling procedure

4.2.1 Required data

The model describing the relationship between weather values based on the number of visits per day to inland beaches, and meteorological factors is similar to the use model:

$$W = \mathrm{f}(z_1 \ldots z_n) \tag{41}$$

where
W = outdoor recreation weather value, based on the number of visits per day
$z_1 \ldots z_n$ = meteorological factors

The variables used in the regression analyses are listed in table 14.

Although data on some meteorological factors were taken at four inland beaches, these data were not used for the calculations since as will be shown, the differences between the values obtained on the projects and those from the official climatological stations were negligible. Moreover, when carrying out a frequency analysis on meteorological factors data over many years are needed, which are only available from

Table 14. Main and subgroups of variables used in the regression analysis of visits per day to inland beaches and meteorological factors.

Main group	Subgroup	Number of variables	
		basic	derived
a. Properties	a.1 day of research	1	–
	a.2 number of project	1	–
	a.3 number of weather station	1	–
	a.4 day-group	1	–
b. Dependent variables	b.1 visits per day	1	8
c. Independent variables	c.1 temperature	4	12
	c.2 relative humidity	2	3
	c.3 rainfall	2	8
	c.4 cloud cover	2	13
	c.5 sunshine duration	1	6
	c.6 wind velocity	2	14
	c.7 air pressure	2	6
	c.8 global radiation	1	1
	c.9 combined variables	–	17

official stations. Therefore the latter were taken. In total 21 basic variables and 88 derived variables were included in the calculations. As mentioned (see step 1), during the analysis it became clear that not all of the introduced variables were useful so a restricted number was used in later calculations.

For the determination of the value of several variables (basic as well as derived) special procedures were developed. These are given in the following section.

4.2.2 Data acquisition

4.2.2.1 Field surveys

Two field surveys were carried out:

- on four inland beaches in the years 1969 and 1970 temporary weather stations were erected to see if the data from official climatological stations of the Royal Netherlands Meteorological Institute in the neighbourhood were applicable;
- from 1968 through 1970 recreationists on inland beaches were asked to give their evaluation of the actual weather conditions.

Temporary weather stations were used on the inland beaches Loofles (no. 7) and Zandenplas (no. 12) during 1969, and Schatberg (no. 10) and Tijnaarlo (no. 11) during 1970. The data obtained were compared with the data of the most nearby official climatological station. With regard to temperature a comparison was made for the mean temperature in the morning (10 to 13 hrs) as well as the afternoon (13 to 16 hrs). It was found that during the period of investigation a maximum difference of 1 °C existed between the stations. Such a close correlation was also found for sunshine duration, wind direction and rainfall. Wind velocity values differed more, however. The measured wind velocity at Tijnaarlo was about 1/3rd of that measured at the official climatological station at Eelde. For Schatberg the wind velocity was approximately 2/3rds of the wind velocity at the Beek climatological station. The main reason of this difference is that on the official station wind velocity is measured at 10 m height, while at the inland beach stations measurements were taken between 1 and 2 m where wind velocity may be strongly reduced by plantations used as wind screens (see also Rijkoort, 1968). Comparison of all data led to the conclusion that the weather data obtained from the official climatological stations could be used in the calculations. It was to be expected, however, that in that case a lower value of the regression coefficient of wind velocity would be obtained than when using data from the temporary weather stations. As already mentioned, another reason for using data of official stations is that data from these stations are available over many years, making it possible to carry out more accurate regression analyses. Moreover, a frequency analysis of outdoor recreation weather values can be carried out over many years also (see Chapter 5).

In a weather model the climatological factors have to be related to a certain measurement of the 'agreeableness' of the weather. For the latter can be used:

– weather evaluations by the visitors (see for instance den Tonkelaar, 1972);
– the total number of visits per day on an inland beach.

The weather evaluations were obtained by means of questionnaires on which the answers of the visitors were coded from 0 to 10. These data showed to have:

– a high variancy making it undesirable to work with a mean weather evaluation per day;
– a low response on many days, making it impossible to use a mean weather evaluation for those days.

It was therefore decided to use as a measure for the 'agreeableness' of weather the total number of visits per day on four inland beaches of which data were available over many years.

This means that as well for meteorological data as for the evaluation of the weather by means of number of visits per day, use was made of existing statistics only.

4.2.2.2 Existing statistics

Regarding the data used for regression analyses, the acquisition will be described of:

– the day-group;
– the total number of visits per day and a number of derived variables;
– the meteorological factors and a number of derived variables.

Day-group The number of visits per day on an outdoor recreation project depends, for a given area, on three important factors: the specific part of the (recreational) season, the day-group and the weather conditions. If the fluctuation in number of visits per day is to be related to the weather conditions, the other influences have to be kept constant. Therefore a subdivision of all days on which an inland beach can be visited in the Netherlands (approximately 105 to 120 per year) was made based on a division of the season as well as the type of day.

The recreational season was subdivided into:

– the early season: from approximately half of May through half of June;
– the main season: from approximately half of June through half of August (with exception of the industrial holidays);
– the industrial holidays: a fortnight in the main season, differing in date from year to year;
– the late season: from approximately half of August to the beginning or half of September.

The type of day was subdivided into:

– Sundays and other official holidays (as Whitmonday, etc.);
– Saturdays;
– workdays.

In this way 12 day-groups were formed. For an average year the number of days in each group is given in table 15.

Table 15. Number of days in the 12-day groups for an average year; between brackets the corresponding day-group numbers.

Type of day	Early season	Main season excl. industrial holidays	Industrial holidays	Late season	Total
Sundays plus official holidays	4 (1)	5 (4)	3 (7)	4 (10)	16
Saturdays	4 (2)	5 (5)	3 (8)	4 (11)	16
Workdays	22 (3)	34 (6)	10 (9)	22 (12)	88
Total	30	44	16	30	120

Most of the days fall in the main season, industrial holidays and the late season occupy the least number of days. Since for each group a regression equation has to be calculated it is clear that data over many years are needed.

Visits The number of visits per day were obtained from four projects over a number of years (see table 16). These data, collected from existing records of the projects, cannot be used directly. The figures on visits per day have to be corrected with regard to:

- changes on the projects which could have an impact on visit rates;
- special groups as holders of season tickets, non-paying small-age children and other groups not taking day-tickets.

It was checked that at the four projects no major changes had taken place during the research years. As regard the second correction this was carried out via survey checks and known other administrative material.

To make the now corrected number of visits comparable over the whole range of years, which is necessary for the correlation with meteorological factors, the following corrections have been applied.

Table 16. Projects and years for which data on visits per day were obtained.

Project	Area (ha)			Accommodation rate	Data available over the years
	water	land	total		
11. Tijnaarlo	3.5	21.5	25	high	1962 through 1964 and 1967 through 1970
13. Bosbad Hoeven	2.5	3.5	6	high	1961 through 1970
14. Natuurbad Wijde Wormer	3	1	4	moderate	1961 through 1968 and 1970
15. Soester Natuurbad	0.4	2.4	2.8	high	1962 through 1970

A regression line was calculated through all values of the mean number of visits per day per day-group and year. The equation of this line is:

$$V_{t.g,j} = V_{t.g,0} + bj \tag{42}$$

where

$V_{t.g,j}$ = mean number of visits per day for day-group g and year j
$V_{t.g,0}$ = value of $V_{t.g,j}$ for $j=0$
b = regression coefficient
j = year; initial year = 0

The construction of the regression line caused some difficulties, as for some day-groups not enough data were available (for instance Tijnaarlo) or no obvious trends were found. A method in which the 3-year progressive sums of $V_{t.g,j}$ were introduced did not give much improvement.

The trend corrections of V_t are possible via:

– addition: a certain number of visits, depending on the span of years between the year taken and the final year of investigation, is added to the measured number. This correction is fixed per day-group. It reads:

$$V_t' = V_t + b(j_9 - j_{9-i}) \tag{43}$$

– multiplication: the measured number of visits is multiplied by a multiplier also fixed for each day-group:

$$V_t' = V_t \frac{V_{t.g,9}}{V_{t.g,j}} \tag{44}$$

The purpose of the trend corrections is to take away differences in number of visits caused by other than weather factors (such as an increase in population, in mobility, in free time, etc.),a must when constructing a predictive weather model. The percentual differences between number of visits in the various years stay constant when applying multiplicative corrections, but decrease after additive corrections. It is for this reason that the corrections were made with the aid of the multiplicative model for the project Hoeven. For the other three projects no trend correction was required.

Meteorological factors Since not all data on needed weather factors were available from all neighbouring official climatological stations some of the data had to be taken from other nearby stations, so in total data from 7 stations were used (the first given station is the main station for the project):

– for Tijnaarlo: Eelde and De Bilt;
– for Bosbad Hoeven: Oudenbosch, Numansdorp and De Bilt;
– for Natuurbad Wijde Wormer: Hoorn, Amsterdam, De Bilt and Lelystad;
– for Soester Natuurbad: De Bilt.

If certain data were not available on the main weather station then a station was chosen which could be expected to give a reasonable good replacement for the missing factor. The replacement of missing data from other stations will be rather accurate with regard to sunshine for Oudenbosch-Numansdorp and Hoorn-Amsterdam, and for air pressure in general. Wind velocity will be less accurate, especially in the case of Oudenbosch-De Bilt.

As regards global radiation, this factor was calculated for the stations Eelde, Numansdorp, Amsterdam and De Bilt based on the following formula (Wesseling, 1960):

$$H_{sh} = \left(0.29 + 0.71\,\frac{S}{100}\right) H_{max} \tag{45}$$

where

H_{sh} = global radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$

S = sunshine duration per day in % of possible maximum

H_{max} = maximum global radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$ (see table 17)

Table 17. The value of H_{max} (maximum radiation on clear days in $cal \cdot cm^{-2} \cdot day^{-1}$) per 10-day period (I, II and III) and as a monthly average ($\bar{m}$) for each month in the Netherlands (after Wesseling, 1960).

Month	Period			$\bar{m}$
	I	II	III	
January	97	110	134	114
February	168	208	253	207
March	305	360	412	361
April	467	520	569	519
May	611	651	684	650
June	705	715	718	713
July	708	685	606	682
August	617	574	525	570
September	472	422	372	422
October	321	267	217	267
November	174	137	115	142
December	101	93	91	95

The variables of subgroup c.9 (see table 14) are introduced for a better goodness of fit because empirical functions with these variables giving the relationship between human comfort and weather factors are known from literature (see Chapter 2), and introduction of these variables leads to other than additive models. In total four new and four already known combined variables were introduced. The first mentioned ones are multiplications of two variables, the dry bulb temperature at 14 h p.m. on the one hand and respectively sunshine, global radiation, relative humidity at 14 h p.m. and wind velocity at 14 h p.m. on the other hand. From the empirical functions the discomfort index (Thom, 1959), a function based on wind velocity and temperature (Schmidt, 1967) and two functions based on the effective temperature (Schmidt, 1967) were used.

4.3 Regression analysis

4.3.1 Method and criteria for goodness of fit

A discussion of the several types of tests for goodness of fit was already given in Section 3.3.1. For the regression analysis of visits and weather a criterion had to be chosen with which the differences between measured and calculated number of visits per day is minimalized for days with reasonable to very good weather conditions, so on days with generally a high to very high number of visits. The goodness of fit for days with a lower number of visits was allowed to be less. The procedure used is a certain way of weighting. The goodness of fit is, as was the case in the regression equations of Chapter 3, expressed by the multiple correlation coefficient (R^2).

4.3.2 Results

During the procedure of regression analysis certain limitations were made. The first limitation was the number of steps, which was initially set at 15 and later reduced to 10. This was possible because in most equations more variables than 10 did not give much improvement, while in many cases the R^2 was already as high as 0.85. As an example the calculations for Tijnaarlo are given in table 18. In some cases only two or three variables were significant (for instance group 8), while other equations did not give a high R^2 with as many as 7 variables (group 3).

The second limitation was the number of variables. From the first calculations it was clear that certain independent variables did not give much improvement in the value of R^2. Factors as temperature, cloud cover, sunshine and wind velocity occur with a high frequency in the regression equations, while other factors like humidity, rainfall and global radiation were used less. For this reason all later calculations were carried out with the following basic and derived variables:

- temperature: especially T_{d2}, the dry bulb temperature at 14 h p.m.;
- cloud cover: especially N_{t1} and N_{t2}, the cover at 8 h a.m. and 14 h p.m. respectively;
- sunshine: S, sunshine duration per day in % of possible maximum;
- wind velocity: especially u_{t1} and u_{t2}, the wind velocity at 8 h a.m. and 14 h p.m. respectively.

The regression analyses were carried out for four projects and 12 day-groups for each project, giving 48 regression equations. The used variables, the standard devia-

Table 18. Increase of the multiple correlation coefficient (R^2) with the number of introduced variables in the regression equation for 12 different day-groups, valid for data of Tijnaarlo over 7 years (1962 through 1964 and 1967 through 1970).

Day-group (see table 15)	Number of data	Variables, multiple correlation coefficient (R^2) and standard deviation							
		1st variable	R^2	2nd variable	R^2	3rd variable	R^2	4th variable	R^2
1	35	$T_{a2}H_{sh}$	0.53	$\ln p_{a2}$	0.65	N_{t2}^{-1}	0.68	$\sqrt{N_{t1}}$	0.70
2	24	$\frac{1}{2}(T_{a1}+T_{a2})$	0.67	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$	0.71	$\ln(\frac{1}{4}T_{a1}+\frac{3}{4}T_{a2})$	0.75	$T_{a2}u_{t2}$	0.79
3	116	$\frac{1}{2}(T_{a1}+T_{a2})$	0.50	$\ln[\frac{1}{2}(T_{a1}+T_{a2})]$	0.53	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$	0.54	$\ln N_{t2}$	0.55
4	39	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	0.76	r_{h1}	0.79	u_{t1}^{-1}	0.82	S^3	0.86
5	38	$\ln(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})$	0.65	N_{t1}	0.70	$\ln N_{t2}$	0.76	$[\frac{1}{2}(u_{t1}+u_{t2})]^{-1}$	0.78
6	233	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	0.49	u_{t2}^{-1}	0.59	N_{t1}^{-1}	0.61	$T_{a2}S$	0.63
7	21	T_{a2}	0.59	r_{h1}	0.68	$\ln(p_{a1}-p_{a2})$	0.74	R_{t2}^2	0.78
8	21	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	0.86	$T_{a2}S$	0.96	$\ln(r_{h2})$	0.97	R_{t1}^2	0.98
9	70	$T_{a2}-T_{w2}$	0.52	$p_{a1}-p_{a2}$	0.65	T_{a1}	0.70	T_{w1}	0.72
10	22	$T_{a2}S$	0.47	$\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2}$	0.72	u_{t1}	0.79	$\ln p_{a1}$	0.81
11	23	$\sqrt{N_{t1}}$	0.72	$\frac{1}{2}(u_{t1}+u_{t2})^2$	0.78	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	0.86	T_{a1}	0.91
12	92	$T_{a2}H_{sh}$	0.42	$\ln(T_{a2}H_{sh})$	0.54	$\sqrt{N_{t1}}$	0.61	$T_{a2}S$	0.64

Day-group	Number of data	5th variable	R^2	6th variable	R^2	7th variable	R^2	Standard deviation
1	35	R_{t2}^2	0.72	$\ln u_{t1}$	0.73	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	0.75	1134
2	24	$\ln S$	0.81	$\ln[\frac{1}{2}(p_{a1}+p_{a2})]$	0.83	N_{t1}^2	0.85	357
3	116	$T_{a2}u_{t2}$	0.57	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	0.58	p_{a1}	0.60	194
4	39	u_{t2}^{-1}	0.88	$S^{2.5}$	0.90	N_{t1}^{-1}	0.91	399
5	38	T_{a1}	0.81	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})^{-1}$	0.84	u_{t1}^2	0.85	249
6	233	$\ln r_{h2}$	0.66	$\ln(T_{a2}-4u_{t2}+12)$	0.66	$T_{a2}-T_{w2}$	0.67	298
7	21	$\ln(T_{a2}S)$	0.81	N_{t2}^{-1}	0.83	$p_{a1}-p_{a2}$	0.85	681
8	21	N_{t2}^{-1}	0.98	$\sqrt{(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})}$	0.99	S	0.99	113
9	70	r_{h1}	0.75	N_{t1}^{-1}	0.78	$\ln T_{w2}$	0.79	467
10	22	$\ln r_{h2}$	0.85	$\ln(T_{a2}S)$	0.88	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^2$	0.90	237
11	23	$\frac{1}{2}(u_{t1}+u_{t2})$	0.93	$(\frac{1}{4}u_{t1}+\frac{3}{4}u_{t2})^{-1}$	0.94	$\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2}$	0.95	43
12	92	N_{t2}^{-1}	0.66	$p_{a1}-p_{a2}$	0.68	$\sqrt{S}$	0.71	125

tions and the multiple correlation coefficients are given in table 19 (pages 67–72). They show that factors as temperature and effective temperature, cloudiness and sunshine, as well as wind velocity are the most important variables.

4.4 Discussion

The following conclusions can be drawn from the regression analyses:

Comparing the several regression equations it can be seen that for each day-group, but also for each project, different independent variables are found to be the significant factors in explaining the variancy in the measured number of visits per day. This, however, does not prove that people react in a different way to weather for the several projects, nor on the distinguished day-groups. It is caused by the fact that many independent variables are intercorrelated which probably is the reason that so many variables show up in the equations. The regression coefficients have mostly a high standard deviation, which proves that the influence of many variables is not very accurately estimated.

There are some other reasons, however, to draw the conclusion that people react differently on weather with regard to projects and day-group. For instance differences in lay-out of the four projects studied, especially with regard to bad weather accommodations, may indeed influence the reaction of people on weather conditions. Taking the type of day and the part of the season into consideration there are systematic differences in the multiple correlation coefficients (R^2), as shown in table 20. The conclusion can be drawn that for three inland beaches (Tijnaarlo, Hoeven and Wijde

Table 20. Multiple correlation coefficients of the calculated regression equations for 12 day-groups and 4 inland beaches in the Netherlands.

Project	Type of day	Season				Values of R^2 per project
		early	main	industrial holidays	late	
Tijnaarlo	Sunday	0.75	0.91	0.85	0.90	medium
	Saturday	0.85	0.85	0.99	0.97	high
	workday	0.60	0.67	0.79	0.71	low
Hoeven	Sunday	0.75	0.84	0.88	0.66	medium
	Saturday	0.85	0.83	0.97	0.73	high
	workday	0.63	0.65	0.74	0.56	low
Soest	Sunday	0.82	0.86	0.79	0.84	medium
	Saturday	0.91	0.88	0.96	0.92	high
	workday	0.78	0.79	0.94	0.86	medium
Wijde Wormer	Sunday	0.78	0.79	0.78	0.86	medium
	Saturday	0.91	0.95	0.97	0.80	high
	workday	0.63	0.67	0.79	0.56	low

Wormer) other factors than weather have on workdays a larger influence on the variancy in number of visits per day than on Saturdays and Sundays. This difference in influence of weather factors may also be a reason for the differences in the used variables in the regression equations and although it cannot be strictly concluded from the analyses, it may be an indication that people react differently on weather on different day-groups.

The multiple correlation coefficients (R^2) of the different regression equations (see table 20) are found to be the highest on Saturdays, medium for Sundays and lowest on workdays (the last except for Soest). Although the population on the types of day differs, it seems that on Saturdays the decision of people to visit an inland beach depends to a higher degree on weather than on the other days. So the number of visits can be predicted for Saturdays more accurately with the aid of weather factors than for Sundays and workdays. Since the number of visits on Saturdays are only a small part of the yearly visits this does not improve to an appreciable degree the overall accuracy of the prediction.

From the equations it appears that only three basic weather variables are needed to construct a weather model. Although most variables appear in various forms in the ultimate equations, most equations are built with: temperature, sunshine and/or cloudiness, and wind velocity. Of these factors sunshine and cloudiness are complements, while for instance temperature and sunshine is correlated. Adding other variables as humidity, air pressure, wind direction and global radiation does not give much improvement in the explanation of the variancy in the number of visits per day. This is probably caused by a high correlation between these factors and one or more of the three mentioned basic factors, as for instance global radiation which depends on sunshine.

Comparing the results of the regression analyses with other studies on the relation between weather and outdoor recreation in the Netherlands, it is found that in most cases the same weather factors are used. Delver (1952–1955) and den Tonkelaar (1972) constructed a non-linear relationship based on cloudiness, wind velocity and temperature. Their goodness of fit was low since weather values based on questionnaires were used. In the studies of Buwalda (1970) in which temperature, sunshine and rain were used, the type of relationship was not determined while the correlation coefficients between the dependent variable (driving for pleasure) and the independent weather variables was found to be low. Smedema (1971) constructed a non-linear relationship between the number of visits per day on inland beaches and temperature and sunshine (on days with less than ½ hour of rain). The R^2-values were mostly high (up to 0.86). Probably the most comparable study was done by Bruning (1971) for beaches in the new polders of the IJssel Lake. The relationship between visits and weather was given in an additive linear model which showed a high goodness of fit (up to 0.98) and was built with temperature, sunshine and wind velocity.

As R^2 in the calculated regression equations is usually high, it can be stated that the variancy in a small number of weather factors is highly correlated with the variancy in number of visits per day on an inland beach. Assuming that people will in the future react in the same way on weather as they did in last decade, it may be expected that the predictive power of the weather model will be high on the long term. This only holds true, however, if certain conditions are met. Creating for instance bad weather accommodations on a large scale will influence the number of visits especially on days with bad weather conditions.

In the light of the above mentioned conclusions and restrictions a weather model will be constructed with a general validity for recreation on inland beaches in the Netherlands, giving the relationship between weather values (based on number of visits per day) for this kind of outdoor recreation and meteorological factors. As meteorological factors will be chosen: dry bulb temperature at 12 h GMT; effective degree of cloudiness at 12 h GMT at wind velocity at 12 h GMT. The choice of these factors is based on the results of the regression analyses and the availability of values of these factors over many years and from many official climatological stations. For this reason sunshine, for instance, could not be used since data on this factor are not available at all stations or not over the whole period of time for which a frequency analysis will be carried out. Type and construction of the weather model will be given in Chapter 5, together with its use in the frequency analysis (Section 5.2.4). The model will also be used in the determination of the planning capacity of an inland beach (Section 7.2.2).

Table 19. Variables used (see List of Symbols), the standard deviation and the multiple correlation coefficient after 7 introduced variables in the regression equations for 12 day-groups (see table 15).

	1	2
Tijnaarlo	R_{t2}	$\frac{1}{2}(T_{a1}+T_{a2})$
1962 through 1964	$\sqrt{N_{t1}}$	$\ln(\frac{1}{4}T_{a1}+\frac{3}{4}T_{a2})$
and 1967 through 1970	N_{t2}^{-1}	N_{t1}^2
	$\ln u_{t1}$	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$
	$\ln p_{a2}$	$\ln S$
	$T_{a2}H_{sh}$	$\ln[\frac{1}{2}(p_{a1}+p_{a2})]$
	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	$T_{a2}u_{t2}$
Standard deviation	1134	357
R^2	0.75	0.85
Bosbad Hoeven	T_{a2}	S^3
1961 through 1970	$\sqrt{(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})}$	$T_{a2}-4\sqrt{(u_{t2})}+12$
	S^3	$\ln[T_{a2}-4\sqrt{(u_{t2})}+12]$
	$\ln u_{t1}$	
	$\ln(T_{a2}u_{t2})$	
Standard deviation	3148	1041
R^2	0.75	0.85
Soest	N_{t1}	N_{t2}^{-1}
1962 through 1970	u_{t2}	$\ln N_{t2}$
	N_{t1}^2	S^3
	$S^{2.5}$	$T_{a2}S$
	u_{t2}^2	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$
	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	
Standard deviation	1263	749
R^2	0.82	0.91
Wijde Wormer	T_{a2}	$\ln u_{t2}$
1961 through 1968	$\ln T_{a2}$	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$
and 1970	$S^{2.5}$	
	u_{t1}^2	
	u_{t2}^{-1}	
Standard deviation	523	235
R^2	0.78	0.91

Table 19 (continued)

	3	4
Tijnaarlo	p_{a1}	r_{h1}
1962 through 1964	$\frac{1}{2}(T_{a2}+T_{a1})$	N_{t1}^{-1}
and 1967 through 1970	$\ln[\frac{1}{2}(T_{a1}+T_{a2})]$	$S^{2.5}$
	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$	$\ln S$
	$\ln N_{t2}$	u_{t1}^{-1}
	$T_{a2}u_{t2}$	u_{t2}^{-1}
	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$
Standard deviation	194	399
R^2	0.60	0.91
Bosbad Hoeven		
1961 through 1970	T_{a2}	u_{t2}
	N_{t1}	N_{t1}^2
	u_{t1}	$S^{2.5}$
	N_{t2}^2	S^3
	N_{t2}^{-1}	u_{t2}^2
	$\ln(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})$	$T_{a2}S$
	$T_{a2}u_{t2}$	$T_{a2}-4\sqrt{(u_{t2})}+12$
Standard deviation	1388	3440
R^2	0.63	0.84
Soest	T_{a2}	T_{a2}
1962 through 1970	$\ln T_{a2}$	S
	$\sqrt{N_{t1}}$	u_{t1}^{-1}
	$\sqrt{N_{t2}}$	u_{t2}^{-1}
	u_{t1}^{-1}	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$
Standard deviation	743	800
R^2	0.78	0.86
Wijde Wormer	T_{a2}	T_{a2}
1961 through 1968	u_{t2}	$\ln T_{a2}$
and 1970	$\sqrt{N_{t2}}$	$\ln N_{t1}$
	$\ln[T_{a2}-4\sqrt{(u_{t2})}+12]$	$\ln N_{t2}$
		$\ln u_{t1}$
Standard deviation	251	339
R^2	0.63	0.79

Table 19 (continued)

	5	6
Tijnaarlo	T_{a1}	$T_{a2}-T_{w2}$
1962 through 1964	N_{t1}^{-1}	$\ln r_{h2}$
and 1967 through 1970	$\ln N_{t2}$	N_{t1}^{-1}
	$\ln(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})$	u_{t2}^{-1}
	u_{t1}^{2}	$T_{a2}S$
	$[\frac{1}{2}(u_{t1}+u_{t2})]^{-1}$	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$
	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})]^{-1}$	$\ln T_{a2}-4\sqrt{(u_{t2})}+12$
Standard deviation	249	298
R^2	0.85	0.67
Bosbad Hoeven	T_{a2}	T_{a2}
1961 through 1970	N_{t1}	S
	$\ln T_{a2}$	$\ln T_{a2}$
	N_{t1}^{2}	N_{t2}^{-1}
	u_{t1}^{2}	$\frac{1}{4}u_{t1}+\frac{3}{4}u_{t2}$
		$T_{a2}S$
		$(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})$
Standard deviation	1313	2093
R^2	0.83	0.65
Soest	T_{a2}	N_{t1}
1962 through 1970	S	$\ln T_{a2}$
	$\ln T_{a2}$	N_{t1}^{2}
	N_{t2}^{-1}	N_{t1}^{-1}
	$\ln u_{t1}$	$S^{2.5}$
	$T_{a2}S$	$\ln u_{t2}$
		$\ln(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})$
Standard deviation	744	900
R^2	0.88	0.79
Wijde Wormer	T_{a2}	T_{a2}
1961 through 1968	$\ln T_{a2}$	N_{t1}
and 1970	$\sqrt{N_{t1}}$	$\ln T_{a2}$
	N_{t1}^{-1}	N_{t1}^{-1}
	$\ln N_{t1}$	N_{t2}^{-1}
	$\ln N_{t2}$	S^{2}
	$\ln u_{t1}$	$\ln u_{t1}$
Standard deviation	174	359
R^2	0.95	0.67

Table 19 (continued)

	7	8
Tijnaarlo	T_{d2}	S
1962 through 1964	r_{h1}	$\ln r_{h2}$
and 1967 through 1970	R_{t2}	R_{t1}^2
	N_{t2}^{-1}	$\sqrt{(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})}$
	$p_{a1}-p_{a2}$	N_{t2}^{-1}
	$\ln(p_{a1}-p_{a2})$	$T_{d2}S$
	$\ln(T_{d2}S)$	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{d2})]^{-1}$
Standard deviation	681	113
R^2	0.85	0.99
Bosbad Hoeven	N_{t1}	S
1961 through 1970	$\sqrt{N_{t1}}$	$\sqrt{(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})}$
	$\ln(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})$	u_{t2}^{-1}
	$\sqrt{S}$	$T_{d2}S$
	$T_{d2}S$	$(0.13+0.47\sqrt{u_{t2}})(36.5-T_{d2})$
	$\ln T_{d2}-4\sqrt{(u_{t2})}+12$	$T_{d2}-4\sqrt{(u_{t2})}+12$
		$\ln[T_{d2}-4\sqrt{(u_{t2})}+12]$
Standard deviation	2503	652
R^2	0.88	0.97
Soest	T_{d2}	T_{d2}
1962 through 1970	$\ln T_{d2}$	N_{t1}
	$\sqrt{N_{t2}}$	
	N_{t2}^2	
	N_{t1}^{-1}	
	N_{t2}^{-1}	
	S^3	
Standard deviation	771	549
R^2	0.96	0.49
Wijde Wormer	$\sqrt{N_{t1}}$	T_{d2}
1961 through 1968	u_{t2}^2	N_{t1}
and 1970	$T_{d2}S$	$\ln T_{d2}$
		$\sqrt{N_{t1}}$
		N_{t1}^2
		N_{t1}^{-1}
		N_{t2}^{-1}
Standard deviation	529	107
R^2	0.78	0.97

Table 19 (continued)

	9	10
Tijnaarlo	T_{a1}	u_{t1}
1962 through 1964	T_{w1}	$\ln U$
and 1967 through 1970	r_{h1}	$\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2}$
	$T_{a2}-T_{w2}$	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^2$
	$\ln T_{w2}$	$\ln p_{a1}$
	N_{t1}	$T_{a2}S$
	$p_{a1}-p_{a2}$	$\ln(T_{a2}S)$
Standard deviation	467	237
R^2	0.79	0.90
Bosbad Hoeven	N_{t1}	T_{a2}
1961 through 1970	$S^{2.5}$	$\ln T_{a2}$
	S^3	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$
	$\ln u_{t1}$	$\ln(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})$
	$\ln(T_{a2}S)$	u_{t2}^2
	$\ln(0.13+0.47\sqrt{u_{t2}})(36.5-T_{a2})$	$T_{a2}S$
	$\ln[T_{a2}-4\sqrt{(u_{t2})}+12]$	
Standard deviation	2403	1995
R^2	0.74	0.66
Soest	T_{a2}	N_{t2}
1962 through 1970	N_{t2}^{-1}	S
	$\ln N_{t2}$	$\ln T_{a2}$
	$T_{a2}S$	$\ln N_{t2}$
		u_{t2}^{-1}
		$T_{a2}S$
		$\ln(T_{a2}S)$
Standard deviation	1055	702
R^2	0.84	0.92
Wijde Wormer	T_{a2}	T_{a2}
1961 through 1968	S	$\ln T_{a2}$
and 1970	$\sqrt{N_{t2}}$	$\sqrt{N_{t1}}$
	N_{t2}^2	N_{t2}^{-1}
	N_{t1}^{-1}	$\ln N_{t1}$
	u_{t1}^{-1}	$\ln u_{t1}$
	$T_{a2}S$	
Standard deviation	400	339
R^2	0.79	0.86

	11	12
Tijnaarlo	T_{d1}	$\sqrt{t}N_1$
1962 through 1964	$\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2}$	N_{t2}^{-1}
and 1967 through 1970	$\sqrt{N_{t1}}$	$\sqrt{S}$
	$\frac{1}{2}(u_{t1}+u_{t2})$	$p_{a1}-p_{a2}$
	$\frac{1}{2}(u_{t1}+u_{t2})^2$	$T_{d2}S$
	$(\frac{1}{4}u_{t1}+\frac{3}{4}u_{t2})^{-1}$	$T_{d2}H_{sh}$
	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{d2})]^{-1}$	$\ln(T_{d2}H_{sh})$
Standard deviation	43	125
R^2	0.97	0.71
Bosbad Hoeven	T_{d2}	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$
1961 through 1970	$\ln T_{d2}$	$S^{1.5}$
	N_{t1}^{-1}	$S^{2.5}$
	N_{t2}^{-1}	S^3
	$(\frac{1}{4}N_{t1}+\frac{3}{4}N_{t2})^{-1}$	u_{t2}^{-1}
	S^3	$\ln u_{t2}$
	u_{t1}^{-1}	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{d2})]^{-1}$
Standard deviation	1088	1046
R^2	0.73	0.56
Soest	S	S
1962 through 1970	$\sqrt{N_{t1}}$	$\ln T_{d2}$
	N_{t1}^2	$\sqrt{N_{t2}}$
	N_{t1}^{-1}	N_{t2}^{-1}
	$\ln N_{t1}$	$\ln N_{t2}$
	u_{t1}^{-1}	u_{t2}^{-1}
	$T_{d2}S$	$[(0.13+0.47\sqrt{u_{t2}})(36.5-T_{d2})]^{-1}$
Standard deviation	676	831
R^2	0.86	0.64
Wijde Wormer	T_{d2}	$\ln T_{d2}$
1961 through 1968	$\ln T_{d2}$	S^3
and 1970	N_{t1}^{-1}	$(0.13+0.47\sqrt{u_{t2}})(36.5-T_{d2})$
	N_{t2}^{-1}	$T_{d2}-4\sqrt{(u_{t2})}+12$
	$S^{2.5}$	
	S^3	
	$T_{d2}S$	
Standard deviation	292	277
R^2	0.80	0.56

5 Construction of use and weather models

5.1 Use model

5.1.1 Choice of variables

The regression equations of Chapter 3 have shown that the number of visits per origin to inland beaches in the Netherlands mostly depends on three factors: population of the origin, travel distance to the project and capacity of the competitive outdoor recreation projects inside and outside the origin. The construction of the final use models, as defined in Chapter 3, is given in the following sections.

