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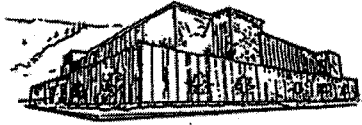
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**THE LEWIS AND CLARK GEOSYSTEM:
A DISTRIBUTED HISTORICAL GEOSPATIAL APPLICATION PORTAL OF
THE LEWIS AND CLARK TRAIL**

by

James Alexander Philp

B.A. Seattle University, 1990

M.I.S. The University of Montana – Missoula, 1997

presented in partial fulfillment of the requirements


for the degree of

Doctor of Philosophy

The University of Montana – Missoula

May 2005

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Chairman



Dean, Graduate School

6-17-05

Date

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The Lewis and Clark Geosystem: A Distributed Historical Geospatial Application Portal of the Lewis and Clark Trail

Committee Chairman: Jeffrey A. Gritzner ^{JAG}

The Lewis and Clark Geosystem is a historical geospatial portal of the Lewis and Clark Trail. The Geosystem presents an interdisciplinary exploration of various geospatial themes through the utilization of advanced, geospatial Web services. The interconnected Web services are based upon an expansive and distributed array of geodatabases (geospatial databases). These geodatabases emphasize local, regional, and continental scale vector and raster data layers. The Web services are presented in specific, user-defined web applications focusing upon discrete portions of the Lewis and Clark Trail environment. The applications are project-based and are designed to explicate a variety of fundamental geographical themes related to Lewis and Clark geography. As a geographic communication system (GCS), the Geosystem demonstrates the value of server-based GIS, the consumption and production of Web services across a range of client-based applications, and the manifestation of application interoperability based upon Arc-Extensible Markup Language (ArcXML).

As a channel of the US Department of the Interior Geospatial One Stop (GOS) portal, the Geosystem is a fully compliant Federal Geographic Data Committee (FGDC) metadata service(s), and has been recognized as a core national asset for furthering the science of Lewis and Clark scholarship. The science emphasizes the geospatial technologies involved in the architecture as well as the geospatial information developed and incorporated into the distributed geodatabase metaframework.

As an interdisciplinary research project, the Geosystem combines the primary disciplines of geospatial IT, history, ecology, and geography, and reflects an unprecedented expression of Lewis and Clark scholarship. The Geosystem as designed provides an interconnected geospatial matrix for exploring multiple historical geographical themes of relevance to the historiography of the Lewis and Clark Expedition. The Geosystem anticipates next-generation advances in ontological Web services, immersive geospatial experience, and distributed connectivity for multi-user experience.

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FOREWORD

This interdisciplinary project has consumed a significant portion of my professional career. Based upon my research into the historical geography of the Sun River watershed, and the attempt to provide a comprehensive examination of the landscape over a ten thousand year period, the goal was to build web-based geospatial applications that would provide educational and research value to vast audiences seeking to understand fundamental geographical processes at multiple scales. Thus, the Lewis and Clark Geosystem concept was born. As Lewis and Clark explored the Sun River (*Na Tus Se*) in 1805 and 1806, the author wanted to follow them out of the *Na Tus Se* and learn more about the rest of the trail's geography.

This project would not have been possible without the fundamental love and support provided by my wife and two daughters over the many years necessary to achieve the objective of completion. Their unending support for my passion is what fueled this endeavor in the face of many obstacles. I also must thank those scholars and assistants who helped build the various applications and solutions presented in this research. Given the magnitude of the undertaking, this Geosystem would not have been possible without their assistance.

As the highlight of the investigation, I had the distinct honor to work with Daniel Botkin and Gary Moulton at The University of Montana, while each attended as visiting scholars. It was a distinct honor to be able to collaborate with each gentleman on these projects, and I remain engaged with Dr. Botkin. His keen ecological insights into the

natural history of the Lewis and Clark Trail remain the most synthetic level of analysis I have uncovered.

As always, I own sincere gratitude to my mentor, Jeffrey A. Gritzner, who has served as my intellectual guide during my academic term at The University of Montana. Guiding me through the Masters of Interdisciplinary Studies and the Individual Interdisciplinary Ph.D. program, Dr. Gritzner provided me with an academic home for my intellectual wanderings. I do not have the words to thank him. After many years of dialogue, I now realize that I have found a geographical home.

INTRODUCTION

The research and development components of this dissertation began six years ago with the design for a Lewis and Clark Geographic Information System (GIS) that would facilitate access to geospatial information about the Lewis and Clark Trail between *ca.* 1803 and 2003. Along the way, the dissertation evolved into a fully interdisciplinary exploration comprised of pioneering research into geospatial technology, Lewis and Clark historical geography, and the manifestation of several active programs designed to deliver this research through the Internet or Web (WWW).¹

The impetus for this research began with a series of informal meetings conducted with representatives of the United States Geological Survey (USGS), the National Aeronautics and Space Administration's John C. Stennis Space Center (NASA), the National Park Service's Lewis and Clark National Historical Trail, Environmental Systems Research Institute (ESRI), and the author.² As plans for the Lewis and Clark Bicentennial Commemoration were being developed, various federal agencies intended to develop a bicentennial cartographic product to highlight the Lewis and Clark Trail. The goal was to develop a comprehensive, interagency product that would provide the American public with a geographical overview of the expedition's route across the United States.

¹ The vast majority of the Lewis and Clark Geosystem is, by definition, a geospatial construct. Therefore, numerous references will highlight operational Web sites and systems that are fundamentally interconnected through advances in distributed geospatial applications, *e.g.*, a distributed geospatial architecture. The Geosystem is a distributed framework of interconnected Web services and geodatabases that provides access to Lewis and Clark related spatial information.

² This meeting occurred in Omaha, Nebraska, May, 1997. At the time, the author was representing the EOS Education Project at the University of Montana – Missoula, a NASA-funded K-12 Earth System Science education program.

Simultaneously, Web-based mapping technologies such as ESRI's ArcIMS (Internet Map Server) were being developed and released, as well as the advent of the geodatabase (geospatial database) concept and architecture.³ Based upon these meetings, it was agreed that an informal, *ad hoc* working group lead by the author would work to assemble and/or develop a relatively comprehensive Lewis and Clark geodatabase(s) of historical and contemporary spatial information, which could be accessed by the general public through these emergent Web-based mapping tools.⁴ The intent was to build a historically-focused, Web-based Geographic Information System (GIS) that would provide a graphical interface to a catalogue of relevant geospatial data about the Lewis and Clark Trail. This system, in time, would evolve into an interconnected set of systems.⁵ This concept slowly evolved into the "Lewis and Clark Geosystem."⁶

Additional notable efforts contributed to the publication of historical geospatial information regarding the Lewis and Clark Trail. During the initial phases of this project, the work of David Rumsey *et al* became available as an outstanding Web-based resource for interacting with Rumsey's historical cartographic collection related to the Lewis and Clark Trail.⁷ A useful resource was also developed and released based upon the work of

³ www.esri.com.

⁴ Geospatial is a term used to describe a class of data that has a geographic or spatial nature. Please see <http://www.martin.fl.us/GOVT/depts/isd/gis/glossary.html>.

⁵ Geographic Information Systems: An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. Please see <http://www.webgis.net/cms.php/glossary.html>.

⁶ This term was developed by the author and originally presented at the ESRI International User Conference Lewis and Clark Special Interest Group Meeting in 1998.

⁷ <http://www.davidrumsey.com/GIS/lewisclark.htm>. The author worked with David Rumsey and provided content review and a Lewis and Clark Trail line as developed with Robert Bergantino, Montana Tech of The University of Montana.

Dr. Harlan.⁸ James Harlan focused upon the Lewis and Clark expedition in Missouri and utilized the General Land Office (GLO) maps of Missouri along with the maps included in The Journals of Lewis and Clark Expedition as the basis for his environmental reconstruction of the Trail geography. Dr. Harlan also succeeded in publishing his research as a Web mapping service. Dr. Harlan's work was limited only to Missouri, and has been referenced in the GOS (Geospatial One Stop) channel ancillary Web resources developed by the author.⁹

Another excellent contribution to this type of research was produced by Andrea Laliberte at Oregon State University.¹⁰ Laliberte concentrated her analysis upon an assessment of Lewis and Clark wildlife observations by Lewis and Clark campsite location. Utilizing the spatial data from Robert Bergantino, as provided and developed by the author in concert with Dr. Bergantino, Laliberte developed the Web-based application as a basis to compare historical wildlife observations against modern species ranges.¹¹

Other researchers and organizations developed similar historical geospatial approaches for portions of the Lewis and Clark Trail. Nevertheless, despite varying public and private sector projects and programs, no one single entity pursued or delivered a comprehensive series of geospatial applications based upon the original Lewis and

⁸ <http://lewisclark.geog.missouri.edu/index.shtml>.

⁹ The Geospatial One Stop channel component of the Lewis and Clark Geosystem will be discussed in more detail below.

¹⁰ <http://www.cof.orst.edu/lewis&clark/mainmap.html>.

¹¹ Dr. Bergantino, Montana Tech of The University of Montana. Dr. Bergantino maintains one of the accurate and comprehensive Lewis and Clark campsite databases in existence. The author worked with Dr. Bergantino beginning in 1997-1998 to convert his database tables into a spatial file format, ESRI's .shp file format, so his data could be included in these initial development phases.

Clark spatial catalogue (geodatabase) concept.¹² Moreover, as the project expanded, it became necessary to develop “distributed” components to the project.¹³ The distributed architecture of the Web-based applications allowed for the incorporation of physically distinct spatial data repositories from multiple data publishers, most notably NASA. As such, the Geosystem metaframework was designed to harvest or “consume” spatial data as Web services as opposed to having to aggregate all the geospatial data into a centralized geodatabase.¹⁴ The Lewis and Clark Geosystem represents the actualization of the original goal. The Geosystem provides the most comprehensive series of interconnected historical geospatial applications of the Lewis and Clark Trail in existence.

The Lewis and Clark Geosystem: A Distributed Historical Geospatial Application Portal of the Lewis and Clark Trail has been promulgated at the highest federal government level as a unique contribution to the Lewis and Clark Bicentennial Commemoration. This honor was conferred by the U.S. Department of Interior (DOI), United States Geological Survey (USGS), Geospatial One-Stop (GOS) program manager, Hank Garrie. The “Geosystem” was accepted as an official “Channel,” and Mr. Philp was named Channel Manager during the National Association of Governors Conference unveiling in March of 2004.¹⁵

¹² In comparison to the other projects briefly discussed here, there have been and remain multiple projects that have succeeded in publishing geospatial Web services as they relate to different regions or portions of the Lewis and Clark Trail. However, most of these applications tend to be limited either in geographical scope or content. In contrast, the Geosystem provides an extensive and interconnected portal of Web services detailing a variety of technical applications and historical geographical content.

¹³ The “distributed” nature of the Geosystem will be discussed in more detail below. The distributed applications utilize Web services as the mechanism for connecting the varying Geosystem applications into a unified portal.

¹⁴ The Geosystem comprises approximately 4.5 Terabytes of spatial information.

¹⁵ http://www.esri.com/news/releases/04_1qtr/geospatial-onestop.html.

Immediately prior to this recognition, Mr. Philp was invited to present his research before the USGS Pardee Symposium, Geological Society of America (GSA) Annual conference in November of 2003.¹⁶ Chaired by James Tate, Science Advisor to Secretary of Interior Gale Norton, the Pardee Symposium highlighted the top scientific research into the Lewis and Clark Trail. Most recently, and as outcome of a Space Act Agreement with the NASA John C. Stennis Space Center, the Lewis and Clark Geosystem was highlighted at the annual North Dakota GIS Conference (November 2004), where Mr. Philp delivered the keynote address revealing the geospatial technologies and historical geographical components of the operational system.¹⁷

¹⁶ The Lewis and Clark Bicentennial commemoration provides an opportunity for interdisciplinary research into the geography of change along the Lewis and Clark Trail. Extending across North America as a discrete transect through a continental historical geography, the Lewis and Clark Trail serves as a biological baseline upon which modern scholars can compare contemporary landscape conditions. Simultaneously, it is now possible through advances in geospatial information technology (IT) to build Web-based systems that allow for the effective sharing of geographical information among Lewis and Clark scholars and researchers. Designed as a collaborative and organic Web system, one such project, "The Lewis and Clark Geosystem," is currently under development by multiple public and private sector organizations. Focusing upon landscape visualization, database mining, and descriptive illustrations of environmental change, the Lewis and Clark Geosystem functions as a distributed GIS network. The purpose of the Lewis and Clark Geosystem is to link significant geospatial databases (nodes) across the Internet and provide the end user with a latticework of geospatial resources, upon which they can form analytical perspectives of the various Trail landscapes. The Lewis and Clark Geosystem is compatible with, and supportive of, related federal geospatial portals, such as the USGS National Map and the recently launched Geospatial One-Stop initiative. Providing spatio-temporal perspectives of landscape change for specific locations along the Trail, the Lewis and Clark Geosystem incorporates modern, georeferenced remotely sensed data (Landsat 7 ETM+, Landsat 5 TM, MODIS, SRTM, ASTER) with historical aerial photography, cartography and other geographical data resources across multiple scales. The Lewis and Clark Geosystem provides an ideal method for communicating science along the Lewis and Clark Trail, and represents significant, cumulative advancements in geospatial information technology.

¹⁷ "The ongoing Lewis and Clark Bicentennial Commemoration (2003-2006) provides opportunities for research and reflection of the significance of the Lewis and Clark expedition (1803-1806). One line of investigation involves the excavation of valuable geographical information from The Journals of the Lewis and Clark Expedition. Historical observations of plant and animal species, landscapes, and Native American cultures along the Missouri and Columbia River watersheds can be used as a baseline for comparison with existing landscape conditions. Utilizing modern geospatial technologies such as GIS, GPS, and remote sensing, it is possible to describe qualitatively and quantitatively changes in the various landscapes Lewis and Clark observed. One such ongoing effort is the Lewis and Clark Geosystem. The Lewis and Clark Geosystem represents a collaborative effort combining private and public sector projects

In sum, as each component of the Geosystem has been completed, actualized as an operational Web system, and integrated into the overarching geospatial architecture, the dissertation has been recognized as a fundamental contribution to the science of Lewis and Clark, and as a pioneering expression of an emergent new discipline – geospatial historical geography.

The Lewis and Clark Geosystem comprises two main components: 1) Web-based geospatial technologies and 2) Lewis and Clark geospatial content.¹⁸ In terms of the Web-based systems, the Geosystem contains two main geographical levels of analysis. At the meso- or regional level of analysis, a geospatial system was designed to describe landscape conditions along the Lower Columbia River between the Dalles and the mouth of the Columbia River. At the macro or continental scale, the Geosystem describes the Lewis and Clark Trail geography between St. Louis, Missouri, and Fort Clatsop, dividing the Trail geography into discrete “ecoregions” as defined by hydrological units.¹⁹

to build a distributed geospatial system for the exploration of the geography of the Lewis and Clark Trail. The Geosystem serves as an organic, developing resource for the American public to explore the geography of the Trail. The North Dakota GIS Day presentation will demonstrate various dimensions of the Lewis and Clark Geosystem, describing various geospatial technologies and how such a geospatial infrastructure could be utilized by multiple organizations for various lines of investigation and workflows.”

¹⁸ The historical content for the Lewis and Clark Geosystem utilized the following primary resource for countless references and editorial guidance: The Journals of the Lewis and Clark Expedition, Vols. 1-13, edited by Gary E. Moulton (Lincoln and London: The University of Nebraska Press, 2002). The vast majority of the geospatial information associated with Lewis and Clark campsite locations utilized the pioneering research of Robert Bergantino, Montana Tech of the University of Montana. Over the past seven years, Mr. Philp and Dr. Bergantino have collaborated on Lewis and Clark geospatial scholarship, resulting in numerous workshops, educational field-trips, programs, presentations, and published works.

¹⁹ The use of the “ecoregion” concept to divide the Lewis and Clark Trail into hydrologically unique segments with ecological and cultural (ecocultural) underpinnings was determined through collaboration with Daniel Botkin, while Dr. Botkin was a Visiting Research Professor at The University of Montana – Missoula, during the Autumn Semester 2002. Dr. Botkin and Mr. Philp, then the Director of the National Lewis and Clark Education Center, collaborated on this research. Mr. Philp utilized this methodology, with Dr. Botkin’s permission, for the macro-scale analysis of the Lewis and Clark Trail and as a discrete geographical unit for the Geosystem. John Wesley Powell’s hydrographic units serve as a foundational component for the hydrologically defined ecoregional units.

Finally, the Geosystem is rearticulated as a consumable set of services, and exists as a “Channel” in Geospatial One Stop (GOS I).

Each level of geospatial analysis is represented as a distinct “geospatial Web service.” Each subsystem, therefore, is based upon a distinct geospatial database (geodatabase) with an associated graphical user interface (GUI) in order for the geospatial data to be examined by the interested user. Each subsystem serves as a stand-alone Web service that can be “consumed” through an ArcXML (extensible mark-up language) Web browser, and key elements of these services are integrated into the penultimate distributed application being the GOS I portal.

In varying instances across all subsystems, additional geospatial and non-geospatial Web services have been integrated at the code level (ASP.NET – Active Server Page.NET) and are consumed dynamically into the primary subsystems. These configurations will be explained in detail below. However, the best and most impressive example of the truly “distributed” dimension of this system remains the utilization of a NASA John C. Stennis Space Center’s Applications Directorate Landsat 5 TM and Landsat 7 ETM+ raster geodatabase service (SQL Server and ArcSDE – Spatial Database Engine), configured for consumption by the Geosystem.²⁰ All subsystems, serving as independent Web services, are designed as independent applications with specific technical achievements, geospatial content, and pedagogical intent. As a dynamic sum of its parts, the Geosystem can be dynamically reconfigured by the user (client) through a variety of Web-based and stand-alone applications (client tools) for consumption,

²⁰ The NASA Stennis Space Center raster geodatabase service was designed and delivered as a key component of a Space Act Agreement between GCS Research and NASA, 2002-2003. This work, an early articulation of the Geosystem concept, was highlighted at the ESRI International User Conference in July, 2003, and was selected for inclusion for GIS Day celebration activities in Washington, D.C., in November, 2003

manipulation, and exploration.

The Geosystem, as a channel on GOS I, will continue to evolve into next-generation applications and solutions. The next-phase of the research will be to construct fully immersive, geospatially accurate simulations of historical landscape conditions based upon probability assessments assigned to geodatabase logic. Ultimately, what began as an idea in 1990, may have an opportunity of being realized as the technology continues to advance and converge.

The following chapters will detail and illustrate the various components of the Geosystem, summarizing both the technical aspects and the geospatial content as promulgated through the system architecture.²¹ Chapter one focuses upon the continental scale biogeography of the Lewis and Clark Trail as articulated in a Web-based mapping application. The system provides query-based access to a geodatabase of all the plant and animal species observed and documented by the Lewis and Clark in The Journals of the Lewis and Clark Expedition. The plant and animal point-based observations can be compared with modern species ranges utilizing dynamic database calls to distributed databases maintained by NatureServe, the geospatial repository of the Nature Conservancy. The application provides a small-scale, overarching description of the Lewis and Clark Trail as defined by ecoregional boundaries. Technically, the continental biogeographical component involved the development of multiple Web map services and

²¹ A next-generation interactive fly-through was created as an extension of this dissertation research. The fly-through was produced using ESRI's ArcGlobe software in collaboration with ESRI and NASA. A series of interactive, Web-based fly-throughs are also available using Keyhole Pro II and the KML files developed by the author for sharing key campsite location information and associated spatial data. These materials and fly-throughs are available upon request from the author and were presented at the dissertation defense.

dynamic calls to distributed databases for comparative analysis and environmental conditions.

Chapter two describes a secondary Web service application designed to emphasize particular regional-scale, geographical thematics of the Lewis and Clark Trail along the Lower Columbia River. Focusing upon specific US Fish and Wildlife Service refuges, the Lower Columbia Web service provides geospatial information depicting landscape change between Lewis and Clark's passage (1805-1806) and the modern period (*ca.* 2000). Emphases are placed on changes in land cover, population, cartography, and wildlife utilizing the innovative application of existing geospatial technologies to derive the Web service architecture and performance.

Chapter three focuses upon the interrelationship and interconnectedness of the aforementioned continental and regional Web services as expressed in the Geospatial One Stop (GOS) channel. Additional geospatial data resources are presented and defined in this application, which utilizes a NASA-based Landsat 5 TM and Landsat 7 ETM+ raster geodatabase. As an XML-based metadata service, the GOS application functions as a primary node of the Geosystem through which all the historical geospatial content can be discovered and accessed through a variety of Web-based and desktop applications. The GOS channel encapsulates the distributed character of the Geosystem in so far as the application can be accessed as an interrelated series of geospatial Web services providing access to historical and contemporary Lewis and Clark geospatial content.

