Coastal Informatics:
Web Atlas Design and Implementation

Dawn J. Wright
Oregon State University, USA

Ned Dwyer
University College Cork, Ireland

Valerie Cummins
University College Cork, Ireland

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Section 1
Principles

Chapter 1
Introduction

Dawn J. Wright
Oregon State University, USA

Valerie Cummins
University College Cork, Ireland

Edward Dwyer
University College Cork, Ireland

ABSTRACT

Coastal web atlas (CWA) development is introduced in this chapter as a relatively new field of technology, driven by a wide range of coastal policy issues such as population pressure and climate change. International interest in CWAs is demonstrated by the large number of CWA initiatives worldwide. However, there is a need to take stock of technological developments as well as other lessons learned. This chapter sets the scene in relation to these issues which in turn provides the context for describing the aims of the book. The aims of the book are articulated as presenting the latest developments in CWAs and helping readers to determine future needs in mapping and informatics for coastal management.

COASTAL WEB ATLASES DEFINED

In recent years significant momentum has occurred in the development of Internet resources for decision makers, scientists and the general public who are interested in the coast. Governments, industry sectors, academic institutions and non-governmental organizations (NGOs) have a tremendous stake in the development and management of geospatial data resources. Coastal mapping plays an important role in informing decision makers on issues such as national sovereignty, resource management, maritime safety and hazard assessment. A key aspect of this trend has been the development of coastal web atlases (CWAs), based on web-enabled geographic information systems (GISs, Figures 1 and 2). A CWA is defined in O'Dea *et al.,* (2007) as: *a collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, all of which are accessible via the Internet.* These atlases organize and coordinate all of the above through a single portal or entry point, with a common design theme that is followed through all of the pages of a CWA site.

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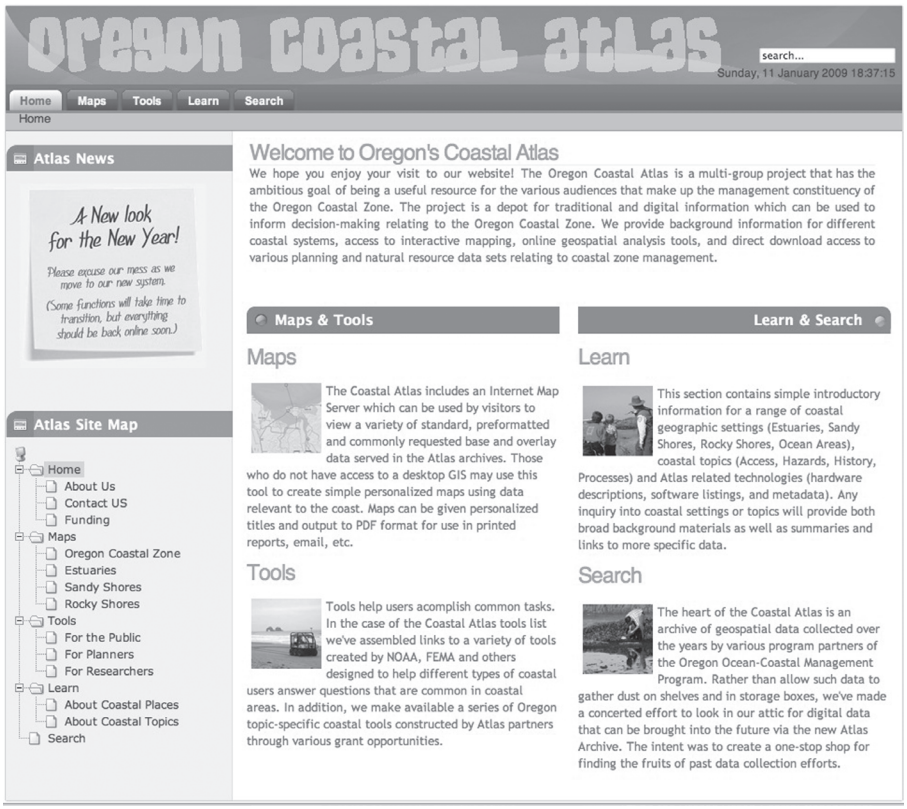
Figure 1. Example of a coastal web atlas, the Oregon Coastal Atlas, http://www.coastalatlas.net, showing opening page with map, tools, learn, and search sections



CWAs are also defined in Tikunov *et al.* (2008) (termed there as "atlas information systems") and with regard to their increasingly important role in national spatial data infrastructures (SDIs).

