THE ADDED VALUE OF CONTEXTUAL INFORMATION IN NATURAL AREAS

Measuring impacts of mobile environmental information

Eduardo Simão Dias

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Contents

Summary

In the past decades, the recreational use of natural areas has changed from a passive and minimalist use into an explosion of tourism as a highly active and dominant driving force of change and influence in the rural areas and associated communities. The direct and indirect negative impacts of tourism are more associated with the behaviour of visitors and with weak visitor management policies rather than with absolute visitor numbers. Good management choices based on the correct information can mitigate negative effects and maximize visitation benefits. Additionally, most protected areas have environmental education and recreation as major goals, beyond the mandate of nature protection.

This thesis addresses the use of Information Technology, in particular of mobile context-aware information systems, in order to realize these human-focused objectives and facilitate information access, exchange and provision in Natural Areas. The basic assumptions are (1) by introducing or improving information flows, it is possible to affect user's behaviour towards a more sustainable use of natural resources, while (2) providing park managers with tools to manage the visitors' distribution and geographic behaviour.

A specific tool that enables the delivery of context-aware information was developed within the framework of a research and development project, WebPark. WebPark developed a series of services for users of recreational and/or protected areas based on wireless technology. It enables users to request information from databases using their Smartphone or PDA and filters the information based on location, time and user profile relevance. Information services include: flora and fauna description linked to the habitat the tourist is visiting; routes, hotels and restaurants close to the visitor; current position on a map; and more. Two specific trial products have been developed to test these concepts for two study areas: The Texel Dunes National Park (the Netherlands) and the Swiss National Park.

These implementations show that Mobile Information Services can play a role in helping visitors achieve full awareness of the richness of natural and cultural resources, improving awareness levels and contributing to eco-friendly visits. Nonetheless the main scientific contribution of this thesis is on the assessment phase. The assessments extend simple usability tests and developed different methodologies to measure and quantify the impacts and added value the mobile information services have on the visitors. To assess the added value, it was necessary to compare different information dimensions: having information or not; and, for the visitors with information, which delivery medium is the most efficient. The visitors were assigned to one of four groups. A group without additional information, the (1) *No info* group, used as the control group, and three test groups with the same information but delivered with different media: (2) conventional information in the form of a *Paper booklet*; (3) *Digital information*, accessed on a digital handheld device; and (4) *Context-aware information*, whereby visitors had the same information and the same device as (3), but augmented with location sensitivity. More than 400 visitors to the Texel Dunes National Park participated on the experiments and the results yield significant differences in the behaviour and valuation between the groups from different perspectives. The empirical research assessed multidisciplinary effects within the frameworks of (a) Geographical science: the spatial behaviour of the visits, (b) Environmental psychology: the appreciation of nature by the visitors, (c) Economic science: measuring contingent valuation of the information using stated preferences, and (d) information science: applying the technology acceptance theory. The implemented methodologies successfully show how and to what extent the developed context-aware tool is able to influence and produce benefits for the visitors.

1 Introduction

The increasing pressure on our planet's natural assets has led to the creation of policies and tools to protect them. The designation of geographical regions that are managed with the intention to protect and conserve some particular aspects are examples of such tools which are termed Protected Areas. The International Union for the Conservation of Nature and Natural Resources (World Conservation Union or IUCN) provides the most-used definition of a Protected Area as "*an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*" (IUCN, 1994). According to Carey et al. (2000), Protected Areas are crucial to many conservation strategies as they enable the protection of biodiversity, ecosystems or even vulnerable human communities. Often these areas provide vital ecosystem services (e.g. freshwater, relaxing places, genetic reservoirs). An illustration of the importance and need for Protected Areas is their inclusion as an indicator to monitor Millennium development goal of *environmental sustainability* (UN, 2005). According to the world and regional trends statistics (UN-web, 2006), nowadays almost 12 per cent of the world's land surface is protected at some level. Nevertheless, different areas require different protection levels and therefore have different management goals. The levels of protection have been standardized (IUCN, 1994) into seven categories ranging from 'strictly protected nature reserves' to 'areas that combine biodiversity protection with a range of other functions', such as resource management or the protection of traditional human cultures. For a detailed description of each category, see Box 2.1 in Chapter 2. Categories are ascribed to the Protected Areas according to their management objectives. Table 1.1 shows for each of the IUCN categories the related management objectives classified per priorities. It is noticeable that the identified management objectives include not only nature protection goals, but also "*Education*" and "*Tourism and recreation*". These people-oriented objectives are interlinked, as tourism and recreation can create the opportunity to raise the environmental awareness of the visitors. Nevertheless, it is essential that any tourism activity preserves the environment where it occurs and attempts to meet the needs of the Protected Areas and also the expectations of the visitors.

It is generally acknowledged that the main function of Protected Areas is the preservation of biodiversity. Nevertheless, other more *human-focused* functions have influential importance and are dedicated specifically to visitors to these Areas: first, the function of education and "passing-on of knowledge" in an attempt to increase the environmental awareness of the visitors, inspiring them to make eco-friendly decisions; and, secondly, but no less important, the function of leisure and recreation.

These visitor-oriented functions set the framework for the research described in this thesis. Information Technology (IT) was developed to improve the goals of communicating with the tourists, informing them of the places they visit in an attempt to make them more aware of the Park's environmental richness and, at the same time, augmenting the pleasure and satisfaction the tourists experience during their visit. As a by-product, the information tool can also be used to monitor and influence the whereabouts of the visitor within the Park. In this way, it can be used for assessing the visitors' impacts and to try to mitigate them by influencing the visitors' spatial behaviour. This thesis is about information management in Protected Areas that specifically concerns their visitors.

1.1 Tourism in Protected Areas

The management of Protected Areas encompasses innumerable and diverse issues (see the diversity of management goals in Table 1.1). In this thesis the focus is on the visitors and tourism management, and specifically the management of information flows between the Park Management and the visitors. As such, the management objectives "*Education*" and "*Recreation*" are the focus of the present research.

Table 1.1 – Management objectives and priorities for the IUCN categories, adapted from Green and Paine (1997)

IUCN Management categories / Management objectives	**Ia**	**Ib**	**II**	**III**	**IV**	**V**	**VI**
	Strict nature reserve	Wilderness area	National Park	Natural monument	Habitat/ species management	Protected landscape/ seascape	Managed resource Protected Area
Scientific research	1	3	2	2		2	3
Wilderness protection	2	1	2	3	3	-	2
Species/genetic diversity	1	2	1	1	1	2	1
Environmental services	2	1	1	-	1	2	1
Natural/cultural features	**-**	**-**	**2**	**1**	**3**	**1**	**3**
Tourism & recreation	**-**	**2**	**1**	**1**	**3**	**1**	**3**
Education	-	-	2	2	2	2	3
Sustainable use	-	3	3	-	2	2	1
Cultural attributes	-	-	-	-	-	1	2

Legend: 1 primary objective, 2 secondary objective, 3 potentially not applicable, - not applicable

Recent years have witnessed a radical change in the exploitation of rural and natural areas for tourism. Tourism now accounts for a significant share of economic activity of those rural communities that enjoy attractive environmental settings, proximity to Parks or to appealing environments and natural surroundings. The effects of this phenomenon are significant and widespread, encompassing social, economic and environmental aspects (Butler et al., 1998).

Numerous Protected Areas in the world were established with at least “environmental conservation” and “recreational usage” as twofold purposes. Therefore, a balance in terms of visitor exploitation and conservation efforts needs to be achieved by the managers of these areas. Even if the area has different emphasis allocated to one of the goals, information about the visitors is of major importance. Basic essential information includes visitor numbers, demographic profiles and visitation impacts. More sophisticated additional information includes visitor needs and spatial distributions within the Park. Such information about the visitors can assist the managers in developing and implementing visitor management strategies (Eagles, 2002; Hendee and Dawson, 2002). Eagles (2001) recommends Park agencies to develop tourism competencies within their own organization and proposes seven main competencies: 1) Understanding the visitors’ needs and wants; 2) Service quality management; 3) Leisure pricing policy; 4) Leisure marketing; 5) Tourism and resource economics; 6) Finance and 7) Tourism management.

A crucial aspect for the first competency, *Understanding the visitors’ needs and wants*, is information and interpretation. Potential and existing Park visitors often have information needs that can range from simple logistic information (e.g. how to get there) to complex and specific interpretations (e.g. description of local ecologies). Therefore, interpretation and education attempts to extend the simple *informing* towards developing an *understanding of*, and *appreciation* for, the environment. Hence, interpretation can be used as a visitor management tool, since it is able to affect visitors’ behaviour by changing the visitors’ needs and emotions.

Since the 1960s, quality standards have grown in importance as a factor for planning and managing Protected Areas and outdoor recreation. An early study by Wagar (1964) started with the goal of defining the carrying capacity of recreation land, *determining it primarily in terms of ecology and the deterioration of areas*. The results show that *the resource-oriented point of view must be augmented by the consideration of human values*.

From an economic perspective, the importance of recreation quality is connected to the fact that Protected Areas are shifting their funding sources from government grants to visitors’ fees and visitor services (Eagles, 2003). For this reason, visitor satisfaction is an influential variable in Park management. Highly satisfied visitors are more likely to return and will recommend the Park to other potential visitors. Satisfied visitors are also more likely to help with donations to conservation and support political initiatives for conservation (Hornback and Eagles, 1999).

Nevertheless, defining quality standards for recreation is not a straightforward process due to the lack of objective criteria. The criteria are subjective, varied, specific to the areas, and specific to the users' motivation to visit the area (Buckley, 1999; Lucas, 1964). The recreation goal in some areas implies the necessity to understand the concept of 'recreational carrying capacity'. This value is the threshold of the maximum number of visitors to the area, above which recreation quality cannot be sustained (Hammitt et al., 1998). And since good information leads to good decisions, the recreation field requires the same level of rigorous scientific data collection techniques and analysis methods as for the established fields of biology and the physical sciences that have been proposing tools to facilitate environmental management in Parks for many years.

Eagles et al. (2002) identified an extensive list of potential benefits of tourism in Protected Areas. These benefits can be grouped into three main categories: "*Enhance economic opportunities*", "*protect the natural and cultural heritage*", and "*advance the quality of life*". Tourists visit Protected Areas to understand and appreciate the values for which the area was established, but also to enjoy themselves and gain personal benefits. As such, tourism development and management aims should take advantage of the interest shown by tourists so as to maximize both the Park Management's and the visitors' benefit. Box 1.1 provides a review of common tourism-related terms within the Protected Areas context.

Box 1.1 - Definitions of terms related to visiting Protected Areas [taken from Hornback and Eagles (1999)]

VISITOR: a person who visits the lands and waters of a Park or Protected Area for purposes mandated for the area.
A visitor is not paid to be in the Park and does not live permanently in the Park. Typically, the mandated purpose for the visit is outdoor recreation for natural Parks and cultural appreciation for historic sites.

VISIT: a measurement unit involving a person going onto the lands and waters of a Park or Protected Area for the purposes mandated for the area.
Each visitor who enters a Park for a purpose mandated for the area creates a visit statistic. Typically, the visit statistic has no length of stay data associated with it. However, the collection of additional data on the length of stay of a visit allows for the calculation of visitor-hour and visitor-day figures. The purposes mandated for the area typically are recreational, educational or cultural. Non-mandated purposes could include passage through the Park on the way to a site outside the Park, or entrance by Park maintenance vehicles. This definition of visit means that if a person leaves the Park and re-enters at a later time, then a second visit data unit is recorded.

VISITATION: the sum of visits during a period of time. Visitation is usually summed for use at periods, such as daily, monthly, quarterly or annually.

TOURIST: a person travelling to and staying in a place outside their usual environment for not more than one consecutive year for leisure, business and other purposes. The definition of a tourist involves two elements, travel of a certain distance from home and a length of stay. For most Parks a portion of the visitors will be tourists, the rest being considered local residents. It is often useful for the Park's visitor management personnel to report on the percentage of Park visitors that are tourists.

Tourism can also create threats or costs to the Protected Areas. Eagles et al. (2002) consider that absolute numbers of visitors have limited negative impacts on the Park's resources, while weak tourism policy, management and staffing can have greater influence. One of the main causes for poor tourism policy and staffing are low levels of funding. As such, high visitor numbers should be considered an additional source of income for the Park Management that can be used to effectively mitigate the negative environmental impacts and enable high levels of positive impacts.

1.2 Impacts of visiting Protected Areas

As discussed before, Protected Areas perform two crucial functions: conservation of biodiversity, and providing leisure spaces in which the increasingly urban society can enjoy nature. Nevertheless, the intensive use of Parks and natural areas by outdoor recreational activities poses sustainability issues and creates new problems for the management of these areas.

The large number of visitors may have negative impacts and cause a deterioration in the natural environmental quality, the very asset that makes the areas attractive. Previous studies have proven the negative effects of outdoor recreation caused by introducing greater and more widespread ecological impacts on natural ecosystems in terms of physical and biological effects.
Over the past decades, the impact of visiting nature areas has been a research topic and visible progress in the knowledge on this field has been achieved. Scientific methods have been applied and have allowed not only a better understanding of visible phenomena, but also the development of knowledge about fine-grained phenomena occurring at spatial and temporal scales not immediately perceived. The collected knowledge and techniques are essential to Protected Area managers by allowing the identification of threats, benefits and opportunities that can influence the ecosystem developments (Cole, 2004).

1.2.1 Biophysical effects

One of the most extensively studied biophysical impacts addressed by the scientific community has been the effects of visitor trampling. For more than 30 years, this issue has been researched, and the documented impacts include loss of vegetation cover, removal of soil nutrients and soil compaction (Bayfield, 1973; Burden and Randerson, 1972). In addition, Weaver and Dale (1978) demonstrated the negative effects of particular recreation activities in meadows and forests due to trampling. More recent research has discovered and explained more complex effects by finding correlations between the trampling and root development and stem growth of understory colonizers

(Bhuju and Ohsawa, 1998). Ikeda (2003) proved that plant variability and species evenness have a negative linear relationship with trampling frequency and that trampling mediated early changes in species diversity patterns. Besides this direct physical destruction or alteration of natural conditions by outdoor recreation, evidence of additional anthropogenic disturbance of wildlife can be found in the literature. The effects include direct stress and wildlife disturbance (Steidl and Anthony, 2000) and can be measured through studies of fright behaviour (Riffell et al., 1996), flight distances (Fernández-Juricic et al., 2002), and stress hormone production (Creel et al., 2002). The disturbance of wildlife by outdoor recreation has energy costs for animals and affects their behaviour and fitness. Influential altered behaviour includes the avoidance of suitable habitats due to the presence of tourists (Taylor and Knight, 2003). Leung and Marion (2000) published a state-of-knowledge review regarding the recreational impacts and management in wilderness areas.

1.2.2 Social effects

In addition to the impacts of visitors on the conservation efforts, it is important to understand the impacts of visitors on the recreation potential of the area. This idea is as simple as it is important, and it can be termed a “negative feedback” effect when the presence of too many visitors has a negative influence on the recreation experience of the visitors themselves. This effect has been extensively studied in the past and also appears in the literature on outdoor recreation under the headings *recreational carrying capacity* and *visitor satisfaction*. This research field tries to understand the influence of use levels and encounters on people’s enjoyment of wild land environments. It started with an early thoughtful analysis by Wagar (1964) and developed into contemporary carrying capacity studies that estimate indicators and standards of quality to define and manage Parks, outdoor recreation and tourism (Manning, 2002). Typically, these studies make use of visitor surveys in order to identify indicators and standards of quality for the visitor experience (Hammitt and Cole, 1998; Martin et al., 1989). Recent research methods propose computer simulation models of visitor behaviour to estimate maximum daily use levels without violating the previously-defined quality standards (Elands and van Marwijk, 2005; Wang, 1999).

1.2.3 The contribution of the present study to impact analysis

Data on visitors and their behaviour are crucial to Park Managers’ decision-making processes on tourism management in order to mitigate possible negative impacts and enhance positive ones. Nevertheless, the common current data collection techniques, based on counts at the Park entrance and end-of-visit questionnaires, have clear shortcomings. Counts are ineffective as the visitors do not use the natural environment uniformly and considerable variation in frequency of use can occur. Furthermore, carrying capacity is also not evenly distributed throughout the Park and varies in time and space. Therefore, it is not sufficient to analyse count data regarding the number of visitors at the Park entrances, and it is important to know where the visitor goes and when. It is necessary to collect space-time activity data (STA) or space-time paths attributed to the activities conducted by the visitor. Collecting STA data traditionally involves cumbersome methods such as recall and activity diaries which require individuals to remember and report activities at a later point in time. This can create errors related to faulty or selective memories (Miller, 2003). Positioning technologies, such as Global Positioning System (GPS) receivers, can enable detailed space-time trajectories to be collected at the individual level. The work described in this thesis proposes techniques and methodologies to use geo-temporal data with high granularity, collected with GPS. Such objective and extensive data collection methodologies can contribute to the understanding of phenomena related to Park usage.

1.3 Information and education as a goal

As described earlier, besides the "*Tourism and recreation*" goal, this thesis also focuses on the education objective associated with visiting Protected Areas. UNESCO and UNEP (1978) describe environmental education as a learning process that increases people's knowledge and awareness about the environment and its associated challenges. It develops the necessary skills and expertise to address these challenges and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action. One way of increasing the effectiveness of education is through entertainment (Singhal, 2004). Educational-entertainment (Edutainment) should be understood in the context of this thesis as a form of entertainment that is designed also to educate. Edutainment is a dual genre that uses visual material and a more informal style to address pedagogic challenges. The purpose of edutainment is to attract and hold the attention of the learners by engaging their emotions. A system that can be defined within the edutainment framework will be proposed in this thesis in order to address the environmental education goals of Protected Areas.

1.3.1 The visitors' information needs

Previous tourism research in Protected Areas has shown that Park[1] visitors have information needs/questions during their visit (Abderhalden et al., 2002). The questions can be related to environmental information, such as the name of a plant or the behaviour of an animal, or practical information, such as: Can I make a picnic here? or, How many hours are left to walk to the peak? The majority of these

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[1] In the context of this thesis, the terms 'Nature Area', 'Protected Area', 'National Park', and 'Park' are used interchangeably.

information requests are dependent on where the visitors are in the Park (Abderhalden et al., 2002). Managers of natural areas are looking into new digital means of Information provision, searching for a way to improve the overall tourist experience. Examples of adoption of such digital means are the recent publication of CD-ROMs and the increasing availability of official Natural Areas websites. However, these new ways of providing dynamic and updated information to the visitors fall short in satisfying the visitor's questions when it is most important: out on the field during the visit.

Eagles (2003) also acknowledges the importance of education while visiting natural Parks: "As educational levels rise, demand for appreciative and learning opportunities associated with Parks and Protected Areas increases." The needs and wants of tourists are crucial concepts to be taken into account by the Park administrations in order to improve the tourist experience. Parks increasingly rely on market funding with a shift from government grants to visitor fees and service charges. This results in higher levels of visitor focus on management: if the focus is shifting towards the visitors, then their needs for information in the field cannot be neglected.

1.3.2 The Park Management perspective

Alongside the "Protection of Nature" and "Research", National Parks play an increasingly important role in the passing on of knowledge. The National Parks provide a wide range of information, thereby helping visitors to have a wider understanding of our environment (SNP-web, 2007).

It must be underlined that Protected Areas are created above all with the aim of conserving the natural heritage and, secondly, for supporting the leisure or tourism industry. Nevertheless, environmental education is, for a majority of the Protected Areas, a major goal (see Chapter 2). As an illustration, *educational aims* can be found listed in the definition of management categories from the IUCN (IUCN, 1994). In Category II, corresponding to the National Parks, one of the three goals reads "*provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible*" (see Box 2.1 in Chapter 2).

Moreover, according to the Alps Network for Protected Areas, a number of Protected Areas have leisure as a goal, not the main goal (which is usually natural assets protection) but as a secondary goal. Hence, it should be emphasized, it is never intended to develop physical infrastructure (e.g. roads, hotels) to support the leisure goal (ANPA, 2000). Looking into the world's oldest example of a National Park, the Yellowstone National Park, Act of Dedication declares that the area "is reserved and withdrawn from settlement, occupancy, or sale under the laws of the United States, and dedicated and set apart as a public Park or pleasuring ground for the benefit and enjoyment of the people..." (Blaine et al., 1872). The Swiss National Park – the oldest

National Park in Central Europe – also has restricted human activities inside the area, but visitors are tolerated, as long as they do not disturb the natural processes (Schweizerische Eidgenossenschaft, 1914).

The last decade was distinguished by the emergence of a different view on the Protected Areas' goals. The initial point was the Convention on Biological Diversity (CBD) that was negotiated under the auspices of the UNEP. It was signed at the "June 1992 UN Conference on Environment and Development" and put into action on 29 December 1993. By October 1998, more than 170 countries had joined. Article 13 of the CBD declares that the parties who sign the convention should "(a) Promote and encourage understanding of the importance of, and the measures required for, the conservation of biological diversity, as well as its propagation through the media, and the inclusion of these topics in educational programs; and (b) Cooperate, as appropriate, with other States and international organizations in developing educational and public awareness programs, with respect to conservation and sustainable use of biological diversity."

Additionally, IUCN has established a Commission for Communication (CEC) "to foster leadership in conservation and sustainable development by innovating, guiding and assisting in the strategic use of knowledge, capacity development, learning, education and communication (…)". CEC proposes a tool for changes in Protected Areas. The tool is called CEPA (Communication, Education and Public Awareness) and provides the link from science and ecology to people's social and economic reality.

The World Summit on Sustainable Development 2002 recommended to the United Nations General Assembly "adopting a Decade of Education for Sustainable Development starting in 2005", which was agreed by consensus in December 2002, resolution 57/254 on the United Nations Decade of Education for Sustainable Development, starting 1 January 2005.

In addition to the role of education and awareness, special support is being given to the involvement of local people in Protected Areas' activities. The CEC, the World Commission on Protected Areas and the EuroParc federation supported a workshop and a publication entitled "Challenge for Visitor Centres – Linking Local People, Visitors and Protected Areas" that focuses on the role visitor centres play in environmental education and in the relationship of the Protected Areas to the surrounding society (Kyostila et al., 2001).

All these examples are illustrative of the international political importance of education and environmental awareness within the framework of Protected Areas, and are an evident support of these international organizations in developing tools and processes that enable access to information, increase environmental awareness, and involve the local communities in the Protected Areas activities.

1.4 Contribution to sustainability

A common long-term goal shared by Park Managers is the promotion of sustainability. In order to achieve this goal, Parks invest strategically in two objectives: nature conservation, and information to the visitors. It is expected that, by providing information to the visitors, they will be more aware of the importance and richness of the environment that they visit and the environment in general. This awareness, mediated by the notion of self-efficacy, will then contribute to the creation of eco-friendly intentions in the visitors. According to the Theory of Reasoned Action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), intention is the main driver for behaviour. Since information can change intention, then visitors' behaviour can also be changed to more eco-friendly levels. In this way, information may contribute to sustainability. This rationale is depicted schematically in Figure 1.1. The work presented in this thesis aims to study the link between information and awareness. The hypothesis is that, by using location-based systems, the visitors will become more motivated to access information, and this has a positive impact on the assimilation of this information, thus contributing to raising the awareness levels of the visitors.

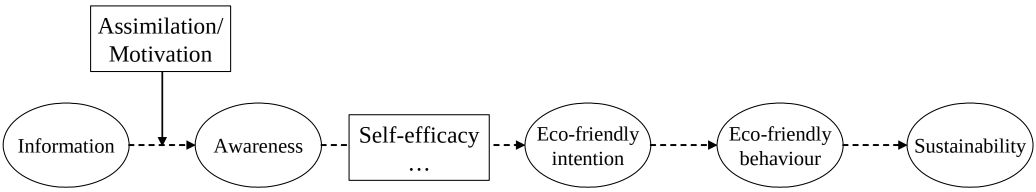


Figure 1.1 – "Information to sustainability" chain

This hypothesis is comparable to the economic model of the Principal-Agent problem (Eisenhardt, 1989). The Principal-Agent is a problem of motivating one party to act on behalf of another. In this model, mechanisms can be used to try to align the interests of the Agent (in our case the visitor to the Park) with those of the Principal (the Protected Area Manager). In other words, the goal of the Park Manager (or Principal) is to educate and make sure the visitor (or Agent) accesses information in order to become more aware of the natural environment and thus contribute to sustainability. A way to achieve this goal is for the Park Manager (Principal) to motivate the visitor (Agent) to learn, by providing him with the use of more effective and efficient information and communication mechanisms. The next section will propose such a mechanism: the context-aware services.

1.5 Context- and location-aware services

It is of major importance to deliver information to the visitors of Protected Areas. Nevertheless, the information delivery should be done in a way that is compatible with the area usage, and its conservation and recreation goals. The information should be ubiquitous and location-dependent, but it should not be intrusive or disturbing for those visitors who do not wish to receive information (as in the case of physical information boards). At this point in time, technology can provide location-awareness and filter the information provision based on the positioning of mobile users. Examples of such location-aware technology are the increasingly popular ‘in-car navigation systems’ that provide door to door navigation aid, and fieldwork inspectors who use mobile handheld devices connected to GPS receivers to collect information about the sites they visit. Such location-aware services are specially suited for supporting activities in unknown and unfamiliar territories. Therefore, these services are potentially useful in Protected Areas, since most of the visitors have never been there before and are, therefore, not familiar with such areas.

Figure 1.2 shows an example of a location-aware service available via a handheld device or Personal Digital Assistant (PDA). This system is aware of the user’s position and uses it to warn the visitor about interesting features around him/her and to continuously indicate the visitor’s location on a Park map. This service is ubiquitous, since the visitor can use it anywhere in the park, and it is not intrusive, since its usage is not mandatory and does not create nuisance to the other visitors who do not wish to receive information.

Figure 1.2 – Visitors accessing context-aware information via a location-aware handheld device.

Context-aware and location-aware services are proposed as a mechanism to improve the information delivery and the efficacy of information in Protected Areas. These services can help to increase the environmental awareness levels, since they enable visitors to access environmental information about the places they visit. This can encourage visitors to make more eco-friendly and safe use of the environment.

Context can act as a filter, filtering the available sources to just the information that is relevant in that particular context. As an example, when a visitor looks for the name of a specific flower along the route, the system should first propose only the flowers that occur in the habitat where the visitor is, and that are blooming at that time.

The subsets of context-aware services that make use of location information are the Location-based services (LBS). LBS exploit their ability to locate in real-time users and/or resources and combine this information with spatial information about their surroundings to provide users with location-specific information. These services are typically deployed in mobile devices (such as Smartphones and PDAs) and make use of wireless technology or locally-stored data.

The services falling under the LBS umbrella can be categorized into one or more of the following types, depending on the service aim(s) (Beinat, 2001):

- **Information services**, which provide information about objects close to the user (in terms of distance, travel time or other). Examples are: locate my position, identify animals around my position, check traffic conditions on the highway, on my route, etc.

- **Interaction services**, which are based on the interaction between mobile users/objects and do not require content sources. Examples are: Where are other park visitors/rangers? Where is my car? Where is the closest emergency car to an accident?

- **Mobility services** that support smart mobility and revolve around navigation capabilities. Examples are: How do I get from A to B? When can I leave to catch the next train/tram?

The LBS technology proposed in the framework of this research can be classified as a pure **Information Service**, in view of the fact that it aims solely to inform the user about interesting nature features and phenomena occurring in the places he/she visits within and around the Protected Area.

1.6 Case studies

Within the framework of a research and development project WebPark[2], a prototype was developed to assess the contribution of LBS in addressing the visitors' information needs and support Park Management decisions with detailed spatial information from the visitors. The prototype was implemented in two very distinct case study areas. One is a coastal area on the island of Texel, off the North coast of the Netherlands, and the other is an alpine mountainous region, the Swiss National Park in the East part of

[2] For details on this project, see the project website: www.webparkservices.info

Switzerland (one of the six partners of the project consortium). It was important to have distinctive areas that host different types of visitors, in order to be able to extrapolate some of the results.

1.6.1 The Swiss National Park, Switzerland

The Swiss National Park (see Figure 1.3 for a photographic impression) was founded in August 1914. The law that defines it also defines the purpose of the Park's existence: «*The Swiss National Park is a reserve in which the entire fauna and flora are protected from any human interference and are left to their natural development*» (Schweizerische Eidgenossenschaft, 1914). It is located in the Grisons Canton, in the Engadine valley with a total area of 172.4 km^2, and its altitude ranges from 1400 to 3174 (at the Pisoc peak) metres above sea level.

The climate in the Park is dry, harsh, with strong solar radiation and low humidity. The most dominant landcover types within the Park are as follows: almost one-third of the park is Forest (of which 99.5 per cent are coniferous trees), one-fifth is Alpine Grasslands (almost all alpine plants can be found in the Park), and around half is Unproductive terrain including scree and rocks especially in the high mountain region. Highlights of the fauna to be found in the Park are the Deer population that can reach 1800 to 2000 individuals during the summer and the Bearded vulture which was reintroduced in 1991 in the Stabelchod area.

This area receives approximately 150,000 visitors per year. To support the visitors' activities, 18 resting areas can be found inside the Park (although camping or camp-fires are not allowed inside the Park itself); there are 10 car parks along the Ofenpass road with a limited number of places and 6 bus stops. The Park has 13 official entrances which are the only permitted entry points. Within and around the Park there are approximately 80 kilometres of official marked paths, two of which are alpine routes. Some information boards are placed at each Park entrance and car Park (at the beginning of trails).

Most of the information about the area can be found in the information centre located in the Park House (which is also the administrative centre) in the municipality of Zernez. Here the tourists can visit an exhibition on the Natural features of the Park and a shop which provides access to extra information on the Park in diverse media. Available information includes a paper "Guide to walks", paper topographic maps, and illustrated books on the flora and fauna of the Park. Information is also available on digital support. The Park House provides access to the area website and sells a CD-ROM with extensive multimedia information. In addition, guided excursions are on offer on every Tuesday and Thursday.

The Park is guarded by eight full-time Park wardens who impose the conservation rules which include: Dogs and other domesticated animals are not permitted, even when on a leash or harness, and there is no winter admittance to the Park (skiing and cross-country skiing are not permitted).

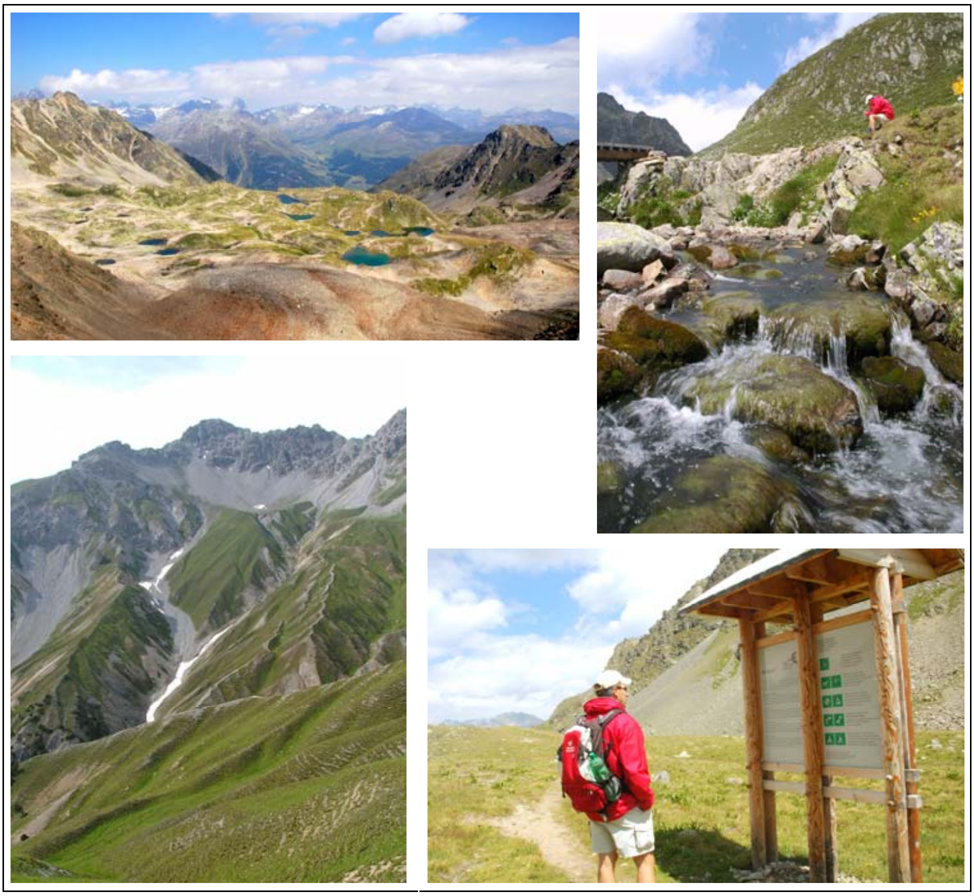


Figure 1.3 – Photographic impression of the Swiss National Park

Furthermore, the Park has three well-defined main goals (SNP-web, 2007):

- **Nature conservation:** In the National Park no animal is hunted, no tree felled, no meadow mown. Conditions reigning in the National Park today are the same as those of 5000 years ago, before mankind interfered with the course of nature.

- **Research:** (…) to document the changes taking place in the National Park. Of particular interest and importance are research projects conducted over prolonged periods. The results obtained help us to better understand the natural changes going on.

- **Information:** Alongside the protection of nature and research, National Parks play an increasingly important role in the passing on of knowledge. The Swiss

National Park provides a wide range of information, thereby helping visitors to have a wider understanding of our environment.

This National Park acted as a case study during the definition of the user needs step in Chapter 2, and as one of the testbeds where the technological solution was implemented and evaluated in Chapter 3.

1.6.2 Texel Dunes National Park, the Netherlands

The Texel Dunes National Park is an extensive nature area that protects important natural assets located on the west coast of the island of Texel, off the north coast of the Netherlands (see Figure 1.4 for a photographic impression). Its website explains that the enjoyment of the natural aspects is an important feature in the National Park (NPDvT-web, 2007). This was achieved by laying out hiking and bicycling paths. The process of delineating these paths was an essential one, as these have to provide opportunities for recreation but, at the same time, guarantee Nature conservation.

The information centre for the Texel Dunes Park is located in the Ecomare museum. At this centre, visitors can find an exhibition explaining the Park's natural ecosystems and additional information in the form of paper maps and illustrated books. In addition, daily guided tours can be booked that consist of a walk in the dunes accompanied by an expert from the State Forestry department who informs the visitors of the most important natural features of this ecosystem. The tours last approximately two hours and cost € 6 per person, and € 4 for children under 12 years old. All paths in the woods are open to the public.

The flora highlights vary in different parts of the Park, as each of the terrains within the Park has its own characteristic flora. In the dune-slacks, one can find uncommon and special vegetation such as Parnassus, early marsh orchids, marsh helleborine, and the chaff weed. The vegetation types are influenced by the age of the dunes. The dunes closer to the sea (young dunes) contain more lime, and Marram grass is frequently found here. The dunes more inland (older dunes) have less lime since the lime dissolves in rainwater and sinks to the bottom. These dunes serve as habitat for various types of heather. There are many highlights to be mentioned regarding the Fauna since the island of Texel is considered a very rich bird sanctuary. It is acknowledged that the rich variety of birds in Texel is determined by the variety of birds that can be found in the dunes. Annually, more than 80 types come to the island for breeding. Some examples of rare birds include the spoonbill, the little tern, and the short-eared owl. Around 10,000 birds use the dunes as an important resting and foraging area during migration time. On the other hand, because Texel is an island (isolated from the mainland), the number of mammals is relatively low. Still, it is possible to find stoats, rabbits, hares, brown rats, hedgehogs, five species of mice (including the root vole) and different kinds of bats (including the serotine). Regarding amphibians, it is possible to find the common and moor frog, the natterjack toad and the smooth newt.

Figure 1.4 – Photographic impression of the Texel Dunes National Park

The management of the area has influenced the flora, fauna and landscape. In order to fight large-scale sand-drifting in the dunes, Marram grass has been planted for centuries. In addition, in the dune-slacks the bushes and grass are regularly trimmed in order to prevent overgrowth which could lead to the disappearance of extraordinary plants and animals. This maintenance task is performed by the State Forestry, which sometimes uses grazing animals (sheep or horses) to accomplish this. Occasionally, large interventions are planned to change or end undesirable natural or man-made developments.

Hiking and bicycle paths, horse trails, playgrounds, outlook points, and other facilities are also maintained by the State Forestry, making it possible to enjoy the surrounding nature.
This National Park acted as a case study in Chapter 2, where visitors to this Park defined possible content and the system layout, and in Chapter 3 where a system was built, implemented and tested specifically for this area. This area also provided the backdrop to test the added value measurements according to the research framework discussed in Chapter 4. Therefore, the added value measurement results (found in Chapters 5, 6, 7 and 8) are based on the tests that occurred in this National Park.

1.7 Aims and objectives of the study

The overall aim of this thesis is to uncover how and to what extent location-aware mobile information services can improve the visitors' experience and the information flows in Protected Areas. This study is a multidisciplinary approach that developed a theoretical and empirical framework to evaluate the direct and indirect effects of using contextual information services. The effects investigated include behavioural responses to information, technology acceptability and institutional advantages in using innovative information delivery mechanisms.

Specifically, this thesis addresses two main research questions:

Question 1

> *What is the contribution of context-aware services in improving information provision to managers and information access to visitors of natural areas?*

Question 2

> *In what ways do context-aware services influence the visitors' behaviour?*

To answer the first question, it is necessary to identify and understand the shortfalls of the existing information services being offered to the visitors of Protected Areas and to investigate potential solutions for these shortfalls. This is achieved by means of three studies: i) benchmarking the "offered-information-services" by the Park with the visitors' declared-information-needs and current information-behaviour (how they get informed nowadays); ii) understanding the issues and problems that the Park Managers face regarding information sharing and visitor management; and iii) exploring the potential advantages of mobile context-aware ICT. Related to Question 1 the following detailed research hypothesis can be formulated:

Hypothesis 1

> *Mobile location-aware information systems improve information provision to managers and information access to visitors of Protected Areas.*

In order to answer the second research question, it was necessary to design a dedicated research framework that included the realization of controlled field-experiments, and the collection of empirical data. At the core of this research framework are the different information dimensions available to the visitors (i.e. no information, and the location-enabled information vs. conventional delivery) that act as the independent variable that allows its effects to be measured in different dependent variables. The second research question was transformed into three more detailed hypotheses to be tested:

Hypothesis 2

The provision of context-aware information influences the visitors' geographic movement.

Hypothesis 3

Context-aware information provision positively influences environmental appreciation.

Hypothesis 4

The perception of the information's added value by the visitors increases when mobile information becomes more location-specific.

Since context-aware services can only change people's behaviour and help Park Managers reach their goals if they are used, it makes sense to investigate a fifth hypothesis:

Hypothesis 5

The adoption of information in future Park visits is positively influenced by having location-specific information.

1.8 Outline and Overview

This thesis can be divided into three different parts. The first part addresses the issues in visitors' management and information management within Protected Areas. The second part evaluates the possibilities for context-information services to tackle these issues and describes the development of a specific tool implemented in two case-study areas. The third part evaluates the efficiency and utility of such a tool using a testing framework that measures its added value and impacts.

This **first chapter** introduces the motivation and structure for this research: (1) it discusses the institutional mandates of Protected Areas, focusing on the education and leisure goals; (2) it reviews the main academic literature on tourism management in Protected Areas; (3) presents the two case studies; and (4) describes the research questions and overall thesis structure.

Chapter 2 addresses the needs and requirements in terms of information access and information provision of both the visitors and the Park Managers, respectively. Four different research activities are described: (1) empirical research was carried out with Protected Area administrators in order to understand and identify important issues related to tourism management and the need for outdoor digital information. The needs and wishes of the visitors were assessed by means of (2) surveys and (3) participant observation. Then, in order to determine if the revealed information on the needs and wishes of the visitors could be satisfied with the presently delivered information, (4) an information audit of a major European Protected Area was performed. This information audit reviewed and analysed all the information sources currently provided to the visitors in terms of their temporal and geographic dimensions.

Chapter 3 tests Hypothesis 1. It presents the concept of context-aware services and explains in detail the advantages of Location-based services, a sub-group of the context-aware field. The theoretical review is followed by a description of the practical implementation of an application. This chapter also presents the implementation of a context-aware system for two case-study areas where the main context is provided by location (obtained from GPS). The chapter further elaborates on the issues of data preparation for use in the mobile information systems in order to facilitate information access, exchange and provision in natural areas. Particular attention was paid to the processing of the information available in order to create added value, geo-enabled content.

Chapter 4 describes an evaluation framework, designed to measure the effects of context-aware information on the visitors to a specific Nature area: the Texel Dunes National Park, in the Netherlands. This experimental design uses questionnaires to measure distinct effects, ranging from emotional responses to Nature to economic valuations. In order to control for pre-existing differences in perceptions and to measure the changes caused specifically by the visit to the Park, the surveys were administered before and after the visit. And in order to control for the effect of the different information delivery mechanisms, the visitors who participated in the research were assigned to four groups to whom different information was provided: the (1) *No info* group, the control group, was given no extra information ; the (2) *Paper booklet* group was issued with information on specific park features in the form of a map and paper booklet; the (3) *Digital info* group was provided with the same extra information , but in digital form accessed using a handheld device; and the fourth and main test group, the (4) *LBS* group, had access to the same information, in the same device, but enhanced with location-sensitivity.

Chapter 5 tests Hypothesis 2. The visitors' GPS tracking logs were collected and the spatial behaviour patterns of the visitors were analysed in an aggregated way for the different control and test groups. Additionally, the effect of context-aware information services in influencing the spatial exploration of the Park was analysed.

Chapter 6 tests Hypothesis 3, where concepts from the field of environmental psychology were used to uncover correlations between Nature Appreciation and the use of different information media.

Chapter 7 tests Hypothesis 4. It presents the analyses of the relationship between the independent variables and personal reactions related to the valuation of the information. Willingness-to-pay was chosen as the construct to describe the visitors' perception of added value. This construct was adapted from the economic research field.

Chapter 8 tests Hypothesis 5, where the usage of information in future Park visits by the visitors was modelled using an existing model from the "Information Systems" research field: the Technology Acceptance Model.

Finally, **Chapter 9** presents the study conclusions, by revisiting the research questions and hypotheses. In this chapter, we also elaborate on the relevance for practice in the form of suggestions to Park Managers, and propose future work opportunities.

Figure 1.5 provides a schematic representation of the chapters' flow.

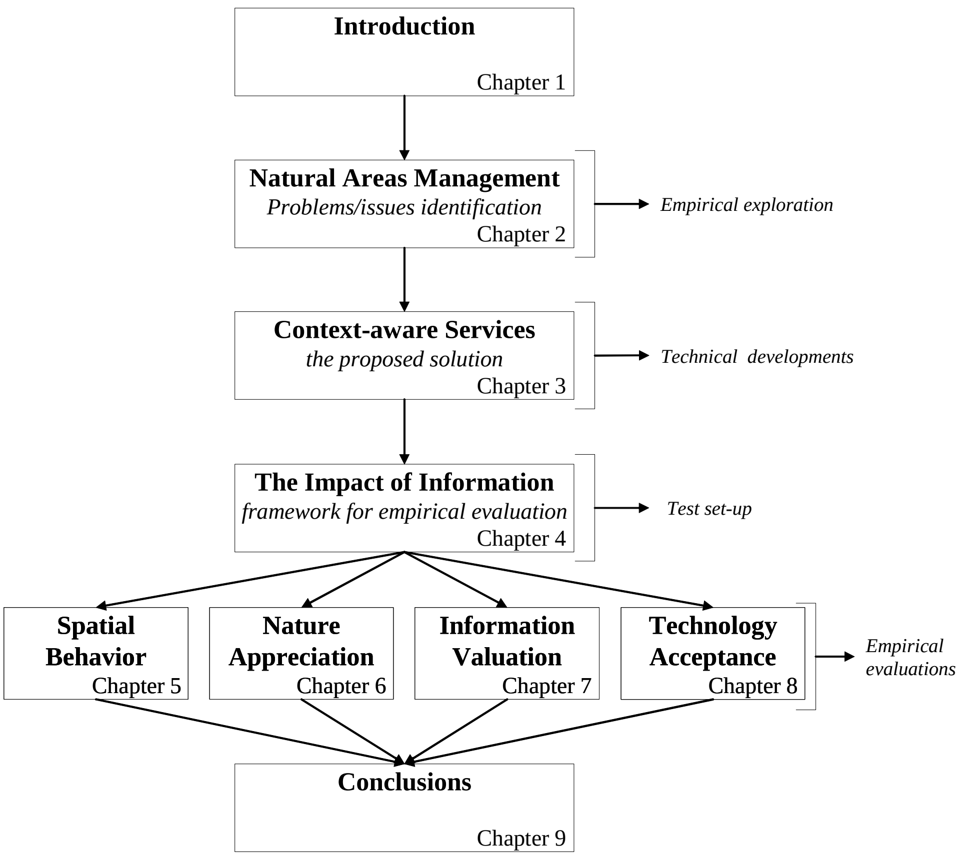


Figure 1.5 – Thesis outline and chapter flow chart.

1.9 Scientific relevance of the study

This research distinguishes itself from the existing literature in a number of ways. First, it provides a complete investigation into real-world issues, starting with the empirical validation of the Park Managers' needs, proposing a technological tool to deal with these issues and extensively evaluate the proposed solution not in the laboratory but in the field with real potential users of such a solution. The evaluation itself has a number of unique and innovative aspects. It provides a multidisciplinary approach that extends the framework of technology assessment from the common usability testing to the use of established scientific knowledge from the disparate fields of geographic information science, psychology, economics and information systems science.

In addition, this research framework is innovative in its capability to measure added value. Using different information dimensions (different groups in the research procedure with access to different information delivery mechanisms) as the independent variable allowed the effects on the dependent variables to be quantified. Thus, this methodology enables the testing and quantification of three dichotomies:

- *No information* vs. *Information*
- *Conventional* vs. *Technological*
- *Non-location-based* vs. *Location-based*

Differences observed in the results measured between the *No info* and *Paper booklet* group (No information vs. Information) can be ascribed to the presence of information. Likewise, differences between the *Paper booklet* group and the *Digital info* group are assumed to be caused by the difference in the delivery mechanism (conventional vs. technological) since the information content is the same. The *LBS* group allows for the most interesting comparisons. In view of the fact that the application that delivers the information is the same as the one available for the *Digital info* group (and therefore also has the same content as the *Paper booklet* group) but is enhanced with location sensitivity, differences between the two technological groups (non-location-based vs. location-based) are assumed to be caused by *location enabling the information*, i.e. by the *location's effect*. These differences are the quantification of the *added value of location* when all the other variables are accounted for. Further innovation from this study was the use of both *ex ante* and *ex post* measurements in order to uncover variations in the perceptions due to the Park visit and corresponding information access.