The first step in constructing the models is the choice of variables which proved to be useful and significant in the regression equations. For the use models they are:

- for the origin factor:

P = number of inhabitants of origin

E = number of inhabitants of origin on vacation elsewhere

B = number of vacationists incoming into origin

- for the resistance factor:

D_r = road distance between origin and site in km

- for the competitive factor:

$A_{c1} + A_{c2}$, where

A_{c1} = capacity of alternative outdoor recreation sites inside origin, weighted according recreation type

A_{c2} = capacity of alternative outdoor recreation sites outside origin, weighted according recreation type and distance between origin and site

5.1.2 Model type

The manner and number of times in which the different variables appear in the regression equations (see Section 3.3.2.2) varies to a large degree from project to project. This is due to several reasons of which the size of the project, the accommodation level and the levying of entrance fees are probably the most important ones. Size, accommodation level and entrance fees often occur in combinations. Therefore the projects were divided in two groups: non-free entrance projects which are of a relatively large size and mostly have a high accommodation level and free entrance projects which are rather small and have low accommodation levels.

From the three important groups of variables (population, distance and alternative sites) in total 35 times basic variables and 155 times derived variables were used in 39 regression equations (one for each project research-day) for 12 projects. The number and manner in which the most important variables appear in the regression equations is given in table 21.

Table 21. Variables and their frequency of occurrence in the regression equations giving the relationship of visits with supply and socio-economic factors (see Section 3.3.2.2) for non-free entrance (a) and free entrance (b) inland beaches in the Netherlands.

Factor	Type of variable	Frequency		Total		Type of relation chosen
		a	b	a	b	
Population (origin factor)	$P-E+B$	14	8	24	14	$V=f(P-E+B)$
	$\ln(P-E+B)$	10	6			
Distance (resistance factor)	D_r	4	1	67	22	$V=f(D_r^{-\log D_r})$ and $V=f(e^{-D_r})$
	D_r^{-x}	40	12			
	$\ln D_r$	16	6			
	e^{-D_r}	7	3			
Alternative sites (competitive factor)	$(A_{c1}+A_{c2})^{-1}$	5	2	7	3	$V=f[(A_{c1}+A_{c2})^{-1}]$
	$\ln[46\times10-(A_{c1}+A_{c2})]$	2	1			

During the regression analyses (Chapter 3) some types of models, in which inhabitants, vacationists, road distance and alternative sites feature, were already tried out. The calculation procedure (estimating the values of the parameters) was done by means of an iteration process.

One of these models was more or less comparable to a distance-decay function (see Section 3.3.2.1), with the exception of a newly included variable 'alternative sites'. The latter gave, however, a low R^2. The other models were built for the dependent variable V. The different equations of this type did not give many differences (in all cases R^2 equalled 0.91) although the sum of squares of deviations could be decreased. In all models P and D were included, while the variables B and A were alternately built in. Good results were obtained with models in which B (incoming vacationists) and A (alternative sites) are used as variables, although a model with only P and A also gave a high R^2. Each model had his own meaning. In one of two models of a comparable form, for instance, it was assumed that the inhabitants and vacationists are reacting in the same way on travel distance, while in the other a different distance sensitivity was taken to occur. In the last mentioned model the deviations between calculated and measured data decreased in comparison with the results of the first model, so there is some ground to assume a different distance sensitivity of inhabitants as compared to vacationists.

Based on the most common relationships between visits to inland beaches per origin on the one hand and population (with incoming and outgoing vacationists taken into account), distance and weighted capacity of alternative sites on the other hand (as shown in table 21) the following models were set up and fitted:

- for non-free entrance inland beaches with a relatively high accommodation level:

$$V = \alpha(P - E + B)\,e^{-\gamma D_r}(A_{c1} + A_{c2})^{-1} \tag{46}$$

- for free entrance inland beaches with a low accommodation level:

$$V = [\alpha(P - E) + \beta B]\,e^{-\gamma D_r}(A_{c1} + A_{c2})^{-1} \tag{47}$$

where

V = total number of visits to an inland beach per origin on a certain day
P = number of inhabitants of origin
E = number of inhabitants of origin on vacation elsewhere
B = number of vacationists incoming into origin
D_r = road distance between origin and site in km
A_{c1} = capacity of alternative outdoor recreation sites inside origin, weighted according recreation type
A_{c2} = capacity of alternative outdoor recreation sites outside origin, weighted according recreation type and distance between origin and site
e = base of natural logarithms

In the model for non-free entrance inland beaches the origin factor was taken to be a function of the inhabitants and the number of outgoing and incoming vacationists. This factor can be seen as a 'potential' for the number of visits to the inland beach under investigation. In eq. (46) the assumption is made that the incoming vacationists in the origin act in the same way as the inhabitants with regard to visits to inland beaches as well as to alternative sites. For the resistance factor another variable was also chosen, namely $D_r^{-\beta \log D_r}$ (see also table 21). In this variable the distance coefficient is a function of distance itself which means that it changes when distance changes. Wolfe (1972) got better results with this resistance factor as part of a simulation model (gravity model) for recreational travel than with the factor $D_r^{-\gamma}$. The resistance factor $e^{-\gamma D_r}$ used in the eq. (46) and (47) proved to be useful in many earlier studies (see for instance van Lier, 1969/1970 and Bakker, 1972). In the calibrations of both models this last resistance factor gave the best results (highest goodness of fit). The variable for the alternative sites $(A_{c1} + A_{c2})^{-1}$ can be expected to be less important if the capacity and accommodation level of the inland beach under study is higher and therefore can be seen as a correction factor on the potential number of visits.

In the model for free entrance inland beaches with low accommodation level the same variables (inhabitants, outgoing and incoming vacationists) were used for the origin factor. Since in the regression equations, however, the variable B proved to be significant this variable was handled separately. In eq. (47) it is assumed that the incoming vacationists react differently on distances and alternative sites than the inhabitants of the origin. Therefore additive models were set up with a special coefficient for the behaviour of the vacationists in the origin. For the resistance factor the same variables were chosen as in the model of the non-free entrance projects, since in the regression equations for both type of projects the same distance variables did show up. The factor for the alternative sites is used in the same way as for the non-free inland beaches.

5.1.3 Results

The four different models were fitted for 4 project research-days (prd), namely two models for Beekse Bergen and Eurostrand on July 27 1969, and two other models for Kibbelkoele on July 2 1967 and Zandenplas on July 27 1969.

From these calculations it could be concluded that the models in which the distance was expressed as an e-power gave the highest goodness of fit. Therefore use models were calibrated for the 37 prd according to the equations (46) and (47), as shown in table 22. The models were calibrated for the ranges of values for the alternative sites and distances which were measured for the different prd. Therefore the use models for Tijnaarlo, Kibbelkoele, Hemelrijk, Ieberenplas and Loomeer are valid for a range of $(A_{c1}+A_{c2})$ from 5×10^3 to 5×10^4 and a distance up to 82 km, while the use models for Beekse Bergen, Eurostrand, Maarsseveense Plassen, Schatberg, Loofles and Zandenplas are valid for a range of $(A_{c1}+A_{c2})$ from 5×10^4 to 3.4×10^5 and a distance up to 96 km. An example of the working of the models is shown in fig. 13.

The α-values in eq. (46), see table 22, show large differences which are probably caused by the fact that high values for the capacity of alternative sites exist in some regions. The γ-values differ less. In almost all the models based on eq. (46) the multiple correlation coefficient is high (with one low value of 0.64) while the standard deviations are low. For this reason the use models of the non-free entrance inland beaches can be considered to be good predictors of visits to new inland beaches when used on the short term (see also Chapter 3).

Of the parameters in eq. (47) α and β also show large differences. For 7 models negative values were found either for α or for β. When, however, α is negative then this is corrected by a high β-value, which means that the total population per origin has a positive value. In cases of a negative β-value the corresponding α-value is high leading to the same. The projects 6, 8 and 12 (table 22) are situated in a typical vacation region and therefore the number of incoming vacationists is high which may impede visits by the inhabitants of the origin. The distance parameter γ is very constant, so the sensitivity for distance is much more constant for the (small) free entrance inland beaches than it is for the, generally larger, non-free entrance projects. As the multiple correlation coefficient is in many cases rather low and the standard deviation high, the use models of this group are not such accurate predictors for visits to free entrance inland beaches as the models for the non-free entrance ones are.

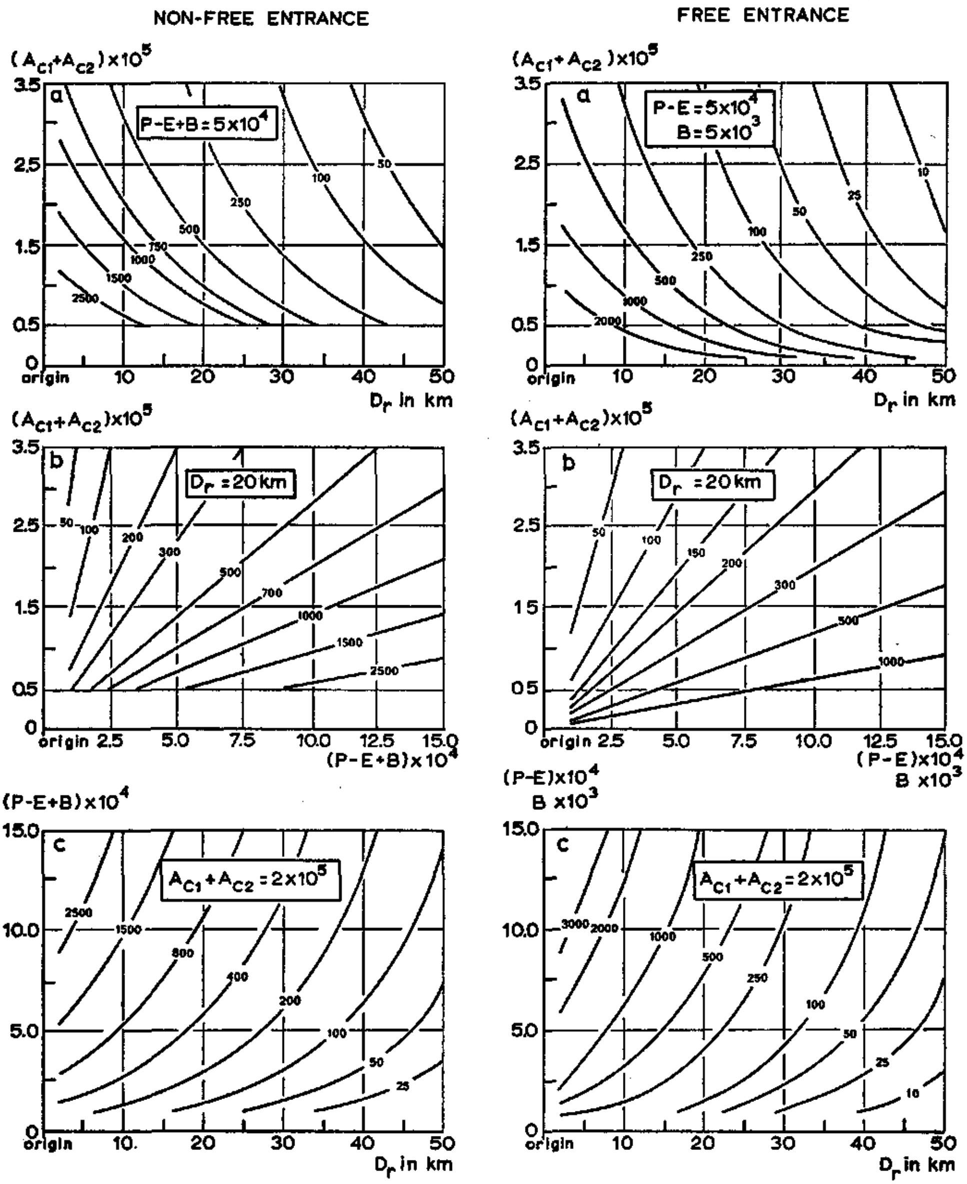

Fig. 13. Visits from a certain origin to a non-free entrance respectively free entrance inland beach, when keeping constant the population of that origin $P-E+B$ respectively $P-E$ and B (a), the distance between origin and site D_r (b) and the capacity alternative sites $A_{c1}+A_{c2}$ (c) for Eurostrand (non-free) respectively Zandenplas (free) on July 27, 1969.

Table 22. Estimated parameters, standard deviation and multiple correlation coefficient for use models of 37 project research-days on 5 non-free entrance and 7 free entrance inland beaches in the Netherlands, as well as the pertaining weather values (see Section 5.2.2.3).

Project	Date	Day-group	Sphere of influence (km)	Parameters			Standard deviation	R^2	W-values calculated by means of	
				α	β	γ			general weather model	regional weather models
Non-free entrance (eq. 46)										
1. Beekse Bergen	1-6-68	2	22	67225		0.615	23	0.99	2.97	7.17
	2-6-68	1	43	10934		0.123	89	0.99	1.80	3.85
	7-7-68	4	54	6826		0.120	55	0.98	2.35	3.75
	31-7-68	6	37	9039		0.129	89	0.98	4.62	7.73
	26-7-68	8	43	4752		0.139	33	0.99	3.90	10.00
	27-7-69	7	59	9016		0.092	77	0.98	3.76	6.16
	6-8-69	9	89	2118		0.059	38	0.87	2.84	6.55
2. Eurostrand	3-6-68	1	96	6849		0.087	74	0.86	3.90	10.00
	30-7-68	6	96	8224		0.150	47	0.80	3.42	6.44
	24-8-68	11	77	4645		0.096	47	0.89	3.77	8.17
	25-8-68	10	96	4020		0.075	60	0.82	3.09	4.87
	26-7-69	8	96	1604		0.101	13	0.87	4.26	10.00
	27-7-69	7	96	6495		0.077	69	0.88	3.60	5.51
	6-8-69	9	96	1545		0.066	27	0.78	2.72	5.89
9. Maarsseveense Plassen	1-8-70	8	18	19898		0.259	56	0.99	4.47	9.30
	2-8-70	7	19	23847		0.196	115	0.99	4.25	6.21
10. Schatberg	2-8-70	7	20	1366		0.055	43	0.76	4.25	6.21
11. Tijnaarlo	14-5-67	1	51	398		0.074	45	0.73	2.94	5.81
	2-7-67	7	51	960		0.059	82	0.89	3.71	6.80
	12-7-67	9	51	1517		0.122	47	0.84	2.13	5.23
	20-7-67	6	51	2063		0.224	30	0.64	2.34	10.00
	29-7-67	5	51	547		0.093	45	0.70	2.71	6.26

Table 22 (continued)

Project	Date	Day-group	Sphere of influence (km)	Parameters			Standard deviation	R^2	W-values calculated by means of	
				α	β	γ			general weather model	regional weather models
Free entrance (eq. 47)										
3. Hemelrijk	2-7-67	7	49	1409	2117	0.093	104	0.41	3.71	6.80
	20-7-67	6	49	352	1179	0.100	36	0.39	2.34	10.00
5. Ieberenplas	2-7-67	7	48	6945	2649	0.135	55	0.73	3.71	6.80
	20-7-67	6	48	1494	1047	0.117	22	0.73	2.34	10.00
6. Kibbelkoele	2-7-67	7	82	4306	−1415	0.070	108	0.84	3.71	6.80
	13-7-67	9	78	4414	−1911	0.097	56	0.89	3.29	6.75
	20-7-67	7	78	1081	−82	0.078	28	0.81	2.34	10.00
7. Loofles	23-7-69	6	42	7255	32722	0.100	344	0.71	9.95	10.00
	27-7-69	7	42	17572	19921	0.100	369	0.71	3.03	4.12
	9-8-69	8	47	6044	8294	0.118	136	0.62	8.95	10.00
8. Loomeer	2-7-67	7	72	3856	−2019	0.086	85	0.58	3.71	6.80
	20-7-67	6	72	1035	−464	0.086	36	0.34	2.34	10.00
12. Zandenplas	19-7-69	5	28	−4003	32036	0.116	212	0.89	2.80	3.52
	23-7-69	6	28	−6195	49831	0.108	352	0.89	9.95	10.00
	27-7-69	7	64	2366	17490	0.097	95	0.82	3.03	4.12

5.2 Weather model

5.2.1 Approaches

As already mentioned in Chapters 2 and 4 the relationship between weather and outdoor recreation can be studied in several ways. For the construction of final weather models, as defined in Chapter 4, two approaches were followed: a statistical approach and a heat exchange approach.

In the first approach the measured variancy in number of visits per day to inland beaches is in a statistical way related to those meteorological factors which are expected to influence the visits, in one way or another. In this study this is done by carrying out a regression analysis, choosing variables from the regression equations, studying the influence of the separate variables and finally by setting up some statistical models and fitting them to the measured independent variable, being the number of visits per day to inland beaches. The regression analysis is given in Chapter 4, while the other steps will be given in the following sections (5.2.2.1 through 5.2.2.3).

The second approach is based on human comfort. Human beings feel comfortable when the body can easily be kept at a constant temperature of about 37°C. The weather influences this comfort via the heat exchange process of the body. Since recreation on inland beaches is more comfortable when it is easier to keep up the body temperature, it is clear that there will be a relationship between the number of visits to an inland beach and the heat exchange of the body. Using known descriptions of the heat balance of human beings (see for instance Brunt, 1947) and a heat exchange formula (Rijtema, 1965), it was tried to construct a weather model giving the number of visits per day in dependence of meteorological factors (see Section 5.2.3).

5.2.2 Statistical model

5.2.2.1 Choice of variables

In Chapter 4 the most important weather factors with regard to number of visits per day on inland beaches were found to be temperature, sunshine and/or cloudiness and wind velocity. The purpose of the construction of a weather model is the prediction of the frequency of number of visits per day by means of the prediction of the frequency of weather values in a normative year. That is to predict the number of times in which weather values occur on different days of the outdoor recreational season for a normative year, for which the average of the years 1951 through 1970 was chosen. This means that a weather model constructed for a frequency analysis over these 20 years, is to be based on variables available over this whole period. From the four mentioned variables sunshine data were not available over all years and all official climatological stations. For this reason three variables temperature, cloudiness and wind velocity were taken for the general weather model; for the regional models sunshine instead of cloudiness could be used.

Another limitation was the fact that these data were only available at 12 h GMT (=13 h p.m. in the Netherlands) over a longer period of time and from all official stations. Cloudiness is measured in two ways namely as the degree of total cloud cover (N) and as the degree of cloud cover by stratocumulus, stratus, cumulus and cumulonimbus (N_h). If taken both measurements the effective cloudiness can be taken into account which is the mean of the total cloud cover and the cover by clouds of the type stratocumulus, etc. (den Tonkelaar, 1972). For the general weather model for the Netherlands the following variables were chosen: T_{d2} = dry bulb temperature in °C at 13 h GMT; $\frac{1}{2}(N_{t2}+N_h)$ = effective cloudiness in okta at 13 h GMT; u_{t2} = wind velocity in $m \cdot s^{-1}$ at 13 h GMT.

The correlation between temperature on the one hand and sunshine (or global radiation) on the other is, however, not constant over the whole of the country (on the coast for instance a given global radiation is correlated with a lower temperature than in the middle or the eastern part of the country). It was therefore felt necessary to construct also models in which sunshine was included. For this reason regional weather models were constructed for the north-western, the north-eastern, the middle and the southern part of the country, based on the variables temperature, wind velocity and sunshine. The type of these regional models will be similar to the general model.

5.2.2.2 Model type

The regression equations (see table 19) did show the different ways in which all the used variables appeared. All these equations have an additive form. The way as well as the number of times in which the different meteorological factors are used in the various regression equations differ to a large degree. From the three important groups of variables (temperature, sunshine and/or cloudiness and wind velocity) in total 16 times basic variables and 63 times derived variables were used. The number and manner in which the most important variables appear in the regression equations is given in table 23.

From these variables the temperature at 14 h p.m., the sunshine duration per day respectively the cloud cover at 14 h p.m. and the wind velocity at 14 h p.m. were chosen for the final weather models. The chosen relation of visits and temperature does not correspond with the types of variables of table 23. The $e^{T_{d2}}$-form was chosen after plotting the research data in a diagram, giving the relation between visits (V_t) and the temperature at 14 h p.m. (T_{d2}). It appeared that the e-function gave a better fit.

The number of visits per day on inland beaches is taken to be proportional to the temperature and inversily proportional to the cloud cover and wind velocity.

After building and fitting an additive and a multiplicative model, as final model the multiplicative one was chosen:

$$V_t = \alpha\, e^{\beta T_{d2} - \gamma \ln N_{t2} - \delta \ln u_{t2}} \qquad (48)$$

Table 23. Variables and their frequency of occurrence in the regression equations giving the relationship of visits with meteorological factors for inland beaches in the Netherlands.

Factor	Type of variable	Frequency	Total	Type of relation chosen
Temperature	$\ln T_{d2}$	6		
	$T_{d2}.S$	5		
	$\ln(T_{d2}.S)$	1	17	$V_t = f(e^{T_{d2}})$
	$\ln[(c_1 + c_2\sqrt{u_{t2}})(c_3 - T_{d2})]$	1		
	$[(c_1 + c_2\sqrt{u_{t2}})(c_3 - T_{d2})]^{-1}$	4		
Sunshine or cloudiness	$S^{2.5}$	2		
	S^3	4		
	$T_{d2}.S$	5	31	$V_t = f(S)$ and
	$\ln(T_{d2}.S)$	1		$V_t = f(N_{t2}^{-1})$
	N_{t2}^{-1}	7		
	$N_{t2}^{+\frac{1}{2}}$	3		
	N_{t2}^2	4		
	$\ln N_{t2}$	5		
Wind velocity	u_{t2}^{-1}	7		
	u_{t2}	1		
	$\ln u_{t2}$	2	15	$V_t = f(u_{t2}^{-1})$
	$\ln[(c_1 + c_2\sqrt{u_{t2}})(c_3 - T_{d2})]$	1		
	$[(c_1 + c_2\sqrt{u_{t2}})(c_3 - T_{d2})]$	4		

where

V_t = total number of visits to an inland beach on a certain day

T_{d2} = dry bulb temperature at 14 h p.m. in °C

N_{t2} = cloud cover at 14 h p.m. in %

u_{t2} = wind velocity at 14 h p.m. in $m \cdot s^{-1}$

e = base of natural logarithms

$\alpha, \beta, \gamma, \delta$ = to be estimated parameters.

5.2.2.3 Results

The weather model was used:

– to carry out a frequency analysis of weather values (W) for outdoor recreation for 19 official climatological stations in the Netherlands over a 20-year period as basis for the mapping of iso-frequency W-value lines;

– as a means for the determination of the design capacity of outdoor recreation projects.

For the frequency analysis a model is needed which is generally valid for the whole of the Netherlands and for all day-groups. Such a model must exclude the different reactions on various weather conditions by people from different regions, to obtain comparable frequencies of W-values of the different climatological stations. Since the probability of occurrance of a certain W-value is equal for Sundays, Saturdays and workdays no distinctions have to be made for the different days of the week. For the part of the season, however, this probability is not equal, so in the frequency analysis a division according to the parts of the season will have to be made. The lower W-values, which represent days with bad weather conditions, are of no importance either for the frequency analysis or for the determination of the design capacity. Therefore in estimating the parameters of the model a bottom limit for temperature and an upper limit for wind velocity was set. All days with a temperature of less than 15°C and a wind velocity over 10 m·s^{-1} were excluded.

The W-values are expressed in a range from 0 through 10, so a transformation of the number of visits per day to a number between 0 and 10 has to be carried out. This can be done by calculating the W-value from the visit data:

$$W = \frac{10V_t}{V_{max}} \tag{49}$$

where
W = outdoor recreation weather value
V_t = total number of visits to an inland beach on a certain day
V_{max} = maximum value of V_t per day-group

Since V_{max} is strongly dependent on the type of day and part of the season, initial estimations for the V_{max} were made per day-group. These estimations can, especially for some day-groups, be rather inaccurate because it might be possible that in the period of measurements no really good weather conditions have occurred. In such cases the V_{max} is estimated at a level which might be too low. After making these estimations, the model was calculated with an iterative procedure after which the V_{max} was calculated again. Table 24 shows this.

For the calculation of the parameters of the model the temperature, wind velocity and effective cloudiness at which the W-value is 10 have to be set. Taken were, based on the measured V_t and the estimated V_{max}, a temperature of 30°C, an effective cloudiness of 1 okta and a wind velocity of 2.5 m·s^{-1}. The resulting general model for the Netherlands, with $R=0.80$ and $R^2=0.65$, was:

$$W = 0.1767\, e^{0.139 T_{d2} - 0.116 \ln \frac{1}{2}(N_{t2}+N_h) - 0.152 \ln u_{t2}} \tag{50}$$

where
W = outdoor recreation weather value (in a range from 0 through 10)
T_{d2} = dry bulb temperature at 14 h p.m. in °C (with $T_{d2} > 15$°C)
$\frac{1}{2}(N_{t2}+N_h)$ = effective cloudiness at 14 h p.m. in okta
N_{t2} = cloud cover at 14 h p.m. in okta
N_h = cloud cover at 14 h p.m. of the type stratocumulus, stratus, cumulus and cumulonimbus in okta
u_{t2} = wind velocity at 14 h p.m. in m·s^{-1} (with $u_{t2} < 10$ m·s^{-1})
e = base of natural logarithms

Table 24. Initial and by means of the general weather model calculated estimations of V_{max} for inland beaches in the Netherlands.

Day-group (see table 15)	Initial value	Calculated value	Day-group (see table 15)	Initial value	Calculated value
1	11000	18285	7	10000	13593
2	8500	12244	8	6000	7983
3	8000	8954	9	9000	10875
4	10000	10962	10	9000	9916
5	8000	9721	11	8500	7969
6	8000	9176	12	7000	5318

The R^2 of the model is lower than the R^2 of the regression equations (Chapter 4) which is caused by:

- the number of meteorological factors taken into account is limited to three;
- the different day-groups are used for one general model;
- possible different reactions of people from different regions on identical weather conditions is neglected.

In fig. 14 the W-values are given when respectively wind velocity, effective cloudiness or temperature are kept constant. In this figure the influence of the three different meteorological factors on weather values for outdoor recreation on inland beaches is shown.

The above given general weather model was the basis for a frequency analysis of W-values over a 20-year period and 19 official climatological stations in the Netherlands. The results of this analysis will be given in Section 5.2.4.

For the regional weather models the following type was chosen:

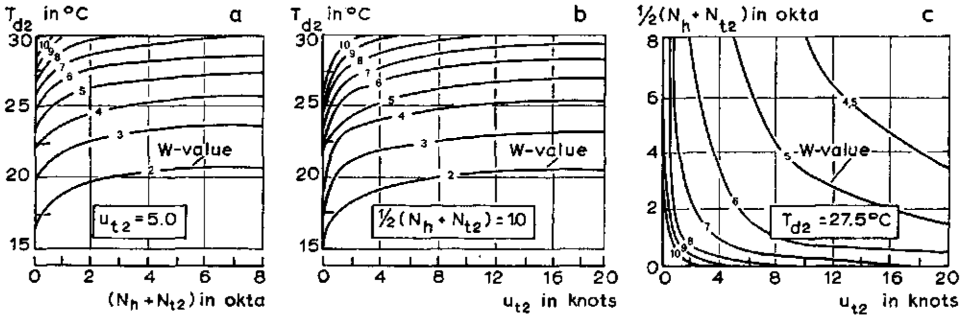

Fig. 14. Weather values for outdoor recreation when keeping constant the wind velocity u_{t2} (a), the effective cloudiness $\frac{1}{2}(N_n + N_{t2})$ (b) and the temperature T_{d2} (c) based on the general weather model for inland beaches in the Netherlands.