CWAs deal with a variety of thematic priorities (e.g., oil spills or recreational uses) and can be tailored to address the needs of a particular user group (e.g., coastal managers or educators). There are many benefits that CWAs can provide, including:

- **A portal** to coastal data and information from **diverse sources**;
- **Up to date** geospatial data which is frequently changing;
- A widely **accessible** coastal resource to a broad audience;
- A comprehensive and searchable **data catalogue**;
- Improved **efficiency** in finding data and information;
- An instrument for **spatial planning**;
- **Interactive tools and resources** which empower users to find their own answers;
- An **educational resource** which raises people's consciousness about coastal topics.

Driving factors for CWA development include the need for:

- Better planning to cater for increased **population pressures** in the coastal zone (e.g., the UN estimate that by 2020 75% of the world's population will be living within

Figure 2. Example of a coastal web atlas, the Oregon Coastal Atlas, http://www.coastalatlas.net,showing polygons of rapidly moving landslide regions resulting from a coastal hazard query.

60 km of the coastal zone; United Nations, 1992; also World Resources Institute, 2001; Shi and Singh, 2003).

- Decision support systems in relation to **climate change** scenarios in vulnerable coastal regions.
- Information to facilitate assessments of **risk to natural hazards** (including tsunamis and floods).
- Access to data and maps to support **marine spatial planning** (MSP) as a tool for better coastal and marine area management (e.g., European Commission, 2007).
- Access to relevant data and information in coastal and ocean **capacity-building** initiatives worldwide, especially for effective **governance**, sustained economic support, and education and training opportunities (e.g., National Research Council, 2008).
- Maps of jurisdictional boundaries for maritime territories in support of claims related to the **United Nations Convention on the Law of the Sea** (UNCLOS), which has a deadline for submission of 2013.
- Information on **resource availability and exploitation** including habitat and species information, and ecological and community resilience as part of ecosystem-based management.
- Spatial information to underpin the development of **emerging offshore sectors** such as ocean energy, offshore aquaculture and marine bio-discovery.

SCIENTIFIC AND RESOURCE MANAGEMENT CONTEXT

The driving factors mentioned above have already resulted in the proliferation of CWA projects (such as those introduced in Section 2 of the book) that have been designed to address thematic (e.g., fisheries management, recreational use) or spatial areas of interest (e.g., country to local level). Important questions asked and potentially answered by coastal web atlases (given sufficient data and personnel), include these (in the realm of coastal erosion as an example):

From a coastal scientist…

1) What is the geomorphic evolution of the coast?
    a. What historic photography, geomorphology profiles, LIDAR surveys, shoreline surveys are available for study?
2) How many major erosion events due to severe storms have occurred within a defined section of shoreline in the past 50 years?
3) How have anthropogenic activities impacted natural coastal erosion processes?
4) Can a predictive model of hot spots be developed with the data available?

From a coastal resource manager…

1) What are the erosion rates along a geographically defined stretch of shoreline?
    a. Where are erosion hot spots based on geology and wave action?
    b. Where are erosion hot spots conflicting with human uses of the coast?
    c. For a defined planning window (e.g., 25 years) what is the anticipated extent and magnitude of coastal erosion risk along a designated stretch of shoreline?
    d. What is the potential for new development in the above designated risk zones? What actions can be taken to avoid, minimize or mitigate the placement of new development in predicted high-risk zones?
2) Where is the potential for habitat loss due to coastal erosion a significant risk?
    a. Where are ecologically vulnerable areas such as essential fish habitats, wetlands, beaches, wildlife refuges and conservation areas?

From a coastal private property owner…

1) What is the erosion rate along my stretch of shoreline?
    a. How close is my home to "the edge"?
    b. Will my home survive to the end of my mortgage?

