BOWLES GREEN LTD

Countryside Mapping Scoping Study

Consultants' Report

Commissioned by a partnership of:
- Forestry Commission Scotland
- Forestry Commission Wales
- Countryside Council Wales
- Scottish Natural Heritage
- Placematters

August 2008

CONTENTS

Steering Group:

- Bob Jones - Forestry Commission Scotland
- Steven Richards-Price - Forestry Commission Wales
- Carl Atkinson - Countryside Council Wales

Supported by:

- Sue Atkinson - Scottish Natural Heritage
- Aaron Lawton - Placematters

Prepared by:

Bowles Green Limited
Vale House
Oswaldkirk
York
YO62 5YH

Consultants:
Steve Green
Dr Tom Hartley
Robin Malton
Jan Erik Burger

Tel: 01439 788980
Fax: 01439 788423
Mobile: 07919 373294
E-mail: info@bowlesgreen.co.uk

August 2008

1 EXECUTIVE SUMMARY

1.1 This study was commissioned by agencies involved in providing mapping for countryside recreation as there appears to be a lack of conclusive evidence for the approaches currently being taken in producing maps for visitors.

1.2 The work consisted of a review of map types currently in use, a review of the scientific research and consultation with practitioners. Current practice was then compared to the scientific evidence in order to identify gaps in the knowledge and a programme of further actions for a second phase of work was proposed.

Scientific Research

1.3 Three areas of scientific research were identified – cognitive psychology, neuro-science and applied research. The applied research is the most relevant, but it also tends to be the least reliable, the result of the way in which it has been carried out.

1.4 Three independent but linked systems which take place in different parts of the brain are used to understand mapped information. These are:

- Landmark Knowledge – the ability to recognise individual landmarks and associate actions to them
- Route knowledge – the ability to join together a series of landmarks and actions in order to follow a specific route
- Survey Knowledge – the ability to understand the relative positions of different landmarks even if they cannot be seen, so that complex decisions can be made, for example calculating an alternative route if a way is blocked or taking a short cut

1.5 There are some differences in people's ability to understand and use maps. Women rely more on landmark knowledge than men and men rely more on survey knowledge than women. However, it is also true that not all men rely more on survey knowledge than women. Similarly, children, older people and people with less experience of visiting the countryside and of using maps seem to struggle with survey knowledge – i.e. reading a map.

Current Practice

1.6 There is general consistency in the approaches taken by the many organisations involved in the provision of mapping for outdoor recreation. Whilst the individuals who produce the maps are, in the main, experienced map readers, what they think and the approach they take generally conforms to the scientific knowledge.

1.7 However, there is a wide variation in the detail of map design for outdoor recreation and recognition amongst practitioners that they are doing what they think is right rather than what they know is right.

Conclusions

1.8 A wide range of map styles has been identified and these are described in terms of their treatment of relief, features and routes. It has also been possible to identify a typology of maps and language to enable accurate descriptions and efficient discussion in the future.

1.9 Comparison of the scientific research and the experience of practitioners has identified a number of areas where there is insufficient evidence to be certain that the approach being taken is effective, and further areas where there is no evidence at all.

1.10 The following programme of actions is recommended for Phase 2 of this initiative:

- Retaining the steering group
- Producing and resourcing a work programme
- Establishing a wider countryside mapping 'forum' to share and disseminate knowledge and experience between practitioners, cartographers, map publishers and businesses which provide new technologies
- Delivering a programme of research consisting of:
    - Testing the effectiveness of different map types in the field
    - Enabling visitors to produce a map to a design of their choice and testing its effectiveness
    - Testing the effectiveness of route profiles in helping people to make route choices
    - Testing the impact of alignment on the effectiveness of interpretive maps
    - Consulting providers of maps for mountain bikers and consulting mountain bikers to test current assumptions in providing maps for this group
    - Scoping the use of new technologies, understanding how effective these are and providing advice for practitioners
    - Testing the effectiveness of different styles of interpretive maps
- Producing and disseminating best practice for practitioners

INTRODUCTION

2.1 A wide variety of UK government agencies, local authorities, charitable trusts and private companies currently provide or manage outdoor access and recreation. These are tasked with encouraging take-up of walking, cycling and horse-riding opportunities, or provide visitors with interpretation to aid understanding of the environment and the landscapes that they find themselves within.

2.2 A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

2.3 At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above. There is also little by way of a knowledge base on best options (for example the pros & cons of different approaches) and what constitutes good practice.

2.4 This study has been commissioned by a partnership including the Countryside Council for Wales (CCW), Forestry Commission Scotland (FCS), Forestry Commission Wales (FCW) and Scottish Natural Heritage (SNH) in association with other agencies to:

- Catalogue and verify existing knowledge
- Identify what currently constitutes best practice
- Define specific research objectives and needs (i.e. phase 2 works)
- Prepare the brief(s) for phase 2 research project works
- Help inform funding bids

3 TYPOLOGY OF MAPS FOR OUTDOOR RECREATION

3.1 Reviewing the main types of countryside recreation maps, they can be seen to fall into the following categories:

- Flat 2-dimensional 'plan' maps
- Panoramas and oblique illustrations
- Aerial photography
- Specialist maps

Flat 2-Dimensional Maps

3.2 These are usually O/S based and show landscape and features symbolically as if viewed from directly above. There is considerable variation in scale and the treatment of relief, vegetation, routes and features. They are used most frequently when navigation is the primary purpose. They can also be liable to significant copyright charges (particularly if OS-based data is involved).

Panoramas and Oblique Illustrations

3.3 These maps are illustrations of an area drawn as if viewed from above, from an oblique angle. A variety of styles is used, determined by the nature of the site mapped and the purpose of the map. They appear to be used most commonly where orientation or interpretation is the main purpose.

Aerial Photography

3.4 Aerial photographs are increasingly available, but not yet commonly used by countryside recreation managers. Where they are used they are often provided in addition to flat maps, to provide an understanding of scale, topography, terrain, etc.

Specialist Maps

3.5 In addition, specialist maps are provided to meet the needs of particular users – for example orienteers, mountain bikers, people with sensory or physical disabilities, climbers – or to convey information for particular purposes – for example consulting on planning proposals, forest design proposals, etc. These might use one of the three styles described above with additional information or with information deleted.

3.6 When looking at these four types, various overlying categories or characteristics were sought to build a typology, which would present the range of choices available to a cartographer in a practical and useful way.

3.7 Whilst reviewing and analysing types of mapping three key characteristics were identified – depiction of relief, features and routes. For each of these, there appears to be a progression or continuum from symbolic to pictorial. In reality there is a wide range of styles, but they can all be located on these continuums. The illustrations below illustrate this.

Depiction of Relief:

3.8 Relief is the hardest challenge for cartographers producing maps for users with a range of map reading skills. It is judged to be the single issue which is most likely to confuse route finding when information is presented in an inappropriate way. Examples range from almost whimsical and artistically pictorial through differing technical and accurate methods to photo realistic.

Depiction of Features and Other Information for Users:

3.9 Various methods are presented for conveying relevant information to assist in route planning, finding facilities and features and keeping on trail. Examples range from the use of keys and standardised symbols, to mixed methods and pictorial.

Indication of Route:

3.10 A route can only be meaningfully conveyed on a map in relation to the terrain and features the route passes through. To a great extent, therefore, it borrows from the other two continuums. As route finding is likely to be the primary purpose of maps produced by authorities and organisations it has warranted its own continuum. Although the actual route is rarely more than a colour coded line it is how that relates to the mapping style, cartographical techniques and interactive methods which differentiates the route style.

New Technology

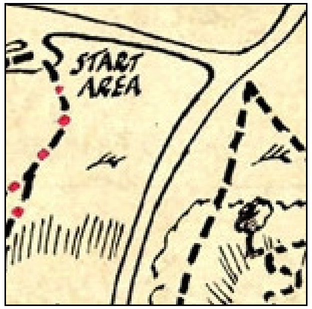
3.11 A variety of forms of electronic mapping and methods of supplying maps have come into common usage in recent years. These are summarised below:

- Maps of countryside sites and routes available as downloads (usually in PDF format) from the websites of recreation managing organisations
- Ordnance Survey and other kinds of mapping available on CD-OM
- Hand held GPS units which can be linked to digital mapping to carry route finding as well as positioning information
- Car mounted satellite navigation systems
- Hand held satellite navigation systems
- Aerial mapping, flat plan mapping and 'hybrid' mapping viewable on and downloadable from the internet
- MP3 technology which enables route descriptions to be downloaded to handheld music-playing devices
- 3G mobile telephones with large screens and internet connection which allow access to mapping websites

3.12 The technology continues to develop apace. Systems currently close to launch include those that enable digital photographic imagery and mapping to be linked so that the user can view real images from any given location, assuming they have been added by people who have been there and taken digital images. An example is Microsoft Photosynth (see www.labs.live/photosynth).

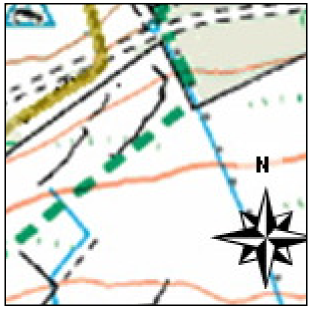
FIRST CONTINUUM – DEPICTION OF RELIEF

Artistic methods through drawing, shading, contours to photo-realistic

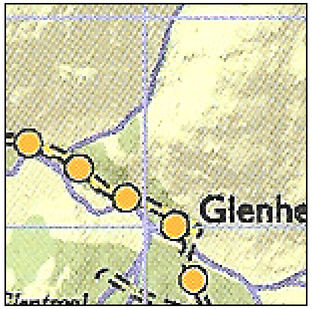


1.1

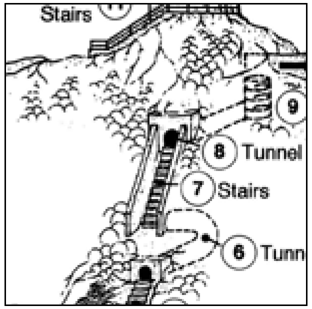
1.2



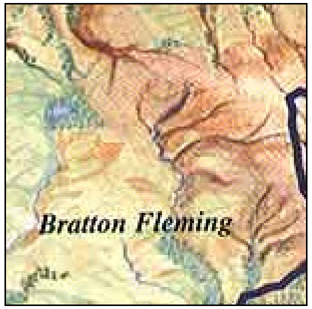
1.3


1.4

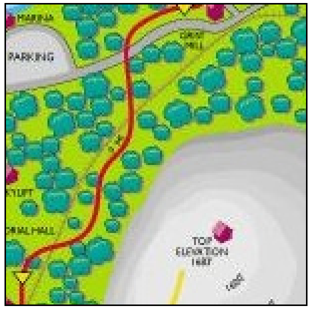
1.5



1.6



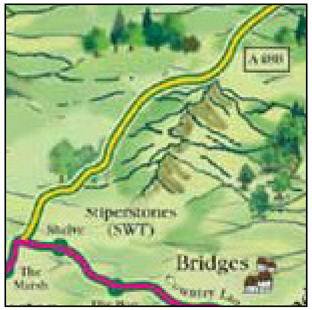
1.7



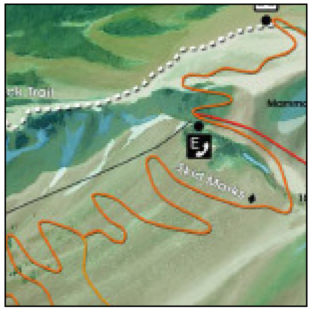
1.8

1.9

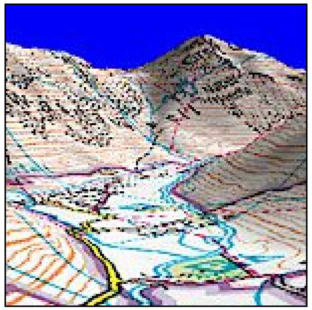

1.10



1.11


1.12

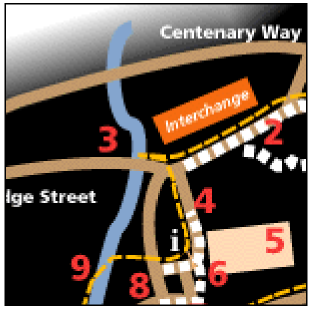
1.13


1.14

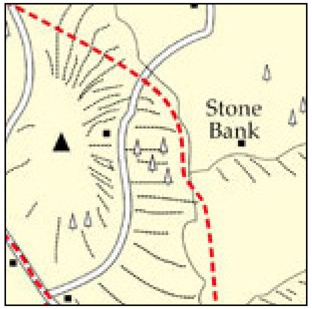
1.15

SECOND CONTINUUM – DEPICTION OF FEATURES

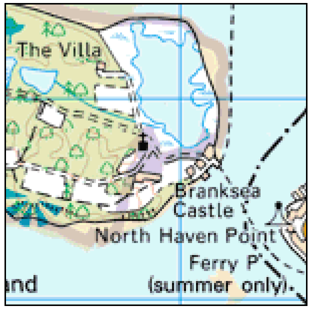
Use of keys and symbols, through mixed methods to representations



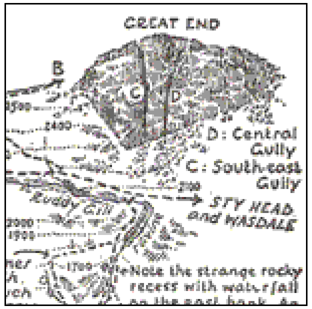
2.1



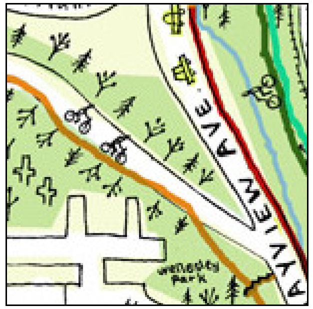
2.2



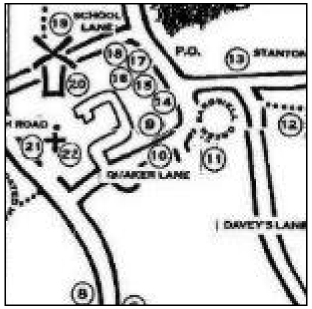
2.3



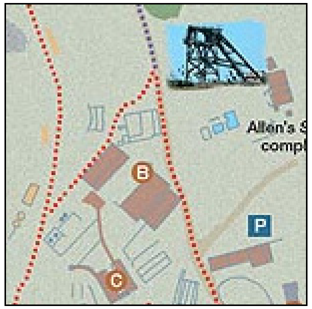
2.4



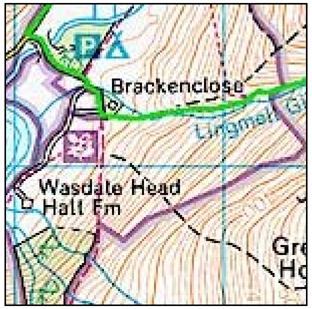
2.5



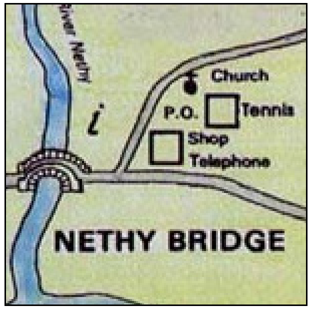
2.6



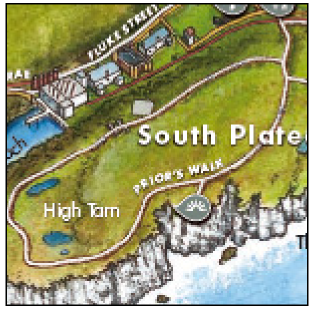
2.7



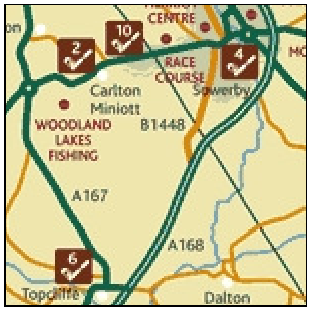
2.8



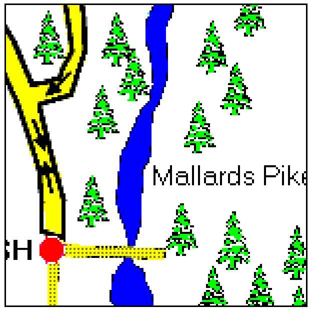
2.9



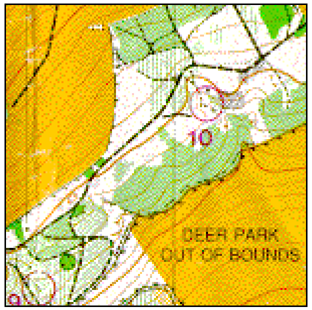
2.10



2.11

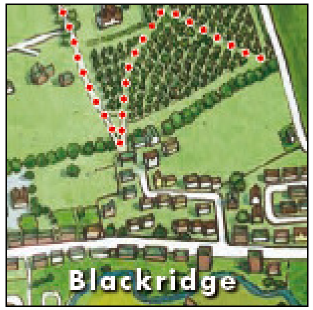


2.12



2.13

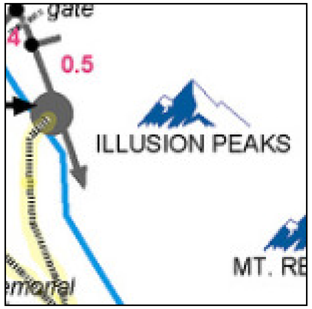
2.14



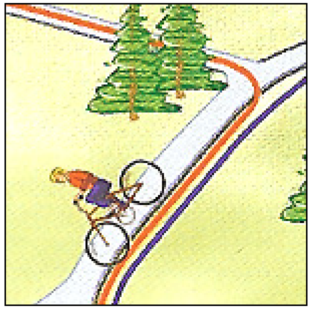
2.15

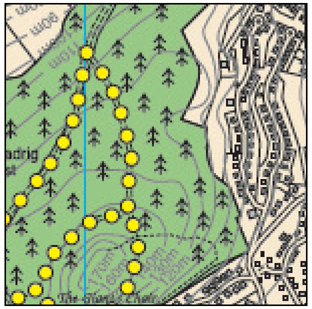
THIRD CONTINUUM – INDICATION OF ROUTE

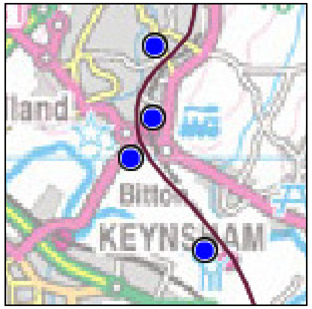
Use of waypoints, lines and interactive web-based methods

