The ArcGIS® Botanical Garden & Zoological Park Data Model

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Abstract

The ArcGIS® Botanical Garden & Zoological Park Data Model is an evolving free and open source geographic information system (GIS) template for implementing GIS projects at botanical gardens, zoos, and similar public landscapes that is designed for Environmental Systems Research Institute's (ESRI) ArcGIS® software. The data model is being designed by a consortium of domain specialists from the botanical garden and zoological park community called the Alliance for Public Gardens GIS that is led by the UC Davis Arboretum to provide institutions of all sizes and funding levels an effective means of achieving a return on investment with GIS. This paper describes the need for GIS in botanical gardens and zoos, the collaborative process used to design the data model, the current status of the project, and the future plans for the model's evolution.

Keywords

geographic information system, GIS, data model, botanical garden, zoo, landscape management, return on investment, Alliance for Public Gardens GIS, , ESRI, ArcGIS®

Introduction

Botanical gardens and zoological parks have been established throughout the world with a similar mission to exhibit wildlife, educate visitors, conserve biodiversity, and perform scientific research. (Miller, Conway et al. 2004). To support these endeavors these organizations often document their living collections using a variety of cataloging methods dominated primarily by traditional database management systems (DBMS) and secondarily by geographic information systems (GIS) (Dawson 2005). For institutions choosing to use a non-spatial DBMS, software solutions such as the Zoological Information Management System (ZIMS) (ISIS 2008) for zoos and BG-BASE (BG-BASE 2007) for botanical gardens have been developed for customized management of living collection data. However, if an institution chooses a spatial system such as GIS, the database schemas that define the types of information cataloged and the relationships between the information needs to be created by each institution. The time and resources associated with designing a spatial database can be prohibitively costly to many institutions, thus resulting in limited adoption of this technology versus traditional DBMS (Dawson 2005).

GIS data models aim to bridge this gap by providing users with a practical template for implementing GIS projects, and additionally provide a common starting point for integrating similar data sets across

multiple institutions (ESRI 2008). The developer of the world's leading GIS technology, ESRI, currently publishes over 30 data models for their ArcGIS® software for different industries ranging from defense and intelligence to hydrology (ESRI 2008). These data models comply with the criteria of the Open Source Initiative thus making them free to modify and distribute via ESRI's website (Coar 2006).

The UC Davis Arboretum is the recent recipient of a Conservation Support Program Grant from the Institute of Museum and Library Services (IMLS) that funds the initial development of an ArcGIS® data model for botanical gardens and zoos that will ultimately not only provide these institutions an effective means of documenting their living collections, but also a comprehensive system to manage all of their assets and spatial data (Greco 2007). With ESRI as a matching partner, the UC Davis Arboretum has assembled a project team of domain specialists called the Alliance for Public Gardens GIS that is guiding the data model design process, and will test and refine the model until its initial release at project end. The release of the data model will be accompanied by a grant program through ESRI that will provide botanical gardens and zoos the ArcGIS® software and extensions along with a suite of training courses designed to give these institutions the tools necessary to launch a successful and cost-effective GIS project. The remainder of this paper presents the design process to date, the current data model contents, and the anticipated next step of the project.

Methods

The data model design process began in September, 2007 with an information gathering meeting attended by public landscape managers and GIS specialists from the UC Davis Arboretum, University of California, Davis, Zoological Society of San Diego, San Francisco State University, San Francisco Zoo, and the San Francisco Presidio Trust. This meeting was closely modeled after Roger Tomlinson's Technology Seminar (Tomlinson 2007), and presented attendees with the concepts of enterprise GIS and data models. Participants were then divided into five groups based the institutional business areas of leadership and administration, facilities and infrastructure, museum and plant records, education and interpretation, and collection planning and maintenance. Each group was then encouraged to create prioritized descriptions of GIS outputs called information products (Tomlinson 2007) that would provide the greatest benefit to their respective institutions. The results of this meeting provided the data model design team with details on the data storage and analysis capabilities the finished model would need to incorporate to meet the needs of its potential users (Morgan and Burke 2007).

The next step in the design process was to conduct a survey of the members of the American Public Gardens Association (APGA) and the Association of Zoological Horticulture (AZH) in October, 2007. This survey asked respondents to answer questions regarding their current collection mapping practices and to rank the usefulness of proposed data model features to their institution. The survey administered through SurveyMonkey.com had a 20.1% response rate from 1,610 members surveyed. Out of ten groups of data model features ranked on a ten point scale with a response of one providing the greatest value to their institution, respondents identified plant collection and animal exhibits (2.88), base map

features (4.61), irrigation and water systems (4.65), and infrastructure and utilities (4.69) as the top priorities for inclusion in the proposed data model (Morgan and Burke 2007).

