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'Locating trees in the Caledonian forest': A critical assessment of methods for presenting series mapping over the web

Keywords: Series mapping, Internet accessibility, web-mapping, usability

Summary

This paper reviews the principal methods currently used for presenting series mapping over the Internet and evaluates each before focusing on the National Library of Scotland's use of these methods as a case study. A critical assessment of these alternatives follows, partly based on website statistics and a usability study undertaken in 2005. Results are then drawn together and interpreted to form some general recommendations for the online presentation of series mapping.

"The world portrayed on our information displays is caught up in the two-dimensionality of the endless flatlands of paper and video screen. Escaping this flatland is the essential task of envisioning information - for all the interesting worlds (physical, biological, imaginary, human) that we seek to understand are inevitably and happily multivariate in nature. Not flatlands."

E. Tufte (1990: 12)

Introduction

Although the vast majority of cartographic materials form part of a set or series, relatively little attention has been devoted to their special characteristics and requirements. Well before the advent of computer technology, map series were generally regarded separately and treated badly; often uncatalogued or at best accessible only by the initiated with perseverance, they were often under-researched, under-utilised, and misunderstood. The advent of digital technologies for making series mapping available has in some ways compounded these problems, as similar assumptions, techniques and metaphors were carried forward into an online arena. Yet digital technologies allow several new possibilities for addressing or reducing the difficulties of making series mapping accessible and available. This paper attempts to contribute ideas and examples to address this apparent paradox of series mapping, that in spite of the importance quantitatively of these cartographic materials, they are the most invisible in our online environments, either as records, indexes or original map images. They merge into Edward Tufte's "information flatlands".

For the purposes of this paper, series mapping is defined very broadly and generally as any cartographic entity that has more than one component, therefore including not only the conventional topographic map series, with a regular scale, title, and series designation, but also multi-sheet maps, atlases, and serials. The important connective thread between these disparate forms is their multi-level characteristic, the fact that any one component part or map forms part of a greater

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whole, as a tree within a forest, as this presents special requirements or opportunities for their presentation and accessibility.

The tools for accessing series mapping in the non-digital world have traditionally been either text-based lists or graphic indexes. In a digital world, both of these methods still have value and with modification, can extend and enhance the effectiveness of their hard-copy equivalents. New technologies in dynamic mapping services, using technologies to crop and geo-reference, and geospatially index component images extend the value even further. These newer methods have no off-line equivalent or antecedent, but they have tremendous capabilities to not only locate desired "trees within the forest" in numerous ways, but to view and interact with these "trees" once located.

Digital access methods

Text

At first glance, there may seem little to say about textual lists, they are so obvious, essential and taken for granted, but in fact, there are many reasons why their correct use and interpretation should be considered. Ordering and arrangement has always been at the heart of information delivery, and in an online environment where ease of use, efficiency and speed are even more important (and scrolling lists and pages to be minimised), a list in a sensible order is even more valuable. Although more time-consuming, it is often the case that the best lists need to be created manually, avoiding the problems of auto-generated lists with correct but often less meaningful ASCII ordering. Frequently, more than one ordering is useful, whether alphabetical, chronological, or by arrangement in the order of the original (for example, pages in a book), with the related need to browse/scroll in this order. Yet multiple orders require multiple choices for access, which in themselves create complexity and potential confusion. (Some users may prefer one sensible order laid before them than a choice requiring mental effort, a point borne out by observation).

The growing dominance of Internet search engines in their capabilities and usage has necessarily transformed the thinking about access in all website design. The inherent search methods of the site itself, its internal architecture and presentation have arguably been superseded by the ability to provide good indexable textual content on pages to allow direct hits/access from outwith the site. This shift has not only enhanced the importance of textual lists and content for retrieval purposes in technical terms, but also enhanced them through following the dominance of textual thinking that the Internet search engines encourage in users.

There are many advantages of textual lists for accessing series mapping. In spite of the need for manual typing rather than auto-generation, they are relatively cheap and easy to create. They consume the lowest bandwidth of all, they are most accessible through all browsers and by any disabled reader. They are the most retrievable of all by Internet search engines, and for this reason alone perhaps should be regarded as essential where sheet titles carry meaning. For most users, they are the most simple, intuitive and efficient access method, and represent their original authentically, for example as lists of contents or as author/title/place-name indexes.