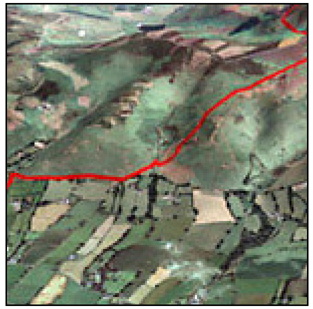


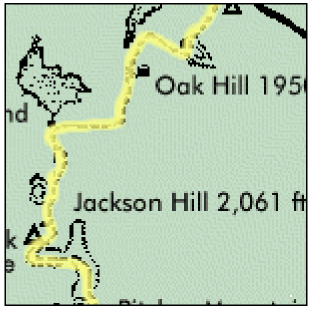
3.1


3.2


3.3

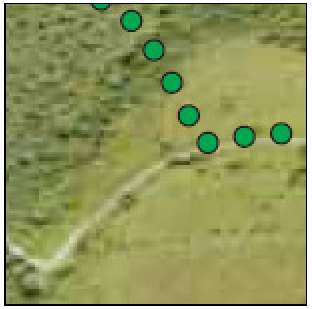

3.4


3.5



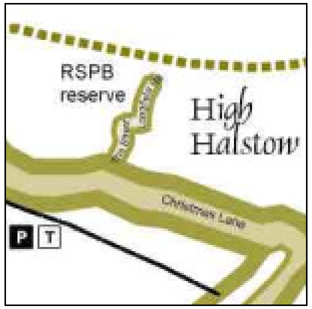
3.6


3.7


3.8

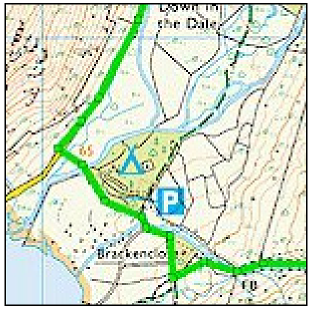
3.9

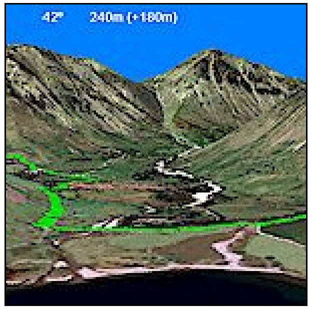

3.10



3.11

3.12


3.13



3.14

3.15

3.13 It has been suggested that there is a need to develop an agreed language for describing different kinds of mapping and map features. The following has been offered by Aaron Lawton of Place Matters and appears to be consistent with the consultation findings:

Map Language

- Symbolic – symbolic representation of physical relief and features, and of conceptual features (e.g. routes or refreshments)
- Pictorial – pictorial representation of physical relief and features

Map Type

- Flat 2-dimensional plan – symbolic plan view showing features and routes (e.g. bus map)
- Topographic – symbolic plan view showing features, routes and relief (e.g. contour, layer tinted or relief shaded map)
- 3D Projection – pictorial plan view with 3D projection of features (e.g. most pictorial town plans)
- 3D Perspective – pictorial 3-D perspective view (e.g. any panorama with a horizon)
- Schematic – representation not based on true plan or perspective view (e.g. tube map or route profile)

Visualisation Technique

- Photographic (e.g. aerial photograph or satellite image)
- Hand drawn (e.g. line or continuous tone image produced by hand)
- Computer aided (e.g. vector line and continuous tone output from illustration software)
- Computer generated (e.g. vector line output from GIS software)

Function

- Mental modelling
- Orientation
- Navigation
- Interpretation

Activity

- Walking
- Climbing
- Cycling
- Mountain biking
- Interpreting

Experience

- Familiar with site/route
- Competent and motivated map reader
- Non-competent or non-motivated map reader

4 PRACTITIONERS' EXPERIENCE

4.1 Much of the existing knowledge on the effectiveness of mapping for countryside recreation is held in the heads of practitioners. The findings of a series of telephone interviews with a range of practitioners in England, Scotland and Wales are summarised in this section.

Recreation Managers Use Mapping for a Variety of Purposes

4.2 Maps for countryside recreation are used for a variety of purposes including the following:

- To promote access
- To help people to navigate around a site
- To interpret a site
- To help people to enjoy the countryside
- To communicate development plans
- To inform visitors of health and safety issues
- For corporate and other communications (to provide information on the countryside, to promote the Scottish Outdoor Access Code, etc)

4.3 People who commission and design maps understand that different styles of mapping suit different purposes, however, knowledge and experience of what individuals believe works is not generally shared widely. Also, little or no evaluation of the success or otherwise of techniques and styles has been conducted.

Recreation Managers Have a Different Understanding to Visitors

4.4 People who produce maps for countryside recreation are, in the main experienced map readers. This is in stark contrast to the map-reading ability of most people who use the maps they produce. As a consequence, recreation managers commonly make assumptions about the mapping needs of visitors which are not appropriate to the users' map reading abilities, for example:

- There is an assumption that people can understand a map
- There is an assumption that people want a map

4.5 A map can make perfect sense to the person who has drawn/published it but it can be difficult to understand or even meaningless to users. Recreation managers rarely ask what the audience wants before they produce a map and once a map has been produced; its effectiveness is rarely monitored.

Demand

4.6 Recreation managers are aware that there is a wide range in visitors' ability to read a map and different kinds of users need different information. Users of mapping in the countryside appear to fall into the following categories:

- *Social/gentle Recreationalists* – the majority of visitors to managed sites or landscapes, especially in the lowlands and at the most-visited sites seek a gentle recreation and social experience with family or friends. Those who are not familiar enough with the site to have memorised their route need to be able to navigate around it without having to stop frequently to consult a map and to know where facilities for visitors are. They are also interested in learning something about the site – its significance, its natural and cultural heritage and so often there is a need to incorporate interpretation onto maps of countryside sites.

- *Serious Recreationalists* – experienced walkers, cyclists, etc bring their own (usually O/S) map with them and are competent at using a map and compass to navigate and to understand the landscape. Most would not seek additional help, though at complex sites, information is sometimes required to find the selected route out.

- *Mountain Bikers* – those visiting mountain biking 'trailheads' are usually following specially-designed, single track routes. These are easy to follow and a map is not generally needed for navigating along the route. However mountain bikers need to know where they are on a route (for example to facilitate speedy evacuation of an injured rider in case of an emergency), to find short cuts if they need them and use a map when discussing the route afterwards.

- *People with Disabilities* – people with physical and sensory disabilities and their helpers require more information to plan a trip than general visitors, including the availability of specific facilities for people with a variety of disabilities, surface type, the width of paths and gates, slopes, location of shelters, etc.

- *Special Interests* – some people require specific information to help them pursue a particular activity or interest, for example location and grade of climbing routes, location of natural and cultural heritage features, etc.

- *Knowledge seekers* – those seeking to understand a place and what went on there.

4.7 Other aspects can also affect people's willingness and ability to use a map, for example people who wear glasses find map reading awkward, and wind and rain can make map reading difficult.

4.8 Providing information for people with disabilities can make a map over complicated and render it difficult or impossible to read. SNH have managed this by limiting provision of information for people with disabilities to its nominated 'access for all' routes

Map Styles

4.9 Recreation managers use a wide variety of styles for maps; there is some consensus, or at least common practice about style, as follows:

- Flat 2-dimensional plan view maps are most effective for navigation
- Three-dimensional illustrations (usually drawn from an oblique angle) are most effective for interpretation and landscape appreciation

4.10 Relief presents a particular difficulty as few non-expert map readers can understand relief presented as contour lines. One approach is to use darker shading to denote higher ground; this is commonly used in atlases, and appears to be understood by the majority of users, though this assumption is only anecdotal.

4.11 The use of colour was felt to be important. Green is commonly understood to indicate woodland and blue to indicate water. The situation can become challenging where there is a need to portray relief and woodland on the same map.

4.12 There were differing opinions in regard to the use of symbols. Some practitioners prefer to use drawings of buildings or features whilst others prefer symbols (usually choosing widely used symbols, such as a letter P for car park, a man and woman symbol for toilets, etc.

4.13 It was widely felt that the number of colours and the number of symbols used should be kept to a minimum to avoid over complicating the map.

4.14 Oblique views work well for relatively flat sites or sites occupying a slope which faces broadly in the same direction. However, they work less well where there is high relief. For example an SNH map of Corrie Fee in the Angus Glens which is drawn from a 45-50º angle shows what the site looks like really well but because it has distorted the terrain, it is poor for navigation. Oblique views have problems with large objects in the foreground, which obscure the view and with complex sites which have areas which are hidden behind ridges or intermediate high ground.

4.15 The Cairngorm National Park Authority has had a positive reaction to five panoramas it has produced. These are to be located at the main entrance points to the Park and show it from the perspective of the viewer at each entrance. Their purpose is to give visitors an appreciation of the extent and nature of the National Park. Since they are not used for navigation, distortion is less of an issue.

4.16 Route profiles, which show the rise and fall of the route in a single line are common in the USA and in Europe, but are little-used in the UK. They can be helpful for deciding whether to choose a particular walk and for understanding difficulty, but since different scales are used, they can be misunderstood.

What to Include on a Map

4.17 Most practitioners consulted were of the opinion that maps should only contain information necessary to achieve their purpose. In addition, the following were commonly used, but sometimes omitted:

- Scale – or an indication of how long it will take to reach different points
- Legend – which explain symbols, colours, etc
- Mini 'locator' map – showing the location of the site on a smaller-scale map covering a wider area

4.18 What is included on a map depends on what the intended users require. Some maps are produced for specific types of user, for example maps of single track mountain bike routes. Forestry Commission Wales found that users of these maps require very little information as the routes are designed to be easy to follow. Maps produced had minimal information – the line of the route, location of numbered posts in case of emergency and the names of the different route sections, which were helpful when talking about the route afterwards. Following discussion with users, linking forest tracks, which could form short cuts or emergency routes out were added. This information is, however, anecdotal and knowledge could benefit from wider testing of this approach.

Education

4.19 In the National Curriculum, map reading skills (using OS maps) are specifically mentioned in recommended guidance on schemes of work at Key Stage 3 for Year 7 pupils. All school age children get some educational experience at this point. Ordnance Survey has made available free OS Explorer Maps for Year 7 pupils, with more than 700,000 maps distributed across Great Britain each year. The map becomes the pupil's personal property for use at home as well as school. A potential 3.8 million could have benefited by having a map of their own to keep.

4.20 A study carried out for the initial year of the OS scheme, shows that:

- Children who go out and about in rural areas are more likely to become better map readers than those in urban areas
- The mapping skills of pupils in inner urban schools were significantly more limited than those attending schools in rural areas
- Pupils who walk or cycle to school tended to have significantly higher standards of map-reading skills than those driven on the home-school run
- Children who travelled more widely in their neighbourhoods by walking or cycling became more aware of their surroundings and so may go on to develop better map skills

4.21 OS research found that the free maps scheme is having an impact on the children who participated. Since the launch of the initiative:

- The number of pupils confident in their understanding of maps has doubled
- The number of pupils who enjoy using maps has trebled
- The proportion of children who perceive maps as important has doubled.

4.22 At A level a relatively high level of map reading skills is developed in a theoretical way as students use maps for a variety of purposes. They do not, however, specifically develop further navigational skills.

4.23 Overall, the number of school pupils studying geography (and therefore developing higher map reading skills) is falling. Geography remains in the top ten most popular subjects studied at GCSE, but numbers are falling. Last year (2007) 213,124 students sat the subject at GCSE, but this represented an 11 per cent fall on 2003. At A level, the number of students has also fallen by more than 11 per cent, to 31,653 over the same period. In addition, OFSTED reported recently that there has been a massive decline in opportunities for fieldwork and trips at all levels.

4.24 Other youth organisations active in the outdoors – Scouts Association, Duke of Edinburgh's Award scheme, Army Cadets principally, all develop navigation skills using OS maps.

4.25 OS maps are the de facto standard used in the development of map reading and navigation skills for young people in education in the UK, though the percentage who achieve any degree of competence is small. It also does not mean that the OS format is necessarily the best format for use by the population as a whole or even by young people – just that it is widely available.

Technology

4.26 Rapid changes have occurred in technology in the last 5-10 years, including:

- Mapping and aerial photography available electronically on CD-ROMs and on the internet
- Electronic mapping working in conjunction with hand-held GPS units
- Mobile telephones with internet access
- Mobile telephones with GPS
- Satellite navigation systems

4.27 One consequence of the proliferation of satellite navigation devices is that people increasingly use postcodes as a means of locating a particular place. Postcode references are more widely available and easier for people to use than grid references.

4.28 Many recreation planners and managers are unfamiliar with, or at least not regular users of these new technologies, whilst a growing proportion of the public, especially younger people, use them frequently. An increasing number of organisations now provide route maps as downloadable files on their websites and some have experimented with providing mapping for outdoor recreation using new technology. However, for most recreation managers this area is one they do not fully understand and an area where guidance is required. Many recreation planners think new technology is a serious threat to map reading, however, it is also a significant opportunity.

4.29 Whilst providing maps as downloadable files is cheaper than printing them, doing this as an alternative to producing and distributing printed maps will exclude some groups (older people, less well-off people, people with learning difficulties, etc). Some useful guidance is available on the provision of downloadable maps, as follows:

- Ensure a quick download
- Remember most people's printers take A4 paper
- Users' printers might be of poorer quality than the ones you are used to so keep mapping simple

5. WHAT THE SCIENTIFIC RESEARCH TELLS US

5.1 Understanding and effectiveness of maps has been examined in psychological, neuroscientific and applied research projects and it is possible to draw a number of conclusions from this.

5.2 What is known about how the brain processes and stores mapped information is described in detail in Appendix 1. In summary, three systems appear to be used, in different parts of the brain as summarised below and in Figure 1.