Chapter four reveals the most recent aspect of the Geosystem – an interactive, Web-based fly-through environment for experiencing the multiple geodatabases that comprise the total system. Specific Lewis and Clark data sets are discussed within the

context of Keyhole software.²² Next-generation research in the visualization of the Geosystem through this emergent, interactive fly-through environment is discussed. While this component is relatively recent and the development is incomplete, the author hypothesizes about the implications of extending the complete Lewis and Clark Geosystem into this Web-based environment.

The intent of this research was not necessarily to dwell upon the historical geography *per se* of the Lewis and Clark Expedition, but rather to develop a next-generation articulation of a distributed historical geospatial application. The Lewis and Clark Trail, and its historical geographical components, serve as the focus of the geospatial application. Clearly, the geospatial information, compiled over years of research and analysis, may serve as the foundation for landscape change analysis, detection, and further research. Any one geographical area, if dissected properly and descriptively, represents a microcosm of complex, dynamic human-land interactions. Given such a vast scope, the author chose to take a broad approach to frame the stories contained within the applications themselves.

In numerous instances, and as a function of the interdisciplinary nature of the research, historical, ecological, and geographical components are woven together thematically to deliver compelling continental, regional, and local geospatial information. This information, when framed within the proper context of landscape change across centennial and decadal temporal scales, provides an inviting educational matrix for investigation by the educational and general-public audiences. The Lewis and Clark Geosystem was designed, from the beginning, to be a heterogeneous, nested series of applications that could and would be used by people. Given the tens of thousands of

²² <http://www.keyhole.com/>.

Web hits that these combined applications receive on a daily basis, this intent has been achieved. Moreover, critical feedback from peers in the scientific investigation of the Lewis and Clark Trail have complimented the author on the extensive and open-access nature of the geospatial content provided by the Geosystem. In so far as usability was a key goal of this research and its practical application through targeted development, this direct evidence demonstrates some margin of success.

It is also important to recognize that the rate of geospatial information technology innovation is exponential in form. Six years ago, when the original concept for the Geosystem was crudely articulated, the solutions currently contained in the Geosystem did not exist. The primary challenge has been to develop a dynamic set of geospatial IT solutions against a backdrop of a profound paradigm shift occurring in the technology. As noted, the rate of this change continues to accelerate, and the applications described and documented in this literature already require modification and enhancement to utilize new techniques that are being manifested. What does this mean?

The paradigm shift harnessed in the Geosystem emphasizes communication through networks and the phenomenon of the WWW. After years of research involving large-scale federal data projects, such as the Earth Observing System, it was apparent that the problem centered upon communication rather than information. In fact, as more and more remote sensors have come into existence, the average person and scientist are, in fact, overwhelmed with information. Without a metaframework and analytical matrix through which these “data” can be meaningfully assembled, the individual is overwhelmed with too much information, and suffers from a lack of understanding.

Data, by itself, can be unintelligible. Thus, a geographic communication system was created: The Lewis and Clark Geosystem.

Having created the National Lewis and Clark Education Center at The University of Montana-Missoula, the Geosystem was born out of a necessity to build a series of interoperable, distributed systems within systems that would allow interested individuals to access assembled, consistent, standardized geospatial representations of the historical geography of the Lewis and Clark Trail. The secondary goal was to organize into discrete spatial-temporal sub-systems a variety of geospatial themes and provide a series of tools for first-order analysis, comparison, and examination based upon cognition theory. If new patterns of experience could be generated from innovative geographic communication systems, the theory holds that new levels of understanding and insight might emerge for the individual. Visualizing complex relationships from a geospatial perspective, thus providing a wealth of geospatial content, would foster comprehensive and questioning. In sum, the goal remains to get people thinking about fundamental geographical concepts in non-traditional ways.

CHAPTER 1

THE GEOSPATIAL MACROCOSM: CONTINENTAL SCALE GEOSPATIAL WEB SERVICE AND INTERFACE

In order to gain a grounding in the overarching significance of the historical geography of the Lewis and Clark Trail, and the expedition's history from May 14th, 1804 to September 23rd, 1806, it was necessary to build a subsystem that illustrated fundamental changes in the landscape ecology along the Trail during the intervening two hundred years since the expedition (*ca.* 1804-2004). This was achieved through the development of the first series of biogeographical geospatial Web services for the Missouri Botanical Garden.²³ The Garden's applications were designed primarily to be used by the members of the educational community, and were a direct extension of Geosystem research conducted by Mr. Philp while he served as Director of the National Lewis and Clark Education Center. Mr. Philp conceived, developed, and secured the federal funding in order to launch the Education Center as an extension of the NASA-funded EOS Education Project at The University of Montana – Missoula.

Given the voluminous amount of geospatial information that could be included in such a system, a particular assessment methodology for descriptive and comparative analysis was defined. This included the extraction of all of the plant and animal (floral and faunal) observations by the Lewis and Clark Expedition, geocoding of these observations by correlating the observation date to campsite date, and developing an enterprise geodatabase schema for the ArcIMS (Internet Map Service) services.

²³ The Missouri Botanical Garden system was funded through a series of National Park Service Challenge Grants. The author served as a co-author. Daniel Botkin, Robert Coulter, and Mr. Philp were the principal investigators during the various iterations of these Web services and graphic user interfaces.

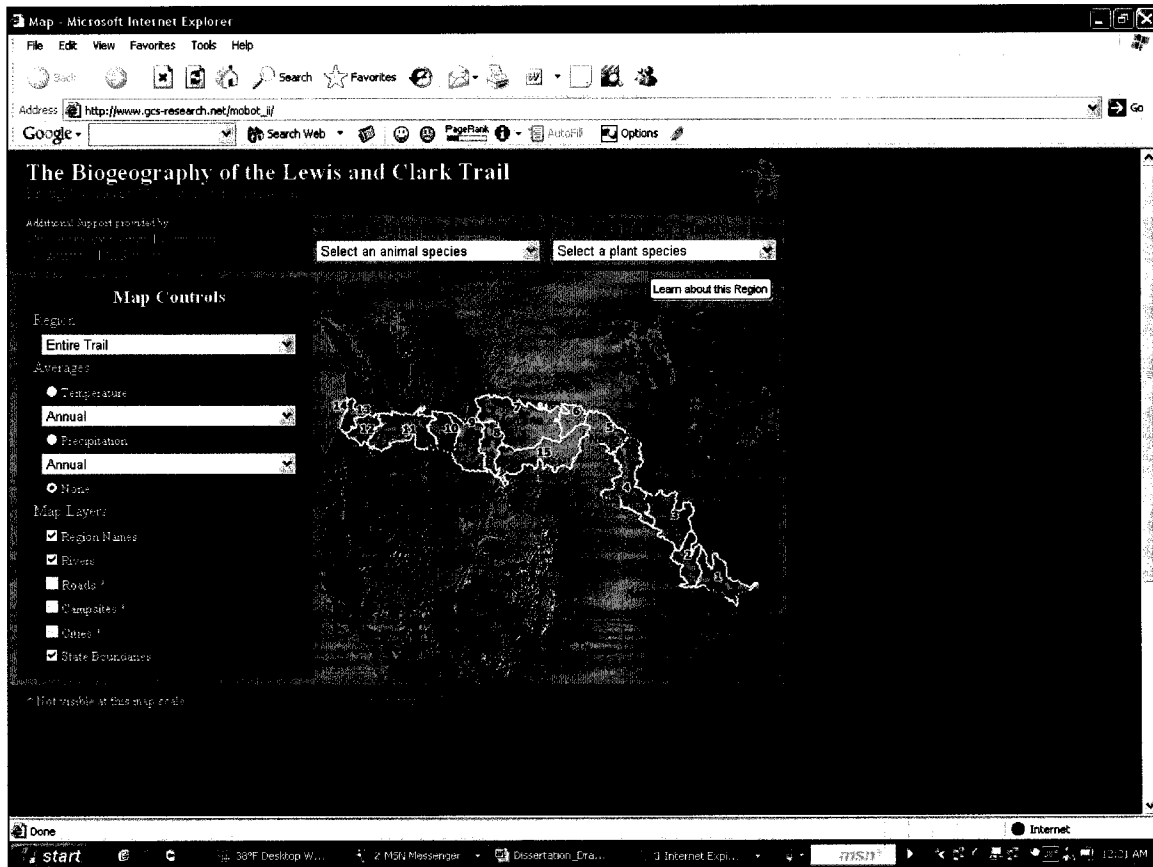


Figure 1. This image shows the primary screen that one sees when accessing the ArcIMS application. All the graphics, layout, design, and architecture were designed as original components of the Lewis and Clark Geosystem. The image shows Botkin's ecoregion concept for dividing the Lewis and Clark Trail into biogeographical units, and access to elemental map layers for viewing and query. Users of the system have the option to select from a pull-down listing of plant and animal species recorded in The Journals of the Lewis and Clark Expedition.

As shown in Figure 1, the macro-scale Geosystem component serves as a stand-alone Web application coded in ASP.NET (Active Server Page). The main map frame window receives the map image (JPEG) for an ArcIMS service, which is hosted and maintained currently by GCS Research LLC. All of the geospatial information contained in the initial map frame window exists as an ArcXML (XML - Extensible Mark-up Language) file written to provide the programming logic for the ASP.NET calls to the ArcIMS application through the .NET Framework residing with MSFT IIS Web server software.

The Lewis and Clark Trail line topology, combined with the segmented “ecoregions” as defined by Daniel Botkin *et al.*, are utilized as the starting point for exploration of the fundamental connections among landscape, historical annual precipitation, and temperature.²⁴ The user of the site has the option of choosing varying selections of temperature and precipitation data as defined by NOAA (National Oceanic and Atmospheric Administration). However, instead of maintaining and updating this

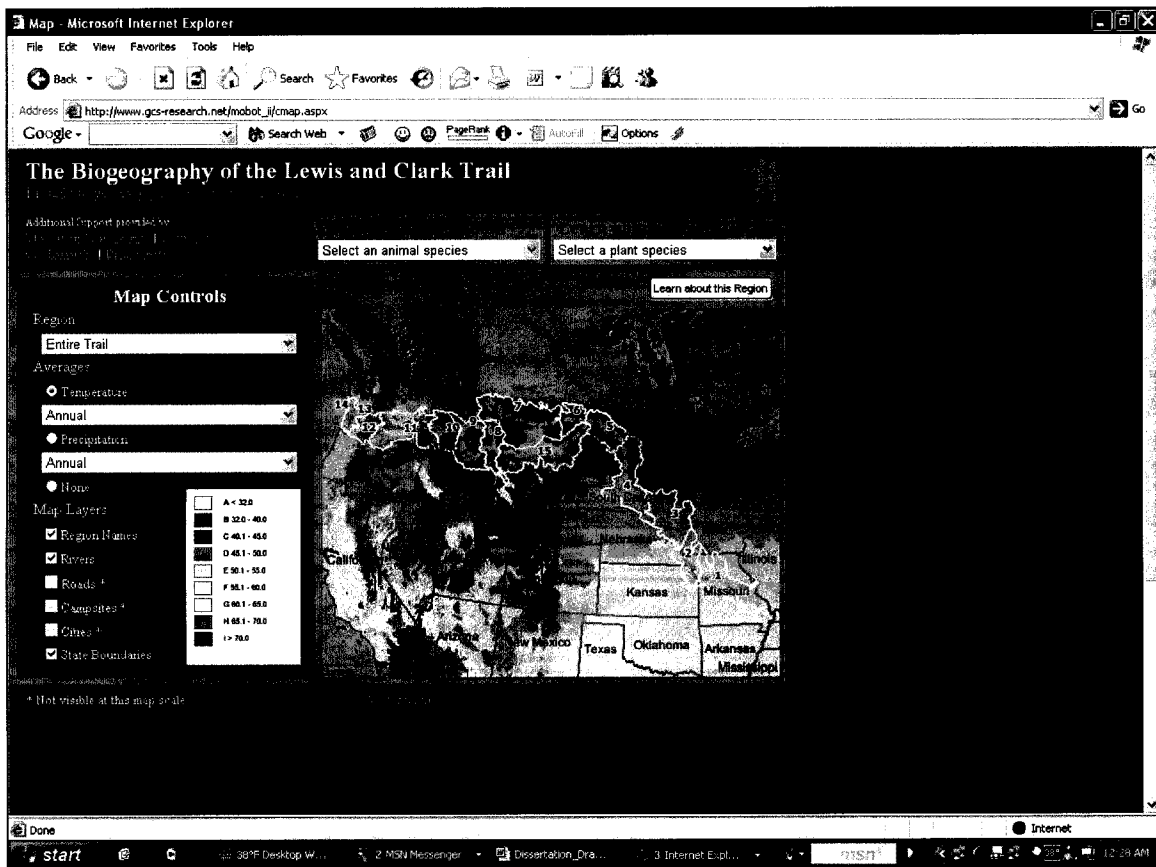


Figure 2. This image depicts the consumption of the NOAA Web mapping services for national average annual and monthly temperature data. The intent here was to provide an effective way to compare and contrast relationships between the ecoregional units and climatological information provided dynamically from the NOAA Web services. Please see <http://www.noaa.gov>.

consumed by an ASP.NET “call” to NOAA spatial data servers, which dynamically deliver this information directly to the map frame window, replacing the previous image

²⁴ Botkin, Daniel B. 2004. *Beyond the Stony Mountains*. Oxford: Oxford University Press.

file (.jpeg) with a new map image. This dynamic call is the heart of a distributed geospatial application, and this pattern is repeated successfully and repeatedly across the overarching architecture of the Lewis and Clark Geosystem.

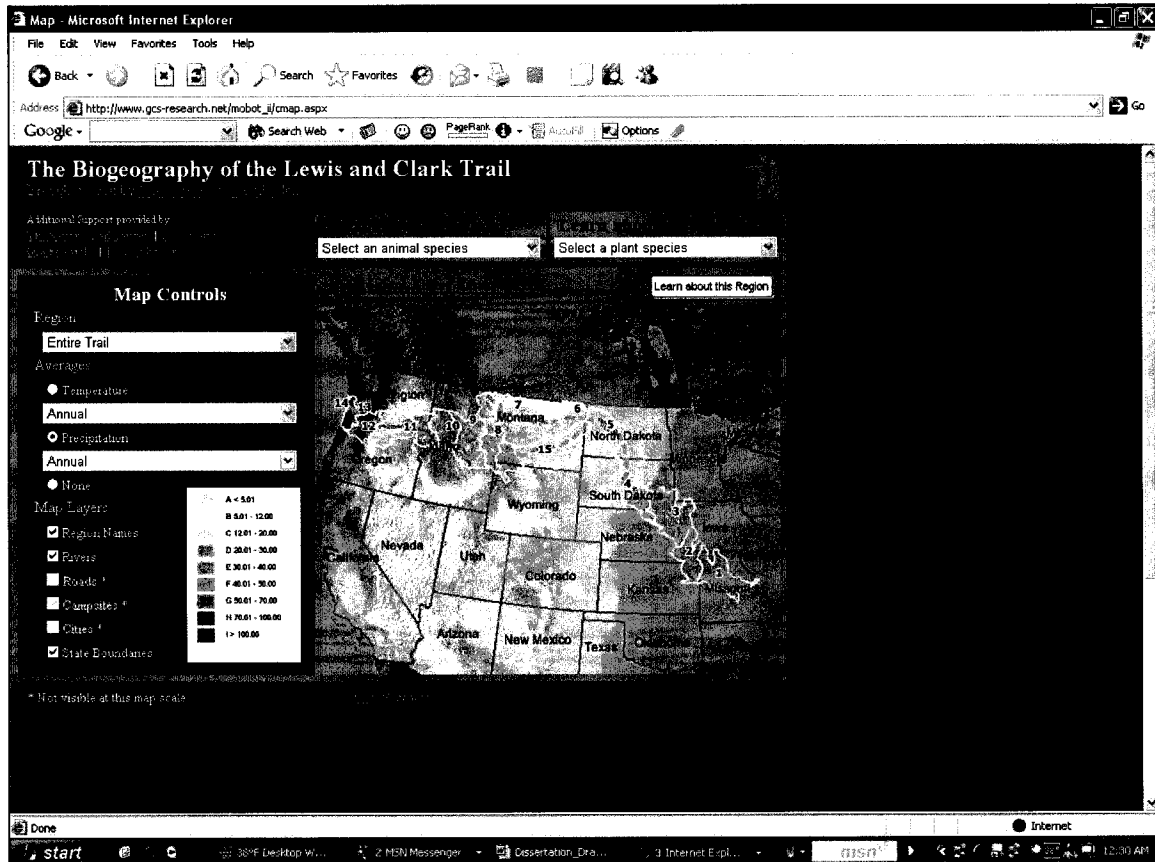


Figure 3. This image depicts the visualization of the NOAA Web service for precipitation data. These data are consumed dynamically from the NOAA Web mapping service, and then are recombined to create a new map image that is sent to the browser client.

The same geospatial Web service calls have been programmed for NOAA temperature data and each climatic variable can be viewed by annual average and monthly average for the entire NOAA historical archive. These comparative tools, designed to be easily used by the average educator and/or student, provide a fundamental set of tools to allow for the comparison of the key climatic drivers that provide hydrological boundaries for the key ecoregions transected by the Lewis and Clark Trail.

In addition, basic orientation layers are included, so the end user has the ability to quickly view the overarching map and determine additional geospatial components. Depending upon map scales, these layers are dynamic and can be chosen by a click of the check box provided in the Web frame. Additionally, each ecoregion unit can be selected and a “zoom” function allows the user to investigate the landscape at a larger scale.

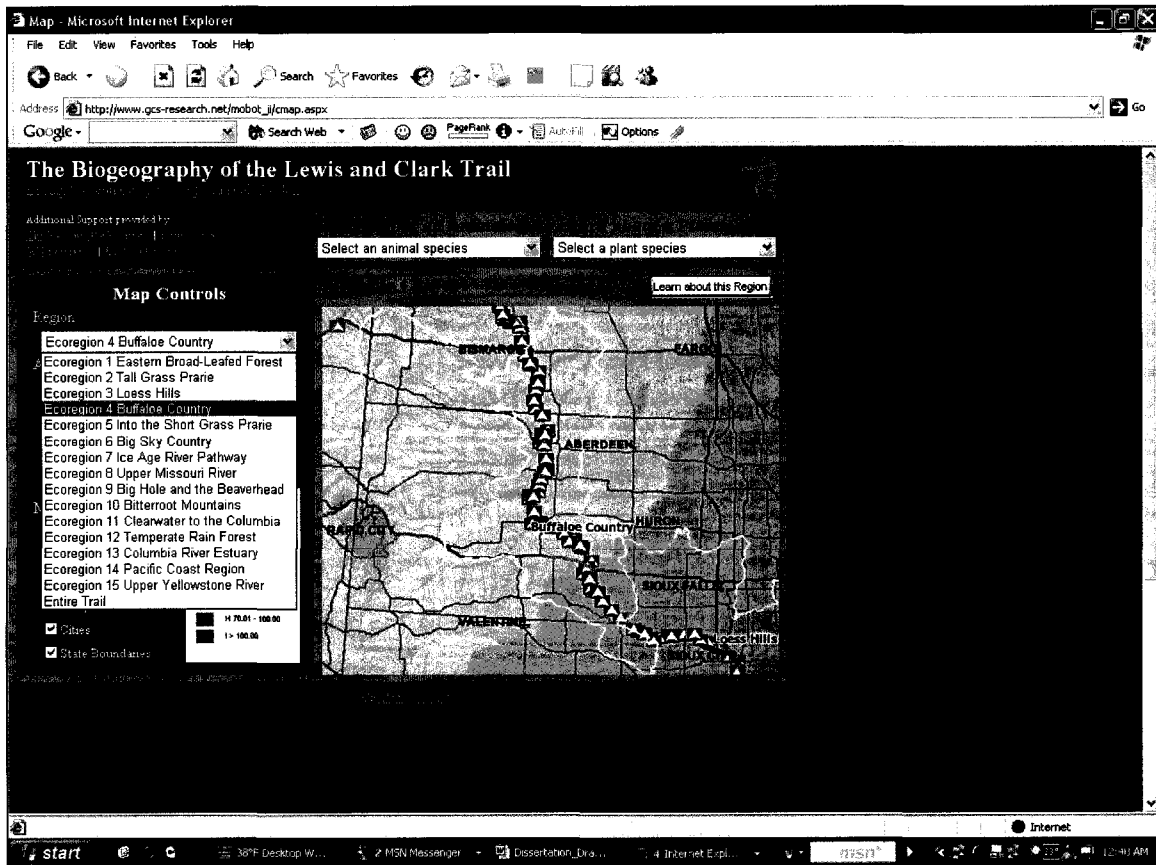


Figure 4. This image show the primary interface selection process when the user selects a particular ecoregional unit. In this instance, the user chose Ecoregion 4, “Buffalo Country,” encompassing the Trail environs between Sioux City, Iowa and Bismarck, North Dakota. Individual Lewis and Clark campsites are now viewable and draped on top of the NOAA precipitation data for the ecoregion. Any ecoregion unit can be easily selected from the primary GUI.

