14 The Archaeological implications of a computerised integrated National Heritage Information System

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14.1 INTRODUCTION

When the Information System for Manx National Heritage was designed, the target was not simply a computerised version of existing manual methods but a radical revision of procedures to exploit new technologies as fully as possible, integrating all current management and documentation functions, providing quantified information rather than raw data, and supporting a new role in education and higher research. One means of achieving this was the creation of a single inter–related spatial–temporal database linked to digitised maps (figure 14.1): however it was not possible to simply bolt a GIS on to an existing database and expect it to work miracles, it required a thorough analysis of aims leading to a completely restructured data model.

14.1.1 The setting

Manx National Heritage is responsible for a wide range of activities including Ancient Monuments Inspectorate, National Library, Archive, Biological Records Centre and Manx National Trust as well as the museum and its branches including two castles, a working farm museum and industrial monuments. Within this organisation archaeology works along side Social and Natural History, so the Information System was designed with an inter– disciplinary approach integrating and cross–referencing all records (over a quarter of a million so far) in the same database: including books, maps, plans and photographs as well as artefacts. In this way each subject could support and enhance the others so that the whole, like a good football team, would exceed the sum of its parts.

14.2 THE SITES AND MONUMENTS RECORD AND THE INFORMATION SYSTEM

The SMR formed the model for the expanded system, resulting in a comprehensive Cultural Heritage Record in which Oracle database files are shared by different applications through SQL paths according to the nature of the enquiry. One pre–selected path, presented via Oracle Forms, performs the range of tasks associated with a traditional SMR, however this separate function has become an obsolete concept replaced by a virtual SMR generated according to need from those general records that have been cross–referenced as having either direct or indirect archaeological relevance (figure 14.2).

The system treats the archaeological heritage not as isolated sites detached from the environment, scattered throughout a modern landscape as if shaken from a great pepper pot, but as one of many characteristics that share, helps to create, and shape it. Its design includes both spatial and temporal attributes for each record, employing a basic GIS (Arc/Info) spatial recording unit of field plots as identified on the first Manx OS maps of 1868–70. It had been the practice of local field workers to identify each site or find spot by its plot number that was included on most of the manual index cards. Each card was in fact not only a "site record" but a description of the archaeological aspects of that plot which may be related to the system's basic geographical data, including: a land use survey published by the Ordnance Survey corresponding to their maps (James 1868–70); a soil survey with distribution map (Kear 1982); and geology maps (Lamplugh 1903); and with aspects such as wild–life habitats, property ownership and access details.

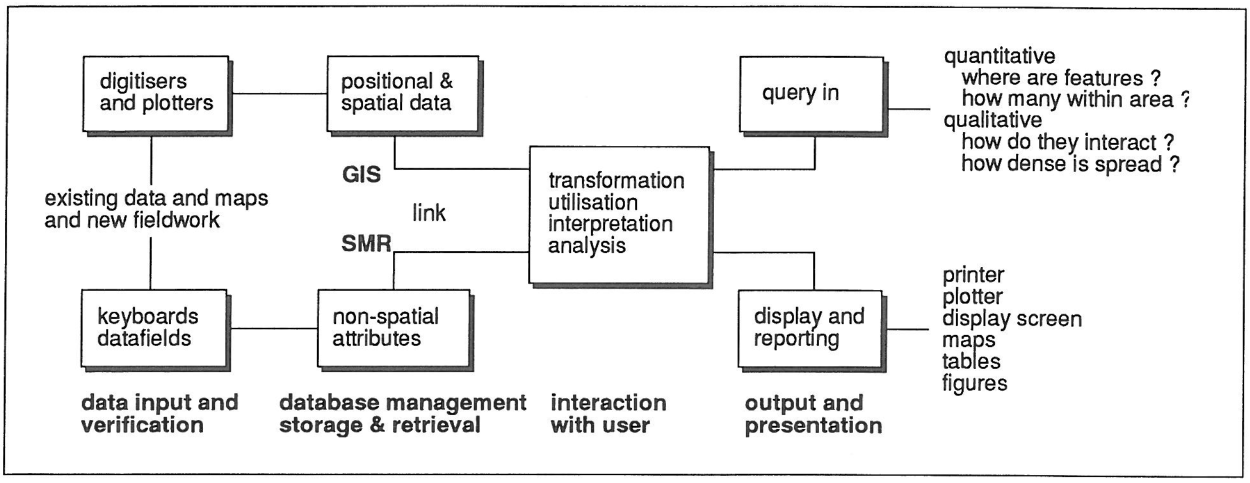

Figure 14.1: The organisation of the use of integrated spatial and non–spatial data. The GIS will form part of the overall information system as an integrated module within its management system. Spatial aspects of the database will not be appropriate to all users, the GIS facilities are an optional module which can be called into use via a system menu according to the user's status (determined by their login code and password) and the nature of their enquiry.

