DESIGN AND IMPLEMENTATION OF A GIS-BASED REPORT MANAGEMENT TOOL FOR THE "ZONA VOLCÀNICA DE LA GARROTXA" NATURAL PARK (CATALONIA, SPAIN)

Arnald Marcer[1], Xavier Pons[2,1] and Jaume Vicens[3]
[1] Center for Ecological Research and Forestry Applications
[2] Department of Geography. Autonomous University of Barcelona
[3] "Zona Volcànica de la Garrotxa" Natural Park
a.marcer@uab.es, x.pons@uab.es , wjvicens@correu.gencat.es

Working Group TC V/8

KEY WORDS: GIS, Protected areas, Parks, Land information system, Report management, Land monitoring, Park management.

ABSTRACT

Report writing and management is one of the main tasks of the staff of the "Zona Volcànica de la Garrotxa" Natural Park (ZVGNP). It approximately takes a third of their work time. According to Catalan legislation reports must be prepared for many sorts of human activities and uses within the park, from forest management practices carried out by individual owners to road maintenance performed by the road management authority in charge. A GIS-based module for report handling and management has been developed within the overall park GIS system. This module complies with the predefined circuit of report handling and writing which already existed in the park and which was also included in the procedures stated by the ISO 9002-1994 quality certification that the park holds. Adaptation to the established procedures implies that the system must be able to operate from any desktop computer of any park staff member. The system provides a way to store and update information on an instant basis, that is, access to information which is continuously updated is possible. Any document written for a given report (texts, spreadheets, maps, etc.) can be accessed from the relational database management system and from the GIS. The module provides full GIS analysis capabilities to report management in the park so that important questions regarding the monitoring of park conservation policy can be answered. The module is based on the MiraMon GIS and it extensively uses current desktop office applications and HTML browsers.

1 INTRODUCTION

1.1 Park management at "Zona Volcànica de la Garrotxa" Natural Park.

1.1.1 **Background.** "Zona Volcànica de la Garrotxa" Natural Park is a protected landscape, a category V protected area according to IUCN (IUCN, 1994). 98% of the park's extension is privately owned. As such, there has been and there still is a very important interaction between people and the environment which has shaped the current landscape. Two objectives of management of this protected area category are: "to support lifestyles and economic activities which are in harmony with nature and the preservation of the social and cultural fabric of the communities concerned" and "to eliminate where necessary, and thereafter prevent, land uses and activities which are inappropriate in scale and/or character. The area currently included in the park was first protected in 1982 (Generalitat de Catalunya, 1982) to stop degradation caused by quarrying activities of volcanic materials and to preserve the unique volcanic landscape. In 1985 (Generalitat de Catalunya, 1985) the area was granted the category of a natural park. Since then, and as a park, the area has had a management team with the responsible for taking care of its preservation. Quite a large amount of information related to the land, from knowledge of natural resources to human activities records, has been gradually acquired about the area. The correct management and handling of this wealth of information is vital for an adequate management of the park so as to meet its conservation objectives. This necessity has grown at the same time that geographical information systems and computer technology have become widely available and a proposal for using such technology for the benefit of the park's management and planning tasks was outlined by the Department of the Environment of the Generalitat de Catalunya (the Catalan government), the steward of the Park.

1.1.2 Project Vulcanus. The proposal of the Department of the Environment materialized in the project Vulcanus, with the objective of developing a GIS-based tool for the management and planning of the Park and which takes care of the whole range of management activities carried out by the Park management team (Department of the Environment,

Generalitat de Catalunya, et. al. 1996). Accurate and readily accessible data, information and knowledge are essential for successful conservation action (IUCN, 2000). In order to achieve it such successful conservation action project Vulcanus provides the management team with a set of tools, mainly based on a GIS, which empower the park with a new capacity in information handling and management. The system is organized in a set of modules which are not self-contained, closed applications but a set of organized graphical, alphanumerical and text data associated with their metadata and protocols used to maintain them. The system takes also advantage of Internet technology to put all information and data available through an HTML browser in the park's LAN (Marcer and Pons, 1998).