Table 25. Initial estimations of V_{max}, the corresponding values of temperature, sunshine and wind velocity, and the calculated estimations of V_{max} by means of regional weather models for inland beaches in the Netherlands.

Day-group (see table 15)	Initial value (Soest)	Corresponding			Calculated value			
		T_{d2}	S	u_{t2}	Tijnaarlo	Hoeven	Wijde Wormer	Soest
1	11000	25	75	4	4135	17910	4051	8318
2	8500	25	75	4	–	6721	1507	5522
3	8000	25	75	4	649	5307	973	4057
4	10000	27.5	75	4	3328	23005	6671	10298
5	8000	27.5	75	4	1670	11399	2641	8309
6	8000	27.5	75	4	1539	10138	2307	6153
7	10000	27	75	4	3355	17891	3606	8509
8	6000	27	75	4	1594	7281	4314	4688
9	9000	27	75	4	2408	11454	3339	7233
10	9000	25	75	4	1329	11169	3027	7736
11	8500	25	75	4	559	5701	–	4962
12	7000	25	75	4	402	2397	1048	2736

$$W = \alpha \, e^{\beta T_{d2} + \gamma \ln S - \delta \ln u_{t2}} \tag{51}$$

where

S = sunshine duration per day in per cent of possible maximum.

The parameters of the different models were estimated in the same way as was done for the general model (eq. 50). The V_{max}-values were estimated per day-group as given in table 25, with their corresponding values of T_{d2}, S and u_{t2}. The regional statistical weather models were all calibrated per day-group within the ranges: $T_{d2} > 15\,°\mathrm{C}$ and $u_{t2} < 10\ \mathrm{m \cdot s^{-1}}$.

The model given in eq. (51) was calibrated for 12 day-groups and 4 projects (Tijnaarlo, Hoeven, Wijde Wormer and Soest). Since, however, for two day-groups (Tijnaarlo group 2 and Wijde Wormer group 11) no good fit could be achieved, the parameters of 46 regional statistical weather models are given in table 26.

From this table it can be seen that the values of α are varying from as low as 0.00003 (group 10, Wijde Wormer) to 1.095 (group 9, Hoeven). The β-value which is a measure for the influence of the temperature on the W-value is more constant with a lowest value of 0.029 and a highest one of 0.304. This proves that in all cases temperature is a rather constant factor for the inclination of people to visit inland beaches. Somewhat less constant are the values of γ, this being a measure of the importance of sunshine for inland beach recreation. The parameter δ for wind velocity gives more

Table 26. Values of the parameters of eq. (51), multiple correlation coefficient and standard deviation for 46 regional statistical weather models for inland beaches in the Netherlands.

Inland beach	Day-group (table 15)	α	β	γ	δ	R^2	St. dev.
Tijnaarlo	1	0.008	0.081	1.132	−0.161	0.45	0.43
	3	0.180	0.112	0.361	0.243	0.37	0.40
	4	0.202	0.155	0.144	0.714	0.79	0.17
	5	0.002	0.035	2.051	0.986	0.68	0.21
	6	0.090	0.164	0.179	0.420	0.58	0.23
	7	0.062	0.081	0.888	0.678	0.67	0.26
	8	0.202	0.128	0.242	0.423	0.95	0.14
	9	0.174	0.082	0.444	0.060	0.52	0.29
	10	0.001	0.088	1.793	0.586	0.57	0.33
	11	0.020	0.029	1.211	−0.170	0.65	0.24
	12	0.010	0.171	0.528	−0.241	0.59	0.38
Hoeven	1	0.219	0.123	0.279	0.325	0.59	0.22
	2	0.351	0.122	0.267	0.614	0.73	0.20
	3	0.916	0.079	0.181	0.268	0.42	0.34
	4	0.079	0.126	0.325	0.013	0.64	0.22
	5	0.130	0.130	0.188	0.038	0.72	0.14
	6	0.203	0.116	0.243	0.249	0.61	0.22
	7	0.074	0.071	0.765	0.226	0.67	0.22
	8	0.335	0.094	0.426	0.716	0.91	0.15
	9	1.095	0.069	0.184	0.329	0.59	0.26
	10	0.003	0.287	0.292	0.169	0.62	0.18
	11	0.002	0.304	0.005	−0.663	0.62	0.22
	12	0.084	0.175	0.250	0.495	0.50	0.48
Wijde Wormer	1	0.065	0.168	0.302	0.342	0.67	0.16
	2	0.109	0.198	0.012	0.338	0.88	0.20
	3	0.171	0.134	0.194	0.096	0.50	0.34
	4	0.003	0.244	0.382	0.230	0.75	0.06
	5	0.006	0.160	0.754	0.177	0.80	0.13
	6	0.011	0.149	0.654	0.052	0.59	0.18
	7	0.0001	0.106	2.021	0.264	0.75	0.16
	8	0.002	0.260	0.374	0.011	0.79	0.06
	9	0.008	0.166	0.665	0.140	0.69	0.14
	10	0.00003	0.190	0.024	0.055	0.62	0.17
	12	0.001	0.171	1.249	0.381	0.48	0.31
Soest	1	0.280	0.126	0.218	0.375	0.63	0.21
	2	0.302	0.093	0.420	0.455	0.71	0.23
	3	0.273	0.107	0.207	−0.198	0.65	0.23
	4	0.025	0.209	0.161	0.338	0.80	0.09
	5	0.018	0.163	0.405	−0.074	0.81	0.11
	6	0.101	0.133	0.286	0.210	0.73	0.17
	7	0.005	0.121	0.986	0.0013	0.85	0.16
	8	0.163	0.108	0.411	0.407	0.84	0.11
	9	0.101	0.110	0.365	−0.046	0.72	0.30
	10	0.0002	0.194	1.443	0.018	0.78	0.15
	11	0.0003	0.138	0.439	−0.592	0.66	0.13
	12	0.058	0.158	0.402	0.386	0.56	0.19

problems, since this parameter has both positive as well as negative values. In this last case the *W*-value increases with an increasing wind velocity, which is not acceptable over the whole range of weather conditions. The negative values are probably caused by the fact that in most cases it holds for a day-group with a low number of data in which the occurrence of days with high temperatures, on which the wind velocity might be directly proportional to visits, can be relatively high. Aside from this it might be caused by the fact that both Tijnaarlo as well as Soest have many wind shelters which indeed cause a lower sensitivity for wind.

The values of R^2 vary to a large degree, from 0.37 (group 3, Tijnaarlo) to 0.95 (group 8, Tijnaarlo), which means that in some 25% of the cases an important influence of other than weather factors occurs. The day-groups 4 through 9, however, representing the longer and the for the planning capacity more important main season, show in almost all cases a high degree of goodness of fit, which makes it justified to use these weather models for the calculations of the frequency of weather values and of number of visits per day.

From the data it appeared that the boundary conditions taken have to be changed to narrower limits to get the best results:

- for temperature: from 15 to 30°C;
- for sunshine: from 10 to 90%;
- for wind velocity: from 4 to 10 $\mathrm{m \cdot s^{-1}}$.

In cases in which *W*-values of over 10 are derived these should be considered to be 10. An application of some of the models according eq. (51) with the parameters given in table 26 will be discussed in Section 5.2.4 and Section 7.2.2.

5.2.3 Heat exchange model

The relationship between visits per day and weather was, so far, studied in a statistical way. Another approach to solve this relationship is one which is based on physical rules. Use can be made of a formulation of the heat exchange of the human body with the atmosphere (see Section 2.2.5). An advantage would be to be able to break the regional correlations between sunshine and temperature (see Section 5.2.2.1). A model, based on this heat exchange was derived with the following meteorological factors: temperature, wind velocity, sunshine, relative humidity and global radiation.

In this model two basic assumptions were made:

$$V_t = \mathrm{f}(H_{upt}) \qquad (52)$$

and (see also Rijtema, 1965):

$$H_{upt} = (1 - r)H_{sh} - H_{lo} - \gamma \mathrm{L} K_u (T_s - T_a) - \frac{K_u \mathrm{L}}{1 + K_u r_s}(e_{sa} - e_a) \qquad (53)$$

where

V_t = total number of visits to an inland beach on a certain day
H_{upt} = heat uptake by human body from atmosphere in $cal \cdot cm^{-2} \cdot day^{-1}$
r = reflection coefficient of human body for global radiation
H_{sh} = global radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$
H_{lo} = net long wave radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$
γ = psychrometer constant in $mm\ Hg \cdot {}^\circ C^{-1}$
L = latent heat of vaporization in $cal \cdot cm^{-3}$
K_u = wind dependent transport coefficient in $cm \cdot mm\ Hg^{-1} \cdot day^{-1}$
T_s = skin temperature of human body in °C
T_a = air temperature in °C
ε_{sa} = saturated vapour pressure of the air in mm Hg
ε_a = actual vapour pressure of the air in mm Hg
r_s = evaporation resistance of human body surface in $cm^{-1} \cdot mm\ Hg \cdot day$.

As said in Section 2.2.5, the heat exchange of the human body depends on radiation, convection and conduction (see Brunt, 1947 and Snellen, 1966). In eq. (53) the radiation is expressed by the first two terms giving the net shortwave and net longwave radiation. The convection is expressed by the third term which stands for the sensible heat flux and by the fourth term which is giving the heat exchange by means of evaporation (latent heat flux). Conduction can be neglected in our case.

To make the relationship between visits per day to an inland beach and the heat exchange of the human body useful for the prediction of visits at certain weather conditions, the function of H_{upt} has to be a continuous one. The fourth term of eq. (53), however, causes a discontinuity in the H_{upt}-values in the range from the point at which the human body starts to evaporate to the point at which the body has just reached his maximum evaporation. Therefore the relationship is based on:

$$V_t = f[(1 - r) H_{sh} - H_{lo} - \gamma L K_u (T_s - T_a)] \tag{54}$$

The different elements of this equation had to be expressed in the meteorological factors of which data were available. Furthermore the equation was made valid on an hourly basis and for the period from 10 h a.m. to 17 h p.m., since this is the main part of the day for recreational activities on inland beaches. The three terms in the equation can be rewritten as follows.

First term of eq. (54) With $r = 0.30$ and the global radiation in the period mentioned 0.7 H_{sh}, this gives on an hourly basis:

$$(1 - 0.3) \frac{0.7}{7} H_{sh} = 0.07\, H_{sh} \tag{55}$$

Second term of eq. (54) (see also W. R. van Wijk, 1966):

$$\frac{H_{lo}}{24} = \frac{\sigma (273 + T_a)^4}{24} f(\varepsilon_a) \left(0.1 + 0.9 \frac{S}{100}\right) + \frac{1}{24} \frac{\sigma (273 + T_a)^4}{\Delta T_a} (T_s - T_a) \tag{56}$$

where

$\frac{H_{lo}}{24}$ = net long wave radiation flux in $cal \cdot cm^{-2} \cdot h^{-1}$

σ = constant of Boltzmann in $cal \cdot cm^{-2} \cdot day^{-1} \cdot K^{-4}$

T_a = air temperature in °C

$f(\varepsilon_a)$ = function of the actual vapour pressure of the air in mm Hg

S = sunshine duration per day in % of possible maximum

T_s = skin temperature of human body in °C

To make H_{lo} applicable for the human body the net long wave radiation of the earth surface had to be corrected with a term which takes into account the higher temperature (and therefore emittance) of the human body. This term is, in the range of 25 through 33°C, 13 $cal \cdot cm^{-2} \cdot day^{-1} \cdot °C^{-1}$. This value has, for convenience sake, been assumed to be constant in the range of 15 through 30°C.

The value of the first term $\sigma(273+T_a)^4$ depends in the range from 15 through 30°C on the air temperature according to the following equation (see fig. 15):

$$\sigma(273 + T_a)^4 = 12(T_a - 15) + 812 \tag{57}$$

so

$$\frac{\sigma(273 + T_a)^4}{24} = 0.5(T_a - 15) + 33.8 \tag{58}$$

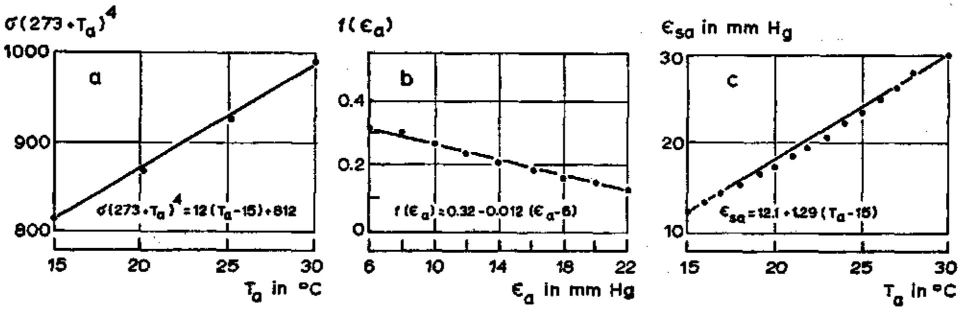

Fig. 15. Relationship between $\sigma(273+T_a)^4$ and air temperature T_a (a), between $f(\varepsilon_a)$ and actual vapour pressure ε_a (b) and between saturated vapour pressure ε_{sa} and air temperature T_a (c). After Wesseling, 1960.

The $f(\varepsilon_a)$ in dependency of the actual vapour pressure is in our range as follows (see fig. 15):

$$f(\varepsilon_a) = 0.32 - 0.012(\varepsilon_a - 6.0) \tag{59}$$

This gives with $\varepsilon_a = r_h \varepsilon_{sa}$:

$$f(\varepsilon_a) = [0.32 - 0.012(r_h \varepsilon_{sa} - 6.0)] \tag{60}$$

where

ε_{sa} = saturated vapour pressure of the air in mm Hg

r_h = relative humidity

ε_{sa} can be expressed in terms of air temperature by means of the following formula (see fig. 15):

$$\varepsilon_{sa} = 12.1 + 1.29 (T_a - 15) \quad (61)$$

so $f(\varepsilon_a)$ finally turns into:

$$f(\varepsilon_a) = 0.32 - 0.012 [[12.1 + 1.29 (T_a - 15)] r_h - 6.0] \quad (62)$$

while the total second term becomes:

$$\frac{H_{lo}}{24} = [0.5 (T_a - 15) + 33.8] [0.32 - 0.012 [[12.1 + 1.29 (T_a - 15)] r_h - 6.0]] \left(0.1 + 0.9 \frac{S}{100}\right) + 0.54 (T_s - T_a) \quad (63)$$

Third term of eq. (54) Taking (see Rijtema, 1965) $\gamma = 0.5$ mm Hg·°C^{-1}, L = 585 cal·cm^{-3} (equal to 58.5 cal·cm^{-2}·mm H_2O^{-1} when energy is expressed in equivalents of mm water evaporating per unit area, here cm^2) and K_u at 1 m height = 0.82:

$$\frac{0.5 \times 58.5}{24} 0.82\, u_{1\,000} (T_s - T_a) = 0.99\, u_{1\,000} (T_s - T_a) \quad (64)$$

where

$u_{1\,000}$ = wind velocity at 10 m height in m·s^{-1}

Substituting in eq. (54) the eqs. (55), (63) and (64) and taking, since human beings feel comfortable when the skin temperature lies between 31 °C and 35 °C with according to den Tonkelaar (1972) an optimum at 33 °C, that $T_s = 33$ the final equation becomes:

$$V_t = f[0.07\, H_{sh} - (0.99\, u_{1\,000} + 0.54) (33 - T_a) - (0.05\, T_a + 0.24\, S + 0.0045\, S T_a + 2.63) (0.39 - 0.015\, T_a r_h + 0.087\, r_h)] \quad (65)$$

For the meteorological factors are taken the available data, also used in the statistical weather model, leading to:

$$V_t = f[(0.07\, H_{sh} - (0.99\, u_{t2} + 0.54) (33 - T_{d2}) - (0.05\, T_{d2} + 0.24\, S + 0.0045\, S T_{d2} + 2.63) (0.39 - 0.015\, T_{d2} r_{h2} + 0.087\, r_{h2})] \quad (66)$$

Eq. (66) has been fitted to data on visits per day to inland beaches according to the following procedure. First the values of the function were calculated. Then some relationships were chosen, the parameters were estimated and the goodness of fit was calculated. The equations chosen were:

$$W = \frac{9\, V_t}{V_{max}} = \alpha\, e^{\beta(H_{upt})} \quad (67)$$

$$W = \frac{9\,V_t}{V_{max}} = \frac{10}{1 + \alpha\, e^{-\beta(H_{upt})}} \tag{68}$$

$$W = \frac{9\,V_t}{V_{max}} = \alpha + \beta\,\frac{H_{upt}}{10^3} + \gamma\left(\frac{H_{upt}}{10^3}\right)^2 + \delta\left(\frac{H_{upt}}{10^3}\right)^3 \tag{69}$$

In contrast to eq. (49) the outdoor recreation weather value (W) is here defined as $9\,V_t/V_{max}$ instead of $10\,V_t/V_{max}$. This was necessary to find in eq. (68) an asymptote at the level $W=10$.

The parameters and multiple correlation coefficients (R^2) were calculated for four day-groups (group 4 and 6 of Tijnaarlo and group 4 and 6 of Soest). The results are given in table 27. In fig. 16 the relationship between heat uptake and visits to inland beaches is shown. From table 27 and fig. 16 it can be seen that the variancy is still very high. For both projects as well as both day-groups the goodness of fit is lower than that of the statistical weather model. This may be caused by the fact that in the heat exchange model:

– several relationships are estimated for unclothed bodies. Many projects, however, have bad weather accommodations making it possible for people more fully clothed

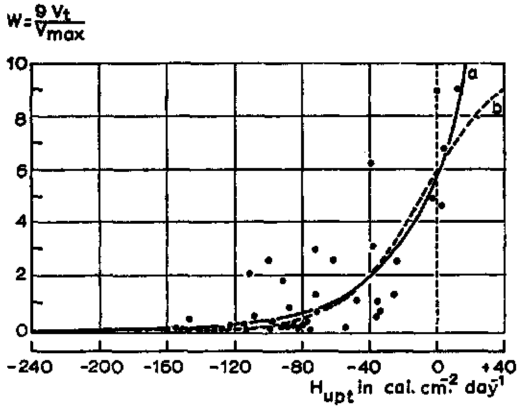

Fig. 16. Relationship between heat uptake of human body H_{upt} and W-values for inland beach recreation in the Netherlands; a = e-power (eq. 67) and b = s-curve (eq. 68).

Table 27. Multiple correlation coefficient (R^2) for four types of weather models, 2 day-groups and 2 inland beaches in the Netherlands.

Project	Day-group (see table 15)	R^2 statistical model	R^2 heat exchange models		
			e-power (eq. 67)	s-curve (eq. 68)	polynomial (eq. 69)
Tijnaarlo	4	0.79	0.72	0.68	0.73
	6	0.58	0.48	0.47	0.49
Soest	4	0.80	0.67	0.64	0.68
	6	0.73	0.57	0.58	0.59

to recreate under less good weather situations. There is a point at which people start to undress to go swimming, etc. This point depends among other things on the layout of the project (especially regarding wind shelter), on experiences of the visitors, etc.;
– a specific reduction of the influence of the wind velocity has been assumed. Use of other reduction coefficients or a lowering of the skin temperature chosen from 33 to, for instance, 25°C (simulating clothed people) did not give better results;
– specific recreationists (e.g. children) compensate their heat loss by activities (playing, swimming, etc.).

It was also tried to fit an s-curve by an iteration procedure in which, aside from the other parameters, also estimates were made for r (reflection coefficient for global radiation), K_u (wind dependent transport coefficient) and T_s (skin temperature). The estimated values for day-group 4 of Tijnaarlo were respectively: $r=0.76$, $K_u=0.037$ $cm \cdot mm\,Hg^{-1} \cdot day^{-1}$ and $T_s=36.47$°C, while R^2 was 0.74, which is (see table 27) still lower than the R^2 of the statistical model.

Since so many factors play their role it is, at this moment, not possible to give a better heat exchange weather model. As the statistical weather model, giving a description of the relationship between weather and visits, gave a better fit than the heat exchange weather model, it was decided to use the first mentioned one both for a frequency analysis of weather values in the Netherlands (Section 5.2.4) as well as for the calculation of the planning capacity of inland beaches (Section 6.1).

5.2.4 Frequency of weather values for the Netherlands

As mentioned, one of the purposes of the weather model is the determination of the frequency of *W*-values in a normative year. If such a year is being considered to be the average of a certain number of years, the frequency analysis has to be carried out for these years. If the *W*-values as given in the previous sections are a measure for the number of visits per day, a frequency analysis of these values will be a frequency analysis of the number of visits per day to an outdoor recreation project. For the construction of iso-*W*-value lines for a certain period in the Netherlands it is necessary to have *W*-values from as many official climatological stations as possible over that period. The number of stations of which data can be used is very limited when many meteorological factors are taken into account. Therefore the weather model should include only a few meteorological factors.

In the Netherlands 19 stations could be found having data over a 20-year period (1951 through 1970) of three meteorological factors: temperature, wind velocity and effective degree of cloudiness. Because of these limitations a frequency analysis had to be carried out with the general statistical model (eq. 50). The period of 1951 through 1970 has been chosen on the one hand to obtain data over a period as long as possible from many weather stations and on the other hand because good, moderate and bad summers within that period had a reasonably good frequency distribution. According to ten Kate (pers. comm. 1972) 4 out of these 20 summers were warm (mean temperature in June, July and August over 16.6°C), 12 had a normal mean temperature (15.6

to 16.6 °C) and 4 were cold (mean temperature less than 15.5 °C). With regard to rainfall 13 summers in this period were wet (more than 235 mm precipitation in June, July and August), 2 were normal (with 175.1 to 234.9 mm precipitation) and 5 were dry (less than 175.0 mm precipitation). There is one summer in the period of 1951 through 1970 with extremely good weather: the one in the year 1959, with a mean temperature of 17.4 °C and 126 mm precipitation in June, July and August (see also Scharringa, 1960). For these reasons it was decided that the period 1951 through 1970 gave the possibility to carry out a reliable frequency analysis of weather values as a basis for the normative year (see Chapter 6).

In table 28 the results of the frequency analysis in weather values from 1 through 10 is given for 19 official climatological stations in the Netherlands. With these *W*-values, den Tonkelaar (Senior Meteorologist, Royal Netherlands Meteorological Institute) drew, for the present study, iso-frequency maps, as given in the figs. 17, 18 and 19. In these figures, the influence of the North Sea and the IJssel Lake were qualitatively taken into account.

From fig. 17 it can be seen that values of $W \geqslant 9.5$ are very rare in the early season, at best once in six years on the average. Even days with $W \geqslant 7.5$ are infrequent, while $5.5 \leqslant W \leqslant 7.4$ has an only somewhat higher frequency. High frequencies are found for $2.5 \leqslant W \leqslant 5.4$. Although the number of days with good weather for recreation on inland beaches (high *W*-values) is not large in the early season, the differences over the country are obvious: good weather conditions are most often found in the south-eastern part, while the north-west generally has a lower number of good days.

The same is found for the main season from June 16 through August 15 (fig. 18), although the number of days with good weather is much higher than in the early season (even when the length of this period is taken into account). *W*-values of $\geqslant 9.5$ are found on the average more than once a year in that season for the south-east, but only once per 20 years for the north-west. The values of $W \geqslant 7.5$ have a higher frequency with on the average 2 to $\frac{1}{4}$ days a year. The frequency of $5.5 \leqslant W \leqslant 7.4$ is very similar to that of $W \geqslant 7.5$, while the number of days with $2.5 \leqslant W \leqslant 5.5$ is very large. The late season (August 16 to September 15; see fig. 19) finally shows that the frequencies of the different *W*-values are half of the frequencies of these values in the main season (the different length of these seasons taken into account).

From the frequency analysis the following conclusions can be drawn:

- for outdoor recreation on inland beaches in the Netherlands the weather is better in the south-east of the country than in the north-west;
- although the number of days with sunshine (high global radiation) is higher in the west, the frequency of good-weather-days for inland beach recreation is higher in the east due to the on the average higher temperatures and lower wind velocities;
- on the average the frequency of days with good weather is highest in the main season (June 16 through August 15), followed by the late season (August 16 through September 15) and then by the early season (May 16 through June 15);
- the ratio of frequencies of good-weather-days in early season, main season and late season is 1:4:2.

Table 28. Absolute frequency of *W*-values from 1 through 10 over the period 1951 through 1970 for 19 weather stations and three seasons in the Netherlands (1=early season: May 16–June 15, 2=main season; June 16–August 15, 3=late season: August 15–September 15).

Climatological station no.	name	Season	Number of days per season	*W*-value ≥1.4	1.5–2.4	2.5–3.4	3.5–4.4	4.5–5.4	5.5–6.4	6.5–7.4	7.5–8.4	8.5–9.4	≥9.5
200	Ypenburg/Rotterdam	1	30	153	109	45	23	6	6	4	0	0	2
		2	60	472	340	133	43	31	13	10	12	4	7
		3	30	268	172	46	32	12	4	3	7	0	4
210	Valkenburg	1	30	145	72	44	12	5	4	2	0	0	2
		2	60	518	296	95	37	20	9	9	3	3	8
		3	30	297	134	45	21	10	9	6	0	1	3
230	Den Helder	1	30	133	74	16	3	2	1	1	0	0	0
		2	60	629	296	66	27	11	3	3	2	1	1
		3	30	364	137	38	9	7	3	2	1	1	0
240	Schiphol	1	30	151	95	47	19	11	6	2	0	0	2
		2	60	413	343	109	59	21	17	10	6	2	7
		3	30	260	144	55	25	8	7	4	0	1	4
250	Terschelling	1	30	112	67	18	7	6	1	0	1	0	0
	(some years estimated)	2	60	516	256	62	33	13	6	3	2	0	1
		3	30	301	126	31	12	6	4	0	2	0	0
260	De Bilt	1	30	161	124	47	26	14	9	2	1	0	3
		2	60	423	376	123	65	32	22	15	14	6	11
		3	30	266	171	51	34	15	11	5	2	0	4
270	Leeuwarden	1	30	141	89	43	14	5	10	1	0	0	1
		2	60	488	294	93	47	28	12	6	5	4	6
		3	20	294	133	42	18	10	8	3	3	1	2
272	Ramspol	1	30	129	71	40	12	5	1	3	1	3	1
	(some days estimated)	2	60	370	249	104	35	21	11	13	2	2	8
		3	30	226	114	36	14	11	5	1	2	2	3

Table 28 (continued)

275	Deelen	1	30	160	114	57	34	12	6	8	0	0	2
	(some estimated years)	2	60	412	343	112	83	42	24	8	17	6	14
		3	30	249	148	57	43	23	11	9	2	2	6
280	Eelde	1	30	155	107	47	24	12	5	1	2	0	1
		2	60	434	335	121	53	32	18	10	5	5	9
		3	30	272	140	54	23	11	12	4	3	3	2
290	Twente	1	30	158	112	55	21	21	5	6	1	2	1
		2	60	375	372	121	78	30	24	25	8	2	20
		3	30	256	153	57	24	30	6	10	4	1	6
310	Vlissingen	1	30	142	92	33	17	7	1	2	1	0	0
		2	60	495	330	96	47	27	10	5	4	7	5
		3	30	257	165	47	23	9	5	5	1	1	0
325	Zierikzee	1	30	142	94	56	22	6	0	0	6	2	2
	(some days estimated)	2	60	526	342	102	50	30	12	6	14	4	6
		3	30	302	156	56	30	6	2	6	0	4	2
330	Hoek van Holland	1	30	131	71	25	16	5	1	5	0	1	1
	(some years estimated)	2	60	579	316	64	28	21	8	7	4	3	7
		3	30	311	134	37	21	4	3	3	2	1	0
340	Gilze Reijen	1	30	168	134	36	32	15	5	5	2	0	1
		2	60	416	369	133	72	34	23	12	10	7	15
		3	30	255	165	58	33	21	9	3	3	1	4
350	Woensdrecht	1	30	162	128	38	27	15	3	0	2	0	0
		2	60	495	360	117	67	18	17	8	7	3	22
		3	30	247	163	68	27	18	13	7	0	3	3
370	Eindhoven	1	30	158	128	45	35	13	11	3	2	1	1
		2	60	390	366	120	71	41	28	17	11	9	23
		3	30	233	151	67	39	16	10	4	7	4	6
375	Volkel	1	30	151	140	42	38	9	13	4	0	1	1
		2	60	398	372	136	64	50	23	22	10	8	23
		3	30	225	171	62	38	25	12	7	1	3	5
380	Beek	1	30	127	135	53	25	21	8	4	2	0	1
		2	60	381	330	138	78	50	31	13	12	10	25
		3	30	220	160	66	43	17	10	9	2	4	6

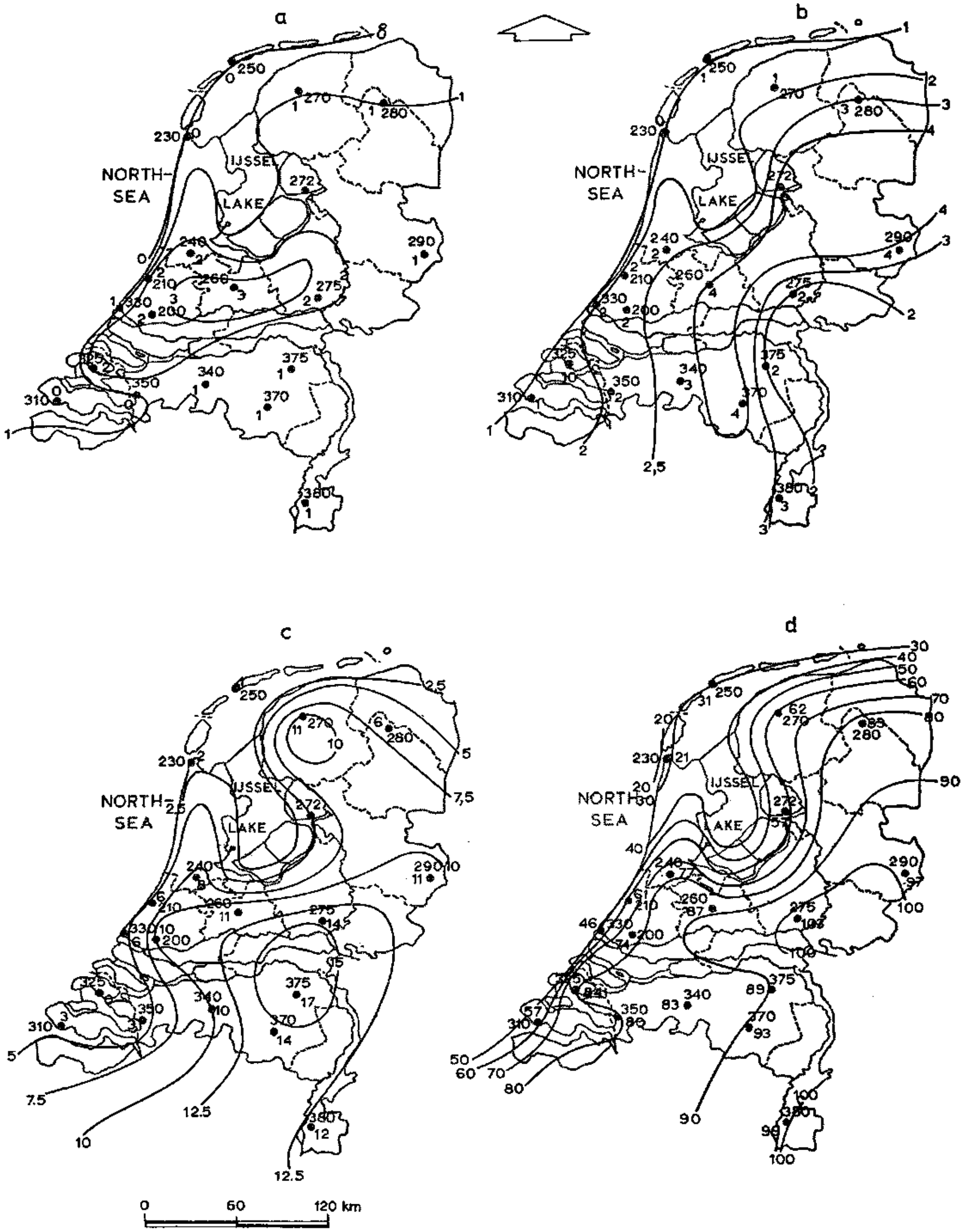

Fig. 17. Iso-frequency W-value lines for the early seasons (May 16 through June 15) of the 20-year period of 1951 through 1970 for the W-value $\geqslant 9.5$ (a), $W \geqslant 7.5$ (b), $5.5 \leqslant W \leqslant 7.4$ (c) and $2.5 \leqslant W \leqslant 5.4$ (d). The numbers in grey indicate the climatological stations (see table 28).