14.3 THE RESEARCH OBJECTIVE

The system was planned be able to support theories testable by experiment as part of its routine function and provide a source of informed data from which comparisons can be made using variables that have previously only been examined in isolation or in limited projects. It covers the whole landscape, rather than only sites, in an evolving system that will become more accurate with accumulative fieldwork and checking. It has been successfully used in a project examining the island's prehistoric settlement in which it was possible to not simply observe or describe the changing pattern but to explain it and assess causal relationships by the formation and testing of empirically verifiable theories. A chronological survey and analysis supported choices of interpretations that have been advanced to explain events, each represented by a causal theoretical model that was tested to see which, if any, best supported the facts. In this way concepts general to archaeology were related to the specific subject, the Isle of Man. This implements Carver's belief that an island is

> «particularly well suited for the examination of ancient society through a long–term strategy of exploration, in which cultural resource management factors and academic issues are matched in a machine–based research planning centre» (Carver 1985:57).

The Manx system is designed to be such a resource, which will promote and direct a more informed, systematic study of Manx archaeology and provide a practical guide to its assets. The combination of statistical analysis with data visualisation provided by a GIS brings closer the integrated study of archaeology's three axes of space, form and time (Spaulding 1960) that theory and conventional methodology find difficult to manipulate simultaneously.

The objective is the routine formulation of such regional syntheses from theoretical models through which a more authoritative insight into processes such as settlement will evolve. This is an attempt to employ a scientific approach in the record using quantitative measures to eliminate vagueness and uncertainty, add objectivity, and create a common currency that can be checked, added to and expanded by other investigators. The system compares and categorises sites and provides a means of defining regularities and recognising patterns in the process of material and cultural change (Clarke 1972).

As change over time is central to archaeological research, the system's spatial–temporal structural design defines its ability to perform valid archaeological work (Stine & Lanter 1990:80). One way to include these general archaeological requirements within a GIS is by employing the concept of the landscape (Savage 1990; Green 1990). Other disciplines, such as ecology and geography, use similar spatial concepts but their methodologies are relatively synchronic so their models, including GIS applications, are not designed for diachronic theory. Some practices adapt better than others, but still lack the «analytical tools designed for the complexity of temporal data» (Zubrow 1990:68).