The information gathered from the previous steps was then presented at the first meeting of the Alliance for Public Gardens GIS in November, 2007 where it was used to inform decisions about how to proceed with the design of the data model. This meeting was attended by representatives of the UC Davis Arboretum, San Francisco State University, Missouri Botanical Garden, Chicago Botanic Garden, Zoological Society of San Diego, San Francisco Zoo, St. Louis Zoo, BG-BASE, and ESRI, among others. This meeting resulted in the development of a project timeline and the assignment of various design preparation tasks to members of the Alliance.

The first stage of designing the data model began with a conceptual design meeting at the ESRI campus in Redlands, CA in February, 2008 which was attended by representatives of the UC Davis Arboretum, San Francisco State University, Zoological Society of San Diego, Fuss & O'Neill, and ESRI. This meeting focused on identifying the thematic layers that would be included in the data model and determining the features, attributes, and relationships necessary to produce some of the information products that were identified as top priorities at the technology seminar meeting in September. During this meeting it was determined that the initial release of the data model would include a base map module and a facilities and infrastructure module. The base map module would provide users with the capacity to work with data such as topography, survey control, and administrative boundaries that serve as essential reference information in most GIS systems. The facilities and infrastructure module would provide users with the capacity to work with data such as roads and pathways, structures, and utilities that have been shown by botanical gardens and zoos already using GIS to provide the greatest return on investment. A complete list of the thematic layers identified at this meeting to be included in the data model can be found in Table 1.

The next stage of creating a logical design that for the data model took place during a series of meetings and conversations with domain experts in March and April of 2008 who helped to identify the features, attributes, and relationships necessary for each of the thematic layers in Table 1. This stage of the design process involved representatives of the UC Davis Arboretum, University of California, Davis, Zoological Society of San Diego, and San Francisco State University. The design of the base map thematic layers of the land cover, hydrology, geodetic control, and cultural features thematic groups in Table 1 was supervised by the San Francisco State University Institute for Geographic Science, and the design of the facilities and infrastructure thematic groups of facilities, transportation, critical infrastructure, and boundaries thematic groups was supervised by the UC Davis Arboretum.

The final stage of creating a physical design for the data model took place in May, 2008 at San Francisco State University and the UC Davis Arboretum. During this stage the features, attributes, and relationships identified during the logical design stage were translated into a physical geodatabase design using a combination of ESRI ArcCatalog and the Geodatabase X-Ray utility which allows editing of XML in Microsoft Excel. Once the base map and facilities and infrastructure module were built as geodatabases, they were combined into a unified prototype as version 0.1. This version of the model included all of the thematic layers listed in Table 1 with the exception of the utilities listed in the critical

infrastructure group. The water, wastewater, storm water, electrical, gas, and telecommunication thematic layers are under development by the Zoological Society of San Diego, and will be included in the initial release of the data model.

The current stage of reviewing and refining the prototype began in June, 2008, and has involved many of the institutions that have participated in the planning and design of the data model. The prototype was first reviewed in its entirety by the UC Davis Arboretum and San Francisco State University. The revised prototype was then reviewed by domain experts at the University of California, Davis, and the Zoological Society of San Diego. The further revised version was then reviewed by the data model team at ESRI, and most recently by the data model design team of the Alliance for Public Gardens GIS. This cycle of review and revision resulted in the current version of the data model titled version 0.9.

Results

As of the end of June, 2008, nine months after the start of the design process, work is nearing completion on a testable, alpha version of the base map and facilities and infrastructure modules of the ArcGIS® Botanical Garden & Zoological Park Data Model. The review and revision of the base map module is complete, and with the exception of the utilities portion of the data model, the review and revision of the facilities and infrastructure module is also complete. Version 0.9 of the data model currently contains two feature datasets, one topology, 52 feature classes and tables, and 45 relationship classes. A complete listing of the geodatabase objects contained in version 0.9 is shown in Figure 1.

The design and review of the data model is scheduled to be completed in August, 2008, and will include the addition of the utilities portion of the model that contains the water, wastewater, storm water, electric, gas, and telecommunication thematic layers, as well as a basic plant collection module that will allow for the mapping and management of living plant collections. Once these features have been added to model and reviewed by domain specialists from the Alliance for Public Gardens GIS, the model will enter the testing phase.