The key driver of this site is the plant and animal geodatabase assembled as the core value of the system. All of the plant and animal species observed by Lewis and Clark, as documented in The Journals of the Lewis and Clark Expedition, can be queried

by this component of the Geosystem. As shown in Figure 5, the user simply utilizes a pull-down menu catalogue of the species maintained in the geodatabase, and selects the plant or animal species of choice. The ASP.NET call then launches an additional, interwoven map service that provides higher order biogeographical information by species.

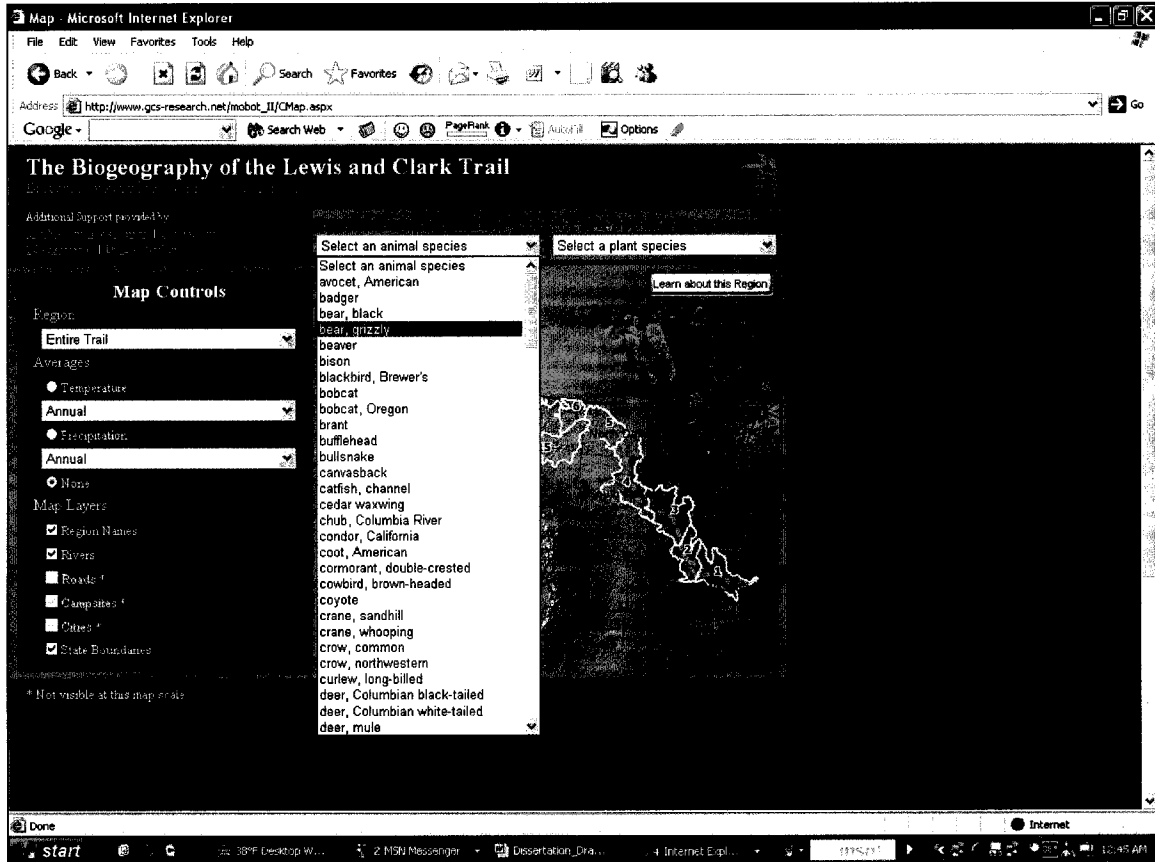


Figure 5. This image depicts the central component of this application. From the primary interface, the user can choose to view the observational location for all of the plant and animal species observed by the Lewis and Clark Expedition. These observations are segmented by ecoregion, and serve as the basis to launch the geodatabase query and subsequent map services for user analysis.

Each individual species is catalogued by common and scientific name, providing for a dynamic indexing of all observed species by geospatial location. While it was impossible to determine the exact location of each observation, it was possible to correlate the observation by journal date, as well as reference date to a known campsite

location (latitude and longitude). Given the scale of this component of the Geosystem, the associated error was seen as permissible, and certainly provides a basis for additional research at larger scales and with a level of precision not intended for this particular component of the Geosystem.

In the example provided below, the grizzly bear (*Ursus arctos horribilis*) was chosen, and this results in the presentation of additional data resources all stored at the geodatabase level. As shown, a secondary page is revealed to the user. Most interestingly, all known observations by ecoregion are extracted from the secondary map

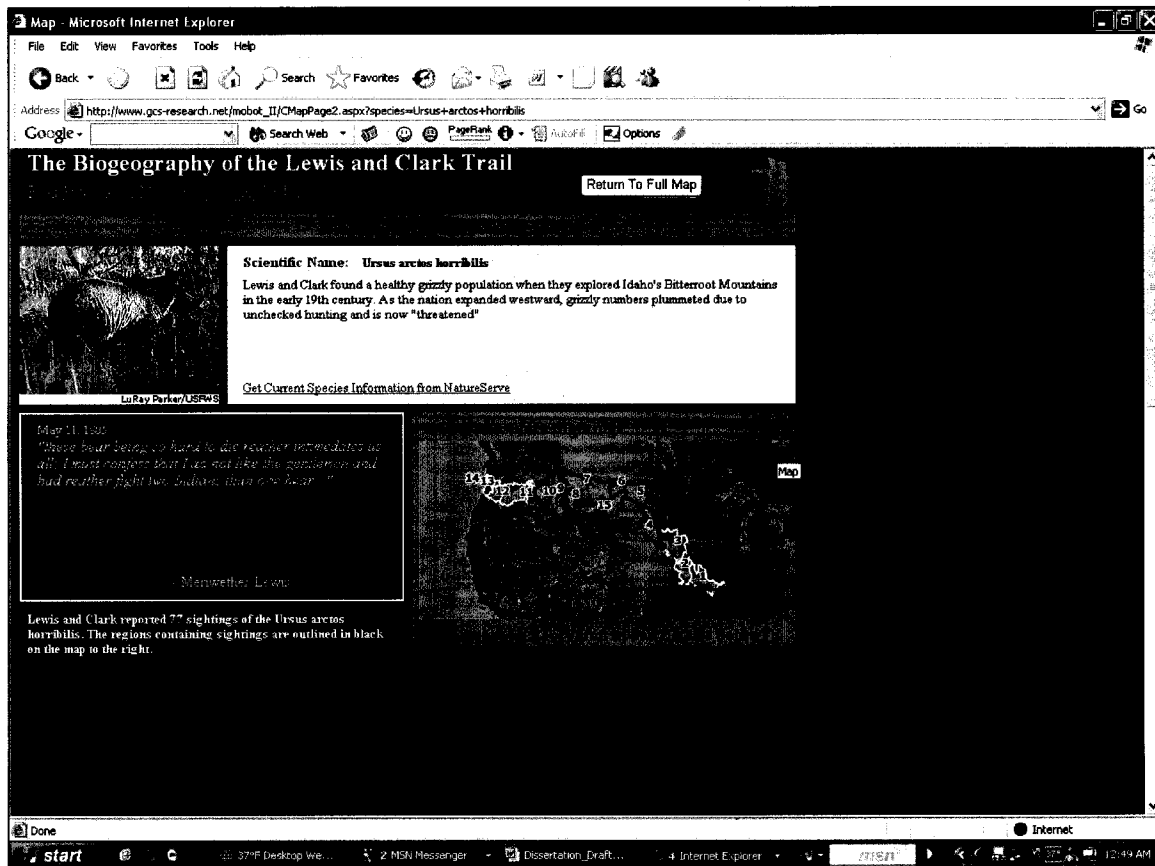


Figure 6. This figure depicts the secondary Web mapping application query results associated with the selection of a single animal species – *Ursus arctos horribilis*. A secondary Web map service is launched, depicting the location of seventy-seven grizzly observations by the Lewis and Clark Expedition.

map service and geodatabase. In the case of the grizzly bear, it is clearly apparent when

the Expedition first encountered the animal, the spatial extent of the contact, and the total number of sightings as catalogued in the *Journals*. In this instance, Lewis and Clark observed the grizzly bear approximately seventy-seven times across a large portion of the Expedition, beginning in the Central Plains and extended through the Northern Rockies. Upon further investigation, the user can select an individual ecoregion and call a third map service dynamically consumed in the same ASP.NET frame, providing a detailed overview of the observations by ecoregion. This map service provides a detailed visualization of the grizzly bear observations by campsite location for distinct ecoregional portions of the Trail.

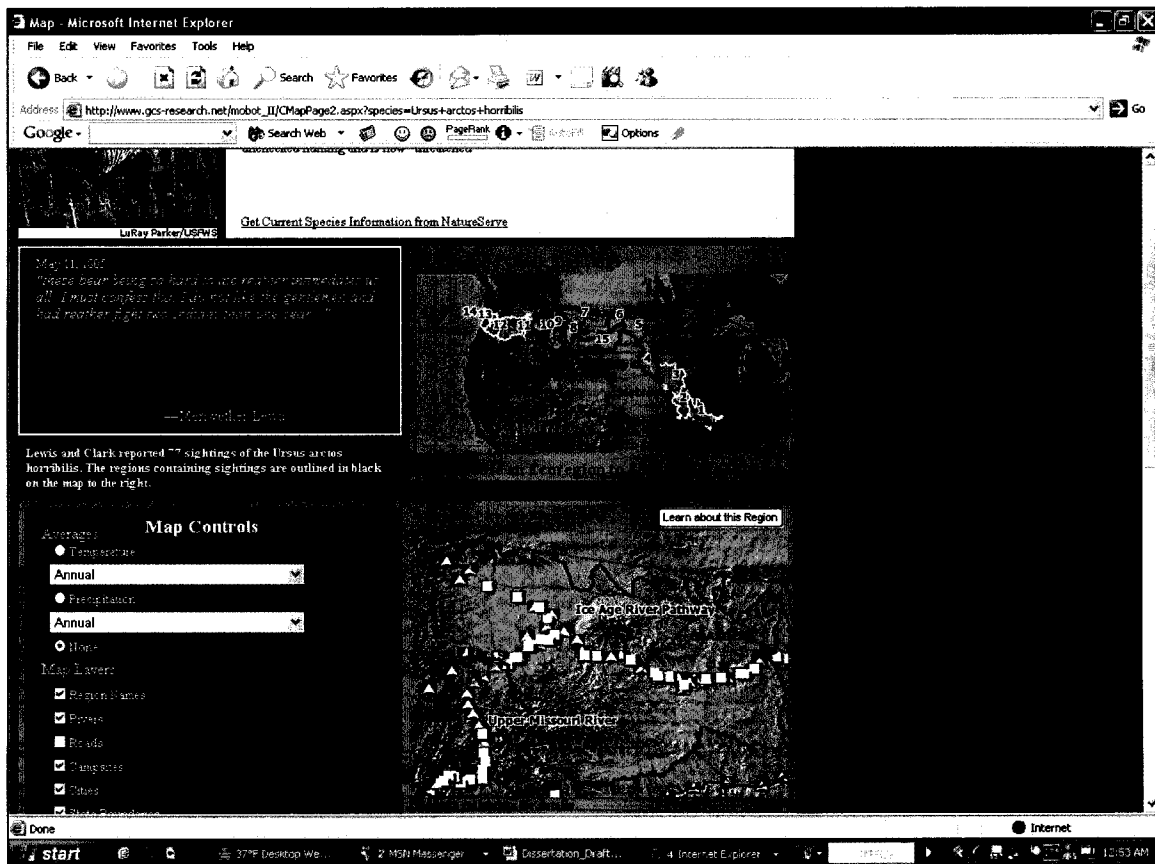


Figure 7. This image captures the projection of two Web mapping services being consumed into a single ASP.NET page. The upper map image provides an ecoregional overview; the bottom map image highlights the Ice Age River Pathway ecoregional focus. Grizzly bear observations are symbolized by the square icons. This scene demonstrates the consumption of two ArcIMS applications in a single ASP.NET frame.

One of the key goals of this system was the ability to compare and contrast plant and animal distributions against modern species ranges. In order to achieve this effect, a direct programmatic linkage was established between existing ASP.NET Web pages and the database systems maintained by NatureServe, a geospatial clearing-house repository maintained by the Nature Conservancy.²⁵ As shown in the image below, it is possible to produce an ASP.NET call directly to the NatureServe database records and return a map image and detailed species information, such as *Ursus arctos*, regarding current habitat and species range. This effect is achieved by conducting a “like-search” query between

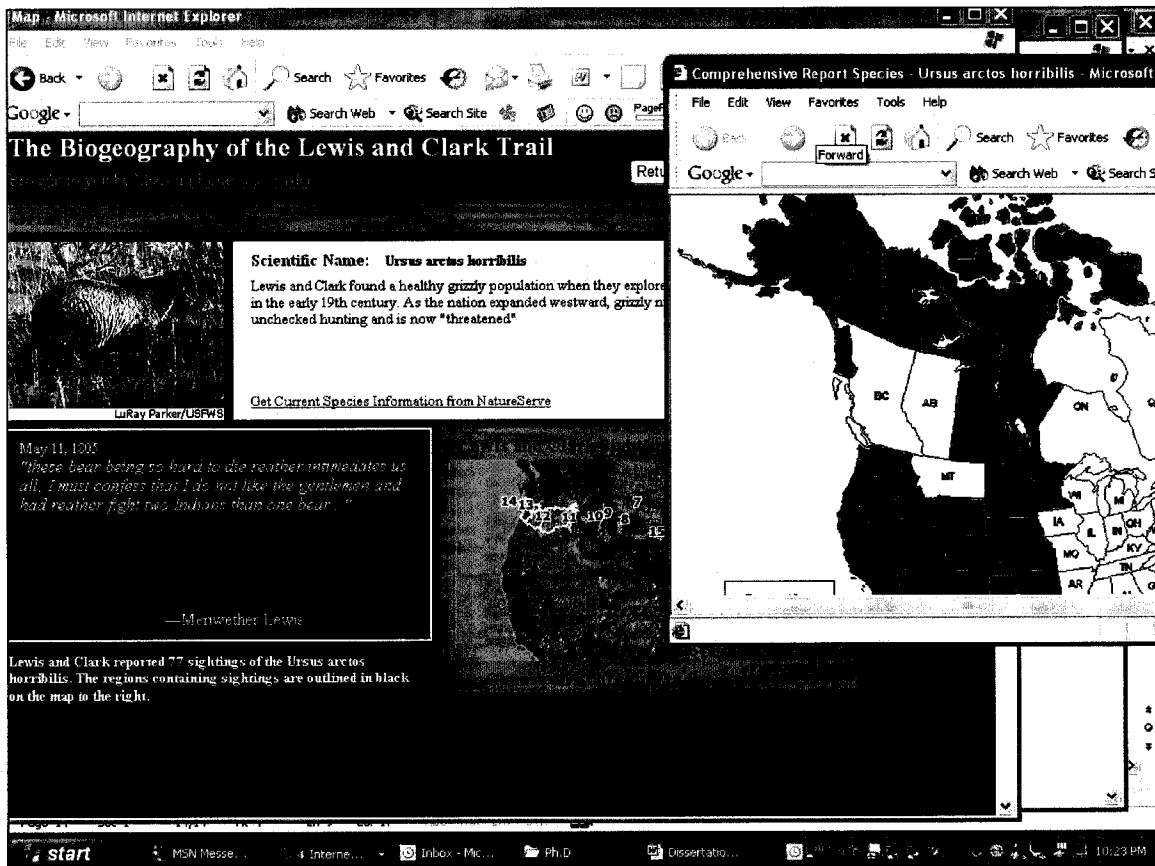


Figure 8. In order to provide a modern analog to the historical observations, the user has the ability to query the NatureServe database. This image showcases the viewing of a modern species range map for the grizzly bear in comparison with the historical observations depicted in the previously described Web map services. Utilizing dynamic browser frames, the user has the ability to view the map applications at the same time on the computer monitor. To achieve the effect, an ASP.NET call is made to the NatureServe database for the particular species of choice.

²⁵ <http://www.natureserve.org/>.

the geodatabase element maintained on the ArcIMS server and the SQL server database maintained by NatureServe. The IE browser windows are completely dynamic and can be moved by the user to achieve the desired visual reference. This is achieved for each and every plant and animal species maintained in the existing system. For additional information regarding the unique eco-cultural characteristics of the particular ecoregion where Lewis and Clark observed a particular species, descriptive essays were written and provided as additional pop-up windows. These essays were provided by Dr. Daniel Botkin.

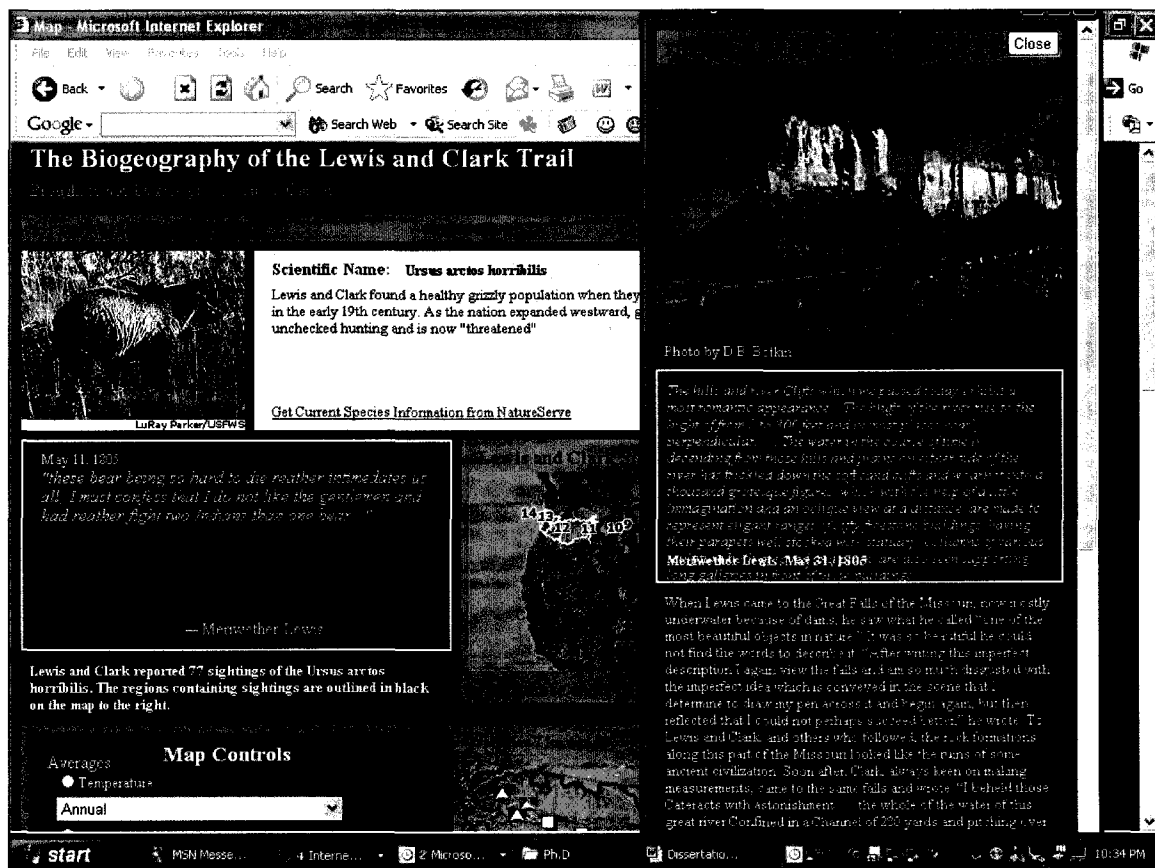


Figure 9. This image exposes additional descriptive natural history information for the particular ecoregion of choice. These ecoregional essays were written and provided by Daniel Botkin, a collaborator on this particular component of the Geosystem. The original impetus for the ecoregional analysis of the Lewis and Clark Trail was developed during Dr. Botkin's Visiting Research Professorship at The University of Montana – Missoula, and the National Lewis and Clark Education Center.

These essays, along with existing biogeographical information, are provided for each of the fifteen ecoregional units within the geodatabase.