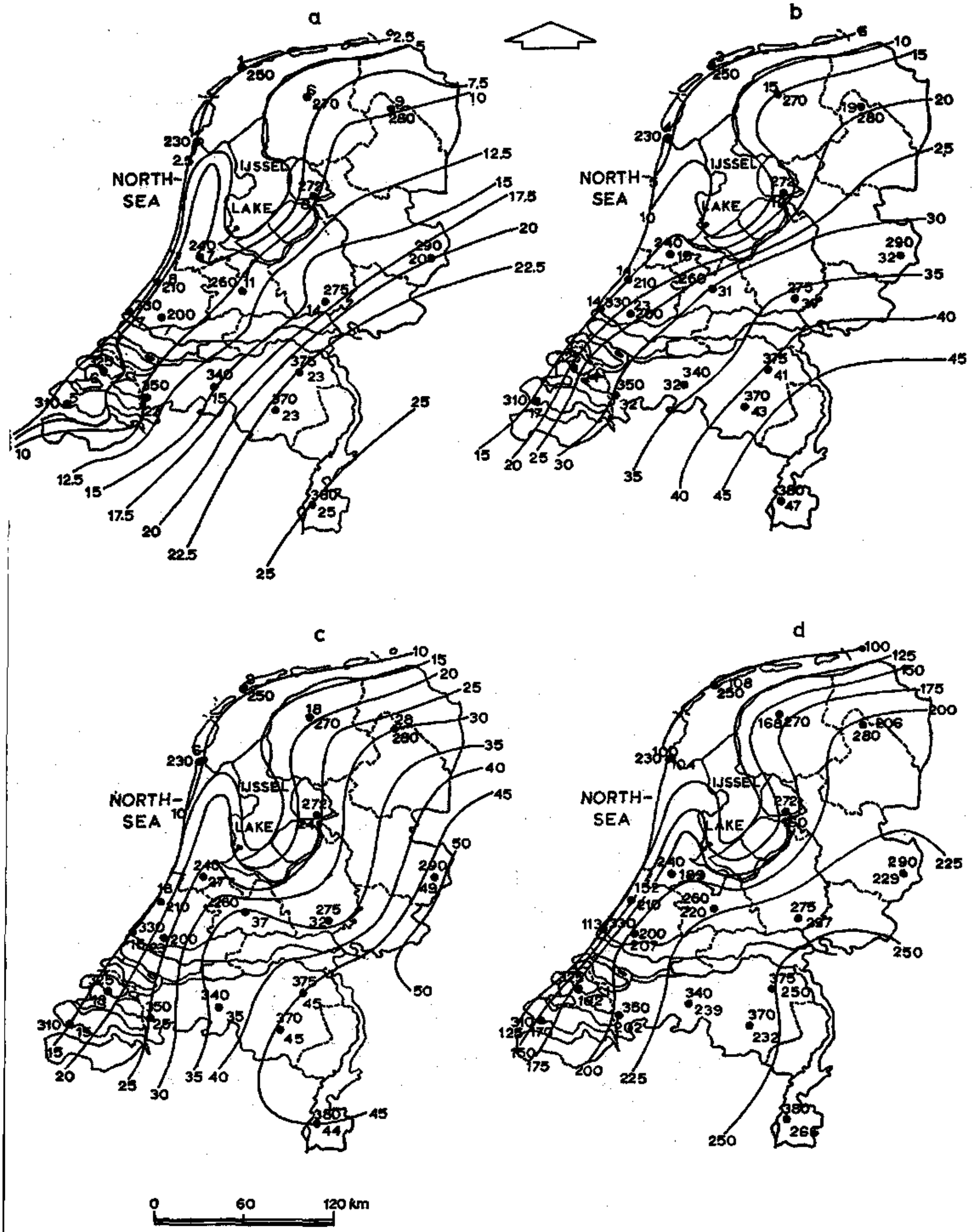

Fig. 18. Iso-frequency *W*-value lines for the main seasons (June 16 through August 15) of the 20-year period of 1951 through 1970 for the *W*-value $\geqslant 9.5$ (a), $W \geqslant 7.5$ (b), $5.5 \leqslant W \leqslant 7.4$ (c) and $2.5 \leqslant W \leqslant 5.4$ (d). The numbers in grey indicate the climatological stations (see table 28).

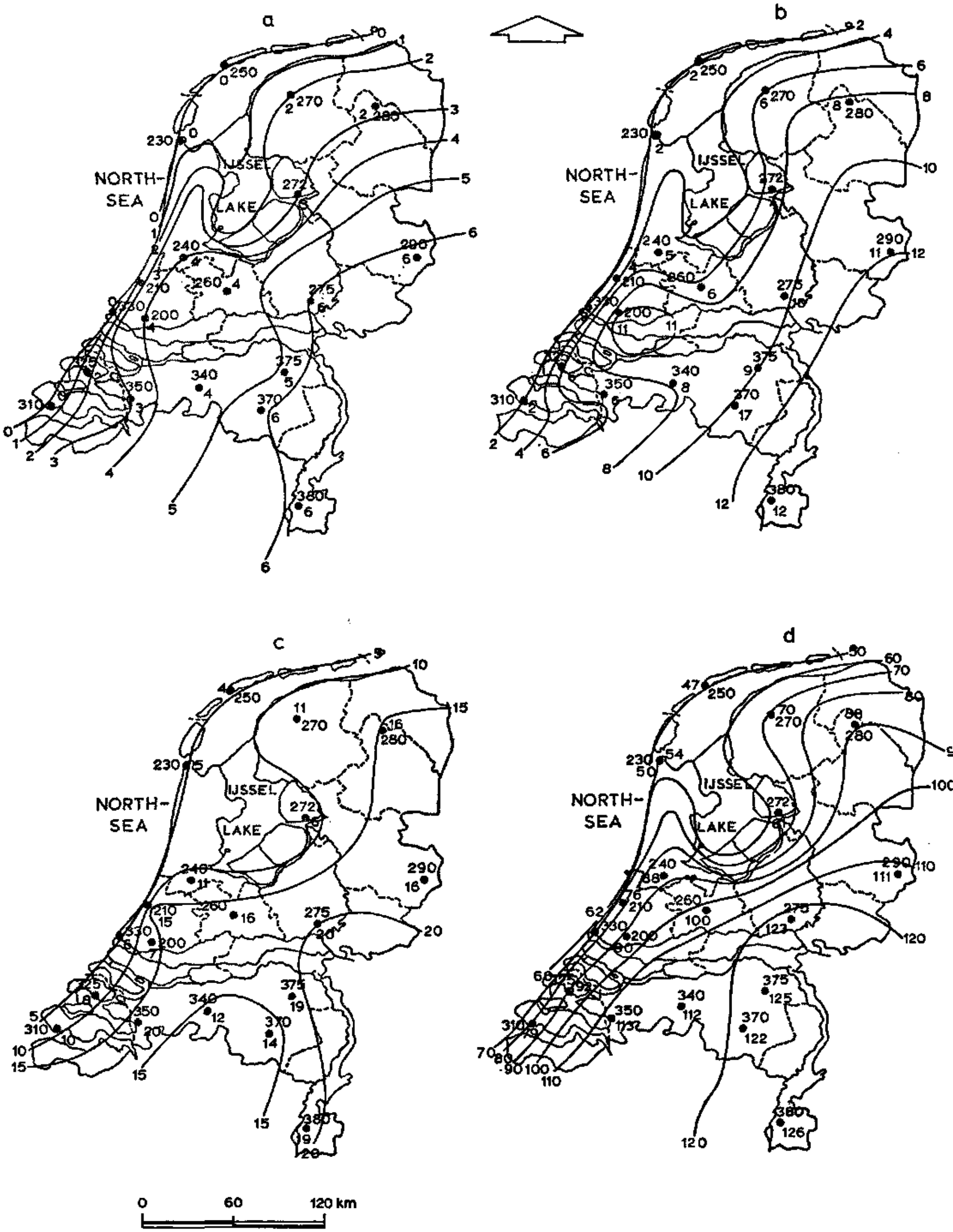

Fig. 19. Iso-frequency W-value lines for the late seasons (August 16 through September 15) of the 20-year period of 1951 through 1970 for the W-value $\geqslant 9.5$ (a), $W \geqslant 7.5$ (b), $5.5 \leqslant W \leqslant 7.4$ (c) and $2.5 \leqslant W \leqslant 5.4$ (d). The numbers in grey indicate the climatological stations (see table 28).

These conclusions are all based on the general statistical weather model which had to be used to be able to compare W-values over the whole country as well as over the 12 day-groups (see table 15). Peak visits, however, do not for all day-groups correspond with a W-value of $\geqslant 9.5$ as calculated with the general model. In the early season, for instance, peak visits are already obtained on days with 25 °C, a low degree of cloudiness and a small wind velocity. At that time there is a strong inclination to go swimming and sunning after the long winter period and people feel already comfortable under less good weather conditions. Therefore W-values calculated with the general statistical weather model are very much underestimated for the early and late season. For this reason table 29 gives a scale transformation of W-values for each day-group. When comparing the W-values of the general model in table 29 with these values in table 22, a discrepancy will be found. The reason of this is that the values in table 29 were calculated with mean values of T_{d2}, S and u_{t2}, while in table 22 the anomalies of specific days have had their influence. When applying the use models use should be made of the W-values of the general model, given in table 29. From this table it can be seen that the W-values in the early season (day-groups 1 through 3) are underestimated with a factor of approximately 2 to 3. The same holds true for the late season (day-groups 10 through 12), while for the main season (day-groups 4 through 9) there is still an underestimation, but to a lesser degree (with a factor of approximately 1.25 to 2).

To calculate the frequency of occurrence of certain W-values in a certain region for a certain day-group the following procedure is to be used. Taking day-group 1 (Sundays in the early season) and a W-value (calculated with the regional statistical model, see eq. 51 and table 26) of 10 as an example, the corresponding W-value as obtained with the general statistical weather model can be found in the column general model of table 29 by interpolating:

$$\frac{10 - 8.86}{11.49 - 8.86}(4.85 - 4.36) + 4.36 = 4.57$$

For the climatological station De Bilt the frequency of $W \geqslant 4.57$ in the early season (May 15 through June 14) is $14+9+2+1+3=29$ (see table 28), so in the 30-day season approximately $\frac{4}{30} \times 29 = 3.85$ Sundays with a $W \geqslant 4.57$ will occur in a 20-year period.

5.3 Discussion

In this Chapter models were set up on the relationship between visits and supply factors (use models) and the relationship between visits and weather factors (weather models), and calibrated with a limited number of variables.

Regarding the use models different types were set up, but only two multiplicative models were calibrated, one for non-free entrance projects and one for free entrance ones. For non-free entrance inland beaches the models show a high goodness of fit (high multiple correlation coefficients and low standard deviations). For this reason

Table 29. Transformation of weather values calculated with the general statistical weather model into *W*-values per day-group, as based on regional statistical weather models (eq. 51 and table 26).

Value of			*W*-values based on												
T_{a2}	S	u_{t2}	general model	regional models for day-group (see table 15)											
				1	2	3	4	5	6	7	8	9	10	11	12
15.0	1	10	0.71	0.78	0.43	2.14	0.26	0.25	0.46	0.03	0.32	0.58	0.004	0.01	0.26
15.0	50	10	0.77	1.83			0.50		1.40	1.45	1.61		1.00		1.23
15.0	50	5	0.85	2.38	0.30	4.20	0.63	1.14	1.62	1.45	2.14	2.36	1.01	1.72	1.61
17.5	50	10	1.09	2.51			0.84		1.95	1.96			1.62		1.82
17.5	50	5	1.21	3.26	3.82	5.49	1.06	1.71	2.26	1.96	2.80	3.11	1.64	2.42	2.38
20.0	50	10	1.54	3.44			1.41		2.73	2.65			2.63		2.71
20.0	50	5	1.71	4.47	4.82	7.17	1.78	2.57	3.15	2.66	3.66	4.09	2.66	3.42	3.54
22.5	50	10	2.18	4.72			2.38		3.80	3.59			4.27		4.02
22.5	50	5	2.42	6.12	6.09	9.37	3.00	3.87	4.40	3.59	4.80	5.39	4.32	4.83	5.25
25.0	50	10	3.08	6.46			4.01		5.30	4.86			6.93		5.97
25.0	50	5	3.42	8.38	7.68	12.25	5.06	5.82	6.13	4.86	6.29	7.09	7.02	6.82	7.80
27.5	50	10	4.36	8.86			6.75		7.39	6.58			11.26		8.86
27.5	50	5	4.85	11.49	9.69	16.00	8.54	8.75	8.55	6.58	8.24	9.34	11.40	9.64	11.58
30.0	50	10	6.18	12.14			11.39		10.31	8.90			18.29		13.15
30.0	50	5	6.86	15.74	12.22	20.91	14.40	13.15	11.92	8.91	10.79	12.30	18.52	13.61	17.19

these models can be of good use in the Netherlands to estimate the number of visits to new non-free entrance inland beaches with a high accommodation level. In these models no socio-economic factors were built in, which makes the accuracy of the estimation doubtful if used on the very long term. After a certain number of years it will be necessary to re-investigate inland beach recreation to obtain data with which new calibrations of the use models can be carried out. The models of the second group (free entrance inland beaches with a generally low level of accommodation) show a worse goodness of fit and large differences in the values of the parameters concerning inhabitants and vacationists are found. For this reason the estimates made with these models are less accurate than the ones obtained with the models for non-free entrance projects.

The weather model was calibrated for two types namely a statistical weather model and a heat exchange weather model.

For each type different functions were tried out: two for the statistical model and three for the heat exchange model. More functions to express the heat exchange were checked, but they did fit less well to the number of visits per day. This was among other things caused by such facts as the possibility to carry out different activities on the several projects and particularly activities which can be done without having good weather conditions (high temperature, bright sunshine, etc.). Despite the fact that peak visits occur on days with really good weather, there are many days with a high number of visits on which the weather conditions are only moderate. This can cause an underestimation of the number of visits (or of the weather value) when calculated with the heat exchange model. The deviations between observed and calculated values are large when using heat exchange weather models and the R^2-values are in all cases lower than of the statistical weather models. For this reason a statistical approach was finally chosen to:

- calculate a general weather model, valid for all day-groups and the whole of the Netherlands as a basis for a frequency analysis of weather values for inland beach recreation;
- calculate regional and day-group weather models for the more exact calculation of weather values for each day-group and region.

The general weather model has a lower goodness of fit than most of the separate day-group models which is caused by the fact that different days and seasons, via a transformation of the visits per day (V_t) in W-values, are taken together. In this transformation a certain value of V_{max} had to be estimated, leading to additional variancies in the dependent variable. The advantage of one model is, however, the possibility to make days, seasons as well as regions comparable. This was done by a frequency analysis of weather values for the Netherlands, showing that the south-eastern part of the country is more suited for inland beach recreation than the north-western part. Comparing the seasons, it appeared that the main season has 4 times and the late season has 2 times more days with high W-values than the early season.

The regional weather models evolved give different W-values from those calculated with the general model. This is because peak visits in the different day-groups (used in the regional weather models) are reached under different weather situations. With the aid of the regional models, however, the frequency of W-values can be calculated per day-group and region.

6 Planning capacity and layout

6.1 Planning capacity

6.1.1 Curve of exceedance of visits per day

Any study dealing with a variancy in magnitude of a phenomenon is concerned with the problem of choosing one value out of a large number. With regard to visits per day to an outdoor recreation project there is in most cases a strong fluctuation in the measured numbers. To determine the planning capacity of a new project one has to take this fluctuation into account and will have to make a choice of one value out of all values of visits per day. The fluctuation in these visits can be presented in different ways. One of the methods is to determine the number of days on which a certain number of visits per day is reached or exceeded (fig. 20).

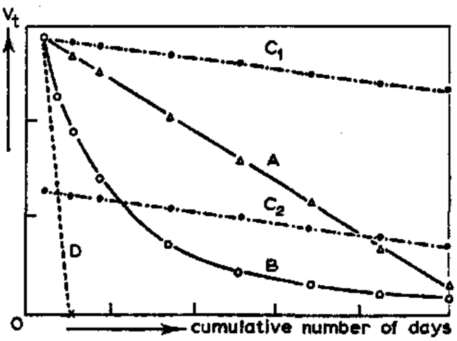

Fig. 20. Some theoretical curves of exceedance of visits per day V_t to outdoor recreation projects.

The curve of exceedance can have different shapes. The type of shape depends on many factors, such as accommodation level of the project, sensitivity to weather conditions, length of season, type of outdoor recreation, etc. In the example given in fig. 20 curve A shows a linear correlation of the cumulative number of days with the number of visits per day. A common type is shown by type B, which was found for inland beaches in the Netherlands (van Lier, 1972). This type shows a proportionally high decrease in number of visits per day for the days with high number of visits (i.e. the 10 most crowded days). The lower end of the curve shows a slower decrease in visits. The sensitivity of the project to a change in weather conditions is high in the range of the most crowded days. This follows from the fact that the fluctuation in visits per day is determined to a large extent by the variancy in weather factors, so a small change in weather conditions causes a large change in number of visits in the range of days with good weather. This change is much lower, however, when the weather is fluctuating in the range of days with worse weather conditions.

More extreme curves of exceedance are given by the types C_1, C_2 and D. In the types C_1 and C_2 a project is shown with a fairly constant number of visits per day. This can be caused by such facts as a low sensitivity of the project to weather or a high level of bad weather accommodations. In most cases such projects have a lower number of peak visits, resulting in a lower level of the total curve (C_2). Type D shows a project which can only be visited three days per season and is very sensitive for weather conditions. In such cases no expensive and durable provisions (e.g. parking lots, etc.) are to be made. In general, curves of exceedance in the area ranging from B to C_1 are met with when dealing with outdoor recreation projects. Owners of these projects often try to change from curve B via A to C_1 by increasing the accommodations.

In fig. 21 some curves of exceedance are given for inland beaches in the Netherlands.

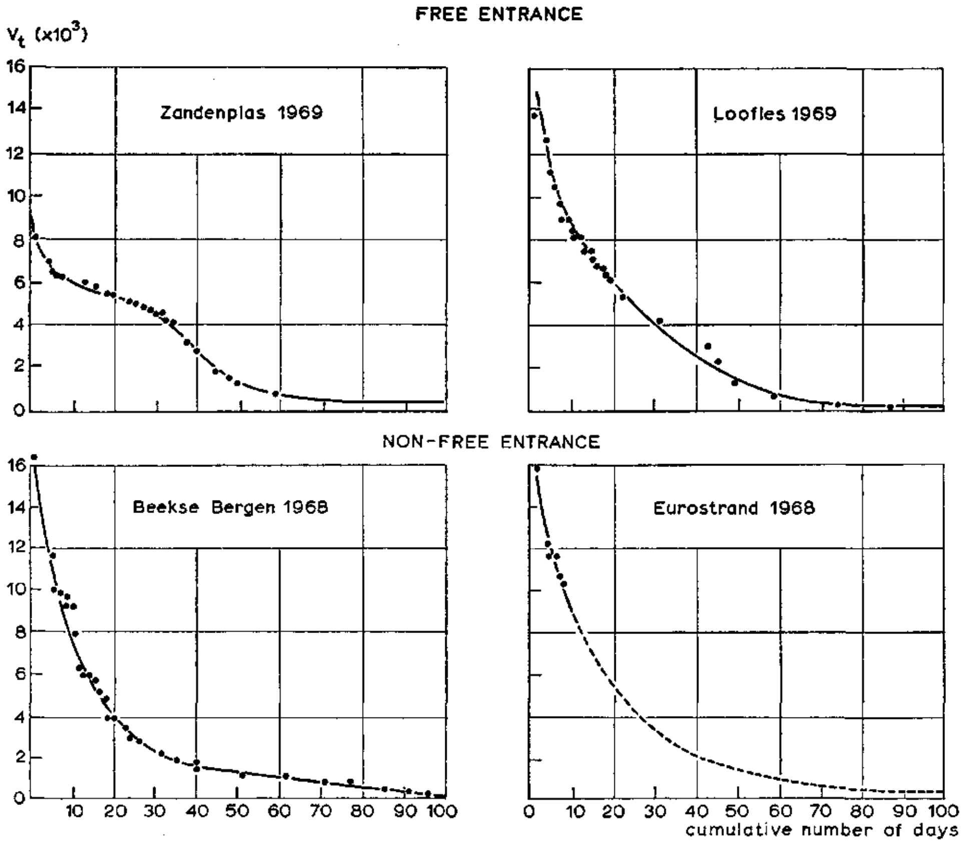

Fig. 21. Curves of exceedance of visits per day V_t for free entrance and non-free entrance inland beaches in the Netherlands.

From the figure it can be seen that there are differences between free entrance and non-free entrance projects. In the free entrance projects a relatively high level is obtained between the 10th and 40th most crowded day, while in the last mentioned projects the number of visits per day quickly decreases. The sustained relatively high level in free entrance projects is probably caused by the fact that these projects have more visitors staying only a short time as one can freely walk in or out. Such projects are therefore also less weather sensitive in the range from reasonable to good weather. The non-free entrance projects have a faster decreasing curve between the 10th and 40th crowdest day, but reach their low points at a higher cumulative number of days. This is correlated with these projects often having a high accommodation level, which makes them less sensitive to bad weather conditions. All curves of exceedance for inland beaches in the Netherlands are of the same type as shown in fig. 21, although their levels are fluctuating from year to year as well as from project to project.

In table 30 the mean number of visits per day is given as percentage of the number on the most crowded day. This table also shows the differences between non-free entrance and free entrance projects.

Table 30. Rounded off means of number of visits per day, as percentage of the number on the most crowded day, for the 1st through 25th most crowded day for 5 non-free entrance (a) and 2 free entrance (b) inland beaches in the Netherlands.

Sequence of crowded days	a	b	Sequence of crowded days	a	b	Sequence of crowded days	a	b
1	100	100	10	55	66	19	34	52
2	90	95	11	52.5	64	20	32.5	50
3	80	92.5	12	50	62	21	31	48
4	75	90	13	47.5	60	22	29.5	46.5
5	70	80	14	45	58.5	23	28	45
6	65	75	15	40	57	24	26.5	43.5
7	62.5	72.5	16	37.5	55.5	25	25	42
8	60	70	17	36	54.5			
9	57.5	67.5	18	35	53.5			

6.1.2 Normative year, normative day and normative number of visits

Neither the level nor the exact shape of the curves of exceedance of one certain project are constant if considered over some years. This is caused by several factors of which the increase or decrease in visits (by changes in such things as behaviour, population and alternative sites) and the weather situation during the total recreational season are the most important ones. It is for this reason that as a basis for the planning capacity of a new outdoor recreation project the mean curve of exceedance over many years must be used instead of the curve of exceedance of one particular year. Since, however, for a new project nothing is known about the different curves of several years a curve is to be constructed which is expected to equal the mean curve over a certain period (in our case the first 20 years) that the project will be in use. This curve will be called the curve of exceedance of the visits per day for the normative year. This normative year can therefore be considered as a mean over a long period sometime in the future. In fig. 22 this situation is given.

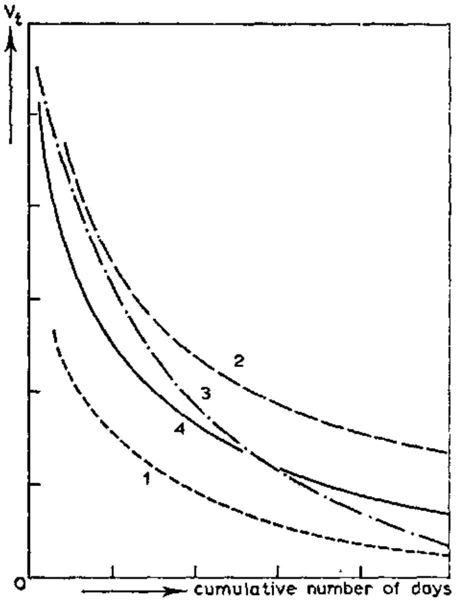

Fig. 22. Some theoretical curves of exceedance of visits per day V_t to outdoor recreation projects in non-urban areas. 1→2: higher level caused by timetrend, general increase in visits; 1→3: change in shape caused by different weather conditions in a certain year; 4: mean curve over a, for instance, 20-year period.

The curve for the normative year can be determined by calculating the frequencies over all years with which a certain number of visits per day are reached or exceeded and dividing them by the number of years taken. Another system would be to construct curves which are valid once in a certain number of years (e.g. once in two or three years on a 20-year period basis). The system used in this study is, however, based on the mean curve for the normative year, since the determination of all curves of exceedance over 20 years was impossible because of lack of data on visits per day.

When the curve of exceedance of visits per day in the normative year has been obtained, the last steps are the choice of:

- the normative day, which can be defined as that day in the sequence of decreasingly crowded days for which the accommodation will be planned;
- the maximum momentary visit on the normative day ($V^*_{m.mom}$), which is identical with the planning capacity for the new outdoor recreation project.

The system is given in fig. 23. For the choice of the normative day out of a sequence of decreasingly crowded days in for example traffic engineering, several criteria are

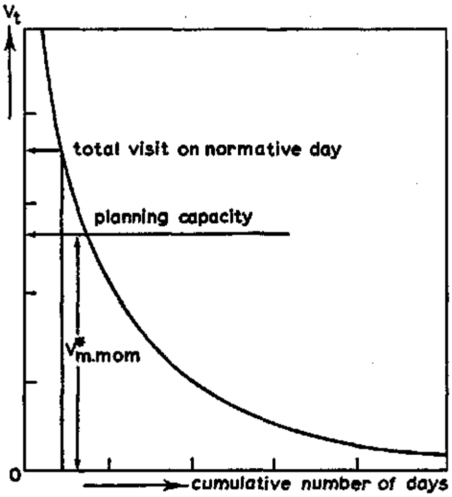

Fig. 23. System of determination of the planning capacity of a new outdoor recreation project by constructing the curve of exceedance of visits per day for the normative year, the choice of the normative day and using the measured momentary visit on the normative day $V^*_{m.mom}$.

used. For inland beaches three types of considerations can be taken into account as a basis for such criteria (van Lier, 1970):

- economic considerations. The benefit (private as well as national) and cost play an important role. The general rule is to equate marginal cost to marginal benefit. In cases where this is not possible or practicable, the principle of the rule is applied with increments of more than marginal size (see Locht, 1969);
- social considerations. One may for instance not be willing to send people away more than $(x-1)$ times in the normative year, which means that x is the chosen sequence number of the normative day;
- technical considerations. These must be taken into account when technical limitations do not allow more visits. The carrying capacity, that is the maximum number of visitors which can be accommodated without destructing the permanent usability of the project, may be less than the planning capacity. This then automatically makes the carrying capacity, instead of the planning capacity, the design capacity.

A change in choice of the normative day has a tremendous effect on the planning capacity if this day is one of the days in the steep part of the curve of exceedance. This problem is rather unimportant if one operates in a flat part of the curve. Since the number of days per year on which inland beach recreation can be carried out in the Netherlands is on the average rather low, the normative day must be close to the peak visit. From table 30 it can be seen that at 70 to 80% of the peak visit on inland beaches in the Netherlands 95 of the days in the 100-day season is covered. Given the fluctuation in curves of exceedance from year to year the chosen normative day can be, for instance, the peak day in the one year and the sixth most crowded day in another.

As said and shown before, the curves of exceedance for inland beaches in the Netherlands are rather steep. It is for this reason that the normative day for inland beaches must in the Netherlands be a day close to the first crowded day (peak day), varying from the 2nd to the 5th most crowded day (van Lier, 1970). In many cases the 3rd most crowded day has proved to be worthwhile to apply for inland beaches (Heester & IJkelenstam, 1971; van Lier, 1972). For other forms of outdoor recreation other normative days have been used. For sport fishing and driving for pleasure, for instance, the 12th most crowded day was chosen as the normative day by Bakker (1972). In the application of the system to determine the planning capacity (Chapter 7) the 3rd most crowded day will be taken as normative day.