1.2 Reports management

1.2.1 Scope. The regulations set by the general management plan of the park state that the Protection Committee of the Park will write a report on any type of works, activities, resource uses and plans that affect the park's area (Generalitat de Catalunya, 1994), that is, any road construction or maintenance, forest thinning or cut, well construction, etc., have to be reported by the park's team. Considering that within the approximately 11171 hectares of the park's territory live 35000 inhabitants that draw their sustenance from the industry, agriculture and services sectors, the number of such issues that need to be reported represent quite a big percentage of the overall annual work time of the park's team. Each report represents for the park staff the study of the location of the activity reported, the analysis of the potential natural resources that will be affected by it, and the search and analysis of any historical reports written for the same location and/or activity. This ends with a written document plus an accompanying map which are handed over to the corresponding administration.

1.2.2 **Historical evolution.** The number of reports written by the park has grown steadily from 115 written in 1986 to 252 written in 1999 (see Figure 1) (MARCER et. al., 2000). This growing number of reports has also meant an increasing demand on the park's management team in terms of time. Report writing represents about 30% of the total annual work-time of the park according to its director (personal communication).

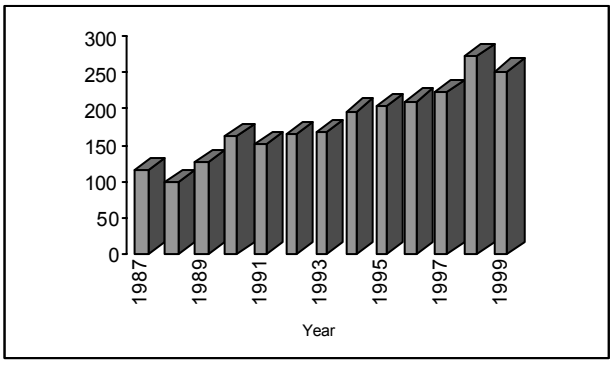

Figure 1. Evolution of the number of reports written per year at the "Zona Volcànica de la Garrotxa" Natural Park.

Traditionally, before the implementation of project Vulcanus, the park used standard non-digital methods to elaborate the maps associated with each report and stored the information of each in a non-standard format of a proprietary software program. No link existed between the graphical part, the alphanumerical part and the textual part of the reports information base. Therefore, it was very difficult to do any kind of analysis of the whole set of reports written by the park in a given year o since the creation of the park. Also, retrieval of information concerning the historical context of a given activity that needed to be reported was very costly in terms of time. In order to keep track of the number and location of reports pins were stuck on a paper map on a cork board in the park's office.

1.2.3 **ISO-9002 Quality Certificate.** Since October 1998 the Park holds the ISO 9002-1994 certificate of quality for its management system and organization which applies to the conservation of its natural and cultural resources, the promotion of public enjoyment of the park, the study of the natural systems within the park and the promotion of sustainable development (Departament de Medi Ambient, Generalitat de Catalunya, 1999). With respect to this certificate, all park processes, e.g. the process that a report follows in the park's organization till it is finally written and sent, have been established and formalized in a set of diagrams that represent the workflow of each process in the park (Parc natural de la Zona Volcànica de la Garrotxa, 2000). This formalization of the park's workflow can be translated into an information organizational design that adapts to it and which can then be used to handle, query and analyze all information related to a given process. If this organization is based on a GIS and implemented in the park's LAN it

means that a system for report management can be established in such a way that it can greatly help each member of the park's staff in their duties concerning report management.

2 SYSTEM DESIGN

2.1 Data organization.

2.1.1 **Types of data for the overall reports database.** Each report instance that the park writes in a year involves the storage of information organized in several different datasets. This information relates to four different types of data: data about the report itself (title, person or firm reported, type of activity reported, etc.), data on the administrative aspects of the report (date of entry to the park, number of entry, etc.), data on the administrative process of report writing (date of technical review, date of proposal approval, etc.) and the report itself (a text document, a map and other related information (spreadsheets, tabular data, photographs, etc.)). All these data comes in several different file formats. On the one hand there are all the data that can be stored in a relational database such as the first three types of the four above mentioned and, on the other hand, there are several more file formats related to the fourth type of information to be stored. These can be word processor files, spreadsheets files, image files, etc., and, more importantly, GIS files. Any type of file can be accepted by the design provided that its corresponding application is installed in the computer that is running the system. The GIS type of information is the most important one in relation to the design of the overall report management system. This is due to the fact that the GIS is gives cohesion to the whole set of data and information and the one gives the possibility to track and monitor human activities within the park's boundaries.