From an architectural perspective, the overall layout for this continental Web service is diagrammed in Figure 10. As previously shown, this continental scale application consumes geospatial Web services and database queries from external systems. Utilizing ASP.NET and the .NET Framework (version 1.1), the Web server

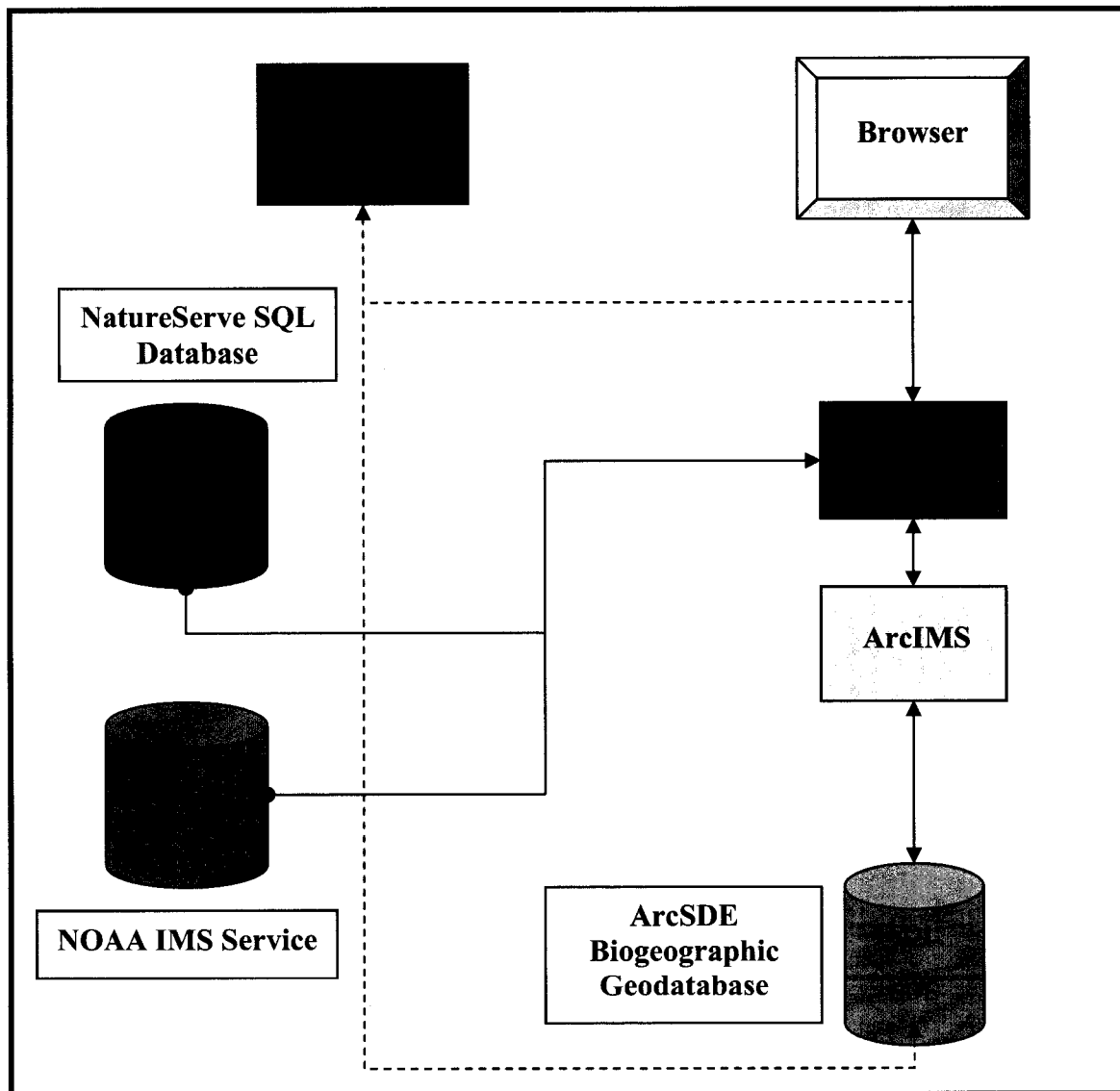


Figure 10. This architectural schematic depicts the design and functionality of the MOBOT application of the Geosystem. The most challenging component was the normalization and standardization of the species names in order to provide an effective programmatic query of the relational databases.

calls NOAA continental scale temperature and precipitation data, and provides this information in three ArcIMS services maintained at the central application level.

Secondly, SQL Server database queries are generated by species name between a geodatabase feature class table maintained as the central application level and NatureServe SQL Server database table. One of the more challenging aspects of this application was the normalization required in scientific nomenclature for the plant and animal species lists. Unfortunately, the common and scientific names maintained by the Missouri Botanical Garden are not consistent with the database records maintained by NatureServe. Thus, it was necessary to create a cross-over table for species names in order for the ASP.NET calls to be correctly developed. Moreover, each species name, approximately three hundred in this particular application, had to be individually checked to denote differences and then re-established within the cross-over table.

The dynamic nature of launching multiple Web map services and database queries across the Web represents a significant programmatic milestone for this application. Given the amount of processing occurring on the server-side (IMS and SDE), the performance of the application is surprisingly efficient. Throughout the design and performance testing of this component of the Geosystem, the primary target was to deliver map images within a 4-5 second interval. Of course, this performance varies depending upon the bandwidth connectivity between the browser application (Internet Explorer) and the Web server. Despite potential bandwidth constraints, and primary source network congestion, the performance is acceptable. If a more powerful Web

server were developed, as well as co-location facilities, performance could be improved marginally.²⁶

The uniqueness of this system rests upon the nested complexity of Web map services, the dynamic database-driven applications across distributed networks, and the integration of fundamental biogeographical information. The continental scale overview provides analytical tools to explore dynamic relationships between the past and present biogeography of the Lewis and Clark Trail. To the best knowledge of the author, it is the only system in existence that provides a geodatabase structure to all of the plant and animal observations provided in The Journals of the Lewis and Clark Expedition, and provides a dynamic mapping application to view the relationships between the past and present biogeography of the flora and fauna.²⁷

²⁶ It should be noted that the hardware for this application follows a typical two-tiered array. The Web server parses browser calls utilizing a custom .NET Connector, IIS, and the .NET Framework version 1.1. ArcIMS is maintained on the Web server box, and makes calls to the data server, wherein SQL Server and ArcSDE are co-located. This entire system exists behind two CISCO PIX firewalls, and is maintained on a Virtual Private Network (VPN) to maintain a high level of network security for the primary system core.

²⁷ A complete publication of the ArcXML behind the primary ArcIMS service associated with the plant and animal views is contained in Appendix A of this document. Please note the extreme complexity and size of this XML publication. Given the amount of XML necessary for the ASP.NET calls to parse, it is quite amazing how well the overall site performs. This is especially true when one considers the complexity of the multiple ArcIMS services being dynamically generated from SQL.

CHAPTER 2

MESO-SCALE ASSESSMENT: A REGIONAL SCALE ANALYSIS OF THE LOWER COLUMBIA RIVER WATERSHED

The second major system developed for the Lewis and Clark Geosystem focuses upon the geospatial historical geography of the Lower Columbia River. Developed as a project for the US Fish and Wildlife Service (USFWS), and an extension of the primary aim to capture discrete examples of change across landscape scales, the USFWS site is the second major component of the Geosystem. As a regional component of the Geosystem, the USFWS provides a different application interface to the geodatabase.

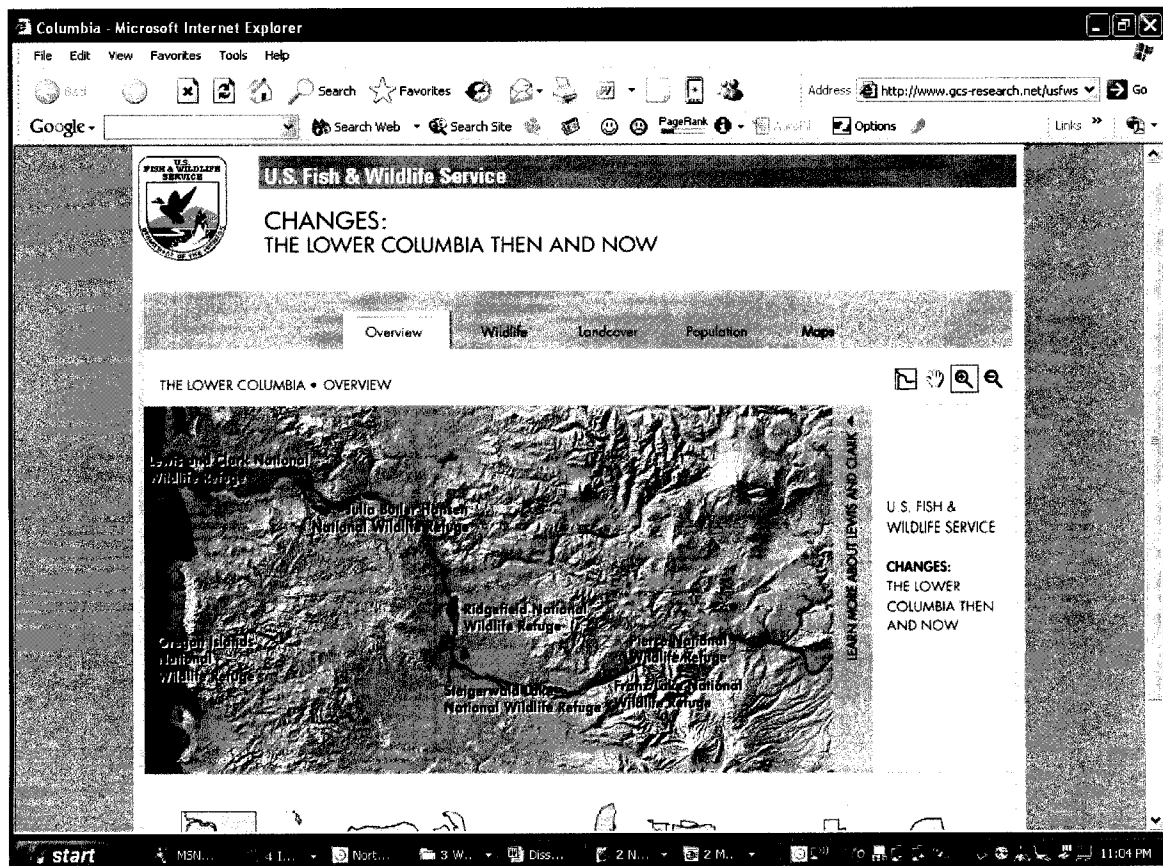


Figure 11. This image depicts the primary interface of the US Fish and Wildlife Service Lower Columbia River element of the Geosystem. The application is driven by a Macromedia FLASH interface calling a .NET Connector for ArcIMS and ArcSDE integration. The application utilizes the caching properties of FLASH to provide optimal performance for viewing and displaying the content.

The Lower Columbia project allows the user to easily navigate from regional scale analysis to a local-scale perspective utilizing a combination of FLASH Web browser programming, a custom .NET connector, IIS and the .NET Framework at Web server level, ArcIMS, ArcSDE, and SQL Server. All data is stored in an enterprise geodatabase and dynamic FLASH calls are made between the GUI and the ArcIMS. Given the unique caching abilities of the FLASH plug-in, the resultant performance of this application represents a significant breakthrough in distributed geospatial applications.²⁸

As determined jointly by the USFWS and the author, certain geographical thematics were chosen to highlight change across the Lower Columbia. These include 1) wildlife; 2) population – demographics; 3) landcover – aerial photography; and 4) historical cartography between *ca.* the late-seventeenth and late-nineteenth centuries. Paralleling this thematic exposition, specific USFWS refuges were chosen from across the study-area extent as micro-scale case-studies for in-depth understanding. These refuges are 1) Oregon Islands; 2) Lewis and Clark; 3) Julia Butler Hansen; 4) Ridgefield; 5) Steigerwald Lake; 6) Franz Lake; and 7) Pierce.

The temporal period of change focuses upon the Lewis and Clark expedition entry into the region *ca.* 1805 and the modern period *ca.* 2005. Detailed research was involved to reconstruct historical population dynamics as a dot density map by US Census county boundaries, as well as population estimates during the territorial period for the region. Animal observations were again correlated between date and location of observation and extracted from the Moulton edition of the Journals. Dr. Bergantino's campsite data was

²⁸ This project alone required two years to complete. The USFWS has asked for additional components and materials to be added. The application is a candidate for innovative application of the year by – Environmental Systems Research Institute (ESRI).

used as the spatial index within the enterprise geodatabase and serves as the primary spatial reference for the IMS Web map service. The historical cartography component was derived from an exhaustive examination of the Library of Congress Digital Map Archive.²⁹ All of this research was original, except where noted.

Beginning with the overview of the region, each essay, observational note, and citation was produced by the author and then combined with the FLASH development platform to produce a very dynamic GUI for examination of both the textual and geospatial elements of the application. Moving to wildlife examinations, key species

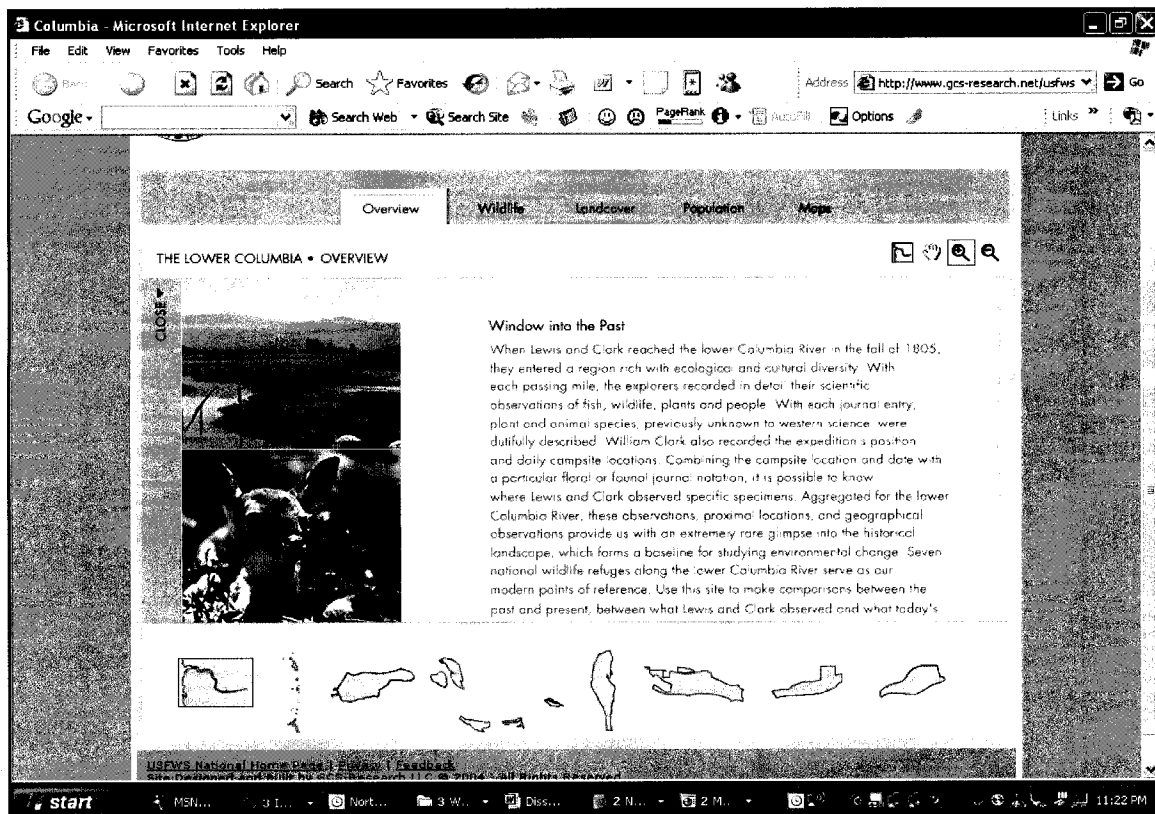


Figure 12. This image depicts the descriptive, geographical essays contained in this component of the Geosystem. All narrative content was developed by the author.

²⁹ Over the past six to seven years, the author has literally spent thousands of hours familiarizing himself with the historical cartography of the Lewis and Clark Trail through an exhaustive examination of the Library of Congress Digital Map Archives. This effort extends detailed research produced in the “Historical Geography of the Sun River Watershed,” the author’s MA Thesis. The author was invited to present his findings and research on the historical cartography of the Lower Columbia River *vis-à-vis* Lewis and Clark at the ESRI International User Conference in August of 2004. This presentation was a special keynote at the Survey Summit.

were selected to highlight ecological change along the Lower Columbia. These species include 1) tundra swan; 2) California condor; 3) steelhead; 4) Chinook salmon; 4) Roosevelt elk; 5) white-tailed deer; 5) river otter; 6) bald eagle; 7) Sandhill crane; 8) assorted waterfowl; 9) assorted shorebirds; 10) white sturgeon; and 11) harbor seal. For historical observations, the point of contact is mapped and viewable as a series of FLASH calls in the application. For modern species ranges, to the extent these data exist, the user has the ability to examine historical point observations against the modern species range.

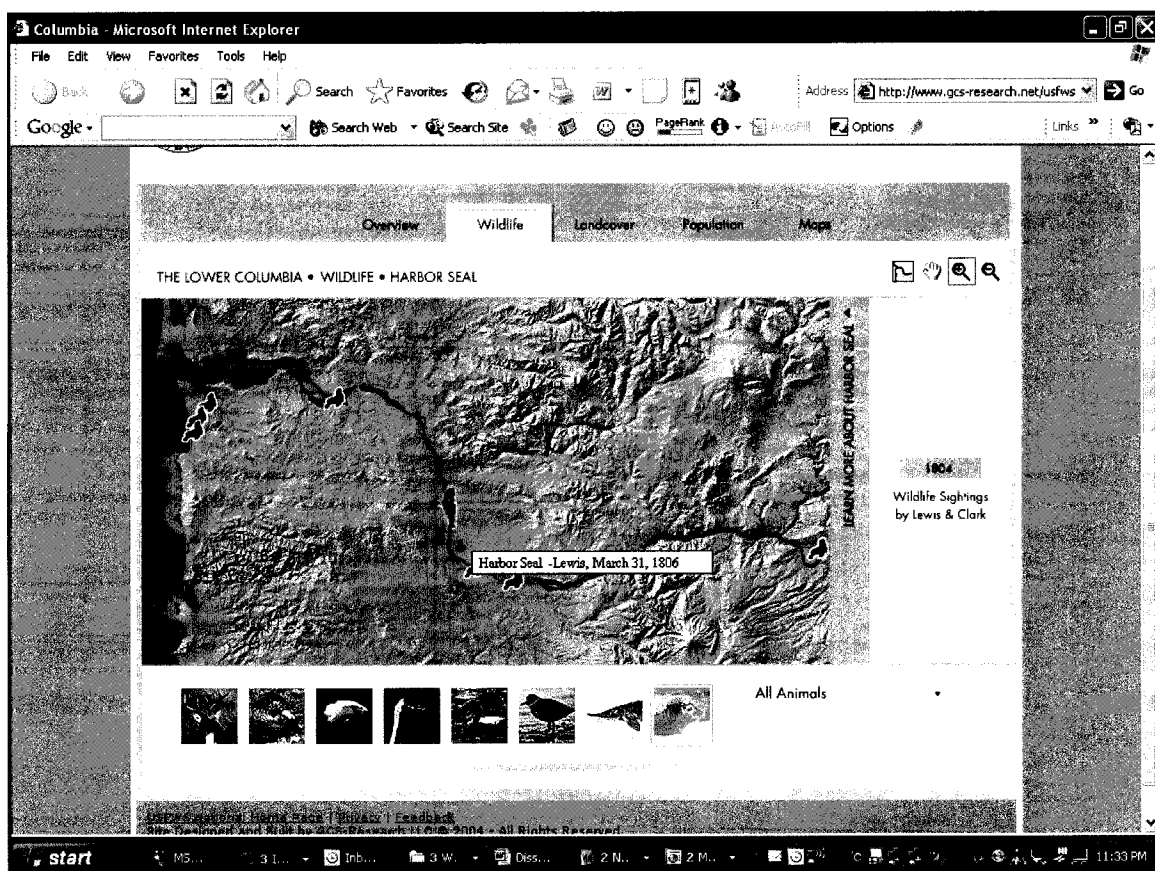


Figure 13. In this image, certain species observations from the expedition are depicted and viewable in the wildlife thematic. As is the case with the MOBOT application, specific species observational dates are correlated to the campsite locations and dates provided by Dr. Bergantino's database. Individual symbols were developed in Flash. In the future, additional data and geographical themes could be added to the application depending upon the requirements of the USFWS.

geospatial location and date of the observation for harbor seal. A concomitant essay and Journal quotations are provided in a pull-across FLASH call, allowing the user to easily shift back and forth between cartographic illustration and journalistic observation. Associated graphics and images of the particular species are displayed. This level of detail is provided for each of the eleven species and/or species groups chronicled in the application.