The $V_{m.mom}$ can be calculated from the difference between the number of incoming and outgoing visitors. This filling up process of the project can be described in several ways. Baron & Schechter (1972) are using formulae analoguous to laws from electricity. The V_{mom} and $V_{m.mom}$ can be defined as follows (see also van Lier & Bakker, 1972):

– the momentary visit V_m of an outdoor recreation project is the total number of visitors which is at present at a certain moment on a certain day;
– the maximum momentary visit $V_{m.mom}$ of an outdoor recreation project is the highest value of the momentary visit which is reached at a certain moment on a certain day

The determination of the V_{mom} can be done by means of the following equation:

$$V_{mom.t} = \sum_{i=1}^{t} \alpha_i - \sum_{i=1}^{t} \beta_i = \sum_{i=1}^{t} (\alpha_i - \beta_i) \qquad (70)$$

where

$V_{mom.t}$ = momentary visit at time t; $t=0$ at the moment the first visitor of the day arrives
α_i = number of incoming visitors in time period i
β_i = number of outgoing visitors in time period i

$V_{m.mom}$ is the highest value of the V_{mom} of each day. The time t at which the $V_{m.mom}$ is reached is the time for which holds:

$$\sum_{i=1}^{t} (\alpha_i - \beta_i) = \text{maximum} \qquad (71)$$

In fig. 24 some examples are given of the filling up process of investigated inland beaches in the Netherlands.

From this figure it can be seen that the respective curves for the different inland beaches have comparable shapes. The $\sum \alpha_i$-curves show two steep inclinations (relative peak visits) around 11 to 12 h a.m. and 15 h p.m. The $\sum \beta_i$-curves are more regularly shaped, showing that the number of outgoing people is continuously increasing over the day, with of course a steep inclination after 16 h p.m. The $\sum(\alpha_i - \beta_i)$ curve is also irregularly shaped with a peak between 15 to 16 h p.m. This maximum momentary visit has a different relative level for free entrance and non-free entrance projects. In fig. 23, the $V_{m.mom}$ of the free entrance ones is varying from 50 to 70% of the visits per day, while for the non-free entrance projects this varies from 80 to 85%.

In table 31 a conspectus is given of the $V_{m.mom}$-values of 7 inland beaches in the

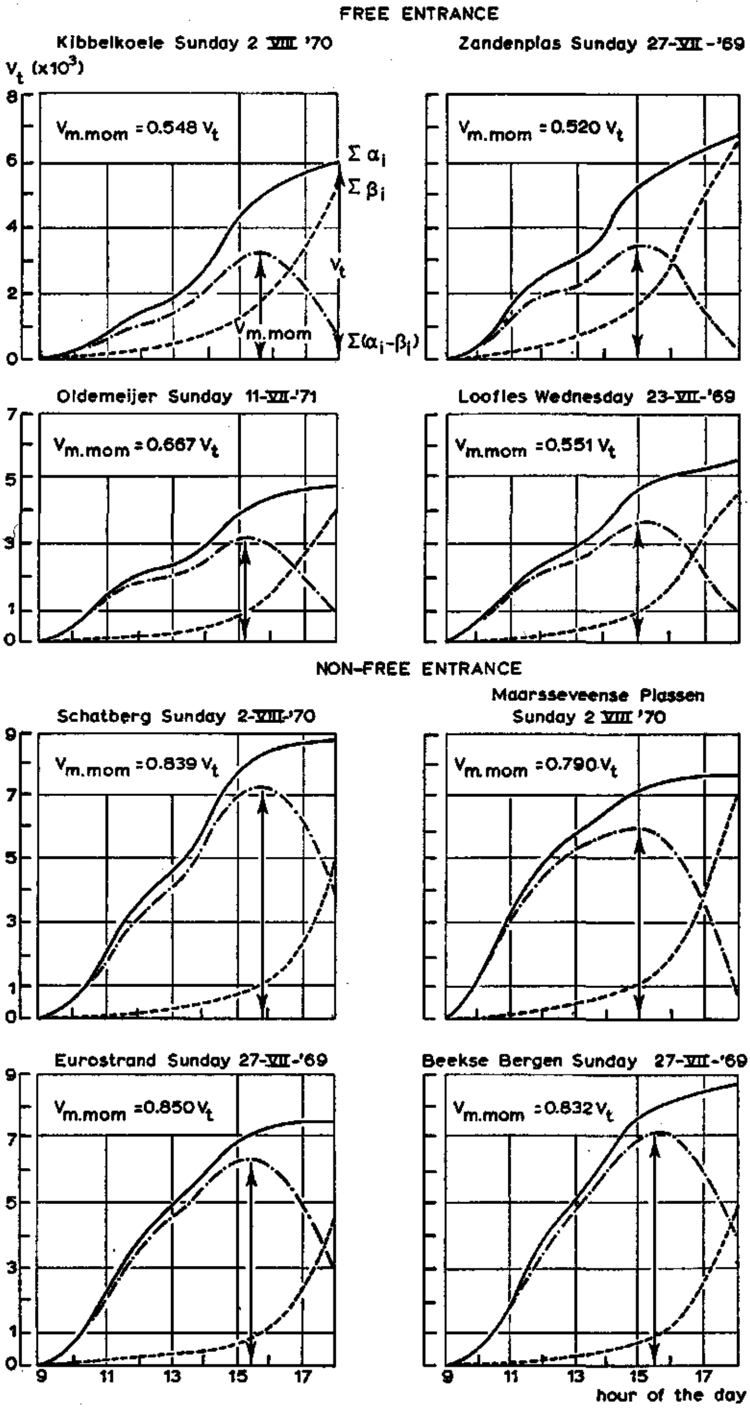

Fig. 24. Filling-up process of some inland beaches in the Netherlands on various days and the determination of the maximum momentary visit $V_{m.mom}$.

Table 31. Conspectus of $V_{m.mom}$, absolute and in per cent of V_t, of 7 inland beaches in the Netherlands.

Project	Date	Type of day	V_t	$V_{m.mom}$		Hour of the day at $V_{m.mom}$
				abs.	% of V_t	
Free entrance						
7. Loofles	7-7-68	Sunday	5959	3392	56.9	15.30
	27-7-68	Saturday	3768	2115	56.1	16.15
	28-7-68	Sunday	3307	1768	53.5	16.30
	10-8-68	Saturday	7154	5267	73.6	15.15
	11-8-68	Sunday	6345	4220	66.5	15.45
	18-7-69	Friday	3118	2120	68.0	15.30
	19-7-69	Saturday	4254	2630	61.8	15.30
	20-7-69	Sunday	6865	4049	59.0	15.30
	23-7-69	Wednesday	13762	7587	55.1	15.00
	26-7-69	Saturday	3239	1620	50.0	15.15
	27-7-69	Sunday	13647	8242	60.4	15.15
	6-8-69	Wednesday	2739	1670	61.0	15.45
	9-8-69	Saturday	4560	3084	67.6	15.30
	10-8-69	Sunday	8471	6053	71.5	15.15
12. Zandenplas	7-7-68	Sunday	5673	1464	25.8	15.30
	27-7-68	Saturday	3232	1559	48.2	15.45
	28-7-68	Sunday	4840	1068	22.1	15.30
	10-8-68	Saturday	3887	2005	51.6	15.00
	11-8-68	Sunday	4873	1970	40.4	15.15
	18-7-69	Friday	3042	1361	44.7	15.30
	19-7-69	Saturday	3858	1701	44.1	16.00
	20-7-69	Sunday	6853	2630	38.4	15.15
	23-7-69	Wednesday	6015	3319	55.2	15.00
	26-7-69	Saturday	2189	907	41.4	14.45
	27-7-69	Sunday	7032	3657	52.0	15.00
	6-8-69	Wednesday	3139	1247	39.7	15.45
	9-8-69	Saturday	2539	1336	52.6	15.45
	10-8-69	Sunday	4299	2127	49.5	14.30
Non-free entrance						
3. Beekse Bergen	1-6-68	Saturday	5232	3889	74.3	15.30
	2-6-68	Sunday	14827	11146	75.2	15.15
	20-6-68	Thursday	1223	912	74.6	14.30
	7-7-68	Sunday	9766	7800	79.9	15.45
	18-7-68	Thursday	6068	4507	74.3	15.00
	31-7-68	Wednesday	11463	9037	78.8	14.15
	10-8-68	Saturday	4924	3727	75.7	16.00
	11-8-68	Sunday	7959	5336	67.0	16.15
	26-7-69	Saturday	4036	2804	9.5	15.45
	27-7-69	Sunday	17156	14265	83.2	15.30
	6-8-69	Wednesday	9429	7344	77.9	15.15

Table 31 (continued)

Project	Date	Type of day	V_t	$V_{m.mom}$		Hour of the day at $V_{m.mom}$
				abs.	% of V_t	
2. Eurostrand	25-5-68	Saturday	2324	1460	62.8	15.15
	29-5-68	Wednesday	1377	810	58.8	15.00
	3-6-68	Monday	11946	9508	79.6	15.15
	2-7-68	Tuesday	7704	5733	74.4	15.00
	27-7-68	Saturday	3360	1648	49.0	15.45
	28-7-68	Sunday	5351	3334	62.3	15.45
	30-7-68	Tuesday	9585	8068	84.2	15.00
	24-8-68	Saturday	6545	5161	78.9	15.00
	25-8-68	Sunday	10463	9120	87.2	15.15
	26-7-69	Saturday	3524	1730	49.1	15.15
	27-7-69	Sunday	15833	12608	85.0	15.30
	6-8-69	Wednesday	6826	5169	75.8	14.45
9. Maarseveense Plassen	1-8-70	Saturday	7989	6359	80.0	15.00
	2-8-70	Sunday	14248	12041	79.0	15.00
	29-8-70	Saturday	3450	2358	68.3	15.15
	30-8-70	Sunday	8571	6580	76.8	15.15
10. Schatberg	1-8-70	Saturday	4120	2431	59.0	15.30
	2-8-70	Sunday	8639	7247	83.9	15.45
	29-8-70	Saturday	1872	1054	56.3	16.30
	30-8-70	Sunday	2739	1716	62.7	15.45
11. Tijnaarlo	23-8-67	Wednesday	472	380	80.5	16.30
	1-8-70	Saturday	1433	1288	89.9	15.30
	2-8-70	Sunday	2951	2671	90.5	15.30
	29-8-70	Saturday	655	583	89.0	15.45
	30-8-70	Sunday	794	702	88.4	15.15

Netherlands. From this table it can be seen that there is a strong fluctuation in these values, from as low as 22.1 up to 90.5%. This is the result of such factors as the type of day, the weather situation, the type of project and the accommodation level. For example the extremely low value on Zandenplas resulted from weather conditions less good than was expected which caused a reasonably high number of visits, but a short time of stay. The extremely high value on Tijnaarlo resulted from swimming games for school boys, causing long stays with a moderate number of visits. The most values of $V_{m.mom}$ are found between 50 and 80% of the total visits per day, while the moment at which these values are mostly reached is found between 15.00 and 15.30 h p.m. In general, inland beaches with a low accommodation level and a free entrance are found to have lower $V_{m.mom}$-values, which is caused by the fact that many people do not stay long at such a project. The $V_{m.mom}$ is high on projects with a high accommodation level and non-free entrance. The most outspoken example of this group is Tijnaarlo.

It is also found that the $V_{m.mom}$ is increasing with an increasing number of visits per day, which can be seen in fig. 25. For the free entrance inland beaches the relationship is not very convincing, however. In the curves it is assumed that $V_{m.mom}$ for free entrance projects increases on the average from 48% at 2000 visits per day to 71% at 11000 visits per day. For non-free entrance projects it is assumed that $V_{m.mom}$ increases on the average from 50% at 1000 visits per day to 90% at 15000 visits per day.

The planning capacity of a future inland beach is the $V_{m.mom}$ of the normative day so in our case the $V_{m.mom}$ on the 3rd most crowded day. Since there is a tendency towards more accommodation on the projects, enabling the visitors to stay longer, it is assumed that the $V_{m.mom}$ will in the future reach values as given in table 32. The figures mentioned in this table will be used in an application of use and weather models leading to the planning capacity of a specific inland beach in the Netherlands (see Section 7.2).

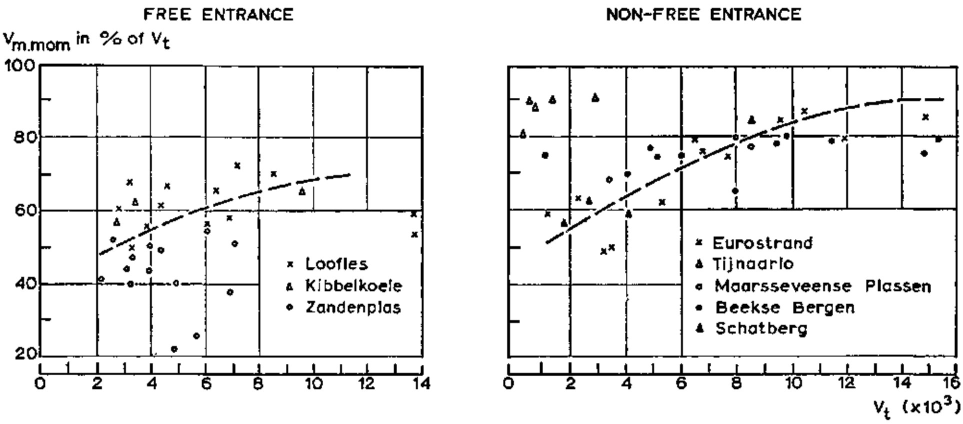

Fig. 25. Relationship between maximum momentary visit $V_{m.mom}$ in % of visits per day, and visits per day V_t for free entrance and non-free entrance inland beaches in the Netherlands. The tentative curves were drawn in while excluding Zandenplas respectively Tijnaarlo.

Table 32. Assumed values for the maximum momentary visit on the normative day $V^*_{m.mom}$ for future inland beaches in the Netherlands

	Free entrance with accommodation level		Non-free entrance with accommodation level	
	low	high	low	high
Highest value of $V^*_{m.mom}$	50	70	80	90
Lowest value of $V^*_{m.mom}$	40	60	60	75
Average value of $V^*_{m.mom}$	45	65	70	82.5

6.2 Layout

6.2.1 General

In the layout of outdoor recreation projects two problems arise (see also van Lier, 1972):

- what type of elements have to be built into the project;
- what is the number, size and arrangement of the chosen elements.

To answer these questions it is necessary to know:

- the behaviour of recreationists on the various elements of existing projects;
- the limitations resulting from technical impossibilities with reference to the site in its final shape, as climate, geography and carrying capacity.

Many aspects have to be taken into account if criteria are recommended for the layout of outdoor recreation projects. It is probably because of this reason that so many different criteria are in use. Van Duin (1971) gives different technical considerations (water quality, plant growth, soil type, etc.), aspects of the use of projects by visitors and possibilities of improvement as well as limitations, this leading to layout criteria for several types of outdoor recreation projects. BOR (1967b) gives different space standards for projects in the USA. Criteria for the size and layout of different types of parks are given by Maas (1968) and the State of Indiana (1970), while Berthery & Riquois (1970) are giving a conspectus of the different criteria with regard to existing outdoor recreation projects in the Netherlands. The relationship between the physical-geographical properties of rural areas and the suitability for outdoor recreation, very important for the layout, have been studied by Edminster (1966) for the USA and by Segers (1970) and C. van Wijk (1970) for the Netherlands. With regard to among other things the technical possibilities and limitations, a classification of outdoor recreation areas was made for the Netherlands by de Zeeuw (1972), while A. L. M. van Wijk & van den Hurk (1971) are giving norms for soils and hydrological conditions required for different elements as playgrounds, woods, etc. A. L. M. van Wijk (1970) also gives norms for recreational roads, footpaths and inland beaches, while Scholte Ubing & Kats (1966) give norms for the amount of water in inland beaches. Based on the latter Scholte Ubing (1969) gives the design capacity and dimensions of beaches. Data on the influence of recreation on nature in a dune valley is given by van der Werf (1970). Ter Haar (1968) gives insight in the use of beaches along the border lakes of newly reclaimed IJssel Lake polders, leading to some layout criteria, while some insight in differences in quiet and crowded zones in a project is given by Riquois (1972). Problems of the differentiation and the principle of zoning in outdoor recreation are described by Kerstens (1971a).

With regard to the layout of inland beaches, in this study attention will only be paid to criteria derived from observed behaviour of recreationists. Study has been made on the use of different elements in some existing inland beaches and it will be tried to distill some layout criteria out of these data. There must be, however, some reasonable doubt about the value of such criteria, as what visitors want to do not need to be identical with what they do. This is especially true if there is a strong limitation in recreational possibilities, making it impossible for visitors to show their real wishes with regard to the mutual location, form and size of the elements. It is for this reason that two projects were chosen for the layout research, namely Beekse Bergen and Eurostrand, as these projects have very high accommodation levels with spacious elements with regard to water, beaches, playgrounds, etc.

6.2.2 Recreationist behaviour

The shape and location of the different parts of an inland beach (as beach, water, playgrounds, etc.) often give rise to the border effect and the existence of zones. The border effect is the behaviour of people in using borders as cover at the back, for example trees and thickets (see for instance ter Haar, 1968 and de Jonge, 1968). The zoning effect is caused by the fact that people walk a limited distance which, if the project is large enough, leads to crowded and quiet zones (see for instance Kerstens, 1971a and van Duin, 1971). The principle of zoning is based on this relationship between crowdedness and walking distance and often is applied in the layout of outdoor recreation projects.

In this section attention will be paid to the border effect, to the relationship between walking distances and crowdedness of beaches, swimming water and other elements and to the distribution of recreationists over the elements. In Section 6.2.3 the determination of the area needed for the various elements on inland beaches in the Netherlands will be treated. The data used in Section 6.2.2 were obtained during the 1968 investigation on the projects Beekse Bergen and Eurostrand. The sampling procedure, being the determination of the number of visitors on the several elements as a function of time and location, was carried out by visual counts and by counts on aerial photographs. In the first case the number of people were counted four times a day according a stratified area sampling procedure. These counts were carried out by two persons and the mean of the two counts was taken. Aerial obliques were taken three times a day.

6.2.2.1 Border effect

On Eurostrand and Beekse Bergen the border effect was found on beaches and playgrounds on non-crowded days. On days with good weather and many recreationists the border effect was found to exist in the mornings when the borders of the beaches and playgrounds were first occupied. At later hours on these days, however, no differences in densities were found between the borders and the middle part of beaches and playgrounds. This is caused by no empty border being left at a certain moment, so people have to find a place elsewhere. In such cases people often erect their own cover at the back, as for example wind shelters.

The border effect can be used as a zoning criterion for the layout of outdoor recreation projects. If on a large beach or playground a great border length is created many people will chose these spots, while the areas in the middle of the beaches or playground will remain more empty. These parts then can be used for playing games (soccer, etc.). De Koning & Scholte Ubing (1968) are giving figures for the width of a beach with regard to the border effect. According to these authors the minimum width has to be 40 m, while at a width of 70 m or more the density in the middle of the beaches is significantly less than on the borders.

6.2.2.2 Walking distances

The influence of the walking distance can be shown with fig. 26, where it is related to the crowdedness of the beaches, the water and the other elements. The last ones are taken to be all the parts of the project which do not belong to the beaches and the water, as for instance the playgrounds, the restaurants, midget golf links, trampolines, etc. In all cases the walking distance was taken to be the distance between the parking lots (Eurostrand) or entrance (Beekse Bergen) to the spot where the recreationists were observed.

With regard to the beaches there is a strong relation between the crowdedness of the beach and the distance people have to walk. For both projects this relationship is

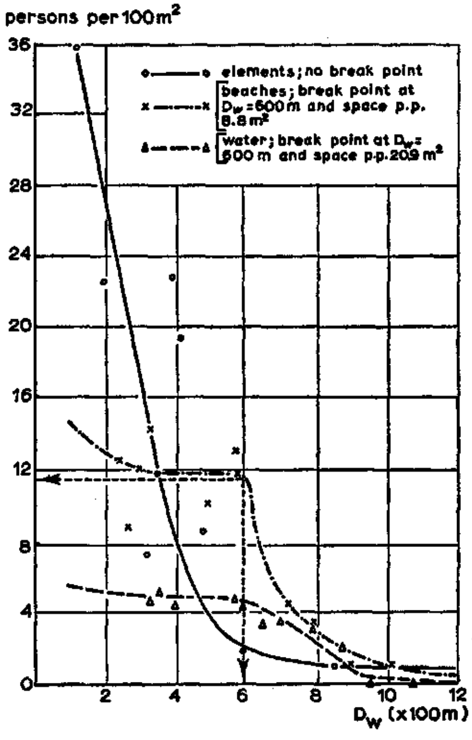

Fig. 26. Relationship between walking distance D_w and crowdedness on beaches, in the water and on other elements for inland beach Beekse Bergen at 14 h p.m. on Sunday 2-6-68 with V_t=14827.

obvious on crowded as well as on less crowded days. For most days on Beekse Bergen there is a break point in the curve which in all cases was found to occur between 500 and 600 m. This point was not found for Eurostrand. The space per visitor at this break point was of course not constant for all days, but varied from 8 to 25 m^2 per person. Since for the beaches values are found from about 4 m^2 per person (equal to 2500 persons per ha), it can be calculated that on days with many visitors the beaches up to 500 m from the parking lots are very crowded, with on the average 2000 people per ha while beaches at a walking distance of over 500 to 600 m are less crowded, with on the average 50 to 100 persons per ha.

For Beekse Bergen the relationship between water crowdedness and walking distances is similar to that found for beaches. For Eurostrand, however, no outspoken relationship was observed. The break point for water also occurs between 500 and 600 m, although on some days such a point did not exist. The space per visitor is, if compared with the beaches, higher namely of about 20 m^2 per person on the most crowded parts (equalling 500 persons per ha) and around 100 m^2 per person on the not very crowded parts (being 100 persons per ha).

With regard to the other elements almost no relationship between crowdedness and walking distances was found. This is probably caused by such things as these elements offering particular forms of recreation with more or less constant numbers of recreationists.

Taken altogether it can be concluded that when wanting to apply the principle of zoning in an outdoor recreation project use can be made of the relationship between walking distances and crowdedness, with regard to beaches and water.

6.2.2.3 Distribution over elements

For this, counts were made of the number of people in the water, on the beaches and on the other elements on several days varying from quiet to very crowded. The results are given in table 33.

In fig. 27 some results are shown for Beekse Bergen and Eurostrand at 14 h p.m. It can be seen that the percentage of people visiting the other elements is decreasing when the total number of visits per day increases. In the case of Beekse Bergen a decrease from about 70 to 20% and for Eurostrand a decrease from 60 to 30% was found. The cause of this is that on days with a large number of visits the weather conditions are good, which does make the beaches and the water more attractive leading to a lower percentage of people using the other elements of the project. Since the distribution is given as a percentage of the momentary visit at 14 h p.m., this does not mean that the absolute number of recreationists on the other elements drops. In the example of Beekse Bergen for instance, approximately 500 people were visiting the other elements at 14 h p.m. on a day with 1200 visits, while on the normative day approximately 1500 people are present on them. For Eurostrand these numbers were 450 and 2500 respectively.

The beaches, in contrary to the playgrounds, etc., have an increasing percentage of

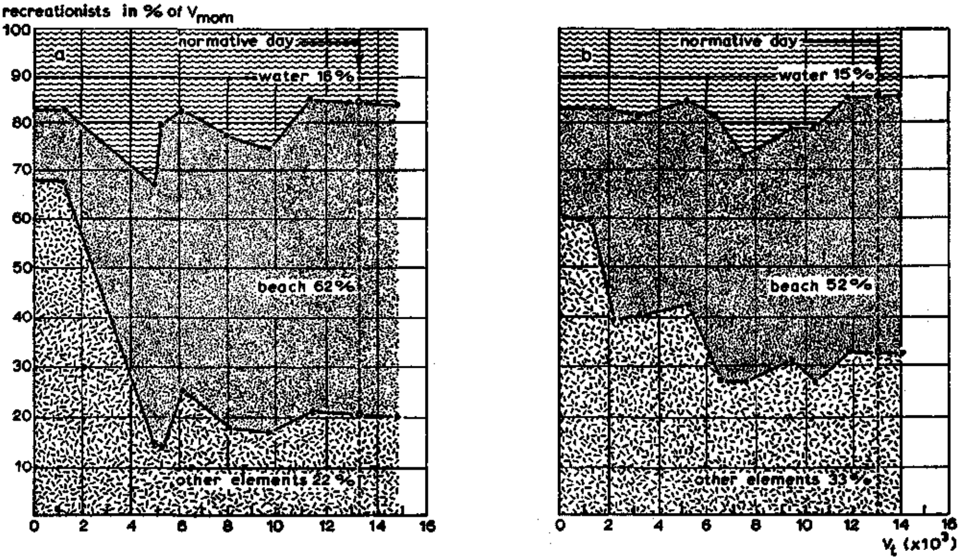

Fig. 27. Distribution of recreationists over water, beach and other elements of Beekse Bergen (a) and Eurostrand (b) at 14 h p.m. in relation to the visits per day V_t and on the normative day (3rd most crowded day in 1968).

visitors when the total number of visits per day increases. As mentioned, the better quality of the weather (higher temperatures, more sunshine and less wind) is causing this. In absolute number of recreationists this is even more striking. For Beekse Bergen the beach visit is 100 persons at 1200 visits per day, but about 5200 on the normative day (both at 14 h p.m.). For Eurostrand these numbers are 150 and 4000 respectively.

The water visit also increases in absolute number with an increase in visits per day, but in percentages of the momentary visit it is on the average staying more or less constant. It varies from 15 to 20%, with 15% for the normative day. In absolute numbers it differs from 110 persons for a day with 1200 visits to 1200 on the normative day (both at 14 h p.m.).

In general it can be said that an increase of the visits per day with a factor 10 results in an increase of water visits with a factor 10, also, of beach visits with a factor 30 to 50 and of visits on the other elements with a factor 5.

The distribution at other moments of the day can of course be different from that at 14 h p.m. (see table 33), but since for the layout of a project the maximum momentary visit, which occurs closely to the 14 h period, is important, this last distribution is taken for the choice of the distribution norms. As norms for the distribution of recreationists on inland beaches in the Netherlands, on the normative day, are taken in per cent of the maximum momentary visit: in the water 15%, on beaches 50 to 60% and on other elements 25 to 35%.

Table 33. Distribution of visitors on the inland beaches Beekse Bergen and Eurostrand in 1968 over beaches, water and other elements for several days and four moments per day.

Date	Hour of the day	V_{mom}	Number of visitors on						Kind of day	Total number of visits	Weather value (regional model)	Number in sequence of most crowded days
			beaches		water		other elements					
			abs.	%	abs.	%	abs.	%				
Beekse Bergen												
1-6	10	346	627	70.3	190	21.3	75	8.4				
	12	2272	2343	66.9	692	19.7	469	13.4	Saturday	5232	7.17	16
	14	3478	2893	66.5	861	19.8	599	13.7				
	16	3702	2566	72.8	356	10.1	605	17.1				
2-6	10	810	837	70.4	88	7.4	264	22.2				
	12	6751	5287	66.4	967	12.1	1709	21.5	Sunday	14827	3.85	2
	14	10073	6538	62.8	1796	17.3	2071	19.9				
	16	10317	5269	65.3	982	12.2	1824	22.5				
20-6	10	24										
	12	682	41	8.6			434	91.4	Thursday	1223	2.13	50
	14	791	76	14.2	95	17.7	366	68.1				
	16	290										
7-7	10	67										
	12	1392	1254	60.9	383	18.6	422	20.5	Sunday	9766	3.75	8
	14	4762	3760	57.9	1623	25.0	1111	17.2				
	16	7751	5759	61.5	1972	21.1	1629	17.4				
18-7	10	161	96	58.5	47	28.7	21	12.8				
	12	2034	1760	66.5	290	11.0	595	22.5	Thursday	6068	7.73	13
	14	3855	2604	57.2	790	17.3	1160	25.5				
	16	4004	1982	56.4	365	10.4	1168	33.2				
31-7	10	1075	767	48.7	605	38.4	203	12.9				
	12	6745	5340	60.6	2271	25.8	1202	13.6	Wednesday	11463	7.73	5
	14	8990	6237	63.7	1442	14.7	2105	21.6				
	16	3326	1583	50.9	451	14.5	1073	34.6				
10-8	10	127	95	39.4	74	30.7	72	29.9				
	12	982	1010	65.7	283	18.4	245	15.9	Saturday	4924	5.11	18
	14	2472	2187	52.6	1347	32.4	624	15.0				
	16	3727	2600	53.8	1528	31.6	707	14.6				
11-8	10	101										
	12	1149	1100	57.2	384	20.0	439	22.8	Sunday	7959	3.03	11
	14	3234	2663	59.8	989	22.2	799	18.0				
	16	5322	4162	64.0	1219	18.7	1126	17.3				

Table 33 (continued)

Eurostrand												
25-5	10	206	83	35.2	6	2.5	147	62.3				
	12	577	159	32.8	87	17.9	239	49.3	Saturday	2324	3.96	38
	14	1002	303	42.7	128	18.1	278	39.2				
	16	1380	288	52.3	81	14.7	182	33.0				
29-5	10	65										
	12	332	61	45.9	25	18.8	47	35.3	Wednesday	1377	3.67	49
	14	619	100	22.8	78	17.7	261	59.5				
	16	637	81	26.6	87	28.6	136	44.8				
3-6	10	1268	956	45.7	255	12.2	881	42.1				
	12	6398	3584	52.5	1022	15.0	2221	32.5	Whit	11946	10.00	5
	14	8998	4184	52.2	1186	14.8	2652	33.0	Monday			
	16	8667	2295	51.3	367	8.2	1812	40.5				
2-7	10	994	864	39.4	745	34.0	584	26.6				
	12	3940	2436	50.8	1232	25.7	1124	23.5	Tuesday	7704	10.00	12
	14	5373	2768	44.7	1707	27.5	1722	26.8				
	16	5215	2222	45.2	1118	22.7	1577	32.1				
27-7	10	117	28	19.9	4	2.8	109	77.3				
	12	600	181	25.8	90	12.8	430	61.4	Saturday	3360	3.25	30
	14	1314	573	40.8	268	19.1	565	40.1				
	16	1638	769	43.3	192	10.8	814	45.9				
28-7	10	234	55	35.0	26	16.6	76	48.4				
	12	1889	458	36.3	103	8.2	701	55.5	Sunday	5351	1.10	20
	14	2768	992	41.5	379	15.8	1022	42.7				
	16	3270	1092	46.2	222	9.4	1049	44.4				
30-7	10	573	690	54.6	319	25.3	254	20.1				
	12	4819	2949	51.9	1066	18.8	1665	29.3	Tuesday	9585	6.44	8
	14	7313	3583	47.0	1624	21.3	2409	31.7				
	16	7573	3525	51.7	1068	15.7	2228	32.6				
24-8	10	576	522	53.4	204	20.9	250	25.7				
	12	2963	2021	55.1	558	15.2	1089	29.7	Saturday	6545	8.17	16
	14	4432	2759	54.2	964	19.0	1363	26.8				
	16	4913	2779	57.5	717	14.8	1338	27.7				
25-8	10	269										
	12	3169	866	33.7	615	24.0	1085	42.3	Sunday	10463	4.87	7
	14	6971	4137	51.6	1718	21.4	2161	27.0				
	16	8416										

6.2.3 *Element area determination*

With the data and relationships with regard to the behaviour of recreationists on inland beaches found, it is possible to calculate the needed areas for swimming water, sand beaches, other elements (playing fields, etc.) and parking lots. This can be done by means of the following general equations, which are all based on and valid for the moment at which the $V_{m.mom}$ on the normative day ($V^*_{m.mom}$) is reached. The needed net area for sand beaches can be expressed as:

$$F_s = y_s V^*_{m.mom} \sum_{k=1}^{n} s_k m_{sk} \tag{72}$$

where

F_s = net area of sand beaches in m^2
y_s = number of visitors on the beaches in % of $V^*_{m.mom}$
$V^*_{m.mom}$ = maximum momentary visit on the normative day on an inland beach
s_k = fraction of beach visitors on beach part k in m^2
m_{sk} = average area per visitor on beach part k

The value of m_{sk} depends, as we have seen, on the walking distance which can be given by means of (see also fig. 26):

$$m_{sk} = \alpha\, e^{-\beta D_{w.k}} \tag{73}$$

where
$D_{w.k}$ = walking distance to beach part k in 100 m
α and β = to be estimated parameters
e = base of natural logarithms

So eq. (72) turns into:

$$F_s = y_s V^*_{m.mom} \sum_{k=1}^{n} s_k \alpha\, e^{-\beta D_{w.k}} \tag{74}$$

In the same way the net area of swimming water can be calculated by means of:

$$F_w = y_w V^*_{m.mom} \sum_{k=1}^{n} w_k \gamma\, e^{-\delta D_{w.k}} \tag{75}$$

where
F_w = net area of swimming water in m^2
y_w = number of visitors in swimming water in % of $V^*_{m.mom}$
w_k = fraction of swimmers in part k of swimming water
$D_{w.k}$ = walking distance to part k of swimming water in 100 m
γ and δ = to be estimated parameters

The needed area for the other elements (playing fields, etc.) can be calculated by means of:

$$F_e = y_e m_e V^*_{m.mom} \tag{76}$$

where

F_e = net area of other elements in m^2

y_e = number of visitors on other elements in % of $V^*_{m.mom}$

m_e = average area per visitor on the other elements in m^2

The needed area of parking lots on an inland beach depends on: the number of visits per day, the duration of stay (given by the $V_{m.mom}$), the mean number of visitors coming by car and the mean number of visitors travelling in one car.