Static images

Although those who work with maps are perhaps too inclined to praise graphic over textual literacy, it might reasonably be assumed that those wanting to find maps in general prefer using graphical methods to do so. With good reason, graphic indexes have a long history - the earliest printed example is believed to be by Philipp Apian in 1568 as a guide to his 24-sheet *Bairische Landtaflen* (Wallis and Robinson 1987). The simplest form of creating a graphic index map for digital use is via scanning; the resultant static image may then be presented as a JPEG or PDF file. Making these scanned images “clickable” through client-side imagemaps is a further enhancement. In this case, map data is stored in the HTML for the page between <MAP></MAP> container tags and clickable or “hot” regions defined by standalone <AREA> tags. The hot regions, associated with a particular sheet or series component, can be made more intelligible and interactive with mouse-over ALT tags, with an associated HREF link to the sheet itself. A simple desktop scanner can create the graphic image, and simple software (such as *Mapedit* from *Boutell.com* - free for educational/non-profit use) can allow the coordinates for a clickable index to be created within minutes.

One of the essential problems of all computer graphics is the fact that whilst a high-resolution printer can display between 1200 to 3400 dots per inch (dpi), a computer monitor can only display about 65-120 dpi. A second obvious problem is that of size, that typically only 14” to 21” in diagonal extent can be viewed on screen at one time. Many clear and useful hard-copy graphic indexes are therefore too large and too detailed to be successfully presented on a screen. To reduce this limitation, new graphic indexes can be drawn electronically, and as for scanned indexes, presented as standalone graphics or as clickable indexes. Jensen, Musser and Andrew (2004) explain how this has been done at Pennsylvania State University using *ArcView* GIS to create series map rectangles, and using the *Digital Chart of the World* for the outline base map. Buhler (2005) describes a similar use of the *Toporama* program developed by Joachim Lamatsch in Freiburg (Germany), again using *ArcGIS* to create electronic index sheets. Although involving more time, effort and commercial software compared to scanned indexes, the result is usually clearer, more flexible, and free of copyright concerns.

The advantages and disadvantages of the graphic index, whether scanned from paper or born-digital, are similar to those of maps in general. For some they are evidently simpler, easier and more intelligible than any textual index, presenting components in their correct spatial context. Where sheet titles have no semantic value (Sheet 1, Sheet 2, etc.) they are obviously essential. Against this must be weighted the fact that many people do not “think graphically”, and the knowledge that perhaps as many as 60% of people can’t even read maps (Peterson 2003: 306). Another disadvantage is the additional time and costs of their creation, especially for born-digital indexes, which also require some expertise in a suitable GIS. Once created, born-digital indexes are more flexible to maintain and update, either with new sheets, new base mapping, or a different design, but clickable image maps in general are less flexible, being specific to the coordinates of a particular graphic, so it is usually only easy to add or subtract particular hotspots.

A further problem, of most importance for retrieval, is that graphic images by themselves are invisible to search engines, and only appear on the information landscape through additional textual content, taking time to add and then still only of indirect value. Finally, for users, images consume bandwidth, although this is steadily less of a problem than it used to be, and the bandwidth is less than in dynamic mapping applications (discussed below). However, it should not be forgotten that graphics are relatively large and can create accessibility problems for visually impaired users.

Dynamic Indexes and Maps

In the last few years, dramatic new possibilities have opened up in web-mapping, integrating the power of GIS with the ability to present geospatial data dynamically over the Internet. As for static clickable maps, a number of possibilities present themselves:

i) whether to use non-georeferenced or georeferenced data;

ii) whether to present just the index to the series as a selectable layer, and/or the components of series itself seamed together; and

iii) whether to integrate search methods and present results dynamically from multiple web servers.

McGlamery (2005) illustrates several aspects of dynamic series mapping applications, in his description of the collaborative project relating to the Austro-Hungarian topographic maps (1877-1914). The project scanned and compressed original images of the maps, cropped each image and georeferenced it, creating bounding rectangles, and presenting both maps and rectangles as zoomable map layers. It required access to high-resolution scanners and imaging software, GIS, a web-mapping server, in this case ESRI's *ArcIMS* and *ArcSDE*, and associated metadata software (*MetaLite for Librarians*), quite apart from good resources of skilled staff time. The results are impressive, not only in making available a series of paper maps as a seamless layer, but also in allowing considerably improved search and retrieval of these maps, once geo-referenced, using gazetteers and modern mapping.