The testing phase of the data model development will be executed in three stages based on the domain expertise of the testing institution, and the availability of appropriate spatial data to test the model with. The first phase will be performed internally by the institutions that have been responsible for the physical design of the data model. The UC Davis Arboretum, San Francisco State University, and Zoological Society of San Diego will load existing from the UC Davis Arboretum, San Francisco Zoo, San Diego Zoo, and San Diego Wild Animal Park into the data model, and test the data model's ability to support existing data, perform spatial analyses common to botanical garden and zoological park operation, and produce the relevant information products identified at the technology seminar meeting in September, 2007. The model will then be revised to correct errors and omissions, and be prepared as a beta version for external testing.

The second phase of testing will be performed by partner institutions that have an existing GIS program in place with relevant base map, facilities and infrastructure, and plant collection data. At the time of

publication these institutions include Missouri Botanical Garden, Chicago Botanic Garden, and Arnold Arboretum. These institutions will be responsible for providing the designers with feedback on the models ability to perform the same tasks included in the first testing phase. During this phase of testing, the design team will create documentation that will detail the use and relevance of each object within the model, and provide instructions for data loading and creation.

The final testing phase will be performed by institutions that are starting a GIS program, and have little or no existing GIS data. At the time of publication these institutions include Olbrich Botanical Garden, San Francisco Botanic Garden, St. Louis Zoo, Pukekura Park, New Plymouth, and Vallarta Botanic Gardens, A.C., and will likely be expanded to include others. These institutions will be responsible for providing the data model designers with feedback on the same tasks as included in the previous testing phases, as well as the model's ability to be used for data collection and creation and the effectiveness of the documentation.

Once these testing phases are completed, final revisions and updates will be made to the data model and documentation, and both will be prepared for initial release as the ArcGIS® Botanical Garden & Zoological Park Data Model Version 1.0. The model will be posted on the data model section of the ESRI website as an XML Workspace Document along with the supporting documentation, and will be made available in early 2009 for free download by any potential user.

Conclusion

The Alliance for Public Gardens GIS plans to continue the development of the data model beyond the capabilities provided in its initial release. The group is actively recruiting new partner institutions to develop additional features for specific purposes such as managing institutional research projects and emergency response plans. The Alliance also plans to seek additional funding to first develop a comprehensive plant collections module, and eventually modules for education and interpretation and leadership and administration.

The goal of the ArcGIS® Botanical Garden & Zoological Park Data Model is to provide botanical gardens and zoological parks of all sizes and funding levels with a practical template and starting point for implementing a successful GIS project. The Alliance for Public Gardens GIS is confident that this data model along with the suite of software, training, and support provided by the ESRI Conservation Program to North American botanical gardens and zoos will provide these institutions with the resources necessary to manage all of their spatial data with GIS, and achieve their increasingly important goals.

For current information on the continued development of the ArcGIS® Botanical Garden & Zoological Park Data Model, please visit the ESRI Libraries and Museums website at http://www.esri.com/industries/libraries/news-community/data-model-botanical.html.

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Tables & Figures

Table 1. Thematic Layers

Land Cover

- Topography (spots, contours, DEM, DTM, TIN, etc.)
- Soils
- Geology
- Land Cover & Land Use (derived)
- Vegetation (non-collection)
- Bio-Climatic zones
- Imagery (aerial photography)
- Scanned Documents (as-built drawings, construction documents, etc.)

Hydrology

- Polygons (lakes, ponds, wetlands, channels, reclamation, etc.)
- Lines (streams)
- Points (wells, sinks, sources, etc.)
- Catchments & Basins
- Watersheds
- Drainage Structures

Facilities

- Drinkers
- Water Fountains
- Impervious Surfaces & Hardscape
- Trash, Recycling, & Compost
- Docks & Piers
- Fences & Walls
- Handrails
- Landscape Structures (rocks/trees)
- Pavement
- Water Treatment
- Towers

Transportation

- Roads (polygons)
- Roads (centerlines)
- Sidewalks, Pathways, & Trails
- Ramps
- Rail & Tram
- Elevators
- Sky Tram
- Escalators
- Bridges
- Stairs
- Traffic Control

Critical Infrastructure

- Buildings
- Entrances & Exits
- Water & Wastewater
- Gas
- Electric
- Storm Water
- Telecommunications
- Street Furniture

Geodetic Control

- Survey Monuments
- Survey Points
- Ground Control Points
- Reference Grid

Cultural Features

- Landmarks
- Cemeteries
- Burial Grounds

Boundaries

- Exhibits
- Planting Areas & Greenscape
- Guest Experience
- Property Boundaries
- Team Area & Administrative Boundaries
- Public & Private Areas
- Quarantine Areas
- Construction Areas
- Area of Interest (AOI)
- Staging Areas

Figure 1. ESRI ArcCatalog Tree View of Version 0.9