Since the planning capacity of an inland beach is based on the normative day the planning capacity of the parking lots have to be based on this day also. Therefore this capacity can be determined by means of:

$$A = \alpha\beta\eta^{-1} V_{t.n} \tag{77}$$

where

A = number of to be parked cars on an outdoor recreation project

α = $V^*_{m.mom}$ in % of $V_{t.n}$

β = number of visits by car as fraction of number of visits on normative day

η = mean number of visitors travelling in one car on normative day

$V_{t.n}$ = number of visits on normative day

If the normative day is not known the planning capacity can be based on the peak day as follows:

$$A = \alpha\beta\eta^{-1}\,\delta\, V_{t.p} \tag{78}$$

where

$V_{t.p}$ = number of visits on peak day

δ = number of visits on normative day as fraction of number of visits on peak day = $V_{t.n}/V_{t.p}$

The different coefficients have been determined for inland beaches in the Netherlands, as given in table 34. Upon counts of incoming and outgoing visits per period of time are based α, β and η, while δ is taken from table 30.

As can be seen it is worthwhile to distinguish between free entrance and non-free entrance projects since the coefficients show in most cases large differences, especially with regard to the α, β and δ-values. On the short run the coefficients given in the two lines at the bottom of table 34 can be used. On the long run the values of the coefficients have to be estimated or determined because it is to be expected that the values will change with time: η will probably decrease, the values of α and β can be expected to increase or stay constant, while the value of δ probably will increase.

The needed gross area of a parking lot can be calculated by transforming eq. (78) into:

$$F_p = m_p \mu\alpha\beta\eta^{-1}\,\delta\, V_{t.p} \tag{79}$$

Table 34. Values of α, β, η and δ of eq. (78) for free entrance and non-free entrance inland beaches in the Netherlands.

Project	Year	α	β	η	δ
Free entrance					
7 Loofles	1969	0.55	0.56	4.16	0.95
12 Zandenplas	1969	0.55	0.60	4.53	0.88
Non-free entrance					
1 Beekse Bergen	1968	0.75	0.61	3.93	0.89
2 Eurostrand	1968	0.79	0.70	3.77	0.73
9 Maarsseveense Plassen	1970	0.79	0.68	3.96	0.75
10 Schatberg	1970	0.84	0.80	4.18	0.61
11 Tijnaarlo	1970	0.90	0.78	3.88	0.40
Chosen value					
free entrance		0.55	0.70	4.0	0.925
non-free entrance		0.75	0.80	4.0	0.80

where
F_p = gross area of total parking space in m^2
m_p = net area per parked car in m^2
μ = ratio between gross and net area of parking lot

Some remarks have to be made:

– The s_k- and w_k-values are also depending on the walking distance. In the calculation procedure of the needed areas for sand beaches and swimming water the division of beaches and water into n parts can be carried out in such a way that the total number of recreationists on each part is equal, which means that the areas of these parts increase with increasing walking distances (see also Section 7.3.2).
– Regarding the desired area per visitor (for instance on sand beaches, playing fields, swimming water, etc.) it is not quite clear what is really wanted: a certain amount of space per visitor or group of visitors or a minimum distance between persons or groups of persons (see also van Duin, 1963).
– In the real layout of an inland beach other than behaviour criteria are playing a role, as for instance the for the maintaining of water quality necessary volume and area of water (see Scholte Ubing & Kats, 1966).
– The layout of beaches and lakes is closely related to the ratio of length and width of the lake and of the beaches. If the total water area is fixed then the shape of the lake determines the length of the shore and with that, among other things, the length of the beaches (see also van Duin, 1971).
– The total area of the inland beach is not the total sum of the areas of swimming water, sand beaches, other elements and parking lots. Other functions, as for instance

sailing on the lake, walking for pleasure in quiet areas (woods, etc.), camping and traffic on the project itself also require space (see for instance Heester & IJkelenstam, 1971 and van Lier, 1972). Therefore the total area is:

$$F_{ib} = F_s + F_w + F_e + F_p + F_f \tag{80}$$

where

F_{ib} = total area of inland beach in m^2

F_f = area needed for additional non-specified functions in m^2 (left to the ideas of the designer)

6.3 Discussion

In this Chapter attention was paid to the theoretical system to determine the planning capacity for outdoor recreation projects and the recreationist behaviour on inland beaches in the Netherlands.

The system is based upon:

- the construction of the curve of exceedance for the normative year;
- a choice of the normative day;
- measurements of the maximum momentary visit, in particular that on the normative day, this being the planning capacity.

The curve of exceedance has two properties:

- a level which is given by the number of visits per day;
- a shape which depends for a certain form of outdoor recreation on frequency of occurrence of various weather conditions.

For the determination of the level use models are used, giving the relationship between the number of visits per origin to a certain project and the properties of the area and (sometimes) socio-economic properties of the population in the area. These models are based on investigations on many projects, making it possible to isolate the real factors influencing the actual visits. Once knowing these factors it is possible to construct models in which these factors operate and for which the parameters can be estimated.

Outdoor recreation projects of the same type (for instance inland beaches in the Netherlands) show many differences with regard to size, layout, accommodation level, accessibility, etc. All these differences have an impact on the number of visits, the properties of the visitors (for instance their duration of stay) and the frequency with which certain numbers of visits per day occur. An estimation of the future behaviour of recreationists can be obtained in several ways, for instance by means of psychological studies of human behaviour or, as is done in this study, by measuring real behaviour (use) of existing projects and relating the data to background variables. Only investigations carried out on many projects of the same type as well as repeating the same research on each project many times, can give an assurance that the relationship found (i.e. the constructed use model) is not based upon coincidental data, but is describing a behaviour in an equation in which some obvious factors are included and their relative weight is properly estimated. Therefore in this study many projects have been investigated, while on each project many repeats were taken, this leading to the construction of two types of use models in dependency of the properties of the project (non-free entrance with a high accommodation level versus free entrance with a low accommodation level).

The shape of the curve of exceedance depends in particular on the frequency with which certain desired weather conditions occur. To make it possible to determine for a new project in another area the frequency of occurrence of certain numbers of visits, it is necessary to know the relationship between visits per day and weather. Based on this relationship, the frequency of visits per day can then be calculated for many years. All frequencies of visits per day are averaged over the number of years taken, giving the frequency of visits per day for the normative year. From these frequencies the curve of exceedance is constructed. It will be clear that the needed weather-visit relationship can only be determined if the phenomenon is studied over a long time in which not only the whole range of weather conditions has occurred, but in which this range has shown up in each day-group. This distinction in day-groups has to be made since the potential for visits depends on the season and the day of the week. Therefore more than one weather model will, for most forms of outdoor recreation, be necessary.

Many researches on outdoor recreation have been carried out on only one day (for instance a sunday in the main season with very good weather). A one-day research on a phenomenon as outdoor recreation gives at best an insight in what happened on that specific day instead of in the frequency of it, making it impossible to predict its magnitude over many years.

With regard to the choice of the normative day many considerations, as economical, social and technical ones, can be taken into account. Not many studies have been dedicated to this. It should be possible for example to carry out an economic study leading to the choice of the optimum day, being the day on which the additional returns equal the additional cost. Some technical studies have been carried out with regard to the carrying capacities of areas, more research in this field especially in the Netherlands is needed, however, because potential areas for outdoor recreation are available but, not knowing the limitations with regard to both number as well as frequency of visits, they cannot be used without the possibility to destroy them. Sociological studies with regard to the attitude of recreationists towards outdoor recreation could give a contribution to understand the phenomenon. Not many studies have been done in this field; the wide research of Kerstens (1972) in two rural areas in the Netherlands should be mentioned in this regard.

The maximum momentary visit is to be measured for each type of project separately. The investigations must therefore be extended over many projects and many days since there is often a large fluctuation in this datum.

In Section 6.2 some attention was paid to layout criteria based upon investigations on two inland beaches. Insight was gained on the border effect, the relationship between walking distances and crowdedness and the distribution of recreationists over the project. Some formulae were constructed with which the area of sand beaches, swimming water, other elements and parking lots can be calculated. The final project, however, might have a layout with a total area which exceeds the sum of the calculated areas of the mentioned parts. This follows from the fact that the project often gives possibilities for other activities as for instance sailing (larger water surface), recreation of longer duration (campgrounds, etc.), walking (parks), nature experiences (nature preserves), etc. An overall formula in which these other functions are qualitatively included is mentioned. The area needed for the other functions should be determined additionally. When planning such a research it should taken into account that there is or can be some intercorrelation between inland beach recreation and other forms of outdoor recreation included in the project.

It is necessary to carry out repeated research to determine layout criteria since the relationships on which they depend show a great variancy from day to day as well as from project to project. Many factors influence human behaviour on the projects as for instance weather conditions, type of day, crowdedness and properties of the project. This makes it necessary to investigate each type of project in a specific way. It is to be expected that the behaviour on the different elements will change in the future, making it desirable to repeat such research within a certain period of time. It should be mentioned that the formula for the calculation of the planning capacity of parking lots is based on the assumption that there is a link between the overall planning capacity and the one for certain elements of the project.

7 Application

7.1 Project

Since the use models fit non-free entrance inland beaches with a high accommodation level best, a really planned project of this type was chosen to give an example of the determination of planning capacity and layout of a new inland beach in the Netherlands. The chosen project is to be situated in the central part of the country. In this project, which is now under construction, a large artificial lake will be made bordered by beaches, playgrounds, parks and woods, together with the necessary roads, parking lots, etc.

7.2 Planning capacity

7.2.1 Number of visits per day

Because of the strong similarity of the planned project with the existing project Beekse Bergen the use models of that project were applied to estimate the number of visits per day. This was done for 7 different days belonging to different day-groups, as the use models for Beekse Bergen are valid for these days. For the calculation a sphere of influence (90%-boundary) was chosen of 34 km for all days, while as data for the different variables (P, E, B, D_r, A_{c1} and A_{c2}) known data for 1970 of the area in which the new project is planned were used. This year was chosen because of the easy availability of the data in this example. In actuality the variables should be estimated for, for instance, 1985. The results of the calculations with the use models (see eq. 46 and table 22, Beekse Bergen) are given in table 35.

From this table it can be seen that on a peak day (day-group 7) about 17000 people would visit the project. When knowing the frequency of the in table 35 given estimated visits, it is possible to estimate the curve of exceedance.

7.2.2 Frequency of visits per day

The project is situated near climatological station 275 (Deelen). In table 36 the frequency of the weather values in the normative year are given for each day-group. The frequency of exceedance per day-group can now be calculated for the normative year (see table 37). For instance for day-group 1 (Sunday in early season, see table 15): take the α and γ for this group in table 22 for Beekse Bergen, apply in eq. (46) and

Table 35. Number of visits for 7 days (each in a different day-group) to a new inland beach, estimated by means of use models (eq. 46 and table 22).

Day-group (see table 15)	Sphere of influence (km)	No. of origins	Visits from within 34 km (V_{90}=90% of total)	Total visits ($1.11 V_{90}$)
1	34	29	13071	14509
2	34	29	6934	7697
4	34	29	8228	9134
6	34	29	9620	10678
7	34	29	15462	17163
8	34	29	4521	5018
9	34	29	6028	6691

calculate number of visits (13071 giving a total visit of 14509, see table 35). Find in table 22 the W-value from regional model for day-group 1 (=3.85) and transform this value by means of table 29 into a W-value for the general model (=1.61), see table 37. Now find the frequencies of all W-values equal to or exceeding 1.61 in table 36 (0.8; 0.4; 0.2; 0.1; 0.1) giving as frequency of exceedance the sum of 1.6, see table 37.

The highest estimated number of visits (peak day) will, on the average, occur only about once in two years (frequency of exceedance 0.4). It must be mentioned that this was calculated from data of only four years of investigation on existing inland beaches, so it is possible that this visit will be incidentally exceeded.

7.2.3 Normative number of visits

The normative number of visits can easily be found if the curve of exceedance, the normative day and the maximum momentary visit on this day is known (see Section 6.1.2). This curve can be constructed if the visits on all days (or at least the 25 most crowded ones) for the normative year are known. Since in our example only 7 use models are available (each day requires a model) a special procedure will now have to be followed to construct the curve of exceedance. From the data on visits per day for most inland beaches investigated it was determined to what day-groups the first 10 most crowded days mostly belong and in what order they occur. Furthermore the ratio of visits per day on the 2nd through the 25th most crowded day with those on the first most crowded day (peak day) was calculated as an average for these projects as given in table 30. With these ratios the number of visits for the 10 most crowded days as well as their frequencies of exceedance are now determined, as given in table 38.

From the number of visits per day it is clear that from the day-groups Sundays in industrial holidays, in the main season and in the early season are the most crowded days, followed by workdays in the main season and in the industrial holidays. The curve of exceedance is now constructed from the values in table 38, as given in fig. 28.

Table 36. Frequency of W-values on station 275 (Deelen) as calculated with the given multiplication factor from the values given in table 28 for the normative year and per day-group. Example: day-group 1 = Sunday in early season; 4 Sundays in the 30-day early season; this given over 20 years in table 28; the frequencies in table 28 to be multiplied by 1/150.

Day-group (see table 15)	Multiplication factor	W-values									
		⩽1.4	1.5–2.4	2.5–3.4	3.5–4.4	4.5–5.4	5.5–6.4	6.5–7.4	7.5–8.4	8.5–9.4	9.5
1	(4/30×1/20)=1/150	1.1	0.8	0.4	0.2	0.1	0.0	0.1			0.0
2	(4/30×1/20)=1/150	1.1	0.8	0.4	0.2	0.1	0.0	0.1			0.0
3	(22/30×1/20)=11/300	5.9	4.2	2.1	1.2	0.4	0.2	0.3			0.1
4	(5/60×1/20)=1/240	1.7	1.4	0.5	0.3	0.2	0.1	0.0	0.1	0.0	0.1
5	(5/60 ×1/20)=1/240	1.7	1.4	0.5	0.3	0.2	0.1	0.0	0.1	0.0	0.1
6	(34/60×1/20)=17/600	11.7	9.7	3.2	2.4	1.2	1.2	0.2	0.5	0.2	0.4
7	(3/60 ×1/20)=1/400	1.0	0.9	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
8	(3/60 ×1/20)=1/400	1.0	0.9	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
9	(10/60×1/20)=1/120	3.4	2.9	0.9	0.7	0.4	0.2	0.1	0.1	0.1	0.1
10	(4/30 ×1/20)=1/150	1.7	1.0	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0
11	(4/30 ×1/20)=1/150	1.7	1.0	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0
12	(22/30×1/20)=11/300	9.1	5.4	2.1	1.6	0.8	0.4	0.3	0.1	0.1	0.2

Table 37. Number of days on which a certain number of visits per day in a certain day-group is reached or exceeded in the normative year, as determined from table 28.

Day-group (see table 15)	Number of visits per day	W-value		Frequency of exceedance (number of days)
		regional model (see table 22)	general model (via table 29)	
1	14509	3.85	1.61	1.6
2	7697	7.17	3.10	2.2
4	9134	3.75	2.92	1.3
6	10678	7.73	4.50	3.7
7	17163	6.16	4.24	0.4
8	5018	12.60	7.27	0.4
9	6691	6.55	3.10	2.6

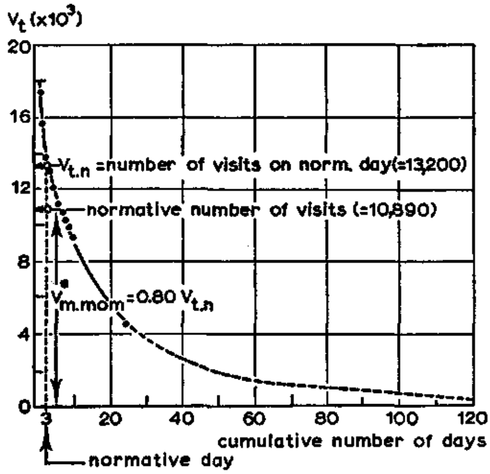

Fig. 28. Planning capacity (=normative number of visits) of a new inland beach as determined by means of the calculated curve of exceedance, the normative day and the maximum momentary visit on this day $V^*_{m.mom}$ (see also fig. 23).

With the maximum momentary visit in per cent of the visit on the normative day (table 32) the normative number of visits (the planning capacity) is finally found.

Table 38. The 10 most crowded days, the day-groups to which they mostly belong, the visits per day in per cent of those on the most crowded day, the number of visits per day and their frequency of exceedance for the new inland beach.

Sequence of most crowded days	Day-group (see table 15)	Visits per day in % of visits on peak day (see table 30)	Number of visits per day to inland beach (see table 37)	Frequency of exceedance (see table 37)
1	7	100	17163	0.4
2	4	90	15447	1.4
3	1	80	13730	2.4
4	9	75	12872	3.4
5	6	70	12014	4.4
6	9	65	11156	5.4
7	9	62.5	10727	6.4
8	9	60	10298	7.4
9	6	57.5	9869	8.4
10	9	55	9440	9.4

7.3 Layout

7.3.1 General

When the normative number of visits is known (see Section 7.2.3), which is the planning capacity of the total project, this value should be translated into areas needed for the main parts of the project. This can be done in several ways, see for instance Scholte Ubing (1969) with regard to beaches and swimming water or van Duin (1971) for sports fields. In this section the areas needed for beaches, water for swimming, other elements (playing fields, etc.) and parking lots will be determined for the project discussed in Section 7.1 and 7.2 with the general formulae given in Section 6.2.3.

7.3.2 Areas of elements

The area needed for *beaches* can be calculated by means of the following formula:

$$F_s = y_s(s_1 m_{s1} + s_2 m_{s2}) V^*_{m.mom} \qquad (81)$$

where

F_s = net area of sand beaches in m^2
y_s = number of visitors on sand beaches in % of $V^*_{m.mom}$
s_1 = fraction of beach visitors on crowded beach area
m_{s1} = average area per visitor on crowded beach area in m^2
s_2 = fraction of beach visitors on quiet beach area
m_{s2} = average area per visitor on quiet beach area in m^2
$V^*_{m.mom}$ = maximum momentary visit on normative day

With $y_s=0.62$ (see fig. 27a), estimating s_1 at 0.75 and s_2 at 0.25, $m_{s1}=5$ and $m_{s2}=50$ (both as average values taken from fig. 26) and $V^*_{m.mom}=10890$ (see fig. 28) this gives:

$$F_s = 109716\, m^2 = 10.97\, ha \cong 11\, ha$$

The area needed for *swimming water* (sailing, etc. not taken into account) can be calculated by means of:

$$F_w = y_w(w_1 m_{w1} + w_2 m_{w2})\, V^*_{m.mom} \qquad (82)$$

where

F_w = net area of swimming water in m^2

y_w = number of visitors in swimming water in % of $V^*_{m.mom}$

w_1 = fraction of swimmers in crowded swimming water

m_{w1} = average area per swimmer in crowded swimming water in m^2

w_2 = fraction of swimmers in quiet swimming water

m_{w2} = average area per swimmer in quiet swimming water in m^2

With $y_w=0.16$ (see fig. 27a), estimating w_1 at 0.75 and w_2 at 0.25, $m_{w1}=20$ and $m_{w2} = 100$ (both as average values taken from fig. 26) and $V^*_{m.mom}=10890$ (see fig. 28), this becomes:

$$F_w = 69696\,\mathrm{m}^2 = 6.97\,\mathrm{ha} \cong 7\,\mathrm{ha}$$

The *other elements* (playing fields, etc.) need an area, which can be determined by means of eq. (76):

$$F_e = y_e m_e V^*_{m.mom}$$

where

F_e = net area of other elements in m^2

y_e = number of visitors on other elements in % of $V^*_{m.mom}$

m_e = average area per visitor on other elements in m^2

Using $y_e=0.22$ (see fig. 27a), $m_e=20$ (average value taken from fig. 26) and $V^*_{m.mom}=$ $=10890$ (see fig. 28) this gives:

$$F_e = 47916\,\mathrm{m}^2 = 4.79\,\mathrm{ha} \cong 5\,\mathrm{ha}$$

The needed gross surface of *parking lots* can be calculated by using eq. (79):

$$F_p = m_p \mu \alpha \beta \eta^{-1} \delta V_{t.p}$$

where

F_p = gross area of total parking space in m^2

m_p = net area per parked car in m^2

μ = ratio between gross and net area per parking lot

α = $V^*_{m.mom}$ in % of $V_{t.n}$

β = number of visits by car as fraction of number of visits on normative day

η = mean number of visitors travelling in one car on normative day

δ = number of visits on normative day as fraction of number of visits on peak day = $V_{t.n}/V_{t.p}$

$V_{t.p}$ = total number of visits on peak day

When taking $m_p = 20$ and $\mu = 2$; and with $\alpha = 0.75$, $\beta = 0.8$, $\eta = 4.0$ and $\delta = 0.8$ (taken from table 34 for non-free entrance projects) and $V_{t.p} = 17163$ (see table 38) this gives:

$$F_p = 823824 \text{ m}^2 = 8.24 \text{ ha} \cong 8.5 \text{ ha}$$

The *total area* needed to accommodate the normative number of inland beach recreationists on the project discussed is (see eq. 80):

$$F_{ib} = F_s + F_w + F_e + F_p + F_f$$

where

F_f = area needed for additional non-specified functions in m^2 (left to the ideas of the designer)

Excluding F_f, this gives:

$$F_{ib} = 11 + 7 + 5 + 8.5 = 31.5 \text{ ha}$$

to be considered as the minimum area of the project.

7.4 Discussion

An application is given of the determination of the planning capacity of a new inland beach in which both use models as well as the calculated frequency of weather values (based on weather models) is used. Although the number of visits on, for instance, the first 20 most crowded days cannot be calculated directly from the use models it is possible to estimate the curve of exceedance of visits per day in the normative year by using the ratios (as an average of several inland beaches over many years) of the number of visits for their 10 most crowded days and their peak day visits. From this curve the number of visits on the 3rd most crowded day was found, as well as the normative number of visits.

To apply the system elaborated in this study in other countries or for other kinds of outdoor recreation it is necessary to carry out a survey, similar to the one described in this study, with which origin data, weather data and data on number of visits for each day and over a longer period of time are obtained.

The translation of the calculated planning capacity was done by means of the layout formulae developed in Section 6.2.3. In this way the needed areas for sand beaches, swimming water, other elements (playing fields, etc.) and parking lots can be calculated if the various coefficients are known, which here was the case. This calculation method is also usable in other countries and for other kinds of outdoor recreation, although the coefficients then have to be determined by means of field surveys. In this context, more research with regard to layout criteria of outdoor recreation projects in non-urban areas is needed.

Although the relationships and data found will not be valid forever, when used and interpreted properly they can be of good use in planning new inland beaches in the Netherlands during the coming decades. The system in general, as developed in this study, can be an aid when planning various types of outdoor recreation projects in the Netherlands as well as elsewhere.

Summary

In most highly industrialized countries the demand for outdoor recreation provisions in non-urban areas increases. When meeting this demand by the construction of new recreation projects, problems arise concerning location, planning capacity and layout. This study deals with the determination of planning capacity and layout. Special attention is paid to inland beaches in the Netherlands.

An outdoor recreation project is considered to be area limited, to be situated in non-urban areas and having a layout enabling visitors to perform one or more forms of outdoor recreation. The planning capacity is the maximum number of visits the project should be able to accommodate at any given moment.

Visits to outdoor recreation projects are influenced by many factors. Therefore two types of models are constructed with which, when used in connection with each other, the normative number of visits can be predicted for a new project. The first model, the use model, gives the relationship per origin between the number of visits, and the supply and socio-economic factors. The second model, the weather model, gives the relationship between number of visits per day and meteorological factors per certain type of day (day-groups). The purpose of the use model is to predict the level of the number of visits, while the weather model has to predict the frequency of this number. The scheme given in fig. 2 shows this.

In Chapter 1 are furthermore given the descriptions and definitions of the terms recreation, outdoor recreation, need, demand, use, outdoor recreation project and planning capacity as used in this study. The general problem dealt with is described as follows: in what way can the planning capacity and layout of a future outdoor recreation project for day recreation in non-urban areas be determined.

In Chapter 2 a conspectus is given of some types of models developed with regard to the determination of the demand for outdoor recreation or similar phenomena such as visits to projects, the relation between visit and weather and outdoor recreational traffic. After describing possible distinctions in models, attention is paid to demand, use, gravity and weather models. The demand for outdoor recreation can be divided into demand in the meaning of potential or latent behaviour and demand in the meaning of actual or existing behaviour. In this study with demand is meant the outdoor recreational behaviour as a total or with regard to a special form, while with use is meant human behaviour with regard to a certain type of outdoor recreation projects or to one specific project. Facing the fact that several factors influence demand, different levels of demand can be distinguished, as shown in fig. 4. A general demand

model is given in eq. (1).

On the use of (visit to) a certain project several factors have an impact as: supply, socio-economic, technical and psychological factors (see figs. 5 and 6). Attention is paid to the supply and socio-economic variables. For the supply factors, properties of the project itself as well as of the competitive projects are generally used. Population is the most important socio-economic factor, but also other variables as income, mobility, free time, education, profession, level of urbanism and population density play their role. Technical and psychological factors cannot be given in a quantitative way. A general use model is given in eq. (2).

Gravity models concern the prediction of recreational traffic from origin to site and are based on the gravity law of Newton (eq. 3). The models depend on three factors: an origin factor, a destination factor and a resistance factor. A general model is given in eq. (5). The sum of the interactions between all origins with one outdoor recreation project is an estimation of the total visit, as given in eq. (6).

The relationship between visits to outdoor recreation projects and weather, being important for the frequencies of numbers of visits per day, is not identical for different forms of outdoor recreation. Weather has a double influence on outdoor recreation, namely directly by the occurrence of certain desired weather conditions and indirectly via the impact on the area itself (nature, plant growth, etc.). In the weather relation the heat exchange processes of the human body with its environment plays an important role. Therefore the relationship can be given not only in a statistical way but also by means of the heat exchange of man. Important meteorological factors for outdoor recreation are: temperature, sunshine and/or cloudiness, wind velocity and global radiation. A general weather model is given in eq. (7).

The last part of Chapter 2 deals with the procedure to construct models (eq. 8 through 11) and with the regression analysis. In the analysis of the relationship of visits with socio-economic and supply factors (use model) or with meteorological factors (weather model) the stepwise regression procedure was followed.

In Chapter 3 the relationship between number of visits per origin to 12 inland beaches in the Netherlands and the supply and socio-economic factors per origin is studied for a number of research days by means of the above mentioned regression procedure. The outcome is a basis for the construction of use models for inland beaches (in Chapter 5). A general use model for inland beaches (eq. 13) and a definition of inland beaches are given.

The needed data were collected by means of:

- field surveys on 12 inland beaches and 50 research days giving 89 prd (project research-days, each being one day research on one project). Investigations were carried out with regard to number of visits, properties of the recreationists and the use of the different elements of the projects by the visitors;
- use of existing data: especially with regard to data of the origins.

The different variables for the regression analysis were divided into three groups, namely properties of the prd, visits per origin and supply and socio-economic variables (see table 2). The last group was subdivided into seven subgroups (population, distance, mobility, households, income, cultural pattern and alternative sites) of which derived variables were made. The analysis consists of four steps: the calculation of the distance-decay functions, a multiple regression analysis of all variables, the same with a limited number of variables and the setting and calibrating of the final use models.

For the determination of the number of visits per origin a special procedure was developed by means of samples fluctuating over time and stratum (type of vehicle) as given in the eqs. (21) through (24).

From the independent variables the number of inhabitants was corrected for incoming and outgoing vacationists, while the level of urbanism (see eq. 25 through 29) and area of origin were taken into account. The distance was expressed in road and air distance. Alternative sites inside as well as outside the origin were measured in two ways namely by means of a score and of a capacity (see eq. 30 through 35 and tables 7 through 11).