2 Understanding information management in Natural Areas

Seldom is there no information about a Protected Area available to its visitors. The managers of these areas usually provide information, ranging from simple paper maps or leaflets to extensive books or multimedia CD-ROMs. This chapter elaborates on two perspectives regarding information in natural areas: 1) the information for tourists, relevant to enhance their experience, that includes items such as information on flora and fauna, facilities, trail descriptions, etc.; and 2) the information needs of the Park organizations, as concerns: a) information provision, i.e. information the Managers wish to transmit to the visitors (e.g. advice, safety, environmental awareness, etc.); and b) data collection about the visitors, especially concerning the intensity of Park usage, the distribution of visitors, and so on.

The first part of the chapter focuses on understanding the issues in Natural Parks concerning visitor management, and in particular, the issues concerning information provision to visitors and the methods to gather information about visitor behaviour. The second part of the chapter focuses on the information for the visitors. The information provision and availability are analysed by means of an information audit. The results of the information audit are then compared with the results of the user needs and wishes, thus making it possible to identify the shortfalls in the information provision and availability. These shortfalls serve as requirements for the development of an information tool.

2.1 Park Managers' information needs and provision

2.1.1 The survey

In order to identify priorities and commonalities, Park Administrators in Europe were contacted and questioned regarding information provision to tourists and general tourism management issues. The questions were organized in a survey that was distributed electronically and on paper. The survey was sent out in the name of, and with the help of, the Swiss National Park. In the autumn of 2003, the Managers of 50 Protected Areas were contacted via e-mail and asked to fill-in a survey online. During the following days, answers to the questionnaire were received from 22 Park organizations. In the following Spring, in 2004, a letter containing a hard-copy of the survey (and reply envelopes) was sent to 200 Protected Areas Managers, addressed to those responsible for tourism and communication within the Park. Of the 200, 50 responded to the survey and returned their answers. From the combined, online and paper version, samples of 72 responses, five were considered invalid because of incompleteness of the answers. This chapter explores the answers from the Administrators of 67 Protected Areas in Europe. The goal was to collect their assessment of the challenges related to the exploitation of the Park resources and the introduction of targeted information provision as a tool for Park sustainability. The opinions and beliefs collected are important to point out trends and directions that are common to Park Managers in Europe. The respondents' sample was diverse and heterogeneous in terms of the Parks' age, size and number of visitors. The age of the Parks range from as little as only two years (for four of the Parks) to as much as 78 years of activity (see Figure 2.1).

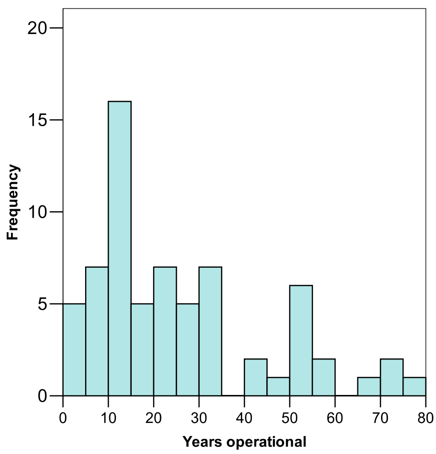


Figure 2.1 – Parks' age in years of activity (Mean = 25.0; Std. dev. = 19.3; N = 67)

Regarding size, the Parks whose Managers answered the questionnaire also have very different dimensions, ranging from as small as 200 ha to as big as 183,000 ha (see Figure 2.2), but a majority of the Parks were smaller than 50,000 hectares.

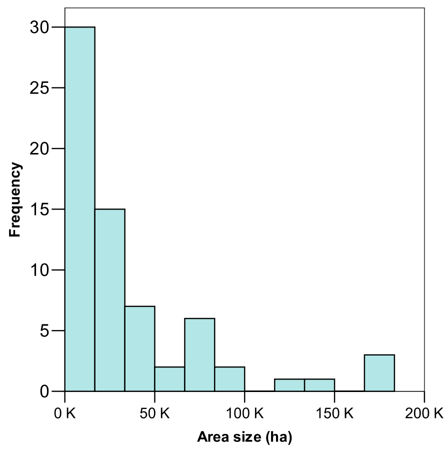


Figure 2.2 – Protected Area sizes (Mean = 35.7K; Std. dev. = 44.0K; N = 67)

In terms of usage, measured in number of visitors per year, the Managers of all Parks that monitor their numbers of visitors stated that their Parks receive more than 5,000 visitors per year. Of these Parks, as many as 14 had more than 1 million visitors (see Figure 2.3).

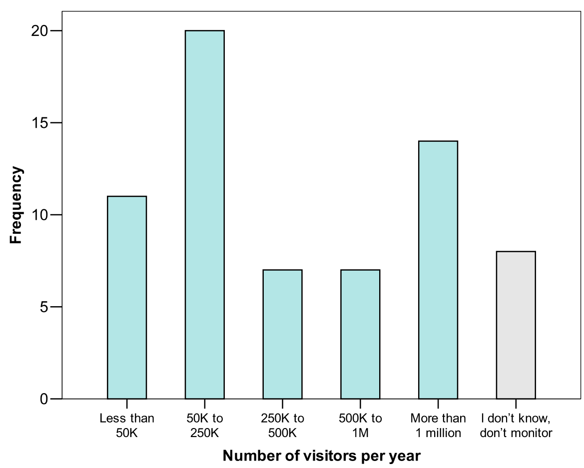


Figure 2.3 – Annual frequency of visitor to the Protected Areas (N = 67)

The same heterogeneity was not found regarding the management types as defined by IUCN (see Box 2.1). Most of the Park Managers (more than three-quarters) who answered the survey stated that their area is included in the IUCN's Area Management Category *II.*, i.e. *National Park*, a *Protected Area managed mainly for ecosystem conservation and recreation*. Figure 2.4 shows the percentage distribution of the IUCN categories for the sample survey. To understand the representativity of our sample, it was necessary to compare it with the overall distribution of the population.

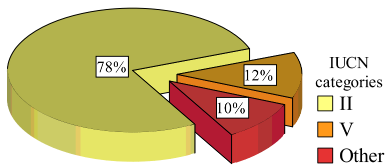


Figure 2.4 – Distribution in percentages of IUCN management categories amongst the survey sample (N = 67)

Box 2.1 – Protected Area Management Categories (IUCN, 1994)

Category Ia
Strict Nature Reserve: Protected Area managed mainly for science.
Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.

Category Ib
Wilderness Area: Protected Area managed mainly for wilderness protection.
Large area of unmodified or slightly modified land and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.

Category II
National Park: Protected Area managed mainly for ecosystem conservation and recreation.
Natural area of land and/or sea, designated to:
1. protect the ecological integrity of one or more ecosystems for this and future generations;
2. exclude exploitation or occupation inimical to the purposes of designation of the area; and
3. provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Category III
Natural Monument: Protected Area managed for conservation of specific natural features.
Area containing one or more specific natural or natural/cultural feature which is of outstanding value because of its inherent rarity, representative or aesthetic qualities or cultural significance.

Category IV
Habitat/Species Management Area: Protected Area managed mainly for conservation through management intervention.
Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

Category V
Protected Landscape/Seascape: Protected Areas managed mainly for landscape/seascape conservation and recreation.
Area of land, with coast and seas as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, cultural and/or ecological value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

Category VI
Managed Resource Protected Areas: Protected Area managed mainly for the sustainable use of natural ecosystems.
Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

UNEP & WCMC (2006) compiled the 'World Database on Protected Areas', a reference document that lists all the recognized Protected Areas in the world. Comparing this resource with the survey sample, major differences were found. The most important difference for this study is in the proportion of the areas classified as Category II, National Parks. While in our study this proportion is more than three-quarters (78 per cent), only 4 percent of the Protected Areas in the world belong to the same Category II. While this finding does not invalidate the results, it does limit their extrapolation to the universe of Protected Areas. The findings from this survey mainly represent the views of Park Managers from the two categories most represented in the survey sample, Category *II* and *V* (which encompass 90 per cent of the survey respondents). Nevertheless, this is an acceptable limitation, since these two categories are the ones that most focus on visitation and recreation (see Box 2.1 for a description of the IUCN categories) and the only ones that specifically mention visitor opportunities and recreation.

2.1.2 Visitors and information provision

Information availability is instrumental to environmental education and awareness: it increases visitors' knowledge about the environment and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO and UNEP, 1978). Environmental education is an indirect instrument for Park Managers to facilitate the protection of the area and promote its sustainable use. Kreft-Burman (2002) considers information as "one of the most important aspects of raising environmental awareness". The concept of environmental awareness is defined as a combination of three elements: motivation, knowledge, and skills. A high level of environmental awareness enables conscious choices to act in an environmentally-friendly way, therefore contributing to more eco-friendly behaviour from the visitors and thus minimizing the impact of tourism in the Protected Area.

The survey answers from the Park Managers reveal that they are aware information can be instrumental in contributing to Park sustainability. Most of the contacted Park Managers rate the importance of information supply to their visitors as "fundamental" or "very important" (see Table 2.1).

Most Parks have in place information channels to address this goal. Figure 2.5 gives an overview of which instruments the Parks have currently implemented. The high rate of adoption of these instruments is also proof of the commitment to informing visitors in the field by the Park administrators.

Table 2.1 – Level of importance of information supply to the Park visitors (in percentages; N = 67)

	%
Fundamental: Improving the level of information for visitors and their awareness is the main goal of the Park	22
Very Important: Improving the level of information for visitors and their awareness is one of the goals of the Park	70
Important: Improving the level of information for visitors is important, but there are other priorities for using the Park resources	8
Neutral: Improving the level of information for visitors does not make a major difference for the Park.	0
Not important: Informing visitors is not a core goal of the Park	0

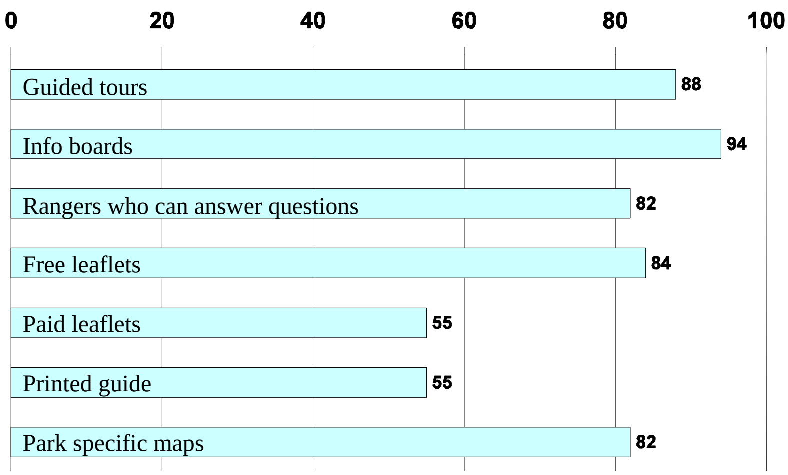
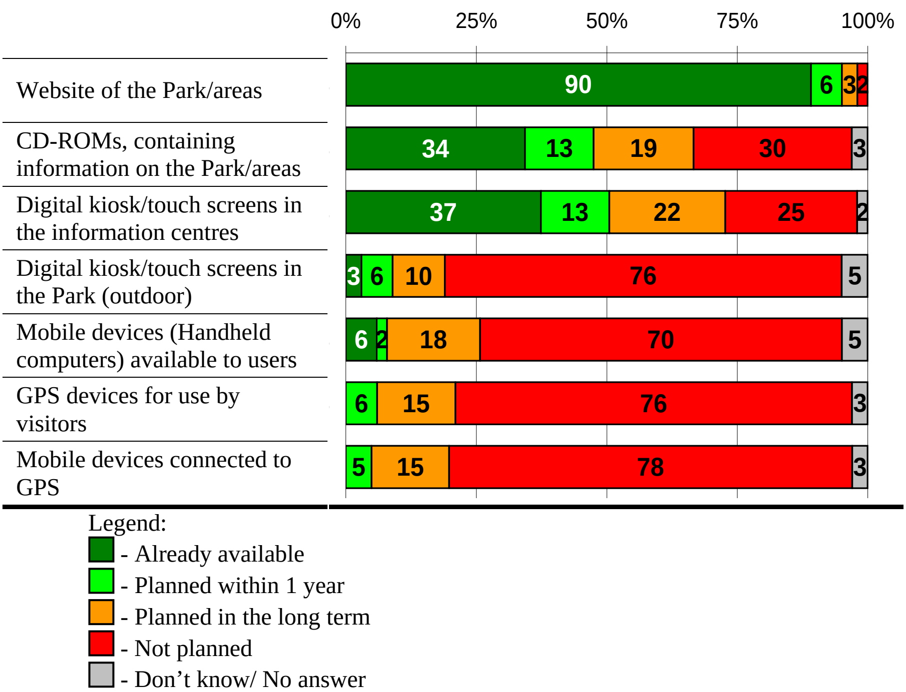


Figure 2.5 – Existing instruments to make information available to the visitors outdoors, i.e. in the field (in percentages; N = 67)

Regarding the investment in information technology for addressing the environmental awareness issue (see Table 2.2), it was observable from the questionnaire responses that websites and CD-ROMs are the only commonly used IT tools to inform the visitors. But these tools are not appropriate to inform the visitors in the field (outdoors) during their visit, the time when questions are mostly likely to occur. For example, only when hiking in the Park do visitors need to know if they are permitted to picnic or light a camp fire in the area where they currently are. The Park's website and CD-Roms typically contain rules and information of this type, but they are not accessible outdoors during the visit.

Table 2.2 – Existing IT tools available for the visitors (N = 67)



It was also observable that access to outdoor information technology (such as outdoor digital kiosks and handheld computers for the visitors) are seldom implemented and not even planned by the majority of the Park administrators. The previous results show that the majority of the ICT investment goes to the tools that are not available outdoors (while visiting the Park). However, the majority of Park Managers agree about the importance of informing visitors outdoors and specifically about their surroundings (Table 2.3). Park Managers understand and agree that information provision can influence the behaviour of the visitors towards a more eco-friendly attitude, acknowledging therefore the value of information as a tool to aid in the quest for sustainability in their Protected Areas.

When asked about the main institutional goals of their area (see Figure 2.6), approximately half of the contacted Park Managers consider leisure as a main goal, though the large majority of the Managers consider environmental education as a main mandate for their Park.

Table 2.3 – Park Managers' opinion regarding the relationship between information and eco-behaviour and the importance of informing visitors about their surroundings (N=67)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No answer
Information provision to visitors changes their behaviour	21	66	12			1
The visitors who are better informed about the Park make more eco-friendly decisions	18	73	6			3
Users are interested in receiving information during their outdoor visit to the Park	27	60	9	1		3
It's important to warn visitors in the field about the proximity of sensitive areas or dangers depending on their location	22	39	19	12	3	4
It would be good to inform visitors about the surroundings of where they are walking	18	64	9	1		7

Legend: Strongly agree; Agree; Neutral; Disagree; Strongly disagree; No answer

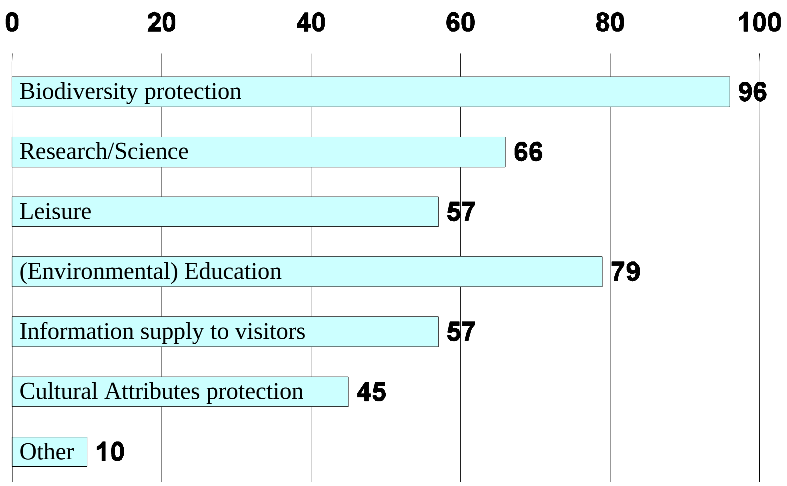


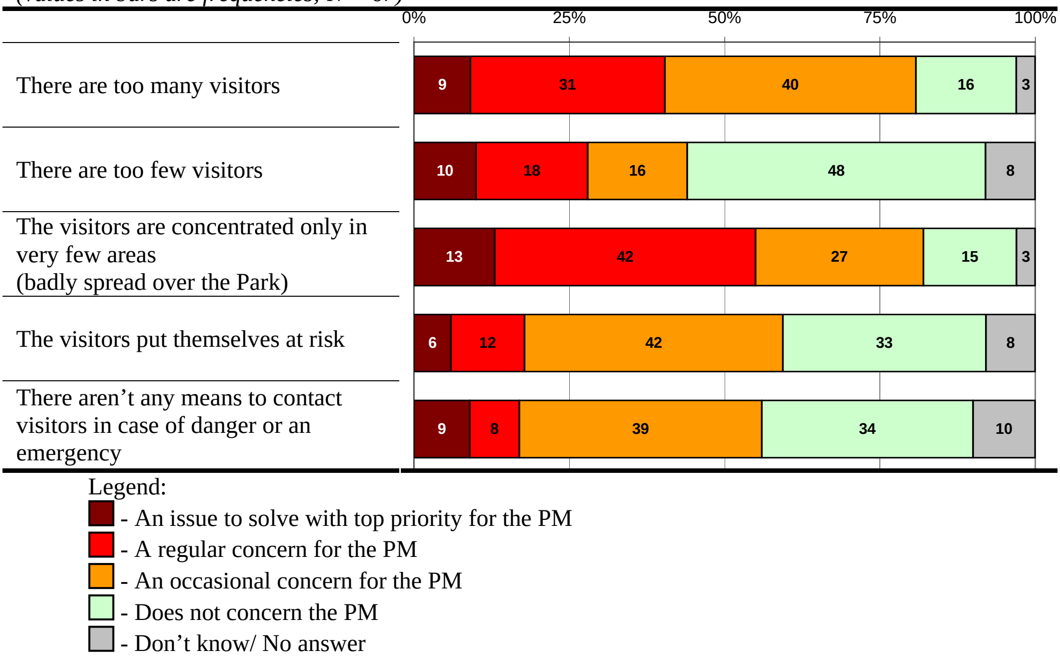
Figure 2.6 – Main institutional mandates of the contacted Protected Areas (in percentages; N = 67)

It can be proposed that some of the effort from the Park administration in developing infrastructure to facilitate tourism/leisure (and therefore increase the number of visitors) should be steered to the improvement of the existing tourism experience by providing access to information and consequently increasing the levels of environmental awareness, since most of the Parks do not have a problem with a reduced number of visitors. On the contrary, most Parks have an issue with too many visitors (see Table 2.4).

2.1.3 Visitors' spatial distribution within the Park area

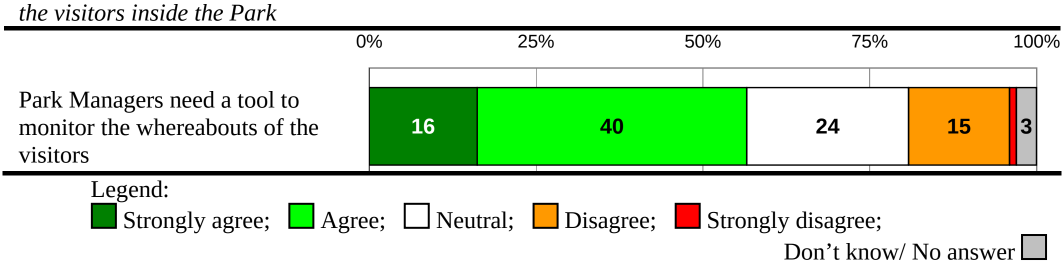
Most of the contacted Park Managers think the distribution of the visitors within the Park is an important concern for the Park Management (see Table 2.4). Any approach to tackle this issue, starts by knowing the location of the visitors in the Park.

Table 2.4 – Visitor management issues rated by the Park Managers (PM)
(values in bars are frequencies; N = 67)



The necessity to contact visitors in case of danger or emergencies was classified as an issue that does *concern the Parks' administration*. This issue is reinforced by the fact that most of the contacted Parks think that *visitors put themselves at risk* while visiting the area. In accordance with the relevance given to the issue of visitor distribution in the Park, most area administrators agree on the necessity to have a tool to monitor the visitors' location (see Table 2.5).

Table 2.5 – Opinion of the 67 contacted Parks regarding the need for a solution to know the location of the visitors inside the Park



The information that such a tool could gather would allow managers to better allocate resources and analyse the impact of tourists inside the Park. The monitoring does not have to operate at the individual scale, i.e. monitoring where a particular visitor goes, which could raise privacy issues. It can operate at different determined aggregation levels. Aggregating the visitors' spatial behaviour would enable the determination of the overall impacts related to the presence of visitors: *Where do they go?*, and *When are they there?*

2.2 Visitors' information structure and characteristics

This section specifies the evaluation and analysis of the information available to the visitors and the information needs of visitors to recreational and Protected Areas. The goal of this research was to understand the current visitor information flows, the structure and possible deficiencies during the field visit. With this understanding, it was possible to determine the system requirements for the mobile information system, i.e. if an information gap is found, system functionality can be developed to fill that gap. This exercise analysed both the supply and the demand sides and it used data from five different studies:

Information Supply side:

- Use of existing services. Abderhalden et al. (2002) uncovered the current information behaviour of tourists preparing for a visit to the Protected Area, i.e. Which available sources do the visitors access in order to be informed about the area? (see Section 2.2.1);

- Existing information analysis. The existing available information services were analysed by means of an extensive exploration of the actual information services available to the visitors. The results were previously published in Dias et al. (2002a) (Section 2.2.2).

Information Demand side:

- Visitors' questions and needs during their time in the field. Abderhalden and Krug (2003) identified the visitors' needs and questions by means of participant observation while visiting the Park (Section 2.2.3);

- Target group characteristics. In order to define the system requirements, the profile and preferences of the target group were empirically identified by means of a survey (Section 2.2.5);

- Services demand. By means of the same survey as in the previous item, the services visitors are most likely to use were also identified (Section 2.2.6).

Figure 2.7 represents the information audit process that involved the steps above and led to the definition of the information requirements. The process started with the identification of the visitors' preferences in terms of information access. Next, the structure of the current information available to the visitors was assessed. Subsequently, the visitors' information needs in the field were captured. By comparing the existing "information services" with the "needs" it was possible to identify *information gaps*, that, together with the first identified preferences, influenced the generic definition of the system requirements. Later, and to particularly define the content and structure of a specific information system, the visitors to the Park were analysed and the target group defined. Finally, the demand for services from this target group was assessed.

Steps 1 to 3 were performed for the "Swiss National Park" case study, with the intention of obtaining a generic and overall understanding of the existing information flows and structures in nature areas. The Swiss National Park was one of the partners within the WebPark project, therefore enabling unrestricted access to the entire tourist information available (essential to complete the extensive information audit, Step 1). Steps 4 and 5 were performed for the Texel Dunes case study and aimed to specify the particularities and characteristics of the information that would be delivered in the information system that was going to be tested and evaluated in this area (in Chapters 4 to 8).

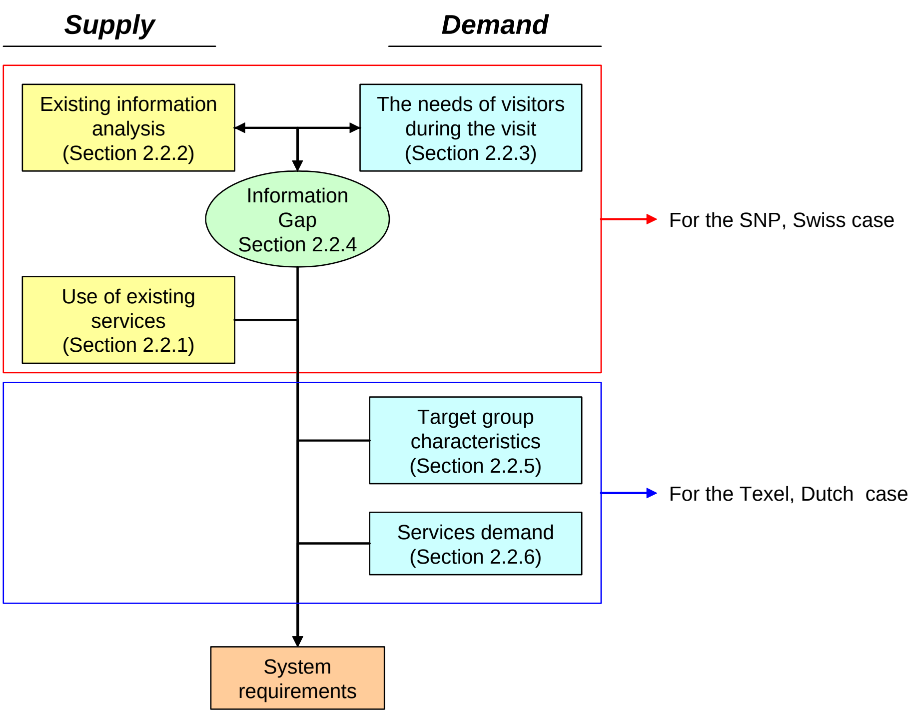


Figure 2.7 – Workflow and interaction between the different information audit components
Note: Information audit is the analysis of all available information sources in the Park and their characterization in terms of categorical content and spatio-temporal accuracy.

2.2.1 Use of existing services: How do visitors get informed?

With the help of a survey, Abderhalden et al. (2002) assessed the current information behaviour of tourists preparing a visit to a Protected Area. This research aimed to understand the actual information behaviour, i.e. to identify the mechanisms that visitors use to obtain information about the area. Table 2.6 lists and ranks the information sources in order of popularity.

Table 2.6 – Information sources used to prepare a visit to the Swiss National Park N = 1520, adapted from Abderhalden et a.l (2002)

Rank	Source	Frequency	Per cent
1	Internet	977	64.3
2	Maps	925	60.9
3	Leaflets	737	48.5
4	Books	657	43.2
5	Friends/Relatives	381	25.1
6	CD-Rom	370	24.3
7	No opinion	26	1.7
8	Other	24	1.6

These results show that the *Internet* is the most popular way to get information about the Park. The second most used source is *paper maps*. This leads to an interesting conclusion: visitors seek digital dynamic information (*Internet*) in combination with geographically enabled data (*maps*). The third source in terms of preferences was *Leaflets* (which are intrinsically mobile: they are intended to fit in a pocket and to be taken onto the field trip).

These findings are the basis of the design of the mobile information system. The system is developed in a way that it can integrate these two familiar information sources (Internet + maps), and it has to be portable.

2.2.2 Existing information analysis

The goal of this step was to evaluate the existing information services in recreation/Protected Areas in terms of what information is currently available and its spatio-temporal relevance, i.e. information audit. The first step of the information audit was to identify the relevant materials provided by the Park Management that are currently available to the visitors. Table 2.7 lists the media sources types and titles that were extensively analysed.

Table 2.7 – Media sources analysed in the information audit

Media Type	Source Title
Multimedia CD-ROM	CD-ROM DIBIS: National Park
Specialized Journal	CRATSCHLA - Information on the National Park 1/2001
Tourist Documentation	A guide to walks in the Swiss National Park by Klaus Robin
	Along the Swiss National Park nature trail by Hans Lozza and Richard Keller
	FOCUS: Munt la Schera - The Geological cycle - tourist leaflet
	Swiss National Park - tourist leaflets
Website	http://www.nationalpark.ch

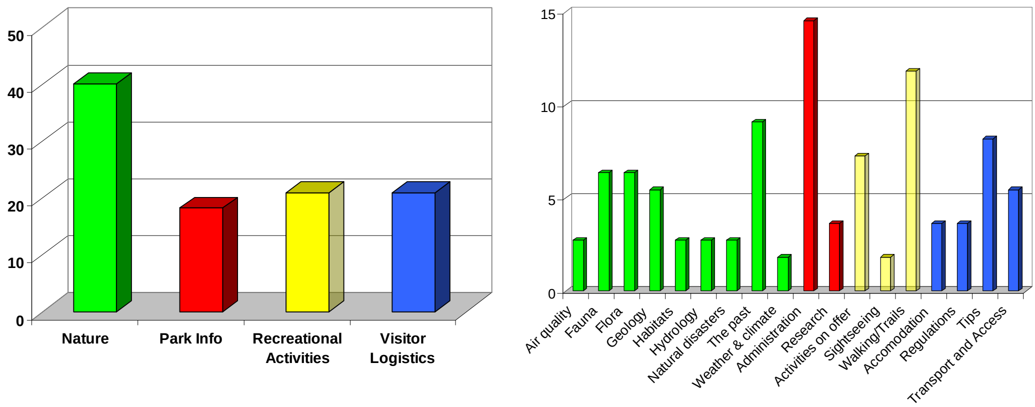
In the analysis, questions were identified that could be answered by the currently available materials. The choice to identify the questions that could be answered by the materials instead of directly classifying the information was made so that the results from this exercise could be compared with the actual information needs assessment phase (in the following section). Therefore, although the answers, i.e. the original texts, were analysed, they were translated into questions that were answered in the sources. The questions identified were as generic as possible, corresponding to blocks of information that tourists could typically use. A question like “What does the Red deer eat?”, although it is answered in the materials, it is very specific and if used would lead to a too meticulous list of all the information available, inadequate for future comparisons. That specific question was integrated into a generic block: “Habitats and behaviour of the animals in the Park” that can also be compared to a question such as “What does the Red deer eat?”

The information was classified in four different dimensions: *Categories*, *Subcategories*, *spatial sensitivity*, and *temporal sensitivity*.

Thematic categorization

The Categories and Subcategories were established based on the information itself. The main Categories found were “Nature”; “Park info”; “Recreational activities” and “Visitor logistics”. Regarding the Subcategories, 18 different classes were defined.

110 “blocks” of information/questions were identified. Figure 2.8 shows the distribution of the questions between Categories and Subcategories and provides an overview of the extent (i.e. data availability) of each information category. If a majority of questions are allocated to a certain category, the more extensive is the information available regarding that specific category.



a) b)

Figure 2.8 – Percentage of questions per Category (a) and per Subcategory (b)

Note that the actual needs of visitors in the field were also classified by means of a similar process which allows comparison between the information supply and demand. The results of the available information (Figure 2.8) are as follows:

- “Nature” is the category with the most questions (45 per cent);
- “Recreational activities” were covered by 21 per cent of the questions;
- The category “Park info” contains 18 per cent of the questions, and;
- Visitor logistics accounts for 16 per cent of the questions.

Spatio-temporal sensitivity

The spatial sensitivity of the information blocks was classified according to the spatial resolution that describes the information, corresponding to different levels of accuracy in location determination technologies (LDTs), as defined in Beinat and Dias (2003).

Table 2.8 – Spatial sensitivity classes and examples

Spatial sensitivity	**Spatial Granularity**		**Information sample**
	Min. accuracy	LDT Min. accuracy can be obtained by means of:	
Independent	Spatially irrelevant	-	Who manages the Park?
Low	1 to 30 km	Cell ID	What is the weather like in the Park?
Medium	30 m to 1 km	Network-enhanced Cell ID or E-OTD	Which animal species have their habitat along the trail X?
High	Below 30 m	GPS	Where to stay (hotels, camping, and huts)?

Because different technologies (e.g. Cell-ID, GPS) are able to deliver different positioning accuracy, four classes were identified in terms of the spatial sensitivity (see Table 2.8 for classes and examples). It was important to understand the spatial sensitivity and relate it to the technology that is able to deliver such sensitivities, in order to choose the appropriate technology for the information delivery. The spatial granularity was defined on the basis of two components, the minimum accuracy that is used to deliver the information and the corresponding Location-determination technology (LDT) that can enable such accuracy.

The temporal sensitivity of the information was classified according to the classes in Table 2.9. The temporal granularity parameter refers to the temporal detail available (or expected) from the source materials. It refers to the information block update frequency and it was calculated based on its changing rate (or updated frequency).

Table 2.9 – Temporal sensitivity classes and examples

Temporal sensitivity	Temporal granularity	Examples
Static	Time independent	When and why was the Park founded?
Low	Less than once a year	What are the main ongoing research projects?
Medium	Several times per year	Which animals can I see in the Park? Depends on the season.
High	Several times during one month	Essential equipment: what to take and wear? Depends on the climate and weather.
Real-Time	Changes during the day	How to get there by bus or train? Timetables.

The distribution of the questions in relation to the different temporal sensitivity and spatial sensitivity parameters is illustrated in Figure 2.9. It is easy to see that the largest set of questions is independent of time and space.

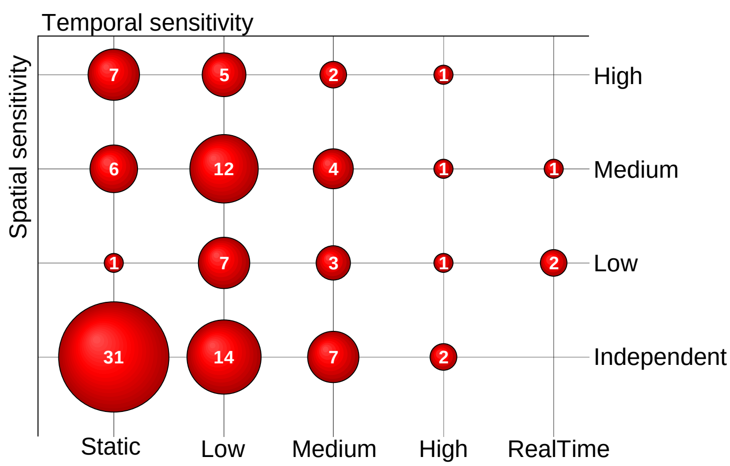


Figure 2.9 – Temporal and spatial sensitivity of the information on offer

Figure 2.9 shows that most of the information available in the visitors' sources has a low degree of spatio-temporal sensitivity. The next section will analyse the actual needs for information expressed by the visitors.

2.2.3 The needs of visitors during the visit

Abderhalden and Krug (2003) applied the method of participant observation to assess the needs of visitors. Participant observation is a popular and widely-used research method in anthropology and ethnography studies, but it is also applied in other scientific fields such as consumer behaviour and marketing (McDaniel and Gates, 2002) or software engineering (Lethbridge et al., 1998). Participant observation is defined as 'the involvement of the analyst in the activities of the people in the context he is studying'. The researcher is able to get a more accurate insight into the values, dynamics, internal relationships, structures, thoughts and conflicts from the observed actions of the individuals/communities, rather than from their normative statements. The observer should (as much as possible) participate in the activities and generally 'immerse' him/herself as deeply as possible in order to understand and document them (Malinowski, 1922).

In the case of assessing the needs of visitors while visiting the Park, the participant observation was implemented through "shadowing". The researcher accompanied the visitors while they visited the Park, in an attempt to detect and record the visitors' problems and questions. The recorded questions were categorized into topics (e.g. fauna & flora, landscape & navigation, Park regulations, history) and classified according to their spatial sensitivity (information that is intrinsically geographical or not). Figure 2.10 displays the results of the questions' spatial sensitivity. The questions with a spatial reference were predominant, 64 per cent of a total of 203 recorded questions (in several observation sessions). Questions without spatial reference accounted for just 36 per cent of the total questions, but were often triggered by a spatial position. For example, the question "Have the marmots started to hibernate?" which has a temporal reference, but no apparent spatial granularity, was triggered by a spatial position since the question appeared in an area where marmot lairs could be observed.

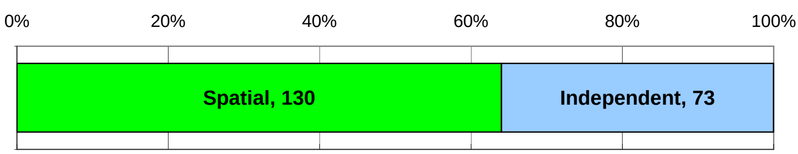


Figure 2.10 – Field questions divided between independent and spatially relevant, adapted from Abderhalden and Krug (2003).

The geographically relevant questions were then thematically categorized (see Figure 2.11). Most of the 130 questions with a spatial reference concern the topic navigation and landscape (41), flora (30), fauna (26), and geology/geomorphology (19). Most of the questions without spatial reference (from a total of 73) concern the topic fauna (24) or flora (20). Only a few questions apply to historical themes or research or the Park in general (Abderhalden and Krug, 2003).

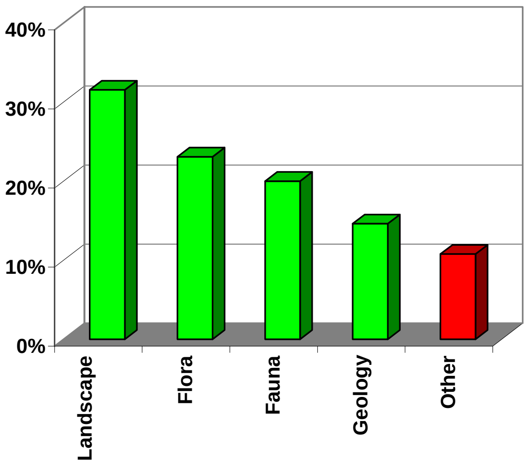


Figure 2.11 – Field questions discriminated per category (in percentages and N = 130), adapted from Abderhalden and Krug (2003)

2.2.4 Information Gap

The comparison of the information demand (based on questions asked during the shadowed field Park visit) and the information supply (based on questions that can be answered by available materials: CD-ROM, Leaflets, website, maps and brochures) in terms of the topics/categories covered does not indicate major gaps. For the actual needs of the Visitors, the majority of the questions were related to ‘nature’ (fauna + flora + geology), and it is also the topic ‘nature’, from the existing information services, that contains most of the available information. In contrast, the temporal and spatial characteristics of the information available (Figure 2.9) are discordant with at least the spatial characteristics of the information demand: there is a clear mismatch. In the previous section, we found that most of the questions from the visitors have a high spatial component, while most of the questions identified in the materials did not have, or have a very limited, spatial component.

In order to satisfy the visitors in terms of information needs in the field, the system must deliver an extensive and diverse collection of ‘Nature’ information, and the existing information should be extended by assigning geographic relevance to the current information blocks. Furthermore, the information that is intrinsically not geographic (e.g. information about the behaviour of animals) should be associated with geographical locations where the need for such information will arise (e.g. the animal habitats or places from where visitors can see the animals). It could also be hypothesized that the visitors mainly raise space-specific questions because they had already had access to non-space-specific answers. Nevertheless, a detailed qualitative analysis of the questions indicated that the field questions were answered by the available materials, although because of their lack of geographic relevance, it proved difficult for non-experts to connect the spatially independent answers to the spatially relevant questions.

The previous sections discussed the information structure and flows in the Swiss National Park. In the framework of this PhD research the valuation tests would be performed in the Texel Dunes National Park, on an island off the North coast of the Netherlands. For that reason, the investigation of the target group (visitors who will use the service) and specific content and services definition need to be investigated by questioning the visitors to the Texel area. This empirical research was carried out in the form of a survey distributed to visitors to the area (the questionnaire was distributed to passengers on a ferry boat, which is the only access to the island). The following sections describe the results that enabled the description of the target group and the definition of the most attractive content and services.

2.2.5 The target group characteristics

One question in the survey allowed a clear identification of the target group from the overall respondents of the questionnaire. The introduction of the question explained the intended Mobile Information Service and revealed whether the subjects (valid N = 178) were willing to use this service (“target group” N = 98) or not (“others” N = 80). It was then possible to analyse the target group independently and compare their behaviour with the remaining subjects (who said that they would not use the service). The cross-analysis between the “target group” and the “others” reveals some interesting differences. The target group is more willing to use their mobile phones during their holidays (see Figure 2.12), showed more willingness to use a map in the area (Figure 2.13), and has more previous experience with mobile Internet services (Figure 2.14). This indicates that the profile of the target group can be defined as more familiar with new (mobile) technologies and interested in geographic concepts (maps). In terms of the delivery mechanisms, the user group stated a preference to read the information displayed on the device screen (57 per cent) as opposed to other solutions.

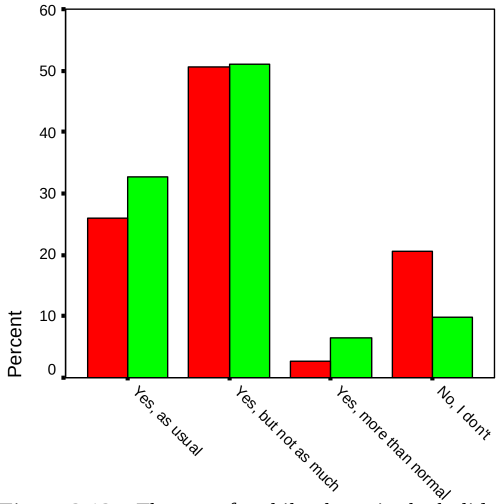


Figure 2.12 – The use of mobile phone in the holidays (N= 178, target = 98)

Legend: ■ - Target group; ■ - Others

Note: The target group appears to be more willing to use the mobile phone on holidays

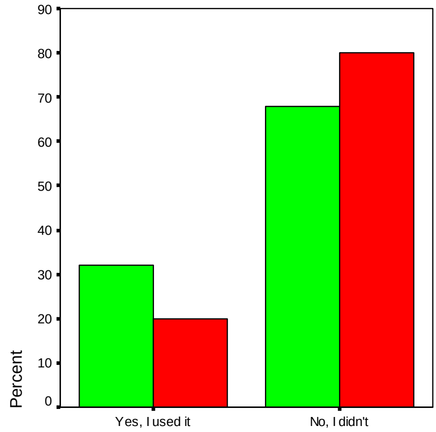


Figure 2.13 – Map usage in the area (N= 178, target = 98)

Legend: ■ - Target group; ■ - Others

Note: People who said they would use the service indicated more use of a map than the others.

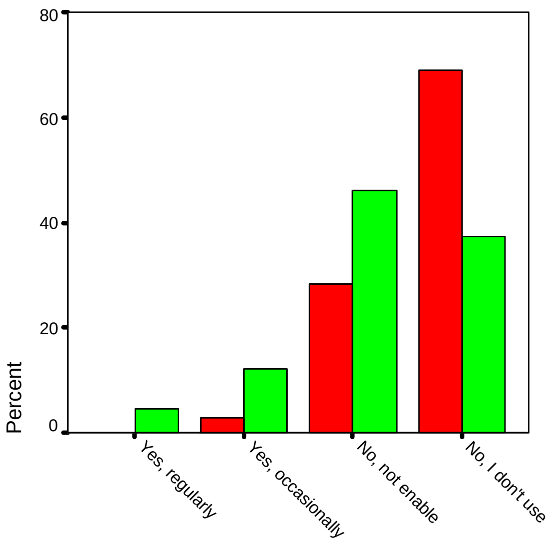


Figure 2.14 – Actual use of mobile Internet on the phone (N= 178, target = 98)

Legend: ■ - Target group; ■ - Others

Note: Most respondents do not use these services; nevertheless, the “target group” uses more internet on their phone (almost 20 per cent) than the “others” group (almost 5 percent).

2.2.6 Services demand: services the visitors are most likely to use

One of the survey questions asked the subjects to rate possible information services. The most important services identified by the target group were "*Maps and other information for orientation purposes based on the actual position*" and "*Safety information such as severe weather warnings, location of shelters*". Table 2.10 summarizes the responses for six possible information services classified according to preferences.

Table 2.10 – Importance of information services

N = 98	Important	Nice to Have	Less important	Not necessary
i) Maps and other information for orientation purposes based on your actual position	38.0%	33.8%	14.1%	14.1%
ii) Information on tidal flats, mud-walking possibilities	33.8%	41.6%	10.4%	14.3%
iii) Information about vegetation and animals	16.7%	43.6%	24.4%	15.4%
iv) Local information about current research projects	7.0%	23.9%	39.4%	29.6%
v) Thematic maps: for example, geological, tidal maps	16.7%	41.7%	18.1%	23.6%
vi) Safety information, such as severe weather warnings, location of shelters	62.5%	26.4%	2.8%	8.3%

2.3 Conclusions

To understand the managers' perspective, 67 Park Administrators were contacted and asked about information provision to tourists and general tourism management issues. The results of this questionnaire indicate trends and reveal common issues: Park Managers are concerned about the distribution of visitors inside the Park, such as high local concentrations that cause a significant disturbance to the environment, and acknowledge the relevance of tools to monitor the whereabouts of tourists. Safety issues are considered important by almost all Park Managers, such as warnings for visitors in the field about the proximity of dangers (e.g. extreme weather conditions, avalanches). Almost all of the Park Managers refer to *environmental education* as one of the main institutional mandates of the Parks and expect users to be interested in receiving information during their outdoor visit to the Park. This implies that Park Managers link information provision to visitors' behaviour: visitors who are better informed are expected to make more eco-friendly decisions. These opinions and beliefs were collected mainly from the Managers of National Parks in Europe and are therefore representative of common trends and directions just for National Parks in Europe.

To understand the information demand side, the Park visitors' needs, opinions and behaviour were assessed by means of user-surveys (questionnaires) and visitor monitoring (participant observation / shadowing). Surveys were carried out in two case-study areas: the Swiss National Park and the Texel Dunes National Park in the Netherlands. Previous work had identified the needs of the Park visitors during their visit using participant observation by following the users on a field trip and recording all information needs/questions (Abderhalden and Krug, 2003). This step also assessed the degree of location dependency for the information needs (i.e. if the questions are dependent on where in the Park the visitor is or not). The information needs that are intrinsically geographic (e.g. "What is the name of that lake?" or "Are we still inside the Park?") account for more then half of the total number of questions. These needs were then compared with the existing information provision. The existing information was audited (all information sources in the Park were analysed and the available information characterized in terms of categorical content and spatio-temporal accuracy). The results reveal that the information content available matches the information requests in the Park, but this information lacks the spatio-temporal accuracy requested by the visitors. There is no need to develop new information, but the existing provision should be spatio-temporally enhanced. In terms of existing information behaviour, the media mostly used by the tourists are, firstly, the Internet, then maps and, in third place, leaflets. These results can be translated into system requirements or characteristics of the system, i.e. the information system should present updated and digital information, like the Internet information; it should have geographical significance, as the maps have, and it should be easy to carry into the Park (preferably pocket-size) like the leaflets. Therefore, the content of existing materials should be adapted to fit the delivery on the small screen of mobile devices and enhanced with higher spatio-temporal sensitivity.