2.1.2 **Relation between different datasets.** The database of the reports management system is organized in such a way that all information for any given report of any given year can easily be retrieved from within the geographical information system by a simple click of the mouse over the graphical object which corresponds to the given report. The system will then retrieve us all information contained as tabular data in the reports database regarding the first three types of data mentioned in the previous point. Within the tabular data there will also be the computer addresses that tell us where the actual report documents (word processor text, spreadsheet, image and map) are located. Thus, the GIS provides us with a simple one-click access to all these documents from the results of a simple query by location onto the map of all reports. The geographical representation of each single report is stored as a topologically-structured vector graphical layer which the GIS relates to the tabular database. In turn, for every document that has been produced and that is stored as a computer file in the park's LAN, its complete address is also stored in the database. This complete address is used by the GIS to offer access to all written documents. The GIS simply detects which application within the operating system environment is associated with each type of file and launches it so as to open the given document. Finally, all graphical layers representing all the reported activities, uses, etc., are organized in a map (see Figure 2 below). Maps are made of simple text files that tell the GIS which graphical layers need to be open, with which

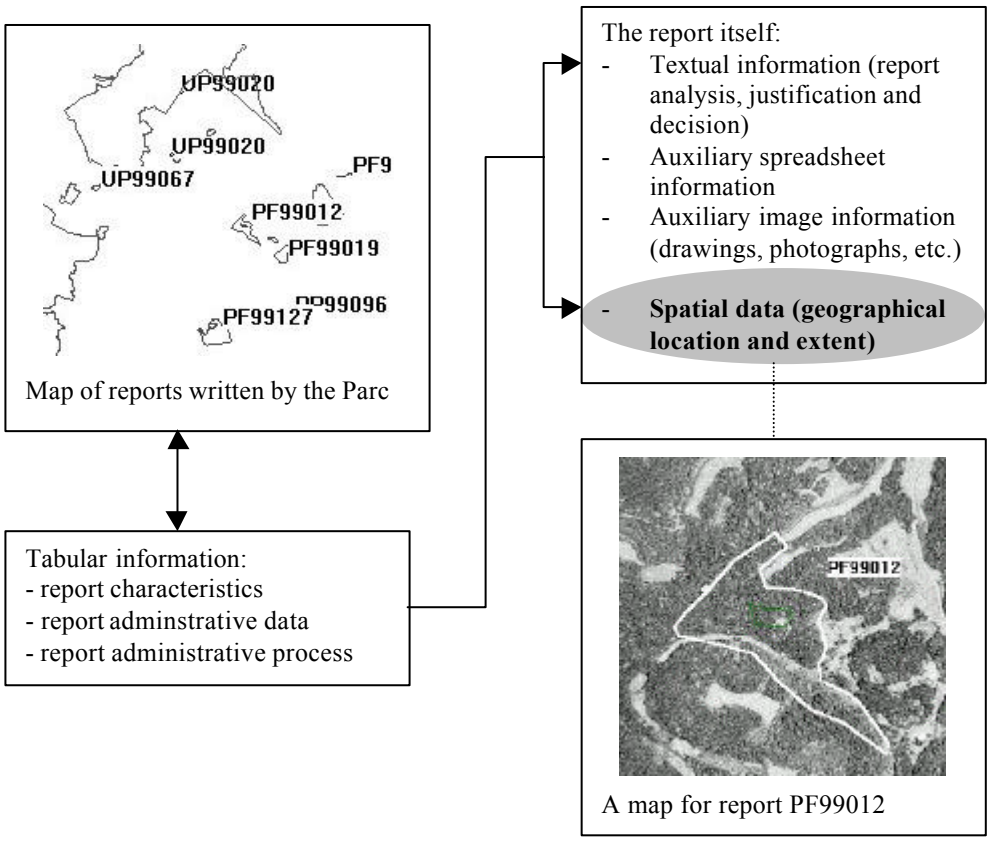

Figure 2. Relation between the different datasets of the reports management module

visualization and printing characteristics and over which geographical extent (PONS, X., 2000). Therefore, the map of reports does not represent any duplicity in the data. What used to be a map on a board where each reported activity was represented by a colored pin is now a digital map which provides visualizing, querying, analysis and printing capabilities. For any given point, line or polygon in the map of reports all its historical information can be accessed in a matter of seconds, as well as the associated documents. Map documents such as the map for report PF99012 shown in Figure 2 are actually the same type of files as the general map of reports. Therefore, and also in this respect, no information is duplicated and only simple text file that define the map as explained above are stored. All graphical layers needed to complement the map of a report are the graphical layers stored for the whole of the Vulcanus database (MARCER et. al., 2000).