From 2001, the development of specifications for Web Mapping Services (WMS) and Web Feature Services (WFS) by the Open Geospatial Consortium (OGC) have allowed the sharing of raster map images and features respectively between separate web server applications. This allows the functionality relating to the search or display of series mapping to be shared or combined from geographically-dispersed web servers. For example, a search interface with gazetteers, postcodes or modern maps could create a WFS query to another web server for series maps or records which relate to this area. Similarly, a seamless set of geo-referenced series maps could be retrieved through a WMS query from another mapping application of a particular area or section of this seamless layer (Mitchell 2005).

This functionality is similar in the context of series mapping to the possibilities popularised by the Google Maps API (Erle and Gibson 2006). This allows base mapping and aerial photography provided by Google Maps to be integrated with other data and/or enhanced functionality in applications on any other remote web server. Coordinates for series mapping could be presented as an overlayed layer of rectangles and linked to original sheet records or maps through customised Javascript commands.

Dynamic mapping applications can overcome many of the visual shortcomings of static graphic indexes, through presenting multiple layers and scales of zoomable mapping. They supersede traditional offline search methods by allowing the ability to integrate the equivalent of gazetteers, atlases, and maps along with the graphic index in one application. They are much more flexible, if the interface needs to be changed, if different mapping or search facilities are required, or in allowing modifications to series and sheet coverage. Finally, they allow the potential for dynamic online collaborative applications, synthesizing the best of selected applications.

Unfortunately, the costs of creating these applications, in terms of software, expertise, and time, are by far the greatest of all. Cropping and seaming together series mapping is labour-intensive, and the resulting image sizes require powerful servers and specialised software. It goes without saying that web-mapping applications are heavy users of bandwidth, even through there a growing number of techniques for reducing this overhead. Given the fact that most of the indexable content of the application is currently invisible to search engines, dynamic web-mapping is hard to discover through these, a disadvantage only slightly reduced by the growing number of metadata catalogues and spatial data infrastructures. Finally, for users, most dynamic web-mapping applications are undoubtedly more complicated than static graphic indexes and textual methods. All these points are summarised in Table 1 and illustrated below in the context of the National Library of Scotland (NLS).

Series mapping from the NLS Maps website (http://www.nls.uk/maps)

From 2001, the NLS Maps website has grown to deliver over 6,000 historical maps of Scotland relating to the time period from 1560 to 1928. Included are maps of Scotland, county maps, town plans, marine and bathymetrical charts, military maps, and early manuscripts. Series mapping forms the bulk of this total quantitatively, with several Ordnance Survey maps series, atlases, and multi-sheet maps, and in total, about 100 graphic indexes (Fleet 2003). From the early development of the site based on the Pont manuscript maps (Fleet 2001), to more recent developments using web-mapping technology, the primary motives of making available mapping in a clear, intuitive and pleasing way have been constrained by limitations of funding, time and expertise. For this reason, the site is useful in illustrating real-world compromise as it illustrates how several of the approaches have been executed.

Table 1. Comparison of the main methods of presenting series mapping

		Ease of use	Aesthetics	Retrieval by search engines	Scalability/ flexibility	Authenticity	Small size / Low band-width	Low Cost	Ease of creation	Ability to synthesize geo-referenced information
2.1 Textual lists		✓	✕✕	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✕✕
2.2.1 Static clickable images	Scanned/original graphic index	✓✓	✓	✕	✕	✓✓	✓	✓✓	✓✓	✕
	Created/born digital graphic index	✓✓	✓✓	✕	✓	✓	✓	✓	✓	✕
2.2.2 Dynamic zoomable mapping	Ungeoreferenced	✓✓	✓✓	✕	✓	✓✓	✕✕	✕	✕	✕
	Georeferenced	✓✓	✓✓	✕	✓✓	✕	✕✕	✕✕	✕✕	✓✓