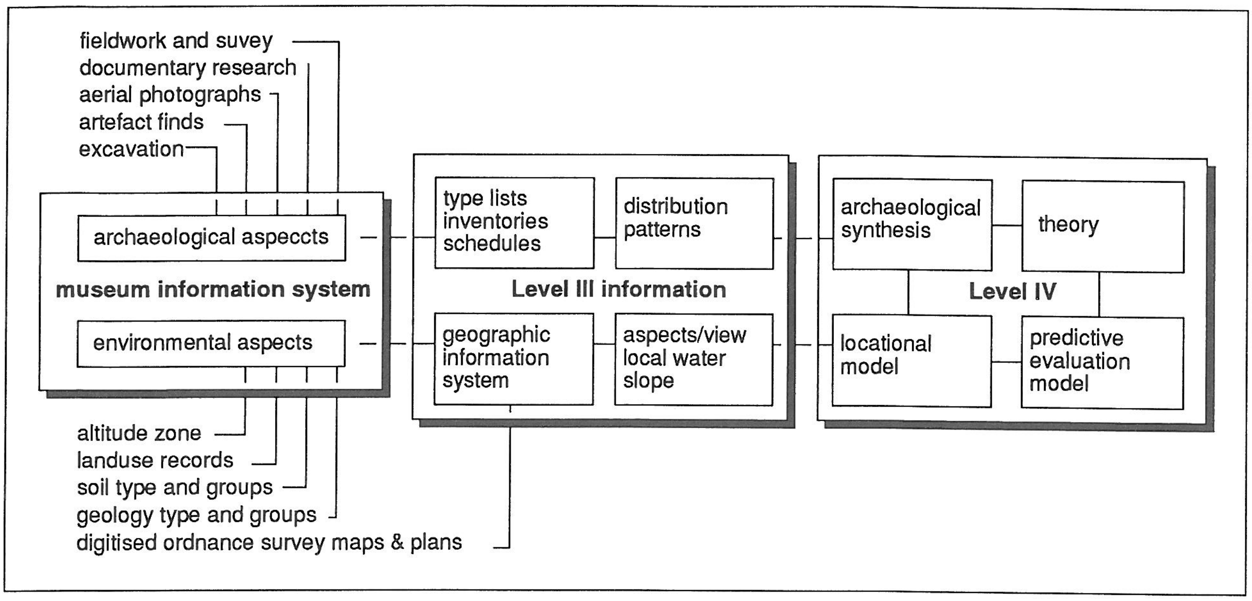

Figure 14.2: The relationship between archaeological discipline and its methods to the Museum Information System in general. The basic database represents Level II data (as defined by CBA) where details of finds, stratigraphies, plans, drawings and photographs (which are stored in the Museum Archive or SMR site file) are recorded and indexed; Distributions, inventories, analyses and cross–refrences are produced at Level III; leading to synthesis and theory at Level IV.

14.4 A DATABASE OF THE WHOLE PREHISTORIC LANDSCAPE

The concept of the landscape as the ultimate artefact introduces the human dimension in a regional SMR, representing the complex relationship between man and his environment. It provides a unifying theme assisting the visualisation and definition of spatial aspects (Crumley & Marquardt 1990:75) and quantifiable models of the prehistoric backcloth against which the nature and relevance of individual sites can be related and inter–related, including the variation in density and arrangement through time of location patterns, are assessed against the distribution of environmental attributes in the general background. The whole potential range of sites compared to known sites asks questions about the recognition and survival of sites and the bias of fieldworkers. It enables the assessment of distortions in the actual pattern and the degree of selectivity of certain features by prehistoric peoples.

14.5 THE DEFINITION OF AN INDIVIDUAL SPATIAL RECORD

Lip service has often been paid to non–site oriented records, but it has rarely been put into effect. The main systems used are: record definition by site; by land parcel; by archaeological entity; or by recorded information (Chadburn 1990; Lang 1990). The "archaeological entity" approach combines the elements of the same cultural identity into a single record; "recorded information" is the most pragmatic, indexing discrete items of data, represented by surveys or aerial photographs, as separate archaeological entities. The "Site" is generally accepted among archaeologists as the basis for typology and indexing, with related information on components such as finds from the site or features and structures contained within it. The concept has irrevocably permeated archaeological terminology, arising from its origin specifically describing an excavation site, a usage analogous to a building site in which case it remains accurate and helpful.

14.5.1 The use of land parcels in a spatial database

The "land parcel" approach uses areas of land whose boundaries can be identified on the ground. It is often used only to define large and complex landscapes, such as crop marks, which are otherwise difficult to split into smaller units and is well suited for the assessment of planning applications that are commonly aimed at specific land parcels.

As its basic recording unit the Manx system employs a combination of a primary land parcel together with a subsidiary element representing archaeological entity in an "object oriented" or (to avoid confusion in a Museum location) "concept related" data model. As each record is related to a plot of land, the archaeological information may be spatially integrated with the whole database. Each plot is identified by a four figure "Prime Record Number" (PRN) allocated in numerical rather than geographical or thematic sequence. The record may be subdivided to identify significant features, periods or changes in use that merit separate consideration and indexing, in which case a two figure suffix appended to the PRN provides a related "Sites and Monuments Record Number" (SMR No). This averts a complicated, and difficult to retrieve, sequence of cross–referenced PRNs scattered through the SMR. Where a record occupies more than one plot, a decision must be made on the merits of each case as to whether to allocate separate PRNs or to relate them by one PRN with different SMR Numbers.

14.5.2 The location fields of information employed

A combination of kilometre square and plot number provides the most useful of the following location parameters for simple searches or relationships without resorting to digital maps:

- Site Name
- Parish or Town
- Sheading
- National Grid Reference
- Kilometre Grid Square: a sequence four figure NGRs which, fortuitously, are not duplicated on the island
- Map Sheet
- Plot or land parcel

14.5.3 An example of a multi–period site occupying one land parcel

The most complicated such record covers the separate aspects of the Chapel Hill, Balladoole complex: the PRN for the whole site is 0001 as the plot number is same; while the features, components and periods are separately indexed as SMR No. 0001.10 to 0001.70 (so far) with each requiring its own eight figure NGR. (Table 14.1)

SMR No.	Site Type	Date	Class	Form
0001.1	Keeill Vael, Chapel	EM	RE	FM
0001.2	Burial Ground, Lintel Graves	EM	BL	FM
0001.3	Viking Ship Burial	EM	BLV	FM
0001.4	Hillfort	IA	DE	FM
0001.5	Burial Cist	BA	BL	FM
0001.6	Viking Long House	LM	DOV	EW
0001.7	Flint Scatter	ME=NE	DO	FS