- *Landmark Knowledge*

  Landmark knowledge concerns the identity of objects within an environment, especially those that will be significant for navigation e.g., salient objects near to junctions or decision points. People can list such landmarks, and reliably produce similar lists

- *Route Knowledge*

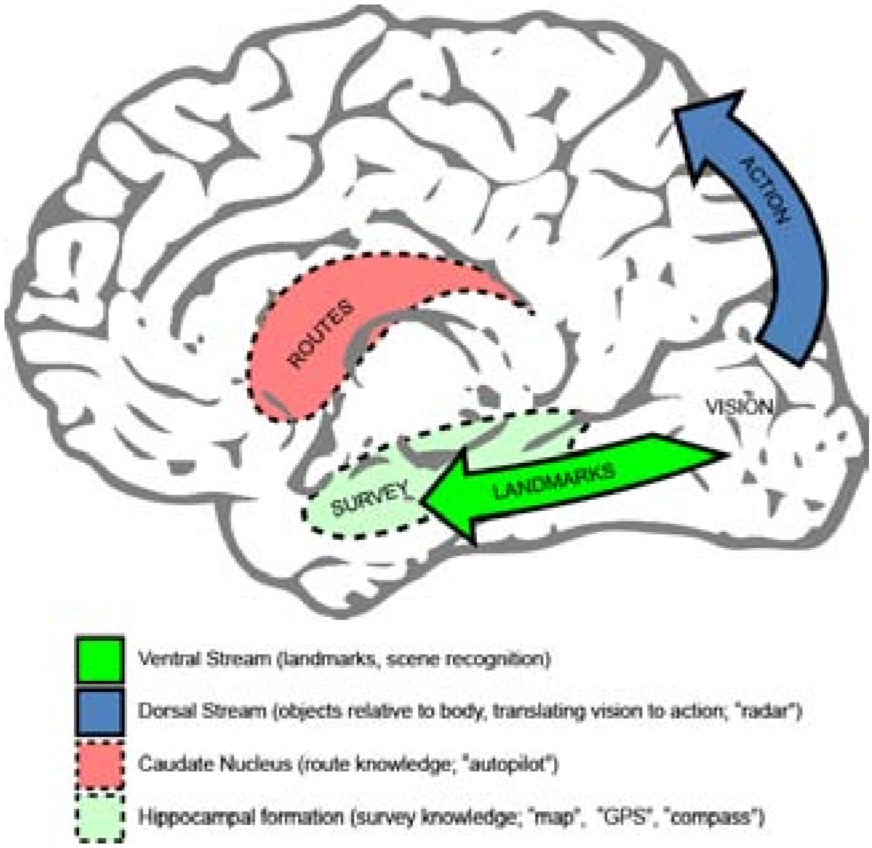
  This form of knowledge (i.e., knowing what is out there) provides the basis for development of procedural knowledge about routes (e.g., knowing how to get from A to B). In this view, initially isolated landmark representations are thought to be linked to form route representations

- *Survey Knowledge*

  Further accumulation and integration of spatial knowledge permits the development of survey knowledge, a more abstract type of representation that includes information about the configuration of elements within the environment, their distances and directions from one another. This understanding is analogous to a map, permitting reasoning about possible alternative routes, directions, scenes that would be perceived from a different viewpoint and so on.

5.3 What is known about the differences in the way different people understand and use maps is described below.

Figure 1: Location of Brain Systems



Individual Differences

Sex Differences

5.4 Differences in spatial ability are reportedly amongst the most reliable gender differences seen in cognition (Lawton & Morrin, 1999). However, it should be noted at the outset that these differences are only seen in the comparison of large groups; individual men and women vary greatly in their performance of different spatial tasks. Nonetheless, on average men outperform women on a variety of spatial tasks relevant to wayfinding (Coluccia & Louse, 2004) and women report having a poorer sense of direction than men (Kozlowski & Bryant, 1977) and make more use of landmark based strategies (Lawton & Morrin, 1999). Collucia and Louse reviewed 27 studies carried out between 1983 and 2003. While a substantial proportion did not show statistically significant sex differences, where they were seen they almost always favoured men.

5.5 As we have seen, complex spatial abilities such as navigation depend on the interaction of a number of distinct brain systems for spatial representation and processing. The underlying causes of the observed sex differences are unclear (cultural or evolutionary factors may play a role), but they can be interpreted in terms of differences in the capacity or use of these systems. For instance, men outperform women on tests of visual spatial working memory (Richardson, 1991) and mental rotation (e.g., in 286 experiments reviewed in Voyer, Voyer & Bryden, 1995). In addition, it appears women's use of landmark-based strategies (Lawton & Morrin, 1999) does not fully exploit survey knowledge.

5.6 Interestingly, the male advantage is somewhat less reliable in map-based tasks (Coluccia & Louse, 2004). This might indicate that sex differences are mitigated by the provision of maps, but it should be interpreted with caution; men reliably outperform women on real-world navigation, e.g., orienteering tasks (Malinowski & Gillespie, 2001), so it may be that women are more proficient in abstract map-based tasks (such as estimating distances based on information provided on a map) than in transferring this understanding to concrete real-world problems. One possibility is that women benefit more from the provision of map-based information, but find it harder to relate to their experience of the environment, perhaps because of their reliance on landmark based strategies.

5.7 Because users who have a relatively poor sense of orientation may be reliant on landmark knowledge they are likely to favour information presented in a non-mapped form (i.e., verbal route descriptions using left-right directions rather than North-South, photographs or drawings of salient objects along a path). Mapping might be made more accessible to these users by linking such material to the relevant locations on the map.

Anxiety

5.8 Women report higher levels of spatial anxiety (anxiety about becoming lost) than men (Lawton & Morrin, 1999) – this anxiety may discourage them from exploring the environment fully, which in turn may lead to relatively impoverished survey knowledge. When animals explore a new environment, they tend to follow the bounding edges of the environment, a pattern of behaviour called thigmotaxis. One recent study using an indoor task showed that levels of trait anxiety (i.e., individuals' stable tendency to be anxious) predicted thigmotaxis in humans (Kallai et al., 2007). In an outdoor environment the boundaries of the environment are less clearly defined, but this result suggests that mapping and other forms of support for orientation (e.g., marker trails) should be accessible from the edges of open areas, near to entrance points.

Changes over the lifespan

5.9 The ability to understand space is thought to change over lifespan. Early studies indicated that young children were not able to imagine the world as it would be seen from a different perspective (e.g., Piaget & Inhelder, 1956). This type of task was thought to require a map-like internal representation of space, which was thought to develop later in life. Current evidence suggests a more complicated picture in which the distinct spatial representational systems appear to develop at different rates (Nardini, Burgess, Breckenridge, & Atkinson, 2006), with an early emphasis on dorsal stream processes (relating locations to the body) and later development of ventral stream processes, including use of landmark information.

5.10 Though there is some indication of a rudimentary cognitive map, even at a young age (Newcombe, Huttenlocher, & Learmonth, 1999), children apparently have problems reconciling different forms of spatial representation to guide coherent behaviour. For example, when disorientated they are prone to overlook potentially useful visual landmarks (Hermer & Spelke, 1994) and are less proficient than adults at integrating information from different sources (e.g., self motion, visual landmarks) (Nardini, Jones, Bedford, & Braddick, 2008). Such developmental trends are typically measurable in simple laboratory tasks over the ages of 3-6 years, but it seems plausible that they have a longer-term impact on the development of more advanced and complex spatial skills.

5.11 Whilst children may be expected to have difficulty integrating information drawn from different sources, and because dorsal representations are dominant in early development, they are likely to favour information presented in a form which is aligned with their current heading. However, understanding simple maps does not appear to pose particular difficulties for children; one study showed that a congenitally blind 4 year old could read and use a tactile map and use the information appropriately despite having had no prior experience (Landau, 1986).

5.12 Although less extensively investigated, there are signs of a decline in spatial ability as we grow old. This appears to affect allocentric (map-like) representational systems (see e.g., Rubin, Attewell, Tierney & Tupelo, 1972; Evans, 1980; Desrocher & Smith, 1998; McDonald & Hamilton, 2002; Inagaki et al, 2002) seeming to reverse the trend seen in childhood. As aging, leads to a decline in the ability to encode spatial relations based on direct experience, older adults are likely to benefit more from provision in the form of maps.

Familiarity and Expertise

5.13 There is abundant evidence from psychological studies that familiarity and expertise with a particular type of information leads to changes in the way it is represented, with potential advantages for memory and processing. The classic example is chess positions; skilled chess players are better than novices at recognizing a pattern of chess pieces on the board, but this advantage only obtains for real positions (i.e., positions that could occur in the context of a game). The explanation is that experts are able to identify functionally meaningful patterns, and that this enables them to encode the information more efficiently.

5.14 Similar findings have been found in a variety of different expertise domains, including outdoor pursuits. For example, experienced hikers recognize mountain scenes better than novices where those scenes contain information relevant to navigational decisions and hazards (Kawamura, Suzuki & Morikawa 2007). Such expertise effects extend to map reading, where the provision of relief information becomes particularly significant; Gilhooly and colleagues (Gilhooly, Wood, Kinnear, & Green, 1988) found that skilled map readers had better memory for information presented in contour maps than novices, and that there was no such advantage for planimetric (flat plan) maps, suggesting that skilled map readers exploit familiar and meaningful topographical patterns to commit aspects of a new map efficiently to memory (Ormrod, Ormrod, Wagner, & McCallin).

5.15 Thorndyke and Stasz (1980) found large individual differences in the way people learned from maps (with performance ranging from 100% through to 19% on their tasks). Although they did not observe an expertise effect (presumably because they used maps without relief information), they found good and poor learners differed in three ways - allocation of attention, encoding strategies and evaluation. In general experts are likely to be able to recognize and use task-relevant information presented in maps better than novices. .

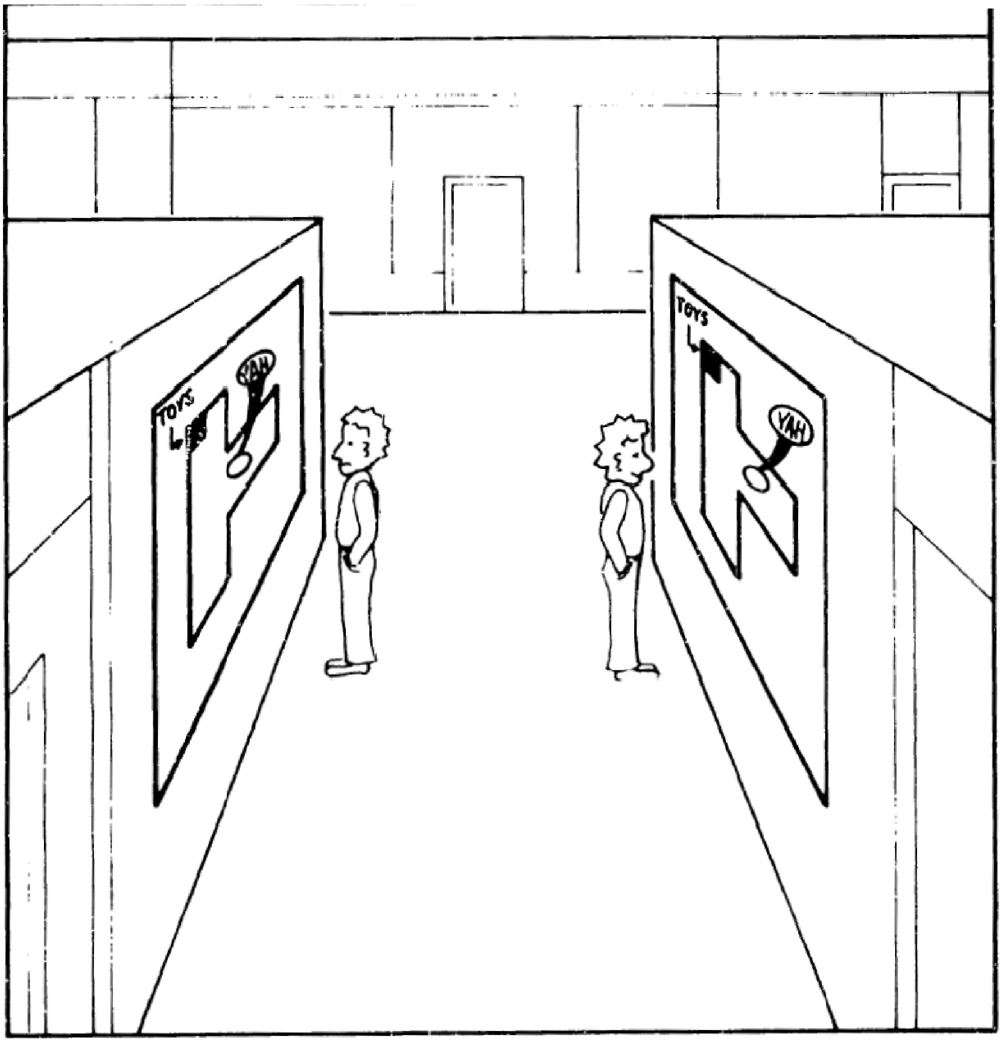
Applied Research

5.16 As outlined above, it appears people and animals have their own internal representation of the spatial world. This internal cognitive map can be learned either through direct experience with the environment, or indirectly through reading a map. Thorndyke and Hayes-Roth (1982) compared the performance of people who either worked in a building with others who learned about its layout from a map, finding that individuals who had gained their understanding of the spatial structure of the building from first-hand experience were better at route distance and direction judgements, while map-learners were better at estimating straight line distances and marking locations.

5.17 Maps vary in the degree to which they communicate different types of information. Schematic maps may be reduced to the bare minimum required to solve a particular task, with other forms of information being eliminated or distorted to accommodate this aim. At the opposite end of the spectrum, aerial photography can provide some of the information required of a map and is not restricted to one use, but this veridical information is hard to interpret; maps typically add additional symbolic information and remove non-essential information, but the selection of which information to include, to add and to leave out will depend to some degree on the cartographer's purpose.

5.18 A famous example of a schematic map would be the London Underground map designed by Harry Beck in 1933, in which information is limited to the names of stations, identity of lines and location of interchanges. Some sense of orientation is preserved with North being up, and the river Thames represented as a zig-zag line, but other spatial properties have been distorted, drastically in places to allow for easier route planning. Bartram (Bartram, 1980) compared similarly schematic maps with conventional road maps and with verbal lists in a task where subjects had to plan a bus journey, showing an advantage for maps in general, and for schematized maps in particular. However, schematized maps will not be as well suited for other tasks (such as distance estimation) which rely on information which has been removed or distorted. There is clearly a tension here in that one of the great advantages of maps is their flexibility, but this must be balanced against the possibility of optimizing a map for a given task.

Figure 2: Map Alignment



Reproduced from (Levine, Marchon & Hanley, 1984). Map alignment matters just as you would expect – it will be easier for the person on the right to find the toyshop

5.19 The phenomenon of map alignment is illustrated in Figure 2 above, reproduced from Levine et al (1984). An effective You-Are-Here map needs to be correctly aligned with the environment in which it is placed, so that forward corresponds with up. In this configuration a destination to the left of the observer will appear on the left of the map. There are significant costs associated with the mental rotation required to interpret information in a misaligned map (Evans & Pezdek, 1980) and more errors are made (Rossano & Warren, 1989). As one might expect, individuals whose performance on mental rotation (disproportionately female: Voyer, Voyer & Bryden, 1995) is relatively poor and particularly susceptible to alignment effects (Pazzaglia & De Beni, 2006).

5.20 The alignment effect has been extensively investigated and is a very robust and reliable phenomenon (e.g., Levine 1984; Presson & Hazelrigg 1984; Evans & Pezdek, 1980) which seems to be apparent whenever spatial information is derived from a map rather than direct experience. Where maps have a fixed location they should thus be aligned with the environment so that *ahead* corresponds to *up* wherever practical. This may mean making different fixed maps for different locations around the same site, but misaligned maps may be worse than useless.

5.21 From the alignment effect it seems that information gleaned through map reading is sometimes stored and represented in an image-like, orientation-specific form (Kulhavy, Schwartz, & Shaha, 1983; Presson & Hazelrigg, 1984), but this does not appear to be the case for internal representations based on direct experience in the environment (Sholl & Nolin, 1997). When learning from a map, memories are also distorted; elements are remembered as being better aligned to the major axes of the reference frame (e.g., determined by the orientation of the map; Tversky 1981). Yet some memory distortions are not compatible with a simple image-based explanation. For example, distances *to* landmark locations (from ordinary locations) are underestimated compared with distances *from* the same locations (McNamara & Diwadkar, 1997).