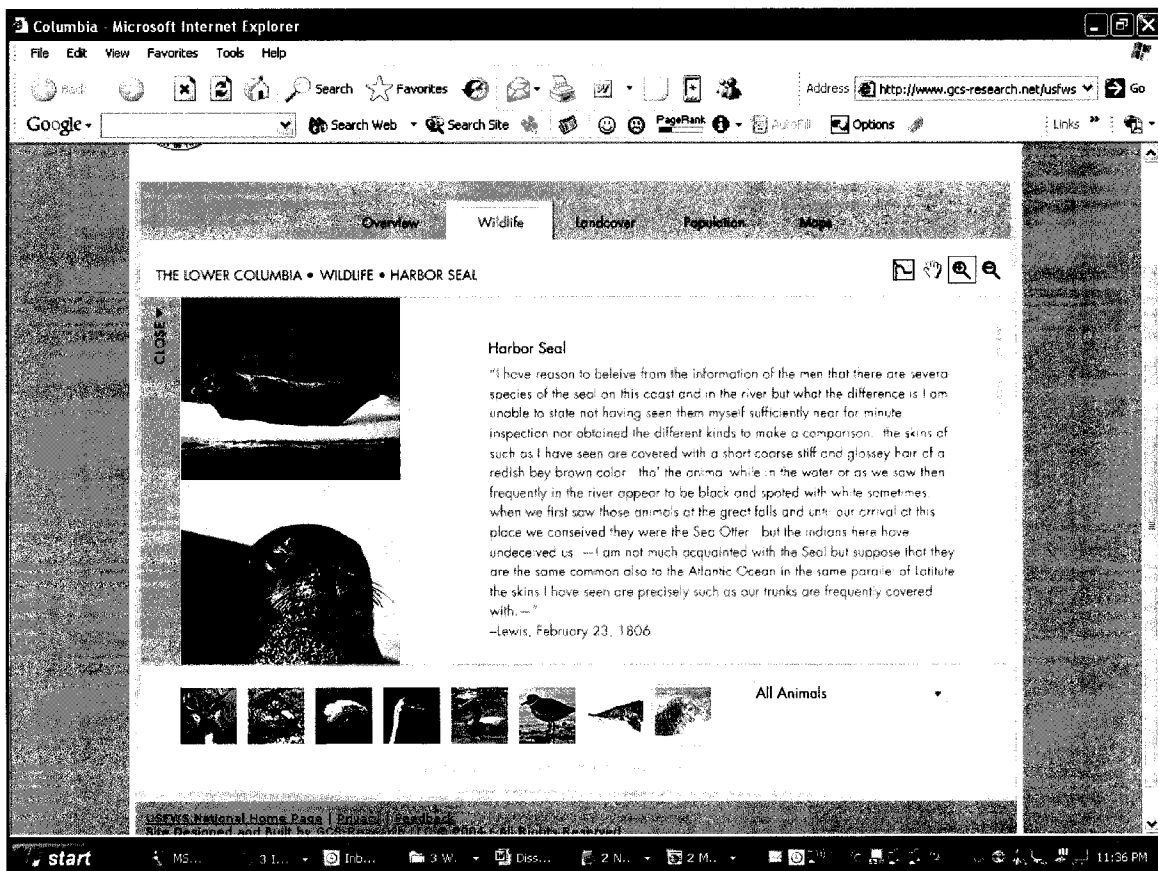


Figure 14. This image depicts the supportive information and quotations from The Journals of the Lewis and Clark Expedition for the individual species that are highlighted in the application.

The landcover component combines information derived from the Interior Columbia River Ecosystem Management Project as compiled and analyzed by the

Interactive Biodiversity Information System (IBIS).³⁰ The IBIS data compares land cover probabilities *ca.* 1853 as chronicled by the Steven's Expedition survey of Oregon Territory. This is contrasted with land-cover information derived from Landsat 5 TM (Thematic Mapper) data from the USGS EROS Data Center.

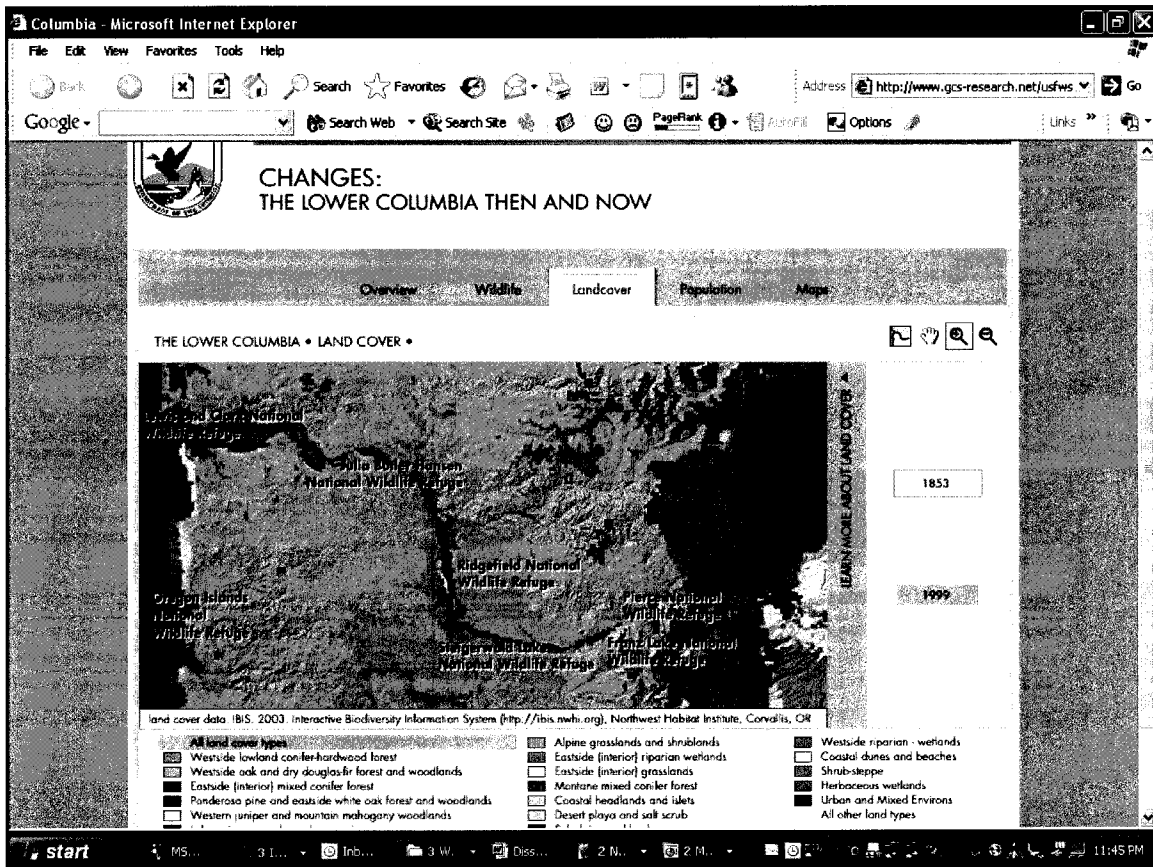


Figure 15. The land-cover thematic map utilizes vegetation classification from the IBIS project, which is derived from the Interior Columbia River Ecosystem Management Project.

Again, each landcover type as defined by IBIS is described in an explanatory notation. Comparing the 1853 approximation with the relatively modern land-cover map

³⁰ Please see <http://www.icbemp.gov/>. For regional-scale analysis of the Lewis and Clark National Historic Trail, the author strongly recommends additional research and analysis. The ICBEMP spatial data resources are underutilized for landscape-scale change detection. If qualified and analyzed properly, significant additional spatial and temporal analysis could be derived from the substantial investment represented in this landmark study. Unfortunately, the policy objectives were not able to be substantiated for regional ecosystem management. See also <http://www.nwhi.org/ibis/home/ibis.asp>.

provides a very revealing alteration of the fundamental land-cover components in the regional ecosystem. Clearly, the expansion of the urban category, the transformation of the conifer to deciduous cover type, and the loss of low-elevation wetland areas represent remarkable landscape transformations during the intervening period between Lewis and Clark's passage and the modern period. A comparison of figures 15 and 16 illustrates the geospatially quantifiable landscape change that has occurred in the Lower Columbia.³¹ This correlates with the population density (dot matrix) map provided as an additional thematic of the meso-scale geospatial historical geography.

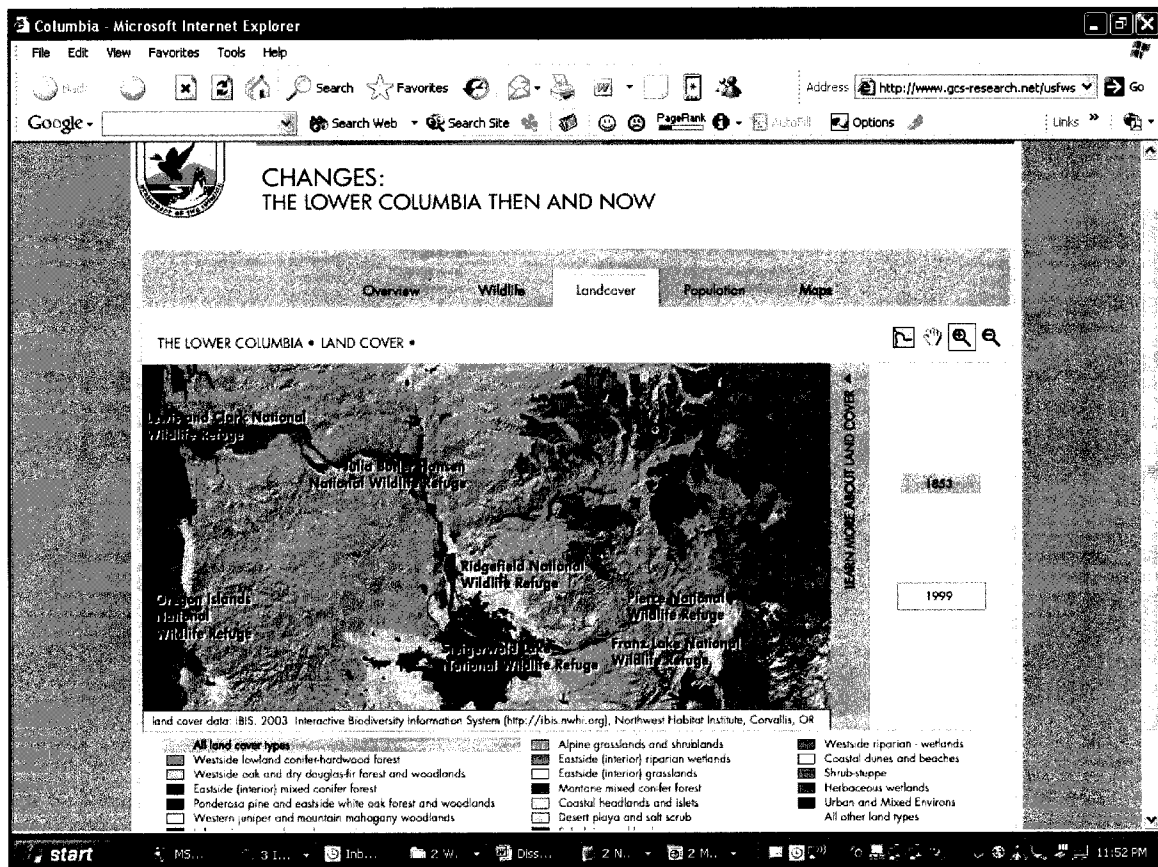


Figure 16. Comparing this image with the image contained in Figure 15, significant landscape scale vegetation alteration has occurred between 1853 and the 1999 analysis. The 1999 analysis was derived from Landsat 5 TM (thematic mapper) remotely sensed data.

³¹ A detailed land-cover change analysis is warranted, but was not the intended scope of the research. The emphasis remains the development of the geospatial application that illustrates certain historical geographical features associated with the regional-scale analysis of the Lewis and Clark Trail.

The population data were derived from the published US Census geospatial data.³² The information was collected and presented at the county jurisdictional level and was broken into decadal segments for population change granularity. Prior to creation of counties as a function of the statehood process, population information was generally assigned. This information was aggregated and stored within the geodatabase and maintained within a SQL-SDE backend application. As illustrated in Figure 17, the user has the ability to select individual snapshots in time to view the changing population

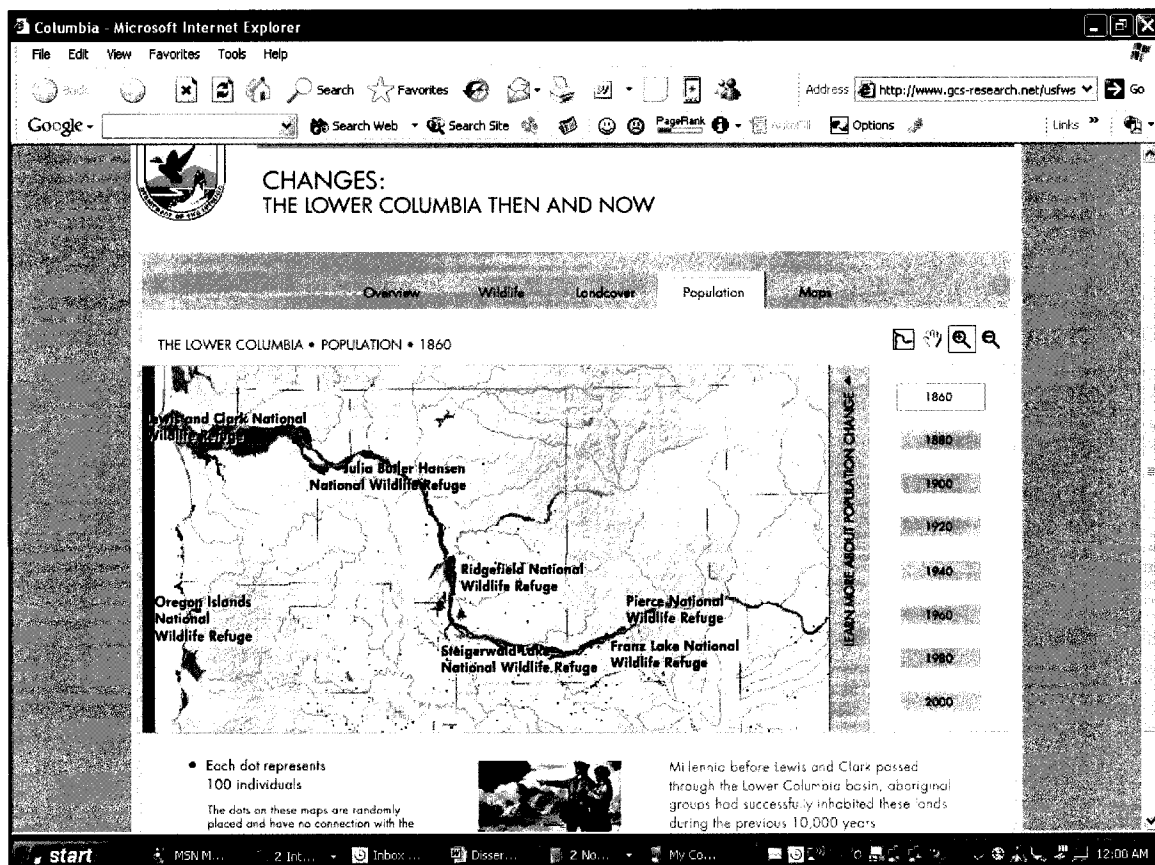


Figure 17. Population density *ca.* 1860, as shown in a dot-density map.

³² Please see <http://www.census.gov/>.

within the region. As illustrated, the population explosion occurred within the second half of the twentieth century as indicated by the dot-density cartography. Comparing figures 17 and 18, a one hundred and forty year shift, it is clearly possible to correlate changes in population, land cover, and wildlife within the emergent urban, suburban, and rural landscapes.

For detailed assessment at the micro-scale or site level, it is possible for the user to simply select an individual USFWS refuge and zoom to a local scale. All of the thematic categories can be examined at this large scale, but the most interesting component is the inclusion of the historical aerial photography for the region. Where the historical aerial photography was available for a given USFWS refuge, these raster data

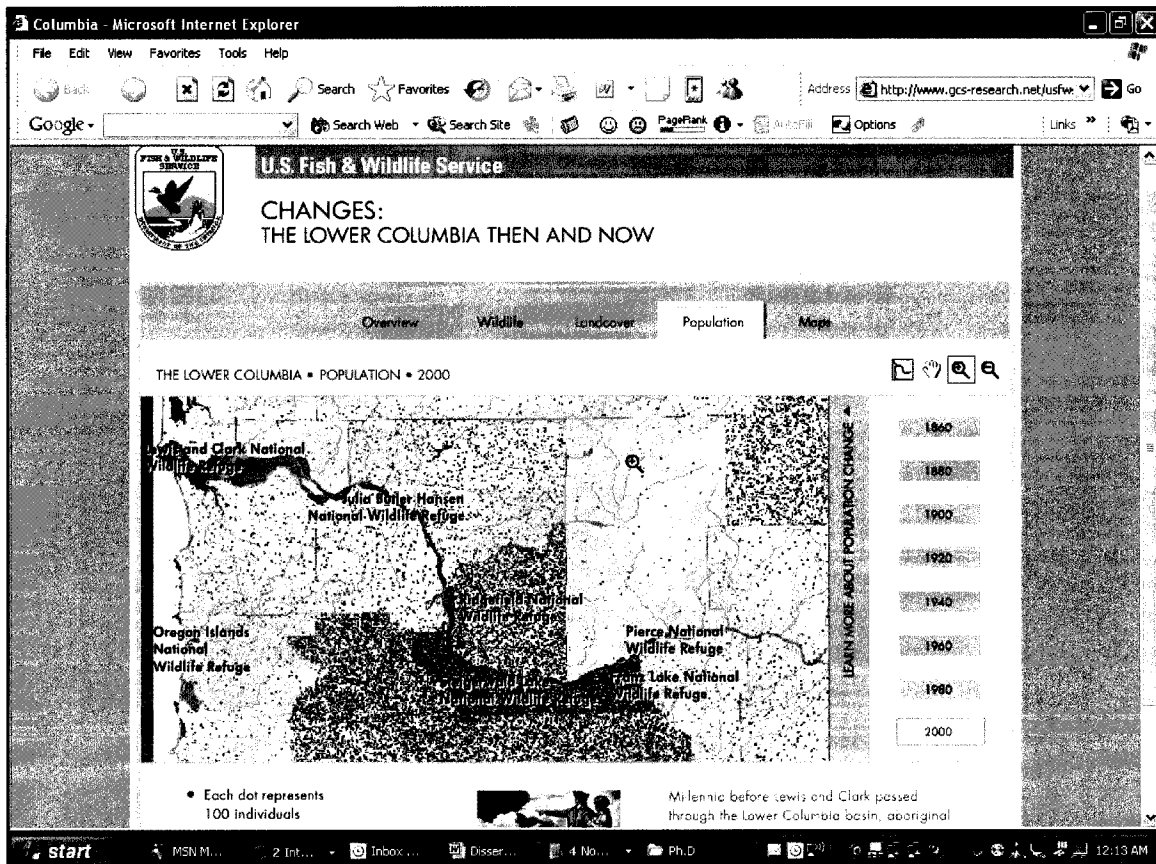


Figure 18. This image depicts the population change by county for the Lower Columbia River Region.

were stored in SDE-SQL server by spatial extent. This imagery includes a vast spatial extent, especially for areas around Ridgefield National Wildlife Refuge. In all, seven wildlife refuges are highlighted in the application, and can be directly accessed by simply choosing one of the refuge icons located at the bottom of the FLASH GUI.

In Figure 19, historical aerial photography for Pierce NWF was included in the application, providing a time series between 1935 and 1994. Comparing the 1935 photograph with the 1994 georeferenced imagery provides a good example of intelligible change detection. Wherever possible, and to the extent that the historical aerial photography existed for the refugia in question, this imagery was gleaned and aggregated into the geodatabase structure.