Table 14.1

14.6 THE QUESTION OF SITE DEFINITION, AND ITS RELEVANCE TO A SPATIAL DATABASE

The consistent definition of what constitutes a "site" in a spatial database is a persistent, yet often unrecognised, problem that confuses, and perhaps invalidates the structured analysis of the prehistoric landscape, reducing it to an archaeological archipelago protruding through the modern countryside. While there is little debate over what forms a field monument, the classification and definition of less substantial or poorly delimited sites remain an obstacle when compiling inventories and indexing databases or spatially correlating abstract concepts such as cultural and subsistence activities with the more quantifiable variables of the natural environment. This is especially true when aerial photography or resistivity survey reveals substantial outworks or field systems associated with hitherto clearly defined monuments: this issue presented several headaches for the author when compiling the Highland Region SMR and convinced him that the site approach was flawed, especially if facilities more ambitious than simple listings were envisaged.

The usefulness and validity of the site concept have often been challenged (Green 1990:4; Foley 1981). Its wide interpretation embraces ill–defined entities ranging from: complete prehistoric landscapes; to individual monuments; down to single find spots. It is impractical and misleading for spatial SMRs to partition prehistoric activity into such clearly defined, yet arbitrary, units: it is often not clear how to define or assess site size or function; how much of it was in use at any time; or how its size changed over time through reoccupation and abandonment. Often, both in the course of survey and when adding findings to an SMR, distinguishing a site and setting its boundaries is a pragmatic «archaeological decision not an observation» (Dunnell & Dancey 1983:267) combining recording convenience, theoretical preconceptions and indexing practicality. Even when survey data has been based on grid squares, the results have been grouped into sites with sometimes ill–defined boundaries.

14.7 THE SPATIAL LIMITATIONS OF SITES AND MONUMENTS RECORDS

The data structure of most computerised SMRs mirrors that of their parent manual card indexes, performing the same sort of analysis albeit quicker and with greater flexibility using Boolean logic and database query language (in this case Oracle's SQL). An SMR structured as described above can successfully handle spatial properties using record attributes. In fact it has been found to be the best approach for simple topological relationships between archaeological, natural and environmental phenomena. However, although it may be able to represent the locations and attributes of linear features and irregular areas, its inability to inter–relate this information precludes further computational analysis (Harris & Lock 1990:34) such as terrain modelling and cost surface analysis. These require a full GIS in which the basic digital encoded elements (or location carriers) of points, lines and polygons define co–ordinates and areas and the links between them (Burrough 1986:13).

14.8 THE TREATMENT OF SPATIAL INFORMATION BY GEOGRAPHERS

Spatial data are considered by geographers at three levels: firstly, general purpose topological physical features used as a base for specialist maps; secondly, overlying the base maps are layers of single characteristic thematic information, such as of soil or geology, represented either by area (choropleth map) or by equal value (contour lines); the third level are qualitative or quantitative maps, such as land use or archaeology, which can present and classify large amounts of complex data in a clear and quickly understood way.

14.8.1 The suitability of spatial parameters in an SMR/GIS

A problem with vector systems such as Arc/Info is that polygonal areas may have to be imposed to encode area attributes. This introduces another interpretative element in site definition, such as deciding where the edge of a site such as a flint scatter is to be drawn; in the Manx system the use of field plots solves this bias, providing a common base and avoiding problems with mismatched overlays. A non–site approach solves the problem of recording poorly demarcated sites and stray finds, and avoids the problem of modern field boundaries, roads and streams splitting sites into two or more separate records.

The validity of results depends not only on the variables used and the accuracy of their encoding, but also on how the GIS deals with difficult to represent land form shapes (Kvamme 1990:165). In the polygon approach, the more digitised layers that are overlaid, the more the accuracy of the map coverage diminish geometrically (Allen *et al* 1990) creating a mosaic of discrete slivers that are difficult to locate on the ground. Solutions to this include replacing schematic polygons with a raster based grid producing a continuous probability surface or, as in the Manx System, using a land parcel coverage.

14.8.2 The advantage of using the land parcel concept

A land parcel unit enables the database to be spatially rather than feature oriented. It allows the system to be expanded to consider all possible alternative settlement locations, enabling the evaluation of the decision making process via theoretical frameworks and techniques that, if based on *ad hoc* single site data tied to the environment of single group, are unlikely to be of relevance elsewhere (Hardesty 1980). From this we are able to determine the relative importance of various physical attributes in choice and to model the process.