5.22 As noted above, landmarks provide an important contribution to spatial knowledge. A good deal of research (Lynch 1960; Appleyard 1969; Evans, Smith & Pezdek, 1982) has been done into key properties of manmade features in the context of the urban environment. It is even possible to specify equations to determine which features are most likely to be useful as landmarks (Raubal & Winter, 2002) and which could be useful in selecting features for inclusion in a map. However, much less research has been conducted on what constitutes a landmark in the rural environment.

5.23 It must be assumed however, that relief information is particularly important with topographical features providing some of the most salient features in a landscape with relatively sparse manmade cues to orientation (Cross, Rugge & Thorndyke, 1982). Unfortunately, relief is hard to convey in an intuitive manner and the correct interpretation of maps depends on specific training and experience (Malinowski & Gillespie, 2001). Accordingly, Sholl and Egeth, (1982) report widely varying individual performance in the interpretation of relief, and suggest principled methods for investigating this: the Relief Format Assessment Test (Potash, Farrell & Jeffery, 1978). One study reports that experts tend to focus on large scale features, using this to gradually home in on their current location, while novices look for small terrain features in an attempt (often unsuccessful) to pinpoint their position. Neither group is skilled at visualizing the real-world appearance of relief in a contour map, but experts tend to use strategies that are less sensitive to this problem (Cross, Rugge & Thorndyke, 1982).

5.24 Relief information can be conveyed in a variety of ways – for instance using tinted layers, contours, shading (as if obliquely illuminated), using numbers to represent local altitude, or combinations of these. One study (Philips, De Lucia & Skelton, 1975) investigated which form of relief information was most useful, finding that the answer depended on the task at hand. Tinted layers were found to be the most useful in visualizing the landscape, an important property for navigation, but other forms of relief representation were found to be more useful in other tasks such as judging absolute height. In interpreting tinted layers, the colour scheme chosen may be significant (Philips, 1982). Philips et al. (1975) estimate that provision of the optimal form of relief information could lead to a fifty percent performance advantage compared to the least appropriate form.

5.25 The generation of arbitrary oblique views of a landscape became feasible with developments in computer technology. Oblique views might be thought to interpret relief information effectively via pictorial cues. However, an early study suggests that, despite their intuitive appeal, oblique views may be harder to interpret than overhead views using contours or layers to convey relief (Phillips & Noyes, 1978). This may be because the oblique map is associated with a particular point of view, making it harder to visualize the landscape as it would appear from one's own perspective – that is, oblique maps may be subject to alignment effects (Warren, 1994). Another potential problem with oblique maps is the potential for occlusion of low features in one area by tall features in another.

5.26 Other details of map construction have been investigated in terms of their influence on behaviour. For example Devlin & Bernstein (1997) looked for effects of colour, level of detail and labelling strategy (using a separate key or directly marking locations on the map), finding that interactive wayfinding was improved where labels were placed directly on the map. Phillips (Phillips, Noyes & Audley, 1977) makes recommendations on the size, weight and such labels, based on an ergonomic study of 256 subjects performance in a range of tasks that involved finding and copying place names presented on maps. For example, lower case fonts with initial capital letters are recommended, while font size should be carefully chosen to maximize legibility (larger being better) while avoiding excessive clutter. As a compromise, more significant locations are often labelled in larger type. Bold type is not found to aid readability (though clearly it may have advantages for partially sighted users who were not considered in this study).

Conclusions

5.27 The basic science of spatial cognition has advanced quite considerably with the advent of neuroscientific methods. We now know a great deal more about the way spatial information is represented in the brain. There are multiple forms of representation, each more useful for some tasks than others. The different systems can potentially conflict with one another, and different individuals will be biased toward use of one or other system, producing wide variations in levels of performance on spatial tasks.

5.38 Different people need different things from maps. All users will benefit from the provision of maps, but women, children and elderly people are particularly likely to require the supplementary information they provide on landmarks as they particularly rely on landmarks to navigate. They report having poorer sense of direction. Spatial anxiety (anxiety about getting lost) affects women more than men. Women perform less well on mental rotation tasks, a sensitive index of the ability to imagine and manipulate spatial information. Further research should be conducted to determine whether this prevents them from fully enjoying outdoor recreation. If so, this is likely to be an area in which improved mapping and steps to enhance users' sense of direction will lead to a substantial improvement of their experience of countryside pursuits.

5.29 The environment itself plays a big part in maintaining our sense of direction (think of the disorientation one experiences in a hall of mirrors, for instance). In natural situations, we are all capable of developing an internal map through our everyday experience at ground level – this type of representation is a great advantage for a variety of tasks that involve planning or following new routes. To speed the acquisition of this form of spatial knowledge, all users are likely to benefit from the presence of clearly identifiable landmarks which allow them to distinguish one place from another, and to gain and maintain some sense of their heading. This can be a problem in outdoor settings where some natural features (e.g. vegetation) may not be sufficiently permanent, while others (e.g., topographical features) are not sufficiently distinctive to the layperson or depend on recognizing aspects of relief that are difficult to convey to users.

5.30 More research is required to establish which cues are most useful. Man-made waymarkers, paths, buildings, signage or other objects placed in a systematic manner around a site could potentially provide useful cues to location, though to be effective they must be distinctive and visible from long distance, which might mar the sought after qualities of the natural environment unless implemented sensitively and imaginatively. The potential for buildings and other artefacts to act as landmarks should be a design consideration when commissioning new facilities. Ideally landmarks should be recognizable from all directions, while providing clear cues to orientation. Thus it is not clear whether symmetrical or asymmetric landmarks are to be preferred – possibly they could contain both symmetrical and asymmetrical elements; more research would be helpful here.

5.31 It should be recognized that many people feel anxious about getting lost in unfamiliar environments. This can lead to a more tentative approach to exploration, which in turn inhibits the acquisition of new spatial knowledge; potentially a vicious circle. In enclosed settings, it might be helpful to place maps etc. designed for less experienced/comfortable users near to the edges of the environment, an area that where more anxious users are likely to explore first.

5.32 There are significant cognitive costs in understanding maps that are misaligned with respect to the real world – the forward up convention should be followed for all non-portable maps and displays. Elsewhere, it may be useful to link particular views (e.g., panoramas, photos taken from particular locations) to particular sites on the map, since many people whose internal cognitive maps are poor are potentially skilled at recognizing landmarks.

5.33 Interactive displays which permit users to visualize a scene from more than one angle (including overhead – c.f., Google Earth) might help here. Another technology (Microsoft Photosynth) is in development which will shortly allow arbitrary photographs to be stitched together to form a 3D (map like) display which can be interactively navigated from all perspectives. IT-based solutions may not seem practical for many outdoor applications, but it should be borne in mind that the cost of portable devices capable of dealing with this type of information is falling to the point where this type of computing power (and even the ability to link to GPS) will shortly be a standard function of a mobile phone/PDA, which users may bring with them to a countryside site.

5.34 When selecting content for maps, relief information can be problematic; it appears to be useful for expert map readers, but may actually impede the acquisition of spatial knowledge in less skilled users. The precise format of relief information is important, but each format has its strengths and weaknesses, with no overall optimum. More generally, there is some evidence that schematized maps are better where a specific task or activity is to be supported. However there is generally a trade-off, in that a schematized map will be less flexible for tasks for which it was not intended. Where practical interactive displays which allow users to select which information is to be displayed are likely to be useful. Alternatively, users could be provided with multiple maps of the same area.

6. CONCLUSIONS

6.1 It is possible to draw a number of conclusions from the scientific research and the anecdotal information obtained from practitioners. These are summarised below.

What the Practitioners Believe they Know

6.2 We can summarise the findings of the practitioner interviews in terms of what recreation managers think they know and do not know about the maps they produce. It is clear that what practitioners think they know is based almost entirely on their own assumptions and experiences and on anecdotal evidence for what works and what does not.

6.3 Practitioners' confidence in the maps they produce ranges from 'thinking they are doing the right thing' to 'hoping they are doing the right thing' but in reality 'not knowing either way'.

6.4 Things practitioners appear to have some certainty about are as follows:

- Males are better at reading Ordnance Survey style maps than females. Practitioners experience suggests that this is also the case amongst children
- In relation to map reading, people have the most difficulty with understanding relief. Contours are particularly confusing to inexperienced map readers, who find it difficult to understand the direction of the slope from contour information
- Flat 2-dimensional plan maps are more effective for navigation
- Three-dimensional illustrative maps and panoramas are more effective for interpretation and landscape appreciation
- Use of colour should be consistent, distinct and simple
- Women, older people, young families and less fit people seem to be more anxious about getting lost and have more need for waymarks to aid navigation and provide reassurance
- Panels showing walking routes are good for raising awareness and for general orientation but of limited use for navigating as people can't remember them
- Maps on orientation panels need to be orientated to the perspective of the viewer
- People appear to like routes which are clearly waymarked, which they can follow without frequent reference to a map
- Less confident users appear reassured by 'infrastructure' – signage, well-defined routes, the presence of facilities for visitors
- A common maxim is 'keep it simple' – only show on the map the information that users need
- Mountain bikers using 'single track' routes require little in the way of route finding information as the routes are well defined; information of shortcuts is useful
- People with learning difficulties seem to relate better to a 3-D model or map

What the Practitioners Say They Don't Know

6.5 Things practitioners really do not know are as follows:

- How people read maps
- What styles of mapping people prefer
- To what extent users rely on mapping and waymarking for route funding
- What styles of mapping and combinations of mapping, panels and waymarking work most effectively for different kinds of users
- Can mapping be used as a tool to encourage people to take trips to the countryside for recreation
- How useful are the maps they already provide
- Whether to use new mapping technologies and how to use them to best effect

Summary of What the Science Tells Us

6.6 The brain uses multiple systems to receive, store and use mapped information – landmark knowledge, route knowledge and survey knowledge. Important areas of the brain are:

- The hippocampus – analogous to a GPS and to a compass
- The Caudate nucleus – analogous to an autopilot
- The parietal cortex – analogous to a radar

6.7 The scientific research tells us the following:

- Men and women generally use different brain systems for understanding maps – men tend to use survey representations, which means that they are better at orientating themselves and navigating with a map, whilst women tend to rely more on landmark knowledge
- Children and older people find it more difficult to understand mapped information – as they also appear to use survey knowledge less
- People with a poor sense of orientation benefit from a written route description – which should be described in terms of left, right, ahead, back, rather than north, south, east, west
- Anxiety of getting lost is higher amongst females than males
- People who are familiar with a site and experienced at map reading are at an advantage when using maps
- Maps aligned to the perspective of the reader are more effective
- Landmarks are important – though most research has been in urban areas and so little is known about the use of landmarks in the outdoors
- It takes time and training to understand mapped relief
- Different methods of showing relief work better for different purposes

Comparing Practitioners Experience with the Science

6.8 The practitioners understanding of what works best in different mapping situations is broadly in line with the scientific evidence. In fact, the anecdotal knowledge of the practitioners is generally supported by what scientific research has been done in this field. Table 1 summarises this fact.

Table 1: Comparison of Practitioner Assumptions and Scientific Research Findings

Practitioner Assumptions	Scientific Research
Males are better than females at reading OS type maps	Males more commonly use survey knowledge and females more commonly use landmark knowledge
Children have difficulty understanding OS style maps	Children have difficulty understanding a perspective other than their own
Women, less fit people and older people appear more anxious about getting lost	Anxiety about getting lost is higher amongst females than males
Experienced walkers don't use panels, special site maps and waymarks, rather they rely on OS naps	Experience is an important factor in being able to read a map It takes time and training to become a competent map reader
Flat maps are more effective for navigation	Gap in the knowledge
Three dimensional maps or illustrations are better for orientation and interpretation	Gap in the knowledge
Use of colour, symbols and labels should be consistent, distinct and simple	Omitting superfluous information makes a map more effective for its chosen purpose Adding relief information can make the whole map confusing
Keep mapping simple	Contours and other portrayals of relief can confuse the user Understanding of topography can be critical to understanding landscape. Unresolved.
People seem to like routes that are clearly waymarked	Some users, especially (but not exclusively) women rely more on landmark knowledge
Less confident people appear reassured by infrastructure	Experience is an important factor in being able to use survey knowledge – less experienced map readers will rely more on landmark knowledge
Mountain bikers need little by way of way finding information	Gap in the knowledge
People with learning difficulties seem to relate well to three dimensional maps	A congenitally blind 4-year-old was able to 'read' a tactile map and use information gained in an appropriate way

7. GOOD PRACTICE ADVICE FOR COUNTRYSIDE MANAGERS

7.1 Insufficient research-based evidence has been identified during the study to enable the preparation of comprehensive ***best practice***. However, there is evidence to support a number of elements of ***good practice***. The paragraphs below summarise what we can describe as good practice at this stage in our exploration of this field. Section 8 identifies areas for further research to plug gaps in the knowledge and these are further detailed in the Appendix.

7.2 The over-riding message from the research is that people use a variety of strategies for reading/interpreting mapped information and, though there are differences in the way different types of people understand mapped information, these are not definitive. For example although males in general understand and can use maps better than females, some females understand maps better than some males. The same appears to be so for the other two continuums identified above – age and experience.

7.3 Therefore, we conclude that good practice is to supply information in a variety of forms – mapped, waymarks and written route descriptions, so that the widest possible audience will be able to understand it.

7.4 Tables 2 and 3 below provide a summary of the different types of map reader and the kinds of information recreation managers should put in place to help them.

Table 2: Characteristics of Different Map Users

<table>
<tr><th colspan="3">Male</th><th colspan="3">Female</th></tr>
<tr><td colspan="3">▪ Use survey knowledge
Good at using maps for navigation</td><td colspan="3">▪ Use landmark knowledge
▪ Experience high levels of anxiety over getting lost</td></tr>
<tr><th colspan="2">Younger</th><th colspan="2">Mid-aged</th><th colspan="2">Older</th></tr>
<tr><td colspan="2">▪ Struggle to understand the environment other than from their own perspective</td><td colspan="2">▪ Better at reading maps</td><td colspan="2">▪ Lose the capacity to understand mapped information</td></tr>
<tr><th colspan="3">Experienced</th><th colspan="3">Inexperienced</th></tr>
<tr><td colspan="3">▪ Good at reading mapped information
▪ Can understand mapped relief</td><td colspan="3">▪ Mapped relief confuses the inexperienced
▪ Experience high levels of anxiety over getting lost</td></tr>
</table>

Table 3: Information for Different Map Users

<table>
<tr><th colspan="3">Male</th><th colspan="3">Female</th></tr>
<tr><td colspan="3">O/S style maps</td><td colspan="3">▪ Waymarks linked to simple maps</td></tr>
<tr><th colspan="2">Younger</th><th colspan="2">Mid-aged</th><th colspan="2">Older</th></tr>
<tr><td colspan="2">▪ Waymarks linked to simple maps</td><td colspan="2">▪ O/S style maps</td><td colspan="2">▪ Waymarks linked to simple maps
▪ Written route description</td></tr>
<tr><th colspan="3">Experienced</th><th colspan="3">Inexperienced</th></tr>
<tr><td colspan="3">▪ O/S style maps</td><td colspan="3">▪ Waymarks linked to simple maps
▪ Written route description</td></tr>
</table>

7.5 Further aspects of good practice, which can be drawn from the scientific and the anecdotal review are as follows:

- Promotional leaflet maps should show site in relation to major roads, settlements and significant features or landmarks. They should include a grid reference and a postcode (this can be used by satellite navigation devices)

- Use 3-D illustrated maps for promotion, orientation, interpretation and landscape appreciation

- Use flat maps preferably linked to features and waymarks for navigation

- Use colour in a simple and consistent way, as follows:
  - Brown – with lighter to darker shading to denote height
  - Green for woodland
  - Blue for water features

- Only use contours if you shade the space between as suggested above

- Using dotted lines for routes enables the viewer to see what the route is crossing over/through

- Produce downloadable maps at A4 size, ensure they load quickly and keep them simple so that they reproduce on poor quality printers, but beware copyright issues also the 'currency' of the map data

- Make sure that maps on panels are aligned to the perspective of the viewer

- Where possible, also ensure that maps on leaflets are also aligned from the perspective of the viewer – i.e. from the main arrival point (this is more difficult when there are multiple arrival points of equal importance