From an emergency responder…

1) How big is an incoming storm / erosion-causing event?
    a. How do I alert affected areas?
2) What public infrastructure is threatened by chronic or severe erosion events (e.g. transportation networks, pubic utilities (waste water treatment facilities, power plants, etc.)?
3) Where are the best evacuation routes during major coastal storm events?

From a coastal geographic information scientist/data analyst…

1) What data and information can I make accessible regarding coastal erosion?
    a. What feature categories (historic photography, geomorphology profiles, LIDAR surveys, shorelines, plant/animal species, surveys etc.) exist in a designated area?
    b. Where do existing data reside? Can my system access the data?

   c. Can the data be shared (data ownership, permissions, licensing)?
   d. How well are existing data documented (reports, metadata), and does the documentation support the potential future uses of the data by my intended audience?
2) What analysis or visualization tools can I provide that can make use of available data to answer common questions from my audience(s) regarding coastal erosion?
3) Can I extract information from the atlas network to bolster data available to support coastal issues within my own program? Are current inventories sufficient?
4) Does my area of Interest extend beyond the geographic boundaries of the available Atlas system?
   a. If so, are there neighboring or regional Atlases that might have supplemental information that might be of use?
   b. If so, are the contents of neighboring or regional Atlases accessible to users of my Atlas, and the analysis or visualization tools it contains?

Significant capacity has been built in the field of coastal mapping and informatics in the last decade as a result of a steady advancement of GIS applications for coastal practitioners. For example, the European Commission is implementing the MARATLAS project as an educational tool and as a means of highlighting common maritime heritage. The web based MARATLAS will be multi-lingual and will link to other European mapping initiatives such as the Water Information System for Europe (WISE). In the U.S. NOAA's Coastal Services Center (CSC) has launched the "Digital Coast" initiative (http://www.csc.noaa.gov/digitalcoast), which seeks new ways to build the U.S. coastal and marine National Spatial Data Infrastructure or NSDI (Mapping Science Committee, 2001), so that U.S. coastal communities have improved access to organized and relevant data and tools needed to make more informed decisions. In addition, NOAA CSC has been working on an inventory and registry of planned, current and completed Federal and non-Federal mapping activities, including coastal web atlases.

Developments in resource management policy can also have implications for the roll out of CWAs. For example, the recent reports of the Pew Oceans Commission and the U.S. Commission on Ocean Policy (Pew Oceans Commission, 2003; Juda, 2005) have clearly shown that coastal communities are critical to the economy of the U.S., and to its overall health and well-being as a nation, and further that geographic technologies will be a fundamental, critical tool to address the threats of climate change, coastal hazards, overpopulation, and more. As such, the State Governors of Washington, Oregon and California signed the West Coast Governors' Agreement on Ocean Health (http://westcoastoceans.gov), which includes in its action plan, the need for harmonized ocean and coastal maps and information that also crosses administrative boundaries. In Europe, the European Commission has now published its vision for an integrated maritime policy for the European Union (European Commission, 2007), which calls for the development of an Atlas of the European Seas for use in regional ocean governance and management. Opportunities exist to facilitate such a development by providing for data interoperability among existing CWAs, and within the context of the Inspire Directive which establishes an infrastructure for spatial information in the European Community. Similar trends in resource management with implications for CWAs can be seen in other parts of the world, such as Australia, the Western Pacific, Africa and the Caribbean, as introduced in Chapter 5.

KEY ISSUES TO BE ADDRESSED

Despite the importance of key drivers described above, little has been done to take stock of the

implications of these developments or to identify best practice in terms of creating an approach that takes lessons learned into consideration. Furthermore, the research community is still working toward providing widespread solutions to deal with common issues such as achieving full semantic interoperability of metadata and databases (where concepts, terminology, even abbreviations that are shared between two or more individuals, systems, or organizations are understood by all to mean the same thing; Gruber 1993; Egenhofer, 2002), reversing the lack of tool integration for coastal analysis and decision-making, and removing most impediments to effective use of online atlases for decision-support.