The site has used a growing range of access methods to series mapping, developed largely in an ad hoc manner. Originally, textual lists formed the main method, often partly generated from image database listings and supplemented by scanned clickable graphic indexes (eg. the Ordnance Survey town plans). Effort was made to keep all these graphic image sizes to below 30 kilobytes, recognising that at 28.8 kbps basic modem speeds, these would still take 12 seconds to load. Often, therefore, clarity and legibility were sacrificed, and other methods, including nested multi-levels of graphic index (eg. for the OS Town Plan of Glasgow (1857-8)) and the creation of graphic indexes in-house, were increasingly adopted where possible (eg. Taylor & Skinner's Road Atlas (1776)). Multi-sheet maps have been traditionally and quite effectively presented as a set of thumbnails laid out within an HTML table (eg. Black's new large map of Scotland [1862]), whilst scrolling buttons for navigation have been added for items within a volume (eg. Blaeu Atlas of Scotland (1654)). From 2004, NLS was able to take advantage of an Ordnance Survey Pan Government Agreement to use modern digital mapping and gazetteers to form a geo-referenced interface using ArcIMS (Fleet 2005). This has allowed two geo-referenced series mapping applications to be developed using dynamic zoomable mapping, all at http://geo.nls.uk. A third project, that has involved scanning, cropping and geo-referencing the Ordnance Survey first edition 1:10,560 maps of Scotland is currently underway and available at: http://www.nls.uk/digitallibrary/map/os6inch/

Analysis of preference by website statistics

During 2005, the main NLS Map home page recorded 2,393,811 hits and 7,163,800 map image views. Log files of website hits provide useful statistics on routes users are taking through the site, and their preference for accessing series maps by textual methods, graphic indexes or dynamic zoomable maps. The figures themselves need to be interpreted in context as site architecture, the presentation of choices, their ordering, and terminology all influence the preference of one method over another, and also deficiencies in a particular list or graphic index may explain a decision to avoid it, rather than the nature of the medium itself. Nevertheless, the somewhat surprising result, is that textual methods were found to be significantly more popular than graphical methods to access series mapping.

For the pages presented in Appendix A, a graphic index was presented as a secondary choice to the main text list in alphabetical or sheet index order, so the results are skewed in favour of the latter. However, the results are still surprisingly skewed, even when adjusted to compensate for this, with only one example where nearly one third of users preferred a graphic index. To most map users, a graphic index showing sheet coverage across a country would surely be chosen in preference to a list of sheet titles in sheet order, but in practice, over 80% of users prefer the text list when presented like this. In searching for maps of counties or of towns, where one would expect the majority to know the relevant names, the statistics indeed confirm that 96-97% choose names over clickable maps. But for items with an irregular spatial extent, such as hydrographic charts or roads, where maps should be inherently more meaningful, the results were even more skewed in favour of textual titles of charts or map plates.

What are perhaps more judicious results may be gleaned from sites allowing a choice of search methods from the opening page (Appendix B). Here the results were more mixed, showing the same general preference for textual and keyword searches, but falling back on maps where these proved difficult. In the *Blaeu Atlas of Scotland* (1654) website, where those searching for textual county descriptions could choose five options, most (34%) chose the keyword-in-box method, followed by the textual place-names index (25%), and the personal names index (16%) before the graphical map of regions (13%). However, the map of regions was preferred to their textual listing, perhaps reflecting the lack of knowledge of the older 17th century regional extents. For the related map search option, when there was no option for keyword search or indexes of place names or personal names, the map search was again marginally preferred (53%) over the text search by region name.

John Home's *Survey of Assynt* (1774) echoes this point, where 53% chose to search by map, compared to 47% by farm name. Arguably the NLS Map Library's graphic design skills had improved by this time, but the results more likely reflect the difficulties most users have with Gaelic farm names in this area, and perhaps the irregular extent of farms.

For the *Bathymetrical Survey of the Fresh Water Lochs* (1897-1909), one might expect that users with a specific loch in mind, would search by an alphabetical ordered list of lochs, and indeed, some 61% do so. A quarter of users chose the dynamic zoomable mapping option, surely in theory the easiest way of searching for smaller lochs with unknown or ambiguous names in a specific geographical area. This was not much greater than the remainder (16%) who chose to search by the textual river basin name.

Analysis of preference by usability studies.

In early 2005, NLS contracted an external company to perform a usability study on the ArcIMS web-mapping application. Eight representative users were asked to perform representative tasks with the application; their interaction was observed and recorded on video, and a post-task interview and questionnaire were completed to obtain feedback. The full range of findings are not directly relevant to this paper, but in that the web-mapping technology is one method of accessing series mapping, this aspect is of interest here.

In general the users all found the site too complex, and ignored much of the functionality or did not use it correctly. In an attempt to design the site to illustrate the potential of the technology, its creators perhaps ignored the virtue of simplicity and the need to reduce confusion. Most reported that the range of search methods, such as by gazetteer, postcode, and county/parish, in conjunction with the main map created a cluttered and complex interface. Many of the standard web-mapping icons for buttons, such as that those for panning, zoom by rectangle, and selection rectangle search were poorly understood, even with mouse-over explanations. Users found the site annoying and frustrating, taking too long to find information, and hard to navigate. More than one user commented that if there was a more familiar and straightforward way of searching, like a text search, they would choose that over dynamic mapping.