2.2 Integration within the park's organization and work-flow

ISO 9002-1994 sets the rules for all administrative processes within the park's organization (Parc natural de la Zona Volcànica de la Garrotxa, 2000). One of these processes is procedure F1.01 (see Figure 3 below), which specifies which steps need to be followed when making a report (Parc natural de la Zona Volcànica de la Garrotxa, 2000). A data entry application is used to correctly store all the information on every single report in the reports database. It is used when an activity to be reported enters the park administrative flow (nr. 1 in figure 3) and when the report is finally written and ready to be sent by the park (nr. 8 figure 3). All this tabular information is stored in the reports database (nrs. 2,6 figure 3) and linked to the GIS (nr. 4, figure 3) via the map of reports (figure 2) by means of a univocal code assigned by the data entry form. The park's staff member in charge of the report labels the digitized graphical attribute with this univocal code. After digitizing, the graphical layer is topologically structured and automatically linked to the alphanumerical and text database. Since the map of reports is available from every work place in the park, historical information on the activity or place which are object of the reported can easily be retrieved. If a geographical entity was already reported in the past, the entity is not digitized again but simply copied and assigned the new code. This guarantees that the graphical database is consistent and that there is always only one representation of every single entity reported, no matter how many times it has been reported.

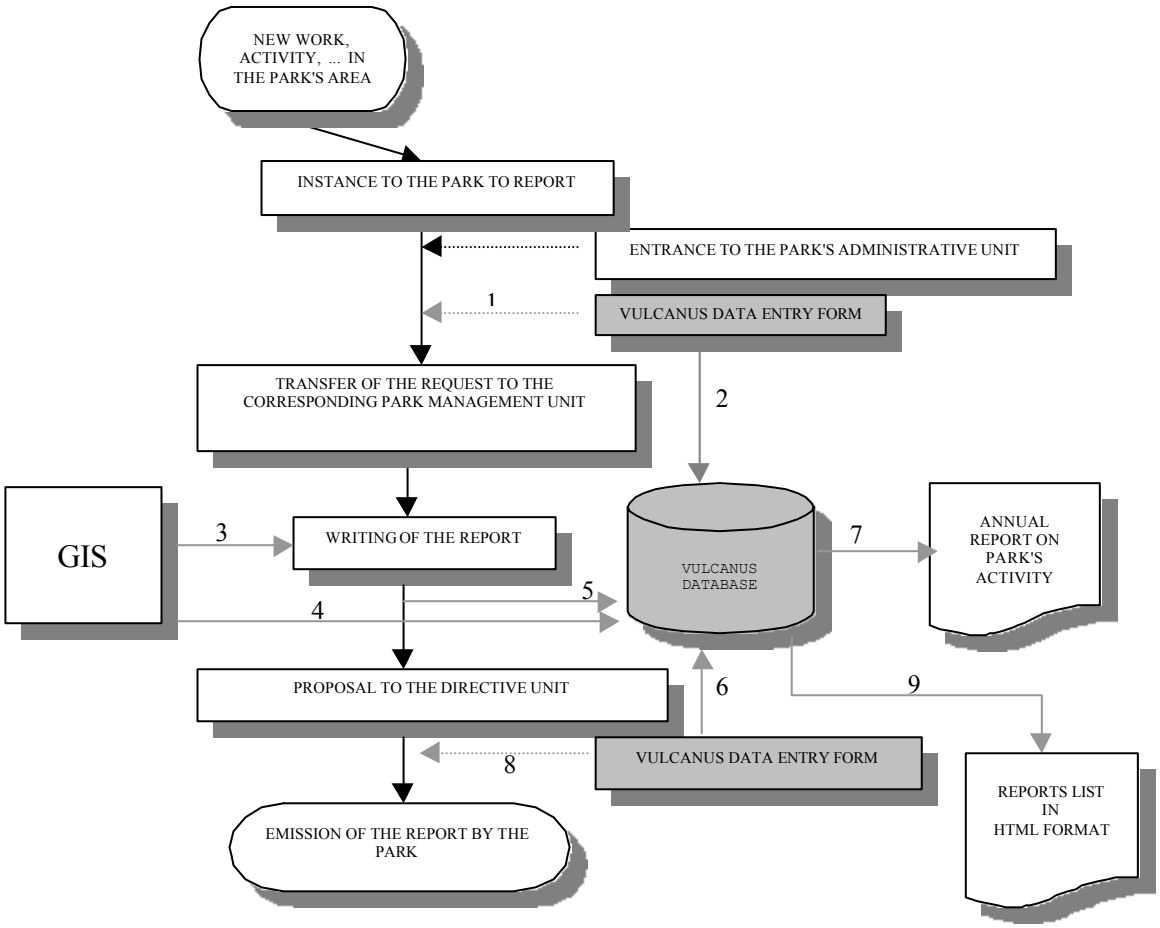

Figure 3. Flow diagram showing the process followed to make a report at the "Zona Volcànica de la Garrotxa" Natural Park, as specified by the F1.01 specification of the park's ISO 9002-1994 (Parc natural de la Zona Volcànica de la Garrotxa, 2000). In grey, points at which the reports management module of the Vulcanus project puts or gets information to and from the process.

Access to the reports database is available at any given time from any computer in the park (nr. 3, figure 3). All documents of the report are also stored in a set of directories in the Vulcanus database (nr. 5, figure 3). Every time a modification is introduced in the database the data entry form application outputs several lists of reports in HTML form which can be accessed with a any HTML browser. Every member of the park staff can know at any given moment from any computer in the park which is the status of every single report in the park's workflow (nr.9, figure 3). Finally, since all information regarding reports management is conveniently stored and organized in the database it is possible to devise a process by which a document on the annual park's work can automatically be produced (nr. 7, figure 3).