While multiple benefits are derived from tailor-made atlases (e.g., speedy access to multiple sources of coastal data and information; economic use of time by avoiding individual contact with different data holders), the potential exists to derive added value from the integration of disparate CWAs, to optimize decision making at a variety of levels and across themes (Chapter 4). And while digital data sets have continued to grow exponentially, our ability to derive meaning, knowledge and management decisions from all of these data in an analytical context remains poor (e.g., Aditya & Kraak, 2006; Deliiska, 2007; Athanasis *et al.,* 2008; Sahoo *et al.,* 2008). Hence, a fundamental research question that applies to CWAs is:

(1) *How best to achieve semantic interoperability so as to mitigate vague data queries, vague concepts or natural language semantics when retrieving and integrating data and information?*

For example, the terminology used to describe similar data in CWAs can vary widely between specialties or regions, which can complicate data searches and integration. Use of the word "*seabed"* in Europe versus use of the word "*seafloor*" to describe the same feature in North America is a good example of this scenario, as is the interchangeable use of "*coastline*" versus "*shoreline*" in both regions. Agreements on content/semantic interoperability must be developed to eliminate such problems, making searches between disparate, but mutually beneficial, projects feasible. The International Coastal Atlas Network (ICAN) aims to address such issues by providing a forum to share knowledge and experience among atlas developers (See Chapter 17). A technical group within the ICAN community have been developing a demonstration prototype as a proof-of-concept to inter-relate metadata and other information between two initial CWAs (the Marine Irish Digital Atlas or MIDA, http://mida.ucc.ie, and the Oregon Coastal Atlas or OCA, http://www.coastalatlas.net). The prototype is in the form of an Open Geospatial Consortium (OGC) catalogue services for the Web (CSW), where web map services (WMS) will be registered. But much more collaborative discussion about refining and extending this prototype is needed, which can best be achieved through the type of international collaboration accommodated through ICAN.

A second major question driving research is:

(2) *What are the best ways to share data and information across multiple distributed organizational and social contexts? And related to this, under what conditions do virtual organizations (such as ICAN) best foster and support transformative scientific research while also providing an effective spatial data infrastructure? Again, very little work has been done in any of these realms with respect to CWAs (e.g., there is a need for an assessment of CWAs used by different communities, and, where possible, to quantify the impact of CWA end user groups such as agencies, regions and states).*

AIM OF THE BOOK

This book is a book, as opposed to a research monograph. *Hence, rather than a lengthy theoretical treatise on basic and futuristic research questions and problems, it has been prepared more as a concise, ready reference, with collections of subject-specific instructions where appropriate*. The purpose of the book is to present the latest developments in the new field of coastal web atlases while also sharing best practices and lessons learned. This will, in turn, help readers to determine future needs in mapping and informatics for coastal management and improve spatial thinking in the coastal context. As such, this book provides a complete guide to CWA development and implementation including established principles and recommendations for atlas design, data requirements, software technology and institutional capacity, as well as best practice for achieving interoperability between CWAs (where concepts, terminology, and even abbreviations that are shared between two or more atlases are understood by all to mean the same thing).

The approach to the book is to present information according to three parts. Section 1 covers the principles of CWAs. Within Section 1, Chapter 2 covers the major features that make up an atlas, Chapter 3 covers how to implement those features, and Chapter 4 describes how to interoperate the services of one atlas with other atlases as part of a network, especially by way of international standards. The chapters of Section 2 provide examples of CWAs from around the world, including North America, Europe, Africa and the Caribbean. The chapters of Section 3 covers CWA management and governance issues, including how to best meet the needs of one's user community, how to make improvements in an atlas based on those user needs and make it grow, how to support an atlas with partnerships, funding, and the like so that it will mature, and how atlases play a key role in SDIs. Table 1 provides more detail by way of summarizing the content and importance of each chapter. This book is also accompanied by a dedicated website (International Coastal Atlas Network, http://ican.science.oregonstate.edu) which includes links to mature CWAs, and is building templates for CWA design, snippets