3 Context-Aware Services: from theory to practice

This chapter introduces the concepts of Context-aware information services and of Location-based services. Context-aware services are services that automatically adapt their behaviour (filtering or presenting information) to the context of the user. Although context can be defined by one or more parameters (e.g. who the user is; where the user is; when the information is being requested), we will focus primarily on the Location parameter. Services that make use of the location component are called Location-based services and are considered a particular subset of context-aware services.

Subsequently, we present an implementation of context-aware services for Natural Areas. Within the framework a research and development project, WebPark, two prototypes were developed for the two case-study areas, the Texel Dunes National Park, in the Netherlands; and the Swiss National Park. In Section 3.3, we present the system, its key-functionalities and architecture, and subsequently, the data preparation process.

As identified in Chapter 2, most of the information made available by the Park Managers lacks the geographical component that is required by the visitors. To tackle this issue and to increase the added value of the information for the field visitors, a procedure was defined to enrich the available information with location sensitivity.

To conclude the chapter, some recommendations and lessons learned are shared and discussed.

3.1 Context awareness

One of the earliest applications to make use of context to support work processes was the development of the *Active Badges system* at the Olivetti Research Lab (Want et al., 1992). This application focused on the hardware design and implementation of badges and networks of infrared receivers and on top of this pioneer installation, a call-forwarding software application was built that enabled the company employees wearing badges to have their telephone calls directed to their present location. This simple, but powerful location-aware tool was later extended using other context dimensions when badge wearers were able to manage the call-forwarding process with information such as: who they are with; where they are; and the time of day (Want and Hopper, 1992).

The term 'context-aware services' was first introduced by Schilit and Theimer (1994) to describe the services that provide clients with information about located-objects and how those objects change over time. Schilit et al. (1994) proposed the first definition for context-aware computing and described four categories of context-aware applications. These are: proximate selection; automatic contextual reconfiguration; contextual information and commands; and context-triggered actions. These early studies opened a new research field and many implementations of context-aware applications followed. Some examples include the *stick-e* document framework (Brown, 1996), the archaeological assistant (Ryan et al., 1997), a tour guide entitled CyberGuide (Abowd et al., 1997), a tourism application called the Guide system, and the CARISMA project (Cheverst et al., 2000). Applications in the entertainment domain include the use of hypermedia applied to the mixed reality concept (Romero et al., 2004; Romero and Correia, 2003) and for the tourism domain, several applications were built. For example, an application that uses context to help visitors in museums (Kuflik et al., 2007) and applications that inform visitors to Protected Areas, such as the WebPark application (Dias et al., 2004). These technological developments were accompanied by theoretical developments in order to define context and context-awareness (Fickas et al., 1997; Pascoe, 1998). In the literature, the most adopted definition of context in the field of context-awareness was proposed by Dey and Abowd (2000) as: "*Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves*."

This definition means that, if a piece of information can be used to characterize the situation of a participant in an interaction, then that information is context. This implies that context is defined by innumerable dimensions that depend on the application scenario. Ryan et al. (1997) and Dey and Abowd (2000) identify **location**, **identity**, **activity**, **environment** and **time** as the most common data types used to derive context. Context-aware applications use data to answer context questions such as *Where is the interaction happening*?, *Who is interacting*?, or *When is it happening*?, amongst others.

It is important to distinguish raw context data from derived context information. Context-aware applications measure different variables or data about the user and the environment the user is in. Raw data are termed the context data and include user and environmental data. User data comprise demographic profiling and activities being performed, while environmental data usually refers to physical variables measured through sensors (e.g. light sensors, biosensors, microphones, accelerometers, location sensors). When analysing raw data (e.g. combining, filtering, categorizing), abstract and useful context information can be derived that is usable in context-aware services. Schmidt and van Laerhoven (2001) proposed a transformation between sensor data into context cues or context information to be used in context-aware applications. Küpper (2005) termed the context data as 'primary context' (main categories: Time, Location, Identity, and Activity), and the context information as 'secondary context', categorized into personal, technical, spatial, social and physical contexts. Some examples of context data being analysed to produce context information are presented in Table 3.1.

Table 3.1 – From context data to information data - transformation examples.

Primary context data	**Operation**	**Secondary context information**
Location data: captured through a GPS receiver in the form of x,y coordinates	Geocoding	*Spatial context*: Information on the street where the user is (if close to home or office)
Date and Time data: from device clock	Matching	*Social context*: Activity and grouping based on the user agenda, e.g. in a meeting with…
Luminosity: Measured by means of sensors	Categorization	*Physical context*: Device knows it is in a drawer and goes into sleep mode.
Environmental sound volume: Measured by means of sensors	Categorization	*Environmental context*: System changes its alert volumes to overcome existing environmental volume.

Location-based services (LBS) are a subset of context-aware services. Figure 3.1 shows the place of location within the primary context and its derived spatial context as secondary information that enables LBS which are a subset of context-aware services.

As explained in Chapter 1, this thesis focuses on the study of Location and only this context component will be considered hereafter. The following section presents and discusses LBS, including their related domains, the enabling technology, and application fields.

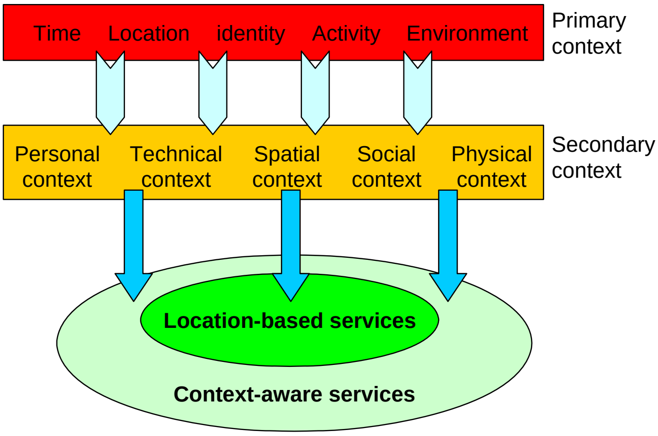


Figure 3.1 – Location-based services as a subset of context-aware services, adapted from Küpper (2005)

3.2 Location-based services

Location-based services (LBS) are a subset of the context-aware services and are often referred to in the literature as 'location-aware services', location-related services, or just 'location services'. Most of the proposed definitions for LBS include the components of mobility, networks, and location. An early definition was proposed by Virrantaus et al. (2001), where LBS were defined as *information services accessible with* ***mobile devices*** *through the mobile* ***network*** *and utilizing the ability to make use of the* ***location*** *of the mobile device*. More recently, the OpenGeospatial consortium (OGC, 2005), which is the main organization in defining location-related standards, defined an LBS as *a wireless-IP service that uses geographic information to serve a mobile user* or *any application service that exploits the position of a mobile terminal*. The three identified components in the definitions link the concept of location-based services to three different domains. The concept of 'mobile' refers us to the field of mobile and ubiquitous computing; the concept of location brings in the knowledge from Geographical Information Science; and the concept of networking refers to the developments in the Internet and the World Wide Web. Brimicombe (2002 in Shiode et al., 2003) illustrated LBS as an intersection of technologies: namely "Geographic Information Systems", "Internet" and "New IT" devices. We have adapted this illustration to the domains (instead of technologies) that relate to the LBS (see Figure 3.2). The domains from which LBS build upon are "Mobile computing", the "Internet" and "Geographical information Science". A review of each of these domains can be found in Section 3.2.1. It is interesting to note on Figure 3.2 that while LBS are the intersection of the three domains in the intersections for each pair of the three domains, other technologies have emerged such as wireless Internet, Mobile GIS and Web GIS.

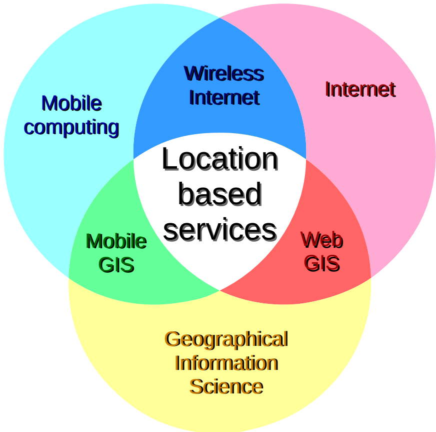


Figure 3.2 – Location-based services as an intersection of domains, adapted from Brimicombe (2002 in Shiode et al., 2003)

3.2.1 Related domains

Weiser's (1991) work on mobile computing was pioneering, but from that date many have contributed to the development of a mobile computing vision and to the implementation of computing beyond the desktop personal computer (Imielinski and Korth, 1996; Stojmenovic, 2002). In the past decades, other theoretical and technical developments related to mobile computing have occurred that led to the emergence of the concepts of 'nomadic computing' (Specht and Oppermann, 1999) and 'ubiquitous computing' (Weiser, 1999). Ubiquitous computing is a human-computer interaction model where the information processing is expected to be integrated into everyday objects and activities. Reviews of the concept of Ubiquitous computing can be found in Abowd and Mynatt (2000) and Camara (2002: pp. 223). This concept is used interchangeably with the concepts of 'pervasive computing' (Camara, 2005; Hansmann et al., 2001), 'embedded computing' (Want et al., 2002) and 'invisible computing' (Norman, 1998).

Stanton (2001) provides an overview of the topic of mobile computing and related fields, but for the LBS discussion, the main factor is that mobile computing and in particular the emergence of wireless handheld portable devices enables a novel palette of possibilities in information services. The new mobile devices, such as Personal Digital Assistants (PDAs), Smartphones and the like, have common characteristics (such as portability, multimedia capabilities and network connectivity) that allow for the presentation of dynamic, up-to-date information to individuals, not bound by space.

Knowledge from the domain of Geographical Information Science and Systems (GIS) is key to the development of LBS. Often the term 'GIS' is used to refer to Geographical Information Science and there are established views that differentiate GIS as a tool or a science (Wright et al., 1997) . Being aware that these terms are not equivalent, since Geographic Information Science is the science that deals with spatial problems, while Geographic Information Systems are the computerized tools or technology that this science uses to solve the problems (Longley et al., 2005), these two concepts are closely interlinked. In the remainder of this study, the acronym GIS will be used for both GISystems and GIScience. If one of the two is meant, it will become clear from the context or the full name is used.

The added value of GISystems has been discussed and proven in many different fields such as urban planning (Nijkamp and Scholten, 1993), participative planning (Dias et al., 2003) , Health sciences(Scholten and de Lepper, 1991) , transportation (Buurman and Rietveld, 1999) and ecology and nature conservation (Dominy and Duncan, 2002). The reason why GIS is successfully used in such disparate sciences is related to its ability to integrate different types of data using a common unique identifier, the location. It allows for attribute data that describe the non-spatial proprieties of objects in space to be linked using the location, or analysed using techniques that make use of the spatial relationships (e.g. distances between objects). Examples of technologies that relate to GIS include remote sensing, automated mapping, image analysis, spatial decision support systems, spatial databases and positioning systems. For this reason, several different definitions of GIS can be found in the literature. Maguire (1991) and Burrough and McDonnell (1998) provide overviews of definitions, but most define it from a functional perspective (Fischer et al., 1996). Worboys et al. (2004) define a Geographic Information System as a "*computer-based information system that enables capture, modelling, storage, retrieval, sharing, manipulation, analysis and presentation of geographically referenced data*".

Although the technology of LBS results from the intersection of the three domains, other technologies have emerged from the domain relationships where only two of the domains intersect (see Figure 3.2).

Mobile GIS are the deployment of Geographic Information Systems on portable handheld devices and represent a combination of Geographical Information Science and the Mobile Computing field. The best-known example of this intersection is the Arcpad© software application, developed by ESRI (Clarke et al., 2002). Mobile GIS combine the advantages and added value of mobility and geodata handling and are therefore mostly used for fieldwork. While diversity and mobility are characteristics that pose specific difficulties for the design, implementation and evaluation of mobile GIS, Wagtendonk and de Jeu (2007) have demonstrated its added value for an scientific data collection framework in a archaeological fieldwork setting.

Wireless Internet is the intersection of the Internet and the mobile computing domains. Increasing marketing attention has been given to this field as a result of the effort that the telecom operators are making in bringing Internet access available to their mobile consumers using UTMS standards (Samukic, 1998). The *Wireless Internet* is now an established technology and Church et al. (2007) recently analysed the mobile information research habits of more than 600,000 European mobile Internet users.

The combination of GIS and the Internet gave birth to what is known as '*WebGIS*', where users (usually non-professional) can have access to simple analytical and visualization tools on the web, not needing dedicated software. The most evident example is the webmapping technology where users can dynamically create their own maps and perform spatial queries in web-hosted applications. For a review on this topic, see Peterson (2003).

3.2.2 Location determination technologies

Technologies which are able to provide location information to applications and are commonly called 'Location Determination Technologies' (LDTs), 'geopositioning technologies', or 'positioning systems' (Kolodziej and Hjelm, 2006). These technologies have been in continuous development for several decades, and different technologies operate at different scales and produce different levels of accuracy. The scales range from global, available in the whole world, to only confined indoor locations, while the accuracies achieved are as low as kilometres to centimetres. Figure 3.3 provides an overview of some of the most common location and identification technologies, distributed along their accuracy and operation scales.

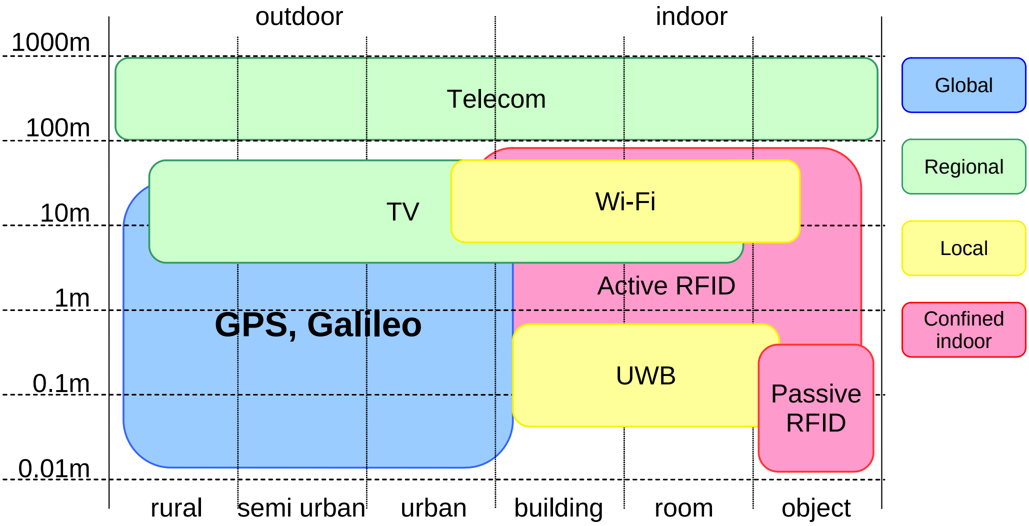


Figure 3.3 – Positioning technologies: accuracy and operation scales, adapted from Beinat et al. (2007)

Location information can be measured or determined in a variety of ways using different techniques with varying degrees of accuracy, coverage, cost of installation and maintenance. Amongst others, location determination technologies include (see also Figure 3.3): the telecom network Cell identifier (Cell-ID), the Global Positioning System (GPS), radio frequency identification (RF-ID) and Ultra-Wide Band (UWB). Hightower and Borriello (2001) classified the LDTs in three main categories based on the techniques used to locate people, objects or both: 1) *Triangulation* which uses multiple distance measurements between known points; 2) *Proximity* that simply defines nearness to a known point(s); or 3) *Scene analysis* that examines a view from a particular point.

A different classification, based on where the computing of the location is performed, is relevant for the telecom operators: *network-based positioning* and *device-based positioning*, but hybrid solutions also exist (Swedberg, 1999). *Network-based positioning* refers to the calculation performed on the basis of the wireless data network infrastructure and Cell-ID provides the simplest, but also most inaccurate solution (Swedberg, 1999). Every device connected to a telecom operator is associated with a cell, and wireless communication is based on the ability to locate the devices so that communication can be established with the handsets. If the location of the cell is known, then also the approximate location of device is automatically known. Using signal run time between the device and the base transmitter station, different methods can be applied to calculate the position more accurately. *Device-based positioning* is when the location calculation is performed at the device itself. The most common example is the GPS receiver. GPS is a network of satellites, monitoring stations and inexpensive receivers used for location data determination and capture. The GPS satellites constantly transmit coded radio signals that indicate their exact position in space and time and the GPS receivers can determine their own position on earth based on the length of time it takes for the signal from the satellite to reach the receiver on the ground. Standard GPS receivers can determine the location at accuracies of 5 to 10 metres. Nevertheless, there are several error sources that can negatively affect this accuracy. One of the main limitations of GPS is the necessity to have three or more satellites in unobstructed view to collect measurements. This can be a problem in dense forests or urban areas with tall buildings and also makes GPS an inappropriate system to use in indoor environments. For indoor environments, other LDT systems had to be devised. There are numerous systems available that calculate a user or object in a space or grid, based on a mathematical model (not necessarily with earth coordinates, but referencing to the local space), these systems are often referred to as “local positioning” systems and typically make use of short-range networks such as *IEEE 802.11*[3]; Bluetooth[4]; RF-ID[5]; UWB[6];or TV radio signals[7]. These systems are typically used for indoor location and are represented in their own local and relative (rather than global) reference system. Local systems typically provide location information in relation to a specific origin or qualitative location information (e.g. the floor in the building or room number where the device is). On the other hand, the global

[3] IEEE 802.11 is a set of standards for wireless local area network communication, developed by the IEEE Standards Committee (IEEE, 2004).

[4] Bluetooth is an industrial specification for wireless personal area networks using short-range radio frequency. For details see the specifications (Bluetooth SIG, 2007).

[5] RF-ID is an identification method that uses a small tag that can be incorporated into the subject/object for the purpose of identification using radio waves. For details on this technology, see Finkenzeller (2003).

[6] UWB: Ultra-Wide Band is a radio technology that can be used for short-range high-bandwidth communications. For details, see Foerster (2001).

[7] The use of synchronization signals that are part of the standard for Television set forth by the Advanced Television Systems Committee to calculate positioning (Rabinowitz and Spilker, 2005).

positioning system provides measurements using a universal reference system, known as the World Geodetic System 1984 (WGS84), which means that the location is represented as a pair of geographic coordinates valid world wide. Kolodziej and Hjelm (2006) provide an extensive and comprehensive overview of LDTs which they refer to as ‘Positioning systems’.

Since the present study focuses on outdoor spaces, protected natural areas, GPS was the most interesting technology on account of its high accuracy, seamless outdoor availability, and low integration costs.

3.3 Implementing context-aware information services in Natural Areas: the WebPark experience

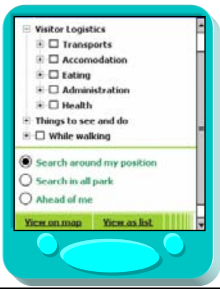
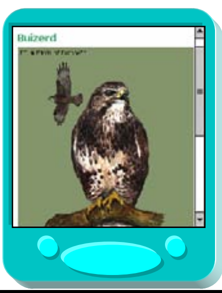
In this section we present the implementation of the concepts of context-aware services (and in particular Location-based) in a nature area. These developments took place within the framework of the WebPark project (IST-2000-31041), a research and development project funded by the European Commission that developed a series of personalized Location-based services (LBS) for users of Protected Areas. The WebPark consortium was composed of six institutions: Geodan Mobile Solutions, the Netherlands; City University London, United Kingdom; EADS Systems & Information, France; LNEC, Portugal, Swiss National Park and University of Zurich, Switzerland. The system was designed to meet the needs of visitors and Park Managers that emerged from the assessments described in Chapter 2. WebPark is meant as a personal digital guide for visitors and is designed for field use. The system was tested in the Swiss National Park (Switzerland) and on the Island of Texel (the Netherlands). The system implemented context awareness using three different types of context: spatial context, personal context, and temporal context. Since the focus of this thesis is on uncovering the added value of location in information management in Protected Areas, the spatial context management (that includes the LBS technology) will be discussed in detail in the remainder of this chapter. Still it is worth noting the other perspectives. The personal context was implemented through the choices of personal preferences. The visitors could state their preferences (whether they prefer information on fauna, on flora or on geology, for example) and the system would adapt the content accordingly. Regarding the temporal context, the system was aware of the date and time and would only present the information relevant to that particular moment (e.g. it did not display information on flowers that were not currently in bloom).

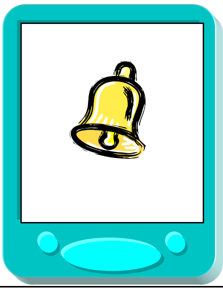
The development of the system showed that technology is mature enough to deploy mobile-context-aware applications. However, most of the data available at the Protected Areas is not ready to be used in such applications. Section 3.4 below elaborates on the complex process of data management for LBS and data handling processes.

3.3.1 Implemented key-services

A prototype was developed by the WebPark team, and its main services are presented in Table 3.2.

Table 3.2 – Main features of the implemented prototype

	**Feature:** Where am I? **Description:** Visitor self-locating on a digital topographic map (through GPS positioning) **Notes:** A shifting cross continuously indicated the current location of the user preventing him/her from getting lost and enabling him/her to plan the visit better.
	**Feature:** *What's around me?* (spatial question) **Description:** Search for points of interest such as hotels, restaurants, bike rentals or Nature information (fauna, flora). **Notes:** The question had two components, a semantic component (or what to search) and a spatial component (where to search). Different options were available: around the position of the user (using a search radius), ahead of the user (using walking models), or in all the Park (info inside the Park boundaries).
	**Feature:** *What's around me?* (spatial answer) **Description:** Visualize accessed information on a map. Information such as the location of a POI or the location of the habitat of an animal. **Notes:** The answers to the spatial questions could be visualized in the form of a list or overlayed on the map.
	**Feature:** Species information **Description:** Access species information (fauna and flora): description and multimedia data. **Notes:** Species can be sorted by habitat closeness to the visitor (location filter for easier identification).



Feature: Location warnings

Description: Receive location-based warnings concerning proximity to interesting landscape features with facts and multimedia about these features.

Feature: Location-based bookmarks

Description: Insert location-based comments (e.g. animal spotting, Parking place). These comments can be private or public. Public comments are shared online with other visitors.

The user could start interacting and exploring the system through an initial page that acted as a portal to the implemented services (see Figure 3.4). One of the services that deeply exploited the use of the location component was the "*What's around me?*". This service dynamically listed the information enabled features that were close to the user, i.e. the service would create a page that contained links to the multimedia information about interesting features (for which information was available) that were relevant to the visitor (see Figure 3.5).

Figure 3.4 – The systems start portal screen mock-up

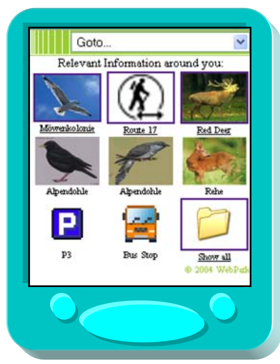


Figure 3.5 – What's around me? Service mock-up implemented as a thumbnail list

The relevance list would automatically update, based on the visitors' current location and context. In this way, the system could answer questions that the visitor has related to the environment she/he is exploring, since the system is making available only the information relevant to the current context of the visitor.

3.3.2 The system

From the Mobile Computing field, several hardware choices were available. It was decided to use a Personal Digital Assistant (PDA) device, which is a portable handheld multimedia device (see example in Figure 3.6). The portability advantage implies a number of limitations for these devices, such as small screens (typically 320x240 pixel resolution), limited processing power, and running on batteries which provide limited autonomy. Different operating systems (OS) are available for these devices, but it was chosen to focus on the PocketPC 2003 OS developed by the Microsoft Corporation. The reason for this choice was that this OS provided a relatively effortless integration and presentation of multimedia information. The connectivity between the PDA and the GPS receiver was set-up using a Bluetooth wireless connection.

Finally, it was necessary for the system to connect without cables to the web. A wireless connection providing freedom of movement was available through the device, and the system could therefore also connect to the Internet. GPRS[8] and UMTS[9] were two data transfer protocols tested at the case-study sites.

Figure 3.6 – WebPark system running on a PDA

[8] GPRS: General Packet Radio Service is a Mobile Data Service available to users of GSM mobile phones. It is standardized by the 3rd Generation Partnership Project (3GPP).

[9] UMTS: Universal Mobile Telecommunications System is one of the third-generation mobile phone technologies used in Europe and also standardized by the 3GPP. For 3GPP specifications see the website: http://www.3gpp.org/specs/specs.htm.

The WebPark consortium chose to develop the system using the JAVA programming language both for the client application and for the server applications that handled the online requests. This language was originally developed by the SUN Corporation and, from May 2007, is available as free software under the GNU General Public License (SUN, 2007). This language has another specific advantage of being platform-independent, which means that programs written in the Java language run similarly on any supported hardware/operating-system platform. It is then possible to write a program once, compile it once, and run it anywhere.

The type of areas targeted in this study are Nature Areas. This has an impact on the system design as these are rural environments that typically have only partial coverage for wireless communication availability. To cope with this partial coverage condition, the WebPark services do not rely on full-time permanent connection, and not even on constant bandwidth. When online, the services access the full range of data, available at the server side. When offline, the services work (seamlessly) with locally stored data. The collection of locally stored data can be built up on-the-go, by downloading and caching bits of information accessed in context-relevant occasions or fully deployed on the device before the visit.

3.3.3 System Architecture [10]

The most important components of the system architecture are graphically represented in Figure 3.7.

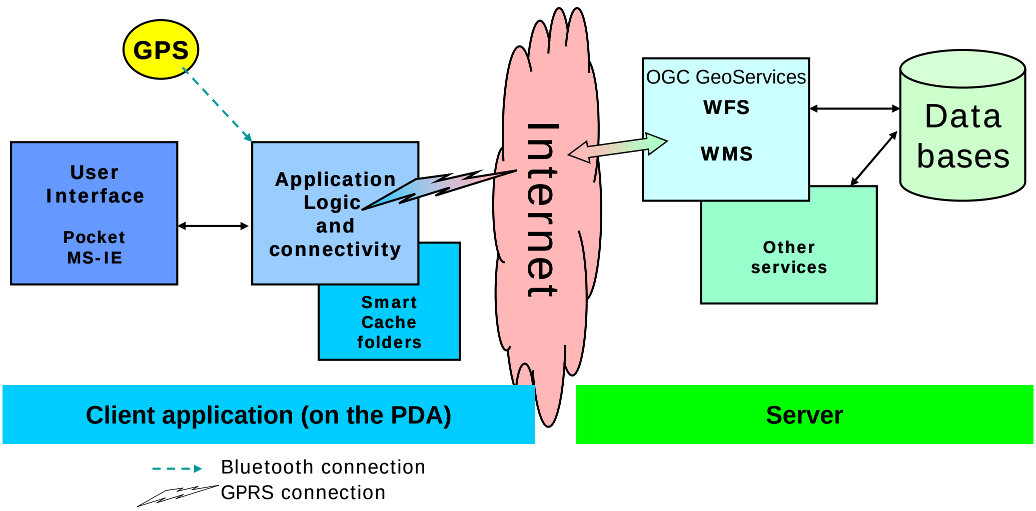


Figure 3.7 – System architecture

[10] Adapted from the WebPark report "*D3.1.1. GI interoperability platform*" (Dias et al., 2002b): http://www.webparkservices.info/deliverables.html

From left to right, the user interacts via the *User Interface* that is deployed as a web-based interface and accessed with a PocketPC browser. The multimedia information and maps are presented on this component to the user. The user interactions and the *GPS* locations are interpreted at the *Application Logic* component that then serves the appropriate information from the *Smart Cache Folders*. The *Smart Cache Folders* is a caching mechanism enhanced with spatial intelligence, and it has WebPark-specific rules for data management. A normal cache would store all downloaded features and, when full, delete the oldest information. WebPark proposes that the information downloaded is managed based on spatial relevance, where multimedia content and map tiles are not deleted based on download order, but are updated based on spatial relevance. When the cache is full, it would start deleting the information and tiles most distant from the user. This logic is based on the assumption that the user will have a higher need to consult information about features close to his location. If the information that needs to be presented to the user is not available at the cache level, then the application will use the *Connectivity* component to connect to the *Internet* and to communicate with the online *Server* applications.

The server applications for data provision are the Web Feature Server (WFS) and the Web Map Server (WMS), these services can deliver information about features (in a predefined XML structured language) and maps, respectively. These services are compliant with the standards defined by the Open Geospatial Consortium (OGC). The OGC is a network of key players in the geographical information market who define standards for data sharing and management. By implementing a client application that was compliant with the OGC standards, the WebPark system guaranteed that it was not limited to pre-defined data sources or data formats. The system can use any data provider that also conforms to these standards.
Other services could include, but are not limited to, map generalization, emergency assistance, or location-based pricing (for access to the Park and/or information).

3.3.4 Testing

The service was tested in two sites, the Island of Texel, just off the Netherlands coast, and the Swiss National Park. Tests were performed with visitors (Figure 3.8), with Park rangers (Figure 3.9) and professionals from the education department (in the Dutch case). The tests aimed at collecting the visitors' reaction to the functionality and performance of the system. Tests with local Park rangers and local education professionals, who are the most knowledgeable persons in the Protected Area, provided valuable insights on the usefulness of the application and its specific content.

Figure 3.8 – WebPark tests with real visitors to the Protected Area in Texel

Figure 3.9 – Functional tests with a Park ranger from the Protected Area in Texel

3.4 Data preparation [11]

The WebPark system can be viewed as a publishing tool that allows information sharing of local knowledge with the visitors. Geographic information (GI) and multimedia content needs to be adapted or created in order to meet the accuracy required and therefore the visitors' expectations.

The (GI) content needed for the WebPark service could be divided into the 'background' (static and reference data) and 'foreground' types (dynamic and processed data). Typical background geographic information consists of topographic base map data, e.g. roads, paths, coastlines, water features and boundaries; false colour

[11] Work done in collaboration with Alistair Edwardes, Department of Geography, University of Zurich. See Dias and Edwardes (2005) and Edwardes et al. (2005) for details.

imagery classified by landcover; terrain information, public service, and safety information. By contrast, foreground geographical information contains processed and interpreted information and multimedia, such as animal distribution, location of Points of Interest (POIs), flowers in bloom, up-to-date photographs, and other multimedia information.

In order to prepare the GI content for WebPark, an extension to an Extract-Transform-Load (ETL) (Vassiliadis et al., 2002) process was defined. Figure 3.10 illustrates the extended ETL process.

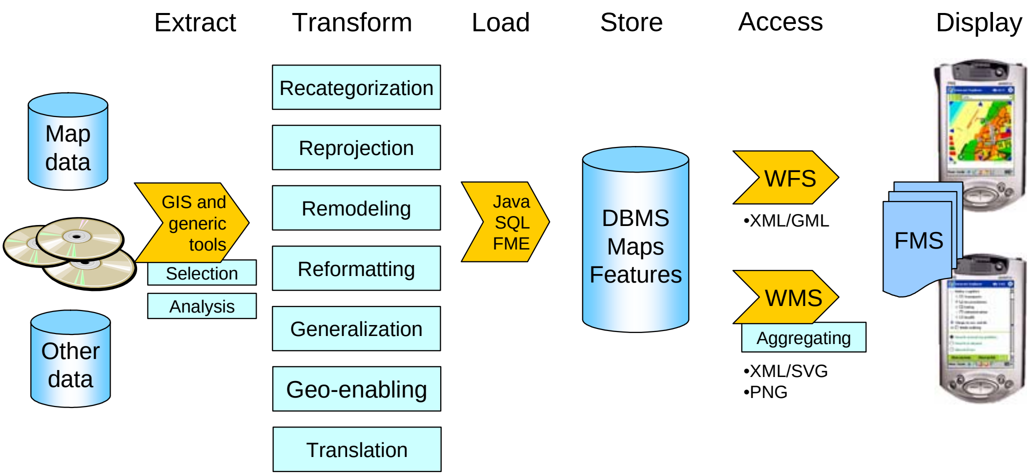


Figure 3.10 – Data handling flow to prepare information for the context-aware application

The process can be considered a linear process that starts with the determination of available datasets (information audit) and ends with the display of the information to visitors. It can be considered an ETL process, as the data is extracted from its original storage medium, transformed in order to cope with the specified data model and loaded into a database. The extraction step also involves the analysis of the data in order to select a relevant data subset (occasionally not all attributes from a data set are relevant and the geo-extent of the data sets should also be limited to area of interest). The selected data is then transformed through a set of operations necessary to harmonize and standardize the data according to the WebPark data model. These operations may involve recategorization, reprojection, remodelling, reformatting, generalization, geo-enabling or translation, depending on the data set:

- *Recategorization* – this involves structuring features hierarchically by subcategorizing them according to their essential/cognitive qualities, i.e. into one universal Park semantic tree system.
- *Reprojection* – spatial data is projected into a single coordinate system.

- *Generalization* – this involves applying various geometric processes such as filtering linework and aggregating features that are too small or are defined with semantics that are too detailed.
- *Remodelling* – the data model of the data source needs to be harmonized to the WebPark data model.
- *Reformatting* – heterogeneous data formats for multimedia content need to be converted into the formats understood by the WebPark technical components.
- *Translation* – WebPark information is served in English, French, German and Dutch.
- ***Geo-enabling*** – associating a geographically-sensitive footprint to data – described in Section 3.4.1 below on Geo-enabling data.

The transformed data are loaded and stored in the database where they can be accessed via OGC web services interfaces: Web Feature Server (WFS) and Web Mapping Server (WMS). The WMS allows retrieval of the background maps and also specific maps linked to foreground information but containing relatively static content, e.g. seasonal animal distributions. The WFS enables access to the feature data. The WFS accesses data stored in the Data Base Management Systems (DBMS) independently of the intrinsic storage structure and outputs these data in XML/GML format, which is a standard also defined by the OpenGeospatial Consortium. The data in this standard format can be readily used by the application The client application caches these data in a File Management System (FMS) and the data are used to build the styled presentation layer (e.g. on demand maps with the location of POIs and HTML lists of the animals around the visitor's position).

3.4.1 Geo-enabling Data

One of the main conclusions of the initial information audit (detailed in Chapter 2) was that there was a clear mismatch between the information currently provided by the Park and the visitor information needs. Most of the questions from the visitors had a high spatial component (e.g. "What animals can I see around me?", "Am I allowed to have a picnic here?"), while the information audit revealed that the available info did not have, or had a very limited, spatial component. A fundamental issue during the transformation process was therefore how to make these data suitable for use in an LBS. One of the main issues for the spatial data gathered for research projects was that it lacked association with background information, such as descriptive text and multimedia information. Another was that the geometry models were often insensitive to the context and geography of a visitor's location. For example, they did not consider the constraints imposed by topography, physical access and visibility. The issue with information that was specifically aimed at tourists was the lack of an association with a context-sensitive-spatial-footprint.

3.4.2 Geo-enabling multimedia

It was possible to extract the information provided by the test sites, in order to create it in the predefined structured features' format, with all the multimedia pieces of information packaged into the data model (category, text descriptions, photos, links and translations). Although the extraction was a straightforward process, there was a limitation to be solved that was the lack of association of any specific geographic space for the multimedia information. Therefore, it was necessary to extend it by means of adding a spatial component to it. The geographic component allows for the information from the Parks to be filtered based on the visitor's location, or sorted by proximity. Based on expert knowledge, the multimedia features were divided into three groups, depending on their geographical effectiveness, and extended accordingly:

- *Non-geographic* - information that is not linked to a specific location but that should still be available through the system (e.g. general rules of the Park, history);

- *Geographic* – information that is directly linked to a physical location (e.g. hotel, sightseeing spot). These data can be precisely portrayed by the mapping service. This information is defined as a point, line or polygon, and specific portrayal rules were defined for the map representation for each category (e.g. specific intuitive icons or coloured polygons).

- *Semi-geographic* – information that is not directly linked to a precise location, but that should be available in certain areas (e.g. background information about marmots). There is no GIS observations data set for marmots in the Park research database, and the precise location of where the visitors can see a marmot is not possible to determine. Therefore the information on the marmots cannot be linked to a specific point or polygon in the map. Nevertheless, based on expert knowledge, there are areas where tourists should be aware (on the lookout) for these animals, and the information on marmots should be available via the system (available as a response from the "What's around me?" query in certain areas). However, these areas or locations cannot be portrayed on the map since, most likely, the visitors will not find a marmot at such location, and it would be frustrating or at least misleading to represent an exact location for the animal. The geometries defined for these data are only to give geographic relevance to the information, and the geometries are not to be visualized on the map. The places are not real physical locations, but rather "meta-physical" locations where the visitor should have access to the information. These locations are typically defined by multipoints or multipolygons as the National Park experts indicate several locations where the tourists should be aware of the semi-geographic information.

3.4.3 Mapping

The mapping requirements for WebPark took three forms:

- *Background maps* (Figure 3.11) – typically topographic maps that allowed the visitors to locate and orientate themselves and could also be used as navigation aids by associating topographic maps with the current GPS position of the visitor. Special cartographic rules were defined as the maps are meant for display in digital small screens and to be used in outdoor environments. For example, highly contrasting and intense colours were found to be more effective in bright daylight conditions in contrast to traditional visualization recommendations, such as pastel colours (Bertin, 1983; Tufte, 1990).

- *Real-time dynamic maps* (Figure 3.12) – Point-of-interest maps, in response to users' ad-hoc queries. Here, data on features were used for searching and indexing, as well as portrayal.

- *Static descriptive maps* (Figure 3.13) – Overview maps: for instance, showing animal distributions, were examples of the static descriptive maps. They showed broad patterns that aggregated information over longer time scales (for example, seasons). These maps could be pre-computed and cached. They were then associated with the features as a form of multimedia content.

Figure 3.11 – Sample of background maps (all the island of Texel is displayed)

Figure 3.12 – Sample of real-time dynamic map displaying the location of restaurants around the visitor

Figure 3.13 – Sample of static descriptive map (seasonal animal distribution)

Temporal sensitivity

The analysis of information needs demonstrated the necessity to provide data at a range of spatial, as well as temporal, scales. The different maps can be categorized into groups, according to the temporal sensitivity of their geographic data. The maps can be divided into:

- *Low sensitivity* – geographic information that rarely changes (e.g. topographic background maps). Such maps are used for navigation and to contextualize foreground information. It is unlikely that these maps will change for several years, thus they can be pre-cached in the device (reducing the need for wireless data traffic and data updates).

- *Medium sensitivity* – corresponds to geographic data that depends on the season and that may change every year or at a maximum of two times a year. Typically derived from aggregated information, these maps are indicative of patterns rather then precise locations (e.g. thematic maps that represent animal distributions or surfaces showing the intensity of observations over time: landscape polygons are graded coloured, depending on the number of animals sightings in that polygon during the previous year). Such maps give geographical knowledge to the visitors. They enable the visitors to be aware of which animals they may encounter. These maps can also be pre-cached in the device.

- *Real-time* or updated every day – corresponds to dynamic geographical data with constant updates (e.g. observations of animals or safety conditions on a particular route/track updated by Park rangers during their walks). The information is updated in the device everyday and even several times a day, by making use of wireless connectivity when available. This opportunity allows for the definition of one interesting scenario that could be implemented for the large game Parks (for example, in Southern Africa). In these Parks, game spotting is the primary activity and, at present, visitors plan their daily trips based on maps available at the base camps where rangers and other visitors indicate with push-pins the latest animal sightings. The mapping service of the mobile information system can provide a 'virtual push-pin board' to record and map animal observations (via wireless Internet when available) in real-time. These maps are typically the navigation maps overlaid with point data sets coloured by time of observation.

Map Scales

The mapping service provides maps at four scales. The scales chosen are not exact relationships but are logical semantic scales. Because the device has a small screen, the scales were defined so that the screen would display logical geographical units, without the need for panning. The geographical units or semantic scales chosen were (ordered from the smallest to the largest scale):

- *Whole Park* (smallest scale) – displays the entire Park on the screen (no panning necessary). Useful for the visitors to locate themselves in the Park (Figure 3.11).

- *Route* – displays the entire route or hiking path on one screen. Naturally, routes differ in size and geometry and this scale is sometimes not effective for all routes. Nevertheless a compromise can be achieved.

- *Habitat* – intends to display the habitats (vegetation polygons) where the visitor is.

- *User* (largest scale) – displays the user position and 50 metres around the user – useful for the visitor to locate points of interest precisely mapped (e.g. a marmot hole, a restaurant).

Edwardes (2007) provides an in in-depth discussion of semantic scales, and in particular within the WebPark framework.

3.5 Conclusions, lessons learned and ideas

This chapter introduced the concept of Location-aware services and described the details of developing and implementing WebPark, a framework of context aware location-based service in nature areas. It is important to underline three issues/constraints that the service architecture has to cope with. First, since the user is mobile, the communication with the services must be wireless. Second, users can carry only small palm-sized devices, with strong limitations in terms of display and computing power. Third, the typical use is in Natural Areas, which may be characterized by partial wireless network coverage. To cope with the latter, WebPark does not rely on a permanent Internet connection, not even on constant bandwidth.

The analysis of information needs revealed a mismatch between the existing information and the visitors' needs for temporal-geo-information. To overcome these limitations a methodology is proposed that goes beyond the spatial definition of data towards a geographical definition that takes into consideration environmental contexts and human factors, and the temporal sensitivity issue was tackled with the aggregation of data series into temporal map scales (e.g. seasonal species distributions). Geo-enabling enhanced the existing data with a geographical component that enables the vast amounts of information available to be filtered and sorted using the positioning of the visitors. These processes augmented the potential added value of the existing data sets. The WebPark services can be built upon:

- Existing information;
- Environmental sciences research data; and/or
- Tailored collected data.

Building on existing information involves the adapting of currently delivered information to tourists (via CD, kiosk and web) to the new delivery mechanism (PDA); Environmental research data (such as animal counts and vegetation maps) can be used after a conversion process that can produce high value tourist information, such as animal location probability maps or plants species density maps. With or without existing data, local communities play a crucial role in collecting and managing content through a defined process (for example, tour guides can register the location of interesting places and present facts and multimedia to describe them), and local communities can manage logistics databases (such as restaurants and hotel details).

WebPark technology can be compared to a mobile website whose contents are dependent on the location of the user. Because it is a digital medium, the users expect high spatial, temporal and semantic accuracies. A visitor can forgive a book that still indicates a restaurant that has been closed, but the digital medium can and should overcome the up-to-date limitations of the paper media. To guarantee that the most current information is available in the system, it is important that the local population is involved and rewarded for its maintenance. Examples include the hotel owner who keeps the room rates up-to-date, or the mountain guide that keeps dynamic information about nature features (e.g. flowers in bloom or open vs. closed trails). Therefore, to produce and maintain the information, the involvement of the local knowledge is of crucial importance. The local Park rangers and the local residents are the people who have an in-depth knowledge of the area, processes and logistics that is valuable for the visitors. This means that the (typically urban) visitors can pay for that knowledge from the locals via a rental system. Therefore, innovative work positions can be created providing useful training skills for capturing and managing content inside and around Protected Areas. The WebPark system enables the valorization of local knowledge and the creation of an economic flow from the visitors to the local communities.

4 The impact of information on the visitors: a framework for empirical valuation

This chapter presents a framework for evaluating information services. One can argue that developing an information service is a fairly straightforward process. However, proving that the system actually brings added value to the users, and that it will indeed be used by the visitors in the future is where the real challenge lies. An empirical research study was designed and carried out to collect information on the behaviour, perceptions and opinions of the most central actors in the information flow processes: the visitors to Protected Areas. The following chapters (5, 6, 7 and 8) introduce and adapt research methodologies from different fields that measure the benefits and added value of the location component of the WebPark mobile information system.

This chapter can be divided into two main components: (1) it starts with a description of the relevant aspects from the test set-up: the area where it took place, the information system used, and the detailed step-by-step research procedure, and (2) it ends with the descriptive results of the empirical tests, including the demographics of the sample population and the descriptive statistics of the collected variables. The following chapters will make use of the research procedure presented here and analyse the data in-depth. Consequently, the present chapter can be considered as a basis for the subsequent analysis chapters.

4.1 The area

In order to measure the added value of location-enabling information for visitors to nature areas, a version of the system was implemented in a Protected Area. The Texel Dunes National Park, located on an island off the North coast of the Netherlands, acted as the testing ground. Part of this area is enclosed and only accessible via the Ecomare visitors' centre and museum. The Ecomare is visited by a large number of visitors, almost 300,000 in the year 2005, according to Ecomare (2006). Therefore the daily number of visitors who were potential test subjects for the empirical investigation was larger than sufficient. Furthermore, the experiments imply that a handheld device is given to the visitors and, therefore, it was necessary to assure the recovery of the device. The fact that the Ecomare Museum is the only entry and exit point to the Dune Park meant that the management of test devices could be done in an uncomplicated way. It enabled a comfortable approach to the visitors and the implementation of very relaxed security measures since the return of the devices was ensured.

Ecomare is the Visitor Centre for the Wadden Sea and North Sea on Texel, and it consists of a museum with an extensive exhibition (including the *Water Hall* with large sea aquaria), the seal and bird rehabilitation centres, the Nature and environmental educational centre (where environmental education projects take place), an information centre (gathering and disseminating information about the North Sea and the Wadden sea) and an extensive outdoor area, the Dune Park (see Figure 4.1 for a photo impression). Ecomare's goal is *to make its visitors more aware of the significance of the North Sea and the Wadden region, its flora, fauna and landscapes, hoping that its visitors will appreciate the need to preserve the area for the future* (Gaaf et al., 2005). To visit Ecomare (including the museum, the aquarium's hall, seal and bird rehabilitation facilities, restaurant and outdoor Dune Park) entrance fees apply: Adults pay €7.50; children aged between 4 to 13 years old pay €4.75, and no fees apply for children under 4 years old.