Although several field surveys have adopted land parcels as basic units, they have all had some degree of trouble in defining them satisfactorily. While calling for a precise definition based on "cultural items or debris" or "entirely synthetic unit" of grid squares, which recognises that in dividing a natural unit such as a hillside, it may give a false picture, in practice they opt for a subjective "site" assessment drawn from experience (Kvamme 1985:284). Other definitions used have included an arbitrary area around a randomly chosen point, and the more systematic gridded square or polygon. The term "land information system" (LIS) rather than GIS is normally applied to such polygon–based systems, especially cadestral types, concerned with changing title to land.

14.8.3 The use of land parcels in the Manx SMR

The System is area–based rather than site–based in that each record is related to a defined area of land as shown and numbered on the OS 1:50,000 maps of 1868–70. This provides several advantages in administrating the archaeological information and relating it to the wider spatially organised database. To index these records each of the island's 43,002 plots of land has been given a unique six figure code number: this has two parts, the first element is a two figure parish code based on the sheading system: the second part is the plot number based on the consecutive numbering sequence shown on the 1868–70 maps. For example, 110001 is the unique number for plot 0001 in Bride parish.

Administratively the island is divided by its watershed into the two "Deemster" areas of Northside and Southside, each with three Sheadings which normally contains three Parishes. Similarly, each parish contains three Treens covering the whole cultivable area, each with usually four Quarterland farms representing family–sized land holdings. Together, these areas comprise a nested five tier hierarchical system of land division whose origins and evolution is debatable, with opinions divided between Norse (Moore 1901) and Celtic (Megaw 1978) influences.

A study of their size and shape reveals that they are not arbitrarily imposed political units, but physical "units of the countryside" (Davies 1956:100) laid out as equatable mixed– farming units each with a roughly equal share of arable and pasture, access to coastal resources and upland rough–grazing (Birch 1954; Pye 1941). Nor are the plots random, but are agricultural fields representing human reaction with the landscape, reflecting its shape and quality. They are related to geographic factors, geology and water courses with their boundaries following contours and streams and are associated with wells, springs (Davies 1956:103) and man–made features such as old trackways, roundhouses (Reilly & Zambardino 1985:18–20), Viking burial mounds (Megaw 1978) and keeills. The plots are small and closely packed where good land is intensely farmed and larger where soils are poorer: the larger plots are usually derived from areas of `intack", commonland once used for grazing and fuel collection. Without any other details as clues, an educated eye may thus accurately deduce both land form and land use from a map showing only field boundaries.

Land parcels thus defined can not be sub–divided as a system unit, and each is part of larger "parent" area from which it inherits certain values. This is to avoid the problems experienced in temporal cadestral systems where the plot can be divided or amalgamated several times until the concept loses any usefulness: the system at present ignores such changes and imposes continuity by using the original plot.

14.9 THE INTEGRATION OF SPATIAL AND TEMPORAL DATA WITHIN AN ARCHAEOLOGICAL INFORMATION SYSTEM

14.9.1 Problems arising with an environmental GIS

A problem in dealing with environmental information is that there are in reality no convenient homogeneous mapping units with abrupt and smooth boundaries as shown, and usually digitised, on maps. Maps are a compromise where, in order to understand large amounts of complex information, the number of data classes and degree of detail is reduced to manageable proportions. This introduces resolution errors as only one attribute can be recorded per geographical unit with the main or average value used: this is a typical problem when large units or a regular grid is used on a complex landscape. However, a map is already a subjective assessment, rendering complex values to areas of a common attribute bounded by lines where in reality there are overlapping zones rather than sharp edges. It is a generalised subjective model in which the scale and range of information has been simplified, such as by the reduction in the number of soil classes to make the map distributions understandable: yet they remain rough representative entities of real fuzzy boundaries and subsets delimited by notional fractal lines or curves that convey a clear visual message.

Fractal theory shows that for most naturally occurring phenomena the amount of resolvable detail is a function of scale: an increase in scale does not result in an absolute increase in precision, but reveals previously unseen variations (Mandelbrot 1982). For example, the length of a soil boundary or a coastline depicted on a map grows logarithmically with increased scale as more previously unresolved features are delineated: ultimately the length becomes infinite. The use of field plots reduces problems arising from mismatched overlays: all attributes uses the same area that, because they are not random, are sympathetic to land form and reflect soil and geology.

14.10 A TEMPORAL DATA MODEL

Atemporal databases hold only synchronic data: they do not support dynamic models of the processes of change so they can not perform backward or forward projections examining past states, future forecasts or predicted values (Vrana 1989). They are designed for the latest correct value of current information, with changed values normally regarded as outdated information to be overwritten or, if economic, archived on tape (Price 1989:233). There is, however, a need for time series analysis capabilities to record and analyse changes in spatial information to assist the understanding of long–term geographical and environmental phenomena such as peat formation and forest clearance and to trace a plot's short–term chain of ownership title as well as to support archaeological research.