The distance-decay functions (table 12 and eqs. 38 and 39) show that the variancy in visits per origin for most days and projects is only partly explained by means of the variancy in distance and in population. The results of the regression analysis make clear that by the introduction of more variables the fit between observed and calculated values increases largely. It also shows that most of the socio-economic variables for inland beach recreation in the Netherlands do not give a significant explanation of the variancy in visits per origin. Useful factors for the construction of use models (as given in Chapter 5) are the number of inhabitants together with outgoing and incoming vacationists per origin (origin factor), the road distance (resistance factor) and the capacity of alternative outdoor recreation projects inside and outside the origin (supply factor).

In Chapter 4 the regression analysis of the relation between visits per day and weather is described for which three groups of variables are formed (see table 14), being the properties of the prd, the number of visits per day and the meteorological factors. The data were obtained from field surveys as well as from existing statistics. The analysis consists of four steps: a multiple regression with all variables, the same with selected variables and the setting and calibrating of a statistical and physical (heat exchange) weather model.

The dependent variable can be either a weather value given by recreationists or the number of visits per day. The last one was used for 4 projects over approximately 10 years. The independent variables can be either the meteorological data measured on the inland beaches or official data from climatological stations of the Royal Netherlands Meteorological Institute. There appeared to be a close relationship between both. The last mentioned data were used because they were available over a longer period of time. The potential for the number of visits per day is not constant over the whole season. Therefore the data on visits were subdivided over 12 day-groups, based on a division in Sundays, Saturdays and workdays as well as a division in early, main, late season and industrial holidays. When necessary trend corrections in the visits per day were applied (eq. 42 through 44).

Regarding the meteorological factors data were collected on temperature, relative humidity, rainfall, cloudiness, sunshine, wind velocity and global radiation, of which derived and combined variables were formed while also empirical functions were used as variables (see table 18 and 19).

The most important result of the regression analysis was that the variancy in the number of visits per day can to a large degree be explained from the variancy in the following factors: temperature, effective degree of cloudiness and/or sunshine, wind velocity, relative humidity and global radiation. The last two are less important because of their correlations with the other ones.

In Chapter 5 the final use and weather models for inland beaches in the Netherlands are presented.

For the use model several types were fitted as given in table 21 and eq. (46) and (47). During these calibrations it became clear that a distinction had to be made in free entrance and non-free entrance inland beaches. For both special models were fitted, as given in table 22 and fig. 13. It can be seen that the goodness of fit was high for the non-free entrance inland beaches, while it was somewhat lower for the other ones, which means that the predictive power of the first group of models is higher than that of the second group.

For the weather models two approaches were taken, namely a statistical one and a heat exchange one. The first one is based upon temperature, sunshine and/or cloudiness and wind velocity. Such weather models were fitted per day-group for 4 projects, giving 46 regional models (see eq. 51 and table 26), while a general model also was calibrated (eq. 50). With the aid of this last model a frequency analysis was carried out for 19 weather stations in the Netherlands over 20 years (1951 through 1970), as given in the figs. 17 through 19 and table 28. From this it can be seen that on the average the occurrence of good inland beach weather in the south-eastern part of the country is higher than in the north-western part.

The heat exchange model is based upon the expression of the radiation and convection in meteorological factors (eq. 52 through 66) being: temperature, wind velocity, sunshine, global radiation and relative humidity. For some day-groups and two inland beaches the heat exchanges were calculated per day and correlated with the weather values by means of three models (eqs. 67 through 69). Although the goodness of fit compared with those of the statistical models was somewhat lower (see table 27), the method has a sufficient reliability. Moreover, the relation is a physical one and therefore generally applicable.

In Chapter 6 the system (see fig. 23) for the determination of the planning capacity of an outdoor recreation project in general and of an inland beach in particular is described. Main point in this is the curve of exceedance of visits per day for the normative year (being the average of a number of years). The level of this curve can be calculated by means of the use models, while the frequency of visits per day can be determined with the weather models. The next step is the choice of the normative day, a certain day in the sequence of decreasingly crowded days, which choice can depend on several criteria as economic, social or technical ones. Since almost no research is done in this field the choice is fairly arbitrary. For inland beaches in the Netherlands the third most crowded day seems reasonable as a basis for the planning capacity. Finally, this capacity is found by taking the maximum momentary visit on the normative day.

In the last part of Chapter 6 some layout criteria for inland beaches are distilled from the behaviour of (use of the elements by) the recreationists. Insight is given in the border effect, the relation between walking distance and crowdedness (see fig. 26), and the distribution of the visitors over the elements (table 33 and fig. 27). Based on these data formulae were made for the calculation of the needed areas of sand beaches (eqs. 72 through 74), swimming water (eq. 75), other elements (eq. 76) and parking lots (eqs. 77 through 79).

In Chapter 7 an application has been given of the determination of the planning capacity as well as of the areas needed for the elements of a planned inland beach in the central part of the Netherlands.

Although the relationships in this study are time and place limited, making it necessary to repeat the surveys after some time and to carry out new surveys, it is to be expected that the found relationships and data, if used in a proper way, can be of good use in planning new inland beaches in the Netherlands within the next decades. The system in general can be an aid when planning various types of outdoor recreation projects in the Netherlands as well as elsewhere.

Samenvatting

Bepaling van ontwerpcapaciteit en ontwerpnormen van openluchtrecreatie-projecten

Het voldoen aan de groeiende vraag naar voorzieningen voor openluchtrecreatie op het platteland roept problemen op ten aanzien van plaatsbepaling, ontwerpcapaciteit en inrichting van deze voorzieningen. De onderhavige studie heeft tot doel een oplossing te bieden voor de twee laatstgenoemde problemen en wel met name voor strandbadprojecten in Nederland. Aansluitend aan theoretische oplossingen wordt met een voorbeeld de toepassing van de ontwikkelde methoden verduidelijkt.

Als een openluchtrecreatie-object wordt beschouwd een in oppervlakte begrensd gebied gelegen op het platteland, zodanig ingericht dat de mogelijkheid bestaat één of meerdere vormen van openluchtrecreatie te bedrijven. Onder ontwerpcapaciteit wordt verstaan het maximale aantal bezoekers dat het project moet kunnen opvangen en waarop de verschillende elementen moeten worden afgestemd.

Aangezien het bezoek aan objecten voor openluchtrecreatie beïnvloed wordt door vele factoren, is getracht een tweetal modellen te construeren. Met behulp van deze modellen tezamen is het mogelijk een schatting te geven van het maatgevende aantal bezoekers aan een te stichten object. Het eerste model, een gebruiksmodel, geeft de relatie tussen het aantal bezoekers van een bepaald herkomstgebied naar een object enerzijds en de aanbodsfactoren (bereikbaarheid, wegafstanden, alternatieve recreatie-objecten, enz.) en sociaal-economische factoren (inkomen, hoeveelheid vrije tijd, autobezit, godsdienst, enz.) anderzijds. Het tweede model, een weermodel, geeft de relatie tussen het totale dagbezoek enerzijds en meteorologische factoren (temperatuur, zonneschijn, windsnelheid, globale straling, enz.) in afhankelijkheid van de daggroep (deel van het seizoen en dag van de week) anderzijds. Het doel van het gebruiksmodel is het niveau van het bezoekersaantal te voorspellen, terwijl het weermodel de frequentie van dat aantal moet bepalen. In fig. 2 wordt dit schematisch weergegeven, waarbij tevens de methode voor het bepalen van het maatgevende bezoek met behulp van de overschrijdingscurve (te berekenen met beide genoemde modellen) en het maximale momentane bezoek (het maximale aantal bezoekers dat op een bepaald moment aanwezig is) wordt aangeduid.

In hoofdstuk 1 worden verder nog omschrijvingen en definities gegeven van de termen recreatie, openluchtrecreatie, behoefte, vraag, gebruik, openluchtrecreatie-object en ontwerpcapaciteit. De algemene probleemstelling die in deze studie wordt behandeld, wordt dan als volgt omschreven: op welke manier kan de ontwerpcapaciteit en de inrichting van een openluchtrecreatieproject voor dagrecreatie in plattelandsgebieden worden bepaald.

In hoofdstuk 2 wordt een overzicht gegeven van een aantal typen modellen die ontwikkeld zijn voor de bepaling van de vraag naar openluchtrecreatie, dan wel van de daarmee samenhangende verschijnselen zoals: het bezoek aan concrete objecten, de relatie tussen bezoek en aard van het weer en het openluchtrecreatieverkeer. Na een beschrijving van verschillende indelingen die mogelijk zijn bij typering van modellen, wordt aandacht besteed aan voorspellingsmodellen in de openluchtrecreatie waarvan achtereenvolgens behandeld worden vraagmodellen, gebruiksmodellen, zwaartekrachtsmodellen en weermodellen.

Bij de vraag naar openluchtrecreatie wordt onderscheid gemaakt naar vraag in de betekenis van potentieel of latent gedrag en vraag in de betekenis van werkelijk of bestaand gedrag. In deze studie wordt met vraag bedoeld het gedrag op het gebied van openluchtrecreatie in zijn totaliteit of met betrekking tot een speciale vorm van openluchtrecreatie, terwijl met gebruik wordt bedoeld het gedrag van de mens met betrekking tot een bepaald type openluchtrecreatie-object of tot een specifiek object. Verschillende factoren beïnvloeden de vraag en daarin kunnen verschillende niveaus worden onderscheiden, zoals is gegeven in fig. 4.

Een vraagmodel is gedefinieerd als een model dat de statistische relatie weergeeft tussen de deelname aan een openluchtrecreatie-activiteit (of een samenvoeging van activiteiten) als de afhankelijke variabele en factoren die deze deelname beïnvloeden als de onafhankelijke variabelen (zie verg. (1)).

Op het bezoek aan een bepaald object, en dus het gebruik, zijn eveneens verschillende factoren van invloed, die in drie groepen zijn onderscheiden, namelijk de aanbodsfactoren, de sociaal-economische factoren en de technologische en psychologische factoren (zie de fig. 5 en 6). Aandacht wordt besteed aan de twee eerste groepen. In de literatuur worden ten aanzien van de aanbodssituatie de eigenschappen van het object zelf zowel als die van concurrerende objecten in beschouwing genomen. Ook de bereikbaarheid van het betreffende object zowel als van de concurrerende objecten is bestudeerd. Bij dit laatste speelt vooral de afstand, maar ook de kwaliteit van de weg, de drukte, verkeerscongesties, enz. een rol. Van de sociaal-economische factoren is het inwoneraantal van de herkomstgebieden de meest belangrijke, maar daarnaast worden in de literatuur tevens variabelen als inkomen, vrije tijd, autobezit, opleiding, beroep, urbanisatiegraad, bevolkingsdichtheid, enz. in de gebruiksmodellen ingevoerd. Ten aanzien van de technologische en psychologische factoren kan worden gezegd dat nog geen gebruiksstudies, waarin deze factoren kwantitatief in beschouwing zijn genomen, bekend zijn. Een gebruiksmodel is gedefinieerd als de statistische relatie van het aantal bezoekers per herkomstgebied op een bepaalde dag aan een bepaald openluchtrecreatie-object met een combinatie van aanbodsfactoren in het recreatiegebied en sociaal-economische factoren van de bevolking in het betreffende herkomstgebied (zie verg. (2)).

Zwaartekrachtmodellen zijn er vooral op gericht het recreatieverkeer van een bepaald herkomstgebied naar een openluchtrecreatie-object te voorspellen en zijn afgeleid van de zwaartekrachtswet van Newton (verg. (3)). Het meer algemene model is gegeven in verg. (5). Aangezien het totale bezoek aan een bepaald object gelijk is aan de som van de afzonderlijke verkeersstromen naar het object is dit te bepalen door middel van een somformule zoals gegeven in verg. (6). In het model worden een herkomstfactor (bevolking, sociaal-economische factoren), een bestemmingsfactor (capaciteit en soort object) en een weerstandsfactor (afstand, reistijd) onderscheiden.

De relatie tussen het bezoek aan openluchtrecreatie-objecten en het weer is vooral belangrijk met het oog op de frequentie waarmee bepaalde bezoekersaantallen optreden. De weerrelatie is niet identiek voor verschillende vormen van openluchtrecreatie. De invloed van het weer is tweezijdig, namelijk direct door de kans van voorkomen van bepaalde wenselijke weersomstandigheden en indirect via de invloed op de streek zelf (natuur, plantengroei, bebouwing, welvaart, enz.). De relatie tussen bezoek en weer berust voor een aantal vormen van openluchtrecreatie (zwemmen, zonnen, enz.) op het warmte-uitwisselingsproces van het menselijk lichaam met zijn omgeving en kan via dit proces worden opgespoord, maar kan ook op statistische wijze worden bepaald. In de literatuur worden als meest belangrijke meteorologische factoren die van invloed zijn op de bezoek-weer relatie beschouwd: temperatuur, zonneschijn, bedekkingsgraad, windsnelheid en globale straling. Het weermodel is in deze studie gedefinieerd als de relatie tussen het dagbezoek aan openluchtrecreatie-objecten, uitgedrukt in weerwaarden, en een (of een aantal) meteorologische element(en) bij constante menselijke-, (sociaal-economische) en gebieds- (geografische) eigenschappen (zie verg. (7)).

In het laatste deel van hoofdstuk 2 wordt stilgestaan bij de constructie van modellen (zie verg. (8) t/m (11)) en bij de gevolgde regressie-analyse methode. Bij de bepaling van de relatie tussen het bezoek per herkomstgebied en de dit bezoek beïnvloedende gebieds- en sociaal-economische factoren zowel als bij die tussen het dagbezoek en meteorologische factoren, is de 'stepwise regression procedure' gevolgd.

In hoofdstuk 3 wordt de relatie tussen het bezoek per herkomstgebied aan een twaalftal strandbaden in Nederland en aanbods- en sociaal-economische factoren per herkomstgebied nader voor een aantal onderzoekdagen onderzocht door middel van de bovengenoemde regressie-analyse. De bevindingen hiervan dienen als basis voor de constructie van strandbadgebruiksmodellen die de statistische relatie weergeven van het aantal bezoekers per herkomstgebied op een bepaalde dag aan een bestaand strandbad met een combinatie van aanbodsfactoren in de regio en sociaal-economische factoren van de bevolking van hetzelfde herkomstgebied. Strandbaden in Nederland kunnen worden omschreven als openluchtrecreatie-objecten bestaande uit zand- of grasstranden en een zoetwaterplas met een wateroppervlakte die varieert van 1 tot 100 ha, verder omvattend speel- en ligweiden en andere accommodatie (variërend van eenvoudig tot uitgebreid), meestal gelegen in plattelandsgebieden.

De gegevens nodig voor de bestudering van bovengenoemde relatie, zijn verzameld:

- door middel van veldwaarnemingen, waarbij op 12 strandbaden in Nederland gedurende 50 onderzoekdagen waarnemingen werden uitgevoerd, die in totaal 89 objectonderzoekdagen (1 objectonderzoekdag is een onderzoek op 1 dag en 1 object) ople-

verden. Gegevens werden verzameld o.a. omtrent het aantal bezoekers (tellingen), herkomst van de bezoekers (enquêtes) en de bezetting van de elementen (luchtfotokarteringen);
- uit bestaande gegevens betreffende de herkomstgebieden.

De regressie-analyse is opgezet zoals is gegeven in tabel 2, waarin de variabelen zijn verdeeld in drie hoofdgroepen, namelijk de eigenschappen van de objectonderzoekdagen (algemene gegevens), het bezoek per herkomstgebied (afhankelijke variabele) en aanbods- en sociaal-economische factoren (als onafhankelijke variabelen). Deze laatste groep is verder onderverdeeld in zeven subgroepen, bestaande uit bevolking, afstand, autobezit, aantal huishoudingen, inkomen, cultuurpatroon (opleiding en godsdienst) en concurrerende objecten. Van elk van deze basisvariabelen werden afgeleide variabelen gemaakt, meestal bestaande uit transformaties van de oorspronkelijke varibele.

De analyse bestaat uit 4 stappen, namelijk: de berekening van de afstandsfuncties; de meervoudige regressie-analyse met alle variabelen en, op basis daarvan, de selectie van de belangrijkste variabelen; voor alle onderzoekdagen en objecten de meervoudige regressie-analyse gebaseerd op het beperkte aantal variabelen (tabellen 3 en 4) en het opzetten en calibreren van de uiteindelijke gebruiksmodellen (hoofdstuk 5).

Het aantal bezoekers per herkomstgebied is berekend door gebruik te maken van een speciale steekproefmethode. Hierbij werd de steekproef per tijdseenheid (uur) en per stratum (voertuigcategorie) genomen, waarna de zo gevonden steekproefwaarden werden vermenigvuldigd met een vermenigvuldigingsfactor die gelijk is aan het quotiënt van de totale populatie (van de tellingen) en de steekproefpopulatie (uit de enquêtes), beiden per tijdseenheid en stratum (zie verg. (21) t/m (24)). De methode heeft het voordeel dat met een vast aantal enquêteurs kon worden gewerkt in een gelijkmatig tempo.

Van de onafhankelijke variabelen werd de bevolking gecorrigeerd voor inkomende verblijfsrecreanten van elders en voor dat deel van de eigen bevolking dat elders op vakantie is. Daarnaast werden in beschouwing genomen de urbanisatiegraad en de oppervlakte van het herkomstgebied. Voor de urbanisatiegraad werd een speciaal verband afgeleid als gegeven in verg. (25) t/m (29). De afstand werd uitgedrukt in de wegafstand over de meest waarschijnlijke route en in de hemelsbrede afstand. De concurrerende objecten zowel binnen als buiten het herkomstgebied werden op twee manieren gewaardeerd, namelijk door middel van een score en een capaciteit (zie o.a. verg. (30) t/m (35) en tabel 7 t/m 11).

De resultaten van de berekeningen van de afstandsfuncties (tabel 12 en verg. (38) en (39)) laten zien dat de variantie in bezoek per herkomstgebied van een aantal objecten, voor de meeste dagen slechts ten dele kan worden verklaard uit variantie in afstand en in bevolking. De resultaten van de regressie-analyse tonen aan dat door introductie van meer factoren de aansluiting tussen gemeten en berekende waarden veel beter wordt. Tevens wordt duidelijk dat een groot aantal sociaal-economische factoren voor de Nederlandse omstandigheden en deze vorm van openluchtrecreatie geen significante verklaring van de variantie in bezoek per herkomstgebied geven. Als bruikbare factoren voor de constructie van gebruiksmodellen (zoals gegeven in hoofdstuk 5) blijven over: het aantal inwoners tezamen met het aantal uitgaande en inkomende vakantiegangers per herkomstgebied (herkomstfactor), de wegafstand (weerstandsfactor) en de capaciteit van concurrerende objecten binnen en buiten het herkomstgebied (aanbodsfactor).

In hoofdstuk 4 wordt de regressie-analyse van de relatie tussen dagbezoek en weer beschreven, die als basis voor de constructie van weermodellen moet dienen. Een weermodel voor strandbaden geeft de relatie van het aantal bezoekers per dag aan een strandbad, uitgedrukt in weerwaarden met een (of een aantal) meteorologische factor(en) bij constante menselijke- (sociaal-economische) en gebieds- (geografische) eigenschappen.

De analyse van de relatie tussen bezoek en weer is gelijksoortig aan die van de relatie tussen bezoek en sociaal-economische en gebiedseigenschappen, namelijk een meervoudige regressie-analyse zowel met alle variabelen als met een geselecteerd aantal. Op basis hiervan werden statistische weermodellen afgeleid. Daarnaast werd een fysisch weermodel gebaseerd op het warmte-uitwisselingsproces van het menselijk lichaam met de atmosfeer. Voor de regressie-analyse zijn een drietal groepen onderscheiden (tabel 14), zoals de eigenschappen van de objectonderzoekdagen (algemene gegevens), de dagbezoekcijfers (als afhankelijke variabele) en meteorologische factoren (als onafhankelijke variabelen). De gegevens werden verzameld deels via veldwerk, deels door gebruik te maken van bestaande gegevens.

Als afhankelijke variabele kan een weercijfer, door de recreanten aan het weer toegekend, dienen of het dagbezoekcijfer zelf. Aangezien uit het enquêtemateriaal bleek dat de variantie in weercijfers voor dezelfde weersomstandigheden te groot was, werden de dagbezoekcijfers van 4 objecten over ongeveer tien jaar als maatstaf voor de weerwaardering gekozen. Als onafhankelijke variabelen kunnen meteorologische gegevens van het object zelf dan wel van nabijgelegen weerstations van het KNMI worden gebruikt. Aangezien de eersten een nauwe aansluiting met de laatsten vertoonden, werden de gegevens van de officiële weerstations gebruikt; temeer daar meerjarige gegevens hiervan beschikbaar zijn. Aangezien het potentieel voor het dagbezoek niet constant is voor het gehele seizoen is het nodig de dagbezoekcijfers te verdelen over 12 daggroepen, gebaseerd op een indeling in zondagen, zaterdagen en werkdagen en op een indeling in voor-, hoog- en naseizoen en bouwvakvakanties. Indien nodig is tenslotte nog een trendcorrectie op de dagbezoekcijfers (zie verg. (42) t/m (44)) toegepast.

Wat betreft de meteorologische factoren werden gegevens verzameld over temperatuur, relatieve vochtigheid, neerslag, bedekkingsgraad, zonneschijn, windsnelheid en globale straling. Hiervan werden een aantal afgeleide variabelen ingevoerd, terwijl daarnaast combinaties en empirische functies werden gebruikt (zie tabel 18 en 19).

Het belangrijkste resultaat van de regressie-analyse is dat de variantie in dagbezoekcijfers voor een zeer groot deel kan worden verklaard uit de variantie in de volgende factoren: temperatuur, effectieve bedekkingsgraad en/of zonneschijn, windsnelheid, relatieve vochtigheid en globale straling. De laatste twee zijn echter minder belangrijk, mede gezien hun correlatie met de andere factoren.

In hoofdstuk 5 worden de uiteindelijke gebruiksmodellen zowel als de weermodellen geldig voor strandbadrecreatie in Nederland gepresenteerd.

Voor het gebruiksmodel zijn diverse vormen gecalibreerd welke zijn gegeven in tabel 21 en de verg. (46) en (47). Het bleek bij de uiteindelijke berekeningen nog nodig een verder onderscheid te maken in vrij toegankelijke strandbaden met een laag accommodatieniveau en in niet-vrij toegankelijke strandbaden met een hoog accommodatieniveau. Voor beiden werd een apart model aangepast, zoals is gegeven in tabel 22 en in fig. 13. Het blijkt dat de aansluiting van de gebruiksmodellen voor de niet-vrij toegankelijke baden hoog is, terwijl die voor de andere strandbaden over het algemeen enigszins lager ligt. De voorspellende waarde van de eerste groep is groter dan die van de tweede.

Voor de weermodellen zijn twee benaderingen uitgevoerd, namelijk een statistische en een via de warmte-uitwisseling. Het statistische model is gebaseerd op temperatuur, zonneschijn of bedekkingsgraad en windsnelheid. Dit model is per daggroep aangepast voor 4 projecten, hetgeen in totaal 46 regionale modellen opleverde, bovendien werd een algemeen model aangepast (verg. (50)). Met behulp van dit model is een frequentieanalyse uitgevoerd voor 19 Nederlandse weerstations over 20 jaar (periode 1951 t/m 1970), zoals gegeven in de figuren 17 t/m 19 en tabel 28. Deze laten zien dat gemiddeld genomen in het zuidoosten van het land de kans op goed strandbadweer groter is dan in het noordwesten.

Het warmte-uitwisselingsmodel is gebaseerd op het uitdrukken van de warmte-uitwisseling van het menselijk lichaam met de atmosfeer, via straling en stroming, in meteorologische factoren (verg. (52) t/m (66)): temperatuur, windsnelheid, zonneschijn, globale straling en relatieve vochtigheid. Voor enkele daggroepen en twee strandbaden werd de warmte-uitwisseling per dag berekend en de zo gevonden waarden gerelateerd aan de weercijfers (als getransformeerde waarden in een schaal van 0 tot 10 bepaald uit de bezoekcijfers) door middel van een drietal modellen (verg. (67) t/m (69)). Alhoewel bleek dat de aansluitingen iets minder goed dan die van de statistische modellen waren (tabel 27), heeft de methode voldoende betrouwbaarheid temeer daar ze fysisch van opbouw is en daardoor meer algemeen geldig.

In hoofdstuk 6 tenslotte, wordt het systeem (fig. 23) beschreven voor de bepaling van de ontwerpcapaciteit van een nieuw aan te leggen openluchtrecreatie-object in het algemeen, en van een strandbad in het bijzonder. Uitgangspunt daarbij is de overschrijdingscurve van het dagbezoek aan het object voor het maatgevende jaar (te beschouwen als een gemiddelde van een aantal jaren), waarbij het niveau van elk punt op de curve berekend kan worden met de gebruiksmodellen, terwijl de overschrijdingsfrequentie ervan met de weermodellen kan worden berekend. De volgende stap is de keuze van de maatgevende dag (een bepaalde dag in de volgorde van afnemend drukste dagen). Deze keuze kan afhankelijk zijn van diverse criteria, zoals economische, sociale en technische considerata. Aangezien hierover nog weinig studie is verricht worden in de praktijk voor verschillende typen openluchtrecreatie-objecten arbitraire keuzen gedaan met betrekking tot de maatgevende dag. Voor strandbaden lijkt de derde drukste dag een redelijk uitgangspunt voor de ontwerpcapaciteit. Om deze laatste te kunnen bepalen is kennis nodig omtrent het maximale momentane bezoek (het aantal bezoekers dat maximaal op een bepaald moment van de dag aanwezig is).

In het laatste deel van het hoofdstuk wordt tenslotte enige aandacht besteed aan inrichtingscriteria voor strandbaden. Deze zijn af te leiden uit het gedrag van (gebruik van diverse onderdelen door) recreanten. Enig inzicht wordt verschaft in het randeffect, de relatie tussen loopafstand en bezetting (fig. 26) en de verdeling van de recreanten over de diverse onderdelen (tabel 33 en fig. 27). Gebaseerd op deze gegevens worden formules afgeleid voor de berekening van de gewenste oppervlakten aan zandstranden (verg. (72) t/m (74)), zwemwater (verg. (75)), andere elementen (verg. (76)) en parkeerterreinen (verg. (77) t/m (79)).

In hoofdstuk 7 wordt een toepassing gegeven van zowel de berekening van de ontwerpcapaciteit als de benodigde oppervlakten van onderdelen van een geprojecteerd strandbad in midden-Nederland.

Ofschoon de in de studie gevonden relaties tijds- en plaatsafhankelijk zijn en daarmee de noodzaak bestaat het onderzoek na een bepaalde tijd te herhalen dan wel een nieuw onderzoek uit te voeren, mag worden verwacht dat de relaties en gegevens, mits op de juiste manier gebruikt, de komende tientallen jaren van nut kunnen zijn bij de planning van strandbaden in Nederland.

Het systeem als zodanig kan een goed hulpmiddel zijn bij het projecteren van andere typen openluchtrecreatie-objecten zowel in Nederland als elders.

Literature

Almon, Ch. Jr, 1966. The American economy to 1975. An interindustry forecast. Harper and Row, New York. 169 p.

ANWB (Algemene Nederlandse Wielrijders Bond). 1969, 1970 en 1971. Variatie in recreatie. Per provincie (11) 1 booklet.

Bakker, J. G., 1972. Openluchtrecreatie Lopikerwaard. Inventarisatie van de huidige openluchtrecreatie (1). Recreatievoorzieningen 4(2): 42–51.

Bangs, H. P. & P. Mahler, 1970. Users of local parks. J. Am. Inst. Planners: 330–334.

Baron, M. & M. Schechter, 1972. Simultaneous determination of visits to a system of outdoor recreation parks with capacity limitations. 53 p.

Bates, M., 1966. The role of weather in human behavior. In: W. R. D. Sewell, (ed.). Human dimensions of weather modification. Univ. Chicago, Dept. Geogr., Res. Paper 105: 393–407.

Belding, H. S. & T. F. Hatch, 1955. Index for evaluating heat stress in terms of resulting physiological strains. Heat. Pip. Air Condit. 27: 129–136.

Bertels, K. & D. Nauta, 1969. Inleiding tot het modelbegrip. W. de Haan, Bussum. 183 p.

Berthery, A. D. & A. Riquois, 1970. Aménagements récréatifs et touristiques de plain air aux Pays-Bas. Meded. CultTechn. Dienst. 95. 59 p.

Boyet, W. E. & G. S. Tolley, 1966. Recreation projection based on demand analysis. J. Fm Econ. 48(4) (part 1): 984–1001.

Bruning, H. A., 1971. Verslag van het onderzoek naar het recreatieverkeer in Oostelijk Flevoland in 1969. RIJP, Zwolle. Intern Rapport 228. 82 p.

Brunt, D., 1947. Some physical aspects of the heat balance of the human body. Proc. phys. Soc. London, 59(5): 713–726.

Bruyn, W. de, 1966. Enkele gedachten over wonen. Weltman, Delft. 20 p.

Burby III, R. J., 1971. A quantitative analysis of factors influencing residential location in reservoir recreation areas. J. Leisure Res. 3(2): 69–80.

BOR (Bureau of Outdoor Recreation), 1967a. Outdoor recreation trends. Dept. Interior, Washington DC. 24 p.

BOR (Bureau of Outdoor Recreation), 1967b. Outdoor recreation space standards. Dept. Interior, Washington DC. 67 p.

Burton, Th. L. (with a part by A. J. Veal), 1971. Experiments in recreation research. Urban and Regional Studies 2. George Allen and Unwin, London. 365 p.

Buwalda, G., 1970. Weer en recreatieverkeer. Verkeerstechniek 21(10) bijvoegsel Recreatievoorzieningen 10: 74–177.

Bijkerk, C., 1969a. Recreatie-onderzoek ten behoeve van de landinrichting. Verkeerstechniek 20(11) bijvoegsel Recreatievoorzieningen 11: 166–173.

Bijkerk, C., 1969b. Wat is nu cultuurtechniek? Tijdschr. Kadaster Landmeetk. 85: 165–179.

Carson, M., 1969. On the use of models in geography. Geogr. Tijdschr. III,5: 432–443.

CBS (Centraal Bureau voor de Statistiek), 1964. 13e Algemene Volkstelling, 31 mei 1960. Deel 2: Bevolking van de gemeenten en onderdelen van gemeenten. De Haan, Zeist. 196 p.

CBS (Centraal Bureau voor de Statistiek), 1965. Vrijetijdsbesteding in Nederland, 1962–1963. Deel 6: Avond- en weekendbesteding, openluchtrecreatie, zomer 1963. De Haan, Zeist.