The system developed focused on the outdoor section, the Dune Park. The Dune Park is 70 hectares in size and has three trails. In the Park one can find a good impression of the various types of dunes found on Texel. Some signs along the trails inform the public about the nature and management of the Dune Park. During the high season, various guided tours to the Dune Park are offered to the visitors on various days of the week. On these tours, an expert from Ecomare explains the most important and interesting natural features so that the visitors can fully appreciate and experience the value that these terrains offer. The Ecomare tours cost € 4.50 per person (for adults and children). The popularity of the guided walks is indicative of the motivation of the visitors to learn more about this particular natural area and the environment in general.

From the available three trails in the Park, the "Blue Trail" was chosen for the testing sessions. This is the shortest trail which enabled faster individual test sessions. At normal leisure speed, this one-kilometre-trail can be traversed in 15 to 20 minutes, depending on individual walking speed and the number of explorative or resting stops. In addition, this trail was not restrictive in terms of the difficulty level. It allowed virtually all visitors to the centre to participate in the tests. The longer trails (~ 3 km) would entail longer test sessions and therefore fewer tests could be performed per day.

Figure 4.1 – Photo collection from test site
Top-left: Seal rehabilitation pools with museum building in the background; other photos: visitors walking the Dune Park paths

4.2 System and Information

Building upon the WebPark experience, a context-aware system[12] was implemented and used in the tests. In a nutshell, the system consisted of three components:

- Map with an overview of the area and information;
- Multimedia content explaining the Park's nature features;
- Software to "push" information at the right place/time.

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[12] This system was implemented in the framework of a project initiated and managed by Ecomare, and included the participation of Camineo Systems, a French company based in Toulouse dedicated to Location-based software development, and Geodan, a Dutch company based in Amsterdam specialized in Geographic Information Systems.

4.2.1 Map Development

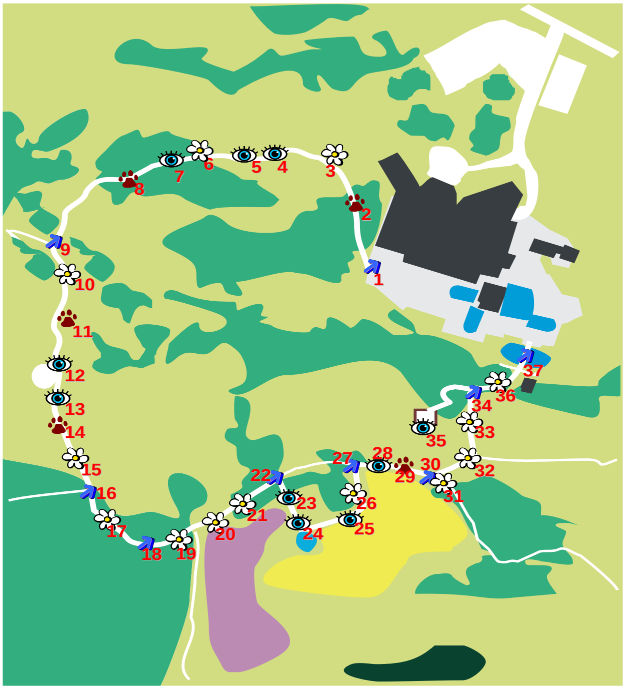
The overview map (portrayed later by Figure 4.3) represented the area of the Dune Park where the blue route is laid. This map was specifically developed for the tests using a four-step process. Figure 4.2 displays the steps and outputs of the map creation process. An up-to-date aerial photograph of the area was acquired from an online provider of remotely sensed imagery. Using ground truth in the form of GPS coordinates, the image was georeferenced, i.e. a relationship between the image coordinates and the real world geographic coordinates was established. It was intended to show a predefined optimal extent of the area on the map, corresponding to just the area where the tests took place – the Blue route – nevertheless in a way that the whole test route would fit on the small screen of the test devices (320 x 240 pixels). The image was cropped in order to obtain a subset that would serve as the basis for the map. This step also defined the scale, i.e. the size of objects in the map in relation to their real-world sizes.

The aerial photo provided too much detail and not enough contrast between the landscape features, which limited its usefulness as a background map, since the different features were not easily perceived. Therefore, it was decided to convert it to an abstract map. The abstraction process involved drawing the landscape features by overlaying the aerial photo, in order to preserve the geographic locations and the distances between them. An additional advantage of the abstraction is that it makes it possible to use a representation of the landscape that is simplified into a vector instead of using the complex raster image. This has the advantage of reducing the computational efforts necessary for the device to display the image.

Figure 4.2 – The map creation process

4.2.2 Information distribution

The map acted as a background, and an interactive layer of information with the location of the Points of Interest (POIs) was the foreground overlaid on it. The POIs are the locations defined by the Park Managers (in this case by Ecomare), where the information is relevant for the visitors. The Ecomare Information Department determined the location of the POIs using GPS receivers and developed the specific content for each location. Figure 4.3 represents the distribution of the information points along the route and their categories.



Legend:

Information on animals

Information on plants

Information on landscape

Navigation and directions

Figure 4.3 – Map available to the visitors showing the Ecomare building and the distribution of the information points along the route

4.2.3 Multimedia information content

The system provides multimedia information services in 1-screen format. The POIs' content consisted of a prominent title, a photo of the feature and a text description. The information points were classified into four categories:

- *Directions* – Waypoints indicating the path the subject should follow (Figure 4.4);
- *Landscape* – Information about landscape features visible from a certain location (Figure 4.5).
- *Plants* – Information about a particular plant visible from the path (Figure 4.6).
- *Animals* – Information about animals that is relevant at a particular point of the path (Figure 4.7).

22 – Go left

Go left here.

Figure 4.4 – Example of a navigation point

23 – Wind tree

Here you can see a beautiful wind tree. It grows from west to east, because the wind comes mostly from the west.

Figure 4.5 – Information regarding landscape features, in this example, the wind tree visible from point 23 in the path

10 – Marram grass

The Marram grass is a tough plant that resists very harsh conditions (windy and sandy places). It has very long roots that allow it to drink water deep in the ground and live where others can't.

Figure 4.6 – Information from the plants category regarding the Marram grass and relevant at the point 10

11 – Meadow pipit

Can you hear a small peeping sound? Coming from a bird that falls like a parachute from the sky? This little bird is the Meadow pipit! It eats small insects, caterpillars, snails and worms. Meadow pipits love the open terrain with low vegetation. They make their nests on the ground, hidden between the vegetation.

Figure 4.7 – Example of information about animals. The place chosen to show this information is a location where Meadow Pipits are commonly spotted

4.3 Testing Protocol

The tests took place between 22 August and 9 September 2005. Figure 4.8 illustrates the overall flow of the research protocol.

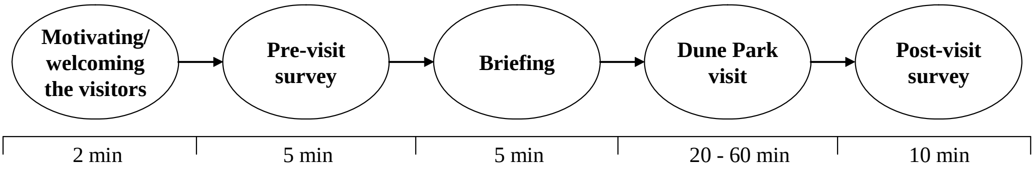


Figure 4.8 – Illustration of the research protocol

First, random visitors to the Ecomare centre were approached and asked to participate in the research (the standard communication was an adaptation of the text in Box 4.1). Because the procedure meant that some of the subjects would have access to information and others not, the discourse to motivate the visitors did not mention the information or any delivery mechanisms and focussed on the Nature valuation exercise, i.e. the visitors were asked to help on a research project regarding Nature valuation.

Box 4.1 – Discourse to motivate the visitors to participate in this study

> “Good Morning! Would you be interested in participating in a research study about the valuation of nature?
>
> It involves a walk in the Dune Park of about 1 km and filling-in two questionnaires, one questionnaire before the walk (about 5 minutes) and another questionnaire after the walk (about 10 minutes).”

The visitors who agreed to participate in the study (about 80 per cent of the approached visitors) were directed to the research control centre (see Figure 4.9). In the control centre, the subjects were asked to fill in a questionnaire (the pre-visit survey) containing questions regarding the demographic background of subjects (such as age, gender, education) and *ex ante* evaluation questions (such as willingness-to-pay for information rental and Nature valuation). The subsequent step, for the subjects to whom information was provided, was to engage them in a short briefing where the information and its delivery mechanisms was explained. Then the subjects visited the Dune Park and upon their return a second questionnaire was administered in order to collect the visitors’ perceptions and valuations regarding the visit and the information mechanism they had experienced.

Figure 4.9 – Research control centre (with visitors filling-in the post-visit survey)

4.3.1 Information delivery as an independent variable

At the research centre, the visitors were randomly assigned to one of the four research groups: one control and three test groups (see Table 4.1). Attention was paid to make sure all the groups had a balance in terms of the subjects' age and gender. The groups were defined by the information dimension, i.e. the type of information to which the subject would have access). There were four information dimensions corresponding to not having/having information and the different delivery mechanisms. The four groups are:

- ***No info* group** – visitors to the Park to whom no extra information was provided;

- ***Paper booklet* group** – visitors to the Park who were issued with information on a paper booklet;

- ***Digital info* group** – visitors to the Park who could access the information on a PDA; and
  (Note: The same information as in the *Paper booklet*, but available through a PDA application)

- ***LBS* group** – visitors to the Park who had access to the same application and information as the PDA group, but enhanced with location sensitivity.

The different groups act as the independent variable where changes are expected to have measurable effects on the dependent variables. This methodology enables the testing and quantification of three dichotomies:

- *No information* vs *Information*
- *Conventional* vs. *Technological* information delivery
- *Non-location-based* vs. *Location-based*

Table 4.1 – Test and control groups

Delivery Mechanism \ Content	**No content**	**Non-Location Based**	**Location-Based**
No medium	Control Group (*No info*)	-	-
Conventional	-	Test Group #1 (*Paper booklet*)	-
Technological	-	Test group #2 (*Digital info*)	Test group #3 (*LBS*)

Attention was paid to the demographics while recruiting and assigning subjects to the groups, in order to ensure all the groups would have identical gender ratios and similar age distributions. The subjects experienced the same route, in the same weather conditions, and the same measurement scales were administered to all the groups. The size of the samples (~ 100 subjects) is expected to filter-out individual differences (an assumption validated by comparing the individual characteristics of the groups). For these reasons, the groups can be considered identical. Therefore, if differences are observed in the results measured from the *No info* and *Paper booklet* group, it can be assumed that the differences are explained by the presence of information, since all the other variables remain constant (No information vs. Information). The same principle is applied to the observed differences between the *Paper booklet* group and the *Digital info* group, since the information content is the same (same photos and texts): the observed differences are assumed to be caused by the difference in the delivery mechanism (Conventional vs. Technological). The *LBS* group allows for the most interesting comparisons. In view of the fact that the application that delivers the information is the same as the one available for the *Digital info* group (and therefore also has the same content as the *Paper booklet* group) but enhanced with location sensitivity (explained below), differences between the two technological groups are assumed to be caused by *location-enabling the* information, i.e. by *the location's effect* (Non location-based vs. Location based). These differences are the quantification of the *added value of location* because all the other variables remain unaltered.

Location-sensitivity component: difference between LBS *and the* Digital info

The location-sensitivity, as present in the application, had two components:

- Mapping user location: the map in the first page showed a cross representing the exact location of the visitor in the Dune Park while he/she walks along the route.

- Location alerts: the information content is "pushed" to the visitor when he/she approaches pre-determined POI-specific locations. A digital recording of a cuckoo song tells when to consult the information on the device display. The page content is automatically changed to the information relevant for the current location of the visitor.

4.3.2 *Ex ante* survey, testing and *ex post* survey

After the welcoming speech, a pre-test was administered (cf. Appendix). The pre-test collected background information about the subjects. The personal features collected were Age (open format); Gender (dichotomous choice), Previous visits to the Park (multiple choice); Reasons to visit the Park (multiple choice); Work status (multiple choice); Education (multiple choice); and Income (multiple choice). In the same pre-test, the *ex ante* willingness-to-pay for visiting the Dune Park and to rent information about the Dune Park (both multiple choice) was also collected. Concluding this survey was a section that attempted to collect the visitors' perceptions of information and nature valuation before visiting the Park, the results of which could then be easily compared with the same measurements after the Park visit. The section included the visitors' appreciation of having information (on a 7-point Likert scale) and the emotional value individual visitors ascribe to Nature, in the form of a photo valuation questionnaire. Visitors have to rate photos representing nature features (from the Protected Area they were about to visit and other areas) on a 9-point Likert scale.

After the pre-survey, a briefing was given to the participants. The briefing was different for each of the groups and it depended on the information dimension. It was explained to the subjects what information they would have available for the walk, i.e. a paper leaflet or a handheld digital device. For the technological groups (*Digital info* and *LBS*), it was also briefly explained what the handheld device is and how to operate it. The subjects from the non-location based groups (*No info*, *Paper booklet* and *Digital info*) had information that was not activated by a location determination device (such as a GPS receiver), but, nevertheless, the subjects in these groups were requested to carry a GPS receiver along their walk. It should be noted that this receiver had no influence on the subjects' behaviour as it did not show location coordinates. The GPS receivers were handed out with the sole goal to collect GPS tracks in order to analyse the subjects' spatial behaviour (results presented in Chapter 5).

When the subjects returned from the Park visit, the GPS tracks were downloaded from the units and a post-visit survey administered to the subjects (cf. Appendix). This survey included a question about the matching of the visit expectations (7-point Likert scale), the *ex post* willingness-to-pay to visit the Dune Park, and the *ex post* willingness-to-pay to rent information about the Dune Park (these two questions were identical to the ex-ante questions and therefore can be directly compared). The subsequent sections of the questionnaire included measurements from the Information Systems literature in order to model technology acceptance (the results are presented later in Chapter 8). The constructs used to measure the technology acceptance were Perceived Usefulness, Perceived Ease-of-Use and Intention to use (just for the *Digital info* and *LBS* groups). In order to investigate the technology performance, questions were included that measured the perception of the visitors concerning technological characteristics such as Speed of the application or Visibility of the screen (both using 5-point Likert scales). The technology characteristics questions were administered to the *Digital info* and *LBS* groups only. Part of the questionnaire was dedicated to measuring the perception of the visitors concerning the quality of the information available, in terms of both the interest of the information and the quality of the map (using 7-point Likert scales). This survey section was not available to the *No info* group. In order to evaluate the learning efficiency of the different information dimensions, the visitors took part in a quiz to evaluate how much they remembered from the information (except the *No info* group). The last section of the post-visit questionnaire was identical to the last section of the pre-visit questionnaire and measured the perception of the visitors regarding information valuation and the perception of nature (measured by the emotional response to the same Nature photos that were used in the pre-visit survey). Using the same photos enabled us to discover whether the valuation of nature changes with the visit and whether information dimensions have an influence on the valuation.

After completing the post-questionnaire, free drinks at the museum's restaurant were offered to the visitors as a recompense for participating in the experiment and completing the questionnaires.

4.4 Analysis of results

The population for this study is the people who visit the Protected Area that is accessible via the Ecomare (described in Section 4.1.). The subjects' sample was randomly chosen from the visitors. Because the participation level was very high (rarely did an approached visitor refuse to participate), the bias introduced by self-selection can be neglected. This section presents the descriptive statistics of the background demographic variables; and the results for the learning efficiency quiz and system performance. The following chapters will analyse in detail the four variables that directly relate to the research questions. In Chapter 5, we present a detailed analysis of the visitors' spatial behaviour. Chapter 6 discusses the results from the investigation on the appreciation of Nature. In Chapter 7, we present the analysis of the economic evaluation of information by means of stated and revealed preferences. And, in Chapter 8, the technology acceptance model is used to evaluate if location-sensitivity can contribute to the adoption of the information system.

The English versions of both the pre-visit and post-visit questionnaires are in the Appendix, at the end of this thesis.

4.4.1 Age and gender

The Age variable was collected in the form of an open question where the visitors expressed their age in years. All visitors responded to this question and the descriptive statistics are presented in Table 4.2.

Table 4.2 – Age descriptive statistics from the test sample

N	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
416	11.0	73.0	41.5	14.2

Regarding gender, the results show that more female subjects participated in this study than male. This is probably because there were more female visitors to the museum than male. Table 4.3 displays the frequencies and percentages of the female and male participants in this study.

Table 4.3 – Gender distribution among the test sample

Gender	**Frequency**	**Per cent**	**Valid Per cent**
Female	228	54.8	55.6
Male	182	43.8	44.4
Total valid	410	98.6	100.0
Missing	6	1.4	
Total	416	100.0	

4.4.2 Previous visits to the Dune Park

It was important to know how many times the subjects had visited the Park before. Since this study is about information regarding the Dune Park, it is expected that the previous experience with the Park would affect the visitor's perception and information needs. The results (see Table 4.4) show that more than two-thirds of the visitors had never been to the Park and just less then 5 per cent had considerable previous experience with the Park, i.e. had visited the Park more then five times or visit it regularly.

Table 4.4 – Frequencies and percentages of the previous visits to the Park

	Frequency	Per cent
Never	289	69.5
Once	70	16.8
Two to five times	37	8.9
More than five times	11	2.6
Regularly (several times per year)	9	2.2
Total	416	100.0

4.4.3 Visit motivation

In order to correctly evaluate the perceptions and valuations of the tourists, it was important to understand the motivation of the visit, i.e. why did the subjects decide to visit the Dune Park? The subjects could choose up to two reasons from the multiple-choice options presented (see Table 4.5 for possible answers and results). Most of the visitors stated that they decided to visit the Park *to appreciate Nature*, and the second most chosen option was *no special reason*, since he or she had found out about the existence of the Dune Park only after visiting the museum and decided to visit it on the spot. The third most-frequent motivation was *to learn something about Nature*. There was also the option of “other”, which provided the opportunity to add a motivation if the visitors felt the motivation for their visit was different from the available options. The outcomes from the “*other*” collection were relatively small (only 10 per cent) and so diverse that no extra group was created for further analysis.

Table 4.5 – Frequencies and percentages of the subjects’ visit motivations

N = 416	**Responses**		**Per cent of Cases**
	Frequency	Per cent	
To appreciate Nature	167	32.3	40.5
To learn something about Nature	101	19.5	24.5
Just to have a walk	46	8.9	11.2
No special reason/coincidently	149	28.8	36.2
Other	54	10.4	13.1
Total	517	100.0	125.5

4.4.4 Work

Regarding the professional occupation of the test sample, most subjects (more than a third) worked for the private sector. Almost a fifth worked for the medical or education sector and the third most significant group was the retired. The frequencies and percentages of the different occupations are presented in Table 4.6.

Table 4.6 – Professional occupation of the test sample

	Frequency	Per cent
Student	34	8.2
Work at a private company	152	36.5
Government work (national, regional of local government)	39	9.4
Work in the medical or education sector	73	17.5
Work for a different employer than the above	28	6.7
Househusband or -wife	33	7.9
Retired	46	11.1
Retired (health-related)	11	2.6
Unemployed	0	0.0
Total	416	100.0

4.4.5 Education

It was important to know the subjects' education level because it may influence their perceptions and valuations. The most relevant result was that more than a third of the subjects of the test sample had already obtained a University degree (or equivalent). Table 4.7 presents the distribution of the test sample among the education levels.

Table 4.7 – Test sample education levels (partially not translated, since they are only valid for the Dutch education system)

	Frequency	Per cent	Valid per cent
Lower education (basic school)	26	6.3	6.3
LBO, LAVO, MAVO, MULO	78	18.8	18.8
MBO, VMBO, HAVO	127	30.5	30.7
MMS, HBS, atheneum, gymnasium	32	7.7	7.7
University degree, HBO	148	35.6	35.7
Other	3	0.7	0.7
Total valid	414	99.5	100.0
No answer	2	0.5	
Total	416	100.0	

4.4.6 Income

In order to better explain the economic valuation mechanisms, the visitors were asked to state their annual income. Six categories were defined, ranging from no income to €40,000 or more. The category to which most of the participants stated they belonged was a yearly income between €15,000 and €25,000. Even though the questionnaire was anonymous (no contact data was collected), this question revealed the highest "no answer" rate from the questionnaire. Almost 9 per cent of the subjects did not feel comfortable about sharing their income levels.

Table 4.8 – Test participants income per year divided per categories

	Frequency	Per cent	Valid per cent
No income	39	9.4	10.3
Less than €7,500	28	6.7	7.4
€7,500 to €15,000	55	13.2	14.5
€15,000 to €25,000	117	28.1	30.9
€25,000 to €40,000	94	22.6	24.8
€40,000 or more	46	11.1	12.1
Total valid	379	91.1	100.0
No answer	37	8.9	
Total	416	100.0	

4.4.7 Appreciation of having information during the Park visit

In order to understand whether the visit would change the visitors' appreciation of having nature information, a 7-point Likert scale was used to collect the value that the visitors ascribe to having information in the field about the nature area they visit, before and after the visit. Table 4.9 presents the statistical descriptives of the results for both the pre- and post-visit answers.

Table 4.9 – Pre and post visit information appreciation descriptive statistics

Information appreciation	N	Minimum	Maximum	Mean	Std. Dev.
Ex ante	414	-3.0	3.0	1.56	1.19
Ex post	412	-2.0	3.0	2.15	1.08

An interesting result is the increase in information appreciation after the visit. A possible explanation for this finding is that the visitors enjoyed and took benefit from the information they received during the visit.

4.4.8 Willingness-to-Pay for information hire

The visitors were asked how much they would be prepared to pay to hire information to take with them during the visit. The question included extra "information about the information": it mentioned that it would be information explaining the Park's natural features, including information about animals, plants and landscapes that visitors can find in the Park. The question format was a multiple choice question with ten alternative bids ranging from €0 to €3.5, and with €0.25 intervals. This inquiry was administered both before and after the Park visit. Before the Park visit, the subjects had to imagine the information and the medium in which they would be hiring it, i.e. they had not yet experienced the information. After the Park visit, the same Willingness-to-Pay question was administered. At this point, the visitors who had experienced one of the three different information mechanisms available could objectively value the information and its mechanism. Table 4.10 presents the results for the pre- and post-visit willingness-to-pay for information rental.

Table 4.10 – Descriptive statistics of the ex ante *and* ex post *willingness-to-pay (WTP) for information rental*

WTP to rent information (€)	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
Ex ante	410	0.00	3.50	1.08	0.73
Ex post	413	0.00	3.50	1.38	0.80

Looking at these results according to each information dimension, it is possible to compare the different valuations the subjects ascribe to the different information mechanisms, by calculating the average difference between the groups (*WTP after experiencing the information* minus *WTP before the visit* = ΔWTP). With this method, individual differences and perceptions are expected to be filtered out, and it is possible to isolate the real value people give to the information dimension. Table 4.11 presents the descriptive statistics of the average differences in post- and pre- WTP for information rental per dimension group, and Figure 4.10 displays graphically the same average differences.

Table 4.11 – Average difference in WTP for accessing information post- and pre- visit

$WTPi_{post} - WTPi_{ante}$ (in €)	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
No info	103	-2.50	1.50	0.05	0.68
Paper booklet	100	-2.50	2.50	0.24	0.69
Digital info	70	-1.50	2.00	0.32	0.65
LBS	134	-2.50	3.00	0.49	0.92
Total	407	-2.50	3.00	0.29	0.78

The results show that the visitors with access to Location-based Information (the LBS group) are willing to pay more than the other groups (with different information dimensions). These results indicate that this Location-based service has an added value for the visitors and that this added value can be measured and quantified using an economic construct. An in-depth economic analysis is presented in Chapter 7.

The ΔWTP for the group who did not have access to information is almost zero (€0.05). This is an expected outcome, as it means that the perception of information appreciation did not change with the visit.

Other conclusions include:

- The difference in ΔWTPs for the *No info* and the *Paper booklet*, €0.19, represents the perceived value of the information itself.
- The difference in ΔWTPs for the *Paper booklet* and *Digital info*, €0.08, indicates the perceived added value of using a technological information mechanism.
- The difference in ΔWTPs for the *Digital info* and *LBS*, €0.18, indicates the perceived added value of using a Location-enabled system.

Figure 4.10 illustrates the differences between the information valuation variations for the test and control groups. Chapter 7 is dedicated to an in depth statistical analysis of these differences.

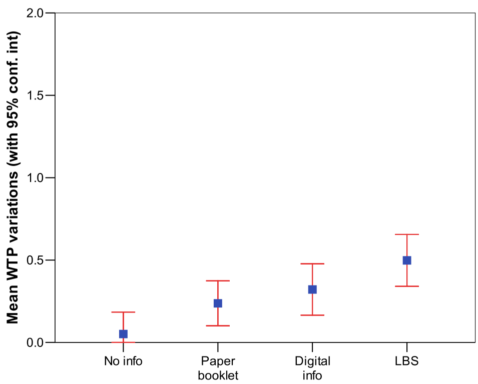


Figure 4.10 – Variation in WTP for information rental: average difference between post- and pre-visit values for the four groups

4.4.9 Expectations of visitors

The expectations (if visitors were disappointed or, on the other hand, more satisfied than expected with the visit) can have influence the process of evaluating information. A Likert scale was developed in order to try to collect the visitors' expectation matching (see the descriptive results in Table 4.12).

Table 4.12 – Descriptive statistics of the expectations matching after the visit

Expectations	N	Minimum	Maximum	Mean	Std. Dev.
	414	-3	3	1.49	1.15

Although there is a high response variation, the results prove that the visitors enjoyed the visit to the Dune Park more than they expected. The average value is located close to the middle point of the positive side of the expectations in the Likert scale.

4.4.10 Enjoyment of the Park visit

The subjects' overall enjoyment of the visit was assessed using 7-point Likert scales on dichotomous adjective pairs (*Nice - Not nice*; *Pleasing – Annoying*; *Interesting – Boring*; *Unique – Common*; *Varied - Dull*). The visitors had to classify their visit by rating it from -3 (the negative adjective) to +3 (the positive adjective). The enjoyment variable was then calculated using the average of the results from the five pairs of adjectives. This technique was chosen because the different concepts might not be understood in exactly the same way by the visitors (Interesting or Pleasing, although similar, may have slight different interpretations by the subjects). Taking the average of several concepts, the small differences in interpretation are expected to be filtered out. The constructs and their average descriptive results are presented in Table 4.13.

Table 4.13 – Descriptive statistics of the average enjoyment and its constituent constructs

	N	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
Nice – Not nice	381	0	3	2.07	0.82
Pleasing – Annoying	371	-3	3	2.02	0.98
Interesting – Boring	391	-3	3	2.03	1.05
Unique – Common	375	-3	3	1.33	1.10
Varied - Dull	363	0	3	1.86	0.91
Average Enjoyment	355	-0.40	3	1.89	0.73

4.4.11 Learning perception and efficacy

The visitors were asked to rate on a Likert scale their self-perceived learning efficacy (see Table 4.14 for descriptives per information dimension and Figure 4.11 for the graphical results).

Table 4.14 – Descriptive statistics of the self-perceived learning efficacy

Information dimension	**Mean**	**Std. Deviation**	**Skewness**	**N**
Paper booklet	1.76	1.09	-1.37	101
Digital info	1.85	0.88	-0.33	73
LBS	1.90	1.05	-1.26	136
Total	1.85	1.02	-1.17	310

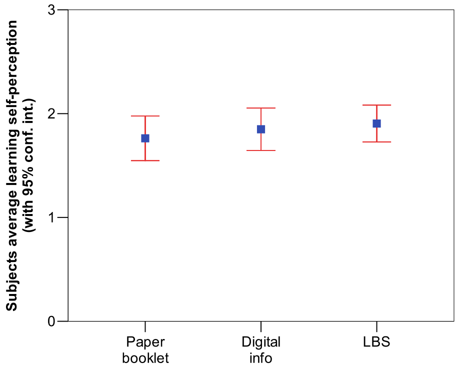


Figure 4.11 – Graphical presentation of the differences in the self-perceived learning efficacy

It is interesting to note that the self-perceived learning efficacy was identical amongst the groups. Nevertheless, the actual learning measurement showed a difference in results between the LBS group in comparison with the other two groups. A quiz was included in the survey, asking the visitors to link information points and their occurrence in the landscape, in order to measure how well the visitors remembered the information and its location. See Figure 4.12 for the quiz layout and Table 4.15 and Figure 4.13 for the average quiz results per group).

Table 4.15 – Quiz results: statistical descriptives per information dimension

Information dimension	Mean	Std. Deviation	Skewness	N
No info	Not applicable			
Paper booklet	3.08	1.71	-0.35	101
Digital info	2.68	1.56	-0.02	73
LBS	3.79	1.52	-0.92	136
Total	2.46	2.02	0.02	415

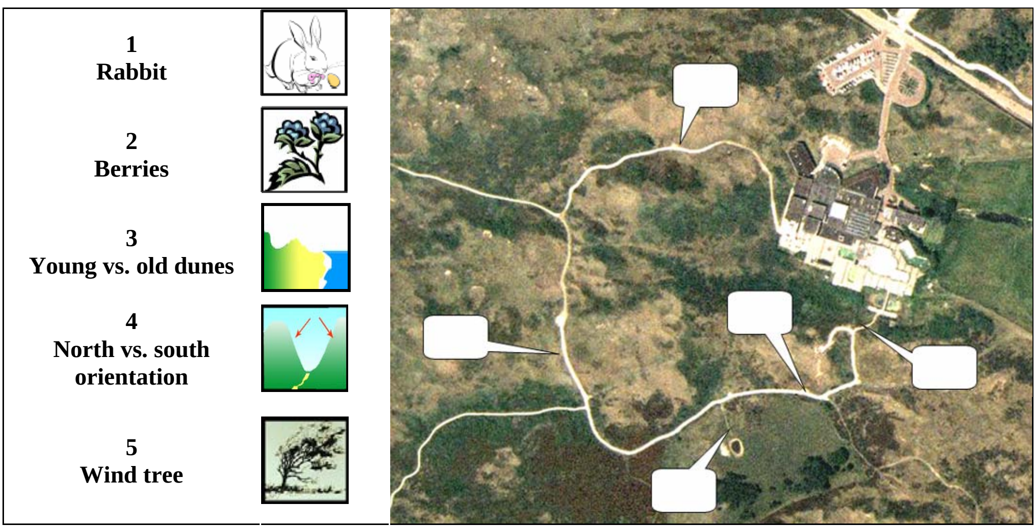


Figure 4.12 – Memory quiz regarding the Park information

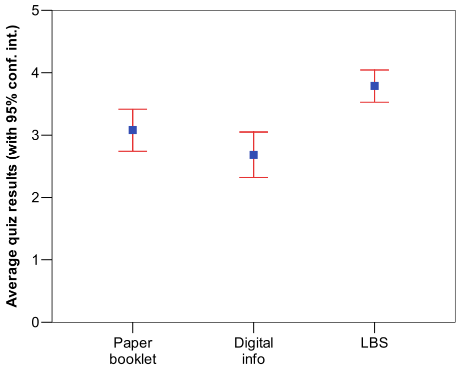


Figure 4.13 – Graphical comparison of the quiz results averaged per information dimension

Even though the self-perceived learning efficiency was identical for all groups, the *LBS* group was able to perform better in the quiz.

4.4.12 System speed

The subjects who experienced the information delivered by the handheld digital device were asked about their perception of the performance of the system. It is interesting to observe that, even though the application and system speed were the same, the *LBS* group perceived the system to be faster than the *Digital info* group did. The explanation for this may be because the location-sensitivity component (explained in Section 4.2.3) substituted for part of the interaction required to display the content and reduced the mental effort necessary to access the information, therefore changing the perception (see Table 4.16, and Figure 4.14 and Figure 4.15).

Table 4.16 – Statistical descriptives of the perceived system speed for the subjects with the information on the handheld digital device divided per information dimension.

Information dimension	**Statistic**	**Map speed**	**Menu speed**	**Average speed**
Digital info	Mean	0.66	0.56	0.61
	Std. Error of Mean	0.16	0.15	0.14
	Std. Deviation	1.35	1.24	1.17
	Skewness	-0.36	-0.63	-0.54
	N	73	72	72
LBS	Mean	1.71	1.69	1.70
	Std. Error of Mean	0.09	0.10	0.09
	Std. Deviation	1.09	1.14	1.05
	Skewness	-0.88	-0.82	-0.72
	N	138	137	135

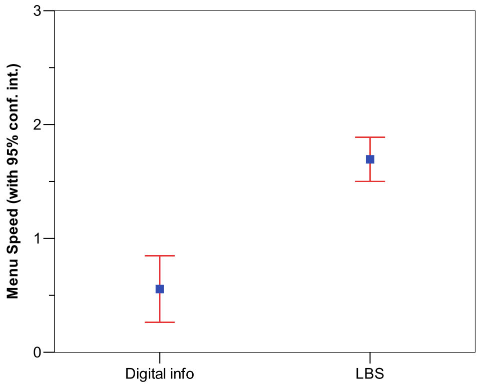


Figure 4.14 – Graphical representation of the perceived menu speed of the application.

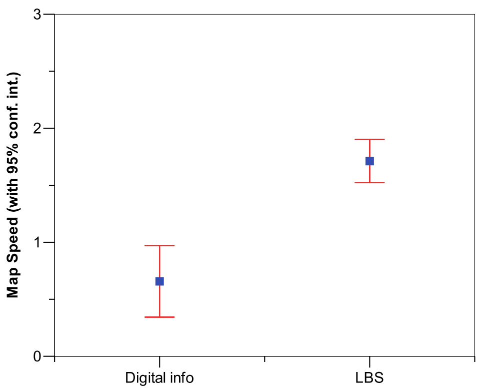


Figure 4.15 – Graphical representation of the perceived map speed

4.4.13 Screen visibility

For the screen visibility, again no differences between the information groups were expected, but in fact major differences in the perception of the visitors were found (see Table 4.17 and Figure 4.16). This variable was collected using a 7-point Likert scale ranging from the minimum negative labelled ‘*very bad*’ to the maximum on the positive side labelled ‘*very good*’. The average results for both groups were negative, meaning that both groups perceived the screen visibility to be ‘*bad*’. Nevertheless, the *LBS* group shows a higher average value that can be interpreted as, when using the location sensitive information, the screen is perceived as ‘*not so bad*’ as without location-sensitivity.

Table 4.17 – Screen visibility per group.

Visibility	Mean	Std. Error of Mean	Std. Deviation	Skewness	N
Digital info	-1.22	0.16	1.35	0.53	72
LBS	-0.39	0.14	1.70	0.24	141
Total	-0.67	0.11	1.63	0.41	213

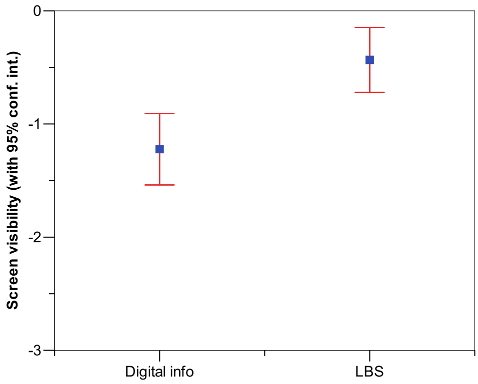


Figure 4.16 – Subjects' perception of the screen visibility, according to the information dimension

An additional study was performed in order to understand the effect of the meteorological conditions in the perception of the system. The weather was monitored and it was used to determine if it has an influence on the screen visibility. According to Figure 4.17, the visitors perceived the screen visibility as negative, regardless of the meteorological conditions. The results indicate that the screen is more difficult to read in the sunny days. The weather variable revealed little variation in our study, only 'sunny' or 'cloudy', since there were no tests performed in other weather conditions (such as rainy), because of the voluntariness of the testing sessions.

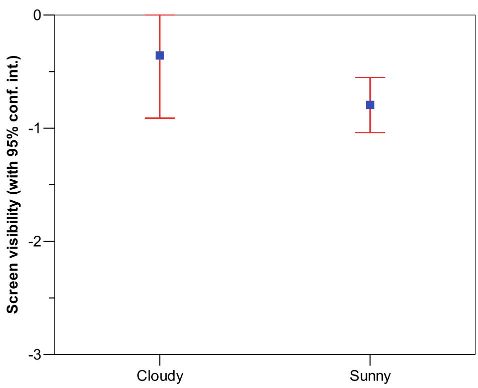


Figure 4.17 – Subjects' perception of the screen visibility, according to the weather dimension

4.4.14 Information interest

Regarding how interesting the visitors found the information they had just experienced, as expected (since the information was the same), no significant differences were found between the groups (see Table 4.18 and Figure 4.18). This perception was measured using a 7-point symmetric Likert scale ranging from "very uninteresting" to "very interesting".

Table 4.18 – Perceived interest of the information available during the dune walk

Info interest	Mean	Std. Error of Mean	Std. Deviation	Skewness	N
Paper booklet	1.78	0.09	0.90	-0.53	96
Digital info	1.88	0.10	0.83	-0.21	73
LBS	1.91	0.08	0.88	-0.36	138

This result is consistent with the protocol assumptions that the only difference between the groups is the delivery mechanism and not the information in itself.

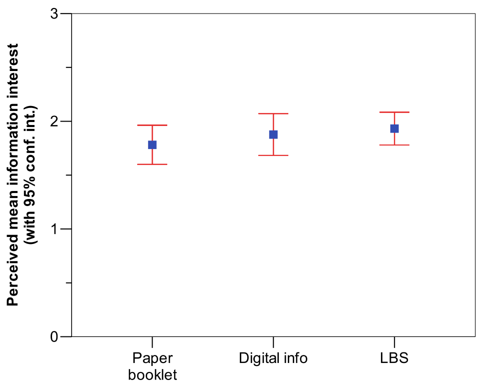


Figure 4.18 – Information perception according to the information groups

4.4.15 Map perception

Different results were found for the way the visitors perceived the map they had available to navigate in the Park and to determine the location of the POIs within the Park.

The map was exactly the same for the three information groups, with an identical scale, similar extent and even comparable resolutions (naturally, the *Paper booklet* had a superior resolution than the one that could be delivered by the digital devices). Nevertheless, the visitors with access to the location-sensitive information perceived the map has having better detail, a better overview and even that it could help them to orientate better (see Figure 4.19, 4.20 and 4.21; and Table 4.19).

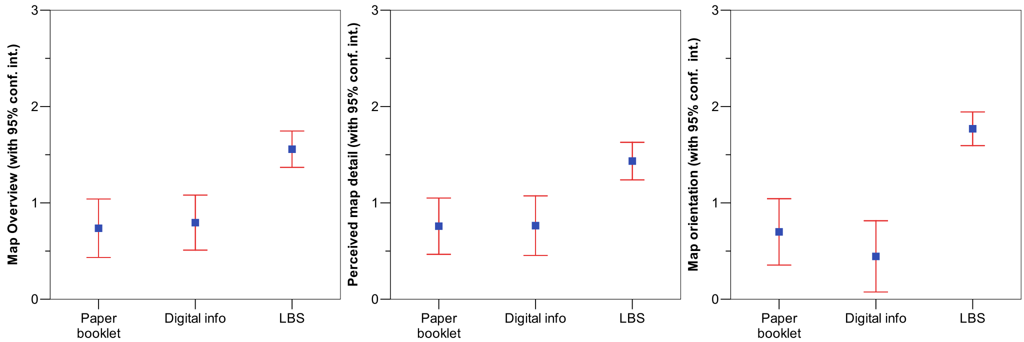


Figure 4.19, Figure 4.20 and Figure 4.21 – Map quality indicators (perceived detail, overview and orientation facilitation respectively) for the different information dimensions.

Table 4.19 – Statistical descriptives for the map quality indicators (perceived detail, overview, and orientation facilitation) for the different information dimensions.

Group	Statistics	Detailed	Overview	Orientation	Average Quality
Paper booklet	Mean	0.76	0.74	0.70	0.70
	Std. Error of Mean	0.15	0.15	0.17	0.15
	Std. Deviation	1.40	1.46	1.67	1.42
	Skewness	-0.87	-0.69	-0.51	-0.70
	N	91	91	93	88
Digital info	Mean	0.76	0.79	0.44	0.67
	Std. Error of Mean	0.16	0.14	0.19	0.15
	Std. Deviation	1.32	1.22	1.57	1.23
	Skewness	-0.50	-0.76	-0.33	-0.36
	N	72	73	72	71
LBS	Mean	1.44	1.57	1.79	1.60
	Std. Error of Mean	0.10	0.09	0.09	0.08
	Std. Deviation	1.10	1.08	1.00	0.98
	Skewness	-0.53	-0.87	-0.39	-0.45
	N	134	136	135	134

4.5 Conclusions

A research framework using control and test groups was developed and implemented in a Protected Area. The definition of the test and control groups is based on the different information dimensions that are necessary to test the added value and effects of the different information mechanisms. The groups are named after the information dimension to which the subjects had access: namely, *No info*, *Paper booklet*, *Digital info*, and *LBS*. The experiment was divided into three components: 1) the *ex ante* survey; 2) the actual Park visit using different information mechanisms; and 3) the *ex post* survey. In order to be able to quantify the *variation* in environmental perception or willingness-to-pay for information hire induced by access to the different information mechanisms, it was important to have *ex ante* and *ex post* measurements. By having *ex ante* and *ex post* measurements for all the test and control groups it was possible to measure the differences and, therefore, have a quantification of added value.

The results indicate that the different information dimensions may have an impact on the behaviour and perceptions of the visitors to the Protected Area. This will be analysed in-depth in the following chapters.

5 Spatial behaviour effects[13]

Good management depends upon good information, and therefore the better the quality of information, the better the opportunity for good management. Information about the visitors and their activities enables managers to deal with the challenge of increasing volumes of tourism (Hornback and Eagles, 1999). This chapter investigates the potential of visitors' geo-temporal data collected using GPS receivers to produce information to assist Park Managers in their decision-making concerning tourism flows within the Park. This was performed in three steps: (1) the data quality was analysed and its usability proven; (2) in particular, the location-based technology was investigated, more precisely, its potential to influence the visitors' position in time and space; and (3) the possibilities to extract information about aggregated patterns of behaviour were analysed and the characteristics of individual behaviour identified.

The first section of this chapter describes the methods that have been developed to spatio-temporally cluster individual behaviour and identify potential locations for specific actions (e.g. Do visitors stop here to look at wildlife?), whilst handling uncertainty in location. In the second part of the chapter, the hypothesis that visitor behaviour is altered by the provision of information through traditional means or when 'pushed' by a mobile device is tested using the previously described techniques. The results of the experiments with the visitors indicate statistically significant differences in the locations of "action places", particularly in the case when information is pushed to the visitors.

[13] The geo-temporal analysis was performed in collaboration with Alistair Edwardes and Ross Purves from the Department of Geography, University of Zurich and published in Dias et al (2007).

5.1 Introduction

In the context of this work, previous research from three different domains is relevant: 1) visitors' exploratory behaviour and its impact upon natural spaces; 2) techniques to analyse GPS tracks from individual users; and 3) methods to visualize, explore and analyse large volumes of what are referred to as 'moving-point objects'. Previous research addressing issues of visitors' spatial distribution and behaviour within natural areas has been carried out in the context of crowding, visitor density, and visitor simulation modelling (Elands and van Marwijk, 2005; Manning, 2002). Such research is typically contained within the field of recreation management, and aims, for example, to model the carrying capacities of natural areas.

As technologies which enable the tracking of individual paths have developed, scientists have started to apply research concerned with the analysis of space and time (e.g. the space-time aquarium suggested by Hägerstrand (1970). However, as real data describing geo-spatial lifelines (Mark, 1998) have become available, the inadequacies of the space-time aquarium as more than a simple visualization tool for a limited number of paths have also become apparent (Kwan, 2000).

These limitations have in turn led to the emergence of 'Geographic Knowledge Discovery Techniques' – for a full review see Laube et al. (2006) – which seek to allow both the qualitative and quantitative exploration of motion tracks. For example, Laube et al. (2005) introduced a set of methods for analysing relative motion in groups of objects, while Mountain and MacFarlane (2007) discuss methods for predicting an object's likely position based on previous fixes, for use in filtering queries to a Geographic Information Retrieval system.

One of the key limitations identified by Laube et al. (2006) is the lack of availability of real data with multiple geo-spatial lifelines for analysis. For this work, data was specifically collected to allow exploration of the behaviour of visitors to a natural area, thus overcoming this problem. In contrast with previous work, Park users were constrained to the same path, with few options to leave the network, thus vastly simplifying the role of space in our work, and enabling us to focus on users' behaviour along this constrained track. A set of techniques was developed aimed at investigating how the spatial behaviour of visitors to a Protected Area changes in response to information being supplied to them in differing forms. This problem is framed within the following research questions:

- How can the tracks of multiple visitors to a Park be used to explore visitor behaviour?
- Is the geographic behaviour of visitors altered by the provision of information?
- Do different information media alter the geographic behaviour of visitors?

5.2 Methodology

5.2.1 Experimental design

As explained in Chapter 4, a controlled experiment was designed to measure the influence that location-based information has on the spatial behaviour of visitors to natural areas. In the experiment all subjects were issued with GPS receivers which recorded their positions regularly. GPS tracks were recorded at a rate of one position fix every *5* seconds in order to analyse the subjects' spatial behaviour. The visitors were also divided into a control and three test groups. The test groups were each issued with different forms of information: a traditional paper-booklet; information on a digital support; and location-based information. The control group subjects were provided with no additional information.

Information content

As explained in Section 4.2, the information provided to the test groups' subjects comprised a map of the route with the locations of a number of Points-of-Interest (POI) displayed (see Figure 5.1). Detailed information about each of these was supplied in the subsequent information. This content consisted of a prominent title, a photo of the feature and a text description. The POIs were classified into four categories: "Directions" (indicating the path the subject should follow); "Plants" (information about a particular plant visible from the path); "Animals" (information about animals relevant at a particular point of the path); and "Landscape" (information about landscape features visible from a certain location).