The general Manx System deals with changing states over time as part of its management facilities using "time modelling" and "process modelling": time modelling is used in its accounts module to record a logical sequence of orders, bills and payments in which future actions can be anticipated if specified conditions apply (reminders sent); and for staff records, detailing dates of changes in values (grades, marital status) and accumulations (training, sickness); Process modelling is used to log the management history of Museum artefacts, including their various locations, valuations and conservation at certain dates.

When correlating physical change, we need to distinguish between the "real" time of an event and the "recorded" time of the database transaction. These "two clocks" (Langran 1989:218) allow past evaluations to be assessed later according to contemporary values: for example, an SMR site description consists of a continuation of the Ordnance Survey Inspectors' log of field reports, these old interpretations are valuable historic records that may look flawed if compared to the current state of the site or with modern interpretations.

The key to temporal representation is the ability to identify and trace entities and their attributes over time, and to compare common values and their changes over equal periods. This ensures that we are dealing with the same object and its changes, not replacements. It does not solve a major problem in that the subjective entity of a "site" may or may not represent continuity, where there may be only an accidental relationship between (for example) Neolithic and Bronze Age aspects of a supposedly multi–period site.

However, these techniques are of limited value to a temporal cultural database that seeks to reflect change either as date–stamped events or as periodic altered states by accepting update of existing data as new sequentially linked records without overwriting the existing values, creating a relational series of values corresponding to each point or period of change. This can be achieved by using either a "temporally–oriented" or "time–relational" data model (Price 1989:234); or by including an attribute of the entity to give a temporal value, for example as "TQuel" the temporally–based extension to Ingress Quel query language provides a time–oriented view of a conventional relational database (Snodgrass 1987).

These models of temporal change employ various concepts relevant to historic enquiry: trends and cycles, such as seasons or climatic or historic periods; "snap shot" state changes represented in a historical series of time slices which model states over time; and continual processes of dynamic change requiring the use of "event calculus" to model their progress.

The Manx model deals with changed values over periods in time slices, splitting the dynamic process into standard stages represented by SMR records and GIS layers: the changing archaeological aspects of the objective entity "plot" include an attribute for time represented by cultural period. This "infological model" (Langefors 1980) is represented by the tuple:

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<object, attribute, attribute value, time/date/
period>
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14.11 ASSESSMENT AND MANAGEMENT ADVICE PROVIDED BY AN ARCHAEOLOGICAL INFORMATION SYSTEM

Besides research, the system seeks to provide selected and quantified data as information as part of its routine support function. Where this information is applicable to various types of evaluation and applications (for example, interest in geology and soil types is shared by the Biological Records Database) the records are held as part of the general database and cross–referenced by Plot Number, namely:

- Land use classification
- Area status
- Physical site attributes: Altitude, Geology Soil Type, Vegetation Type

Where the evaluation is specifically archaeological, the records are part of the SMR indexed by PRN, namely:

- Class Characterisation
- Monument Discrimination
- Management Appraisal

These criteria are commonly recognised in order to judge the importance of a monument in a national context, notably by English Heritage to assess monument evaluation for scheduling (Darvill *et al.* 1987; Startin 1988). The classes have been adopted as part of the record structure and quantified using a scale of points.

14.11.1 A basis for a formal scale of priorities
The establishment of priorities strikes a balance between local and specialised interests, data–winning, the resolution of current problems and the anticipation of future requirements. A formal procedure for achieving this balance not only increases objectivity, but also ensures that at all stages in adjudication the same criteria are used so decisions are not made on an *ad hoc* basis where expediency, not disciplined thinking, determine policy (Groube 1978). Such a ranking enhances objectivity by employing weighted evaluations to establish a scale. The weakness of this approach is the inevitable subjectivity of the scaling decisions and biased pressure to class certain classes as special; it requires scrupulous fairness without specialist or career–oriented interests.

The class characterisation of a monument is assessed under four criteria to establish class profiles against which different types can be compared:

a) length of time it was used
b) rarity of the monument
c) diversity of form of features
d) periods represented

Codified values, which award each site a score in the range from 4 (low status) to 24 (exceptional), are assigned to these criteria as follows:

a) (1–2) short use, (3–4) medium use, (5–6) long use
b) (1–2) common, (3–4) fairly common, (5–6) rare
c) (1–2) single element, (3–4) medium, (5–6) complex features
d) (1–2) one period (3–4) more than one period, (5–6) extended continuous occupation

Monument discrimination uses seven criteria to define relative importance by comparing certain characteristics of each site with those of all other known examples of the same class:

a) Survival
b) Diversity of features
c) Group value, by association
d) Group value, from clustering
e) Documentation
f) Amenity value
g) Potential

In each of these criteria, professional judgment is used to award each monument a score of either: (1) poor, (2) average or (3) good, thus assessing a range between 8 (low quality) and 24 (outstanding).