3 IMPLEMENTATION

3.1 Software and hardware.

The geographical information system MiraMon (PONS, X., 2000; CREAF, 2000) is used for all the GIS part of the implementation. The reports database has been created with Microsoft Access and its data entry form with Visual Basic for Applications. For all the administrative work (writing, calculations, etc.) the park uses the Microsoft Office package in its 1997 version. Netscape Communicator is used as HTML browser for accessing reports list in the park's server.

The park's hardware is composed by a set of 18 personal computers and two Windows NT servers (the whole set ranging from a Pentium 60 to a Pentium II 300 and from 32Mb RAM to 64 Mb RAM) in two separate buildings. All PCs are connected in a local area network (LAN) at 10Mbps.

3.2 Set-up within the park's LAN

The MiraMon GIS application resides in the server and can be launched from any of the PCs in the park's LAN. The core application is only 1.3Mb and behaves in a very agile and fast way. All data are also stored in the server and, as mentioned above, can be accessed from any computer.

3.3 Calendar and training

The reports management system is operational since January 1999 and over 300 reports have already been produced to date, following the procedures described in this article. Several in-house training sessions have been delivered to the park staff on how to use the data entry application, how to use the GIS to digitize, how to build topology and how to use perform queries to the database. GIS training has only been in form of complementary sessions to the training sessions programmed by means of the Vulcanus project.

4 DISCUSSION

4.1 Improvement in efficiency, effectiveness and overall data organization.

Prior to having the system, report maps were absolutely done with manual methods. Maps were prepared by mosaicking pieces of photocopies of cartographic maps and then the reported geographical objects were hand drawn on them. Finally, the map was also composed by hand (legend, scale, textual information, etc.). The final map was filed with the written report in a filing cabinet at the park's office. Distribution of reports across the park was followed by pins stuck on a map board, of course only visible at the office where it was placed. A small database on the reports was kept in a custom-made application. Thus, all information regarding every single report was stored in an unconnected way: a custom-made database, paper documents in a filing cabinet, text computer files in a computer directory and a map board with pins on it hanging on a wall at the park's headquarters.