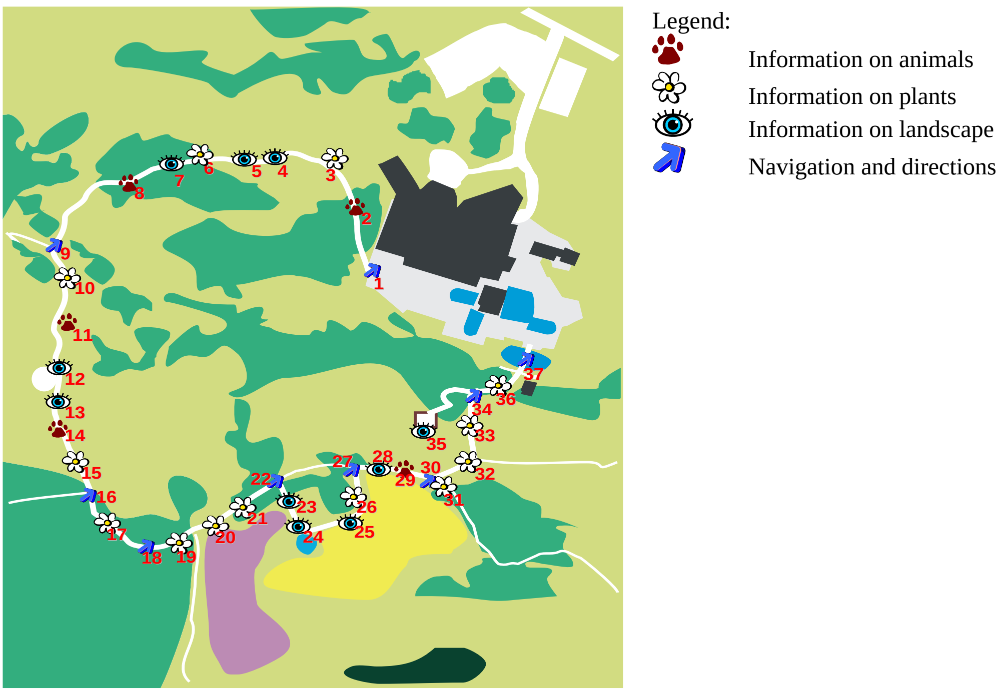
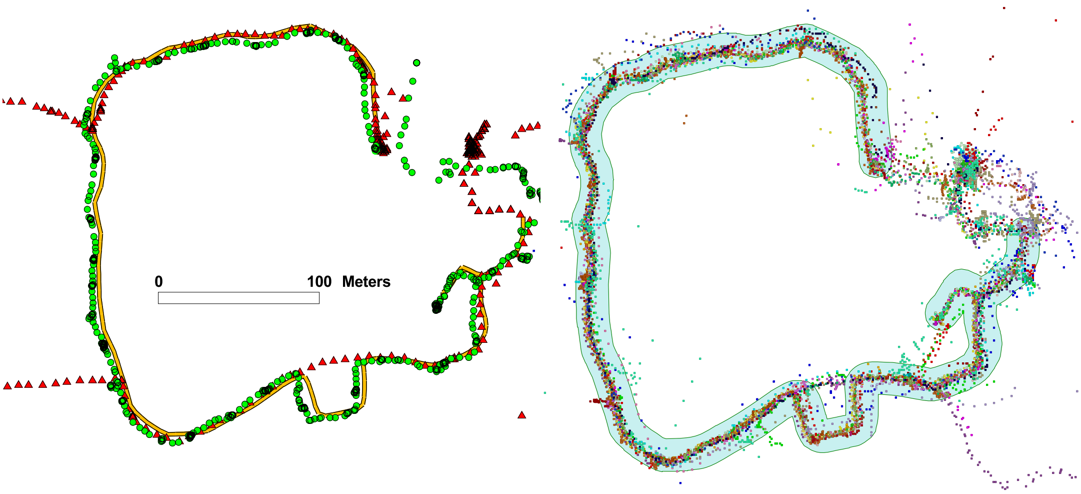


Figure 5.1 – Map of the trail given to visitors

5.2.2 Analysis techniques

The passage of each visitor traversing the Dune Park was recorded by a unique GPS track. Although analysis of these tracks independently could yield valuable information about individual movements, the purpose of the analysis here was to investigate whether significantly different types of behaviour occurred across groups as a result of the introduction of information in different forms. As such, our first task was to develop a method to aggregate the data. As shown in Figure 5.2 a) and b), the GPS tracks vary as a function of both the precision of the device and differences in subject behaviour. The main types of variability include:

- Uncertainty introduced by imprecision in the GPS coordinates recorded;
- The visitor leaving the prescribed path;
- Missing GPS data for certain periods of traversal;
- Individual differences in walking pace; and
- Differences in the period of time spent stopping at particular locations.



a) Two samples of visitor tracks with differing kinds of behaviour. Circles represent a visitor who followed the path; triangles correspond to a visitor who did not follow the path.

b) As more tracks are added, the difficulty to perceive information increases. Here 30 tracks are visualized within the 10 metre path buffer. Almost all points are within the defined validation region.

Figure 5.2 – Example of GPS tracks superimposed on the digitized path (each point is a fix collected every 5 seconds)

In order to allow data analysis two main methods were employed: linear referencing and aggregation. The purpose of linear referencing was to associate all individual GPS fixes with a single common baseline. In our case, the path provided the obvious reference to perform this function. It was therefore extracted as a linear geometry using a 1:10,000 topographic base map (the TOP10 vector data set of the Dutch National Mapping Agency). GPS fixes were referenced by projecting them onto their closest path position. Aggregation involved the definition of a sampling frame segmenting the path, into which the referenced positions could be aggregated. To achieve this, the path was indexed at 5 metre intervals and the number of fixes occurring in each interval recorded. This size of the interval was chosen because it reflected the approximate precision of the GPS receivers.

A number of issues were encountered in performing these tasks. During aggregation, situations were found where the GPS fixes were not representative of the visitor's movement along the path: for example, fixes occurring at a considerable distance from the path. To handle these situations, a filter was employed to reject fixes that were projected over a distance of more than 10 metres. This value represented twice the theoretical GPS precision and was validated by visual inspection of the tracks.

A second problem was that at one point the path forked taking visitors up to a viewpoint, indicated by the POI labelled 34 in Figure 5.1. This presented a difficulty in defining a single linear reference. To handle this, the stretch of path leading to the viewpoint was duplicated within the linear reference, once for each direction. The closest fix to the viewpoint, measured along the path, was then used to determine which of the duplicated path segments should be referenced. Fixes within the segment that occurred before the closest position were assigned to the first segment and those thereafter to the second.

Two additional aggregations were also performed to consider sources of error that might influence the data quality. A possible source of error was the different GPS receivers used. The non-tech groups (*No info* and *Paper booklet*) were issued with standard handheld receivers, while the data for the tech groups (*Digital info* and *LBS*) were recorded on the PDA connected to Bluetooth GPS. To investigate the errors arising from the two different GPS receivers used, the dispersion of fixes allocated to each interval was recorded. This involved computing the centroid of the fixes assigned to a particular interval and the mean distance of the points to this centroid. To consider errors in the digitization of the path, the average projection distance to an interval for every segment was also calculated. This value was signed according to the side of the path on which the fixes fell.

After indexing each valid fix to its corresponding path interval, fix frequencies were calculated for each interval. Using these results, the tracks were visualized graphically and statistically analysed. One issue emerged from this analysis: for a particular track, an interval could have zero recorded fixes. This situation could be indicative of one of two possibilities: either the visitor had moved rapidly through the 5-metre interval and there were truly no fixes, or there was no data available for the segment due to receiver issues. Since it was relatively unlikely that a visitor could move fast enough that there were no fixes over more than two segments(since the frequency of fixes was 5 seconds, this would represent a speed of more than 7 km/hr), consecutive intervals with no fixes were selected and their values set to null. The average number of fixes on each interval for each visitor was calculated and used as a measure of time spent at an interval. Aggregated values for each information medium were also calculated and allowed inter-group comparisons.

5.3 Track Analysis

5.3.1 General observations

The main goal of this research was to uncover differences in the spatial behaviour caused by the provision of different information media to visitors of Protected Areas. The characterization of behaviour was simplified into the variables 'time' and 'place'. This simplification was implemented by linearizing the space, dividing it into consecutive 5-metre segments and calculating for each segment the time the visitors spent there. When the visitors spent 15 seconds or more in a segment, then it was considered that they either stopped or significantly slowed down there.

Table 5.1, Table 5.2 and Table 5.3 summarize the overall influence that the different information media have on the behaviour. Table 5.1 shows the average time each group spends per interval. This value is indicative of the overall time spent in the Park, therefore we can conclude that the technology has some effect since it is evident that visitors who had access to information via the PDA (the digital and the LBS groups) spent, on average, more time in the Park (around 45 per cent) than the other groups (the *No info* and *Paper booklet* groups).

Table 5.1 – Time statistics on the time the user spends in each segment

	Mean (sec)	Std. Dev. (sec)	Min. (sec)	Max. (minutes)	N (Subjects)	Avg. (segs/subj)	N (Segs)
No info	7.0	19.6	0	17.9	37	131.0	4848
Paper	8.7	22.2	0	23.0	49	136.4	6684
Digital	11.9	24.7	0	12.0	46	149.9	6896
LBS	11.3	21.6	0	20.8	75	163.0	12228

The maximum amount of time that a visitor has spent in a certain segment is also displayed in the same table. It is interesting to observe that, for all groups, visitors can be found who have spent long amounts of time in a segment (more then 10 minutes for a visitor from the digital info and the no info groups and more then 20 minutes for visitors from the other groups). These values are indicative of the usage of the place for other activities than walking, e.g. stop for a picnic or to read a book.

Table 5.2 shows the average time the visitors spent in the Park. Since, for some users, we did not have complete data sets (as a result of reception issues), the missing data was interpolated for each user based on his/her personal speed. The short cuts (parts of the path not followed by the visitor) were kept as no data as they influence the overall time spent in the Park. When the visitors receive location-based information, they tend to spend the most time on the visit. Also noticeable, is the technology effect on the spatial behaviour: the *Digital* and *LBS* groups clearly spend more time in the Park when compared with the *No-tech* groups. As expected, the visitors in the *No info* group spend the least amount of time in the Park.

Table 5.2 – Time statistics regarding the time the user spends visiting the Park, missing data interpolated based on personal speed per segment (short cuts were not interpolated)

	Mean (minutes)	**Std. Dev. (minutes)**	**Minimum (minutes)**	**Maximum (minutes)**	**N Subjects**
No info	17.1	6.4	9.4	39.0	37
Paper booklet	22.1	8.1	9.2	43.1	49
Digital info	30.4	11.3	17.4	68.1	46
LBS	31.5	9.0	16.4	63.6	71

Table 5.3 displays the number of stops each visitor made during their visit, averaged over the group. A stop was defined as when a visitor spends 15 consecutive seconds (or more) in the same segment. The visitors without information, the control group, stop on average in 12 places. When visitors have access to information, they tend to stop much more often.

Table 5.3 – Average number of stops (15 seconds or more in a certain place) per visitor per group

	Mean	**Std. Dev.**	**Min.**	**Max.**	**N**
No info	11.54	7.44	0	33	37
Paper booklet	18.78	12.84	2	60	49
Digital info	30.67	11.67	13	56	46
LBS	38.52	11.95	11	64	75

For the visitors with *Paper* information, the average number of stops increases to 19 stops (around 63 per cent more stops). For the visitors with access to *Digital information*, the average number of stops increases to 31 (166 per cent more than the control group). Finally, the visitors receiving *Location-based* information stop on average 39 times (234 per cent more than the *No info* group). These results suggest that the number of stops increases according to the increasing complexity of the information delivery mechanism.

5.3.2 Visual analysis of results

The previous results demonstrated the influence of information on the number of stops, but we also wanted to analyse where the stops occur, and if these stops are correlated in space.

Figure 5.3 shows the information on spatial behaviour for all the segments and for all the visitors grouped by information medium. In order to simplify the visual analysis, segments were coloured according to the time spent in the segment. Four classes were defined: Green indicates *walking* (the visitor spent less than 15 seconds); Yellow indicates short stops (the visitor spent 15 or more seconds, but less than half-a-minute in the segment); Red indicates long stops (more than 30 seconds, but less than 2 minutes); and Black indicates resting places where the visitors rested for 2 minutes or more. The segments for which there is no data collected (either because of the extreme inaccuracy of the GPS receiver or because the visitor takes a short cut) were coloured Grey.

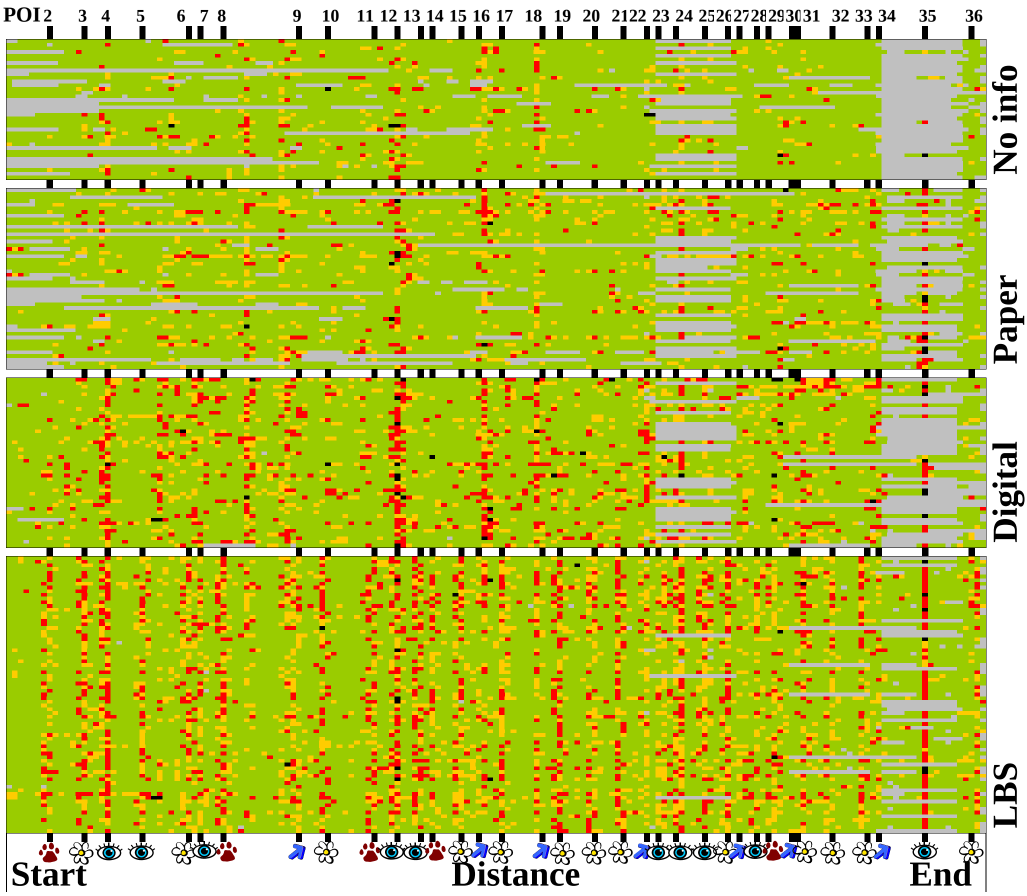


Figure 5.3 – Visualization of the frequency of fixes per interval of path for every track, grouped by information type

Note 1: POI numbers are shown at the top of the figure, indicating places where visitors were provided with information;

Note 2: Information categories are shown at the bottom of the figure using the same pictograms as in Figure 5.1.

Legend:
- Walk - until 15 seconds in the segment (3 or less fixes)
- Short stop - 15 to 30 seconds in the segment (3 to 6 fixes)
- Long stops – 30 seconds to 2 minutes in the segment (6 to 24 fixes)
- Rest - more than 2 minutes in the segment (more than 24 fixes)
- No data.

This method of presenting the data was also used by Laube et al. (2005) as a technique for identifying relative motion patterns. The visualization reveals the stops that are spatially auto-correlated amongst the visitors (these are indicated by the darker vertical bars). The smeared areas (where the darker cells are not aligned along vertical structures) are indicative of low autocorrelations. Scattered missing values that are not correlated in space (not vertically aligned) are caused by GPS inaccuracy if they occur singly, or if temporally auto-correlated (i.e. horizontal bands of null values) indicate individual users leaving the path. This figure is also helpful in revealing short cuts where the visitors did not take the correct path. Two areas of common short cuts are clearly visible in the second half of the path, indicated by continuous missing data for about 13 segments.

Figure 5.3 also indicates “natural” stopping places. Places where all groups stop, irrespective of the information medium. These are particularly obvious in the cases where there are “physical points” in the landscape that draw a crowd of visitors, meaning that the stop has high spatial autocorrelation (perfectly aligned yellow or red bars in Figure 5.3). Benches to rest during the walk are examples of “physical points” (POIs #12 and #35).

The group with location-sensitive digital information appears to display more correlated stopping places (clearly defined darker bars) which means that this information delivery mechanism is able to create interest points, just as the “physical points” can.

These overall data were averaged according to information media and then plotted along the path in order to visualize the coordinated stops in space in the form of four path maps (see Figure 5.4). The first map, Figure 5.4-a), shows that for the visitors with no access to information, there are, nevertheless, places that were common stopping points (the natural stopping places earlier discussed). This indicates that the control group, i.e. the reference group, does not move at a constant pace along the entire route. It is also noticeable that most of the stops defined by the *No info* group are also to be found in the other groups. A visual analysis of the aggregated tracks shows little difference between the *No info* group (Figure 5.4-a) and the *Paper booklet* group (Figure 5.4-b). Although the *Digital info* and the *LBS* groups show some similarities, the *LBS* group in particular has more stopping points and these stopping points are more uniformly scattered along the path.

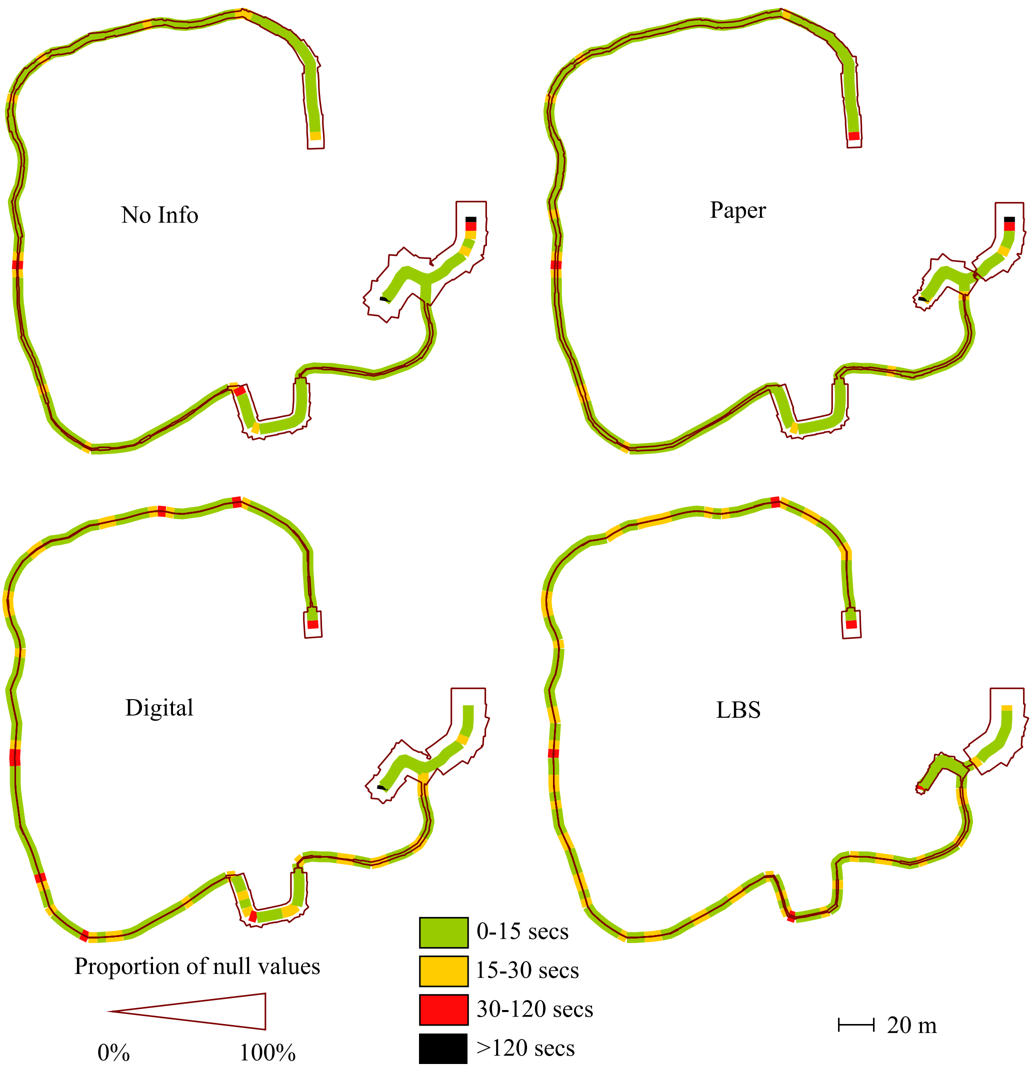


Figure 5.4 – Average number of fixes per interval shown along the path for each information dimension

Table 5.2 and Table 5.3 show that the test groups spend more time in the Park and that the visitors with information stop more often than those without information. But, in order to uncover the spatial effect of the information delivery mechanisms in the distribution of time and stops, it was important to compare the spatial behaviour of the test groups with the reference case. Figure 5.5 shows the difference in number of fixes (translated in time) for each test group in relation to the control group. For each segment, the average number of fixes of the reference case was subtracted from the average number of fixes for a particular group on the same segment. This method yields more clear results in terms of inter-group differences than the paths visualization in Figure 5.4. The first map proves that there are few differences between the *Paper booklet* and the *No info* group, and that the group with *Location-based information* is the one that presents more locations where differences with the reference case can be found. It is also interesting to notice that most differences are caused by more time being spent in the Park by the groups with information, and there are just two locations where the group with no information spent more time than the information groups.

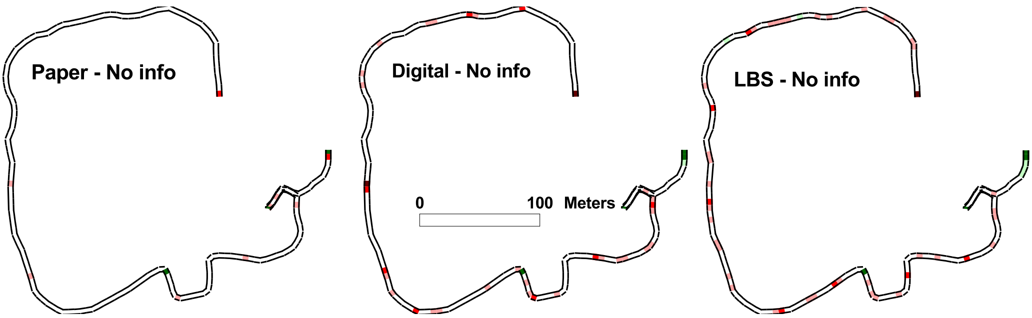


Figure 5.5 – Difference of number of fixes per group from the reference case (No info)

Legend:

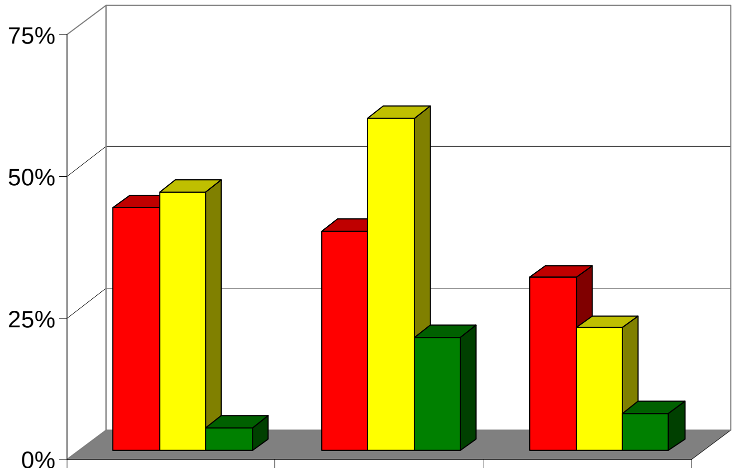
Less time than the reference case:
< 3 fixes (15 seconds)
3 to 6 fixes (15 to 30 seconds)
> 6 fixes (more than 30 seconds)

More time than the reference case:
< 3 fixes (15 seconds)
3 to 6 fixes (15 to 30 seconds)
> 6 fixes (more than 30 seconds)

Small or no difference (1 fix, +/- 5 seconds)

5.3.3 Influencing behaviour to achieve sustainability

By observing Figure 5.3 it becomes apparent that some visitors followed a different path than the one they were instructed to take. As described before, we can clearly identify two areas where some visitors *took a short cut*: one starting at the navigation point 22 and the other at the navigation point 34. This behaviour was expected for the *No info* group, as these visitors had no indication of a “correct” path and just took the most obvious way, Nevertheless, the information groups were instructed to follow a specific path. The information provided to the three information groups was intended to help the visitors fully explore and become more aware of the Park’s natural richness, therefore it recommended the visitors to walk through the south loop, POIs 23 to 26 (*short cut*), and see a breathtaking Park (over)view by climbing to the dune top, POI 35 (*viewpoint*). Figure 5.3 also shows the number of visitors who illegitimately left the trail (*off-path*) and trampled the protected dunes. This behaviour is revealed by stretches where there is no data and there is no possibility for an alternative path. The most obvious example is when visitors appear at the viewpoint (POI 35), but have not followed the trail till that point (consecutive no data segments). As the spatial behaviour of the visitors is collected and visually displayed in Figure 5.3, the efficiency in influencing the chosen path and behaviour can be measured for each information delivery mechanism. The results are summarized in Figure 5.6.



	Shortcut	Viewpoint	Off-path
Paper	43%	39%	31%
Digital	46%	59%	22%
LBS	4%	20%	7%

Figure 5.6 – Percentages of visitors (per category) who ignored the Park management's advice (taking a route short cut, not visiting the viewpoint) or showed disrespect for Park rules (going off-path)

For the *Paper booklet* group, of the 49 visitors analysed, 21 visitors took the short cut (43 per cent), 19 did not visit the viewpoint (39 per cent), and 15 went off-path in one or more places (31 per cent). The results are even more alarming for the *Digital information* group, from the 46 visitors in this group, 21 took the short cut (46 per cent), 27 did not visit the viewpoint (59 per cent) and 10 went off-path at least once (22 per cent). Significantly different results were obtained for the *LBS* group: from the 75 visitors that composed this group, only 3 took the short cut (4 per cent), only 15 did not visit the viewpoint (20 per cent) and only 5 went off-path (7 per cent).

These results indicate that delivering location-based information is more efficient, since more visitors follow the Park Managers' indications. Therefore, the adoption of location-based information supports the hypothesis that LBS can influence the visitors' behaviour towards eco-friendliness.

5.3.4 Analysis of errors

The collected data (GPS fixes for moving visitors) had different possible sources of errors and uncertainty, primarily related to GPS positional error through canyoning effects and multi-path reception, and the representation of the base path (on to which the fixes were being projected). These errors were analysed visually and statistically – see details in Dias et al. (2007) – and the results give confidence on the choice of both buffer size (10 metres) and segment length (5 metres), indicating that the potential positional and digitizing errors did not significantly affect the location counts and the resulting classifications.

5.3.5 Statistical analysis

This section is dedicated to the quantification of the influence that information and the mode of its delivery has on the visitors' movement behaviour. In an attempt to create "artificial" stopping places, information was provided to the three test groups (*Paper booklet*, *Digital info* and *LBS*). This information was relevant to the locations along the path indicated in Figure 4.3 and Figure 5.3 as the Points of Interest (POI) with numbered icons.

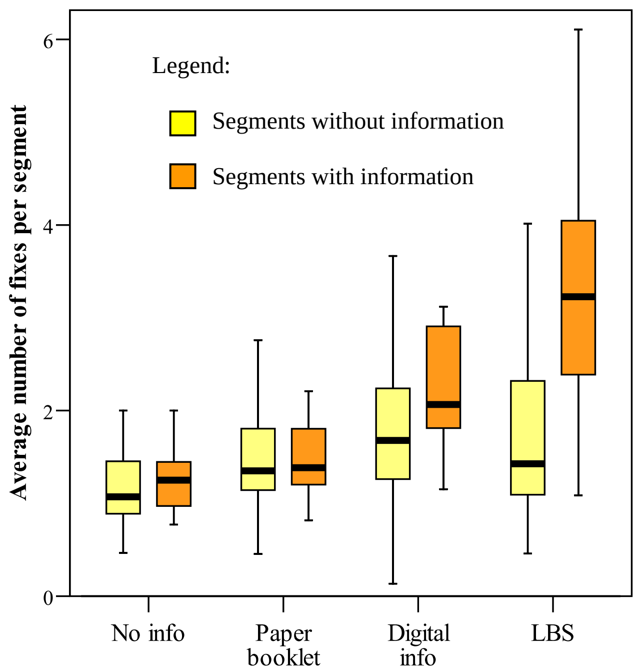


Figure 5.7 – Box plot of average number of fixes per path segment, grouped by information medium and whether the interval was related to a location with information (POI) or without information

Figure 5.7 illustrates the average number of stops per segment for each information type, classified according to whether locations were POIs or not. Both the *No info* and the *Paper booklet* groups spent approximately the same amount of time in all segments on the path. This finding was expected for the *No info* group because these visitors do not have knowledge of the information at certain segments, but is more surprising for the *Paper booklet* group where it was expected that the visitors would spend more time at the POIs exploring these places and the information. By contrast, the group issued with *Digital info* shows a significant difference in their behaviour at POIs, even though the only difference between them and the *Paper booklet* group was in the method of information provision. Finally, the *LBS* group displayed similar behaviour to the *Digital info* group, once again spending significantly more time at POIs.

These results suggest that the method of providing information had an influence on visitors' behaviour. In a second step, we examined whether the type of information also influenced behaviour. As explained in Section 5.2.1, the information available could be classified into four categories (POIs related to Animals, Plants, Landscape, and info for directions/navigation in the Park).

Table 5.4 presents the results of four binary logistic regressions between stops (defined as more than 15 seconds in a segment) and four information types that generated four different types of spatial behaviour. In the first column, below the information type, are the overall model statistics. χ^2 and *M.Sig* are the chi-square statistic and its significance. They result from the Omnibus Tests of Model Coefficients and measure how well the model performs.

Table 5.4 – Logistic Regression results for the influence of POI push positions in the spatial behaviour, represented by stops (longer then 15 seconds, freq > = 3)

Spatial behaviour	**POI category**	**Exp(B)**	**Wald**	**V.Sig.**
No info	Navigation	0.000	0.000	0.999
χ^2 = 9.029	Animals	0.000	0.000	0.999
M.Sig = 0.060; Nagelkerke R^2 = 0.154	Plants	0.000	0.000	0.999
N = 166	Landscape **	8.929	7.364	0.007
Paper booklet	Navigation	0.000	0.000	0.999
χ^2 = 5.328	Animals	0.000	0.000	0.999
Sig = 0.255; Nagelkerke R^2= 0.086	Plants	0.000	0.000	0.999
N = 169	Landscape	3.938	2.478	0.115
Digital info	Navigation	0.897	0.010	0.922
χ^2=5.026	Animals	0.000	0.000	0.999
Sig = 0.285; Nagelkerke R^2 = 0.049	Plants	0.978	0.001	0.978
N = 169	Landscape *	3.587	3.449	0.063
LBS *	Navigation	0.000	0.000	0.999
χ^2=33.688	Animals **	19.304	6.728	0.009
Sig = 0.000; Nagelkerke R^2= 0.268	Plants **	5.630	8.250	0.004
N = 169	Landscape **	19.304	12.935	0.000

*significant at the 10% level.
**significant at the 1% level.

Only the model for the *LBS* group has a high performance, meaning that the stops and the information provision places are correlated for this group. For the other groups, a correlation could not be found. *N* is the number of valid segments included in the regression and the *Nagelkerke* R^2 is an approximation of the proportion of the variation in the response that is explained by the model (comparable to the R^2 in linear regressions). As expected, the *LBS* information provision explains a bigger proportion of the stops than any of the other groups. Also presented in Table 5.4 are the specific results for the variables' performance within the models. *Exp(B)* is the predicted change in odds for a unit increase in the predictor. The *Wald* and *Variable Sig.* columns provide the Wald chi-square value and 2-tailed p-value used in testing the null hypothesis. Coefficients that have *V. Sig.* (p-values) less than alpha=0.01 are statistically significant at the 1% level.

For the control group, who were given no information, there is none-the-less a significant correlation with the Landscape POIs – this suggests that these POIs are in locations where Park users might naturally stop. For both groups who were provided with information passively, no significant correlations were found.

Finally, the group who were pushed information show significant correlations with all POIs, except the navigation information. It is suggested that this is because when they were pushed information, users stop to read it. However, at navigation points, given the simplicity of the route the users were on, it was not necessary to walk significantly slower.

5.4 Discussion

5.4.1 Observations on spatial behaviour

In order to obtain knowledge of the spatial behaviour of visitors, it is required to capture fine-grained spatio-temporal data, but the collection of this high resolution data leads to a problem in itself: individual tracks contain too much variation (in terms of data quality and actual movement) to allow direct inter-track comparisons of spatial behaviour between them. To deal with this issue, several techniques were applied to extract useful information and identify trends. The first step was to define when to accept or reject data as a valid measurement. To do this a distance-based filter was applied, such that only the points close enough to the path (within 10 metres) were considered. The second step involved the aggregation of the data to a common baseline, i.e. valid GPS tracks were projected on to the path. This technique allowed the high variability of the tracks to be handled by referencing them all to a common baseline. In addition, because the data sets were often not complete (because of the inaccuracies of the GPS receivers or visitors' short cuts), the analysis was not performed over the full tracks (which would require complete data sets). Instead, the data were analysed by averaging them over single path intervals which allowed null values to be ignored.

Impact of paper information

Providing visitors with information was expected to have an influence on their spatial behaviour. Comparing the *No information* and *Paper booklet* groups, there is evidence to support this hypothesis. The average number of stops (more than 15 seconds in a 5-metre segment), shown by Table 5.3, is significantly higher (T-test $p>0.001$), but analysing the differences between the two groups (visual analysis of the patterns shown in Figure 5.4 and the pattern subtraction in Figure 5.5) shows similar walking patterns. More importantly, the interpretation of the box plot in Figure 5.7 indicates little difference in behaviour, both between the *No info* and *Paper* groups and between the segments with and without information for the *Paper* group. Likewise, the Logistic Regression shown in Table 5.4 was unable to find evidence that the positions of POIs were influencing the stopping behaviour of these two groups. This indicates that the access to paper information does not change the visitors' geographic behaviour in a significant fashion.

Digital info influence

Since the *Digital info* and the *Paper* groups had access to the same information content, and both groups required a 'pull method' to receive it, it was not expected to find differences in behaviour between these two groups. Nevertheless, the results do show significant differences. The visitors with the *Digital info* not only stopped more (see Table 5.3) overall, but the places they stopped at were correlated along points of the path not thoroughly explored by the *Paper* group. This fact can be observed in Figure 5.4 and Figure 5.5. However, interpretation of the box plot in Figure 5.7 suggests that this difference should not be stressed too strongly, and the Logical regression shown in Table 5.4 was unable to correlate the places where visitors stopped with the POI information for the digital information group.
Two reasons can be hypothesized to explain this relevant finding: 1) the visitors from the *Digital info* group needed to interact with the device, causing them to stop more because of the device handling effort – intrusive effect of technology – or 2) the technology had a positive "novelty effect", i.e. the visitors were more motivated to explore both the information and the Park thoroughly, because the information was presented in a media that was perceived as new and innovative.

Location sensitivity impression on behaviour

Although both tech groups (*Digital info* and *LBS*) spent more or less the same amount of time walking along the route (see Table 5.1 and Table 5.2), two main differences were observable. The visitors with *LBS* information stopped more (see Table 5.3). Visual inspection of the data presented in Figure 5.3, Figure 5.4 and Figure 5.5 clearly shows more frequent auto-correlated stops for the *LBS* group when compared with the other groups. In addition, Figure 5.7 indicates that there is a significant difference in behaviour around path segments where the POIs were positioned and those without information, proving in this way the capacity for Location-sensitive information to create artificial stopping places and alter the exploration behaviour of visitors according to the managers' goals. In terms of the information themes that influence behaviour, the Logistic Regression of Table 5.4 is able to detect that the behaviour for this *LBS* group is significantly influenced by the animal, plant and landscape POIs. It was not possible to show any influence by the navigation POIs. However, this was expected since this information was meant to be comprehensible without requiring the visitors to pause.

Potential limitations

It is important to consider the potential impact of granularity – for example the sensitivity of the results to the chosen length of stopping time (15 seconds) – and further work is required to explore this issue. Equally the chosen segmentation length (5 metres) and GPS sample rate (5 seconds), although to some extent validated by the experiments on GPS uncertainty, is another example of variable granularity whose influence on the results should be explored. Previous work from Laube and Purves (2006), has shown that seemingly significant results can be artifacts produced as a function of granularity.

5.5 Conclusions

The results described in this chapter underscore the value of spatio-temporal data for assessing the impact of mobile information technologies. This is particularly important because it provides a geographical basis for evaluating such technologies that extends and complements more commonly-used approaches grounded in psychology and usability (also applied in subsequent chapters).

The main issue for the development of methods in this regard was how to handle the uncertainty associated with the variability of high-resolution track data. This uncertainty arises from errors in positioning, incomplete information, and the general variability in individual movements. To cope with these issues a number of techniques were described in this work. In terms of data handling, filtering, linear-reference and aggregation techniques were described that brought the data into forms that allowed comparison between tracks to be made and the influence of different variables to be explored. In terms of analysis, a number of visualization techniques were described that identified patterns of autocorrelation within the data that could be explored and the patterns suggested using these techniques were then validated using statistical methods.

The combination of these methods proved successful in allowing inferences about spatial behaviour to be made. In particular, it could be shown that location-sensitive provision of information significantly affects how visitors behave, while other media for delivery have lower effects. This conclusion in itself should be of value for Park Management authorities wishing to increase visitor awareness of the Park's natural resources through active exploration techniques.

Additionally, it was found that there are places where visitors tend to stop, irrespective of the mode of delivery and information content. To some extent, these could be related to features in the landscape. This suggests future avenues of work that might attempt to complement track data with participant observation and interviews, as well as analysis of track data as a function of the environment.

It was also noted that technology had an effect on the behaviour. Nevertheless, it is unclear if it is a positive "novelty effect" or a negative intrusive effort in interacting. It will be important in future work to better control for this effect and determine whether it is undesirable, transient, or useful in terms of encouraging visitors to explore natural environments, either through participant observation or dedicated surveys.

Location-sensitive information provision can alter the spatial behaviour of the visitors. In terms effectiveness in behaviour-altering, of the type of POIs, plant and animal information seem to cause "un-natural" stops, since the Landscape information POIs appeared to be natural stopping points anyway, as shown by the correlation with the stopping points of the *No info* group (see Table 5.4). Therefore, information about plants and animals can encourage people to explore the Park in a different way. Information about plants *at the right place*, for example, can lead people to direct experiences of nature, stopping to see the plants about which they are receiving information.

While aggregation was useful to smooth out local variations amongst the singular tracks and so explore the more general trends of the data, it also caused much potential interesting information about individual behaviour to be lost. The next chapter will aim to look at the data more when disaggregated and when using particular information.

The collection of anonymous aggregated movement data enabled two additional qualitative behaviour analyses concerning: 1) where do visitors leave the trail and trample the protected dunes; and 2) whether visitors accept the Park Management advice to visit particular places. Regarding the latter, the information provided to the three information groups was intended to help the visitors fully explore and become more aware of the Park's natural richness (e.g. it recommended the visitors to walk round a south loop [POIs 23-26] and to see a breathtaking Park (over)view by climbing to the top of a dune [POI 35]). The spatial data shows that of the *Paper booklet* group, 43 per cent did not walk round the loop, 39 per cent did not see the viewpoint and 31 per cent went off-path in one or more places. The results were even more alarming for the *Digital info* group, where 46 per cent took the short cut, 59 per cent did not visit the viewpoint, and 22 per cent were off-path at least once. Significantly different results were obtained for the *LBS* group, where only 4 per cent took the short cut, 20 per cent did not visit the viewpoint and only 7 per cent were found off-path. These results indicate that delivering location-based information is a more efficient channel for the Park Managers to communicate and influence visitors' behaviour towards eco-friendliness.

6 The effect of information on Nature appreciation

6.1 Introduction

This chapter describes the effect of the information dimension on the environmental appreciation and valuation by the visitors. It has been hypothesized that visitors with access to information about a certain place would appreciate it more and, additionally, that visitors with the right information at the right time (context-aware information) would excel in their appreciation. The appreciation value was measured using a visual preference methodology in the form of a photo-questionnaire (pre-visit and post-visit). In such a research method, the participants are typically asked to rate a set of photographs of different settings as a way of stating their emotional appreciation response to the stimuli of nature scenes (in other words, how much they like the photos).

The goals of this chapter are to verify: 1) if Park nature features are appreciated more highly after the visit compared with the appreciation before the visit; 2) if accessing information affects the post-visit nature valuation of the Park features; 3) if the type of information delivery in particular affects the post-appreciation; and 4) what are the factors that influence the variation of post-valuation of nature.

The importance of measuring the visitors' nature appreciation is linked to proving the effectiveness in addressing the education and recreation goals of the Park Management (as stated in Chapters 1 and 2).

6.1.1 Visual preferences

A vast body of previous research has addressed the issue of valuation and categorization of natural concepts, particularly the visual quality of landscapes. The visual approach methodology has mainly taken the form of photo-questionnaires (Kaplan and Kaplan, 1989). Shuttleworth (1980) and Ulrich (1979) describe extensively the clear advantages of using photographs for such research. They mention, for example, the elimination of the experimental “noise” of the actual physical settings and the possibility to present a great number of scenes as some of the advantages. Other studies have shown strong similarities in the responses when the stimuli are photos or on-site questionnaires for the same environments (Levin, 1977 in Kaplan and Kaplan, 1989) and therefore photographs are accepted as a valid and reliable substitute to the actual settings (Coeterier, 1983). This method’s validation and reliability have been proven (Zube et al., 1987), and it has been used in very diverse studies in the past (Brabec, 2001; Buhyoff et al., 1982; Hammitt et al., 1994; Nelessen, 1994; Strumse, 1996; Sullivan, 1996; Tilt et al., 2007). Therefore, presenting photographs instead of the real settings as the nature-stimuli was the method chosen for the nature valuation in this research.

Nevertheless, despite the extended use of the visual preferences methodology using photographs, Palmer and Hoffman (2001) encountered some limitations with respect to its potential for extrapolating results. They claim that the confidence in the reliability of rating scales and photographs to value landscape qualities, developed by researchers over the past 30 years, can not be extended to all visible qualities. Even so, this study concludes that there are no limitations when the research results are limited to revealing scenic preferences. This limitation does not affect the present study since it intends to use only the measurements of scenic preferences (how much people like the scenes), rather than the extrapolation of landscape qualities (what are the characteristics in the photos that make people like it). Actually, this limitations study concludes with the recommendation to use photographs to determine nature preferences.

Since the photography sets used in the tests represented Dutch landscapes (dunes), it was important to know beforehand what are the landscape attributes that can influence the subjects’ perception. The importance of this knowledge refers to the possibility to control and account for photographs that could have very high or very low valuations, creating ceiling effects on the scale and biasing the data collected. Coeterier (1996) studied the perception of Dutch landscapes by the inhabitants of the Netherlands and identified some attributes that can be considered basic qualities of the landscape. These qualities that influence perception can be summarized as the *nature of the landscape as a whole (*unity), its *function* (use), *maintenance*, *naturalness*, *spaciousness*, *development in time*, *soil and water*, and *sensory qualities* such as colour and smell. It could be expected that some qualities visible in the photos would make the valuation of the landscape higher by the Dutch respondents. The photographs in this study did not include more than two of the qualities simultaneously and therefore it was expected that the scale was sensitive enough to small variations. Additionally, the aim of this study is to detect variations in the *ex ante* and *ex post* measurements and also the inter-group differences rather than to explain the absolute measured values. Therefore, it was not relevant to model the photographs' intrinsic qualities.

6.2 Methodology

6.2.1 Scaling Nature appreciation

During the *ex ante* valuation, i.e. the questionnaire administered before the Park visit, the subjects were asked to classify a set of 15 photographs of nature scenes using an asymmetric Likert scale with nine values:

- A negative value labelled *I don't like it;*
- A neutral value labelled *Neutral; and*
- Seven positive values ranging from *Slightly like* (+1) to *Extremely like* (+7).

At an early stage of this research, a different scale was applied. This first attempt used a 7 item symmetric Likert scale with three positive points, a neutral point and three negative points, but this scale was shown to have limitations after the analysis of the first results. Most respondents answered on the positive side, and even if they did not like the feature, they would always answer in the middle. Therefore, to make the final scale more sensitive to the small variations in perceptions and to avoid a ceiling effect, the final scale had a greater number of positive possibilities against just one negative.

6.2.2 Preference variation

The test can be divided into three main components: (1) A pre-visit test where the visitors are asked to value the photos, (2) the visit to the Park where subjects have the opportunity to see and explore (or not) personally the features represented in the photos and (3) the post-visit test where the scales were again administered (but putting the photos in a different order). However, the determination of the visitors' overall visual preferences for the Park photographs, although yielding interesting results in themselves, was not the goal of this study. For example, the results from the pre-test can be used independently to determine which landscapes are preferred by the visitors (by inter-group comparisons of the absolute photo scores).

This study aimed to discover if significant differences could be found in the preference for the same local nature scenes before and after the visit, and to determine whether these differences are correlated with the information experience. Therefore, the photo questionnaire was administered to the visitors before they visited the Park, as a measurement of the visitors' absolute environmental preferences, and again after the Park visit, in order to look for changes to the absolute value.

In addition, it can be assumed that different visitors have different levels of appreciation for natural environments. Visitors who enjoy natural environments more were expected to rate the photos more highly than the visitors who are less emotionally attached to environmental settings, or simply prefer urban environments. By using the variation technique, the pre- and post-measurement are expected to filter out these individual differences.