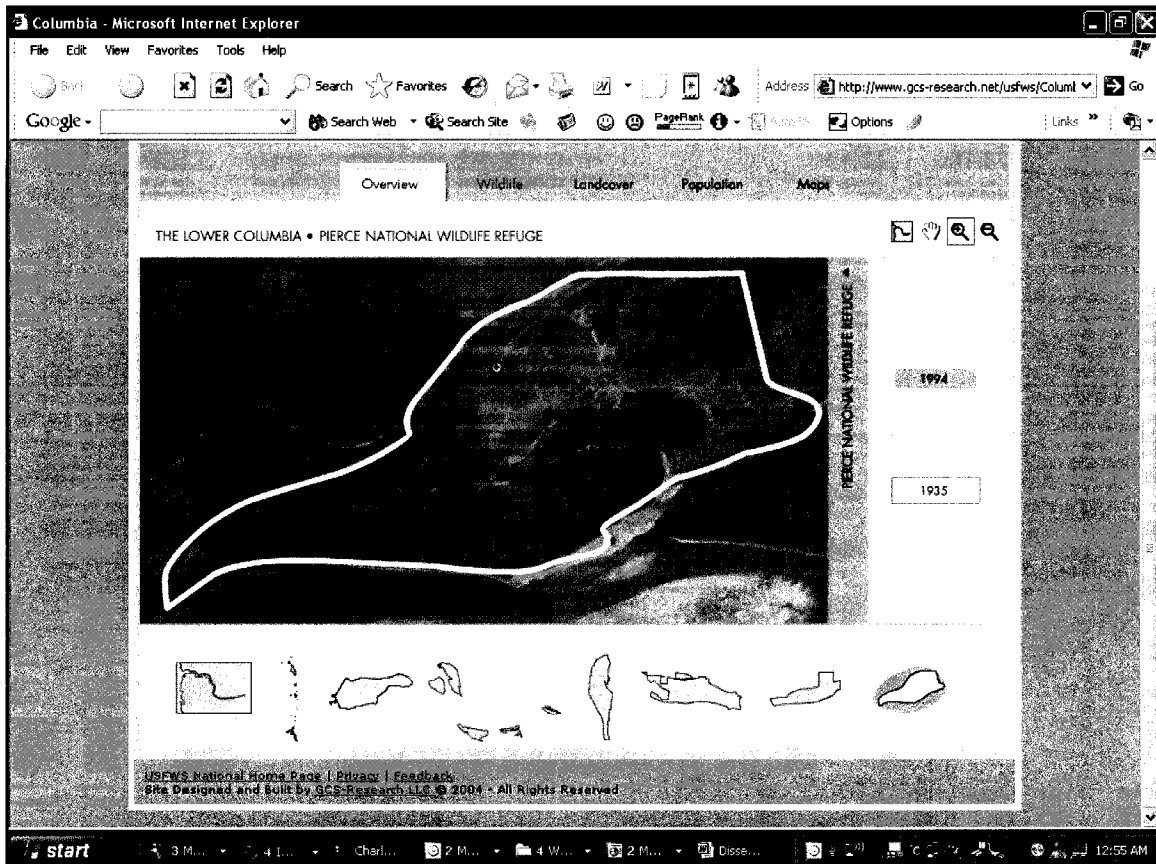


Figure 19. Pierce National Wildlife Refuge aerial photography from 1935.

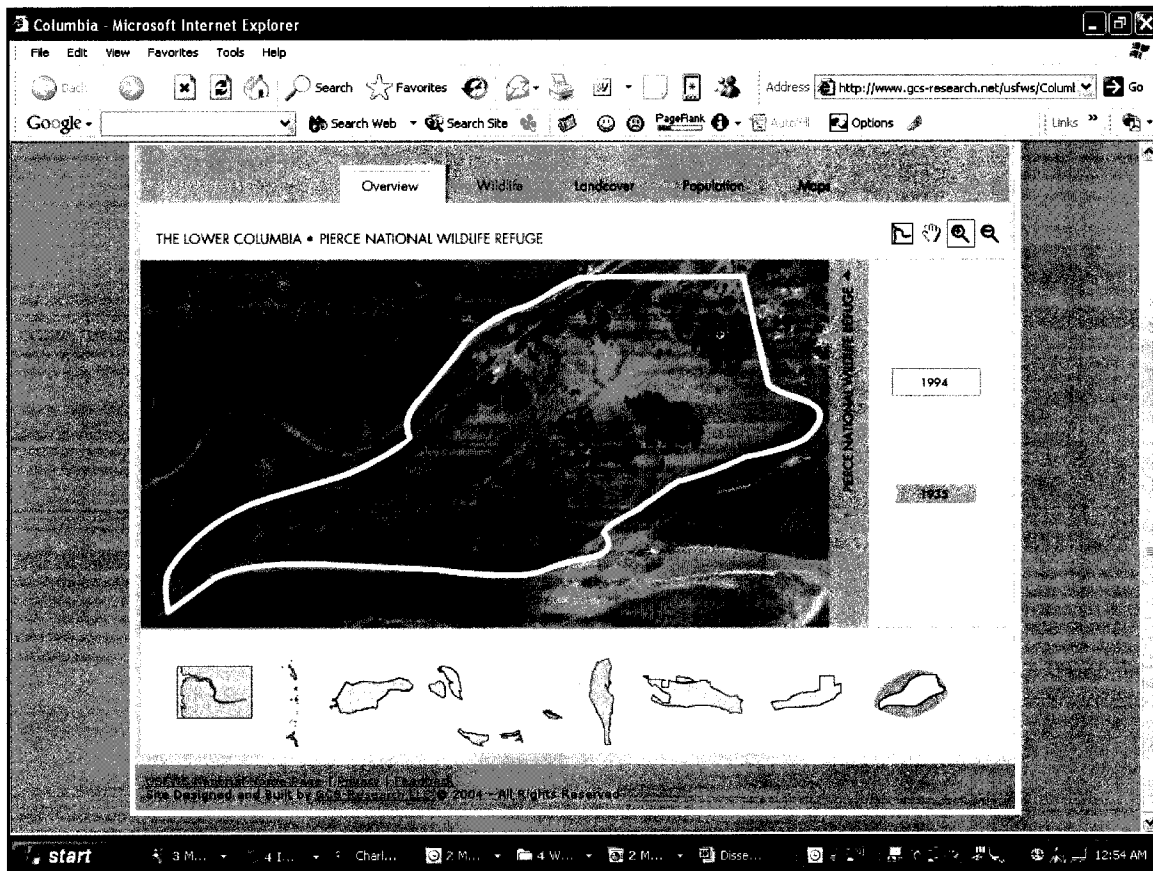


Figure 20. This image shows the historical and modern digital orthorectified imagery for the Pierce National Wildlife Refuge. To the extent possible, historical photography was included for each of the refuges included in this component of the Geosystem. This image shows the area in 1994.

Ideally, as additional aerial photography become available, a seamless mosaic of temporal frames could be added to the application, allowing for comprehensive, regional-scale examination of remotely-sensed changes detection. Modern-feature analytical tools could be applied to the imagery, and unique landscape features could be harvested for examination.

One of the more revealing aspects of this Geosystem service is represented by the historical cartography presented as “Maps” in the application.³³ As noted, the author

³³ An outstanding resource to assist in understanding the historical cartography of the Lower Columbia River Region is The Historical Atlas of the Pacific Northwest by Derek Hayes. Lewis and Clark’s contribution to the historical cartography of this region falls relatively late in the sequence of Asian and European maps of the Pacific Northwest coastline.

spent significant time researching an historical cartographic time series for the Lower Columbia River Geosystem. The purpose of this research was to provide a chronological review of the changing cartographic impressions of the Lower Columbia as presented by the various colonial powers seeking to explore and establish claim to the resources of the Lower Columbia River. Dominant imperial interests included Russia, Spain, Great Britain, France, and, as highlighted, the Lewis and Clark expedition as a literal extension of Thomas Jefferson's designs on the expansion of the United States. Long before Lewis and Clark moved into the area in late-1805 and 1806, the aforementioned colonial powers had established contact with the aboriginal people inhabiting the Pacific Coast and the interior waterways of the Lower Columbia.

One of the more compelling ways to view this competition and expansion is to view the geopolitical intelligence maintained and preserved in the cartography developed by the varying powers. Over time, a more detailed cartographic representation of the region emerges. Clark's expeditionary map, finally published in 1814, represented a landmark expansion of the cartographic understanding of the region, and set the stage for rapid population expansion and settlement. By the mid-nineteenth century, a second wave of military expeditions followed Lewis and Clark and began an intensive mapping agenda designed to document trade routes and resources, fort establishment, aboriginal populations, and future settlement patterns. Concomitant with these expeditions, the implementation of the Public Land Survey System (PLSS) ushered in the land grant system and the dominant land-use pattern still in existence today.

Of course, the national railroad systems, beneficiaries of the PLSS, conducted their own surveys and substantiated the transference of massive land holdings from the

public domain into the private sector. The railroad survey maps provide a detailed and valuable visualization of the land base within the Lower Columbia River Region. A series of these maps was included in the Geosystem to depict the multifaceted effect that these maps had upon the conceptualization of the landscape. Just as colonial imperial powers had depicted the region for geopolitical purposes, the major railroads of the Columbia Basin devised the surveys to recruit potential homesteaders, provide a clear mechanism for the movement of commercial goods across the transportation network, and to identify the connectivity between the urban core and rural periphery.

As the historical cartographic records merge with the modern, geospatial data as depicted in the historical aerial photography, cartographic representation is transformed. Geospatial and remotely-sensed data combine with the historical cartographical records to give new series of geospatial abstractions upon which one can judge landscape change through the Geosystem. The objective here, as in past historical geographical analysis, was to provide a multifaceted window into regional landscape dynamics as represented by the Lewis and Clark Bicentennial Commemoration – 1804-1806. The Geosystem provides a mechanism for examination and individual exploration through new levels of interactivity provided by the WWW.

CHAPTER 3

GEOSPATIAL ONE STOP CHANNEL: DISTRIBUTED HISTORICAL GEOSPATIAL APPLICATION PORTAL

The primary distributed nature of the Lewis and Clark Geosystem has been expressed in the development of delivery of the Geospatial One Stop I (GOS) Channel. The Lewis and Clark Geosystem Channel was developed and published to GOS in March 2004. In addition to being designed to consume both the Lower Columbia regional scale geospatial Web service and the continental-scale Web services associated with the Missouri Botanical Garden project, the GOS I Channel also provides, in and of itself, additional materials and geospatial content regarding the historical geography of the Lewis and Clark Trail.³⁴

The GOS channel functions as a primary portal concept.³⁵ It represents the culmination of a Space Act Agreement developed between GCS Research and the John C. Stennis Space Center. Mr. Philp served as the Principal Investigator on the project, along with Marco Giardino, then Acting Director of the Earth Science Applications Directorate. The Lewis and Clark Geosystem, as a distributed set of geospatial Web services, is fully consumable and viewable within a variety of thin and thick client applications.

GOS Channel Geospatial Data Resources

The most original and unique data resources available through the GOS portal include a scanned, georeferenced set of maps from the 1893-1894 Missouri River

³⁴ The GOS Channel and Geosystem components can be viewed at <http://www.gcs-research.net/gos/mapindex.htm>.

³⁵ Mr. Philp was named a GOS Channel Manager by the Director of the USGS GOS program. Mr. Philp continues to serve as a channel manager, and provides update and content management solutions to the USGS.

Commission Survey.³⁶ These maps were provided by the US Army Corps of Engineers, and had been originally published by the USGS. However, owing to a lack of funding, the entire series of scanned maps was removed and failed to be republished within an online mapping application. These maps were transferred from the Army Corps to GCS Research, loaded into a SQL Server using ArcSDE, and are viewable with

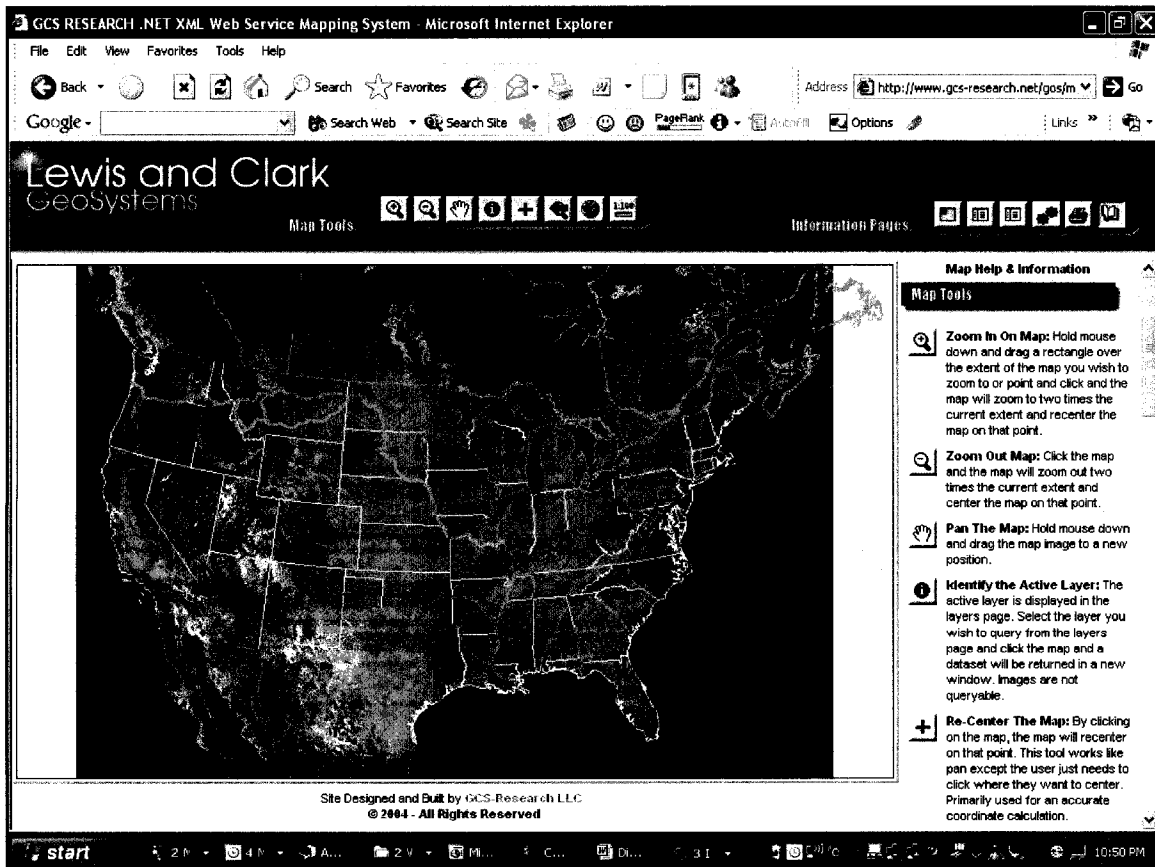


Figure 21. Lewis and Clark GOS Channel Portal application interface. This interface provides a web-based .NET XML-enabled browser for viewing and consuming Geosystem services. This application is linked directly to the GOS Channel Lewis and Clark Bicentennial Commemoration Web link.

additional data sets collected and combined into an enterprise geodatabase.

³⁶ Full FGDC compliant metadata was developed for the Missouri River Commission Maps by the author, and is published on the GOS ArcIMS Metadata Service. FGDC compliant metadata was required for publication of these additional data resources to the GOS Channel as a federally-supported Web service. Please see <http://aa179.cr.usgs.gov/1894maps/index.htm>.

The most remarkable achievement from a distributed geospatial capacity, and a test of the GOS Channel concept, is the inclusion of an entire Landsat 5 TM (thematic mapper) and Landsat 7 ETM+ imagery geodatabase from the John C. Stennis Space Center. Totalling roughly 4.3 terabytes in size, a raster geodatabase Web service was established at the Stennis Space Center for dynamic consumption by the IMS and .NET IIS application maintained at GCS in Missoula. As opposed to physically transferring the voluminous amount of raster data, a SDE connect was established between the Missoula-based application and Stennis Space Center. Thus, when users use a variety of client applications – Web, desktop, workstation, or mobile OS – the data are consumed across existing network connections. Again, this is similar to techniques deployed in the

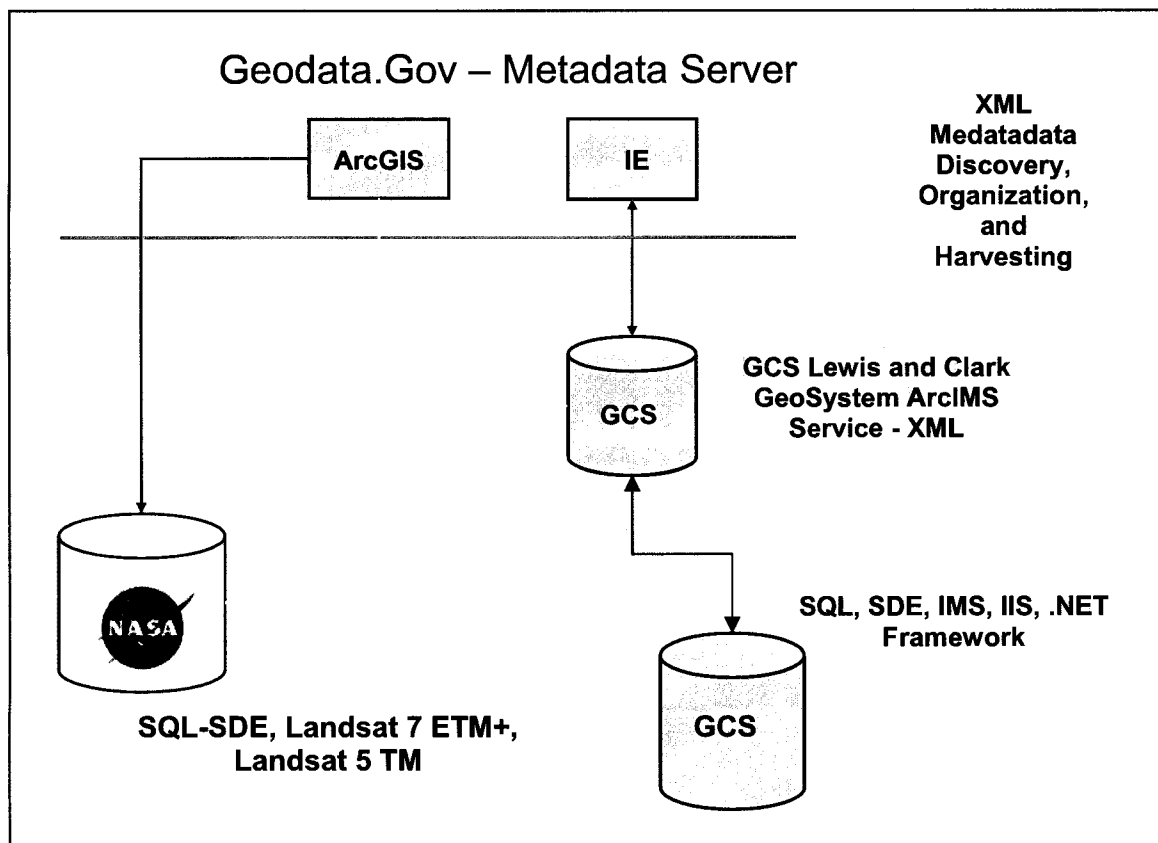


Figure 22. Configuration schematic for the GOS Channel of the Geosystem.

in the two previous applications. In Figure 22, the details of the engineering schematic for the GOS portal are displayed for review. Note that the primary level of interoperability is established once again utilizing ArcXML syntax between the two systems. Figure 23 below highlights the total comprehensive view of the Landsat 5 TM data holding being consumed from the Stennis server.³⁷ The ability to easily view a Landsat mosaic for the

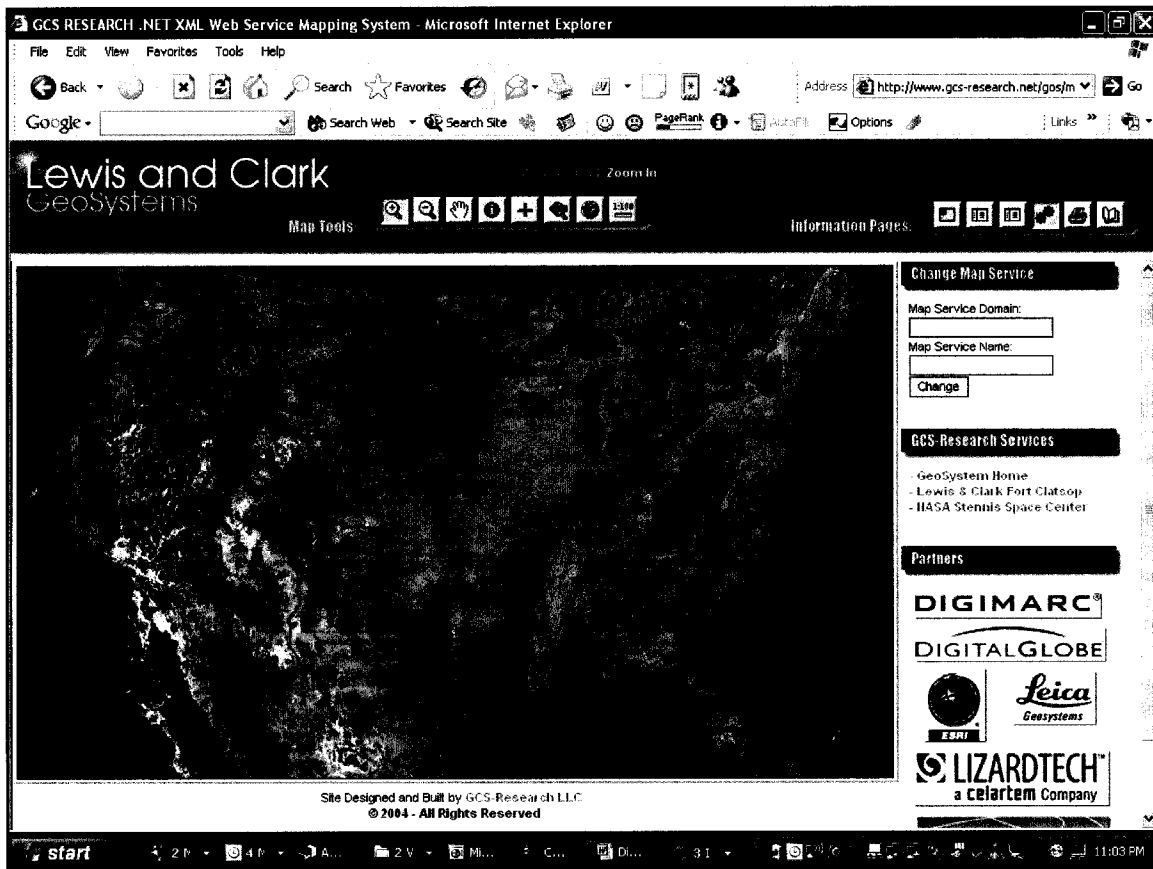


Figure 23. Comprehensive Landsat 5 TM mosaic from NASA John C. Stennis Space Center ArcSDE raster service. The total data volume for this service is approximately 3.7 terabytes. This represented one of the largest standards-based commercial off-the-shelf implementations of a distributed raster system ever produced by NASA.