As observed by ANDERSEN (1995b), collecting the information needed to make a decision often consumes much more time than the analysis of the request. This was specially true at the park given the unconnected information organization above mentioned. To write a report, a staff member had to access data from file cabinets, computer files, custom-made databases and there was no easy way to check whether the park had historical records for the activity being reported and to track them back. With the current system efficiency in the overall effort dedicated to report writing has greatly improved, particularly for the part of it regarding the elaboration of maps. Each member of the park's staff can now access all information regarding any specific reported activity from his or her desktop computer through the geographical information system. Besides, since information can be accessed from the geographical information system, any information layer from the more than 2 Gigabytes of data of the overall park system (Vulcanus) can also be accessed and related to the reports layers. What used to be a time-consuming task of information gathering is now just a few mouse clicks away from the park's staff.

In order for a GIS to be most effective in an organization, it needs to be integrated as a component within its overall information system and it should involve users at each stage of the development life cycle so that users feel that they have taken part in the design of the system (CAMPBELL, 1989). The experience at the "Zona Volcànica de la Garrotxa" Natural Park completely agrees with this statement by Campbell. It can be added that in the case of this park, the existence of a formalized workflow for report writing under the ISO 9002-1994 certificate has been a key factor in the success of the overall reports management implementation. The experienced park staff which already knew in great detail this process highly contributed to the implementation of the reports management system. The effectiveness of the system has been benefited by this participation of the staff . It has been possible to fine tune the system to the actual needs of the park and thus to make it accurately match its management needs.

4.2 New query and analysis possibilities.

As found by Andersen et. al. (1995a), the park's staff is now able to review all documents related to past decisions with respect to report writing so that consistent decision-making is highly facilitated. Prior to the implementation of the reports management module, this was currently done by relying on what each member of the park's staff remembers for every single report he or she has worked on in the past. The possibility to have access to all past reports written by the park is a major improvement in the park's decision process. Not only previous tasks can now be carried more effectively and with more efficiency but new possibilities have arisen which were not previously possible and without an extra cost. The whole range of GIS query and analysis tools is now available to gain insight into human activities within the park and along time. Questions such as what is the spatial distribution of unfavorably reported forest cut petitions over the park's area and in which cadastral parcels were they made, or has the park policy regarding water use permits over time been consistent, can now be answered. The park has now a tool which can help to improve its conservation policy by enabling to monitor it with real data over time. The possibility to cross-analyze report management data, that is data on human activities, with data on the park's natural resources is now in the park's hands. This can contribute to enlarge the park's knowledge-base on sustainable management policies and practices and to draw conclusions on real data on human activities and environmental impact over time.

4.3 Design extensibility and future directions.

We believe that the reports management system design can easily be adopted by any private or public institution with land record activities, e.g. a town council, a forest or wildlife department, etc. Its modular design (GIS, DBMS and Office applications) allows it to be adapted to different software configurations. However, for this design to be implemented there are several requisites which need to be met by the GIS software: 1) it needs to be fast and small enough to work on a standard LAN network; 2) it needs to have a file format which allows the combination of different graphical layers without data redundancy and which allows to be programmatically updated; 3) to be able to address in its database structure and its overall functionality the work with any given file format for which the computer on which it runs has its associated application.

Future work will address the extension of the system to the record of park sanctions for non-allowed activities in the park. This will add the possibility of keeping track not only of those activities which at some time the park was asked for its permission but also for all those activities made without the corresponding petition for permission and detected by the park's rangers. This new functionality will allow the park to have a much more accurate picture of human activities in the park. This knowledge will contribute to improve park policies and practices on information dissemination, environmental education and law enforcement.

Once the sanctions will be integrated within the system the final step will be to integrate it all in an overall system for park activities management which will have to include all other park areas of action: studies, public works, guided visits, etc.

5 CONCLUSIONS

It is possible to build a GIS-based system for reports management in a protected area, or in any other institution working in land management, that integrates with an existing workflow process within the organization and which allows to handle all information involved in the report writing process in a connected manner. The GIS can be integrated within a LAN and thus be available from any of the steps of the given workflow process. Park staff members can have access to real-time data on park's activities from any of the computers of the park's LAN.

Existing consolidated workflow processes, if correct, are a major factor in the successful implementation of such a system. In the case of the "Zona Volcànica de la Garrotxa" Natural Park, the existing ISO 9002-1994 certificate greatly helped in the design and implementation of the system.