Table 1. Summary of the content of each chapter in this book

Section 1: Principles	
1: Introduction	General introduction to the entire book, including definition of a coastal web atlas and key issues surrounding it uses. The chapter also identifies the intended audience and gives a brief overview of topics and importance for all remaining chapters.
2: Coastal Web Atlas Features	This chapter features an overall summary with more detailed descriptions of common coastal web atlas features and the forms/functions they may take. This includes an extensive discussion of the various types of tools that one might find in a web atlas.
3: Coastal Web Atlas Implementation	Following on the previous chapter, which describes what the basic features of a coastal web atlas are, this chapter goes on to present considerations and recommendations for actually implementing an atlas (i.e., design, development, deployment). This chapter includes lists of the advantages/disadvantages and applicability/execution challenges for various technical resources. And finally, it includes helpful information on open source versus proprietary software, as well as various technology standards.
4: Coastal Atlas Interoperability	This chapter provides A general definition of interoperability is the ability of diverse systems and/or organizations to work together, especially in the use and exchange of information. This chapter is about interoperability between computer systems, especially those systems that underlie a coastal web atlas. It reviews the relevant standards for interoperability between coastal web atlases, and gives practical guidelines on how to make atlases interoperable through the use of standards, web services, vocabulary words and ontologies. It concludes with a description of the International Coastal Atlas Network's interoperability prototype under development.

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Table 1. continued

Section 2: Coastal Web Atlas Case Studies Around the World	
5: Overview of Coastal Atlases	This chapter provides a brief overview of various coastal web atlas projects around the world, providing a contextual bridge to the atlas case studies of Chapters 6-14. A summary of the policy context within which many European atlases operate is followed by a summary of other efforts emerging in Australia, the Western Pacific, Africa, and the Caribbean.
6: Oregon, USA	Case study for the U.S. state of Oregon, focusing on the Oregon Coastal Atlas in action. This atlas, along with the Marine Irish Digital Atlas, has been online and in constant development for a long period of time, and therefore one of the more mature coastal atlases on the Internet. Each case study chapter describes the situation in country or state regarding the accessibility of coastal information, the motivation for the producing the, atlas, the knowledge gap that it is trying to fill, the intended audience for the atlas, and where possible, how is it financed. Case study chapters also identify issues of data collection, system design, usage and associated statistics, strengths and weakness of approaches to date, and future plans, including its relationship to ICAN.
7: Ireland	Case study for Ireland focusing on the Marine Irish Digital Atlas in action. This atlas, along with the Oregon Coastal Atlas, has been online and in constant development for a long period of time, and is therefore one of the more mature coastal atlases on the Internet. The case study follows the "template" of topics as described for Chapter 6.
8: Virginia and Maryland, USA	Case study for the Chesapeake Bay region of the U.S. states of Virginia and Maryland, focusing on the Virginia Coastal Geospatial and Educational Mapping System and the Maryland Shorelines Online in action. The case study follows the "template" of topics as described for Chapter 6.
9: Wisconsin, USA	Case study for the U.S. state of Wisconsin, focusing on the ongoing development of the Wisconsin Coastal Atlas, with a future eye toward a regional Great Lakes Coastal Atlas. The case study follows the "template" of topics as described for Chapter 6.
10: Belgium	Case study for Belgium, focusing on the Belgian Coastal Atlas, which was first published as a hardcopy book but then transitioned to the web. The case study follows the "template" of topics as described for Chapter 6.
11: Africa	Case study for the continent of Africa, focusing on the African Marine Atlas. The case study follows the "template" of topics as described for Chapter 6.
12: Caribbean	Case study for the Caribbean region, focusing on the Caribbean Marine Atlas. The case study follows the "template" of topics as described for Chapter 6.
13: UK	Case study for the United Kingdom, providing a brief overview of the origins and evolution of coastal web atlases throughout the country. The case study follows the "template" of topics as described for Chapter 6.
14: Spain	Case study for Spain, focusing on the SIGLA (Sistema de Información Geografica del Litoral Andaluz or Coastal Information System of Andalusia). The case study follows the "template" of topics as described for Chapter 6.
Section 3: Coastal Web Atlas Management and Governance Issues	
15: The International Coastal Atlas Network	This chapter transitions from coastal web atlas (CWA) case studies to atlas management and governance issues, by way of a summary of the International Coastal Atlas Network (ICAN). ICAN is a newly founded informal group of over 30 organizations from over a dozen nations who have been meeting over the past two years to scope and implement data interoperability approaches to CWAs. Most of the atlases profiled in Section 2, Case Studies, are members of ICAN.
16: Coastal Atlases in the Context of Spatial Data Infrastructures	This chapter summarizes key projects and initiatives that are being implemented on very large scales (national/international) by national governments and commissions to build coastal spatial data infrastructures (SDIs). These include SDI efforts in the U.S. and Europe that are closely related to ICAN, and as such are of great value to its mission of developing interoperable atlases, providing along the way solutions for the integration of not only technologies, but people, institutions, and institutional objectives.
17: Creating a Usable Atlas	Having covered some overarching management and governance issues for coastal web atlases, the book returns to the user level with 3 concluding chapters that guide the reader on how to create an atlas that is the most usable for its audience, how to make that seed effort grow, and how to maintain it. This chapter provides guidelines on how to better understand coastal web atlas users, how to undertake user-centered design and development for improved web site usability, and how to avoid major pitfalls with web interfaces.
18: Improving a Growing Atlas	This chapter covers aspects of atlas monitoring via web server statistics, user surveys, and other sorts of feedback mechanisms, and how to obtain improvement over time. Also covered are issues of scalability (how to accommodate increasing datasets and users), and the latest in reviewing/updating technology.