³⁷ The Landsat 5 TM holdings are from *ca.* 1990. The Landsat 7 ETM+ data is more recent, but less comprehensive. Funding for population of Landsat 7 ETM+ was exhausted during this phase of the project.

entire Trail had not been achieved prior to this Web service and SDE connection. The ultimate goal was, and remains, the ability to have multiple Landsat mosaics available for viewing, analysis, and change-detection analysis with advanced ArcObject-based functionality programmed into the application.

The entire GOS channel data holdings include:

- 1) MODIS – SRTM hillshade relief map;³⁸
- 2) a MODIS multispectral image map;
- 3) 1894 Missouri River Commission Maps – Big Bend, Lake Francis, Fort Peck, Garrison Dam, Gavins Point, Lake Oahe, and Lower Missouri;
- 4) jurisdictional boundaries – US state boundaries, Canada and Mexico, and Louisiana Purchase boundaries;³⁹
- 5) transportation networks, primary and secondary hydrology, and the three segments of the Lewis and Clark Trail: pre-expedition development, the 1803 route, and the 1804-1806 route of the Corps of Discovery;⁴⁰
- 6) Lewis and Clark campsites.⁴¹

³⁸ This single MODIS-SRTM image is a combination of the MODIS (Moderate-Resolution Imaging Spectroradiometer) and the Shuttle Radar Topography Mission (SAR) national DEM. This single image file, viewable interactively in the GOS Channel application, is approximately 7 GB in size and represents the processing ability of database-drive applications to manage and process complex BLOBS – binary large objects as raster data types in the SQL Server environment.

³⁹ The Louisiana Purchase boundary, spanning both the Hudson’s Bay and Gulf of Mexico watersheds, was developed by George Dailey of ESRI. The author graciously thanks Mr. George Dailey for allowing the utilization of these data.

⁴⁰ The Trail line segments, mapped at a relatively small scale, were developed by Joseph Spruce of the NASA John C. Stennis Space Center. The author thanks Mr. Spruce for the authorization to use his data for this particular project. The author also wished to thank Marco Giardino for his outstanding efforts and support of this project over years. Dr. Giardino is a good friend and colleague. His support for the enabling Space Act Agreement made this component of the Geosystem possible. The author also wishes to thank MSU TechLINK and David Weston for his support over the years.

⁴¹ Again, as noted above, the campsite data was developed by, and maintained by, Robert Bergantino, Montana Tech of The University of Montana. Dr. Bergantino is a fluvial hydrogeologist, and has combined his knowledge of hydrological, landscape ecology, professional surveying and navigation, and a detailed reading of the Journals of the Lewis and Clark Expedition to develop one of the best and more accurate campsite databases in existence. The author had the opportunity to work with Dr. Bergantino on this research for many years, and appreciates his willingness to share his work with the author.

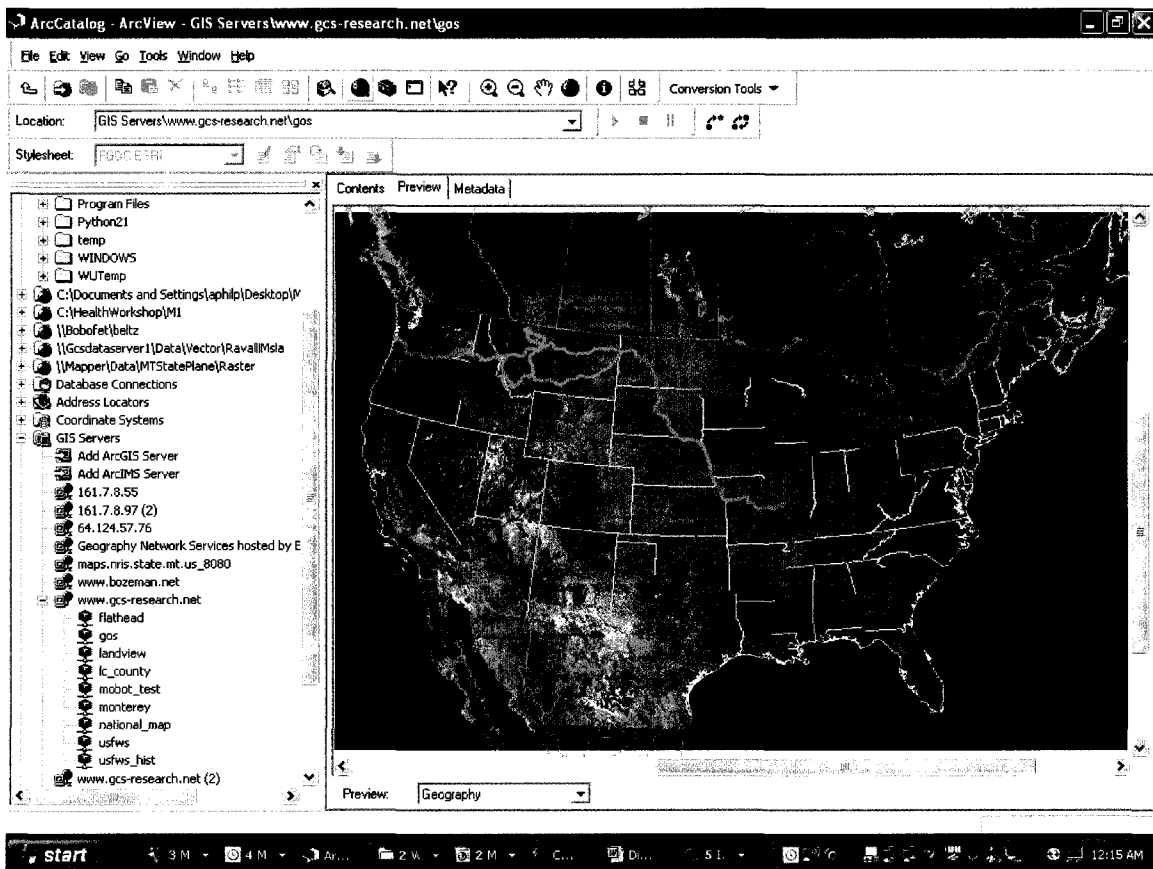


Figure 24. GOS Channel Web service discovery utilizing ArcIMS Metadata Server functionality as developed by author.

GOS Channel Applications

In addition to the geodatabase structure and architecture described above, the GOS Channel provides a method of discovery for determining the nature of the XML-based metadata services being hosted across the network. To build and deliver the GOS Channel for the Geosystem, it was necessary to develop, publish, and host the XML metadata service so users of the GOS Channel would have the ability to identify the data sets and service currently available. This functionality is illustrated in Figure 25 below. Utilizing ESRI ArcGIS ArcCatalog software, the GOS_Browse_Metadata services can be discovered and examined, including the Lewis and Clark Geosystem.

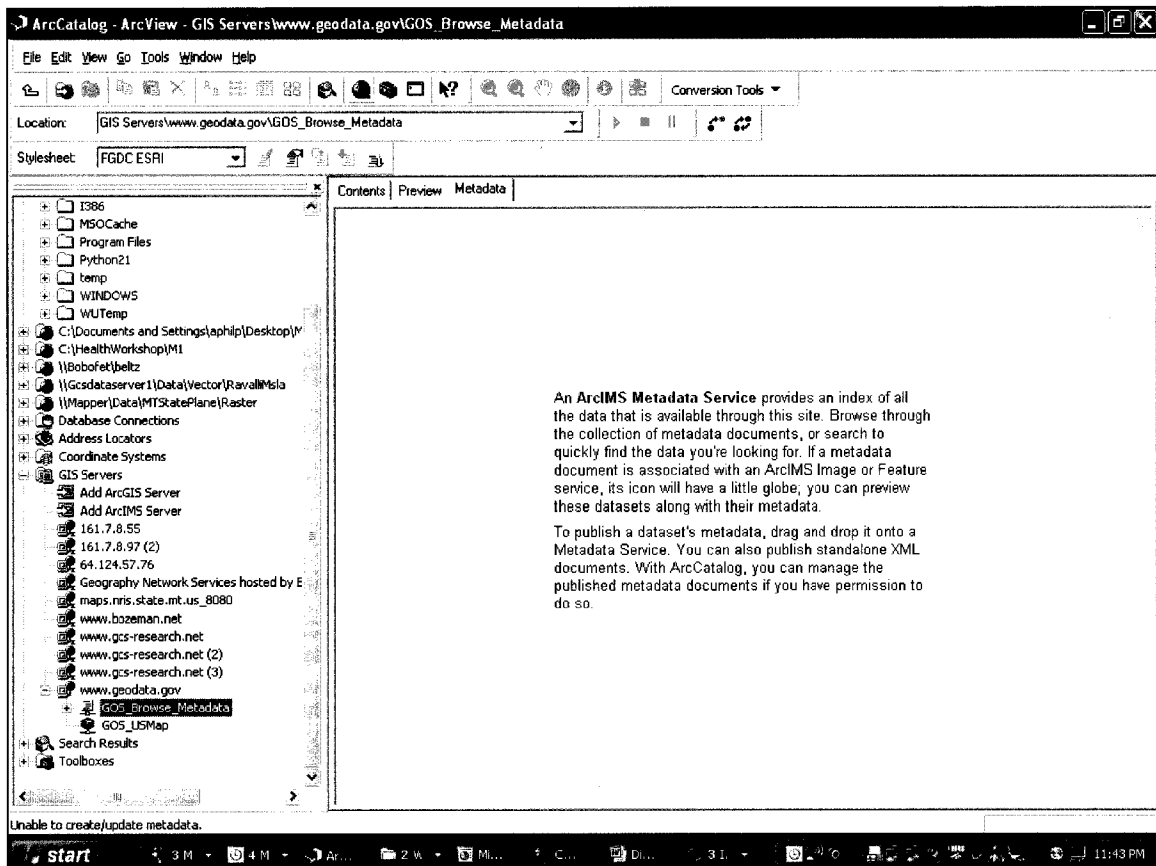


Figure 25. GOS Geosystem ArcIMS Metadata Service browse.

Once the Lewis and Clark Geosystem XML Web service is discovered and maintained, it is possible to consume the application directly in ArcGIS. Moreover, and to promote the ability to visualize and conduct basic analytical functions against the application, it is possible to access the same Geosystem Web services directly from the GOS portal itself.

As shown in Figure 26, the Geospatial One Stop channel maintains a hyperlink to the Lewis and Clark Bicentennial Commemoration, which is a proxy for the Lewis and Clark Geosystem set of geospatial Web services currently maintained and

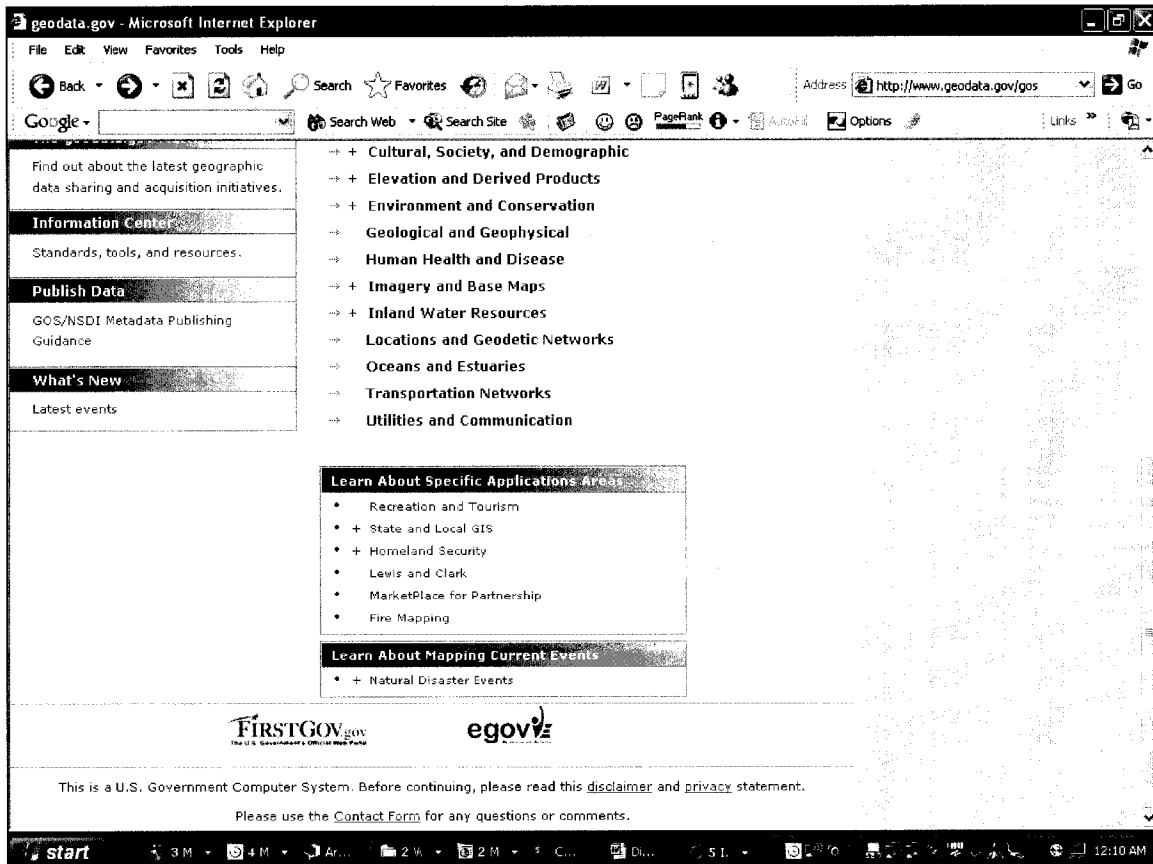


Figure 26. Existing Geospatial One Stop Portal entry page showing Lewis and Clark Geosystem Web link.

delivered.⁴² It is possible to access the Web services through two options: 1) GOS portal mapping application and 2) the Lewis and Clark Geosystem .NET XML Web mapping application, as discussed and shown above. As shown in Figure 27, the initial introductory GUIs for the application provide an introduction to the application, and describe the overarching objectives.⁴³ This splash screen allows the user to understand

⁴² <http://www.geodata.gov/gos>.

⁴³ “Lewis and Clark Geosystem Content Summary: The Lewis and Clark Geosystem is a collection of private, state, local and federal data resources associated with the geography of the Lewis and Clark expedition (1803-1806). Data has been compiled from key partners, including NASA - John C. Stennis Space Center, The Army Corps of Engineers, the US Fish and Wildlife Service, Montana Tech of The University of Montana, the US Forest Service, and a collection of Lewis and Clark scholars. The Geosystem is intended for educational and research purposes, and its primary goal is to provide a Web-

the general intent of the application, explore the FGDC-compliant metadata and information systems associated with the application, and launch the Web-based mapping applications.⁴⁴

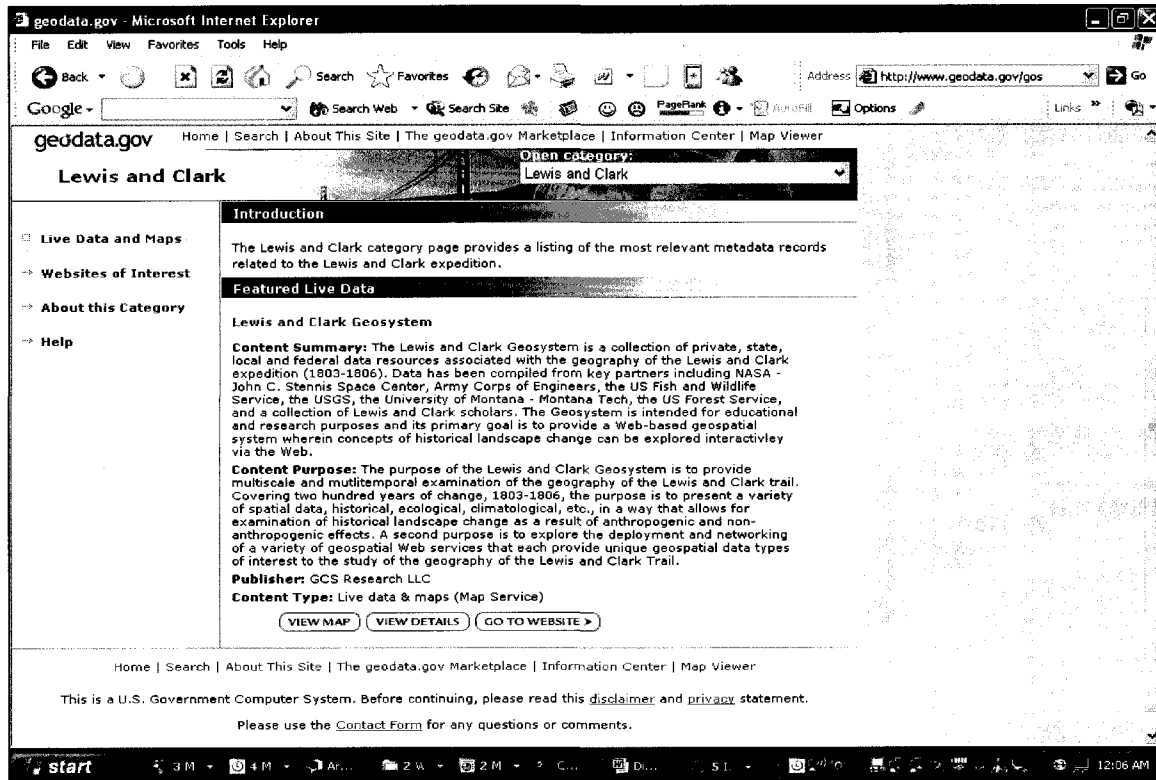


Figure 27. Lewis and Clark Geosystem GOS description. All XML-based programming and authoring was developed by author

As previously noted, the user is presented with a variety of options. To access the Geosystem Web services, it is possible to utilize a JAVA-based Web-client developed by

based geospatial system wherein concepts of historical landscape change can be explored interactively through the Web. Content Purpose: The purpose of the Lewis and Clark Geosystem is to provide multiscale and multitemporal examination of the geography of the Lewis and Clark Trail. Covering two hundred years of change, 1803-1806, the purpose is to present a variety of spatial data - historical, ecological, climatological - in a way that allows for examination of historical landscape change as a result of anthropogenic and non-anthropogenic effects. A second purpose is to explore the deployment and networking of a variety of geospatial Web services. Each provides unique geospatial data types of interest to the study of the geography of the Lewis and Clark Trail. Publisher: GCS Research LLC. Content Type: Live data & maps (Map Service).

⁴⁴ The full XML-based FGDC compliant metadata service records can be viewed in Appendix D. This XML ArcCatalog function allows users to view and interact with the spatial information.

ESRI for GOS. This application is a modified version of ArcExplorer modified as a Web-based application. This application is highlighted in Figure 28.