Part of these results can be explained by deficiencies in this particular interface design, as well as the lack of instructions, and a confusion between the tools for searching and the tools for selection. It also may reflect too the relative novelty of online map searching, in spite of the popularity of map websites such as MapQuest/MapBlast/Google Earth and Maps. One must also not generalise too far from one usability study of eight users. It is felt, however, that the study does reflect something of the innate preferences of users, their desire for simple, quick results, and the fact that given these preferences, textual search methods are preferred by a majority. This result is more alarming when one remembers that often the simple textual search methods deliver a poorer and less comprehensive result in this case for series mapping than graphical, map-based alternatives.

Discussion and recommendations

The experience of designing and using the established three methods for accessing series mapping, combined with the observations of website statistics and usability studies, suggests some general recommendations.

First, the experience at NLS points to the continuing and growing need for a range of methods for accessing series maps. Where choices are provided, textual lists, a range of static graphics, and zoomable maps are all used, and each offer particular advantages. The choice of method and mix would depend on a range of criteria, not least the size of the series and its importance, the broader context of the website, and especially the institutional resources, expertise and time available.

A second recommendation relates to the importance of designing the website for multiple entry points. Within the last few years, the predominance of search engine access has increasingly bypassed the website's own search/browse mechanisms. This has not only tended to emphasise textual lists over graphical alternatives, and reduced the relevance of all the site-specific access methods described in this paper, but also heightened the importance of good navigational guides, site diagrams, scrollable buttons for browsing, and links to related components. For series mapping, it is important that users are aware of the broader context; a holistic understanding of the component as a part of a greater whole, rather than as an individual item, is crucial for properly appreciating its information value. Although web presentation of series mapping demands a reformulation of traditional techniques, much historical expertise, theory and literature and its conclusions are very relevant in the online environment. For example, Jacques Bertin's *Semiologie Graphique* (1967) with its classification of the six retinal variables in visual communication (size, value, texture, colour, orientation and shape) is still fundamentally useful in designing a good online graphic index, with form and colour of most use in differentiating this qualitative information. Similarly, Edward Inhof's rules of colour provide useful principles for creating aesthetically pleasing and intuitive graphic index images (Imhof 1982: 72-3). The preference for textual searching described here for the NLS website in part reflects aesthetic shortcomings in the graphic indexes and dynamic mapping applications. Good graphic design should make it a pleasure to visit a particular site, with the design serving the main purpose.

In spite of the difficulties of anticipating future technology, there are real advantages in transcending traditional metaphors of series map searching. For some, dynamic zoomable maps with overlaid series rectangles, and with other geo-referenced search methods move beyond the confines of the traditional static graphic index. In that geo-referenced search methods - textual (gazetteer, postcode, Grid Reference, etc.) and graphical can all define a location with coordinates, these coordinates can then match and retrieve geo-referenced sheets in a series. Given the clear preference by many - at the very least a significant minority - for keyword text search in boxes, avoiding maps, to retrieve sheets, surely it will not be long before web designers or search engine companies will create this functionality as well? A simple text search box for a place name or postcode could retrieve the relevant sheet in a series without the need for a graphic index or understanding a web-mapping interface (Figure 1). The integrative possibilities of WMS/WFS and related dynamic sharing of web-mapping applications and data allow a range of novel search methods, especially if more map series coordinates could be made available at affordable prices. For example, translating GEODEX records from the American Geographical Society (McGlamery 2005) or using MODMAP series records from the UK Defence Geographic Imagery and Intelligence Agency (Antonelli 1999).

There is no prescriptive solution to presenting series mapping over the web, but a growing range of possibilities each with strengths and weaknesses. The disparities in what is affordable and achievable technologically are growing, and there is no doubt that impressive results can be obtained with dynamic, geo-referenced applications through big investments of money and time. That said, the experience of the NLS website confirms that simple, basic access methods and records also have enduring value. The most important point in making these approaches successful is a conceptual one, of appreciating the importance of allowing proper access to the part within the whole, so that it can be understood in context, and of communicating the multi-dimensional nature of the original to the user. There much to be done to make series maps rise up out of their current "informational flatlands", but the possibilities for doing so are steadily greater, provided their special qualities and requirements are understood.