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Table 1. continued

19: Supporting a Successful Atlas	This concluding chapter of the book is about to maintain a successful coastal web atlas. It discusses issues relating to securing long-term support for an atlas and provides guidance based on existing practice and experience with atlas developments at national and international levels. Specific topics include institutional capacity, institutional support, partnerships, funding, governance, and continued promotion. Also included is a discussion of data and metadata ownership issues, intellectual property rights, and the legal protection of atlas content.

of scripts and programming routines to achieve interoperability with partner atlases, and several other resources mainly for online GIS developments and online data providers.

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KEY TERMS AND DEFINITIONS

Coastal Web Atlas: A collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, all of which are accessible via the Internet. Also known as web atlas, digital atlas, digital coastal atlas.

Capacity Building: With regard to coastal atlases, the actions involved in building local GIS infrastructure, including maintenance and update of GIS data layers, software, computer equipment and labs/offices, salaried personnel, and action items for project initiatives.

Coastal Informatics: A broad academic field encompassing the management and analysis of data collected from and representing the coast. Informatics can include spatial data infrastructure, hardware and software infrastructure, computational networking, modeling, and experimentation, the design and deployment of data portals and Internet mapping sites, as well as the creation, analysis, and understanding of data/metadata vocabularies and ontologies, metadata creation/extraction/cross-walking tools, geographic and information management systems, and grid computing.

Information Management: The means by which an organization, agency, or individual collects, documents, shares, and uses information. It often involves creating or identifying the appropriate resources to find quality information in order to fill gaps in knowledge. Coastal web atlases are therefore a key component of information management as applied to coast region of the world.

Marine Spatial Planning: A critical part of regional governance that involves the integrated, forward-looking planning and consistent decision-making regarding various uses of the coast and nearshore. Marine spatial planning must be guided by specific policies and regulations governing usage, the conditions that apply, and an eye toward what possible conflicts in use may arise. Marine spatial planning is often aided by a coastal web atlases which can provide data on habitats, species migrations, land and territorial sea use by humans, navigation, managed areas (parks, reserves, disposal sites, etc.), commercial and recreational fishing, and the like.

Regional Governance: Policies and initiatives that allow state and local governments to pursue concrete, practical steps toward more coordinated and holistic management of ocean and coastal resources. This often includes establishing lines of communication among regions to facilitate implementation of best practices, forming partnerships among regions, and deploying proven management principles and approaches (e.g., ecosystem-based management). Coastal web atlases often provide the datasets, mapping tools, and contextual information needed for effective regional governance

Research Collaboration Network: A collaboration of research scientists, resource managers, technical staffers, and other interested parties to develop a coordinated research network focused on a particular topic. The group fosters communication among those with common goals and interests, along with collaboration on common projects across disciplinary, organizational, institutional and geographical boundaries. The International Coastal Atlas Network is an example of a research collaboration network.

Spatial Data Infrastructure or SDI: A framework via an organization of people or government agencies, via the Internet, or via a series of guiding policies or standards to assist people with acquiring, processing, using, and preserving spatial data. The spatial data are often in geographic information system (GIS) format, are not, but not limited to this.