7.6 The two approaches described below have been developed by Forestry Commission Wales and Scottish Natural heritage based on many years' experience. They provide a useful general method of approach for managed sites:

Forestry Commission Wales Approach

- 3-D oblique view at visitor centre (for orientation, orientated to perspective of visitor/viewer)
- Welcome panel at arrival point - 3-D representation (for landscape appreciation, not orientation, to attract people to walk/cycle/explore the site, provides context, basic information only)
- Map panel – at start of routes (flat, simplified O/S style supported by coloured waymarkers)
- Leaflet – available on site and round about (flat, simplified O/S style supported by coloured waymarkers)

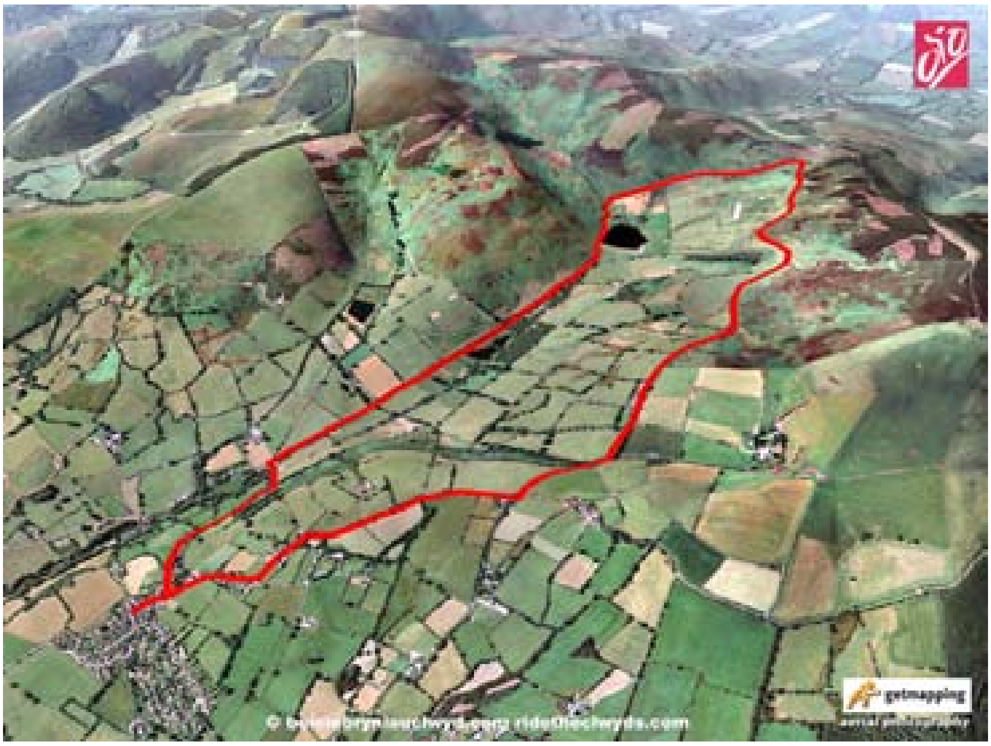
Illustrated landscape of Coed Maenarthur (Forestry Commission Wales) gives visitors an understanding of the landscape

Scottish Natural Heritage Approach

- Pre-visit leaflet (promotional, very cheap, easy to read, shows location and major roads, grid ref and postcode (for sat.navs.)
- Use oblique, illustrative map 75-80º angle (90=vertical) for all or part of site as introduction (orientation and landscape appreciation)
- Downloadable trail guides – O/S, simplified

Extract from Flanders Moss leaflet (Scottish Natural Heritage) with stylised, illustrated landscape

7.7 Providing mapped information in different forms – i.e. as a flat map and as aerial photography can help more people to understand the information. This is illustrated by Forestry Commission Wales walking guides and the Ride the Clwyds (www.ridetheclwyds.com) and Ride the Hiraethog (www.ridehiraethog.com) cycle route guides (See Appendix 3).



Aerial photography is used to give an overview of a mountain bike route in the Clwyds

7.8 Maps produced for specific types of users should be produced in consultation with the users in question as, in general insufficient is known about their needs. Some good practice has been developed in relation to mountain bikers and people with disabilities, as follows:

Mountain Bikers

- Provide a simple map showing the route with the following:
  - Names of features/route sections
  - Steep ascents and descents
- Show forest roads which provide short cuts and links to other routes
- Show numbered waymarkers if these are in place along the routes

Mountain bike route guide for the Twrch route at Cwmcarn (Forestry Commission Wales)

People with Disabilities

- Provide as much information as possible in advance on
    - Length of routes
    - Gradients
    - Surfaces
    - Path widths
    - Gate widths
    - Facilities on site (parking, WCs, catering, etc)
    - Shelter/resting opportunities

8 RECOMMENDATIONS FOR FURTHER RESEARCH

8.1 There are a number of gaps in the scientific research, especially in the area of how people use landmark knowledge in the countryside. In addition, there is a need from practitioners, for advice on the use on new technology. This is summarised in Table 4, below.

Table 4: Summary of Need for Further Research

Degree of Knowledge	Aspect
What we believe, but needs further research to confirm	▪ Shading appears to be an effective way to communicate relief on flat maps ▪ Route profiles appear to be useful in helping people to make route choices ▪ Alignment of oblique maps to the perspective of the viewer appears to be important to understanding ▪ Mountain bikers need only limited information on the line of the route, location along the route and short cuts ▪ Flat maps work better for navigation and illustrated oblique view maps seem to work better for orientation, landscape appreciation and interpretation
What we don't know	▪ What types of information are most useful (for different types of users) for different tasks involving maps (navigation, landscape appreciation, interpretation, etc?) ▪ What types of landmarks are most useful for navigation and orientation in the outdoors? ▪ What is the comparative effectiveness of computer-generated and illustrator rendered oblique maps? ▪ What is the best way to use new technology – digital mapping, GPS and the various devices for accessing them?

8.2 Table 5, below shows how 8 recommended research projects will address the research need.

Table 5: Summary of Research Recommendations

Research Need	Test Different Map Types at One Location	Build Your Own Map	Route Profile Experiment	Alignment Experiment	Site Manager Meeting and Focus Groups	Landmark Experiment	Scoping Study	Interpretive Map Experiment
Test whether shading is an effective way to communicate relief on flat maps	✓	✓						
Test whether route profiles help people to make route choices			✓					
Test whether the alignment of oblique maps to the perspective of the viewer is important to understanding		✓		✓				
Test whether mountain bikers need only limited information on the line of the route, location along the route and short cuts		✓			✓			
Test whether flat maps work better for navigation and illustrated oblique view maps work better for orientation, landscape appreciation and interpretation	✓	✓						
Explore what types of information are most useful (for different types of users) for different tasks involving maps	✓	✓						

Research Need	Test Different Map Types at One Location	Build Your Own Map	Route Profile Experiment	Alignment Experiment	Site Manager Meeting and Focus Groups	Landmark Experiment	Scoping Study	Interpretive Map Experiment
Investigate what types of landmarks are most useful for navigation and orientation in the outdoors?						✓		
Compare the effectiveness of computer-generated and illustrator rendered oblique maps	✓	✓						✓
Scope the best way to use new technology – digital mapping, GPS and the various devices for accessing them?							✓	

Research Recommendations

8.3 The following research projects are recommended. Draft research briefs are included in the appendix:

Testing Map Types in the Field

8.4 This research involves producing several types of map for the same site and testing these on a sample of users. The experiment will test the effectiveness of maps for navigation and for interpretation and it will research a number of areas where knowledge is incomplete, including the use of shading for relief and the effectiveness of aerial photography, computer generated images and artist rendered images.

8.5 This research would require recruiting of different kinds of visitors at a site and gaining their approval to undertake an interview or complete a questionnaire before leaving.

Build a Map: Action Research

8.6 An alternative, or parallel approach would be providing the opportunity for users to produce a map themselves, giving choices such as flat map/oblique illustration/aerial photo and the ability to select different types of information (relief, symbols for different features, etc) would be a very valuable piece of 'action research'. This could be done in a visitor centre at a site for which a variety of mapping is already available or could be cheaply produced.

8.7 Visitors would be invited to use a computer terminal to design a map for them to use during their visit. At the same time, they would be asked to provide basic information on their sex, age, experience of using maps, purpose of visit, etc. Having used the map on-site, they would be asked what they liked and disliked about the map they produced.

8.7 Over a period of time, this would produce a body of information on what kinds of mapping work best for different types of user.

Route Profile Experiment

8.8 Little is known about the effectiveness of route profiles in the UK. This research would test the usefulness of route profiles at one or more sites where there is a choice of routes for visitors. The research would consist of:

- Selecting a site where there is a choice of routes
- Producing route profiles for each route and displaying these at the site entrance/ orientation point
- Interviewing visitors as they leave the site to explore the usefulness of the route profiles

Alignment Experiment

8.9 A single site would be selected where an illustrated 3-D view map already exists, but where there are several entrance points. The research would consist of providing visitors with the map on arrival and interviewing them on departure to test the usefulness of the map. Comparing the results from visitors arriving at different points would determine whether or not orientation is significant for this type of map.

Mountain Biker Research

8.10 To test the best practice approach to mountain biking maps described above, the following is recommended:

- Bringing together managers of mountain biking sites to share experience, test thinking and agree best practice
- Focus group research with mountain bikers to test the best practice and explore mountain bikers needs and opinions

Landmark Experiment

8.11 This experiment would ideally be carried out on a number of sites – upland, wooded, lowland – and consist of:

- Selecting a range of sites (upland, wooded, lowland)
- Recruiting visitors as they arrive to ask them to follow a route
- Interviewing recruited visitors as they leave to explore their use of landmarks

New Technology Scoping Study

8.12 Scoping the use of new technologies in providing mapping and other information for countryside recreation would be a useful starting point in developing guidance on the use of new technologies by practitioners.

8.13 This work should include consultation with organisations which provide existing digital mapping technologies (and those involved in developing new mapping technologies for the future (e.g. Microsoft for 'Photosynth').

8.14 The aim of this study should be to produce guidance on the use of new technology for countryside recreation managers (list the mapping and devices available, describe their potential, describe the advantages and disadvantages of each technique, give an indication of 'product lifestage' – so understand popularity and longevity, give an indication of cost and provide contact details for suppliers.

Interpretive Map Experiment

8.15 Research to understand which kinds of maps are most effective in the communication of interpretive messages about countryside sites is also recommended. This should test the assumption that 3-D and illustrated maps are the most effective for this purpose. It should also compare the relative effectiveness of illustrator rendered and computer generated maps and the effectiveness of the use of different styles (cartoon, realistic, etc).

Moving Forwards

8.16 Considerable interest has been shown in this study and the topic of mapping for countryside recreation by all of the individuals who have been consulted during this study. Whilst there is a danger of becoming 'bogged down' by involving too many people in further work, some type of forum is recommended to encourage sharing of information. The following is suggested:

- A small steering group (with representatives from the national agencies, with others as required from time to time) continues to drive the process

- A network of practitioners and interested parties is established as a wider discussion forum and a means of disseminating information. In the first instance, this could be an e-mail based circulation list, but it could be developed in the future, possibly along the lines of the national interpretation groups (Interpret Scotland, Dehongli Cymru)

8.17 The steering group and proposed forum should include representation from cartographers, map publishers and businesses involved in new technologies for mapping.

Summary Table of Recommended Actions

8.18 Table 6, below lists the recommended actions for Phase Two of the countryside mapping project.

Table 6: Summary of Actions for Phase Two

Task	Description
1	Steering group meets to agree work programme for Phase 2
2	Establish mapping research forum
3	Test map types in the field
4	Build a map action research project
5	Alignment of maps research
6	Mountain biker research project
7	Countryside landmarks experiment
8	New technologies scoping study
9	Test interpretive map types
10	Produce and disseminate best practice advice based on the findings of the Phase 2 research (tasks 3-9)

APPENDIX

Appendix 1: Brain Systems
Appendix 2: Research Briefs
Appendix 3: Other Mapping Collected
Appendix 4: Bibliography

APPENDIX ONE: BRAIN SYSTEMS

Psychology and Neuroscience of Maps, Wayfinding and Spatial Cognition

The aim of this section is to explore the findings of scientific research on spatial cognition and the use of maps, and to show how these may impact on the provision of maps and other tools for outdoor recreation in the future.

Research relevant to the use of maps, wayfinding and individuals' understanding of the environment around them falls into three categories:

- Psychological research using behaviour to infer the nature of mental processes underlying spatial cognition
- Neuroscientific research, looking at brain activity in humans and animals to uncover brain systems that support individuals' understanding of their surrounding environment
- Applied research (a strand of psychological research, but also including interdisciplinary research which might involve geographers, cartographers, planners, architects etc) aimed at discovering how our mental toolkit can best be enhanced through the provision of extra information for example, verbal descriptions, maps, signposts, waymarkers and so on

The last category is most directly relevant to the current project. However, this literature is diverse in terms of content and methodology, and scientific value of the work is variable. Psychological and neuroscientific studies paint a more coherent picture and provide a strong framework within which present applied research can be better interpreted and in which further research can be planned. Here we review the basic science and then the applied research.

Basic Cognitive Neuroscience of Spatial Behaviour

Historically, our understanding of human behaviour has been largely based on psychological experiments in which aspects of behaviour are measured in experimentally controlled situations. These measures have been used to predict and describe future behaviour in terms of learned associations between different forms of stimulus and response (behaviourism) and, more recently, to infer the more complex underlying structure of mental processes (cognitive psychology).

Contemporary ideas about spatial cognition are influenced both by our existing understanding of the mind (psychology), formerly treated as a rather abstract entity, and our increasingly concrete understanding of the brain (neuroscience). This process has been driven by advances in neurophysiology (including studies of the brain basis of complex behaviours in animals), the emergence of brain imaging technologies, and an increasing emphasis on studies with patients with brain damage. We are now in a period during which earlier psychological and neuroscientific findings are being reconciled and new findings concerning the brain basis of cognition are contributing to a rapid advance in our understanding (cognitive neuroscience).

Simple reflexes, such as withdrawing one's hand from a burning candle flame, do not require much complex processing, and may not even involve the brain at all. But, in general, human behaviour is not just a matter of responding reflexively to the external world. This is as true of complex spatial behaviour (e.g., planning a route) as it is of any other area of human behaviour; whether information comes from a map, from the sight of natural or man-made objects in the environment, or from other sensations such as hearing or proprioception (the sense of the position of neighbouring parts of the body), it must first be converted into a form that can be stored and/or further processed by the brain.

The catch-all term cognition refers to the way in which this internal code (representation), itself resulting from the combined activity of millions of neurons, is subject to further processes. It is the nature of these representations and processes that ultimately determine behaviour. In turn they are often determined by, or at least involve interaction with previously stored information (learning and memory). Together these factors limit what we can do, and thus determine what forms of additional information are useful for a given task.

Multiple Forms of Spatial Representation

Just as we can represent spatial information on different ways on paper (e.g., a map, a photograph of a place, a list of directions to a given destination), so the brain employs different internal representations of spatial information (Burgess, Jeffery, & O'Keefe, 1999).

Psychological investigations suggested that at least three forms of topographical knowledge can be distinguished – landmark knowledge, route knowledge and survey knowledge (Siegel & White, 1975; Waller, Loomis, Gollege, & Beall, 2000).

- *Landmark Knowledge*

  Landmark knowledge concerns the identity of objects within an environment, especially those that will be significant for navigation [e.g., salient objects (Lynch, 1960) near to junctions or decision points (Appleyard, 1969)]. People can list such landmarks, and reliably produce similar lists (Milgram & Jodelet, 1977; Evans, Smith & Pezdek, 1982).

- *Route Knowledge*

  It was argued (Siegel & White, 1975) that this form of declarative knowledge (i.e., knowing what is out there) provides the basis for subsequent development of procedural knowledge about routes (e.g., knowing how to get from A to B). In this view, initially isolated landmark representations are thought to be linked to form route representations (i.e., landmarks along a given path are associated with one another, and with the actions required at each point to reach a goal).

- *Survey Knowledge*

  Further accumulation and integration of spatial knowledge permits the development of survey knowledge, a more abstract type of representation that includes information about the configuration of elements within the environment, their distances and directions from one another. The survey representation is analogous to a map (O'Keefe & Nadel, 1978; Tolman, 1948; Trowbridge, 1913), permitting reasoning about possible alternative routes, directions, scenes that would be perceived from a different viewpoint and so on.