Management Appraisal uses four criteria to establish profiles against which different types can be compared and identify the most important monuments meriting priority attention and conservation :

a) Condition
b) Vulnerability
c) Fragility
d) Conservation value, including overlap with other interests including Natural History and Tourism

Codified values award a range of scores from 4 (low value) to 24 (exceptional), as follows:

a) (1–2) poor condition, (3–4–5) medium, (6) outstanding
b) (1–2) low, (3–4) medium, (5–6) high
c) (1–2) low (3–4) medium, (5–6) high
d) (1–2) low, (3–4–5) medium, (6) outstanding

Each of these stages provides an equal part of a numerical evaluation of each monument that may be used separately or together up to a maximum assessed value of 72.

14.11.2 A predictive model for settlement choice
The next stage of the system involves guidance using speculative assessment. Correlation models found to be successful in the interpretation of settlement patterns can be adapted into one extrapolating projections of potential site occurrence (Carr 1985). The identification of areas of archaeological potential may be possible by combining the technology of GIS with the statistics of logical regression analysis to build a model (figure 14.3) which is both deductive, using premises deduced from theory, and inductive, employing patterns detected by observation (Warren 1990). Typical

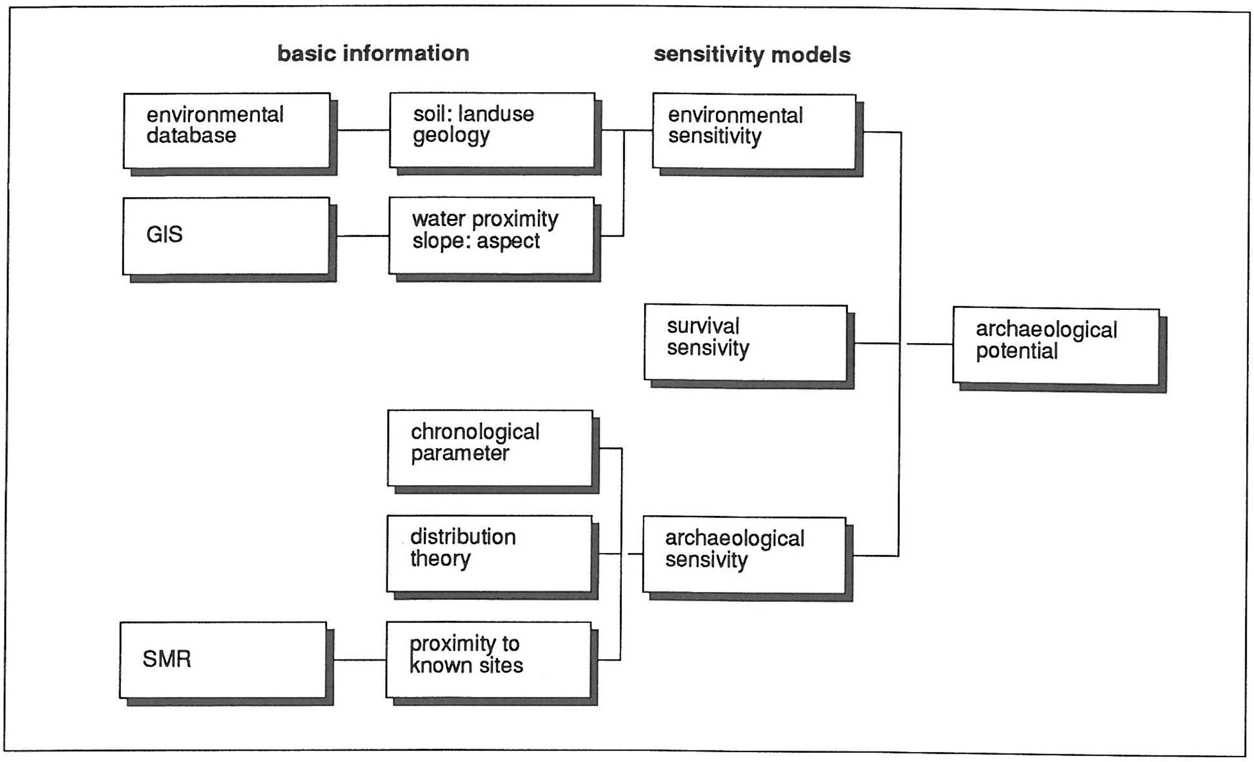

Figure 14.3: Predictive modelling proceedure to assess the archaeological potential of a plot of land.