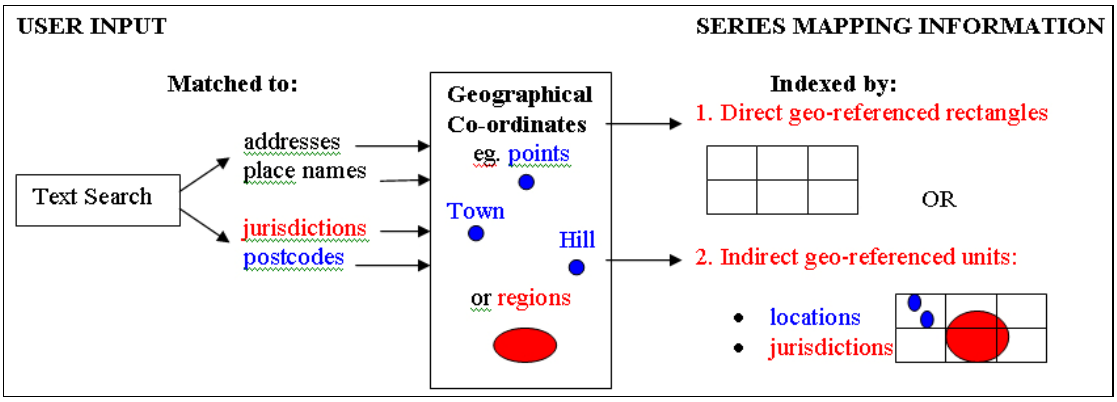

Figure 1. Illustration of geo-referenced search and retrieval based on text.

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Appendix A

For these choices below, the first page by default was a textual list, from which a graphic index could be chosen, so in calculating the percentages, the page hits of the graphic index have been deducted from the textual list page. However, the design of the site deliberately favoured the textual list.

OS Scotland One-Inch Popular edition -text graphic index (http://www.nls.uk/digitallibrary/map/early/os_scotland_popular_list.html)	20,499 3,037	83% 17% **100%**
OS Scotland 2nd edition with colour parishes graphic index (http://www.nls.uk/digitallibrary/map/early/os_scotland_2nd_ed_list.html)	18,422 4,245	70% 30% **100%**
Bartholomew Survey Atlas - list of sheets graphic index (http://www.nls.uk/digitallibrary/map/early/bartholomew_survey_atlas_list.html)	12,304 874	92% 8% **100%**
Taylor & Skinner Road Atlas (1776) - contents list graphic index (http://www.nls.uk/digitallibrary/map/early/taylor_and_skinner_list.html)	7,728 889	87% 13% **100%**
Admiralty Charts - text list graphic index (http://www.nls.uk/digitallibrary/map/early/admiralty_charts_list.html)	5,804 725	86% 14% **100%**
Search by county list clickable county map (http://www.nls.uk/digitallibrary/map/early/counties.html)	79,430 3,019	96% 4% **100%**
OS town plans of Scotland textual list of town names clickable map of Scotland (http://www.nls.uk/digitallibrary/map/townplans/townplans.html)	 326,757 9,185	 97% 3% **100%**

Appendix B

For these examples of series mapping, the opening page presented a choice of textual or graphical methods.

Bathymetrical Survey of the Fresh-Water Lochs of Scotland (1897-1909) (http://www.nls.uk/digitallibrary/map/early/bathymetric/index.html) Opening page allows a choice (in this order) of searching: • By Loch Name - alphabetical list (text list) • By River Basin Name - alphabetical list (text list) • By zoomable map of Scotland (dynamic map)	10,983 2,915 4,203	61% 16% 23% **100%**
Blaeu Atlas of Scotland (1654) (http://www.nls.uk/digitallibrary/map/early/blaeu/blaeu_atlas_index.html) Opening page allows a choice (in this order) of searching: Search for maps in atlas • Browse maps graphically • Browse maps by list Search for texts in atlas • Browse texts graphically • Browse texts by list • Browse texts by place name • Browse texts by personal name • Search the texts (by keyword search in box)	3,080 2,689 1,241 1,036 2,259 1,350 2,983	53% 47% **100%** 13% 12% 25% 16% 34% **100%**
John Home's Survey of Assynt in 1774 (http://www.nls.uk/digitallibrary/map/early/assynt/index.html) Opening page allows a choice (in this order) of: By Farm Name - by order within volume By Map of Assynt	2,352 2,757	46% 54% **100%**