Neuroscientific research is broadly consistent with the psychological findings discussed above. In particular, parts of the visual processing system on the underside of the brain's surface (called the ventral stream) respond selectively to landmarks (Janzen & Van Turennout, 2004) and scenes (Epstein & Kanwisher, 1998; Hasson, Nir, Levy, Fuhrmann, & Malach, 2004). These regions provide input to the hippocampus; this is an ancient structure known to be critical for memory of personally experienced events (Tulving & Markowitsch, 1998), but it also seems to act as a survey representation, or cognitive map (O'Keefe & Nadel, 1978; Tolman, 1948). This is an internal representation of the outside world which captures the relationships between places, allowing one to develop complex spatial plans in a flexible manner, for example calculating new shortcuts when the path ahead is blocked. Experiments with animals suggested that the hippocampus is important for this type of behaviour (Morris, Garrud, Rawlins, & O'Keefe, 1982) and neuroimaging studies (Hartley, Maguire, Spiers, & Burgess, 2003; Maguire et al., 1998) have confirmed that it plays an important role in human wayfinding too.

An important characteristic of such a map is that the information it represents is independent of the observer's current location and heading. This property seems essential if it is to represent spatial relationships between places that lie beyond the scope of one's current perception. The clearest evidence to show that the hippocampus represents information in this way is that individual hippocampal neurons fire when a person or animal is in a particular location (Ekstrom et al., 2003; O'Keefe & Dostrovsky, 1971) regardless of heading.

Inputs to the hippocampus also include cells which encode location in terms of an elegant grid reference system, analogous to a GPS system (Hafting, Fyhn, Molden, Moser, & Moser, 2005) and others which encode the current heading (Taube, Muller, & Ranck, 1990), analogous to a compass.

A second ancient system, buried deep within the brain, appears to be involved in learning patterns of behaviour that reliably lead to a goal. If one always enters an environment from the same place, and reaches a goal by following the same sequence of actions (e.g., turn left at the post box, go straight on till you reach the traffic lights, then turn right), the sequence itself can be learned. In animals, the striatum is known to be specialized for learning such responses (Packard & McGaugh, 1996; White & McDonald, 2002), and human neuro-imaging studies show that good navigators tend to activate a part of this region, the caudate nucleus, when following familiar routes (Hartley et al., 2003) or when using a fixed non-spatial strategy to solve a spatial task (Iaria, Petrides, Dagher, Pike, & Bohbot, 2003).

Like a well practiced piece of music or golf-swing, over-learned action sequences may become automatic, no longer requiring conscious control. In this sense the striatum acts like an autopilot in that it can be used to follow a fixed "pre-programmed" route without intervention, but is not useful when a new path must be calculated.

Thus rather than being built on one another, as psychological theories had suggested, route and survey knowledge have their bases in distinct brain systems which, though they interact in the control of behaviour, are to some extent independent of one another.

A complementary brain system located at the back of the brain (parietal cortex) represents the object-locations in terms of their relationship to parts of the body (an egocentric representation). This system (called the dorsal stream) appears critical for attending to or acting on objects in the immediate environment. Parts of the parietal cortex are involved in storing and manipulating information about such objects over short intervals (visuo-spatial working memory: Baddeley, 1986) and, it is increasingly suggested, for visualizing remembered places (Byrne, Becker, & Burgess, 2007) and for imagery in general (Fletcher et al., 1995).

Neuroscientific research (e.g., Hartley et al., 2003) also suggests that complex, large-scale spatial behaviour (such as navigation) depends as heavily on these processes as much as it does on pre-existing knowledge. Intuitively this is because we need to integrate information about where we are now, and what we are currently doing with our knowledge about the world beyond our immediate perception in order to make effective navigational plans and decisions.

There is some evidence to suggest that the parietal representation provides adequate spatial memory for scenes and object locations to support behavioural decisions where the viewpoint does not change, or where location of few objects must be stored, but that the hippocampus becomes more important where the view of the environment changes radically, or where more objects are involved (Hartley et al., 2007; King, Burgess, Hartley, Vargha-Khadem, & O'Keefe, 2002). It is thus analogous to a radar system, in that it relates the current location of nearby objects to the body (corresponding to the radar antenna in this metaphor), permitting this type of information to be stored and updated over a limited period as either objects or body move (e.g., Farrell & Robertson, 1998; Wraga, Creem & Proffitt, 2000)

Clearly a number of different and largely independent brain systems and processes are used to understand a map and to relate mapped information to the environment in which the person is using it. As a result, there are many variables therefore the degree to which different individuals are good or bad at using these various systems and processes, impacts on their ability to understand maps.

APPENDIX TWO: RESEARCH BRIEFS

1. Testing Map Types in the Field

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified. Finding out which type of map people prefer for different types of visit is a key research need.

Aim & Objectives

Aim

To test people's ability to glean information form different kinds of map

Objectives

- To gather information which will confirm which types of map are most effective for communicating information to help visitors to navigate, appreciate the landscape, understand aspects of the natural and cultural heritage, be aware of health and safety issues, etc.

- Specifically to test which types of relief information people prefer/understand, the relative merits of flat plan maps and oblique 3-d maps and the effectiveness of computer generated and illustrator rendered maps

Specific Requirements

The contractor is required to design and implement research at a managed outdoor recreation site as follows:

- Select a managed outdoor site at which to carry out the research
- Develop a statistically robust sampling plan which is representative of the users of the site and recruit the sample
- Develop a list of mapping objectives which are to be tested during the study and devise a set of questions to measure these in interviews

- Produce several different maps of the site using different mapping techniques and different levels of complexity
- Recruit people to match the sample and ask them to use one version of the map to find their way around the site and to inform their visit
- Conduct interviews with people as they leave the site to test the effectiveness of the maps for the range of purposes agreed
- Analyse the results
- Draw conclusions from the research and amend the 'best practice' identified during the scoping study

Notes for Client

Since this research is likely to be relatively costly, it could usefully be piloted in a laboratory situation to test its effectiveness and to identify any issues or weaknesses. Otherwise, an on site pilot with a small sample of users if recommended in advance of the main study

2 Build a Map: Action Research

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified. Finding out which type of map people prefer for different types of visit is a key research need.

Aim & Objectives

<u>Aim</u>

To discover what kinds of maps people choose for themselves and to discover hoe useful their choices are.

<u>Objectives</u>

To provide visitors to managed countryside sites with a choice of map types and information to understand which types of mapping and information different kinds of visitors prefer.

To understand what types of mapping and kinds of information visitors found useful and not useful during their visit to the site.

Specific Requirements

The contractor is required to:

- Select one or more managed countryside sites where the research will take place
- Develop software, or adapt existing software, to enable visitors to the site to produce their own map, with options for different styles of mapping (flat plan, illustrated, photographic) and for showing different kinds of information (relief, symbols, words, interpretation, facilities, etc)
- Collect some basic profile information about users so that they can be categorised, including purpose of visit, sex, age, party type, first time/repeat visit, level of map reading experience
- Install a computer terminal at the selected site(s) with appropriate hardware and software to enable users to produce their own map, print it out for use at the site and complete a questionnaire at the end of their visit
- Devise a questionnaire and user instructions that can be completed by visitors
- Brief staff at the site on promoting the project
- Staff the project initially to identify and address any issues
- Analyse the results
- Draw conclusions from the research and amend the 'best practice' identified in the scoping study

Notes for Client

Memory Map software would appear to offer the functions required (see link), but mapping would need to be bought. To minimise cost, this research could be delivered in partnership with a map publisher.
http://www.amazon.co.uk/exec/obidos/ASIN/1845141253/shopzilcouk-computer-software-21/ref=nosim

This research could be undertaken at a single site to pilot its effectiveness. Ideally it would then be run at a variety of sites which should be selected to be representative of different types of site (e.g. lowland, wooded and upland) and of different types of visitor.

3 Route Profile Experiment

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified, one of which is, understanding whether or not route profiles are helpful in enabling visitors to choose which route suits them best.

Aim & Objectives

Aim

To test the effectiveness of route profiles in helping visitors select which route(s) to follow at managed countryside sites.

Specific Requirements

The contractor is required to:

- Select one or more managed countryside sites at which to undertake the research. The site(s) should have a number of walking routes of varying difficulty/steepness of terrain, length, etc
- Produce route profiles for the routes
- Devise a sampling plan which will give a robust and representative sample of visitors
- Interview a sample of visitors on leaving the site to ask which route they followed, how they made the choice of route, whether the route was easier, more difficult or what they had expected.
- Display route profiles at the site and repeat the interviews
- Analyse the results and compare the results from the two samples to determine whether or not route profiles helped people select the kind of route they sought

Notes for Client

In the event that route profiles are shown to be helpful to visitors, follow up research could be undertaken to explore what kinds of profiling people prefer and good practice guidance could then be produced to encourage a consistent approach.

4 Alignment Experiment

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified, one of which is to understand whether alignment of 3-d illustrated maps is more effective if they are aligned to the perspective of the user.

Aim & Objectives

Aim

To test the effect of alignment of 3-d illustrated mapping on people's ability to understand the map

Specific Requirements

The contractor is specifically required to:

- Select one or more countryside sites for which 3-d illustrative maps exist and which have more than one entrance. The maps might be located on a panel or in printed form
- Develop a sampling plan to generate a representative sample of visitors to the site, minimising variation between the two groups to be questioned
- Devise a set of questions to test people's understanding of the mapped information (to cover orientation and interpretation)
- Interview visitors on site, at two entrances to the site – one which is aligned correctly for the arriving visitor and one which is not
- Analyse the results and identify any differences between understanding amongst the two samples
- Draw conclusions and amend the 'best practice' outlined in this report as appropriate

5 Mountain Biker Research

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified, one of which is to understand what types of maps mountain bikers prefer.

Aim & Objectives

Aim

To establish best practice in provision of maps for mountain bikers

Objectives

To share the experience of practitioners/managers
To test the assumptions made by FCW producing maps for mountain bikers
To agree and disseminate best practice in relation to maps for mountain bikers

Specific Requirements

The researchers are required to:

- Assess and review the FCW approach to providing mapped information for mountain bikers
- Organise and facilitate a meeting of mangers of mountain biking sites to share and agree best practice
- Produce draft best practice and circulate this to the meeting participants amending as necessary following any comments received
- Organise and facilitate focus groups of mountain bikers to test the best practice proposals
- Review the focus group findings and amend the managers best practice proposals as appropriate
- Circulate the best practice

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above. Landmarks (local features associated with a particular location) play a key role in orientation and navigation, and information about salient landmarks can be incorporated into maps or supplementary information (e.g., verbal directions) to improve visitors' experience.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. This exercise identified a gap in our current understanding of which landmarks people use in a rural environment, most previous work having been carried out in urban settings.

Aim & Objectives

Aim

To identify local features which play a role in orientation, navigation and spatial memory in rural settings, and to identify any effects of age and sex in the selection of landmarks used.

Specific Requirements

The researchers are required to:

- Identify features and dimensions of the rural environment which are accurately remembered in familiar and unfamiliar rural environments. Extending methods used by Evans et al. (1982). This could be done by asking specially recruited representative volunteers to place photographs of local features onto a grid such that they maintain their correct spatial relations. Photographs would be rated for the presence of relevant features/dimensions by independent judges
- Identify properties of scenes that are consistently recognized after volunteers follow a route through an unfamiliar. This could be done by asking volunteers to identify which of a set of images show places along the route, where half the images are drawn from a different route/site, which the participants have never seen
- Identify properties of scenes that consistently produce brain activity in the parahippocampal gyrus, a region responsible for the processing of landmarks. This could be done by presenting the same photographs to volunteers while monitoring brain activity in an fMRI scanner
- Record any differences in landmark features/dimensions which predict accurate spatial memory or parahippocampal brain activity in children, young adults and older adults, or between male and female participants

7 New Technology Scoping Study

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified, one of which is to understand how people use new technologies and how these can be used most effectively by recreation managers.

Aim & Objectives

Aim

To understand how new technology can be used to provide mapping for countryside recreation

Objectives

- To understand the extent and capability of new technology for mapping
- To understand current research and development in the field to identify emerging technologies
- To provide guidance to outdoor recreation managers on how they can best use new technologies
- To identify partners for future collaboration

Specific Requirements

The contractor is specifically required to:

- Compile a list of new technologies for mapping – digital mapping, aerial and other photography, delivery platforms
- Research each of the above to identify the capability, extent, cost, etc
- Identify the providers of each of the above
- Assess the effectiveness of each technology for outdoor recreation
- Identify opportunities to use the technologies to deliver mapping for outdoor recreation, identifying partners for this activity
- Identify gaps in knowledge and recommend research
- Identify possible pilot projects

Notes to Client

This project could be delivered jointly with a map publisher to reduce costs

7 New Technology Scoping Study

Background

A key part of environmental interpretation is connecting people with landscapes through the medium of maps, making people aware of the available opportunities and the stories to be found in a particular landscape. Ensuring visitors have access to the information and media required to take advantage of these opportunities enjoyably and safely is crucial, as is enabling visitors to orientate themselves to an area or site and to navigate around it confidently and safely. This orientation and navigation information is most often communicated using maps. As well as an aid to route planning, orientation and navigation, maps also have an important role in landscape appreciation, with a variety of techniques available to help visitors get a feel for a particular landscape.

At present, whilst a large number of organisations are involved in providing mapping for countryside recreation, there is insufficient authoritative, evidence-based information to ensure that the maps they produce are fit-for-purpose maps for the functions described in the paragraph above.

A recent study has scoped existing scientific and applied research, as well as anecdotal knowledge amongst practitioners. A number of unknowns have been identified, one of which is to understand which kinds of interpretive maps work best.

Aim & Objectives

Aim

To understand which kinds of interpretive mapping are most effective at communication understanding to visitors to countryside sites

Objectives

- To test the relative effectiveness of illustrator rendered and computer/photo generated interpretive maps

Specific Objectives

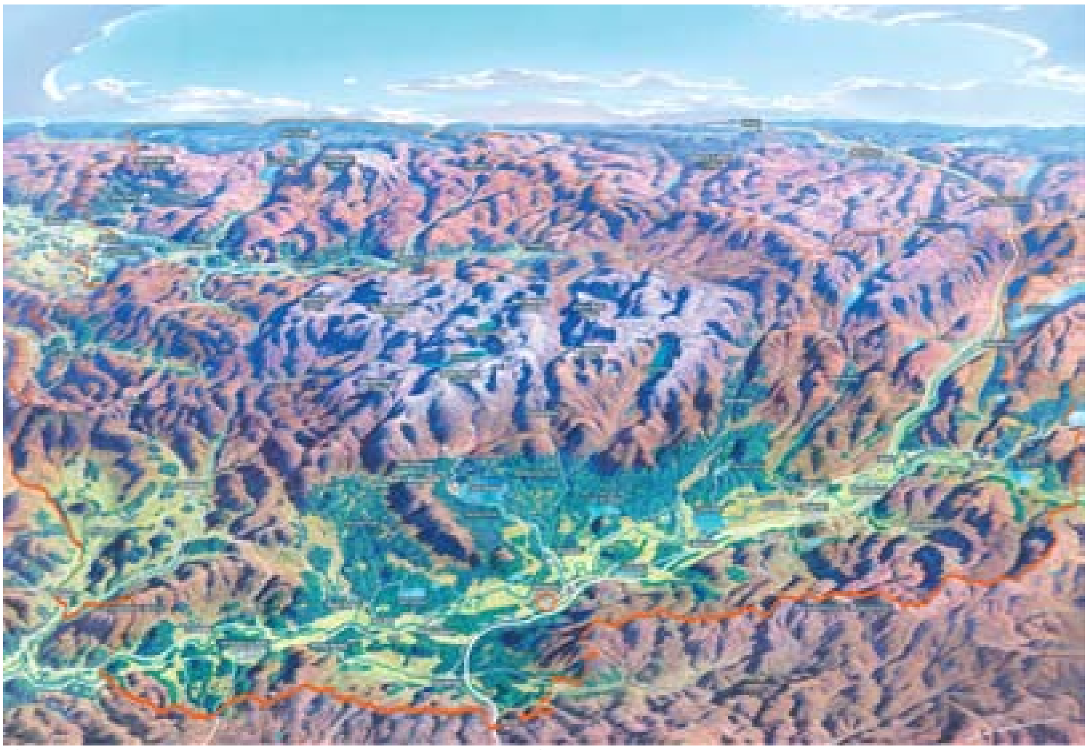
The contractor is required to:

- Select a managed outdoor site for the research
- Design a representative sample to include the different groups identified in the scoping study
- Produce different hinds of interpretive map for the site
- Provide the maps to the sample of visitors
- Interview visitors on leaving the site to test their awareness and understanding of agreed interpretation objectives
- Determine which kind of map works best
- Identify any significant differences amongst the different type of visitor

Notes to Client

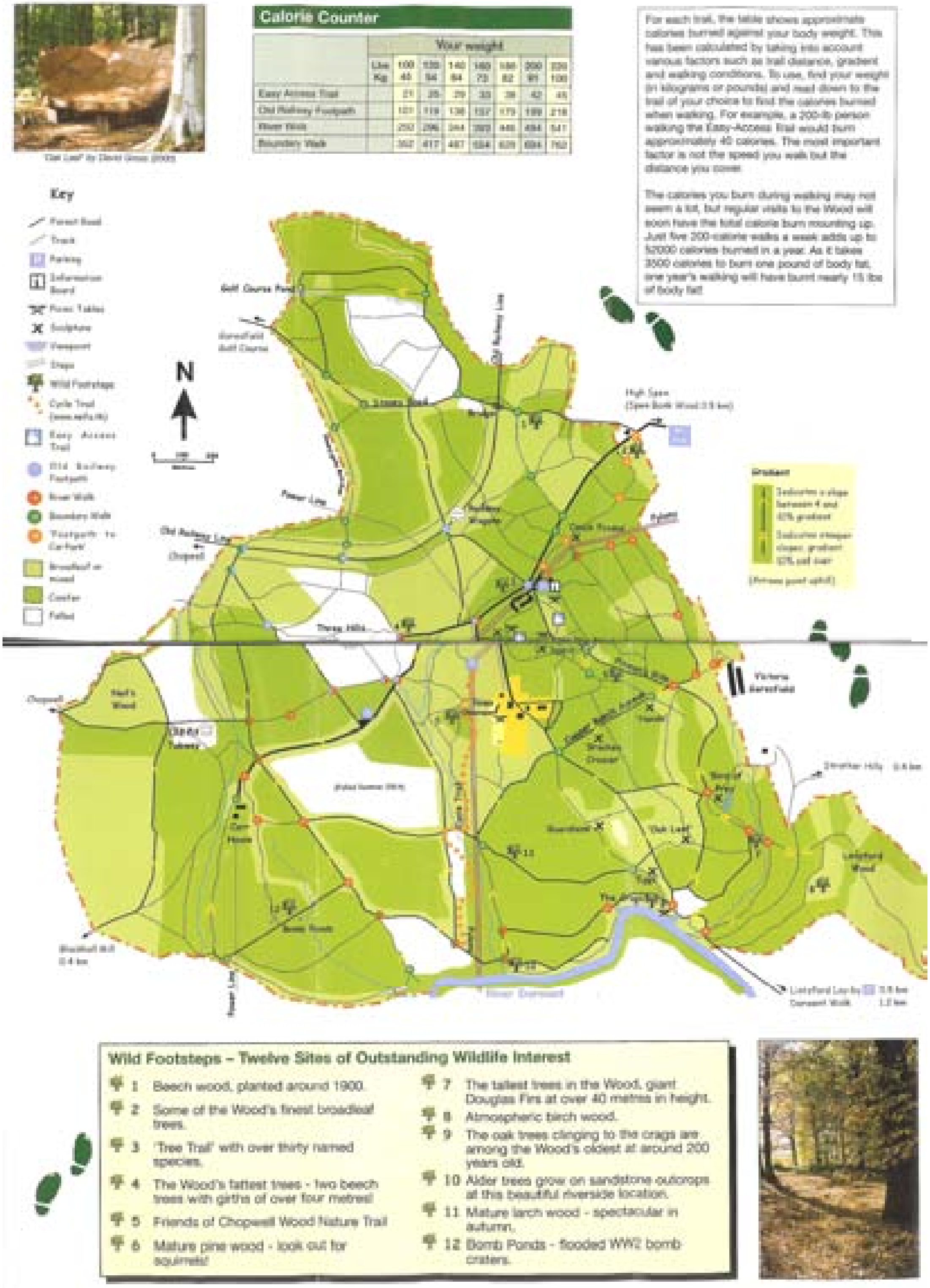
It should be noted that there will be an element of personal preference which will affect the results. The contractor should be asked to minimise this where possible, and to take it into account when drawing conclusions from the results.

APPENDIX THREE: OTHER MAPPING COLLECTED



One of several panoramas produced for the Cairngorms National park to give visitors and residents an appreciation of the extent of the park

A number of different map examples are shown below to illustrate the range of types currently being used.



'Oak Leaf' by David Gross (2005)

Calorie Counter

	Your weight							
	Lbs / Kg	100 / 45	120 / 54	140 / 64	160 / 73	180 / 82	200 / 91	220 / 100
Easy Access Trail		21	25	29	33	38	42	45
Old Railway Footpath		101	119	138	157	179	199	218
River Walk		250	296	344	393	446	494	541
Boundary Walk		352	417	487	554	629	694	762

For each trail, the table shows approximate calories burned against your body weight. This has been calculated by taking into account various factors such as trail distance, gradient and walking conditions. To use, find your weight (in kilograms or pounds) and read down to the trail of your choice to find the calories burned when walking. For example, a 200-lb person walking the Easy-Access Trail would burn approximately 40 calories. The most important factor is not the speed you walk but the distance you cover.

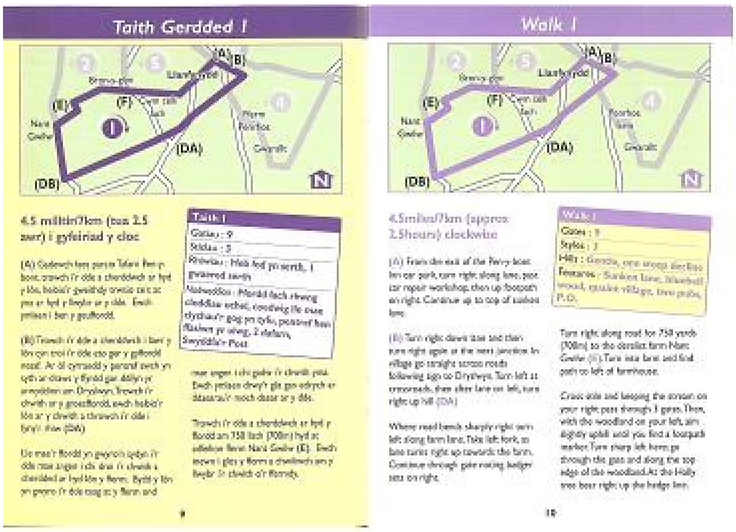
The calories you burn during walking may not seem a lot, but regular visits to the Wood will soon have the total calorie burn mounting up. Just five 200-calorie walks a week adds up to 52000 calories burned in a year. As it takes 3500 calories to burn one pound of body fat, one year's walking will have burnt nearly 15 lbs of body fat!

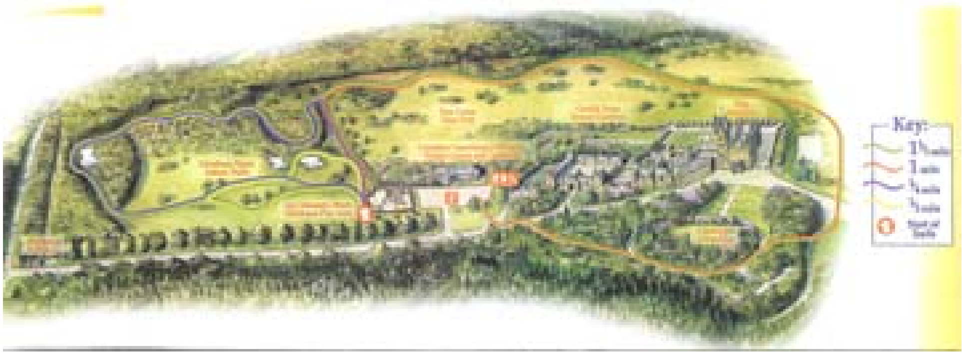
Wild Footsteps – Twelve Sites of Outstanding Wildlife Interest

1. Beech wood, planted around 1900.
2. Some of the Wood's finest broadleaf trees.
3. 'Tree Trail' with over thirty named species.
4. The Wood's fattest trees - two beech trees with girths of over four metres!
5. Friends of Chopwell Wood Nature Trail
6. Mature pine wood - look out for squirrels!
7. The tallest trees in the Wood, giant Douglas Firs at over 40 metres in height.
8. Atmospheric birch wood.
9. The oak trees clinging to the crags are among the Wood's oldest at around 200 years old.
10. Alder trees grow on sandstone outcrops at this beautiful riverside location.
11. Mature larch wood - spectacular in autumn.
12. Bomb Ponds - flooded WW2 bomb craters.

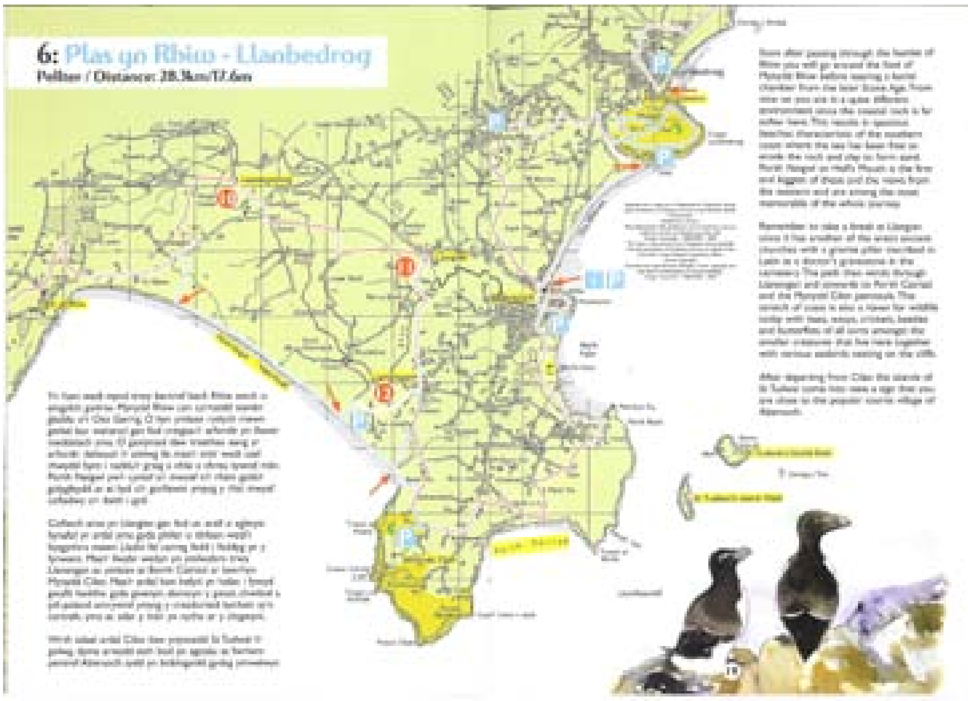
Tel:01439 788980 Fx:01439 788423 Mob:07770 803835 Email:info@bowlesgreen.co.uk

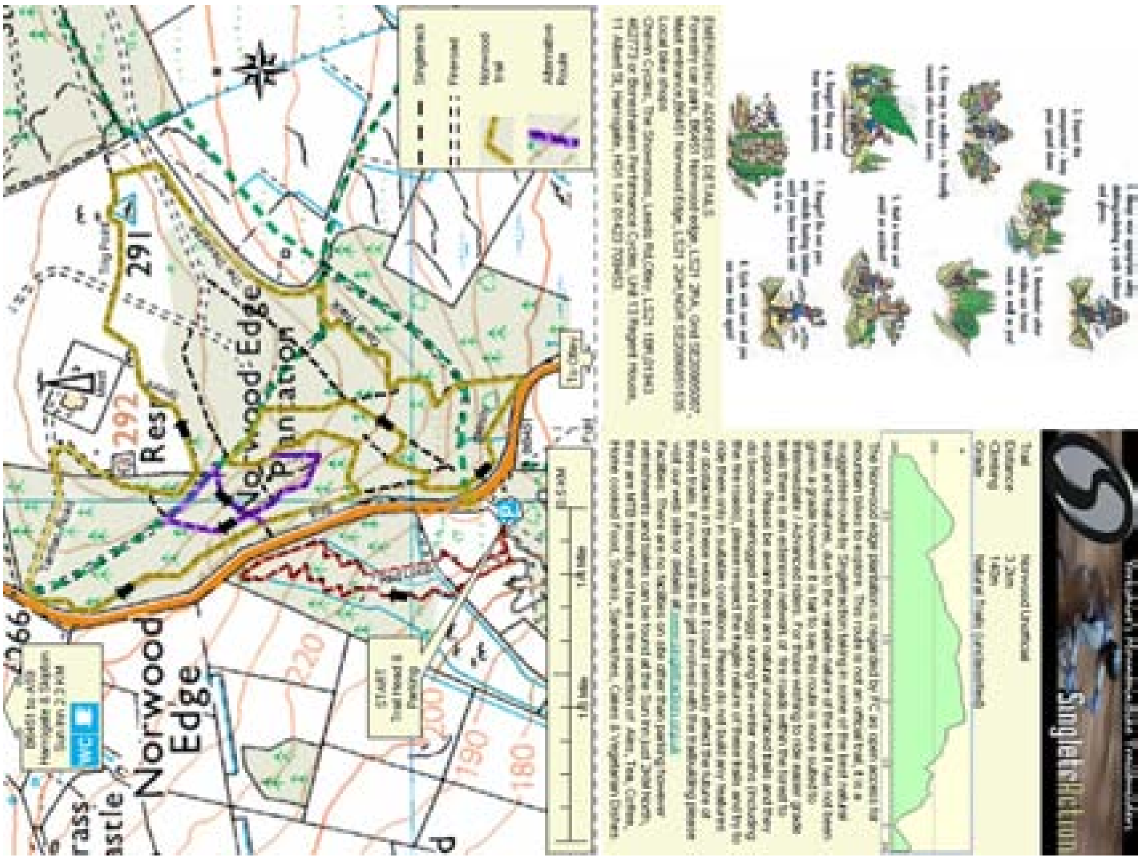

Glentrool
7 stanes
Forestry Commission Scotland


Taith Gerdded 1
Walk 1
4.5miles/7km (approx 2.5hours) clockwise


Key:

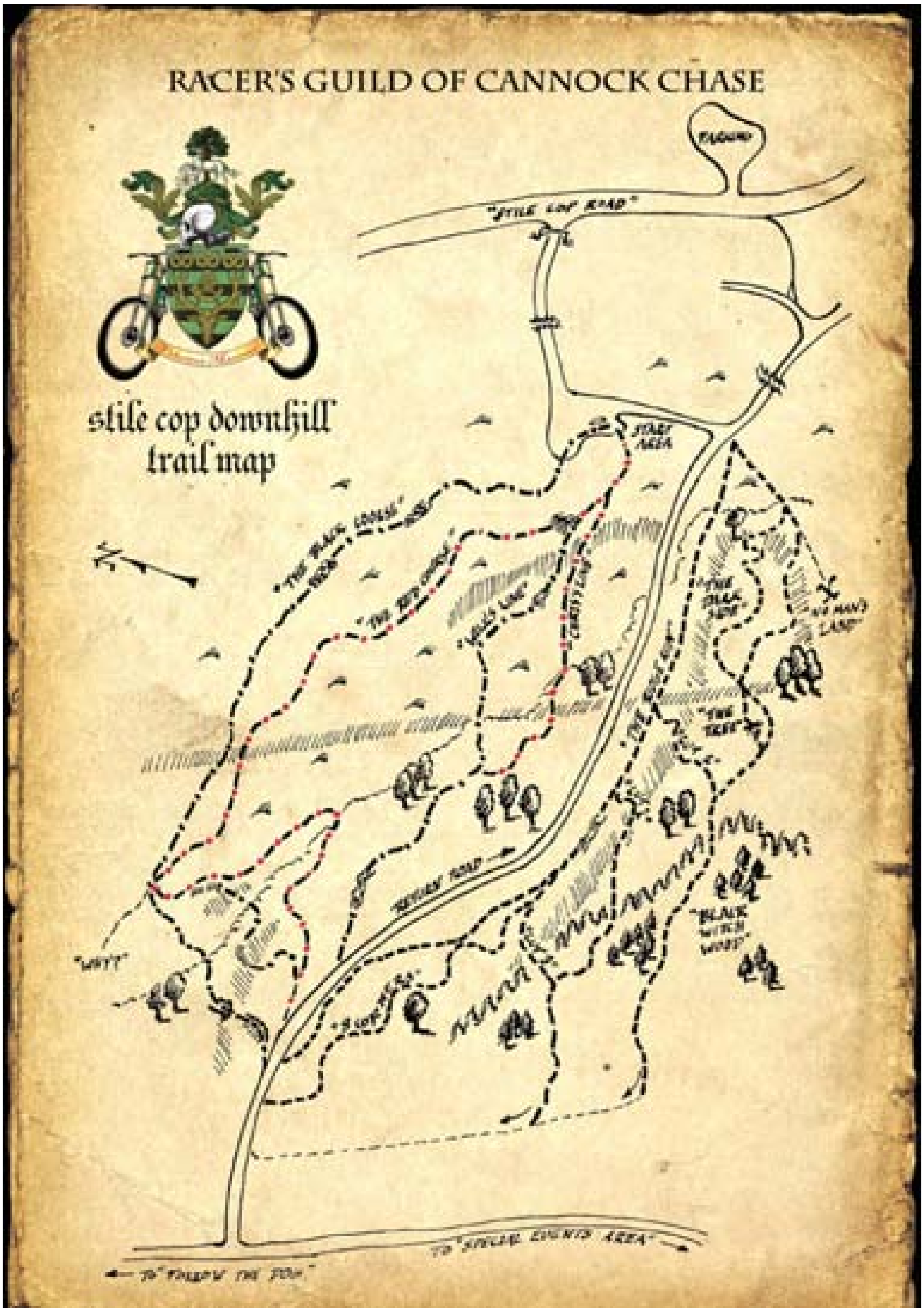

Dogs are welcome but must be kept under strict control at all times
PEMBREY FOREST
CEFN SIDAN BEACH
CEFN SIDAN BEACH
KEY:
Car parks No. 1-8
Beach Access Points A-F
ALLWEDD:
Meysydd Parcio Rhif 1-8
Pwyntiau Mynediad i'r Traeth A-F


6: Plas yn Rhiw - Llanbedrog
Pellter / Distance: 28.3km/17.6m




ARTHUR TRAIL
© Copyright: Shropshire Tourism


Lundy Island
ILFRACOMBE
Combe Martin
Mortehoe
Woolacombe
EXMOOR AND
THE NORTH
DEVON COAST
Georgeham
Croyde
BRAUNTON
Bratton Fleming
Brayford
TAW/ TORRIDGE
ESTUARY
BARNSTAPLE
Instow
BIDEFORD
SOUTH MOLTON
CLOVELLY
HARTLAND
Umberleigh
TAW VALLEY
TORRIDGE VALLEY
UPPER TORRIDGE
Langtree
Bradworthy
Chulmleigh
Dolton
Eggesford
Winkleigh
TAW VALLEY
Sheepwash
HATHERLEIGH
HOLSWORTHY
North Tawton
Jacobstowe
OKEMENT VALLEY
OKEHAMPTON
Sticklepath
N


RACER'S GUILD OF CANNOCK CHASE
stile cop downhill
trail map
"STILE COP ROAD"
TO "SPECIAL EVENTS AREA"

APPENDIX FOUR: BIBLIOGRAPHY

Appleyard, D. (1969). Why Buildings Are Known - Predictive Tool for Architects and Planners. *Environment and Behavior, 1*(2), 131-156.

Baddeley, A. D. (1986). *Working Memory*. Oxford: Oxford University Press.

Bartram, D. J. (1980). Comprehending Spatial Information - Relative Efficiency of Different Methods of Presenting Information About Bus Routes. *Journal of Applied Psychology, 65*(1), 103-110.

Burgess, N., Jeffery, K. J., & O'Keefe, J. (1999). *The hippocampal and parietal foundations of spatial cognition*: Oxford University Press.

Byrne, P., Becker, S., & Burgess, N. (2007). Remembering the past and imagining the future: A neural model of spatial memory and imagery. *Psychological Review, 114*(2), 340-375.

Coluccia, E., & Louse, G. (2004). Gender differences in spatial orientation: A review. *Journal of Environmental Psychology, 24*(3), 329-340.

Cross, K. D., Rugge, S. M., & Thorndyke, P. W. (1982). *Cognitive processes in interpreting contour line portrayal of terrain relief* (No. 429-1): Ancapa Sciences Inc.

Devlin, A. S., & Bernstein, J. (1997). Interactive way-finding: Map style and effectiveness. *Journal of Environmental Psychology, 17*(2), 99-110.

Desrocher, M., & Smith, M. L. (1998). Relative preservation of egocentric but not allocentric spatial memory in aging. *Brain and Cognition, 37*(1), 91-93.

Ekstrom, A. D., Kahana, M. J., Caplan, J. B., Fields, T. A., Isham, E. A., Newman, E. L., et al. (2003). Cellular networks underlying human spatial navigation. *Nature, 425*(6954), 184-188.

Epstein, R., & Kanwisher, N. (1998). A cortical representation of the local visual environment. *Nature, 392*(6676), 598-601.

Evans, G. W., & Pezdek, K. (1980). Cognitive Mapping - Knowledge of Real-World Distance and Location Information. *Journal of Experimental Psychology-Human Learning and Memory, 6*(1), 13-24.

Evans, G. W., Smith, C., & Pezdek, K. (1982). Cognitive Maps and Urban Form. Journal of the American Planning Association, 48(2), 232-244.

Farrell, M. J., & Robertson, I. H. (1998). Mental rotation and the automatic updating of body-centered spatial relationships. *Journal of Experimental Psychology-Learning Memory and Cognition, 24*(1), 227-233.

Fletcher, P. C., Frith, C. D., Baker, S. C., Shallice, T., Frackowiak, R. S. J., & Dolan, R. J. (1995). The mind's eye--precuneus activation in memory-related imagery. *Neuroimage, 2*, 195-200.

Gilhooly, K. J., Wood, M., Kinnear, P. R., & Green, C. (1988). Skill in map reading and memory for maps. *Quarterly Journal of Experimental Psychology Section a-Human Experimental Psychology, 40*(1), 87-107.

Hafting, T., Fyhn, M., Molden, S., Moser, M. B., & Moser, E. I. (2005). Microstructure of a spatial map in the entorhinal cortex. *Nature, 436*(7052), 801-806.

Hartley, T., Bird, C. M., Chan, D., Cipolotti, L., Husain, M., Vargha-Khadem, F., et al. (2007). The hippocampus is required for short-term topographical memory in humans. *Hippocampus, 17*(1), 34-48.

Hartley, T., Maguire, E. A., Spiers, H. J., & Burgess, N. (2003). The well-worn route and the path less travelled: Distinct neural bases of route following and wayfinding in humans. *Neuron, 37*(5), 877-888.

Hasson, U., Nir, Y., Levy, I., Fuhrmann, G., & Malach, R. (2004). Intersubject synchronization of cortical activity during natural vision. *Science, 303*(5664), 1634-1640.

Hermer, L., & Spelke, E. S. (1994). A geometric process for spatial reorientation in young children *Nature, 370*(6484), 57-59.

Iaria, G., Petrides, M., Dagher, A., Pike, B., & Bohbot, V. D. (2003). Cognitive strategies dependent on the hippocampus and caudate nucleus in human navigation: variability and change with practice. *J Neurosci., 23*(13), 5945-5952.
Inagaki, H., Meguro, K., Shimada, M., Ishizaki, J., Okuzumi, H., & Yamadori, A. (2002). Discrepancy between mental rotation and perspective-taking abilities in normal aging assessed by Piaget's Three-mountain task. *J.Clin.Exp.Neuropsychol., 24*(1), 18-25.
Janzen, G., & Van Turennout, M. (2004). Selective neural representation of objects relevant for navigation. *Nature neuroscience, 7*(6), 673-677.
Kawamura, S., Suzuki, S., & Morikawa, K. (2007). Short report: The affect of expertise in hiking on recognition memory for mountain scenes. *Memory, 15*(7), 768-775.
Kallai, J., Makany, T., Csatho, A., Karadi, K., Horvath, D., Kovacs-Labadi, B., et al. (2007). Cognitive and affective aspects of thigmotaxis strategy in humans. *Behavioral Neuroscience, 121*(1), 21-30.
King, J. A., Burgess, N., Hartley, T., Vargha-Khadem, F., & O'Keefe, J. (2002). The human hippocampus and viewpoint dependence in spatial memory *Hippocampus, 12*, 811-820.
Kozlowski, L. T., & Bryant, K. J. (1977). Sense of Direction, Spatial Orientation, and Cognitive Maps. *Journal of Experimental Psychology-Human Perception and Performance, 3*(4), 590-598.
Kulhavy, R. W., Schwartz, N. H., & Shaha, S. H. (1983). Spatial representation of maps. *American Journal of Psychology, 96*(3), 337-351.
Landau, B. (1986). Early map use as an unlearned ability. *Cognition, 22*(3), 201-223.
Lawton, C. A., & Morrin, K. A. (1999). Gender differences in pointing accuracy in computer-simulated 3D mazes. *Sex Roles, 40*(1-2), 73-92.
Levine, M., Marchon, I., & Hanley, G. (1984). The placement and misplacement of you-are-here maps. *Environment and Behavior, 16*(2), 139-157.
Lynch, K. (1960). *Image of the city*. Cambridge, Massachusetts: MIT Press.
Maguire, E. A., Burgess, N., Donnett, J. G., Frackowiak, R. S., Frith, C. D., & O'Keefe, J. (1998). Knowing where and getting there: a human navigation network. *Science, 280*(5365), 921-924.
Malinowski, J. C., & Gillespie, W. T. (2001). Individual differences in performance on a large-scale, real-world wayfinding task. *Journal of Environmental Psychology, 21*(1), 73-82.
McDonald, L., & Stuart-Hamilton, I. (2002). Egocentrism in older adults-Piaget's three mountains task revisited. Educational Gerontology, 28(1), 35-43.
McNamara, T. P., & Diwadkar, V. A. (1997). Symmetry and asymmetry of human spatial memory. *Cognitive Psychology, 34*(2), 160-190.
Milgram, S., & Jodelet, D. (1977). Way Parisians See Paris. *New Society, 42*(787), 234-237.
Morris, R. G. M., Garrud, P., Rawlins, J. N., & O'Keefe, J. (1982). Place navigation impaired in rats with hippocampal lesions. *Nature, 297*(5868), 681-683.
Nardini, M., Burgess, N., Breckenridge, K., & Atkinson, J. (2006). Differential developmental trajectories for egocentric, environmental and intrinsic frames of reference in spatial memory. *Cognition, 101*(1), 153-172.
Nardini, M., Jones, P., Bedford, R., & Braddick, O. (2008). Development of cue integration in human navigation. *Current Biology, 18*(9), 689-693.
Newcombe, N., Huttenlocher, J., & Learmonth, A. E. (1999). Infants' coding of location in continuous space. *Infant Behavior.and Development, Vol 22*(4), 483-510.
O'Keefe, J., & Dostrovsky, J. (1971). The hippocampus as a spatial map. Preliminary evidence from unit activity in the freely-moving rat. *Brain Res., 34*(1), 171-175.

O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map*. Oxford: Oxford University Press.
Ormrod, J. E., Ormrod, R. K., Wagner, E. D., & McCallin, R. C. (1988). Reconceptualizing map learning. *American Journal of Psychology, 101*(3), 425-432.
Packard, M. G., & McGaugh, J. L. (1996). Inactivation of hippocampus or caudate nucleus with lidocaine differentially affects expression of place and response learning. *Neurobiol.Learn.Mem., 65*(1), 65-72.
Pazzaglia, F., & De Beni, R. (2006). Are people with high and low mental rotation abilities differently susceptible to the alignment effect? *Perception, 35*(3), 369-383.
Potash, L. M., Farrell, J. P., & Jeffrey, T. (1978). A technique for assessing map relief legibility. *Cartographic Journal, 15*, 18-35.
Piaget, J., & Inhelder, B. (1956). The child's conception of space. London: Routledge & Kegan Paul.
Phillips, R. J. (1982). An Experimental Investigation of Layer Tints for Relief Maps in School Atlases. Ergonomics, 25(12), 1143-1154.
Phillips, R. J., De Lucia, A., & Skelton, N. (1975). Some objective tests of the legibility of relief maps. Cartographic Journal, 12, 39-46.
Phillips, R. J., & Noyes, L. (1978). An objective comparison of relief maps produced with the SYMAP and SYMVU programs. Bulletin of the Society of University Cartographers, 12, 13-25.
Phillips, R. J., Noyes, L., & Audley, R. J. (1977). Legibility of Type on Maps. Ergonomics, 20(6), 671-682.
Presson, C. C., & Hazelrigg, M. D. (1984). Building Spatial Representations through Primary and Secondary Learning. *Journal of Experimental Psychology-Learning Memory and Cognition, 10*(4), 716-722.
Raubal, M., & Winter, S. (2002). Enriching Wayfinding Instructions with Local Landmarks. In M. J. Egenhofer & D. M. Mark (Eds.), Geographic Information Science (Vol. 2478, pp. 243-259). Berlin: Springer.
Richardson, J. T. E. (1991). Gender differences in imagery, cognition, and memory. In R. H. Logie & M. Denis (Eds.), Mental Images in Human Cognition (pp. 271-303). Amsterdam: Elsevier.
Rossano, M. J., & Warren, D. H. (1989). Misaligned Maps Lead to Predictable Errors. *Perception, 18*(2), 215-229.
Rubin, K. H., Attewell, P. W., Tierney, M. C., & Tumolo, P. (1973). Development of Spatial Egocentrism and Conservation across Life Span. Developmental Psychology, 9(3), 432-432.
Sholl, M. J., & Egeth, H. E. (1982). Cognitive Correlates of Map-Reading Ability. *Intelligence, 6*(2), 215-230.
Sholl, M. J., & Nolin, T. L. (1997). Orientation specificity in representations of place. *Journal of Experimental Psychology-Learning Memory and Cognition, 23*(6), 1494-1507.
Siegel, A. W., & White, S. H. (1975). The development of spatial representation in of large-scale environments. In H. W. Reese (Ed.), *Advances in child development and behavior*: New York: Academic Press.
Taube, J. S., Muller, R. U., & Ranck, J. B., Jr. (1990). Head-direction cells recorded from the postsubiculum in freely moving rats. I. Description and quantitative analysis. *J.Neurosci., 10*(2), 420-435.
Thorndyke, P. W., & Hayesroth, B. (1982). Differences in spatial knowledge acquired from maps and navigation. *Cognitive Psychology, 14*(4), 560-589.
Thorndyke, P. W., & Stasz, C. (1980). Individual-differences in procedures for knowledge acquisition from maps. *Cognitive Psychology, 12*(1), 137-175.
Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychol.Rev., 55*, 189-208.
Trowbridge, C. C. (1913). On fundamental methods of orientation and "Imaginary maps". *Science, 38*(1), 888-897.

Tulving, E., & Markowitsch, H. J. (1998). Episodic and declarative memory: role of the hippocampus. *Hippocampus, 8*(3), 198-204.
Tversky, B. (1981). Distortions in Memory for Maps. Cognitive Psychology, 13(3), 407-433.
Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of Sex-Differences in Spatial Abilities - a Metaanalysis and Consideration of Critical Variables. Psychological Bulletin, 117(2), 250-270.Waller, D., Loomis, J. M., Gollege, R. G., & Beall, A. C. (2000). Place learning in humans: The role of distance and direction information. *Spatial Cognition and Computation, 2*, 333-354.
Wraga, M., Creem, S. H., & Proffitt, D. R. (2000). Updating displays after imagined object and viewer rotations. J.Exp.Psychol.Learn.Mem.Cogn, 26(1), 151-168.
Warren, D. H. (1994). Self-localization on plan and oblique maps. *Environment and Behavior, 26*(1), 71-98.
White, N. M., & McDonald, R. J. (2002). Multiple parallel memory systems in the brain of the rat. *Neurobiol Learn Mem, 77*(2), 125-184.