CBS (Centraal Bureau voor de Statistiek), 1966. Vrijetijdsbesteding in Nederland, 1962–1963. Deel 8: Een samenvattend overzicht. Karakteristieke patronen. De Haan, Hilversum. 57 p.
CBS (Centraal Bureau voor de Statistiek), 1967a. Bevolking der gemeenten van Nederland op 1 januari 1967. Staatsuitgeverij, 's-Gravenhage. 69 p.
CBS (Centraal Bureau voor de Statistiek), 1967b. Statistiek der motorrijtuigen, 1 augustus 1966. Staatsuitgeverij, 's-Gravenhage. 54 p.
CBS (Centraal Bureau voor de Statistiek), 1969a. Bevolking der gemeenten van Nederland op 1 januari 1969. Staatsuitgeverij, 's-Gravenhage. 98 p.
CBS (Centraal Bureau voor de Statistiek), 1969b. Vakantiebestedingsonderzoek 1965–1966. Staatsuitgeverij, 's-Gravenhage. 51 p.
CBS (Centraal Bureau voor de Statistiek), 1969c. Vakantie-onderzoek 1969. Reprints from Sociale Maandstatistieken en Meded. Staatsuitgeverij, 's-Gravenhage.
CBS (Centraal Bureau voor de Statistiek), 1970. Inkomensverdeling 1965. Regionale gegevens. Staatsuitgeverij, 's-Gravenhage. 109 p.
CBS (Centraal Bureau voor de Statistiek), 1971a. De Nederlandse bosstatistiek 1964–1968. Staatsuitgeverij, 's-Gravenhage. 67 p.
CBS (Centraal Bureau voor de Statistiek), 1971b. Maandschrift December 1971. Staatsuitgeverij, 's-Gravenhage: 1090–1182.
CBS (Centraal Bureau voor de Statistiek), 1971c. Nationale rekeningen 1971. Staatsuitgeverij, 's-Gravenhage. 120 p.
CBS (Centraal Bureau voor de Statistiek), 1971d. Sportaccommodatie 1 januari 1970. Staatsuitgeverij, 's-Gravenhage. 82 p.
CBS (Centraal Bureau voor de Statistiek), 1971/1972. 14e algemene volkstelling. Voorlopige uitkomsten (separate publications per municipality).
CBS (Centraal Bureau voor de Statistiek), 1972. Onderzoek naar vakanties en uitgaan 1970. Staatsuitgeverij, 's-Gravenhage. 68 p.
Cesario, F. J. & J. L. Knetsch, 1970. Time bias in recreation benefit estimates. Water Resources Res. 6(3): 700–704.
Chubb, M., 1967. Outdoor recreation planning in Michigan by a systems analysis approach. Part III: The practical application of 'Program Recsys and Symap'. Techn. Report 12. Michigan Dept. Commerce. 298 p.
Chueng, H. K., 1970. A day-use park visitation model. Progress Report Canadian Outdoor Recr. Demand Study. 36 p.
Ciriacy-Wantrup, S. V., 1959. Conceptual problems in projecting the demand for land and water. Univ. Calif., Berkeley. Giannini Foundation Paper 176. 34 p.
Clawson, M., 1959. Methods of measuring the demand for and value of outdoor recreation. Resources for the future. Reprint 10. Resources for the Future Inc., Washington DC. 36 p.
Clawson, M., 1966. The influence of weather on outdoor recreation. In: W. R. D. Sewell (ed.). Human dimensions of weather modification. Univ. Chicago. Dept. Geography Res. Paper 105: 183–193.
Clawson, M. & J. L. Knetsch, 1966. Economics of outdoor recreation. Resources for the Future Inc. The Johns Hopkins Press, Baltimore. 328 p.
Crapo, D. & M. Chubb, 1969. Recreation area day-use investigation techniques. Part I. A study of survey methodology. Michigan State Univ. Recreation Res. Planning Unit. Dept. Park and Recr. Res., Coll. agric. and nat. Resources. Techn. Report 6. 125 p.
CRM (Ministerie van Cultuur, Recreatie en Maatschappelijk Werk), 1971. Openluchtrecreatie 1971–1975. Meerjarenplan voor het rijksbeleid op het gebied van de openluchtrecreatie. Staatsuitgeverij, 's-Gravenhage. 55 p.
Cultuurtechnische Dienst, 1970. Jaarverslag 1969. Afd. Openluchtrecreatie. Meded. 85. 24 p.
Daiute, R. J., 1966. Methods for determination of demand for outdoor recreation. Land Econ. 42(3): 327–338.

Delver, A., 1952–1955. Strandweeronderzoek deel I t/m V. Scientific Reports KNMI (unpublished).
Doren, C. S. van, 1967. An interaction travel model for projecting attendance of campers at Michigan State Parks: a study in recreational geography. Michigan State Univ. Ph.D. Thesis. 264 p.
Douglass, R. W., 1969. Forest recreation. Pergamon Press, Oxford. 336 p.
Draijer, A. A., 1971. De economische baten en kosten van openluchtrecreatieprojecten. Meded. CultTechn. Dienst 89. 42 p.
Draper, N. R. & H. Smith, 1967. Applied regression analysis. John Wiley Sons Inc., New York. 407 p.
Duffell, J. R. & C. M. Peters, 1971. Recreational travel in urban and rural areas. 1. A comparative evaluation of some recreation studies. Traffic Engng. Control: 616–618.
Duin, R. H. A. van, 1963. Problemen van plattelandsinrichting (I). Cultuurtechniek 1(3): 76–81.
Duin, R. H. A. van, 1966. Boeren, burgers en buitenlui. Het platteland in de smeltkroes van de maatschappelijke ontwikkeling. Cultuurtechniek 3(6): 162–171.
Duin, R. H. A. van, 1971. De inrichting van recreatieterreinen. Band A en Band B Kandidaatscollege Cultuurtechniek, Landbouwhogeschool, Wageningen. 74 and 197 p.
Duin, R. H. A. van & P. Loos, 1969. De inrichting van het platteland. In: Cultuurtechnische Verhandelingen. Staatsdrukkerij, 's-Gravenhage: 87–124.
Edminster, F. C., 1966. Finding the potentials for rural recreation. Soil Conserv. Serv. 32(3): 51–54.
Ellis, J. B., 1966a. Outdoor recreation planning in Michigan by a systems analysis approach. Part I: A manual for 'Program Rescys'. Techn. Report 1. Michigan Dept. Commerce. 69 p.
Ellis, J. B., 1966b. Outdoor recreation planning in Michigan by a systems analysis approach. Part II: Computer mapping for recreation planning. Techn. Report 7. Michigan Dept. Commerce. 24 p.
Ellis, J. B. & C. S. van Doren, 1966. A comparative evaluation of gravity and system theory models for statewide recreational traffic flows. J. reg. Sci. 6(2): 57–70.
ETI (Economisch Technologisch Instituten Nederland), 1971. Watertoerisme in Nederland. Deel II. Gedrags- en bestedingspatronen in de watersport. 84 p. (with addendum 67 p.)
Gillespie, G. A. & D. Brewer, 1968. Effects of nonprice variables upon participation in water-oriented outdoor recreation. Am. J. agric. Econ. 50,1: 82–90.
Gregorczuk, M., 1968. Bioclimates of the world related to air enthalpy. Int. J. Biomet. 12: 35–39.
Haar, E. ter, 1968. Dagrecreatie langs het Veluwemeer. Verslag van een onderzoek. Flevoberichten 58. RIJP, Zwolle. 155 p.
Hamerslag, R. (with ass. of G. Hupkes), 1967. Het integrale verkeers- en vervoersonderzoek. Verkeerstechniek 11: 473–479.
Hartman, J., 1968. Het verkeersonderzoek met behulp van modelmethoden. Wegen 42(10): 296–304.
Heertje, A., 1969. Enkele opmerkingen over groeimodellen. De Economist 117(4): 361–380.
Heester, J. & G. F. P. IJkelenstam, 1971. Nadere uitwerking van een recreatieconcentratie in de Lopikerwaard. Nota ICW, Wageningen 630. 17 p.
Hellinga, F., 1971. De evolutie in het denken over landinrichting in Nederland. Cultuurtechn. Tijdschr. 11(2): 47–53.
Hendriksen, J., 1970. Recreatiecapaciteit van watersportplassen. Verkeerstechniek 21(6). Bijvoegsel Recreatievoorz. 21(6): 99–102.
Heytze, J. C., 1965. Bermrecreatie: een onderzoek naar enige vormen van openluchtrecreatie in enkele recreatiegebieden in het westen des lands. SISWO en Meded. Soc. Inst. Rijksuniv. Utrecht. 112 p.
Heytze, J. C., 1968. Bos en recreatie: een onderzoek naar vormen van openluchtrecreatie in de boswachterij Nunspeet. Staatsbosbeheer, Utrecht. 115 p.
Hotelling, H., 1949. The economics of public recreation. In: The Prewitt Report. An economic survey of the monetary evaluation of recreation in the national parks. Washington DC. (see also Prewitt, 1949).
Houghton, F. C. & C. P. Yagloglou, 1923. Determining equal comfort lines. J. Am. Soc. Heat. Vent. Engng. 29: 165–176.

Houmam, C. E., 1967. Meteorological factors affecting physical comfort (with special reference to Alice Springs, Australia). Int. J. Biomet. 11(2): 151–162.
Howe, R. T., 1963. A critical analysis of an origin-destination survey. Highw. Res. Rec. 41: 79–98.
ITS (Instituut voor Toegepaste Sociologie, Nijmegen), 1972. Sportvisserij in Nederland. 92 p.
Johnston, W. E. & V. S. Pankey, 1968. Some considerations affecting empirical studies of recreational use. Amer. J. Agric. Econ. 50(5): 1739–1744.
Jonge, D. de, 1968. Plaatskeuze in recreatiegebieden. Bouw 23(1): 13–15.
Kamphorst, T. J., 1969. De sportvisserij in Midden Utrecht (een terreinverkenning). Meded. Sociaal Inst. Rijksuniv., Utrecht 55. 232 p.
Kerstens, A. P. C., 1971a. Differentiatie van de openluchtrecreatie en het zoneringsprincipe. Meded. CultTechn. Dienst 90. 33 p.
Kerstens, A. P. C., 1971b. Prognoses en planning, openluchtrecreatie in de toekomst. In: Gemengde bedrijvigheid: een kwart eeuw Wageningse sociologie. Afd. Soc. Landbouwhogeschool, Wageningen: 149–169.
Kerstens, A. P. C., 1972. Recreatie en Platteland. Een explorerende studie over de ontwikkeling van de recreatieve functie van het platteland, de betrokkenheid bij deze ontwikkeling van de bewoners van het platteland en hun houding ten opzichte van deze functie. Meded. Landbouwhogeschool, Wageningen 72(28). 357 p.
Klaassen, L. H., 1968. Social amenities in area economic growth. Ch. VII, Recreation. OECD, Paris: 105–120.
Klaassen, L. H., 1971. Enkele economische aspecten van de stedelijke groenvoorziening. Groen 27(8): 181–185.
Knetsch, J. L., 1963. Outdoor recreation demands and benefits. Land Econ. 49: 387–396.
Knetsch, J. L., 1967. A design for assessing outdoor recreation demands in Canada. (Prepared for National and Historic Parks Branch, Dept. Indian Affairs and Northern Development: Mimeo). 32 p.
Knetsch, J. L., 1970. Testimony of Dr. Jack Knetsch (Mimeo). 26 p.
Koning, H. S. de, 1965. Zandwinputten en openluchtrecreatie. Cultuurtechniek 3(3): 79–83.
Koning, H. S. de & D. W. Scholte Ubing, 1968. Strandbaden. Rapport 1 WIRO (secr. RIJP, Zwolle). 33 p.
Koot, J. W., 1969. Watertoerisme in de kop van Noord-Holland. Stichting Ontwikkeling Kop van Noord-Holland.
Kunze, D. M., 1970. Fremdenverkehr in ländlichen Gebieten. Bauen auf dem Lande 21(3): 62–64.
Lambooy, J. G., 1971. Inleiding over het gebruik van het modelbegrip in de ruimtewetenschappen. In: De gemengd agrarisch-recreatieve gebieden. Capita Selecta, Landbouwhogeschool, Wageningen: 11-1 tot 11-15.
Lee, D. H. K., 1958. Proprioclimates of man and domestic animals. Arid Zone Res. Unesco 10: 102–125.
Leyendeckers, P. & H. van Duyse, 1969. Bouwwijze en binnentemperatuur (1). Samenhang tussen invloed klimaat en bouwkundige structuur op de temperatuur in grote gebouwen. Frigotechnica 7: 183–186.
Lier, H. N. van, 1969/1970. Capaciteitsberekening voor nieuw te stichten strandbaden. Verkeerstechniek 20(12) en 21(1), bijvoegsel Recreatievoorzieningen 12: 186–190 en 1: 2–6.
Lier, H. N. van, 1970. Prognosemethoden in de openluchtrecreatie. Nota ICW, Wageningen 586. 38 p.
Lier, H. N. van, 1972. Research on some technical aspects of outdoor recreation, as part of multipurpose rural reconstructions in the Netherlands. Neth. J. agric. Sci. 20(3): 154–179.
Lier, H. N. van & J. G. van Keulen, 1970. Een gravitatiemodel voor recreatieverkeersstromen toegepast op strandbadbezoek. Verkeerstechniek 21(9), bijvoegsel Recreatievoorzieningen 9: 150–154.
Lier, H. N. van, J. G. Bakker & H. Bergman, 1971. Onderzoek ten behoeve van openluchtrecreatievoorzieningen bij de inrichting van het platteland. CultTechn. Tijdschr. 11(3): 97–128.

Lier, H. N. van & J. G. Bakker, 1972. Een onderzoek op het strandbad Oldemeijer. Nota ICW, Wageningen 700. 112 p.
Locht, L. J., 1969. Evaluation of rural reconstruction projects with the aid of a model of regional economic growth. In: M. G. Kendall (ed.). Cost Benefit Analyses. 1971. 328 p.
Locht, L. J., 1970. Planalternatieven en beoordeling. Nota ICW, Wageningen 539. 13 p.
Locht, L. J., H. J. Proper & G. Hoogendoorn, 1971. Economische beoordeling van voorzieningen voor recreatie en natuur in Midden Maasland. Nota ICW, Wageningen 623. 76 p.
Maas, F. M., 1968. Beeld en ontwikkeling van het Nederlandse landschap tot omstreeks 2000. Forum 21(1).
Maunder, W. J., 1962. A human classification of climate. Weather 17: 3–12.
Maunder, W. J., 1970. The value of the weather. Methuen & Co Ltd, London. 388 p.
Merewitz, L., 1966. Recreational benefits of water resource development. Water Resources Res. 2(4): 625–640.
Milan, R. L. & E. C. Pasour Jr, 1970. Estimating the demand for an on-farm recreational service. Am. J. agric. Econ. 52(1): 127–131.
Moss, W. T., L. Shackleford & G. L. Stokes, 1968. Recreation and personality. J. Forestry: 182–184.
Mutch, W. E. S., 1968. Public recreation in national forests: a factural survey. Her Majesty's Stationery Office, London. Forestry Commission Booklet 21. 100 p.
Niedercorn, J. H. & B. V. Bechdolt Jr, 1969. An economic derivation of the 'gravity law' of spatial interaction. J. reg. Sci. 9(2): 273–282.
Nixon, H. N., 1970. White shell provincial park visitor use study. Dept. Tourism and Recreation, Winnipeg. 89 p.
NKR (Nederlandse Kampeer Raad), 1971. Registratie van kampeerbedrijven (card index).
Oostrum, H. J. van, 1971. Resultaten van het sportvisserij-onderzoek in de provincie Drenthe gedurende de maanden september en oktober van 1968. CultTechn. Tijdschr.: 275–288.
ORRRC (Outdoor Recreation Resources Review Commission), 1962a. Prospective demand for outdoor recreation. Study Report 26. Washington DC. 61 p.
ORRRC (Outdoor Recreation Resources Review Commission), 1962b. National recreation survey. Study Report 19. Washington DC. 394 p.
ORRRC (Outdoor Recreation Resources Review Commission), 1962c. Participation in outdoor recreation: factors affecting demand among Am. adults. Study Report 20. Washington DC. 94 p.
Prewitt, R. A., 1949. The economics of public recreation. An economic survey of the monetary evaluation of recreation in the national park service. Mimeo Nat. Park Serv., Washington DC.
PPD (Provinciale Planologische Dienst) Groningen, 1970. Dagrecreatie in de provincie Groningen. Rapport 70-3. 25 p.
Provinciale Raad voor de Recreatie in Zeeland, 1971. Een inventarisatie van jacht- en visboothavens in Zeeland. Recreatievoorzieningen 8: 235–238.
Rijkoort, P. J., 1968. The increase of mean wind speed with height in the surface friction layer. Staatsdrukkerij, 's-Gravenhage. 116 p.
RNP (Rijksdienst voor het Nationale Plan), 1961. Mensen op zondag. Publ. 14. Staatsdrukkerij, 's-Gravenhage. 166 p.
RNP (Rijksdienst voor het Nationale Plan), 1966. Zondagsbesteding Rotterdam zomer 1964. Staatsdrukkerij, 's-Gravenhage.
RIJP (Rijksdienst voor de IJsselmeer Polders), 1971. Flevoland, feiten en cijfers. Zwolle. 24 p.
Rijtema, P. E., 1965. An analysis of actual evapotranspiration. Agric. Res. Rep. 659; also thesis, Wageningen. 107 p.
Riquois, A., 1972. Aménagements touristiques et récréatifs des plans d'eau. Génie Rural 65(2): 76–79.
Scharringa, M., 1960. Beoordeling van zomers. Hemel en Dampkring 58: 227–230.
Schmidt, F. H., 1967. Inleiding tot de meteorologie. Aulareeks, Het Spectrum N.V., Utrecht, derde druk. 315 p.

Scholte Ubing, D. W., 1969. Het milieubeheer van recreatieplassen met strand. De ontwerpgrondslag en de dimensionering. Verkeerstechniek 20(9), bijvoegsel Recreatievoorzieningen 9: 134–138.

Scholte Ubing, D. W. & W. Kats, 1966. Vervuiling en kwaliteitsbeheer van het water in ondiepe recreatieplassen. Water 50: 78–83.

Seckler, D. W., 1966. On the uses and abuses of economic science in evaluating public outdoor recreation. Land Econ. 42(4): 485–494.

Segers, A. J. A. M., 1970. Bepaling van de fysisch-geografische geschiktheid van plattelandsgebieden voor openluchtrecreatie. Nota ICW, Wageningen 574. 53 p.

Sinden, J. A., 1967. The evaluation of extra market benefits: a critical review. Supplement to Wld agric. Econ. rur. Sociol. Abstr. 9(4): 16 p.

Smedema, R. H., 1971. De relatie tussen het bezoek aan strandbaden en weersfactoren. Nota ICW, Wageningen 646. 36 p.

Snedecor, G. W. & W. G. Cochran, 1968. Statistical methods. The Iowa State Univ. Press, Ames, 6th ed. 593 p.

Snellen, J. W., 1966. Mean body temperature and the control of thermal sweating. North-Holland Publ. Comp., Amsterdam. 174 p.

State of Indiana, 1970. The Recreation Model. Dept. National Resources.

Stevens, J. B., 1966. Recreation benefits from water pollution control. Water Resources Res. 2(2): 167–182.

Stroband, A., H. Dijkstra & J. Wegner, 1970. Capaciteiten van watersportgebieden. Verkeerstechniek, bijvoegsel Recreatievoorzieningen 21: 236–242.

Studiegroep Behoefteprognosen, 1971. Prognosemethoden in de openluchtrecreatie. Rapport 3 WIRO (secr. RIJP, Zwolle). 60 p.

Tatham, R. L. & R. J. Dornoff, 1971. Market segmentation for outdoor recreation. J. Leisure Res. 3(1): 5–16.

Taylor, C. D., 1969. History and technique of recreation demand prediction. Predicting Recreation Demand. Michigan State Univ. techn. Report 7. Recreation Res. and Planning Unit: 4–13.

Taylor, C. D., 1970. Elements of outdoor recreation demand. Paper presented to Canadian Ass. Geographers. A. Meeting May 29. 19 p.

Taylor, C. D., W. Penmott Jr, W. H. Colburn & M. Chubb, 1969. Prediciting recreation demand. Michigan State Univ. Techn. Report 7. Recreation Res. and Planning Unit. 50 p.

Terjung, W., 1966a. Physiological climates of California. Yearbook Pacif. Coast Geographers: 55–73.

Terjung, W., 1966b. Physiological climates of the conterminous United States: a bioclimatic classification based on man. Annls Ass. Am. Geogr. 56: 141–179.

Thom, E. C., 1959. The discomfort Index. Weatherwise 12: 57–60.

Tiedeman, C. E., 1965. Transportation factors. Chapter V of Part II: Demand factors. In: Study Report of Michigan Outdoor Recreation Demand Study (Mimeo, 2nd Draft). 28 p.

Tonkelaar, J. F. den, 1972. Het strandweer. Wetenschappelijk Rapport 72(10) KNMI, De Bilt. 70 p.

Ullman, E. L. & O. J. Volk, 1962. An operational model for predicting reservoir attendance and benefits: Implication of a location approach to water recreation. Papers Michigan Acad. Sci., Arts and Letters 47: 473–484.

U.S. Dept. of Commerce, 1967. Tourism and recreation. Economic Development Administration, Washington DC. 301 p.

Voet, J. L. M. van de & H. Dijkstra, 1971. Recreatie-onderzoek rond Kagerplassen en Braassemermeer. Recreatievoorzieningen 3(6): 171–179.

Wennergren, E. B. & D. B. Nielsen, 1968. A probabilistic approach to estimating demand for outdoor recreation. Utah agric. Exp. St. Bull. 478. 27 p.

Werf, S. van der, 1970. Recreatie-invloeden in Meijendel. Meded. Landbouwhogeschool, Wageningen 70-17. 24 p.

Wesseling, J., 1960. Hulpmiddelen bij de berekening van de verdamping uit een vrij wateroppervlak. In: Commissie voor Hydrol. Onderz. TNO: Verdampingssymposium. Agrohydrologisch Colloquium COLN en rapport inzake de lysimeters in Nederland (II). Versl. en Meded. 4. 271 p.

Wijk, W. R. van, 1966. Physics of plant environment. North-Holland Publishing Company, Amsterdam. 382 p.

Wijk, W. R. van & D. A. de Vries, 1952. Weer en klimaat deel II: Het klimaat. Erven F. Bohn N.V., Haarlem. 161 p.

Wijk, A. L. M. van, 1970. Eisen te stellen aan de grond ten behoeve van de aanleg van wegen, paden en strandbaden. Mimeo ICW, Wageningen.

Wijk, A. L. M. van & J. A. van den Hurk, 1971. Geschiktheid voor speel- en ligweiden en bos. Rapport 1 Werkgroep Bodem en Water Twiskepolder. ICW, Wageningen. 50 p.

Wijk, C. van, 1970. Een methode ter bepaling van de potentiële mogelijkheden voor diverse vormen van openluchtrecreatie. Note ICW, Wageningen 594. 26 p.

Wippler, R., 1966. Vrije tijd buiten. J. Niemeijer, Groningen. 201 p.

Wippler, R., 1968. Sociale determinanten van het vrijetijdsgedrag. Thesis Groningen. Van Gorcum, Assen. 188 p.

Wolfe, R. I., 1972. The Inertia Model. J. Leisure Res. 4: 73–76.

Wright, J. D. & W. H. Bondurant, 1970. Some factors influencing family expenditures for outdoor recreation. Can. J. agric. Econ. 18(2): 35–40.

Zeeuw, J. G. de, 1972. Proeve van een klassificatie van openluchtrecreatieruimten in Nederland. Mimeo CRM, 's-Gravenhage. 32 p.

List of symbols

Some of the symbols in consecutive equations falling outside the main line of argument are defined in the text only. The letters α, β, γ and δ are also used for to be estimated parameters in different models.

Symbol	Interpretation
A	number of to be parked cars on an outdoor recreation project
A_{c1}	capacity of alternative outdoor recreation sites inside origin, weighted according recreation type
A_{c2}	capacity of alternative outdoor recreation sites outside origin, weighted according recreation type and distance between origin
A_{s1}	score of alternative outdoor recreation sites inside origin, weighted according recreation type
A_{s2}	score of alternative outdoor recreation sites outside origin, weighted according recreation type and distance between origin and site
$a_1 \ldots a_k$	supply factors in the area
B	number of vacationists incoming into origin
$b_1 \ldots b_n$	socio-economic factors of the population in the origin
C_1	educational level of population of origin
C_2	religion of population of origin
$c_1 \ldots c_m$	psychological and technical factors
c_n	capacity of alternative outdoor recreation sites
c_{v1}	capacity value of alternative outdoor recreation sites inside origin
c_{v2}	capacity value of alternative outdoor recreation sites outside origin per distance zone
D_a	air distance between origin and site in km
D_r	road distance between origin and site in km
D_w	walking distance in 100 m
$D_{w.k}$	walking distance to a certain part k of the project in 100 m
E	number of inhabitants of origin on vacation elsewhere
e	base of natural logarithms (e=2.71828...)
F	area of origin in km^2
F_e, F_s, F_w	net area of respectively other elements, sand beaches and swimming water in m^2

F_f	area needed for additional non-specified functions in m^2 (left to the ideas of the designer)
F_{tb}	total area of outdoor recreation project in m^2
F_p	gross area of total parking space in m^2
$g_{i,j}$	weight for hour i and stratum j
g_n	weight number per type of outdoor recreation
H	number of households in origin
H_{lo}	net long wave radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$
H_{max}	maximum global radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$
H_{sh}	global radiation flux in $cal \cdot cm^{-2} \cdot day^{-1}$
H_{upt}	heat uptake by human body from atmosphere in $cal \cdot cm^{-2} \cdot day^{-1}$
K_u	wind dependent transport coefficient in $cm \cdot mm\ Hg^{-1} \cdot day^{-1}$
k	number of nuclei per origin
L	latent heat of vaporization in $cal \cdot cm^{-3}$
M	total number of cars in origin
m_e, m_{sk}, m_{wk}	average area per visitor respectively on other elements, on beach part k and in part k of swimming water in m^2
m_n	availability of alternative outdoor recreation sites
m_p	net area per parked car in m^2
N_h	cloud cover at 14 h p.m. of the type stratocumulus, stratus cumulus and cumulonimbus in okta
N_{t1}	cloud cover at 8 h a.m. in % resp. okta
N_{t2}	cloud cover at 14 h p.m. in % resp. okta
n	sample size
n_t	number of tax payers in origin
P	number of inhabitants of origin
P_q	number of inhabitants of origin in nucleus q
p	proportion of questioned people from a certain origin
$\hat{p}$	estimate of p
p_{a1}	air pressure at 8 h a.m. in mbar
p_{a2}	air pressure at 14 h p.m. in mbar
p_q	percentage of inhabitants of origin in nucleus q
prd	project research-day: a research during one day on one particular project
R_{t1}	rainfall from 8 h a.m. through 14 h p.m. in mm
R_{t2}	rainfall from 14 h p.m. through 19 h p.m. in mm
r	reflection coefficient of human body for global radiation
r_{h1}	relative humidity at 8 h a.m.
r_{h2}	relative humidity at 14 h p.m.
r_n	reduction factor according distance of capacity of alternative outdoor recreation sites
r_s	evaporation resistance of human body surface in $cm^{-1} \cdot mm\ Hg \cdot day$
S	sunshine duration per day in % of possible maximum
s_k	fraction of beach visitors on beach part k

s_{v1}	score value of alternative outdoor recreation sites inside origin
s_{v2}	score value of alternative outdoor recreation sites outside origin per distance zone
T_a	air temperature in °C
T_{d1}	dry bulb temperature at 8 h a.m. in °C
T_{d2}	dry bulb temperature at 14 h p.m. in °C
T_s	skin temperature of human body in °C
T_{w1}	wet bulb temperature at 8 h a.m. in °C
T_{w2}	wet bulb temperature at 14 h p.m. in °C
U	urbanisation level of origin
u	wind velocity
u_q	urbanisation level of nucleus q
u_{t1}	wind velocity at 8 h a.m. in $m \cdot s^{-1}$
u_{t2}	wind velocity at 14 h p.m. in $m \cdot s^{-1}$
$u_{1\,000}$	wind velocity at 10 m height in $m \cdot s^{-1}$
V	total number of visits to an outdoor recreation project per origin on a certain day
V_c	cumulative percentage of recreationists on outdoor recreation projects per road distance zone from origin
V_{fc}	cumulative percentage of sports fisherman per air distance zone from origin
V_{max}	maximum value of V_t per day-group
V_{mom}	momentary visit at a certain moment on a certain day on an outdoor recreation project
$V_{m.mom}$	maximum momentary visit on a certain day on an outdoor recreation project
$V^*_{m.mom}$	$V_{m.mom}$ on normative day
V_t	total number of visits to an outdoor recreation project on a certain day
$V_{t.g.j}$	mean number of visits per day for a certain type of day g and year j
$V_{t.n}$	V_t on normative day
$V_{t.p}$	V_t on peak day
W	outdoor recreation weather value
w_k	fraction of swimmers in park k of swimming water
w_n	value of alternative outdoor recreation projects
$x_{i,j}$	number of visits for hour i and stratum j
$x_1 \ldots x_n$	combination of supply and socio-economic factors
Y	income level of population in origin
y_e, y_s, y_w	number of visitors respectively on other elements, sand beaches and in swimming water in % of $V^*_{m.mom}$
$y_{i,j}$	number of questioned people for hour i and stratum j
$Z_{i,j}$	absolute value of property Z for hour i and stratum j
$z_{i,j}$	sample value of property Z for hour i and stratum j
z_n	reduction factor for alternative outdoor recreation sites

$z_1 \ldots z_n$	meteorological factors
α	$V^*_{m.mom}$ in % of $V_{t.n}$
β	number of visits by car as fraction of number of visits on normative day
γ	psychrometer constant in mm Hg·°C^{-1}
δ	number of visits on normative day as fraction of number of visits on peak day $= V_{t.n}/V_{t.p}$
ε	random error
ε_a	actual vapour pressure of the air in mm Hg
ε_{sa}	saturated vapour pressure of the air in mm Hg
η	mean number of visitors travelling in one car on normative day
λ	parameter in the Mitscherlich equation
μ	ratio between gross and net area of parking lot
π	participation in one outdoor recreation activity (or a cluster of activities
ρ	chosen error in absolute numbers of visits per origin
σ	constant of Boltzmann in cal·cm^{-2}·day^{-1}·K^{-4}