The tests took place in a controlled environment, since most of the variables are accounted for: the demographics of the different samples is identical, and the path that the visitors take is the same (in identical weather conditions). Therefore, if a variation (delta) in the visitors' perception is found, it can be assumed to be related to the information dimension that the visitors experienced (the main independent variable). In this way, it is possible to reveal and measure the effect that the information (and its different dimensions) has on the visitors' appreciation of nature.

6.2.3 Photograph types

The photos presented in the preference test were heterogeneous and displayed very diverse scenes. Two different types of photos were included:

- 10 *test photos* (see examples in Figure 6.1, Figure 6.2 and Figure 6.3), and
- 5 *control photos* (see example in Figure 6.4)

(Photo: Oscar Bos, Ecomare)

Figure 6.1 – Wind-tree. Test photo #1 representing a Park feature where the visitors have information from the "Landscape" category

Figure 6.2 – Marram grass. Test photo #3 representing a Park feature where the visitors have information from the "plants" category

(Photo: Ariaan Dijksen, Ecomare)

Figure 6.3 – Meadow Pipit. Test photo #6 representing a Park feature where the visitors have information from the "Animals" category

Figure 6.4 – Cork tree, Alentejo, South Portugal. Control photo #15 representing a natural area that is not to be found in the tested Park

The *test photos* showed natural features that the subjects would find in the Park along the proposed walk during their visit. The photos were chosen from the set of Points of Interest (POIs) multimedia content. Therefore, these ten test photos were also displayed on the information content given to the visitors (see Section 4.2.3 for detailed information on the content), and they aimed to evaluate the preference of the tourists regarding the Park features. These are the actual photos that were used to reveal whether the valuation and perception would change after the visit and receiving information (as explained in the previous section).

The *control photos*, on the other hand, aimed at controlling the intention of the subjects, since problems with response bias could arise as a result of the *researcher's effect*. The effect that the researcher can pose on the subjects is a very well known issue in social research (Paulhus, 1984), specially when the researcher is physically present as is the case in interviews (De Santis, 1980; Kahn and Cannell, 1957). Some subjects may 'unconsciously' (or not) try to answer in the way they believe the researcher expects them to, in this case, rating the photographs higher after the visit, because the subjects believe that is what is expected from them. To account for this possible bias, 5 control photos were included in the test. These photos show places and landscapes that are not inside the Park and for which the visitors do not receive any additional information. Thus, it was expected that the visitors would value these control photos with the same, or a similar, score both before and after the Park visit.

6.3 Results

Table 6.1 presents the 10 Park photos used in the questionnaire to measure the valuation of nature features in the Park along with the basic descriptive statistics for each of them. 80 mean values are presented corresponding to the two measures at different times (pre- and post-visit), for the four information groups and for the 10 photographs. For the first measurement, before the visit, the minimum mean value for a photo valuation was of the *wooden rabbit* photo by the *No info* group. The maximum value from a pre-valuation was for the ‘Meadow Pipit’, by the *Digital info* group. Regarding the second measurements (after the visit), the smallest average valuation by a group was also for the *wooden rabbit* by the same group, the *No info*. For the post-valuations, the maximum average value was given by the *Digital info* group, for the photo of the ‘Honeysuckle’. Regarding variations, the maximum standard deviation found was of 2.2 for the ‘Meadow Pipit’. It is worth noting the appropriateness of the scale for all the park photos, since the 80 means presented were around the middle values of the scale, i.e. two points above the minimum and two points below the maximum of the scale.

Regarding the descriptive results for the control photos, the overall results were slightly higher. The smallest average first measurement was found for the ‘Texel sheep’ for the *Paper booklet* group. The highest mean pre-visit measurement was awarded to the (Swiss) ‘Alpine view’. Regarding the post-visit measurements, the smallest mean was also ascribed to the ‘Texel sheep’ by the *No info* group, and the highest mean was attributed to the ‘Alpine view’ by the *Paper booklet* group. In terms of the variation of the valuation within the groups, the smallest variation in the pre-visit measurements was found for the photo ‘Texel sheep’ by the *Digital info* group (standard deviation of 1.7), while the highest variation for the same measurements was achieved by two groups for different photos, both the *No info* group valuing the ‘alpine view’ and the *LBS* group valuing the ‘Cork tree’ in Portugal had a standard variation of 2.2 points. The overall results of the control photos were similar to the test photos and show the appropriateness of the scale used by having average values in the middle of the scale around two points away from the scale’s higher and lower limit.

The goal of these tests was not to reveal individual differences between the photographs, but in fact to reveal differences between the different information dimension groups. Therefore, the next section will analyse these data in an aggregated fashion, where the results for the 10 photographs are averaged per information dimension.

In order to facilitate the visualization of the variations, the individual differences for three test Park photos (Figure 6.1, Figure 6.2 and Figure 6.3) and for one control photo (Figure 6.4) were graphically plotted in Figure 6.5, Figure 6.6, Figure 6.7 and Figure 6.8, respectively.

Table 6.1 – Descriptive statistics for all the Park photos, both for the pre-visit valuation (column named pre) and post-visit valuation (pos) according to each of the four information dimensions

Test Park photos		**Statistic**	**No info**		**Paper booklet**		**Digital info**		**LBS**	
			pre	pos	pre	pos	pre	pos	pre	pos
#1 Wind-tree		Mean	2.2	2.6	2.0	3.5	2.2	3.8	2.1	3.8
		Std. dev.	2.0	2.4	1.5	1.8	1.8	1.9	1.9	2.1
		N	104	86	100	90	72	69	135	129
#2 Marram grass		Mean	1.7	2.1	2.0	2.7	2.1	3.0	2.0	2.9
		Std. dev.	1.9	1.7	1.9	1.7	1.6	1.8	1.9	1.9
		N	103	86	101	91	71	69	135	129
#3 Wooden rabbit		Mean	1.0	1.2	1.2	1.7	1.4	1.7	1.5	1.9
		Std. dev.	1.8	2.1	1.9	2.1	1.9	2.1	2.0	2.3
		N	103	86	101	91	71	69	136	129
#4 Peat beds		Mean	1.2	1.9	1.6	2.6	1.6	2.7	1.6	2.8
		Std. dev.	1.8	1.9	1.7	1.6	1.6	1.8	1.9	1.9
		N	102	87	101	90	71	67	134	128
#5 Honeysuckle		Mean	3.3	3.7	3.5	4.2	3.7	4.5	3.7	4.3
		Std. dev.	2.1	2.0	2.0	1.7	1.7	1.5	1.8	1.9
		N	102	86	101	92	72	68	134	129
#6 Meadow Pipit		Mean	3.3	2.9	3.2	3.4	3.8	3.8	3.4	3.5
		Std. dev.	2.1	2.2	2.0	2.1	1.7	1.9	1.9	1.9
		N	102	85	101	89	72	64	136	125
#7 No management		Mean	2.7	3.0	3.0	3.2	3.3	3.9	3.4	3.5
		Std. dev.	1.9	1.7	1.8	1.6	1.6	1.4	1.7	1.9
		N	98	86	97	91	72	68	132	129
#8 Dunes		Mean	2.4	2.7	3.1	3.2	2.9	3.6	2.9	3.1
		Std. dev.	1.8	2.1	2.0	1.8	1.9	1.9	1.9	2.2
		N	98	87	98	90	71	69	131	129
#9 Tree branches		Mean	1.8	1.5	2.1	2.1	2.2	2.4	1.9	2.5
		Std. dev.	2.0	2.0	2.1	1.8	1.9	1.5	2.0	2.1
		N	102	88	101	90	72	68	136	129
#10 Rabbit hole		Mean	1.9	1.3	2.0	2.0	2.0	1.6	2.3	2.5
		Std. dev.	2.2	2.0	2.0	1.7	1.8	1.7	2.1	2.1
		N	103	88	101	90	72	68	136	129
Average for all test photos		Mean	2.2	2.4	2.4	2.9	2.5	3.1	2.4	3.1
		Std. dev.	1.3	1.4	1.3	1.1	1.1	1.2	1.2	1.5
		N	92	81	93	84	68	62	125	124

Legend:

(Animals icon)	Photo from the category "Animals"
(Plants icon)	Photo from the category "Plants"
(Landscape icon)	Photo from the category "Landscape"
Pre	Pre-visit valuation measurement
Pos	Valuation measurement after the Park visit.

Table 6.2 – Descriptive statistics for the control photos (representing features not to be found during the Park visit), both for the pre-visit valuation (column named pre) and post-visit valuation (pos) discriminated for each of the four information dimensions

Control photos		**Statistic**	**No info**		**Paper booklet**		**Digital info**		**LBS**	
			pre	pos	pre	pos	pre	pos	pre	pos
a) Texel sheep NL		Mean	2.8	3.0	2.7	3.4	2.8	3.5	2.9	3.6
		Std. dev.	1.9	1.9	1.9	1.9	1.7	1.8	1.9	2.0
		N	104	86	100	90	71	69	136	129
b) Wadden sea NL		Mean	4.4	4.1	4.4	4.2	4.3	4.2	4.5	4.4
		Std. dev.	2.0	2.0	2.0	1.9	1.8	1.7	1.7	2.0
		N	102	85	99	91	72	68	133	127
c) Waterfall PT		Mean	4.5	4.9	4.7	4.9	4.3	4.2	4.9	4.9
		Std. dev.	2.0	2.0	2.0	2.0	2.2	2.4	1.9	2.0
		N	101	87	96	89	70	68	136	129
d) Alpine view CH		Mean	4.6	4.6	4.9	5.1	4.6	4.2	5.0	4.9
		Std. dev.	2.2	2.1	2.0	2.0	2.2	2.3	1.9	2.1
		N	101	86	98	88	72	69	136	129
e) Cork tree Alentejo, PT		Mean	3.3	3.8	3.7	4.0	3.6	3.8	3.8	3.9
		Std. dev.	1.9	1.9	2.0	1.9	2.0	2.0	2.2	2.0
		N	103	87	98	90	72	68	136	129
Average for all control photos		Mean	3.9	4.1	4.1	4.3	3.9	4.0	4.2	4.3
		Std. dev.	1.2	1.3	1.4	1.5	1.5	1.5	1.3	1.5
		N	98	83	91	87	69	66	133	127

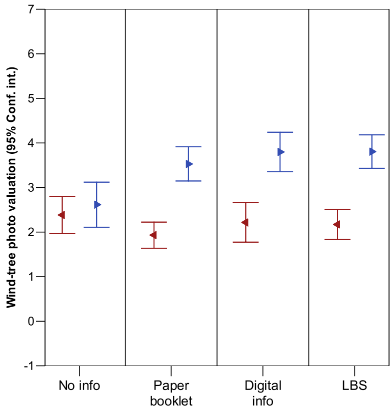


Figure 6.5 – Ex ante ( ) *and* ex post ( ) *valuation for the Wind-tree test Park photo (Figure 6.1)*

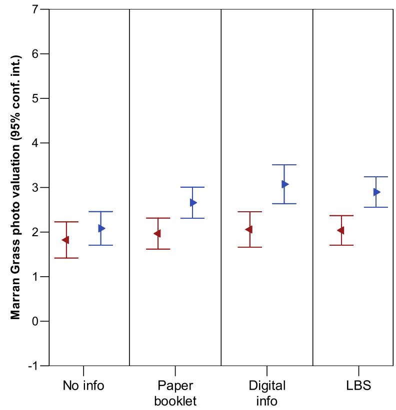


Figure 6.6 – Ex ante ( ) *and* ex post ( ) *valuation for the Marram grass test Park photo (Figure 6.2)*

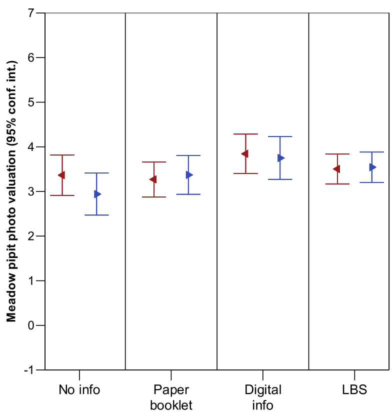


Figure 6.7 – Ex ante ( ) *and* ex post ( ) *valuation for the 'Meadow Pipit' test Park photo (Figure 6.3)*

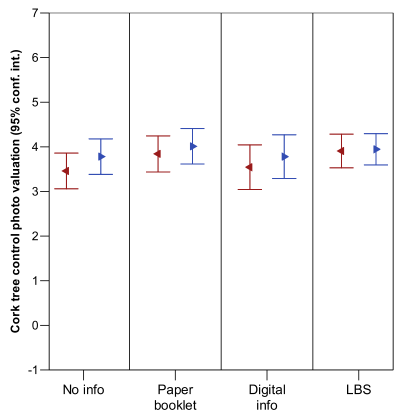


Figure 6.8 – Ex ante ( ) *and* ex post ( ) *valuation for the Cork-tree control photo (Figure 6.4)*

6.3.1 Aggregated results

Table 6.3 displays some descriptive statistics according to information group for the overall valuation of the 10 test Park photos. An additional group was created, the *with info* group. This group is an aggregation group and was created to account for the effect of the information itself, regardless of the delivery medium. Its results represent the aggregated results from all subjects by integrating the three information groups: *Paper booklet*, *Digital info* and *LBS* group. To compute this indicator, only the valuations for the respondents who evaluated all the photos both for the *ex ante* and *ex* *post* measurements were taken into account, and therefore the sample number of cases (N) is lower than in the case for the individual photos.

Table 6.3 – Descriptive statistics of the average difference in valuation of the Park photos (pre-valuation subtracted from the post valuation) per information dimension.

	No info	Paper booklet	Digital info	LBS	With Info	Total
Mean	0.12	0.48	0.55	0.62	0.56	0.46
Std. Deviation	0.89	0.82	1.01	1.14	1.02	1.01
Minimum	-2.8	-2.4	-2.9	-3.4	-3.4	-3.4
Maximum	3	2.5	3	4.9	4.9	4.9
N	79	83	60	123	266	345

As expected, the group without access to information displays the smallest increase in valuation, almost zero, i.e. this group valued the photos in the same order of magnitude before and after the Park visit. This is an expected result as this group was the reference case. It means that the visit to the Park in itself does not contribute to an increase in the valuation of the visited features.

The groups with information (*Paper booklet*, *Digital info* and *LBS*) all show a positive variation of more than half a point from the scale used, which leads to the assumption that information does affect (in a positive way) the appreciation about a particular natural feature. These results can be observed graphically in Figure 6.9.

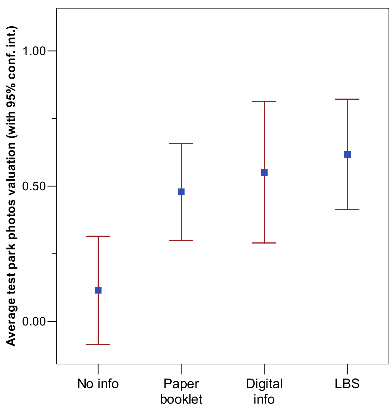


*Figure 6.9 - Graphical comparison of the average variation (*ex post *minus* ex ante *measurements) in the valuation of the Park photos for each information dimension*

The same preliminary exploration was also carried out for the *Control photos* (see Table 6.4 and Figure 6.10). The results show that the reaction to the control photos was as expected: all groups of visitors evaluated the control photos (photos from features outside the Park) approximately in the same order of magnitude both before and after the visit. Therefore the variation results are almost zero.

Table 6.4 - Descriptive statistics of the average difference in valuation of the control photos (post-visit valuation minus pre-visit valuation) according to each information dimension

	No info	Paper booklet	Digital info	LBS	With info	Total
Mean	0.05	0.11	0.03	0.08	0.08	0.07
Std. Dev.	0.85	1.04	0.68	0.93	0.91	0.89
Minimum	-3	-4	-2.4	-2.2	-4	-4
Maximum	1.8	2.2	1.8	3	3	3
N	80	81	64	124	269	349

This result validates the findings from the 10 test Park photos. As explained in the introduction of the photograph types (Section 6.2.3), this result proves that the variations in the perception and appreciation of the nature features for the 10 test Park photos was indeed caused by the access to information and not by biases introduced by the researcher's effect.

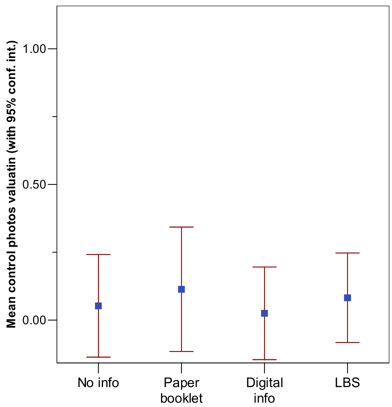


Figure 6.10 - Graphic comparison of the average variation in valuation of the control photos for each information dimension

6.3.2 Pre- and post-visit statistical differences

Although the visual analysis of the differences in valuation per photo is indicative of major differences, it was important to prove these differences in a statistically reliable way. A common test to assess if two subject samples have answered the same question in a different way is the Student's t-test. Nevertheless, this test is only reliable if the data respects the normal distribution. Therefore, the next step was to verify this assumption and the Kolmogorov-Smirnov and the Shapiro-Wilk statistical tests were used to test the hypothesis that the data are normally distributed. Unexpectedly, the normality test results for the photo appreciation of both the pre-visit and post-visit evaluations indicate that all the photo valuations before and after the visit are not normally distributed. Both the Kolmogorov-Smirnov test (with the Lilliefors improvement) and the Shapiro-Wilk test showed low significance values (less than 0.05) which indicates that the distribution of the data differs significantly from a normal distribution. Given these results, it was necessary to use non-parametric tests to verify the differences between the pre- and post-visit valuations, since the non-parametric tests do not require normally distributed data.

The non-parametric test used to detect differences between the pre-visit and the post-visit valuations was the Wilcoxon Signed-Rank. The Wilcoxon Signed-Rank test is an alternative to the paired Student's t-test for the case of two related samples (that does not assume a normal distribution of the data), and it is especially applicable when the data are scale data.

Table 6.5 displays the results for the Wilcoxon Signed-Rank tests for each photo, comparing the pre-visit and the post-visit results. The significance values with "(-)" indicate that, for that specific pair of variables, the post-visit appreciation was lower than the pre-visit appreciation (negative relation). The light blue cells indicate a significant positive difference ($\alpha<0.05$), meaning that the visitors for that cell significantly valued the photo more highly after the Park visit. The tan-shaded cells indicate a significant negative difference ($\alpha<0.05$), meaning that the visitors gave a significantly lower valuation to the photo after the Park visit.

Table 6.5 – Significance results for the Wilcoxon Signed-Rank tests for the Park photo measurement pairs (before and after the visit)

Test Park photos	No info	Paper booklet	Digital info	LBS	With Info
Wind-tree ( )	0.373	0.000	0.000	0.000	0.000
Marram grass ( )	0.203	0.000	0.000	0.000	0.000
Wooden rabbit ( )	0.279	0.001	0.187	0.012	0.000
Peat beds ( )	0.000	0.000	0.000	0.000	0.000
Honeysuckle ( )	0.123	0.001	0.000	0.000	0.000
Meadow Pipit ( )	(-) 0.015	0.639	(-) 0.675	(-) 0.945	0.997
No management ( )	0.023	0.202	0.001	0.469	0.006
Dunes ( )	0.118	0.317	0.001	0.424	0.005
Tree-branches ( )	(-) 0.261	(-) 0.932	0.104	0.006	0.008
Rabbit hole ( )	(-) 0.001	(-) 0.946	(-) 0.074	0.237	(-) 0.937

(-) Post-visit valuation lower than pre-visit valuation.
Shaded cells indicate significance at the 5% level. Positive ☐ or Negative ☐.

Most of the groups with information display significant positive differences (at the 5% level), which means that receiving information on the specific Park features did have an effect on its appreciation by the subjects.

As expected for the control group, the *No info* group, it did not show significant differences between the pre- and post-valuations, with the exception of two photos:

'No management' and 'Peat beds'. The results for these two photos in particular, at first sight seem contradictory (since the control groups should not display changes in valuation) but are nevertheless consistent with the expectation because, coincidently, these are the only two features that are also explained on physical boards located along the path (see Figure 6.11 for an example of a Park board). Therefore, even though this was not planned in the research procedure, the *No info* subjects also received information for these two particular features. The fact that these features show higher valuation after the walk is therefore consistent with the rest of the findings: *information increases the appreciation of Nature,* regardless of the delivery mechanism.

(Photo Xavier Zimmermann, Camineo)
Figure 6.11 – Example of an information board found along the route walked by the visitors

Two other photos (the 'Meadow Pipit' and the 'Rabbit hole' photos) also showed a significant difference, but in these two cases it was a negative difference. This means that the visitors valued these features less after the visit. The lower post-visit valuation could be related to the disappointment in not viewing/finding the features during the actual visit (as they did for the other photos) because of the uncertain whereabouts of these "animal" features. After visiting the Park, the visitors would probably recognize most of the landscape and plant features displayed on the photographs they were being asked to value, but, if they had not spotted these two particular "animal" photos of a bird and a hidden rabbit hole during the visit (which was most likely), then, in comparison with the other explored feature photos, they ended up receiving lower scores.

As before, in order to assess the effect that the information itself had on the visitors, a fifth group was defined that aggregated the results from the *Paper booklet*, the *Digital info* and *LBS* groups. This was designated the *With Info* group. For this group, eight out of ten photos proved to have a significant higher valuation after the Park visit and the only two photos that were not significantly valued higher were two of the "Animal" photos. An explanation for this finding, as explained before, is that both these features correspond to the "Animals" category type of information. Although, the visitors had received information about these animals, in fact most of them did not actually see the animals, so they felt disappointed and valued these features less. This disappointment did not occur for the other "Animals" category photo, the 'Wooden rabbit' photo, since this photo represented a tangible statue of the animal and was easily spotted by all the visitors.

Regarding the control photos (Figure 6.9), as expected, the visitors did not value them significantly differently before and after the visit. An interesting exception is the *Texel sheep* photo. This particular photo was indeed valued more highly for all the groups with access to information. This interesting finding could be related to the fact that the visitors became more aware and more appreciative of the Texel environments.

Table 6.6 - Significance results for the Wilcoxon Signed-Rank tests for the Control photo measurement pairs (before and after the visit)

Control photos	No info	Paper booklet	Digital info	LBS	With Info
Texel sheep, NL ( )	0.434	0.000	0.000	0.000	0.000
Wadden sea, NL ( )	(-) 0.077	(-) 0.208	(-) 0.579	(-) 0.354	(-) 0.105
Waterfall, Pt ( )	0.449	0.605	(-) 0.592	(-) 0.494	(-) 0.665
Alpine view, CH ( )	(-) 0.844	(-) 0.579	(-) 0.001	(-) 0.084	(-) 0.004
Cork tree Alentejo, Pt ( )	0.179	0.304	0.174	0.762	0.175

(-) Post-visit valuation lower than pre-visit valuation.
Shaded cells indicate significance at the 5% level. Positive ☐ or Negative ☐.

6.3.3 Effect size

In the previous section, the significance of the difference between the pre- and post-visit valuation was determined for each photograph and for each information dimension. Nevertheless, it was expected that the effect of the information would be of different sizes, depending on the type of information and on the feature being valued. The Effect size, *d*, is a measure that is used to determine the dimension of the observed effects. It was proposed by Cohen (1988) and it can be calculated using Equation 6.1.

Equation 6.1 – Effect size calculation

$$d = \frac{M_1 - M_0}{\sigma}.$$

Where:
M_1 is the average of the valuation of the photo after the Park visit;
M_2 is the average of the photo valuation before the Park visit; and
σ is the standard deviation of the sample.

Since the samples have different standard deviations, the pooled standard deviation (Rosnow and Rosenthal, 1996) was used based on Equation 6.2.:

Equation 6.2 – Calculation of the pooled standard deviation

$$\Sigma_\sigma \sqrt{\frac{\sigma_1{}^2 + \sigma_0{}^2}{2}}.$$

Cohen (1988 - p. 25) proposed a 'non-rigorous' classification of the effect sizes in order to help interpretation. He defined the effect size as: "small, d = 0.2," "medium, d = 0.5," and "large, d = 0.8", with the reservation that "There is a certain risk inherent in offering conventional operational definitions for those terms for use in power analysis in as diverse a field of inquiry as behavioural science." Being aware of the risks and in order to determine which photos and pieces of information have the greatest effect on the post-valuation, the effect size, represented by the Cohen's d measurement, was calculated for each photo valuation pair (before and after the visit). The results are displayed in Table 6.7 and are coloured depending on the effect size to help their interpretation. The classification applied to the photo valuation data. The effect sizes in the table were adapted to the presented values and, six different categories ranging from *negative* to *very large* effect were defined.

Table 6.7 – Effect sizes for the ten test Park photos.

Test Park photos	**No info**	**Paper booklet**	**Digital info**	**LBS**
Wind-tree ( )	0.18	0.93	0.87	0.81
Marram grass ( )	0.19	0.35	0.57	0.45
Wooden rabbit ( )	0.12	0.22	0.13	0.18
Peat beds ( )	0.39	0.57	0.67	0.61
Honeysuckle ( )	0.18	0.42	0.51	0.32
Meadow Pipit ( )	-0.15	0.09	-0.03	0.07
No management ( )	0.18	0.16	0.35	0.04
Dunes ( )	0.16	0.06	0.38	0.09
Tree-branches ( )	-0.12	-0.02	0.14	0.26
Rabbit hole ( )	-0.29	0.00	-0.23	0.09
TOTAL	0.07	0.25	0.29	0.28

Proposed classification and legend, extended from Cohen (1988):

Negative	< - 0.2	
No effect	- 0.2 to 0.2	
Small	0.2 to 0.4	
Medium	0.4 to 0.6	
Large	0.6 to 0.8	
Very large	> 0.8	

According to Table 6.7, different photos show different effect sizes across the different information groups. When summarizing the overall effects per group (averaging the results for all photos and analysing them per group), it becomes clear that the information, regardless of the delivery mechanism, has an effect on the variation of information appreciation, even though a small one. The *No info* group behaved in accordance with the expectation that the control group would show no effect of the valuation changes before and after the visit, thus giving credibility to the small effects found for the test information groups.

Analysing the individual results per photo, some photos show large effects, while others show small or non-existent effects. The 'Wind-tree' photo reveals a very large effect for the information groups and the 'Peat beds' photo also shows medium to large effects for the *info* groups. On the other hand, other features show negative or no effect (e.g. the 'Meadow Pipit' and the 'Rabbit hole' photos). These results are consistent with the statistical differences analysed in the previous section (Section 6.3.2), where an explanation for this finding was given.

This analysis was also performed for the control photos and it also produced the expected results. Table 6.8 shows that the overall results (i.e. results averaged for all control photos according to each of the four information groups) indicate that the Park visit had no effect on the nature valuation by the subjects. This is in line with the expected behaviour by a control group and indicates that the effects found for the test Park photos are indeed caused by the information provision and not biased as a result of the researcher's effect (as already explained in Section 6.2.3).

Table 6.8 – Effect sizes of control photos

Control photos	No info	Paper booklet	Digital info	LBS
Texel sheep, NL ()	0.07	0.35	0.36	0.38
Wadden sea, NL ()	-0.11	-0.11	-0.08	-0.07
Waterfall, Pt ()	0.17	0.12	-0.05	0.01
Alpine view, CH ()	0.02	0.10	-0.20	-0.09
Cork tree Alentejo, Pt ()	0.24	0.16	0.08	0.06
TOTAL	0.08	0.12	0.01	0.05

Note that the first control photo, 'Texel sheep', shows a small effect for all the information groups. This behaviour differs from the other photos which revealed no effect. A possible explanation for this finding is the fact that the information accessed by the visitors during the walk explained the Park environment which is part of the island of Texel's environment. This could have led to a better understanding of the overall Texel natural environments and to an actual increase in awareness and overall appreciation of these environments.

6.3.4 Explaining the valuation of the different information categories

The previous overall results indicate that the visitors with information do value the nature features they visited more than the visitors without information. Nevertheless, it is expected that access to information is not the sole factor that has an impact on the valuation. In order to determine a more accurate quantification of the impact of information on the post-valuation process by the subjects, other factors have to be taken into account. A model to explain the post-valuation process was hypothesized

(Figure 6.12) using three different types of factors: a) individual features of the visitors (Gender, Age, Education level); b) perception of the area (including their features valuation before the visit and how well they already know the Park); and c) the visit characteristics (how the visitor enjoyed the overall visit; whether the visitor had access to information or not; and the time the visitor spent at the feature being valued).

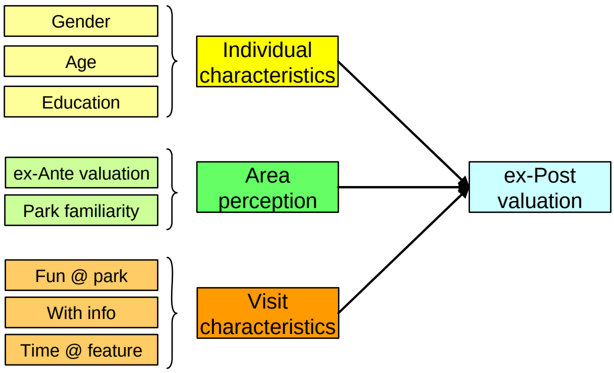


Figure 6.12 – Nature valuation model

The model was estimated using the Ordinary Least Squares (OLS) method using a single-equation regression. In single equation regression models, the explanatory variables, *Q*, *W*,… *P*, relate to an independent variable *Y* (see Equation 6.3). The parameters β give the impact of each variable; the parameter α is a constant; and the parameter ε the errors. For a broader discussion on the OLS method, please refer to a statistics or econometrics textbook such as Rice (1995) or Pindyck and Rubinfeld (1998).

Equation 6.3 – Generic single equation regression model

$$Y = \alpha + \beta_1 Q + \beta_2 W + \ldots + \beta_1 P + \varepsilon.$$

Each factor hypothesized to have an influence was integrated in the model, and Equation 6.4 describes the model as a single equation regression.

Equation 6.4 – Single equation regression for the nature valuation model

$$\begin{aligned} \textit{Ex post}\text{ valuation} = {} & \alpha 1 \\ & + \beta 1(\text{Age}) \\ & + \beta_2(\text{Gender}) \\ & + \beta_3(\text{Education}) \\ & + \beta 4(\textit{ex ante}\text{ valuation}) \\ & + \beta_5(\text{Park familiarity}) \\ & + \beta_6(\text{Fun @ Park}) \\ & + \beta_7(\text{info access}) \\ & + \beta_8(\text{time @ feature}) \\ & + \varepsilon. \end{aligned}$$

Gender
The factor Gender was integrated in the model as a dummy variable where male subjects = 1 and female subjects = 0.

Age
The Age factor was also considered in the model as a dummy variable. Two groups were defined: 1) the visitors who were younger then 30 years old; and 2) visitors older than 30 years old.

Education
The Education factor was expected to have an influence on the individual's appreciation of Nature as it may have an impact on the efficacy of the information. Visitors with access to higher education were expected to appreciate nature more, as a result of their better understanding and assimilation of the information provided. The visitors were divided into two groups: 1) the visitors who had completed higher education (University); and 2) the visitors who did not have University degrees.

Ex ante nature valuation
As explained in the methodology (Section 6.2), the valuation scale was administered at two different points in time: before and after the Park visit. The *ex ante* nature valuation includes the results from the valuation before the visit, and it is expected that it plays a significant role in explaining the *ex post* nature valuation. This variable is introduced in the model to account for the pre-existing variation in different visitors' perception of Nature. If a visitor values one or more of the photographs with high values in the *ex ante* measurement, it is expected that the *ex post* measurements will also be accordingly high (with a small variation due to the effect of other independent variables such as the information access).

Park familiarity
It was expected that the pre-existing knowledge of the Park would have a great influence in the nature appreciation, i.e. visitors who already know the Park well would be less inclined to make valuation changes, when compared with the visitors who do not know the Park. In order to represent these two groups, the visitors were distinguished by the number of previous visits: 1) the visitors who have been to the Park five or more times (or visit it regularly); and 2) the visitors who have visited the Park less then five times.

Fun at the Park
The subjects' overall enjoyment of the visit was assessed using 7-point Likert scales on dichotomous pairs of adjectives (*Nice - Not nice*; *Pleasing – Annoying*; *Interesting – Boring*; *Unique – Common*; *Varied - Dull*). The visitors had to classify their visit by rating it from -3 (the negative adjective) to +3 (the positive adjective). The Enjoyment variable was then calculated using the average of the results from the five pairs of adjectives. This technique was chosen because the different concepts might not be

understood in exactly the same way by the visitors (Interesting or Pleasing, although similar, may have slightly different interpretations amongst the subjects). By taking the average of several concepts, the small differences are expected to be eliminated. Only the answers that rated all the five pairs of adjectives were considered when calculating the average enjoyment.

Information access

If the visitors had access to information (the subjects from the *Paper booklet*, *Digital info* or *LBS* groups) or not, this factor was inserted in the model as a dummy variable where subjects from the *No info* group =1, and subjects from any of the info groups = 0. It was expected that the coefficient of this factor would be negative, meaning that not having information has a negative effect on the post-visit valuation of the photographs.

Time at the feature

The absolute time spent at every 5-metre segment of the path was calculated in the previous chapter (see Chapter 5). For this model, the time spent at the feature being analysed was calculated based on the average time spent around the segment closest to the feature and standardized based on the total time the visitor spent in the Park.

Equation 6.5 – Calculation of the individual time the visitor spent at the feature

$$\text{Time@feature} = \frac{\text{Mean}(\text{time}_{\text{feature segment}}, \text{time}_{\text{feature segment -1}}, \text{time}_{\text{feature segment +1}})}{\text{Total time@Park}}$$

The data was standardized per person because different people have a different exploration pace and the proportion of the total exploration time was more appropriate than the absolute time. The detailed regression results (R^2, Beta coefficients, standard errors, and significance levels) are presented in Table 6.9 for each of the photos representing the three different categories: ‘Wind-tree’ (Landscape), ‘Marram grass’ (Plants), and ‘Meadow Pipit’ (Animals).

Using OLS linear regression for the estimation of the model parameters, the variables could explain different shares of the variation in the *ex post* nature valuation: namely, 11.1 per cent for the Animal photo, 31.2 per cent for the plant photo, and 31.4 per cent for the Landscape photo. The remaining variation is accounted for by unobserved factors. The Landscape and the Plant photos showed similar results. For these two categories, the regression analysis proved that the factors *Pre-Park visit valuation*, the *fun people had at the Park*, and the *access to information* all significantly influence the variation of the dependent variable. The factors *Gender*, *Age*, *Education level*, *Park familiarity* and the *Time the visitor spent at the feature* do not have a significant impact on the variation of the post-visit valuation of nature. However, slightly different results were found for the “Animal” category photo. Even though its model was able to explain less variation of the dependent variable, more independent variables were found to have an influence. *Age* and the *Park familiarity* were also shown to have a significant impact on the variation of the valuation in addition to the *pre-visit valuation*, *Park fun* and *information access* that were also found to influence the Landscape and Plant photo variations.

Table 6.9 – Nature valuation model. Regression analysis explaining the valuation of the Park features after the visit

Model statistics		Variables (C)	Gen	Age	Edu level	Pre-val.	Park famil	Park fun	No info	time @feat
Wind-tree	B	1.53	-0.24	0.38	-0.24	0.46	0.64	0.69	-0.91	-7.57
R^2 = 0.314	SE	0.37	0.21	0.26	0.21	0.06	0.48	0.13	0.25	17.2
N = 303	Sig	0.00	0.26	0.15	0.25	0.00	0.19	0.00	0.00	0.66
Marram grass	B	0.85	0.22	0.19	-0.25	0.45	0.28	0.57	-0.52	-14.2
R^2 = 0.312	SE	0.34	0.19	0.24	0.19	0.05	0.42	0.12	0.22	22.3
N = 297	Sig	0.01	0.24	0.42	0.18	0.00	0.51	0.00	0.02	0.53
Meadow Pipit	B	2.17	-0.17	-0.63	-0.25	0.20	0.94	0.33	-0.48	-2.4
R^2 = 0.111	SE	0.53	0.24	0.30	0.24	0.06	0.52	0.15	0.28	25.7
N = 286	Sig	0.00	0.49	0.03	0.31	0.00	0.07	0.03	0.09	0.93

Legend:
(C) - constant
▪ - Significant at the 5% level;
▫ - Significant at the 10% level.
B – Unstandardized coefficient.
SE – Standard Error of the coefficient.
Sig – Significance.

The impact of having access to information in the Nature valuation variation is indicated by the coefficients of the variable *No info*. These coefficients were used to calculate a *relative impact factor* that corresponds to the variation caused by the access to information, but in relation to the absolute post-visit feature valuation by the *No info* subjects. The results of the calculation of this relative impact factor are displayed in Table 6.10. According to the OLS results, concerning the feature from the category "Landscape" (the 'Wind-tree'), the visitors with information valued it higher by almost one scale point, 0.91, but when considering that the visitors without information valued the feature after the visit with 2.6 scale points, then the relative impact of having information is 35 per cent. For photos from the category "Plants" (the 'Marram grass'), the absolute coefficient of having information is slightly higher than half a scale point, 0.52. But when compared with the valuation of the absolute post-visit valuation, 2.1 scale points, then the relative impact factor is 25 per cent. The photo of the 'Meadow Pipit' (the "Animal" category photo) displays the relative smallest impact factor, 17 per cent, since the absolute coefficient of having information is 0.48 scale points and the absolute post-visit valuation by the *No info* subjects is 2.9.

Table 6.10 – Calculation of the information impact factor for each category

	Information coefficient on valuation increase (from Table 6.9)	**Post-visit valuation by *No info* subjects (from Table 6.1)**	**Impact factor**
Wind-tree	0.91	2.6	35%
Marram grass	0.52	2.1	25%
Meadow Pipit	0.48	2.9	17%
Mean	0.64	2.53	25%

6.4 Conclusions

This study was able to prove that, when visitors have access to information about the places they visit in a Protected Area, their perception changes and they have greater appreciation for the landscape and natural features they are visiting.

The photos used in this study revealed variation in terms of their effects, so it is advisable to use a sufficient number of photos to achieve reliable results. To determine the reasons why particular photos/features show higher effects and more clear differences is outside the scope of this study that aims at proving the effect of information on the valuation of landscapes and natural features.

The delivery mechanism does not seem to have an impact on the variation of the perception of Nature, since the visitors with access to information delivered by means of a technological support (the *Digital info* and the *LBS* groups) showed similar results to the conventional delivery mechanism (the *Paper booklet* group). The following chapter is dedicated to determining the perception of added value for each delivery mechanism by the visitors.

7 Information Valuation

7.1 Introduction

In a previous chapter a mobile information tool was introduced as a way to improve information flows in Protected Areas (Chapter 3). To test the effects of this tool on visitors to nature areas, a research framework was designed using different information dimensions as control and test groups (Chapter 4). These information dimensions acted as an independent variable so that the effects of each of the dimensions could be isolated and measured. This research procedure was implemented with visitors to the Texel Dunes National Park accessible via the Ecomare Museum on the island of Texel (in the Netherlands). The visitors who participated in the research were divided into four groups. A first group of subjects: the *No info* group, visited the Park without access to additional information: the *No info* group; a second group of visitors: the *Paper booklet* group, were provided with information in the form of a paper booklet composed of an area map with points of interest (POIs) on it that were indexed to pages explaining these particular interesting places with text and photos (for details on the information available, see Section 4.2); a third group of subjects: the *Digital info* group, were given the same information, but it was delivered using a digital handheld device; the fourth and last group was issued with the same information as the second group and used the same device as the third group, but it was augmented with location sensitivity. Connecting the device to a GPS receiver, the system was aware of the visitors' location and could therefore enhance the information delivery in two ways: 1) a shifting cross on the map represented the visitor's moving position; and 2) the system alerted the visitor, by means of a soft cuckoo sound when it was the right time/place to read the information.

This chapter is dedicated to determining and quantifying the perceived added value of context-aware information for the visitors to the Texel Dunes National Park. The value that the visitors ascribe to each of the information dimensions was captured using a well-established economic construct, the stated Willingness-to-Pay (WTP). Therefore, the added value of the information dimensions is represented by the differences measured between the different information delivery mechanisms. A specific valuation model was designed in order to explain the process of information valuation by the visitors, and to isolate the information dimension's specific contribution to this valuation, thereby enabling the measurement of the value of location. The model, designated Information Valuation Model (IVM), uses as the main dependent variables the WTP measurements. WTP translates people's preferences for non-marketed goods or services into economic values. Since this context-aware service is unique, and as yet there is no market value established for it, it was necessary to estimate it. The pre- and post-visit WTP were measured by means of the Contingent Valuation Method (CVM) using the Stated Preference (SP) technique. In this technique, visitors are asked to state the maximum monetary value that they are prepared to pay for the information service. It is assumed that the visitors who value the information more will make higher bids on their maximum WTP. The same technique was administered to the different visitors, regardless of whether they had information or not or the information delivery mechanism. The combinations of information or not and delivery medium corresponds to the four information dimensions tested (*No info*, *Paper booklet*, *Digital info* and *LBS*).

The model comprises five parts (A - E): Parts A to D use stated preferences, while part E uses revealed preferences. Part A explains the information appreciation of the visitors based on their individual characteristics. Part B explains the *ex ante* (pre-visit) WTP for information based on the visitor's Information Appreciation and also Income. Part C explains the enjoyment the visitors revealed according to their personal features and the information dimension. Part D explains the *ex post* WTP for information based on the pre-visit WTP, the expectations matching, the fun visitors had, and the information medium used by the tourists (*No info*, *Paper booklet*, *Digital info* and *LBS*). By comparing the results obtained for the different information dimensions, it is possible to quantify the added value that the visitors ascribe to a certain information delivery mechanism in relation to the others. In this way, the model has the particularity of being able to reveal the valuation differences for the different information media, thus enabling the measurement of the unique value of:

- The Information content – the difference between the *No info* and the *Paper booklet* groups;
- The medium-related novelty effect – the difference between the *Paper booklet* group and the group with the same information in the *Digital info* media.
- Location-enabling the information – the difference between the *Digital info* group and the group with the location-enabled information, the *LBS* group.
  NB: This third value is the added value of using location-enabled information vs. conventional information.

Part E of the model also is a validation assessment. The stated preferences explained in part D, were validated with revealed preferences. The time spent in the Park was used as an objective measurement because it is assumed that, if the visitors value their visit more when using information, they will spend more time in the Park exploring Nature and the associated information.

7.2 Economic assessment

7.2.1 Economics of Information

Economics of information is a branch of microeconomics dedicated to studying the effect of information in an economy and on economic decisions. Some aspects of this field are relevant to the present study, particularly the concept of ‘information pricing’. Although information can be considered a normal good in the economic sense, there are intrinsic aspects to information that make it require a different economic approach (Ouwersloot et al., 1991). DeLong and Froomkin (2000) have summarised the main aspects that distinguish transactions of information from the buying and selling of most other goods: First, information is non-*rivalrous* (consuming information does not imply that someone else cannot also consume it, like it happens in food or house markets); Second, *exclusion* is not a natural property of information goods (if it is available, it is difficult to exclude others from its use); Third, there is a lack of *transparency* in the information market, i.e. information as an “experience good” (to evaluate the information you have to know it – e.g. to accurately evaluate a movie, you have to watch it). Forth, information has typically a *low marginal cost* (information is costly to create, but cheap to reproduce and distribute).

These differences had to be considered in the design of this study, since we define added value as the difference in evaluation between the different information delivery media. The non-*rivalry* and non-*exclusion* aspects of information meant that more than one person can access the information in the field on the device or paper booklet, therefore allowing more research subjects. Since the information is an ‘experience good’, we evaluated it after the subjects experienced it. The aspect of *low marginal costs* is not applicable since we propose a hiring model for the information delivery mechanism when asking the visitors to evaluate the information. If a hiring model is not applicable, the location-based information can have a considerable marginal cost, since the delivery medium we used requires an expensive digital handheld device and a GPS receiver.

For further details on the economics of information, Shapiro and Varian (1999) provide an extensive discussion on the application of economic laws to the new markets of digital information.

7.2.2 Distinction between price and value

In perfectly competing markets, the price of goods already reflects the (transaction) value of the good in monetary units. The transaction value results from the interaction between the production, or ‘supply’, and the needs or preferences of the individual buyers, also known as ‘demand’. The market is limited to the possibilities of income and/or choice. However, not all values can be obtained in this way. For some resources, markets do not always function in a state of perfect competition, in which case the price at which the resource is traded does not necessarily reflect the transaction value. And, in the case of some commonly-owned goods and services (e.g. clean air, nature preservation, local biodiversity), there is no real market for them, and therefore there is no market transaction price (Hoevenagel, 1994; Nunes et al., 2000). This is the case for the location-based information system developed for this study (see Chapter 4), because it is a new and unique product for which a market does not yet exist, and it was also provided to the visitors at a zero price. Therefore, it was decided to estimate the economic value of the information dimensions by means of the contingent valuation method.

7.2.3 The contingent valuation method

The contingent valuation method (CVM) tries to translate preferences or emotional value into economic or monetary variables. It is a survey method in which respondents are asked how much are they prepared to pay for the use (or non-use) of goods or services. This method has been extensively used in the literature mainly to measure the value of environmental and other non-market goods. (e.g. clean air, nature preservation, local biodiversity) (Mitchell and Carson, 1989), but it has also been used to ascertain the monetary value of information (systems) not yet available in the market (Rollins and Shaykewich, 2003). It is a method that provides great flexibility and can be used to determine the economic monetary value of practically everything. Nevertheless, it is best used to determine the valuation of goods and services that are clearly understood by the subjects of the study. On account of this flexibility and because it is uncomplicated to implement, the CVM was chosen to value the information dimensions including the Location-based information.