From the GIS and by simple queries, any information (map, tabular data, spreadsheets, photographs, text information, etc.) of any given report can be retrieved. Historical information on a previously reported activity can be recovered and incorporated in the new report. As a consequence there are consistency improvements in report writing and thus in park policy and practices.

Overall, report writing time can be greatly reduced while providing a fully functional GIS to reports management that allows for the query and analysis of all past and present human activities in the park's territory.

These new available tools offer a vast range of possibilities to monitor and evaluate park planning and management policy and evaluate sustainability of different human activities.

ACKNOWLEDGEMENTS

The authors thank the institutions participating in the Vulcanus project for their continuing institutional support, without which none of the developments and findings related in this article would have been possible. Special mention needs to be given to the Department of the Environment of the *Generalitat de Catalunya* for their funding support and to the staff of the "Zona Volcànica de la Garrotxa" Natural Park for their insightfullness, working knowledge and personal support always given.

REFERENCES

ANDERSEN, D., AVERY, P., BLONIARZ, P., DAWES, S., HYDE, S., KELLY, K., MILLER, A., and RICH, E. Balancing Environmental Quality and Economic Vitality in the Adirondack Park. CTG Project Report 95-3. Adirondack Park Agency. Center for Technology in Government. December 1995.

ANDERSEN, D., AVERY, P., HYDE, S., KELLY, K., KIM S. and ROHRBAUGH, J. Evaluating the APA Prototype: Prospects for Providing Cheaper, Faster, and Better Services to APA's Customers. CTG.APA-015. A Research Report of the Center for Technology in Government. October 1995.

CAMPBELL, G., 1989. Management Considerations in Applying GIS Technology within an Organization's Information System Strategy. Canadian Conference on GIS, Ottawa, Canada, March 1989.

CREAF, 2000. MiraMon. Geographic information system and remote sensing software.
http://www.creaf.uab.es/miramon/index.htm

IUCN, 1994. Guidelines for Protected Areas Management Categories. IUCN, Cambridge, UK and Gland, Switzerland. 261pp.

IUCN, 2000. Key Result Area 6: Information and communications. In *Stepping into the new millennium.* IUCN Quadrennial Programme 2001-2004.
http://WWW.IUCN.ORG/2000/about/content/newprog.html

Departament de Medi Ambient, Generalitat de Catalunya, et. al. 1996. Sistema d'informació Geogràfica per a la gestió del Parc Natural de la Zona Volcànica de la Garrotxa. Descripció i demostració. Centre for Ecological Research and Applied Forestry, Department of the Environment of the Catalan Government and Cartographic Institute of Barcelona. December 1996. ISBN 84-393-4138-5.

Departament de Medi Ambient, Generalitat de Catalunya, 1999. Memòria d'actuació 1998. Parc natural de la Zona Volcànica de la Garrotxa.

Generalitat de Catalunya, 1982. LLEI 2/1982, de 3 de març, de protecció de la zona volcànica de la zona volcànica de la Garrotxa. DOGC 206, 10/03/1982.

Generalitat de Catalunya, 1985. LLEI 12/1985, de 13 de juny, d'espais naturals. DOGC 556, 28/06/1985.

Generalitat de Catalunya, 1994. DECRET 82/1994, de 22 de febrer, pel qual s'aprova el Pla especial de la zona volcànica de la Garrotxa. DOGC 1888, 25/04/1994.

MARCER, A., PONS, X. And VICENS, J. 2000. El projecte Vulcà. Un Sistema d'Informació Geogràfica integrat a la gestió del Parc natural de la Zona Volcànica de la Garrotxa. In "*Conèixer per Conservar*". Institució Catalana d'Història Natural. Barcelona. In press.

MARCER, A. and PONS, X. 1998. Park GIS Implementation. A GIS implementation model which takes advantage of internet technology to embed the system into the organization of a protected area organization. The case of "Zona Volcànica de la Garrotxa" Natural Park GIS. In *Proceedings of GIS PlaNET'98 International Conference and Exhibition on Geographic Information 7-11 September 1998. Lisbon – Portugal*

Parc natural de la Zona Volcànica de la Garrotxa, 2000. Arxiu de qualitat del Parc natural de la Zona Volcànica de la Garrotxa. Internal document.

PONS, X., 2000. MiraMon Manual. Center for Ecological Research and Forestry Applications. http://www.creaf.uab.es/miramon/index.htm