probability models require responses to a set of questions to assess the favourability of a location as having high, medium or low potential (Limp & Carr 1985). This raises problems in choosing the unit size to ensure validity, as the smaller the land parcel used the greater the resolution achieved (Kohler & Parker 1986). This is especially relevant if a project employs a grid system, in which case the number of units increases geometrically with decreased scale.

Quantitative location study uses independent non–cultural environmental variables as control factors that can be compared and correlated with site locations that, as they tend to recur in favourable environment settings, are assumed not to be randomly distributed. This may demonstrate patterning and show that site characteristics differ significantly from those of random points (Kellogg 1987). The technique assumes that the SMR forms a representative sample and that prehistoric environmental variables are reflected by information found on modern maps and by fieldwork. This type of application requires specific models for different classes and types of sites. These must be precise, reflecting different patterns and lengths of stay, and vary in their success and reliability according to the nature and validity of the data and their consequent ability to define a "typical" generic site.

In this way a known pattern can be projected onto similar environmental areas, comparing the variables of the known sample with non–site locations (Marozas & Zack 1990) leading to the prediction of settlement patterns in other landscapes, rather than simply describing and generalising on a known distribution. For example, new sites of rock paintings in South Africa have been predicted from combining information on locations of suitable rock outcrops with typical environmental conditions (Butzer 1982:9).

14.11.3 Predictive models and local planning strategy

The main use for predictive location models has been to identify sensitive areas in advance of development (Parker 1985:179–87) defining "sensitivity zones" or "site frequency zones" on "favourability maps" where archaeological material has a more than random chance of survival and recovery. If properly developed these exercises may be extended as permanent applications that can support and test theoretical models.

14.11.4 Probability and predictive models applied to a landscape

If environmental data is known only for locations where sites are found, then it is not valid to extend the framework to a general predictive or explanatory model: this can not be achieved by using the site as the unit of analysis, but by using all possible site location options within the landscape. There is much more environmental variation among none–site locations in the landscape than among a biased sample of site locations occupying a preferred limited portion of the whole. The Manx System seeks to solve the problem of valid control locations by using all the island's 43,000 field plots as a background, providing non–site area data against which locations can be compared (Kvamme 1985).

This will enable the definition of site profiles that could prove useful in interpreting known sites. For example, in Highlands of Scotland there are hundreds of mounds of stone of no obvious function. A comparison of their location profile with calibrated values for certain groups of monuments such as burial cairns or ruined brochs or duns would provide an interpretative tool for guidance. Work on this by the author did not get past the planning stage, however a similar site distribution and evaluation project at Fort Hood, Texas employed characterisation and classification field survey results in a GRASS GIS (Williams, Limp & Briuer 1990). Another GRASS survey of stone cairns on the island of Hvar suggested, by their statistical relationship to agricultural good land, that they were clearance cairns; this is confirmed by excavation (Gaffney & Stančič 1991:60). The Manx System aims to provide a more general theoretical system rather than simply a restricted, albeit useful, aid to fieldwork.

A variation of this type, applied in the Arizona State database AZSITE, is called a "Red Flag Model": it compares sites with favourability zones to highlight anomalies for closer study and theory testing (Altschul 1990:231). A corollary of this is the investigation of the lack of appropriate sites in favourable areas, suggesting a degree of cultural selection otherwise not detectable: such a study of Bronze Age ritual sites on the isle of Mull has identified a preference for sites with astronomical and topographical orientations, suggesting new lines of enquiry not revealed by tradition fieldwork (Ruggles 1993).

14.12 SUMMARY

The Manx Information System's spatial and temporal capabilities have proved to be successful in integrating and enhancing a multi–purpose database. These attributes were incorporated into the data model at an early stage of its development several years ago before the author, in common with most archaeologists, was aware of the advantages of a GIS. While the author is an enthusiastic supporter of GIS, and will endeavour to explore and exploit their advantages, this experience has taught him an important lesson: while a GIS may support impressive single projects, it can not be simply linked to a conventional SMR in the expectation of automatically improved abilities. The key lies in an appropriate, well thought out data structure that will remain valid long after current GISs become obsolete: without a careful analysis of what added value a GIS will contribute, it will not only be a waste of money and time but may lead the SMR up a technological blind alley.

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