Even though the CVM has been widely used in academic, industry and policy studies, there is considerable controversy and known issues surrounding it (Diamond and Hausman, 1994; Nunes, 2002). Most of the criticism can be summarized into four limitations of the method. First: the CVM method might not produce valid measurements when people are unfamiliar or inexperienced with the studied goods or services. Validity could be a problem since it is very difficult to describe a good in all of its detailed attributes if people are unaware of it (e.g. a nature area). Therefore, the respondents could imagine (slightly) different representations and would be stating their preference with respect to different concepts. However, this limitation does not affect the present study, since the service being valued is an existing good that was experienced by the visitors. Therefore, the subjects were not asked to imagine the product, but could make concrete bids based on their experience with the information. Second: there is the existence of the "warm glow" effect (Nunes, 2002) where respondents may express a higher WTP because they feel good about the act of giving money for a social good, even if they do not believe in the importance of the good itself. Again, this limitation is not expected to affect the results of this study, since even if a warm glow effect occurs, it will be present in both *ex ante* and *ex post* measurements and in all the info groups, and therefore will not affect the comparative results. Third: the results are biased because of the high occurrence of “Protest bids”. Protest bids are answers that do not reveal people’s real value, but that are a protest to a certain situation For example, in the case of valuation of public goods (such as clean air), even though the good is valuable for a person he/she can bid a zero value because he/she believes the government should take care of the costs. In the case of this research, the service/device is available to hire on a voluntary basis, and therefore, protest bids were not applicable. The fourth and last main criticism of the CVM method is the validation issue regarding the different results that WTP and Willingness-to-Accept (WTA) studies provide. WTA is a technique that asks the respondents how much they are prepared to accept as a minimum compensation for the lost or non-use of the good. In theory, the two techniques WTP and WTA should give similar results but the literature disagrees. It has been demonstrated that the WTA value is always greater than the WTP value for the same issues (Brown and Gregory, 1999; Horowitz and McConnell, 2002). Theoretical explanations relative to this issue can be found in the literature (Shogren et al., 1994). Nevertheless, this is not a limitation for the present study. The determination of absolute monetary value of the WTP is of little interest in this research. The main focus of the study is on the explanation of the *differences* in valuations of the various information media.

As indicated above, the CVM method has clear advantages (flexibility and easiness of implementation), and, since the disadvantages could be eliminated or mitigated, the method was implemented in the form of a questionnaire (see Chapter 4 for test set-up details) and distributed to the participants.

7.2.4 Willingness-to-Pay

The economic valuation of innovative and off-market information systems is based on consumer theory, where consumers tend to maximize their satisfaction derived from consumption (constrained by their income). Consider the distribution of willingness-to-pay (WTP) across consumers as given in Figure 7.1, which presents the *Marshallian demand curve*. For a good that is supplied at price P_0, the number of consumers buying the good is Q_0. For the remaining consumers, the price is higher than their WTP. Some consumers are willing to pay more for this good – the fact that they pay less, results in a consumer surplus. The area under the demand curve and above P_0 (or area A in the graph) is the maximum gain an individual can obtain from the information service at price P_0. The economic value, or the total WTP by consumers for the environmental good, is equal to the sum of area A and B, or the area under the demand curve (Pearce and Turner, 1990). Since P_0 can be directly observed in the market, area B, or total expenditure, is usually the first approximation of economic value. However, since this omits consumer surplus, the economic value, or total WTP, is more than what we observe from market prices.

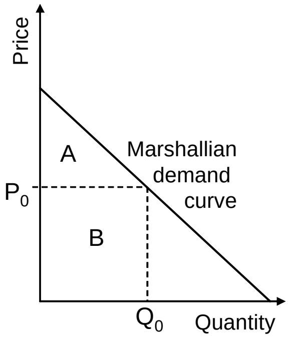


Figure 7.1 – Marshallian demand curve and consumer surplus

Conclusion: according to Pearce and Turner (1990), WTP is a technically correct measure of economic value. The WTP is the maximum amount an individual is willing to pay to acquire some good or service. This may be elicited from stated or revealed preference approaches (UNEP, 1995). The WTP measurements were performed via stated preference techniques implemented by means of a questionnaire. In the questionnaire, the subjects could state their WTP for information by choosing from a set of 10 predefined price alternatives, ranging from €0 to €3.5.

7.3 The Information Valuation Model

A model was designed to explain the information valuation process and to measure the value differences attributed by the visitors to the different information dimensions. The variation in the WTP is expected to be affected by the demographic features of the subjects (age, gender, education, income), pre-existing knowledge of the Park, generic information appreciation, enjoyment the visitors experience during the visit, and also by the information dimensions. Figure 7.2 illustrates the information valuation model.

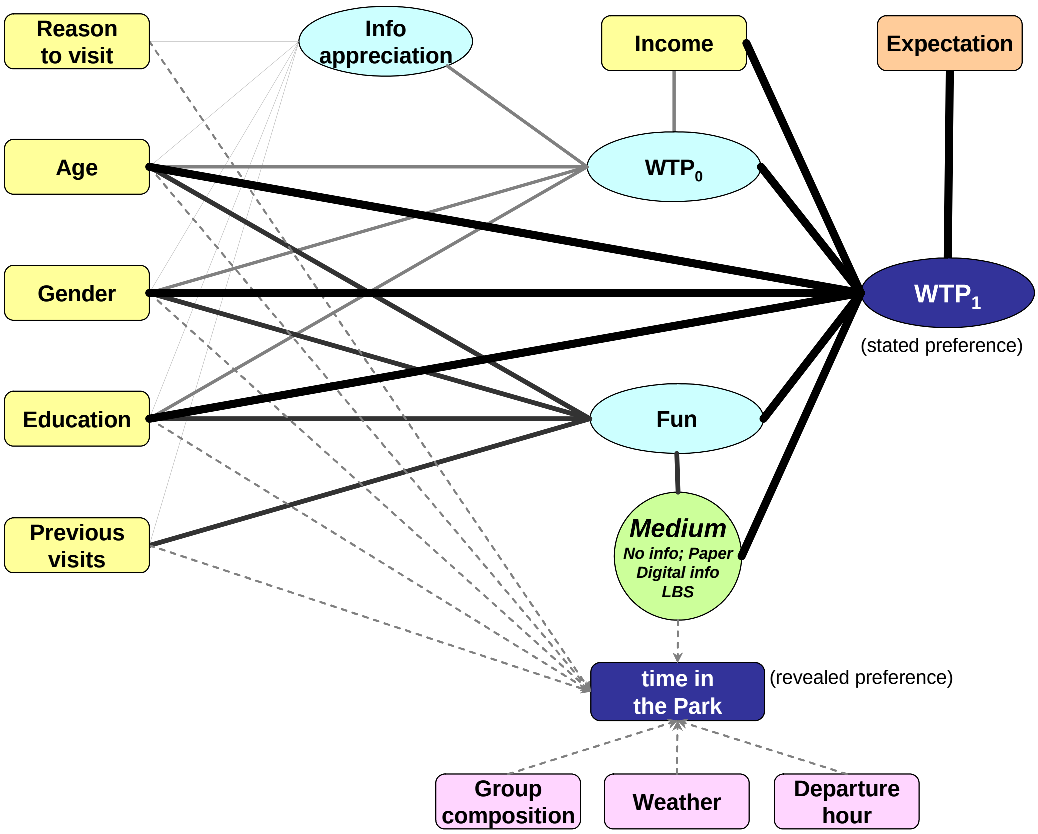


Figure 7.2 –Information Valuation Model (IVM) composed of "stated preferences" (with four explanatory sub-models) and one "revealed preference" sub-model

Legend:

Independent variables:
- Individual features
- Visit characteristics
- Information dimension, delivery mechanisms
- Other independent Variables

Dependent variables
- Intermediate
- Final (stated preference)
- Final (revealed preference)

Partial model relations:
- Part A
- Part B
- Part C
- Part D
- Part E (revealed preference)

The four interlinking parts that compose the model will be estimated using the Ordinary Least Squares (OLS) method. Single-equation regressions were defined for each part of the model. In single equation regression models, the explanatory variables, *Q*, *W*,… *P*, relate to an independent variable *Y* (see Equation 7.1). The parameters $\beta_{1\text{to n}}$ give the impact of each variable, the parameter α is a constant, and the parameter ε the error.

Equation 7.1 – Generic single equation regression model

$$Y = \alpha + \beta_1 Q + \beta_2 W + \ldots + \beta_n P + \varepsilon.$$

For a broader discussion on the OLS method, please refer to a statistics or econometrics textbook such as Rice (1995) or Pindyck and Rubinfeld (1998).

7.3.1 Part A – Estimating the information appreciation

Part A tries to understand which individual characteristics influence the information appreciation process. It was hypothesized that the features *age*, *gender*, *education*, *previous visits (to the Park)* and the *reason to visit (the Park)* would influence the appreciation of having information about the Park. Equation 6.4 describes Part A of the model as a single equation regression.

Equation 7.2 – Single equation regression IVM part A

$$\begin{aligned}\text{Info Appreciation} = \quad & \alpha_1 \\ & + \beta_{A1}(\text{age}) \\ & + \beta_{A2}(\text{gender}) \\ & + \beta_{A3}(\text{education}) \\ & + \beta_{A4}(\text{previous visits}) \\ & + \beta_{A4,5,6,7}(\text{reason to visit}_{1,2,3,4}) \\ & + \varepsilon_1.\end{aligned}$$

The detailed regression results (R^2, Beta coefficients, standard errors and significance levels) are presented in Table 7.1, and the variables used are explained thereafter. The dependent variable, Information Appreciation, was measured using a 7-point Likert scale ranging from -3 (strongly dislike) to +3 (strongly like). The mean value for this variable is 1.6 (with standard deviation of 1.2 and N = 414).

Table 7.1 – Information valuation model Part A: Regression analysis explaining Information Appreciation based on Age, Gender, Education, and previous visits to the Park

Explanatory Variables	Coefficient	Std. Error	Sig.
Constant ***	1.521	0.221	0.000
Age (years)	0.002	0.004	0.712
Gender (“Male” = 1) **	-0.237	0.116	0.042
Education (“High” = 1) ***	0.414	0.121	0.001
Previous visits (“≥ 5 times” = 1) **	-0.547	0.276	0.048
Reason: enjoy Nature	-0.133	0.140	0.341
Reason: learn **	0.366	0.153	0.017
Reason: have a walk	0.097	0.199	0.628
Reason: coincidence *	-0.268	0.158	0.091
N =	404		
R-square =	0.080		
Adjusted R-square =	0.061		

NB: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The variables in Part A of the model are:

Age
It was expected that older visitors would appreciate information more then the younger ones. However, the regression analysis proved that Age did not have a significant influence on information appreciation.

Gender
On the other hand, and contrary to our expectations, the factor Gender proved to have a significant influence on information appreciation. It was expected that both genders would equally appreciate information on the Park. Nevertheless, the regression analysis shows that Female visitors appreciate having information more than the Male visitors.

Education
The education factor was expected to have some influence on the individual information appreciation. Visitors who had obtained higher education degrees were expected to appreciate information more than visitors with a lower level of education. The visitors were divided into two virtual groups: 1) visitors who had finished higher education (University); and 2) the visitors who had not finished University degrees. As expected the higher educated people significantly appreciated information more than the other group.

Previous Visits
It was expected that the pre-existing knowledge of the Park would have a great influence on the appreciation of information, i.e., visitors who already know the Park

well would be less interested in having information, when compared with the visitors who do not know the Park. In order to represent these two groups, the visitors were divided by the number of previous visits: 1) the visitors who had been to the Park five or more times (or visited it regularly); and 2) the visitors who had visited the Park less than five times. The results from the linear regression show that the number of previous visits to the Park significantly influences the individual information appreciation. The visitors who have been to the Park many times are less likely to appreciate the idea of having information during their visits.

Reason to visit the Park

The visitors were asked why they visited the Dune Park. The multiple options were 1) To enjoy Nature; 2) To learn about Nature; 3) Just to have a walk; and 4) No particular reason, I came to see the museum and found out about the Dune Park. It was expected that the different motivations to visit the Dune Park would influence the appreciation to have information about Nature in the Park. The reasons were considered as dummy variables in the model, i.e. virtual groups were defined using dichotomous variables. Naturally, there can be more than one reason behind the decision to visit the area. A visitor could be extremely motivated to have a walk in the Dune Park and, at the same time, be equally motivated to learn while he does so. Therefore a visitor could belong to more than one group category. The results show that the visitors who state they visit the Park to learn about nature have a greater appreciation of having information and that the visitors who did not plan to visit the Dune Park, but just coincidently found out about it at the museum, appreciate having such information less (-0.27). It could not be proven that the remaining reasons (to appreciate Nature and to just walk) had any influence on the dependent variable.

Summary

Using OLS Linear regression for the model estimation, the variables could explain 8.0 per cent of the variation in the information appreciation. The remaining variation is accounted for by unobserved factors. The regression analysis proved that the factors Gender, Education, Previous visits to the Park, and the reason to visit the Park significantly influenced the appreciation of information. The model estimation also revealed that age did not have a statistically significant influence and apparently does not affect the information valuation process.

7.3.2 Part B – Estimating the *ex ante* willingness-to-pay for information

Part B of the information model is dedicated to explain the individual willingness-to-pay (WTP) for information. Information appreciation, personal features and income are assumed to be the features that affect WTP. Equation 7.3 describes the single equation regression for Part B of the model.

Equation 7.3 – Single equation regression IVM part B

$$
\begin{aligned}
\text{WTP } (\textit{ex ante}) = \; & \alpha_2 \\
& + \beta_{B1}(\text{Info appreciation}) \\
& + \beta_{B2}(\text{Income}) \\
& + \beta_{B3}(\text{Age}) \\
& + \beta_{B4}(\text{Gender}) \\
& + \beta_{B5}(\text{Education}) \\
& + \varepsilon_2.
\end{aligned}
$$

The WTP variable was measured using a multiple choice question with ten alternative bids ranging from €0 to €3.5 and with increases of €0.25. The mean value for the *ex ante* WTP for information is €1.08, with a standard deviation of €0.73 (N=409). It was hypothesized that, before the actual visit takes place, the WTP for information would be influenced by the information appreciation (explained in Part A of the model) and by personal features, particularly, the income of the visitors. These constructs were able to explain 4.8 per cent of the variation in the WTP for information. Although, most of the variation is explained by unobserved factors, the model proves that the information appreciation influences the WTP as expected, and that income, unexpectedly, does not seem to be a determining factor in the variation of the dependent variable. The main results, , beta coefficients, standard errors and significance levels are presented in Table 7.2. This model was analysed using a sample of 367 subjects. This is a smaller sample size than the test samples for the other parts of the model. This is because some subjects were uncomfortable about stating their annual income, and therefore more missing values occurred in this variable.

Table 7.2 – Information valuation model Part B: Regression analysis explaining ex ante *willingness-to-pay for information appreciation, Income and personal features (Age, Gender and Education)*

Explanatory Variables	Coefficient	Std. Error	Sig.
Constant ***	0.676	0.132	0.000
Info Appreciation ***	0.114	0.033	0.001
Income (in categorical intervals as scale)	0.000	0.000	0.688
Gender (Male = 1)	0.110	0.085	0.196
Age (years) *	0.005	0.003	0.085
Education (“High” = 1)	-0.091	0.086	0.291

N =	374
R-square =	0.032
Adjusted R-square =	0.026

NB: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The variables used in Part B of the model are:

Information appreciation

The Information appreciation was explained in Part A of the model, and it is a construct that represents how much the visitors would like to have information about the Park they are about to visit (using a 5-point Likert scale). The analysis results show that this construct significantly influences the variation of the WTP for information pre-visit.

Income
The factor Income was expected to have a positive influence on the WTP for information variation. Visitors, who have a greater income, were expected to make higher bids for the hypothetical payment for information. The income was classified into six average categories ranging from zero, then €4.5k per year until €60k per year. However, the variations in income did not influence the variations in the WTP for information. This is probably because the available bids to pay for the information were relatively low. The visitors could choose from 10 price values, ranging from €0 to €3.5 euros. As explained before, the average value of the bids to pay for access on the pre-visit questionnaire was € 1.08 (with a standard deviation of 0.73). Such a low value may be the cause of the finding of no influence of income on WTP. Acknowledging the fact that €1 is less than the price of a cup of coffee in the Park restaurant, and that the entrance to the museum itself is €7.5, it can be assumed that it is equally easy for someone with a high income to pay €1 as it is for someone with a low income, in light of the fact they have already decided to visit the museum and pay €7.5 for the entrance fee.

Gender
Unlike in the previous model, in this part, Gender does not seem to affect the dependent variable. It was expected that both genders would be prepared to pay equal amounts and this assumption was corroborated since this variable showed a non-significant level.

Age
This time the Age factor was considered as a continuous variable. It was expected that older visitors would be ready to pay more for information than younger ones and according to the model estimates, Age does have a significant influence in the *ex ante* WTP for information, even though it is a relatively small one.

Education
As explained before, the visitors were divided into two virtual groups: 1) visitors who had finished higher education (University); and 2) the visitors with no university degrees. Nevertheless, Education does not seem to have an impact on the individual *ex ante* WTP for information.

7.3.3 Part C – Explaining visitors' enjoyment experienced during the visit.

The subjects' overall enjoyment of the visit was assessed using 7-point Likert scales with opposing pairs of adjectives (*Pleasing – Annoying*; *Interesting – Boring*; *Unique – Common*; *Varied – Dull, Nice - Not nice*). The visitors had to classify their visit by rating it from -3 (the negative adjective) to +3 (the positive adjective). The Enjoyment variable was then calculated using the average of the results from the five adjective pairs. This technique was chosen because the different concepts might not be understood in exactly the same way by the visitors (Interesting or Pleasing, although similar, may have slightly different interpretations amongst the subjects). By taking the average of several concepts, the small differences are expected to be eliminated. Only the answers that rated all the five pairs of adjective were considered to calculate the average enjoyment, therefore the N was lower: 354 subjects. The statistical mean value is 1.89 with a 0.73 standard deviation. It was expected that the dependent variable, average Enjoyment, would be influenced by Personal features such as Age, Gender, Education and previous visits to the Park, and also by the information dimension that the visitors experienced. Equation 7.4 depicts the single equation regression for Part C of the model.

Equation 7.4 – Single equation regression for IVM Part C.

$$\begin{aligned}\text{Average Enjoyment} = \; & \alpha_3 \\ & + \beta_{C1}(\text{Age}) \\ & + \beta_{C2}(\text{Gender}) \\ & + \beta_{C3}(\text{Previous visits}) \\ & + \beta_{\text{mediumC1}}(\text{Paper}) \\ & + \beta_{\text{mediumC2}}(\text{PDA}) \\ & + \beta_{\text{mediumC3}}(\text{GPS}) \\ & + \varepsilon_3.\end{aligned}$$

The model was estimated using the OLS technique and the results (R^2, beta coefficients, standard errors and significance levels) are presented in Table 7.3.

Table 7.3 – Information valuation model Part C: Regression analysis explaining Enjoyment during the visit based on individual characteristics (Age, Gender, Education, previous visits to the Park) and the different information dimensions (information mechanisms)

Explanatory Variables	Coefficient	Std. Error	Sig.
Constant ***	0.872	0.148	0.000
Age (years) ***	0.020	0.003	0.000
Gender (“Male” = 1) ***	-0.229	0.074	0.002
Previous visits (“never been to the Park” = 1) **	0.165	0.081	0.042
Medium – *Paper booklet* **	0.256	0.105	0.015
Medium – *Digital info* **	0.261	0.111	0.020
Medium – *LBS* ***	0.264	0.096	0.006

NB: reference category = *No info*

N = 348
R-square = 0.164
Adjusted R-square = 0.150

Note: *** significant at the 1% level; ** significant at the 5% level.

All the variables used in Part C of the model had a statistically significant influence (at least at the 5 per cent level) in the variation of the dependent variable, Average Enjoyment. The variables are explained below:

Age

The variable Age was inserted into the model as a continuous variable. It was expected that older visitors would enjoy the visit to the area more than the younger ones. The regression analysis shows that a difference in ten years between two visitors should correspond to a difference in a fifth of a point on the Enjoyment scale (0.2).

Gender

The factor Gender also proved to have a statistically significant influence on the enjoyment of the visit. The regression analysis shows that female visitors appear to enjoy the visit more than the male visitors. The (negative) value of the gender coefficient quantifies the difference in enjoyment (-0.23) between the genders.

Previous Visits

It was assumed that first-time visitors to the Park would enjoy the visit more than visitors who have been in the Park before and know what to expect. In order to represent these two groups, the visitors were divided by the number of previous visits: 1) the visitors who have never been to the Park; and 2) the visitors who have visited the Park one or more times in the past. The results from the linear regression confirmed that the first-time visitors enjoy the visit more.

The medium

The subjects were divided into different groups, depending on which information dimension they experienced. All subjects were included in one (and only one) of the information dimension groups (*No info*, *Paper booklet*, *Digital info* or *LBS*). The information dimensions were treated as dummy variables, i.e. dichotomous variables that only record if a subject belongs to a certain group or not. In that way, the beta coefficients for each information medium indicate its influence on the visit enjoyment. All groups significantly influenced the value of the dependent variable.

The group *No info* was considered the control group and therefore taken as the reference category and by means of the Linear Regression estimates it was possible to uncover the effect each medium had in the enjoyment. First, it is important to notice that the fact of having information (for any medium) increased the Enjoyment factor. Second, one can distinguish between the information dimensions. But it is remarkable that all the information dimensions showed a similar effect on enjoyment with a contribution of around 0.26.

7.3.4 Part D – Explaining the value given to the information after experiencing it.

Part D explains the valuation of the information mechanism after the visit. Since different visitors had access to different information mechanisms, the differences in the valuation indicate the relative value of the mechanism.

Equation 7.5 – Single equation regression IVM part D

$$
\begin{aligned}
\text{WTP } (\textit{ex post}) \quad = \quad & \alpha_4 \\
& + \beta_{D1}(\text{Age}) \\
& + \beta_{D2}(\text{Gender}) \\
& + \beta_{D3}(\text{Education}) \\
& + \beta_{D4}(\text{Income}) \\
& + \beta_{D5}(\text{WTP}_0) \\
& + \beta_{D6}(\text{Expectations}) \\
& + \beta_{D7}(\text{Enjoyment}) \\
& + \beta_{\text{mediumD1}}(\text{Paper booklet}) \\
& + \beta_{\text{mediumD2}}(\text{Digital info}) \\
& + \beta_{\text{mediumD3}}(\text{LBS}) \\
& + \varepsilon_4.
\end{aligned}
$$

This last part of the model, entitled Part D, tries to explain the WTP for information after visiting the Park (WTP_1). This valuation happens after the test subjects have experienced the information hands-on, so they now have an objective image of the information mechanism they are evaluating. The *ex post* WTP_1 (the dependent variable in this part of the model) was collected using the same tool scale as the one used to measure the *ex ante* WTP_0, by means of a multiple choice question with ten alternative bids ranging from €0 to €3.5 (and increasing at €0.25 intervals). The mean *ex post* WTP is €1.38, with a standard deviation of €0.80 (N = 412 subjects). The factors expected to influence the WTP_1 were individual features (Age, Gender, Education, Income), the WTP for information before visiting the Park, expectations matching (whether the visit was better or worse than the expectations of the visitors), the overall Enjoyment that people had during the visit and the medium used by the visitors to have access to the information. These constructs were able to explain 32.1 per cent of the variation in WTP_1. The remaining variation is accounted for by undetermined factors. The model was analysed using OLS Linear regression. The results, R^2, beta coefficients, standard errors and significance levels are presented in Table 7.4.

Table 7.4 – Information valuation model Part D: Regression analysis explaining ex post *WTP for information based on personal features (Age, Gender, Education, Income),* ex ante *WTP, Expectations, Enjoyment, and the information dimension (Paper booklet, Digital info and LBS – reference category is No info)*

Explanatory Variables	**Coefficient**	**Std. Error**	**Sig.**
Constant ***	0.499	0.155	0.001
Age (years)	-0.004	0.003	0.209
Gender (Male = 1)	-0.069	0.083	0.406
Education (High = 1)	-0.025	0.083	0.760
Income (in 6 categories as scale)	0.000	0.000	0.937
WTP (*ex ante*) ***	0.508	0.050	0.000
Expectations *	0.074	0.041	0.073
Enjoyment *	0.127	0.066	0.058
Medium – *Paper booklet* *	0.194	0.110	0.079
Medium – *Digital info* *	0.215	0.117	0.067
Medium – *LBS* ***	0.368	0.103	0.000

NB: reference category = *No info*

N = 312
R-square = 0.321
Adjusted R-square = 0.299

Note: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

The regression analysis proved that all factors (except for the individual features) included in Part D of the model influenced the dependent variable (post-visit WTP for information) in a statistically significant manner. The variables used in the information valuation model part D were:

Individual features: Age, Gender, Education and Income.
The individual features Age, Gender, Education and Income (used and explained in the previous parts of the model, see above) did not show a significant impact in the variation of the dependent variable.

Pre-visit WTP for Information
Before entering the Park (and even before knowing what kind of information was available) the visitors were asked how much they were willing to pay for information about the animals, plants and landscape in the Park (WTP_0). This value (also described in Part B of the model) is significantly correlated to the *ex post* WTP for information.

Expectations
The subjects were asked about the degree to which the visit to the Park matched their expectations or it was a disappointment. The expectations were translated into a 7-point Likert scale ranging from -3 (worse than expected) to +3 (better than expected) with a neutral value 0 (as expected). This factor proved to be significantly related to WTP_1. Nevertheless, the contribution is limited, since the coefficient is relatively

small. For each unitary increase in the expectations, the WTP_1 increases only €0.074 (6.9 per cent of the mean bidding price for the reference *No info* case, which is €1.07).

Enjoyment
After the visit to the Park, the subjects were asked to rate the visit in terms of Enjoyment using 7-point Likert scales and several dichotomous adjectives (see details above in the variable explanation of the model Part C). The model estimation proved that Enjoyment is significantly correlated with WTP_1.

The medium
The subjects were divided into different groups, depending on which information dimension they experienced. All subjects were included in one (and only one) of the information dimension groups (*No info*, *Paper booklet*, *Digital info* and *LBS*). Then, by means of Linear Regression it was possible to determine the effect each medium had in the WTP for information, thus revealing the **added value** that the visitors ascribe to the different delivery mechanisms.

The information dimensions were treated as dummy variables, i.e. dichotomous variables that only record if a subject belongs to a certain group or not. In that way, the beta coefficients from each information mechanism indicate the monetary added value in the WTP for the information for each mechanism. All groups significantly influenced the value of the dependent variable.

The group *No info* was considered the control group and therefore used as the reference category. This means that the beta coefficients of the other dimensions do not represent absolute values, but the extra value the group ascribes to the information mechanism. The coefficient from the medium *Paper booklet* (0.194) indicates that the subjects who experienced the paper information during their Park visit are willing to pay almost €0.2 more for access to information than the visitors who did not have access to information. In the same way, the subjects who experienced the information in the digital format (*Digital info*) are willing to pay €0.22 more, and the visitors who had access to information that was triggered by location (*LBS*) were willing to pay €0.37 more.

7.4 Revealed preferences: duration of visit (Model part E)

The model estimations described above clearly demonstrated the added value the visitors ascribe to the different information mechanisms when using the stated-preference method to quantify the evaluation of information (and by comparison its delivery mechanism). A final study was carried out in order to find a relationship between the information dimensions and a valuation with a revealed preference method, when considering the time each visitor spends in the Park. The measurement of this variable was described in Chapter 5, and its results aggregated per information dimension are presented in Table 5.2. Time can be described as a limited resource (especially vacation time), and therefore, it is expected that visitors will allocate this limited resource to the activities that they value the most in order to maximize their benefit. In other words, the time the tourists spend visiting the Dune Park cannot be spent visiting other places or in other recreational activities (e.g. at the beach), and therefore the more time people spend in the Park, the higher they value their visit.

A regression model was designed to explain the time the visitors spend at the Park, taking into account individual features of the visitor, the visit characteristics, and the information dimension (see Table 7.5). It was expected that visitors who receive information about the Park will enjoy it more and therefore spend more time during their Park visit. Additionally, it was expected that visitors with access to the innovative LBS information will excel in their enjoyment, and that this information delivery mechanism will have a higher impact on visit duration in relation to the other information dimensions.

In addition to the information dimension, it was expected that individual features (such as Age, Gender, knowledge of the Park, and reasons to visit the Park) and some visit characteristics (such as weather during visit, group size, if there were young children in the group) would also have an effect on the duration of the visit. The model was analysed using OLS Linear regression. The results, R^2, beta coefficients, standard errors, and significance levels are presented in Table 7.5. The dependent variable, duration of visit, had a mean value of 61.5 minutes (std. dev = 25.9 and N = 346). The minimum value measured was of 22.5 minutes and the maximum of 163.4 minutes. The variables used were able to explain 44.9 per cent of the variation in the different visit durations. The remaining variation is accounted for by undetermined factors.

The regression analysis showed that not all the factors included in the duration of visit explanation model influenced the dependent variable:

Individual characteristics
As expected, Age influenced the duration of the visit. The older the visitor, the more time he/she spends in the Park. This finding could be related to the (more) limited mobility of senior citizens. Gender also had a significant influence. The male visitors apparently spent more time during their visit, about 4.1 minutes. The fact that a visitor had never been to the Park before (previous visits) does not seem to influence the duration of the visit. As expected the reasons to come to the Park influence the time duration: the visitors that stated the enjoyment of Nature and to learn as their main aims of their visit showed statistically significant longer visitation periods.

Visit characteristics
Most of the visit characteristics that were expected to influence the amount of time in the Park did not seem to be significantly correlated. An impact was found when the visitor was walking alone (almost 10 minutes faster), and those who started their visit late in the day (after 15:30) took less time (around 6 minutes) to complete the tour. Unexpectedly, the size of the group, the fact there were young children also walking,

and the weather conditions (note that the tests occurred during sunny or cloudy days only) did not show an influence on the duration of the visit.

*Table 7.5 – OLS results for the regression analysis explaining duration of visit (in minutes) based on individual features, visit characteristics, and the information dimensions (*Paper booklet*,* Digital info *and* LBS *– reference category is* No info*)*

	Explanatory Variables	Coefficient	Std. Error	Sig.
	Constant ***	18.372	6.089	0.003
Individual features	Age***	0.250	0.080	0.002
	Gender (Male = 1) *	4.108	2.220	0.065
	Prev. Visits	2.036	2.533	0.422
	Reason: enjoy Nature ***	8.687	2.762	0.002
	Reason: learn about Nature ***	12.290	2.938	0.000
	Reason: have a walk	2.997	3.734	0.423
	Reason: coincidence **	6.233	3.108	0.046
Visit characteristics	Alone (group size =1) *	-10.823	6.514	0.098
	In group (group size >2 =1)	2.611	2.544	0.306
	Kids (group with kid(s) <14yo = 1)	1.048	3.499	0.765
	Weather (Sunny = 1)	-0.137	3.449	0.968
	Late departure (after 15:30) **	-6.617	3.267	0.044
Information medium	*Paper booklet* ***	10.084	3.128	0.001
	Digital info ***	33.249	3.424	0.000
	LBS ***	35.575	3.103	0.000
	NB: reference category = *No info*			
	N =	323		
	R-square =	0.449		
	Adjusted R-square =	0.422		

Note: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Information medium

As explained before, each visitor was assigned to a group depending on the information dimension to which she/he had access. The *No info* group is considered the reference case and is therefore excluded from the analysis. This means that the coefficients from the other information dimensions show the difference to the *No info* case. It is interesting to see that all the groups with access to information tend to spend more time visiting the Park. Among the different delivery mechanisms, the visitors with the conventional information, *Paper booklet* spent around 10 minutes more in the Park than the reference case. The visitors who had access to the information via the technological mediums (the *Digital info* group and *LBS*) spent much more time in the Park than the reference case, around 30 minutes. This means that these visitors were more motivated to explore the information and the Park than the *Paper booklet* group. The visitors with the *LBS* system were revealed to be the group who spent the most time in the Park, though only slightly more than the *Digital info* group. The unexpected small difference between the *LBS* and the *Digital info* groups can be explained by the combination of two opposing forces: since the visitors definitely find the *LBS* information more useful, they spend more time in the field exploring Nature and the associated information, but, on the other hand, since the information is more efficient (it displays automatically at the right place), this leads to a more efficient time expenditure since there are no time tolls from interacting with the device or even trying to find the appropriate information at a certain place or places (since the right information displays automatically at that particular spot). This aspect indicates that LBS can lead to a higher efficiency of time use.

7.5 Conclusions and impact factor

Parts A and B of the model were useful in determining the strength with which each independent variable affected the dependent variables. The factors “Gender”, “Education”, “Previous visits” and the “Reason to visit the Park” have a significant influence on the appreciation of information. Unexpectedly, it was not possible to prove an effect of Age on the information appreciation variation. In order to explain the *ex ante* WTP for information, the previously explained information appreciation shows a significant effect, but, unexpectedly, income did show a significant influence.

Part C of the model was able to explain the enjoyment the visitors experienced during their visit. It proved that the personal features, such as Age and Gender, influence the enjoyment during the visit. Older visitors and female visitors appear to enjoy the visit more. The model also revealed that first-time visitors have higher enjoyment of the visit. Finally, the model was able to prove that having information about the Park’s natural features generally increases the enjoyment, and that this increase is similar for all information dimensions.

Part D of the model was able to explain the *ex post* WTP for information. All the chosen independent variables, *ex ante* WTP, expectations, enjoyment, and Information medium proved to have influence on the variation (with different levels). The influence of the different information media or information dimensions is at the core of this study. The differences in valuation introduced by the medium enable the quantitative comparison of the added value the visitors ascribe to the different information media. According to the analysis, using paper information increases the WTP by €0.20. Similarly, using technological information (the PDAs) increases the WTP by €0.22. Finally, using technological and location-enabled information increases the WTP by €0.37. These figures may appear small considering their absolute monetary value. However, considering the **relative** impact they have in the WTP for information, it is easier to compare and measure the real added value of the different media. An impact factor was defined based on the average value people were willing to pay for information after visiting the Park and not having had access to the information. These subjects composed the control group and their mean average WTP for information about the Park was €1.07 (with standard deviation = €0.69 and N = 103). The impact factor was calculated by using this value and the model coefficients of each information dimension (Equation 7.6).

Equation 7.6 – Calculation of the information Medium impact factor

$$\text{Impact} = \frac{\beta_{\text{medium}}}{\text{avg. } \textit{No info } \text{WTP}_1} * 100.$$

This formula calculates the relative influence that the different information dimensions have on the final valuation of the information. The results are displayed graphically in Figure 7.3.

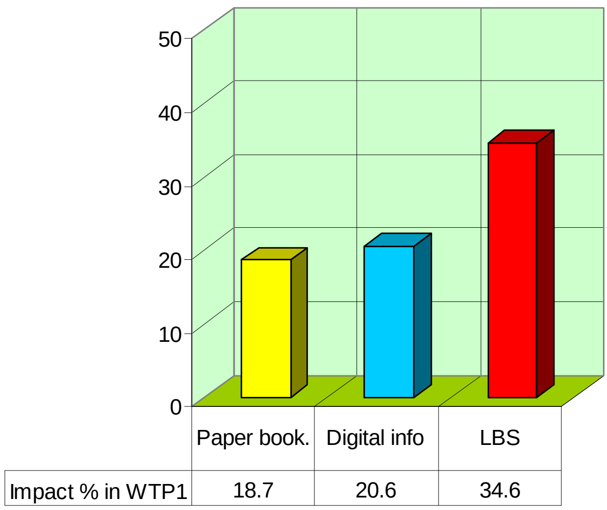


Figure 7.3 – Relative impact of the different mediums in the information valuation

It is now clear that receiving information using an *LBS* system is more valuable than any of the other dimensions. Visitors are prepared to pay about a third more to have access to location-sensitive information. The conventional information delivery group, the *Paper booklet* group showed that information has a significant added value: people valued it more highly after experiencing it (around 19 per cent). And the same valuation for the location-sensitive information group shows that the added value perception by the *LBS* group is higher by twofold when comparing it with the conventional delivery mechanism (around 35 per cent).

The results from the stated preference analyses were validated by the revealed preference study, where similar patterns were found. For both techniques, it was found that the visitors ascribe positive value to the information in general and that the different delivery mechanisms showed different results. The most valued mechanism is the *LBS*, then comes *Digital info*, and, finally, the *Paper booklet*.

8 Technology Acceptance

8.1 Introduction

In the previous chapters, the effects and benefits of using information (and in particular of location-based information) were proven for both visitors and Park Managers. The visitors clearly stated a perceived added value in receiving location-based information, translated into their willingness-to-pay (see Chapter 7). The information proved to have the capacity of increasing the value visitors ascribe to Nature (see Chapter 6). In addition, we demonstrated the efficiency of using location based information as a tool to change the spatial behaviour of visitors in natural areas. This possibility can be used by Park Managers to influence the exploration patterns of the area visitors and, in this way, contribute to the conservation efforts (see Chapter 5).

Nevertheless, these proven benefits will only take place in reality if, and only if, the location-based system is indeed used by the visitors to the nature areas. Therefore, it is crucial to predict the acceptance of the technology and to identify the factors that contribute to the use of such an information mechanism. The present chapter *uses* the Technology Acceptance Model (TAM) as a framework for answering these questions.

8.1.1 The Theory of Reasoned Action

The TAM was first described and applied by Davis (1985). This model is based on the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975; Fishbein and Ajzen, 1981), which states that a person forms an attitude about a situation, object or action on the basis of his/hers beliefs. The two hypotheses that form the TRA are: (1) intention positively affects usage; and (2) attitude positively affects intention. Additionally, on the basis of attitude, an intention is formed to handle the situation and this intention completely determines the actual behaviour. The TRA has been extensively researched in the past (Madden et al., 1992; Sheppard et al., 1988), and the validity of this model has been proven successful in predicting and explaining user behaviour in a varied range of domains and fields, such as National Parks management (Bright et al., 1993), environmentally-conscious behaviour (Goldenhar and Connell, 1993) or wireless Internet adoption (Lu et al., 2003). According to the TRA, a person's behaviour is determined by her or his behavioural intention, which is determined by both the person's attitude and subjective norm concerning the behaviour. The intention can be considered a measure of the strength of a person's intention to adopt a specific type of behaviour. The attitude is defined as a person's positive or negative feelings about performing that behaviour, and the subjective norm refers to the person's perception that most people who are important to her or him think she or he should (or should not) perform that behaviour (Fishbein and Ajzen, 1975). It is also important to note that the TRA is a general model and not specific to a given domain or technology type. Therefore, it is not particularly suited for a specific domain and requires adjustments to fit the particularities of a study. Thus, the beliefs that motivate behaviour in a particular case have to be explicitly specified (Davis et al., 1989).

8.1.2 Technology Acceptance Model's constructs and assumptions

Davis developed the TAM as an adaptation of the TRA, specifically designed to test the acceptance of information systems (IS). The TAM uses the TRA as the theoretical underpinning for defining the links between the two basic constructs and attitude, intention and the adoption behaviour. The TAM defines that the acceptance of technology is dependent on two independent constructs: the *perceived usefulness* (PU), and the *perceived ease-of-use* (PEoU), and on the causal chain from the TRA: *attitude*, *intention*, and, finally, *usage behaviour*. The *perceived usefulness* is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). In other words, it is a quantification of the users' perception of how the technology can help them perform their job better. The *perceived ease of use* is defined as the "degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). This construct is extremely important because, even when a person considers a technology to be useful, this person can still reject it if she believes that the effort to use it is greater than its performance benefits.

Previous research has explained *perceived ease of use* to be the based on a model composed of three anchors that determine early perceptions about the ease of use of a new system. These anchors are: *control* (internal and external – conceptualized as computer self-efficacy and facilitating conditions, respectively); *intrinsic motivation* (conceptualized as computer playfulness); and *emotion* (conceptualized as computer anxiety) (Venkatesh, 2000).

The cost-benefit paradigm is an important concept to understand the relation between *perceived usefulness* and *perceived ease of use*. TAM is based on a rational evaluation, where the behavioural intentions are the outcome of the rational assessment of the presented software (balancing the PU and PEoU), and the outcome determines the behavioural intention to use it (Davis, 1989). According to Davis (1989), the perceived usefulness is a major determinant of people's intention to use the tool, whereas perceived ease of use is a (significant) secondary determinant of intention.

Figure 8.1 shows the TRA combined with the technology acceptance model. The arrows represent the relations that underlie the model. The first two relations are based on the TRA, while the others are TAM-specific:

T1: intention determines usage;
T2: attitude determines intention;
T3: perceived usefulness affects intention;
T4: perceived usefulness influences attitude;
T5: perceived ease of use affects attitude;
T6: perceived ease of use affects perceived usefulness;
T7 and T8: external variables (that depend on the field of study) relate to perceived usefulness and ease of use.

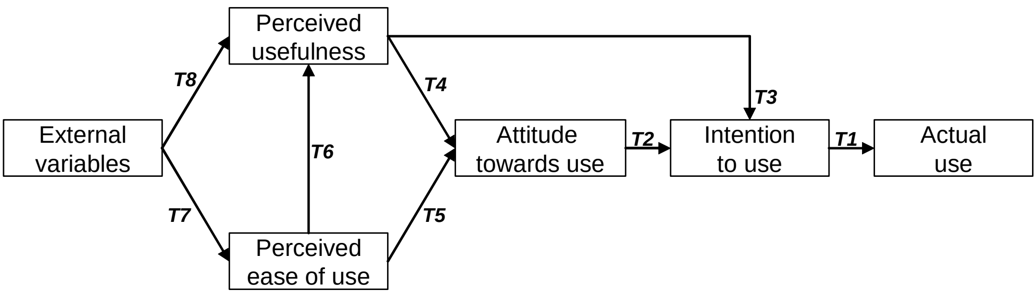


Figure 8.1 - The Technology Acceptance Model (Davis, 1989)

The model was originally designed to measure the factors that explain the acceptance and usage of classic information technology in the desktop and office work. Nevertheless, it has proved to be robust enough, and has been extensively adapted and applied, including for wireless services (Lu et al., 2003; Wu and Wang, 2005) and mobile devices (Sarker and Wells, 2003).

8.1.3 Scaling perceptions of information systems

The most common way to collect data on the constructs is by administering questionnaires. In a nutshell, the study subjects become acquainted with the information system (through a presentation and/or direct usage experience), and afterwards they fill in questionnaires by answering a series of questions that measure their perceptions of the technology. These questions are called 'scale items' and are typically Likert scales with five alternative multiple-choices, ranging from *completely disagree* to *completely agree*. As in most social research, the formulation and definition of the questions is very important as it is necessary to distinguish between the factors and not bias the data collection. Using the Likert scale makes it possible to quantify the relations between the different model constructs. Therefore, the questions have to be designed in such a way that they translate these relations. Davis's research was aimed at measuring acceptance of a new software tool by users and introduced a standard set of questions that can be used in standard TAM studies, called the *Davis's scale* (see Table 8.1.)

Table 8.1 - The original Davis' scale items.

Scale item	**Construct**
Using <*TestTool*> in my job would enable me to accomplish tasks more quickly	**PU**
Using <*TestTool*> would improve my job performance	
Using <*TestTool*> in my job would increase my productivity	
Using <*TestTool*> would enhance my effectiveness on the job	
Using <*TestTool*> would make it easier to do my job	
I would find <*TestTool*> useful in my job	
Learning to operate <*TestTool*> would be easy to me	**PEoU**
I would find it easy to get <*TestTool*> to do what I want to do	
My interaction with <*TestTool*> would be clear and understandable	
I would find <*TestTool*> to be flexible to interact with	
It would be easy for me to become skilful at using <*TestTool*>	
I would find <*TestTool*> easy to use	

8.1.4 The hedonic extension

Depending on the application, modified and/or extended versions of the model have been designed and applied by a number of authors (Gefen and Straub, 1997; Venkatesh and Davis, 2000). One particular extension is extremely relevant to the mobile information system discussed in this thesis: the *perceived enjoyment* construct. Davis et al. (1992) introduced *perceived enjoyment* has an addendum and defined it as "the extent to which the activity of using the computer is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated" (Davis et al., 1992, p. 1113). Most studies present *perceived usefulness* as the most significant predictor of user acceptance, followed by *perceived ease of use* and *perceived enjoyment* (Igbaria et al., 1996; Shang et al., 2005). Nevertheless, the opposite has also been reported in the literature (Atkinson and Kydd, 1997; Moon and Kim, 2001; Van der Heijden, 2004; Venkatesh, 2000) where the subject systems are accepted mainly because of their *perceived enjoyment* and *ease of use* and less because of their perceived usefulness. A common denominator to these studies is the fact that the systems under study are pleasure-oriented rather than the classic productivity-oriented systems. The pleasure-oriented are also called Hedonic information systems. They are connected to leisure activities that focus on the fun aspect of information and aim to provide self-fulfilling value to the user, while the productivity-oriented systems focus on the utilitarian value of the information. These are mainly connected to work-related, productive usage and aim to provide instrumental value to the user (Van der Heijden, 2004). Here, the instrumentality concept indicates that the system usage objective is external to the user, while the self-fulfilling concept indicates that using the system per se is an objective in itself.

Concluding, user acceptance depends on both the extrinsic motivation and the intrinsic motivation. Extrinsic motivation manifests itself when the user expects a reward or external benefit by interacting with the system. Intrinsic motivation occurs when a user derives benefit just from using the system (Brief and Aldag, 1977, p. 497). Referring to the context of this study, even though receiving information during and about the walk can be perceived as useful, the visitors to the National Park were on holiday and, therefore, the usage of the system is based on voluntariness and has a strong leisure component: the visitors will only use the system if they perceive it to be enjoyable. It is a Hedonic information system. Consequently, the technology acceptance model should be extended with the *perceived enjoyment* construct.

8.2 Protected Area's information system acceptance model

Based on the technology acceptance model and its extensions, a model for the acceptance of the systems described in Chapter 4 was designed. Figure 8.2 shows the proposed model for this research. Note that the full Theory of Reasoned Action (TRA) was substituted by a simplified version. In order to simplify the TRA, the construct *behavioural intention to use* replaced the original two constructs *attitude towards use* and *intention to use*, as proposed in the theoretical extension of the technology acceptance model, by Venkatesh and Davis (2000).

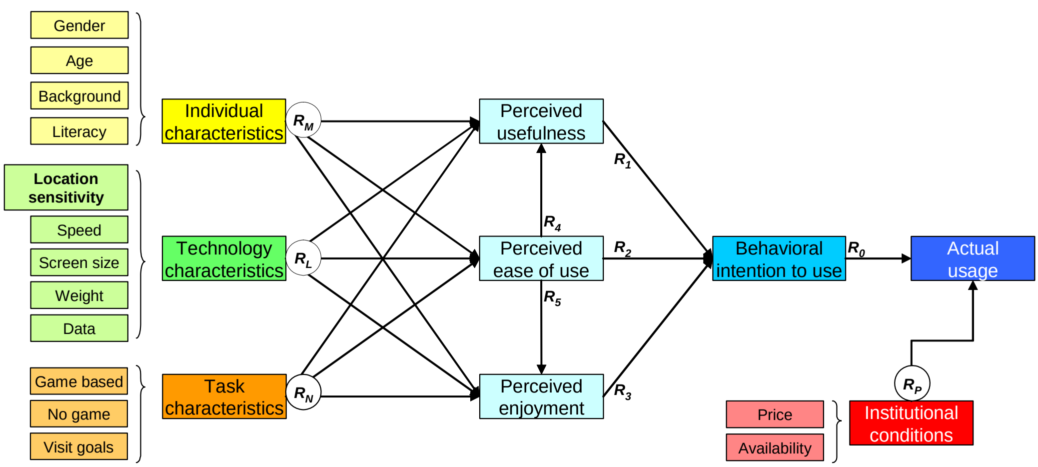


Figure 8.2 – Theoretical model to explain the actual usage of the mobile information system in Protected Areas.

This model tries to explain Actual usage based on factors. The factors and variables are represented by coloured rectangles and the relationships between them are represented by arrows. When a certain factor is composed of several items, examples of these items are presented on its right, and a bracket aggregates these into the factor.

8.2.1 Model relationships

As explained previously, the *actual usage* of an information system is determined by the *behavioural intention to use* (**R_0 – BIU influences the actual usage**). This relationship is established by the TRA and has been extensively studied in the literature; therefore it will not be empirically tested in this study. The *behavioural intention to use* is influenced by the *perceived usefulness* (**R_1 – PU influences BIU**), by the *perceived ease-of-use* (**R_2 – PEU influences BIU**), and by the *perceived enjoyment* (**R_3 – PE influences BIU**). It is also expected that the *perceived ease of use* influences both the *perceived usefulness* (**R_4 – PEU influences PU**) and the *perceived enjoyment* (**R_5 – PEU influences PE**).

Different people have different perceptions of the experiences and surrounding environments: certain *individual characteristics* have an impact on perceptions. Therefore, it is expected that all the TAM constructs, *perceived usefulness*, *perceived ease of use*, and *perceived enjoyment* would be influenced by some *individual characteristics*. Examples of characteristics expected to have great impact are *Gender*, *Age*, *Professional background*, and *Literacy level*, amongst others (**R_M – Individual characteristics influence TAM perceptions**).

Naturally, not all systems are alike and therefore the intrinsic *technology characteristics* are also expected to influence the subject's perception (**R_L – Technology characteristics influence TAM perceptions**). Some examples of technical characteristics that are expected to have an influence on the perception of users are the *software response speed*, the *screen size*, *weight* (because it is carried by the user), the *data* (one of the most important factors because it is what the user actually sees), the *look-and-feel* of the application (design and layout), and the *location component* for mobile applications.

The last factor is what this thesis has been focusing on and will be explained in detail in the following section. Junglas (2003), Goodhue and Thompson (1995), Dishaw and Strong (1999) have highlighted the importance of task-technology fit. This construct states that if a technology is to have a positive impact, it must be a good fit with the task it supports. Since, in the case of the information system for Protected Areas, we have a voluntary usage and not a clear task to fulfil, the technology fit will depend on the goals of the visitors when visiting the Park. For example, students will be looking forward to learning about the ecosystems they are visiting, while the leisure-oriented visitors are hoping not to get lost in the Park, and probably a game-based information system with questions/quizzes would have an impact on their perception of the technology (**R_N – task characteristics variables influence TAM constructs**).

The last construct is an external construct from the TAM model itself and the overall individual acceptance of the technology. It refers to the institutional conditions imposed by the Protected Area managers. Only if the system is made available, can the visitors actually use it in the future (**R_P – Actual usage depends on institutional conditions**). This construct will be further explained in Section 8.2.3.

8.2.2 Location as a determinant of acceptance

This thesis focuses on the added value of context-awareness, and particularly on the potential of location (as a determinant of context) to improve the information flows inside nature areas. It is hypothesized that location can increase the adoption of the information technology, and increase the motivation to learn and use technology. Therefore the location sensitivity was used as an independent variable and manipulated in the research, and the effects of this manipulation are measured acceptance levels (the TAM constructs). This was the only empirically tested external variable. As explained in Chapter 4 (test set-up) and also in the following chapters, there were two different technological implementations of the system, one called *Digital info* and the other *Location-based service* (LBS). In both implementations the information was available in a portable handheld computer (PDA). In the *Digital info* implementation, the user had to *pull* the information by simply selecting the icon on the map corresponding to the place where he was at the time. For the *LBS* implementation, the system is aware of the location of the user (via GPS positioning) and it *pushes* the information to the user at the right place. This is the only difference between the systems, therefore, if differences in the acceptance of the technology are found they can be ascribed to the location component.

8.2.3 Institutional conditions as a crucial determinant of usage

Usage will only take place if the system is available at reasonable conditions on the Protected Area site. Even if the individual motivations to use the system are very high, if the pricing is prohibitive, usage will not take place. Therefore, it is crucial that the Park Managers create an infrastructure to make the system available and affordable to its visitors. With regard to pricing, the results from Chapter 7 (Information Valuation) can indicate the appropriate parameters[14].

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[14] Author's note: As explained in Chapter 4, this research used a prototype of a location-based information system jointly created by Ecomare, Geodan and Camineo systems implemented at the Texel Dunes National Park. The system proved to be so successful with the visitors during the voluntary usage for

As determined in Chapter 2, the Park Managers recognize the need for such a tool in order to improve the information flows inside the Park, not only in order to inform tourists and to have more environmentally-aware visitors but also because this tool allows for the collection of valuable and highly detailed information on the visitors' behaviour which enables analysis on sustainable usage and environmental protection, as described in Chapter 5. Therefore, it is in the interest of the Park Management to create and maintain the infrastructure that facilitates the actual usage.

8.3 Results

As explained before, from the model presented on the previous chapter, not all the relationships will be empirically tested. Because the TAM constructs need to be adapted to the technologies being tested, the inter-construct relationships of the technology acceptance model were empirically tested and its reliability, measured by means of scales, validated. Once confidence was established that the instruments are able to measure technology adoption, the location sensitivity was manipulated and its effects measured on the TAM constructs. This manipulation of the independent variable enabled the measurement of the impact of location on adoption. Therefore, the empirical analyses carried out in the framework of this study were the quantification of the relationships in the model presented in Figure 8.2 with the labels: R_1, R_2, R_3, R_4, the R_5 and part of the R_L.
The values for PU, PEU and Intention were computed from the responses to the *ex post* questionnaires. The scores for these constructs are based on the average of the corresponding scale items responses.

8.3.1 Reliability

In social sciences, and especially when measuring attitudes and human perceptions, it is important to check for the reliability of the tests administered. Reliability tests have two main objectives: (1) to check if the group of questions or items used measure the same construct; and (2) to check if there are two or more items that are too similar, so that they duplicate the measurement and therefore can be removed from the scale. Because it is difficult or impossible to establish absolute standards for the meaning of human responses to a survey, the reliability analysis can at least measure the consistency of the scale.

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testing that it was further developed and implemented commercially by the Park Management. The initial pricing of the rental was based on the results presented in this thesis, and it cost 2 euros to rent the information at the time of printing this thesis.

The reliability analysis determines the properties of the measurement scale and its items by measuring the relationships between the scale's individual items. The Cronbach's alpha (Cronbach, 1951) was the model chosen to determine the reliability level. This is a model of internal consistency, based on the average inter-item correlation. The alpha is a lower bound for the true reliability of the survey. In mathematics, reliability is the size of the variability in the responses that results from differences in the respondents. In other words, the answers to a reliable survey can have differences because the subjects have different opinions and not because of misinterpretations of the questions. The Cronbach's alpha is calculated by using the number of items in the survey (k) and the ratio of the average inter-item covariance to the average item variance, according to Equation 8.1.

Equation 8.1 – Cronbach's alpha calculation

$$\alpha = \frac{k(cov/var)}{1+(k-1)(cov/var)}$$

According to Nunnally and Bernstein (1994: pp. 264), when interpreting the reliability coefficient, a value of 0.70 is sufficient for the early stages of research, but basic research should require test scores to have a reliability coefficient of 0.80 or higher. Table 8.2 displays the reliability indicators for the constructs used in the model. The reliability for the five measured constructs is higher than 0.8, which indicates that the scales are reliable and the questions were well understood by the respondents. For the constructs *Perceived Usefulness* and *Behavioural Intention to Use*, the reliability was even higher than 0.9 and 0.95, respectively. This was an important result since the original scale was in the English language and the items were translated to the Dutch language.

Table 8.2 – Model constructs reliability indicators (Cronbach's alpha)

Construct	**# Items**	**N**	**Alpha**
Perceived Enjoyment	5	197	0.832
Perceived Usefulness	5	198	0.928
Perceived Ease of Use	4	203	0.877
Behavioural Intention to Use	2	200	0.964

In order to see if there were redundant items (items measuring exactly the same perception) or items that measured contradictory results, the correlations between the items for each scale were also measured. The results are shown in Table 8.3, Table 8.4, Table 8.5 and Table 8.6 for the constructs Perceived Enjoyment, Perceived Usefulness, Perceived Ease-of-Use, and Behavioural Intention to Use, respectively.

For all the items that comprise the four used constructs, there is positive correlation and no duplicating results were found. This means that the scale used was appropriate and yields reliable results that can be used for deeper analysis and to discover the external variables that influence these constructs.

Table 8.3 - Inter-Item Correlation Matrix for the Perceived Enjoyment items

	Exciting	Enjoyable	Interesting	Amusing	Delightful
Exciting	1.00				
Enjoyable	0.49	1.00			
Interesting	0.48	0.32	1.00		
Amusing	0.57	0.51	0.48	1.00	
Delightful	0.51	0.42	0.45	0.78	1.00

Table 8.4 - Inter-Item correlations matrix for the Perceived Usefulness items

	Useful	Practical	Functional	Handy	Efficient
Useful	1.00				
Practical	0.67	1.00			
Functional	0.69	0.80	1.00		
Handy	0.62	0.80	0.82	1.00	
Efficient	0.62	0.72	0.75	0.74	1.00

Table 8.5 - Inter-Item correlations matrix for the Perceived Ease of Use items

	Clear	Effortless	Understandable	Easy
Clear	1.00			
Effortless	0.71	1.00		
Understandable	0.71	0.70	1.00	
Easy	0.56	0.56	0.68	1.00

Table 8.6 - Inter-Item correlations matrix for the Behavioural Intention to Use items

	Future	Next time
Future	1.00	
Next time	0.93	1.00

8.3.2 Inter-construct correlations

The correlation between two variables reflects the degree to which the variables are related and gives a quantitative indication of the strength of correlation. The most common measure of correlation is the Pearson's correlation. This statistic relies on the assumption that the variables being tested have normal distributions, and that the relationship between the variables is a linear one, but these assumptions are not met for the scale data. Examining the descriptive statistics of the constructs (Table 8.7), it is observable that the skewness value is different from *zero* which indicates that the data are not normally distributed.

Table 8.7 – Descriptive statistics for the construct scales.

	Mean	**Std. Dev**	**Skewness**	**N**
Hedonic	0.82	0.99	-0.86	199
PU	1.52	1.19	-0.83	199
PEoU	1.77	1.04	-1.08	204
BIU	1.36	1.53	-1.33	202

Therefore, the *Spearman's rank correlation coefficient* (designated by the Greek letter ρ) was used to reveal the relationships. The Spearman's test is a non-parametric measure of correlation that does not make assumptions on the frequency distribution of the variables, and, additionally, it does not require that the relationship between the variables should be linear. This methodology has been extensively used in the TAM literature (Cartwright and Shepperd, 2000; Konradt et al., 2003; Konradt et al., 2006; Mavri and Ioannou, 2006). The results are displayed in Figure 8.3. As expected, all the relationships studied were found to have a positive correlation and be significant at the 1% level (2-tailed).

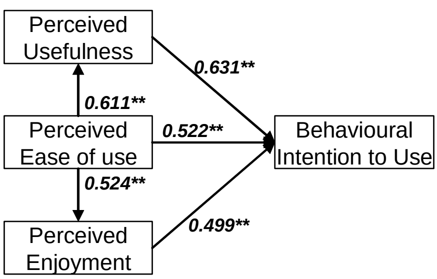

Figure 8.3 – Correlation's strength between the constructs (Spearman coefficients).
Note: ** Correlation is significant at the 1% level (2-tailed).

In order to test if the location component of the application does influence the perception of the visitors, and therefore the adoption of the technology, the two groups (*Digital info* and *LBS*) were compared for significant differences. The average scale results for both groups were plotted in Figure 8.4, which indicates that the location-based group had higher values for the technology perception.

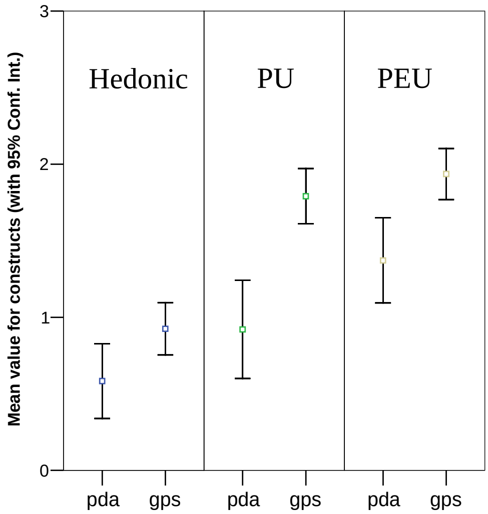

Figure 8.4 – Average scale results for the perception constructs for both location-based (gps) and non-location based (pda) information services

The two groups were also compared for significant differences using the non-parametric Mann-Whitney test. The Mann-Whitney test shows significance levels below 0.01, meaning that for all constructs there are significant differences at the 1% level.

Table 8.8 – Significance of differences according to the Mann Whitney test

	Mann-Whitney U	**Wilcoxon W**	**Sig. (2-tailed)**
Hedonic	3347.5	5492.5	0.008
PU	2610.5	4755.5	0.000
PEoU	3186.5	5532.5	0.000

It is observable, nevertheless, that the location component has different levels of influence on the constructs. The strongest influence is on the perceived usefulness: the users with location-enabled information perceive the application as much more useful. The smallest influence (but still significant) is on the perceived enjoyment: both systems were found to be ‘fun to use’, but the location-based system was ‘enjoyable’.

8.4 Conclusions

An extended version of the Technology Acceptance Model was applied to the information service both for the *Digital info* and the *Location-based service* versions. The analyses of the results show that *perceived usefulness*, *perceived ease of use* and *perceived enjoyment* (or hedonic value) influence the intention to use the system in the future. On different strength levels, the location component was found to have a significant positive influence on all the constructs that influence adoption. This suggests that, if the information system is location-enabled, the visitors to Protected Areas are more likely to use it in the future.

9 Conclusions

This study has discussed the added value of location-aware information provision for visitors and managers of natural and recreation areas. The main result is that context-aware location-based applications are able to satisfy visitor needs and to provide Park Managers with tangible benefits. New methodologies to measure the effects of information delivery were developed and used in two case studies in order to determine the visitors' perceived and revealed added value. These results address, in a comprehensive way, the evaluation of IT tools in Protected Areas beyond simple usability tests.

The overall goal of this thesis was to study how and to what extent location-aware services can improve the visitors' experience and the information flows in Protected Areas. It has presented a theoretical and empirical framework to evaluate the direct and indirect effects of using contextual information services in a multidisciplinary setting. The effects investigated include behavioural responses to information, technology acceptability, and institutional advantages in using information delivery mechanisms.

9.1 Improving information flows in Protected Areas with context-aware location-based services

This section addresses the first research question: "What is the contribution of context-aware services in improving information provision to managers and information access to visitors of natural areas?" The first hypothesis proposed was: "*Mobile location-aware information systems improve information provision to Managers and information access to visitors of Protected Areas.*"

The opinions and beliefs of Park Managers' were collected by means of a survey. They were then compared with the visitors' needs and behaviour to detect similarities or differences. The implementation of a context-aware service in two Protected Areas allowed the qualitative analysis of the benefits to Managers and visitors resulting from the adoption of location-aware information systems.

The main advantage of context-aware services is the opportunity to deliver dynamic and targeted multimedia information when it is most needed: during the visitors' field visit. This contributes to the education and recreation goals of the Parks. (Chapters 4 to 8 are dedicated to proving and quantifying the impacts of the location-aware information service on the visitors' perception, learning attitudes and behaviour). In addition, it was proved that context-aware mobile information effectively improved communication of Park rules, advice and recommendations to the visitors (see Section 5.5.1). The reason is that these systems deliver the information at the exact place and time, where and when the visitor needs it. In this way, context-aware services can contribute to increasing the visitors' awareness of the natural and cultural richness of the Park and indirectly contribute to sustainability by providing Park Managers with tools that can influence visitors' behaviour in a more eco-friendly manner.

Regarding the information flows from visitors to Managers, one of the new opportunities offered by the mobile information system is the gathering of location-based inputs or bookmarks (see Table 3.2) from the visitors. In this way, Managers can collect visitor's feedback and experiences, as well as their perceptions and comments. Context-aware services also provide Managers with detailed visitors' spatial information that is representative of Park usage. Since the tool is based on positioning data from the users, managers can make use of these data in an aggregated or individual way to derive information for visitor management within the Park. The derived information includes crowding measurement and the identification of the most/less popular areas or places.

Without the availability of these innovative tools, attempts to understand the visitors' behaviour and perceptions within the Park were performed with end-of-day surveys (that are inaccurate and imprecise because of memory errors) or by following visitors during their Park visit, an exercise that is time-expensive and introduces biases due to the presence of the researchers. The deployment of context-aware services through a mobile information system is an efficient way to collect data and derive information for the operational and strategic long-term management of the Park.

9.1.1 The needs of Park Managers and of visitors

This work started by exploring and detecting trends in Park Management and identifying common issues for Park Managers in Europe (Chapter 2). Visitor management and distribution of visitors inside the Park were found to be relevant issues for Park Managers (for example, high local concentrations of visitors may cause a significant disturbance to the environment). Nevertheless, methods or techniques to monitor the whereabouts of tourists inside the Park are seldom in place. Furthermore, *Environmental education* was found to be one of the main institutional mandates of the Parks, and tourists are expected to be interested in receiving information during their outdoor visit. This implies that Park Managers link information provision to visitors' behaviour: visitors who are better informed are expected to make more eco-friendly decisions. On the other hand, it was found that, of the investment in information technology, little was actually invested in services to inform the visitors during their visit to the Park.

The analysis of the visitors' perspective showed that the information currently on offer, although of high quality, is not able to meet the information demands of the visitors who have a high location component (Section 2.3). Visitors have specific questions that arise during the field visit and relate to the place they are visiting. By location-enabling the currently available multimedia information and adapting it for delivery on handheld and location-aware digital devices, it is possible to address the visitors' information needs at the right place and at the right time.

9.1.2 The context-aware solution proposed

A context-aware location-based service (LBS) was used in this study to address the requirements and needs of visitors (Chapter 3). Location-based services are a subset of context-aware services and can be defined by three main technological domains: mobile computing, the Internet, and Geographic Information Systems. Any application service that exploits the position of a mobile terminal can be considered as a Location-based service (OGC, 2005).

The system was implemented in two Protected Areas that were used as case studies for evaluating the hypothesis of this study. The areas selected were the Swiss National Park and the Texel Dunes National Park on an island in the Netherlands. The system is based on wireless technology and is available for location-aware Smart phones and PDAs (see Section 3.3). The system can be simplistically viewed as a publishing tool for efficient information sharing with the visitors. In order to provide true added value for the visitors, however, geographical information and multimedia content needed to be adapted, or re-created, to meet the accuracy required, the location relevance of information, and the visitor's expectation for timely and relevant information. The analysis of information needs in fact revealed a mismatch between the existing information and the visitors' needs for Geographical and Temporal information (Chapter 2). To overcome limitation of the lack of geographical information, the study proposed a methodology for data preparation that goes beyond the simple spatial definition of data into a geographical definition that takes into consideration environmental contexts and human factors (presenting interesting features based on visibility analyses from a particular position, rather than simple Euclidean distances). The mismatch in temporal sensitivity between the information on offer and the information demanded by the visitors was an issue tackled via the aggregation of data series into comprehensive temporal map scales (e.g. seasonal species distributions). In addition, geo-enabling the existing multimedia information enhanced the existing data with a geographical component that allowed for the vast amounts of information available to be filtered and sorted using the positioning of the visitors. These processes augment the potential added value of the existing data sets (Section 3.4).

After the implementation of the system in the Park and the first tests with the visitors, the benefits of using the system became apparent. It was possible to prove that mobile information systems can enhance convenience, learning and interaction in the heart of the Park: convenience, because they allow the access to information anytime and anywhere; learning, because they can answer questions and give information about the natural features where visitors are most motivated to know: on the field visit when they are actually in contact with these same natural features; and interaction, since tourists can become a valuable “active visitors” who collect field data and share it with other visitors (using the location-based bookmarks: see Table 3.2). With the right information and the right tools, visitors become more environmentally aware and at the same time they interact with each other and the Park Management by leaving behind a potentially valuable intellectual contribution themselves in the form of spatio-temporal comments and multimedia. As discussed in Chapter 2, Park Managers acknowledge that the provision of information is a way to influence visitors’ behaviour. More eco-friendly behaviour is expected from tourists who are more informed. Mobile information systems can be a valuable tool in addressing this issue. When visitors are in the field they are more motivated to know about the area’s natural richness.

9.2 Influencing visitors’ behaviour with context-aware location-based services

9.2.1 The research framework

It can be argued that developing an information service is a fairly straightforward process. Proving that such a system actually brings added value to the users, and that it will indeed be used by the visitors, is where the real challenge lies.

Chapter 4 illustrates a research framework designed to address the second research question: *In what ways do context-aware services influence the visitors’ behaviour?* The framework borrows research methods from behavioural sciences, geographical information sciences, and economics. Its goal is to support a quantitative measurement of the benefits of adopting a location-aware information system. The method relies on the comparison of survey results from users which have available different sources of information and different information delivery mechanisms.

A key design feature of the evaluation framework is the role of the information delivery mechanism, which is treated as an independent variable, in addition to the role of information itself. The experiments were designed to measure the effects of two variables: information availability and the information delivery mechanism.

Visitors were assigned to one of four research groups, which are different in terms of information availability (available or not available) and delivery mechanism. The four groups were:

- *No info* – visitors to the Park to whom no extra information was provided;
- *Paper booklet* – visitors to the Park who were provided with information on a paper booklet;
- *Digital info* – visitors to the Park who could access the same information as in the paper booklet, but delivered in a digital information medium on a PDA ;
- *LBS* – visitors to the Park who had access to the same application and information as the *Digital info* group, but enhanced with location sensitivity.

This methodology enables the testing and quantification of three dichotomies:

- *No information* vs. *Information*
- *Conventional* vs. *Technological* (information delivery)
- *Non-location-based* vs. *Location-based*

The differences observed between the *No info* and *Paper booklet* group can be ascribed to the presence of information. Likewise, since the information content is the same, the differences between the *Paper booklet* group and the *Digital info* group are assumed to be caused by the difference in the delivery mechanism, conventional vs. technological The *LBS* group allows for the most interesting comparisons. Because the application that delivers the information is the same as the one available for the *Digital info* group (and therefore also has the same content as the *Paper booklet* group) but enhanced with location sensitivity. Differences between the two technological groups are assumed to be caused by *location-enabling the information*, i.e. by the *location's effect*. These differences are the quantification of the *added value of location* when all the other variables are accounted for. A further novelty of this study was the use of both *ex ante* and *ex post* measurements in order to reveal variations in the perceptions resulting from the Park visit and corresponding information access.

An additional unique research aspect is that the measurements were not confined to a laboratory setting, and nor did they use dedicated research subjects. The measurements were performed in the field with real visitors to Protected Areas, at the Ecomare Natural Museum and Texel Dunes National Park in the Netherlands. Nonetheless, the environmental and testing conditions were somewhat controlled, since, for instance, a defined path was available and the visitors were not supposed to leave the path during the visit. More than 400 visitors, with diverse personal profiles, participated in the research, thus making it possible to draw significant conclusions about the effects of context-aware location-based information on revealed and stated preferences.

9.2.2 Spatial behaviour

The second hypothesis: "*The provision of context-aware information influences the visitors' geographic movement*", was discussed in Chapter 5 together with the analysis of the visitors' spatial behaviour. Using anonymous movement data collected by the visitors in the form of GPS tracks, it was found that location-sensitive information provision can alter the spatial behaviour of the visitors. Therefore, this information can lead people to explore the Park in a different way. For example, information provision about plants at the right place can lead visitors to stop to see the plants about which they are receiving information, altering the walk-stop pattern. From the perspective of nature conservation, it was found that delivering location-based information is an efficient channel for the Park Managers to communicate and influence visitors' behaviour towards eco-friendliness. The visitors who have this information delivery medium available tend to deviate from the path less frequently, thus avoiding trampling the protected nature dunes. They remain on the path more than visitors that do not have information or do not have location-based information. Additionally, the visitors with location-based information are observed to be more predisposed to accept the Park Management's advice to visit particular places, which enabled them to fully explore, and become more aware of, the Park's natural richness.

9.2.3 Nature appreciation

The third hypothesis: "*Context-aware information provision positively influences environmental appreciation*", proved to be true not only for the location-sensitive information but also for the other information mechanisms (Chapter 6). The visitors' appreciation perception was measured using a visual preference methodology in the form of a photo-questionnaire (administered pre-visit and post-visit). This study was able to statistically validate that the perception of the visitors changes when they have access to information about the places they visit. This is perceived as a positive change and information enables them to be more appreciative of the landscape and natural features they are visiting. The delivery mechanism does not seem to have an impact on the variation of nature perception, since the visitors with access to information delivered with a technological support (the *Digital info* and the *LBS* groups) showed similar results to those having the conventional delivery mechanism (the *Paper booklet* group). However, the study of the information valuation (Chapter 7) and the technology acceptance (Chapter 8) showed that visitors do ascribe more added value to the location-sensitive information and are more willing to use information during their visit if this is location-sensitive.

9.2.4 Information valuation

The fourth hypothesis: "*The perception of the information's added value by the visitors increases when mobile information becomes more location-specific*", was analysed with reference to economic theory in Chapter 7. A model was designed to explain the information valuation process and to measure the differences in value attributed by the visitors to the different information dimensions (*No info*, *Paper booklet*, *Digital info* and *LBS*). The different values that the visitors ascribe to the different information delivery media can be quantitatively measured by measuring the differences in valuation between the groups. The conventional information delivery group, the *Paper booklet* group, showed that information has a significant added value since people valued it more highly after experiencing it (around 19 per cent). Similarly, the use of technological information delivery (the Digital info group) increases the valuation by 21 per cent. Finally, the same valuation for the location-sensitive information group shows that the perception of added value by the LBS group is the highest (around 35 per cent). The stated preferences results were validated by the revealed preferences results (time spent in the Park), although the numerical differences are not the same.

9.2.5 Technology Acceptance

The fifth and last hypothesis: "*The adoption of information in future Park visits is positively influenced by having location-specific information*", was evaluated by extending the Technology Acceptance Model (TAM) commonly used in Information Systems research (Chapter 8). The study has demonstrated the benefits of using information (and in particular of location-based information) for both visitors and Park Managers in Protected Areas. Nevertheless, these benefits materialize only if the location-based system is actually used by the visitors of the nature areas. Using a TAM analysis the study found that location information has a significant positive influence on the constructs that influence adoption by visitors. This suggests that, if the information system is location-enabled, the visitors of Protected Areas are more likely to use it. Additionally, *institutional conditions* play a role in facilitating the use of the system. The system can only be used if it is made available by the Park Management at affordable prices.

9.3 Practical implications of the study

The absolute monetary value stated by visitors as their maximum willingness-to-pay (WTP) for the information is a particularly interesting result for Park Managers. This value was determined using the contingent valuation method by means of the stated preference technique (Chapter 7). The absolute value was revealed to be very small for every group tested. The average WTP value before visiting the Park was not much higher than €1 and the average WTP value for the location-sensitive information was around €1.5, which was the highest average measured in all the groups. One explanation for such a low value is that the sample used was randomly selected from all visitors. This means that the results also include bids from visitors who are not interested in any information. Furthermore, this measurement technique assumed an unlimited supply of the good, which would not happen in a real market (since there will be a limited number of devices available for hiring). If the valuation were to be repeated with only the visitors who usually buy information in the Park shop, we would expect that the resulting absolute value would most probably be higher. On the other hand, the low value measured with generic visitor groups is a strong indication to the Park Managers that if they want the information to be accessible and used by a diverse and large number of visitors, the information should be provided at a very low price or made freely available (for instance, as part of the entrance fee).

The user-needs assessment (Section 2.2) was recognized as a fundamental step to create a meaningful service. Brown and Duguid (2002) draw attention to the danger of innovations that fail to improve the mechanism they intend to replace, "[new technologies] *often aim to remove a surface constraint (objects, organizations, practices, institutions) without appreciating their submerged resourcefulness. When this happens, the old resourcefulness often wins, to the frustration of technologists and futurologists*". In this work we do not intend to suggest replacing conventional information mechanisms, such as paper maps or tour-guides. These are undoubtedly very helpful and valuable information sources. The solutions proposed here aim to offer complementary services and information that are only possible via a context-aware location-based system. Large paper maps are still irreplaceable. It is not possible for a 10 cm screen (with limited colours display) to compete with the quality of artistic hand-made paper maps. However, digital maps can offer other useful features, such as the real-time position of the user via GPS, and can be tailored to represent (for each visitor) the spatial distribution of only those natural features that are of most interest for that particular visitor (and not all information on offer). Such possibilities are not available with the traditional static paper-based media. A digital system is also an appropriate form to present information that changes rapidly and needs constant updating, e.g. the location of where the last Red Deer was seen, or the closed routes due to rock fall, or the bird breeding season.

It is worth noticing that Park workers or rangers who continuously monitor the Park often represent the largest source of dynamic information, frequently unavailable to anybody else. Channelling this information into formats that visitors can consume appears as one of the key challenges for producing and maintaining the highly dynamic information requested by the visitors. Although beyond the scope of this study, it is interesting to consider the implications for Protected Areas in developing countries or in economically depressed areas. Local communities have in-depth knowledge of their surroundings, natural processes and area logistics, a knowledge that is valuable for the visitors. Tourists often tap these sources by purchasing guided-tours or local guides, revealing their interest in this knowledge by paying for it. Context-aware services can provide an additional channel for these communities to utilize their knowledge. Innovative jobs can be created to capture and manage location-based content inside and around protected areas. Context-aware systems can contribute to the valorization of local knowledge and the creation of additional economic opportunities stemming from the needs of visitors to these local communities.

9.4 Future research

This research produced a large amount of spatio-temporal data from visitors to a nature area in the form of GPS tracks. Since the goal of this research was to compare the general behaviour amongst the different information dimensions, the individual data was filtered and aggregated which lead to a loss of detail. For example: where did the visitors (who did not follow the path) actually go?; and, some detailed pattern information of individual geographic movements were also lost. Although these issues are not relevant for the comparison of different information delivery mechanisms, it is an interesting future research the analyses of these particular geographic patterns from the persons who did not follow the path.

An interesting question raised by the results is why visitors who have access to digital information spend more time in the Park. The group who used digital information stayed longer in the Park than the *Paper booklet* group. This was an unexpected result for which there are two possible explanations. The first explanation is that the information system and the device consume some of the visitor time simply to operate the system and obtain the information requested. In this case the additional time is an overhead to the time spent exploring the Park, which could remain unaltered. The second possible explanation is that the visitor is more motivated to learn about, and explore, Nature because of the information being available through this uncommon medium. In this second case the additional time spent in the Park is dedicated to reading information and exploring the Park. An additional analysis of the system logging files (files that record all interaction with the system) could help to answer this question.

Possible additional research concerns the substitution of some of the dependent variables captured using stated preferences with variables measured using the revealed preferences of the visitors. The perception of Nature is one example: instead of using stated preferences (the photo questionnaires) to show the emotional responses to nature, it would be interesting to measure the emotional responses on site with an objective measurement such as the galvanic skin response (which measures arousal and emotional levels). This instrument could be used instead of stated preferences (the photo valuation survey in Chapter 6) to measure the visitors' response to nature scenes and then see if this response changes as a result of access to information. The galvanic skin response devices can measure the continuous emotional state of the users which could be linked to the users' position in space. An ongoing project that uses such instruments is already showing promising results by creating city maps of the emotional states of the city dwellers (Nold, 2007).

The replicability and extrapolation of the findings of this study to other natural and Protected Areas would represent an important subject for future research. Since different areas have different characteristics and receive different visitors, it would be interesting to discover which visitors and areas could gain more from the introduction of location-sensitive information. In addition, the extrapolation of these research methodologies to other environments, such as cities, could also yield interesting differences. Nevertheless, the research framework would need major adjustments to be adapted to, for instance, city usage. As an example, the research carried out for this study confined visitors to a path, which can be compared to a laboratory setting where most variables are accounted for. But, when implementing these methodologies in a city environment, it becomes hard to confine users to a path without introducing significant experimental distortions. The control environment in an urban area would need to be completely re-designed.

The location-sensitive applications described in this work are implemented and currently being hired out to the visitors of the case study areas: the Swiss National Park and the Texel Dunes National Park on island of Texel in the Netherlands.

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DE TOEGEVOEGDE WAARDE VAN CONTEXTUELE INFORMATIE IN NATUURGEBIEDEN

Het effect meten van mobiele informatie over de natuurlijke omgeving

Samenvatting

In de afgelopen decennia is er veel veranderd in het gebruik van natuurgebieden, was recreatie voorheen minimaal, tegenwoordig is er een explosie aan toeristische activiteiten in de natuur. Deze verandering heeft een enorme invloed op de natuurgebieden. De zware belasting op de natuur heeft meer te maken met het gedrag van de bezoeker en met het onvoldoende managen van deze groep, dan met het absolute aantal bezoekers in een natuurgebied. Goed management, gebaseerd op de juiste informatie, kan de negatieve effecten op de natuur verminderen en profijt halen uit het aantal bezoekers. Naast het belang van beschermd gebied, hebben de meeste natuur gebieden als doel dat ze leerzaam moeten zijn en recreatie moeten kunnen bieden.

Dit proefschrift beschrijft het gebruik van Informatie Technologie, in het bijzonder dat van mobiele "*context-aware*" informatie systemen, om de informatievoorziening over de natuurgebieden te verbeteren voor de bezoekers. De aannames zijn (1) door het introduceren en verbeteren van informatie over het gebied, wordt het gedrag van bezoekers milieuvriendelijker. Tegelijk (2) krijgt de beheerder van het gebied een beter inzicht waar de bezoeker zich bevindt en hoe de bezoeker zich gedraagt.

WebPark, een onderzoeks en ontwikkelings project, heeft een systeem ontwikkeld om informatie te kunnen leveren over specifieke omgevingen. Met behulp van draadloze technologie (de Smartphone of PDA) kan een bezoeker informatie krijgen over de flora en fauna in de omgeving waar die zich op dat moment bevindt, alsmede over routes, hotels en restaurants in de buurt. Twee proeven met dit systeem zijn gehouden in het Nationaal Park Duinen van Texel (in Nederland) en het Nationaal Park in Zwitserland.

Het gebruik van Mobiele Informatie Diensten kan bezoekers helpen om bewuster te worden van de natuur, waardoor hun gedrag verbeterd wordt. Het wetenschappelijk zwaartepunt van dit onderzoek ligt in de evaluatiefase. In de evaluatie zijn verschillende methoden ontwikkeld om de toegevoegde waarde van de mobiele informatie diensten voor de bezoeker te meten. Om de toegevoegde waarde te kunnen

meten werden bezoekers op verschillende manieren van informatie voorzien. Groep 1 kreeg geen informatie over de omgeving, dit was de controle groep. Groep 2 kreeg conventionele informatie in de vorm van een papieren folder. Groep 3 kreeg informatie, door middel van een digitaal apparaat dat in de hand kon worden meegenomen. Groep 4 kreeg "*context-aware*" informatie, dat wil zeggen hetzelfde digitale apparaat als groep 3, maar de geleverde informatie is gebaseerd op de locatie van de bezoeker. Meer dan 400 bezoekers van het Nationaal Park Duinen van Texel deden mee met dit onderzoek en de resultaten geven weer dat er significant verschil zit in gedrag en waardering van de natuur tussen de verschillende groepen.

Het empirisch onderzoek stelde velerlei effecten vast, betrekking hebbend op (a) Geografische wetenschap; het ruimtelijke gedrag van de bezoekers, (b) Omgevingspsychologie; de waardering van de natuur door haar bezoekers, (c) Economische wetenschappen; het meten van de waarde van de geleverde informatie voor de bezoekers en (d) Informatiekunde; de acceptatie van de technologie door de bezoekers. De gebruikte methoden geven goed weer hoe het "*context-aware*" informatie systeem een hoge waardering krijgt van de bezoekers en een positieve invloed heeft op hun gedrag.

Appendix: Questionnaires

Dune Park Information research
Pre visit
All groups

Nr: _____-____________
Date: ____ / ___ / 2005
Time (departure): ___:___
Weather: ______________
Nr. Persons:____(<14___)

Ecomare is trying to make your visit to the dune park as attractive as possible. This survey will help us to improve the information provided. Thank you for contributing your time.

Age: _______ **Years** **Gender: F** O **M**O

How many times have you visited the Dune Park before?

- O Never
- O One
- O A couple
- O Several
- O I visit it regularly (more then once a year).

Why did you decide to visit the Dune park?
(tick at least one and maximum two)

- O To enjoy the nature
- O To learn about nature
- O Just to have a walk
- O No particular reason, I came to see the museum and found out about the dune park
- O Other :________________________

What is your work situation?

- O Student
- O Work at a private company
- O Government work (national, regional of locale government)
- O Work at the medical- or education sector
- O Other: _______________________
- O Houseman or –wife
- O Retired
- O Health related retirement
- O Unemployed

What is your education level?
<NB: not translated since they are only valid in the Dutch education system>

- O Lager onderwijs (basisschool)
- O LBO, LAVO, MAVO, MULO
- O MBO, VMBO, HAVO
- O MMS, HBS, atheneum, gymnasium
- O HBO, universiteit
- O Other: ____________________________

What is, approximately, your yearly income (after taxes)?

- O I have no self income
- O Less than € 7.500,-
- O € 7.500 - € 15.000
- O €15.000 - € 25.000
- O € 25.000 - € 40.000
- O More than € 40.000

Would you like to have information during your walk about the landscapes, Plants and Animals that you may find in the Dunes?

Not at all		No	Neutral	Yes		Absolutely
-3	-2	-1		+1	+2	+3
O	O	O	O	O	O	O

How much would you be ready to pay for RENTING such information? (in €)

0	0,25	0,5	0,75	1	1,25	1,50	1,75	2	2,25	2,50	2,75	3	3,25	3,5 (+)
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O

In general, how much do you like these landscapes, plants or animals?
(Before starting, please browse through all the photos)

Photo #	I don't like it	Neutral	I slightly like it						I like it a lot
	-1	0	1	2	3	4	5	6	7
1	O	O	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O	O	O
3	O	O	O	O	O	O	O	O	O
4	O	O	O	O	O	O	O	O	O
5	O	O	O	O	O	O	O	O	O
6	O	O	O	O	O	O	O	O	O
7	O	O	O	O	O	O	O	O	O
8	O	O	O	O	O	O	O	O	O
9	O	O	O	O	O	O	O	O	O
10	O	O	O	O	O	O	O	O	O
11	O	O	O	O	O	O	O	O	O
12	O	O	O	O	O	O	O	O	O
13	O	O	O	O	O	O	O	O	O
14	O	O	O	O	O	O	O	O	O
15	O	O	O	O	O	O	O	O	O

Enjoy the visit and see you when you're back!

Dune Park Information research
Post visit
GPS Info group

Nr: _____-_____________

Time (arrival): ____:____

Welcome back! A few more questions while you have some coffee/tea and we're done…

To what extent did the visit match your expectation?

Worse then expected			What I expected			better then expected
-3	-2	-1		+1	+2	+3
O	O	O	O	O	O	O

How did you find the visit?

	-3	-2	-1	0	+1	+2	+3	
Bad	O	O	O	O	O	O	O	Good
Annoying	O	O	O	O	O	O	O	Pleasing
Boring	O	O	O	O	O	O	O	Interesting
Common	O	O	O	O	O	O	O	Unique
Dull	O	O	O	O	O	O	O	Varied

Would you like to have information during your walk about the landscapes, Plants and Animals that you may find in the Dunes?

Not at all		No	Neutral	Yes		Absolutely
-3	-2	-1		+1	+2	+3
O	O	O	O	O	O	O

How much would you be ready to pay for RENTING the information? (in €)

0	0,25	0,5	0,75	1	1,25	1,50	1,75	2	2,25	2,50	2,75	3	3,25	3,5 (+)
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O

Please classify the following statements according to the degree to which you agree?

Accessing and Exploring the information was…	**Strongly disagree - 3**	**- 2**	**- 1**	**Neutral**	**+ 1**	**+ 2**	**Strongly agree + 3**
… Exciting	O	O	O	O	O	O	O
… Delightful	O	O	O	O	O	O	O
… Thrilling	O	O	O	O	O	O	O
… Amusing	O	O	O	O	O	O	O
… Cheerful	O	O	O	O	O	O	O

I found the mobile information…	**Strongly disagree - 3**	**- 2**	**- 1**	**Neutral**	**+ 1**	**+ 2**	**Strongly agree + 3**
… Useful	O	O	O	O	O	O	O
… Practical	O	O	O	O	O	O	O
… Handy	O	O	O	O	O	O	O
… Helpful	O	O	O	O	O	O	O
… Efficient	O	O	O	O	O	O	O

	Strongly disagree - 3	**- 2**	**- 1**	**Neutral**	**+ 1**	**+ 2**	**Strongly agree + 3**
*The interaction with the system is **clear and understandable**.*	O	O	O	O	O	O	O
*Interaction with the system does not require a lot of **mental effort**.*	O	O	O	O	O	O	O
*I find the system **easy to use**.*	O	O	O	O	O	O	O
*I find it easy to get system to **do what I want it to do**.*	O	O	O	O	O	O	O

	Strongly disagree - 3	**- 2**	**- 1**	**Neutral**	**+ 1**	**+ 2**	**Strongly agree + 3**
*I **learned** about the park.*	O	O	O	O	O	O	O
*My questions were **answered**.*	O	O	O	O	O	O	O

Imagine a similar info-system is available in future destinations you visit:

	Strongly disagree - 3	**- 2**	**- 1**	**Neutral**	**+ 1**	**+ 2**	**Strongly agree + 3**
*I intend to use this info-system on **future visits** to parks.*	O	O	O	O	O	O	O
*I predict that I will use this info-system on my **next visit** to a park.*	O	O	O	O	O	O	O

How do you rate the speed of the system?

	Very slow - 3	**- 2**	**- 1**	**Neutral**	**+1**	**+ 2**	**Very fast +3**
Map display/handling	O	O	O	O	O	O	O
Menu navigation	O	O	O	O	O	O	O

How would you rate the visibility of the display?

Very bad			Neutral			Very good
-3	-2	-1		+1	+2	+3
O	O	O	O	O	O	O

In general, how interesting was the information available?

Very boring			Neutral			Very interesting
-3	-2	-1		+1	+2	+3
O	O	O	O	O	O	O

How good was the resolution/detail of the map?

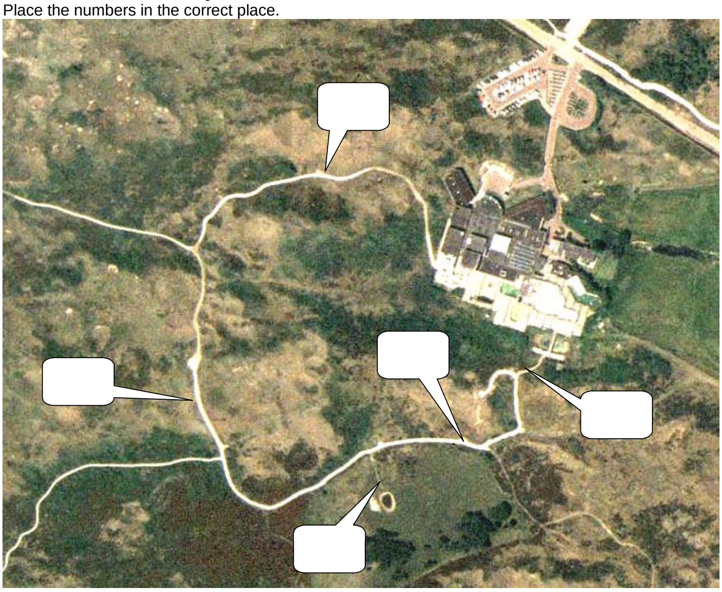
Very bad			Neutral			Very good
-3	-2	-1		+1	+2	+3
O	O	O	O	O	O	O

In general, how much do you like these landscapes, plants or animals?
(Before starting, please browse through all the photos)

Photo #	I don't like it	Neutral	I slightly like it						I like it a lot
	-1	0	1	2	3	4	5	6	7
1	O	O	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O	O	O
3	O	O	O	O	O	O	O	O	O
4	O	O	O	O	O	O	O	O	O
5	O	O	O	O	O	O	O	O	O
6	O	O	O	O	O	O	O	O	O
7	O	O	O	O	O	O	O	O	O
8	O	O	O	O	O	O	O	O	O
9	O	O	O	O	O	O	O	O	O
10	O	O	O	O	O	O	O	O	O
11	O	O	O	O	O	O	O	O	O
12	O	O	O	O	O	O	O	O	O
13	O	O	O	O	O	O	O	O	O
14	O	O	O	O	O	O	O	O	O
15	O	O	O	O	O	O	O	O	O

Which information did you see where?

Place the numbers in the correct place.



Fill the correct space above with the correct number:

1
Rabbits

2
Berries

3
Yong vs. Old dunes

4
North-South dune slopes

5
Wind-tree

If you remember, write something that you learned **today** about it:

Thank you for your help!

vrije Universiteit *amsterdam*

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