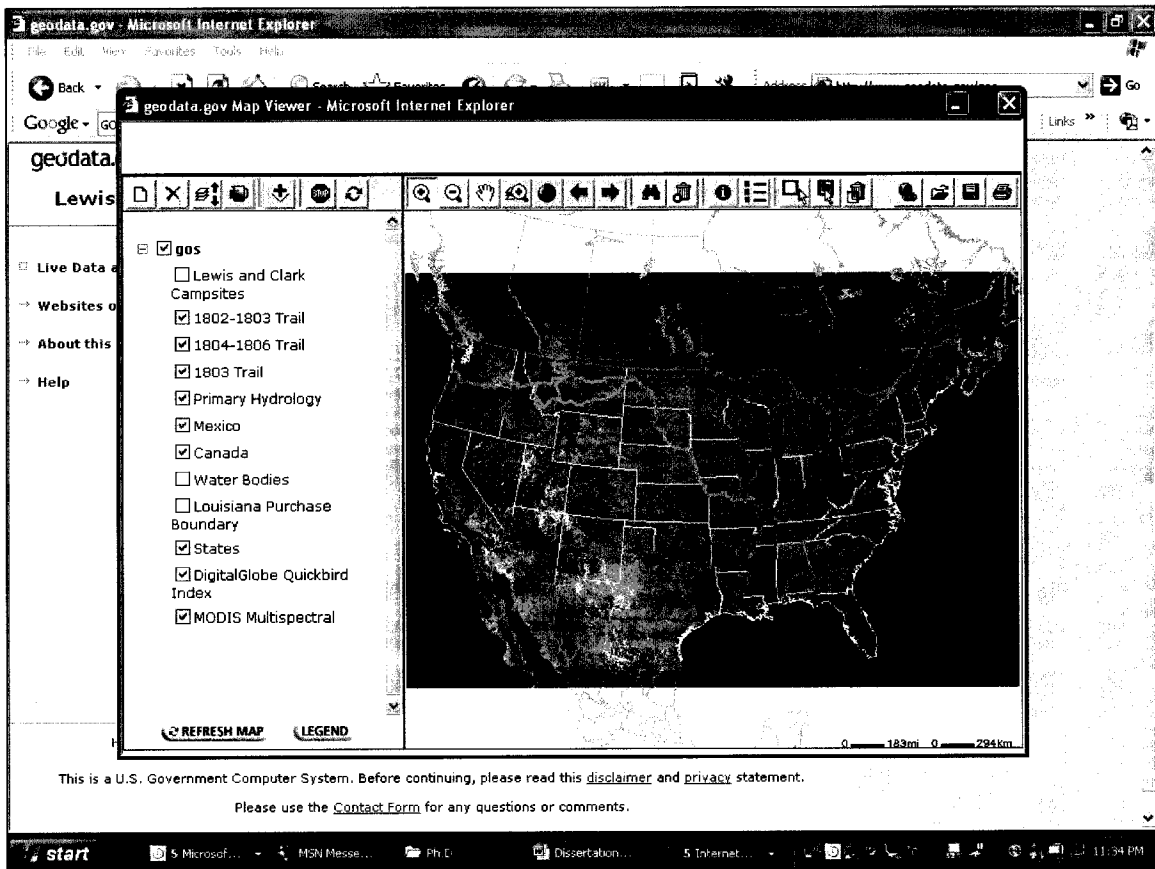


Figure 28. ArcWeb Explorer modified browser for consuming Geosystem Web services.

Additionally, the user has the ability to launch the GCS .NET XML Web browser interface, and view the Web services in this application (Figure 29). This functionality highlights the interoperable and distributed nature of the Geosystem framework as Web services. Depending upon the interests of the user, the Geosystem can be consumed into a range of applications that provide a variety of geospatial analytical capabilities. These capabilities range from a standard, browser-based application to a more sophisticated thick-client represented in the form of ArcGIS. Leveraging the power of the projection-

on-the-fly capability of the ArcGIS ArcMap ArcView, it is possible to consume the Geosystem Web services as projected in Albers Equal Area Conic, and combine these historical geospatial assets with modern data and create sophisticated cartographic products and analyses. The Web-browser tools, contrastingly, do not allow for these functions. However, the recent deployment of the ArcGIS Server platform allows for server-based functions, such as reprojection to occur across distributed networks. This means that the essential ArcObjects necessary for reprojection and/or more sophisticated geometric transforms to occur can now be substantiated across a distributed network.⁴⁵

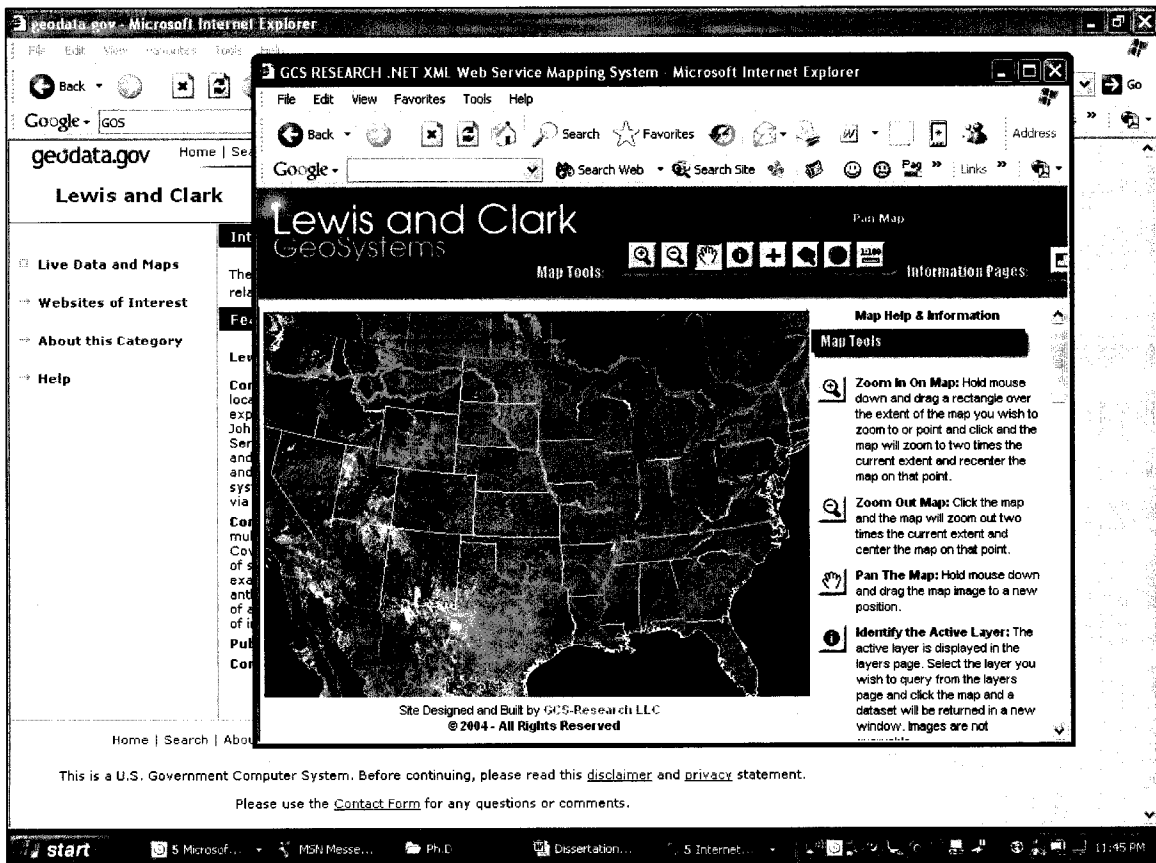


Figure 29. Lewis and Clark Geosystem XML-browser portal as instigated from the GOS Channel.

⁴⁵ ArcObjects is a COM-based programming environment developed by ESRI and is the core platform for ArcGIS.

In so far as the core of the Geosystem was built and architected as a series of interrelated ArcIMS Web services, as well as other pure Web services, it is possible in the future for ArcGIS Server protocols and applications to be designed that would extend the geospatial analytics of the Geosystem to a more advanced level. The author, regrettably, did not have the capacity at this time to develop such applications under the existing scope of the project. Nevertheless, server-based GIS, and its applications for geospatial historical geography, needs to be explored as a means of combining a variety of relevant content into a next-generation distributed application. This paradigm shift centers upon a movement away from mere publication of geospatial assets toward truly distributed GIS functionality, wherein a variety of assets could be co-mingled and analyzed from a peer-to-peer perspective.

CHAPTER 4

“CYBERSCAPES”: WEB-BASED VISUALIZATION OF GEOSYSTEM - FLYING THE TRAIL

The most recent explication of the Geosystem rests upon the consumption of specific historical geospatial information within a desktop “fly-through” software application developed by Keyhole Inc. Originally designed as a geospatial intelligence application by the Central Intelligence Agency (CIA), Keyhole was formed as a commercial venture dedicated to providing a way to access global assets through a streaming data set, consumed within a client application. While a variety of solutions exist for 3-D visualization of remotely-sensed assets, Keyhole’s application allows for relative ease and co-mingling of locally-maintained resources with a massive archive of remotely-sensed data. This archive is stored remotely in a fashion similar to the NASA Landsat 5 raster geodatabase.

The intent of this research was to develop the ability to consume the Geosystem Web services directly into the Keyhole client application. In effect, this represents the consumption of the geodatabase within the Keyhole client application for distributed visualization of the historical geography of the Geosystem. Over the past seven months, this objective has been marginally successful. Keyhole has yet to publish a SDK (software development kit) for customization of the protocols necessary to modify the client application for consumption of ArcXML and/or geodatabase feature classes. While it is possible to consume WMS (Web map services – OGC) services within the Keyhole Pro client, visualization of the WMS service(s) is only possible within the “overview” frame.

Nevertheless, it is possible to consume specific raster and vector feature types within the Keyhole client applications and georeference these geospatial data types. For purposes of this advanced research element, the Lower Columbia River Geosystem was chosen as a case study to explore visualization and customization of localized data sets within the Keyhole client application. As shown in figures 30 and 31, the user has the ability to observe the global environment from a radically unique perspective.

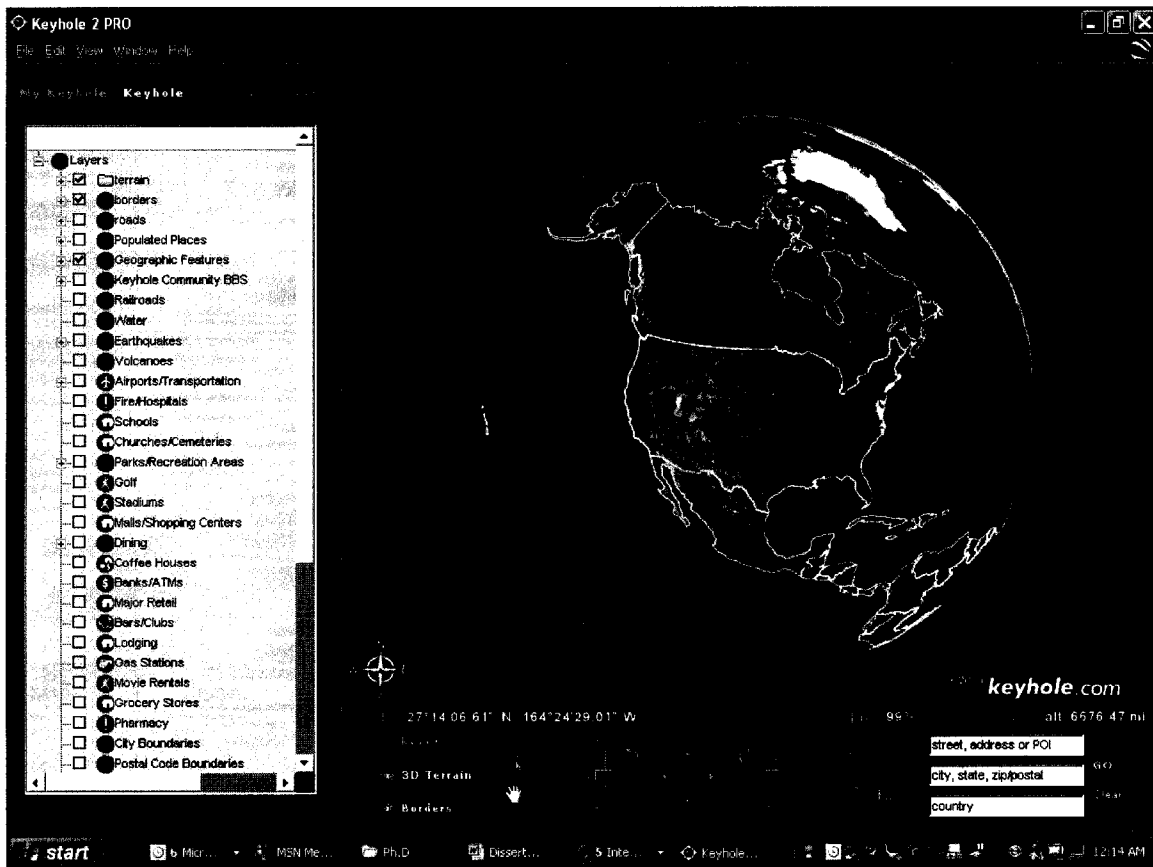


Figure 30. Keyhole Pro II client application. All remotely sensed data is streamed into the application through the Internet. Geosystem features have been added as an example of geodatabase visualization across a distributed fly-through environment.

Depending upon the interests of the user, specific data sets can be loaded and dynamically streamed into the application, using proprietary compression algorithms essentially developed for the gaming industry. In the case of the Lower Columbia, Dr. Bergantino's

campsite data were reprojected into decimal degrees (WGS 84), and added to the application as a vector data set. The user can then “fly” into the landscape, and begin to interact with the data from a 3D-level of experience. Additional remotely-sensed imagery, primarily from DigitalGlobe’s Quickbird satellite have been added to this application on the server-side, expanding the modern reference data associated with the geospatial historical geography.

While it is difficult to communicate the experience in this particular dissertation, there are some fundamental phenomenological observations to be discussed. First, this application extends the notion of the Geosystem into a level of interactivity and immersion that revolutionizes the pattern of experience. Essentially, the interface allows

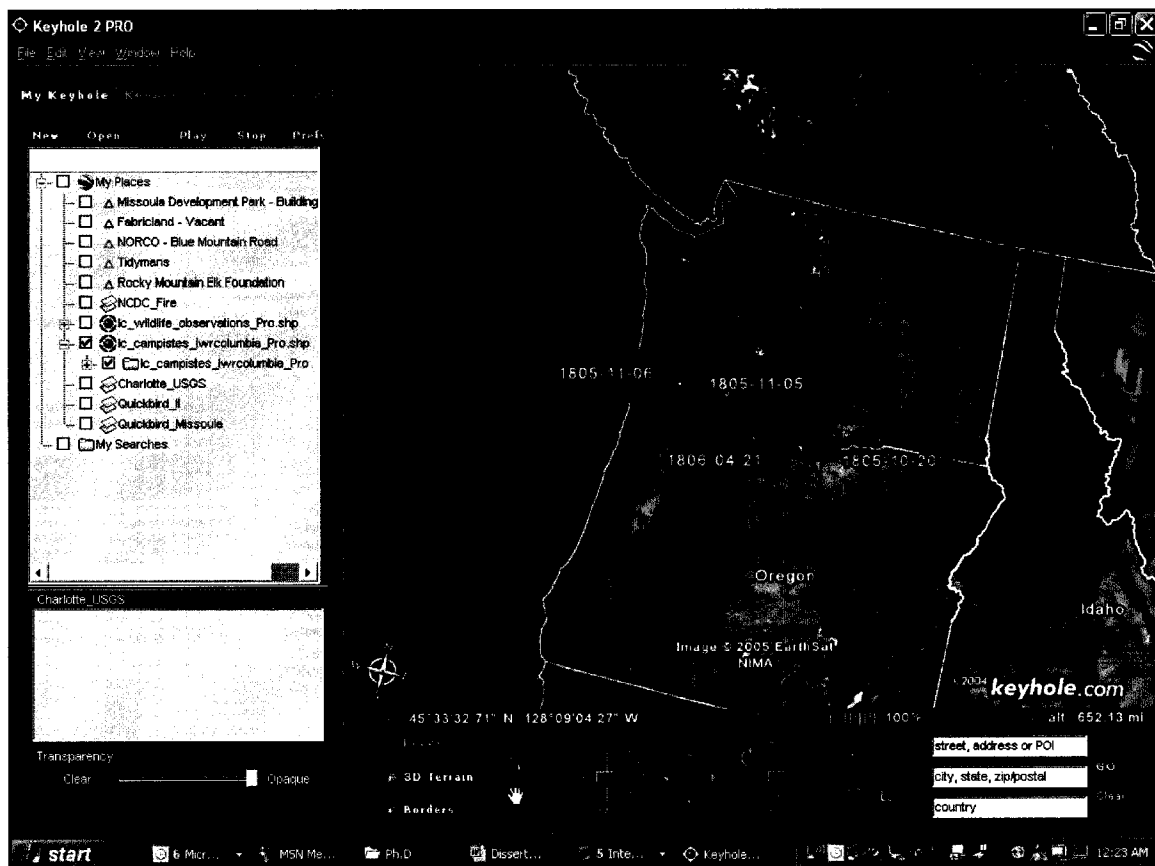


Figure 31. Lower Columbia River Geosystem spatial data, campsite locations, are consumed and viewable within the Keyhole application based upon a server and local compilation routine.

for the exploration of geographical relationships that are only possible in a 3D environment. This is very important from an educational and research perspective. Varying patterns of data immersion foster new levels of insight into pattern, process, and function associated with the geospatial historical geography. Second, the practical capabilities of this platform allow for relatively easy deployment and utilization. Historically, such a tool would have required massive hardware and software requirements in order to achieve a similar effect. Now, it is possible to conceive of

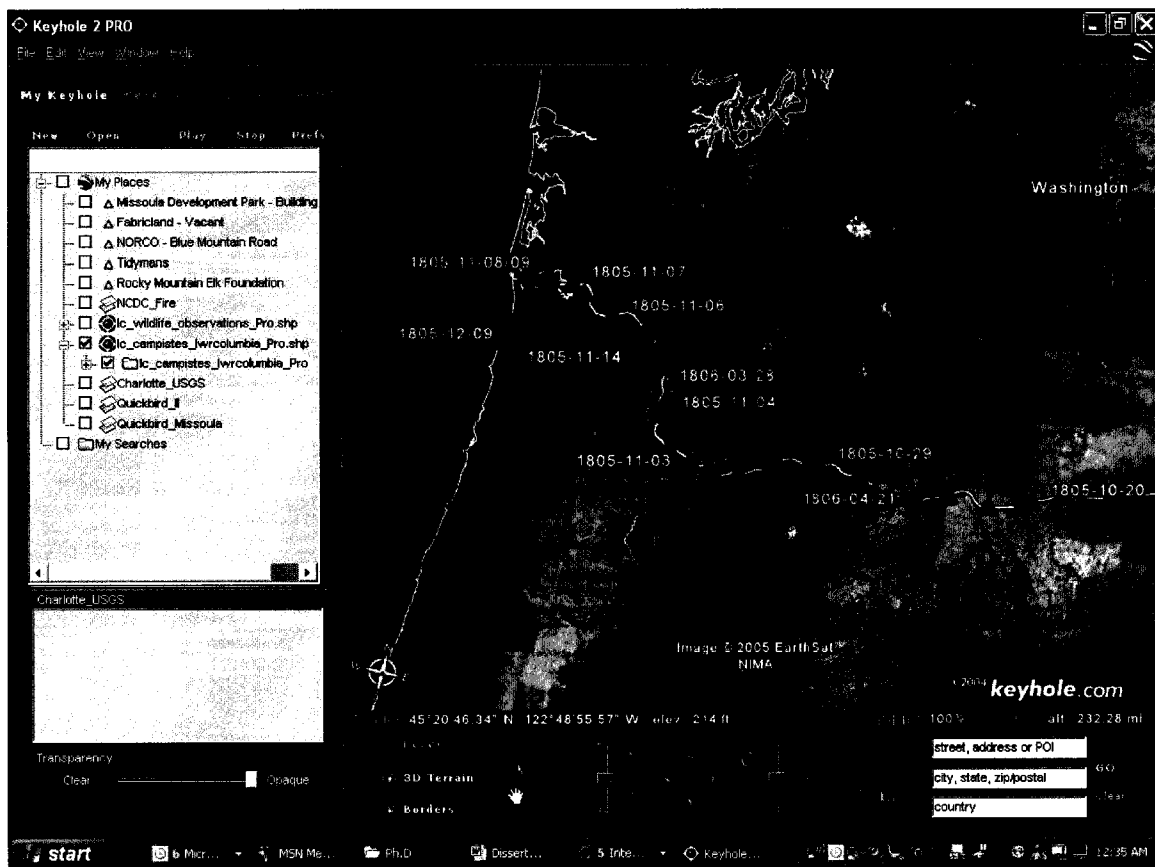


Figure 32. Close-up of Lower Columbia River Geosystem vector data – campsite feature class.

and build relatively sophisticated fly-through experiences and simulations derived from a combined series of geospatial information. This form of visualization represents the future pattern of experience for increasing numbers of individuals seeking to understand landscapes in an intuitive, visually-stimulating manner. Third, in so far as Keyhole is based upon an XML-based language for definition of spatial coordinates (KML – Keyhole Mark-up Language), geospatial historical geography can be packaged into discrete message strings, and easily distributed and consumed among Keyhole clients across a vast network.⁴⁶

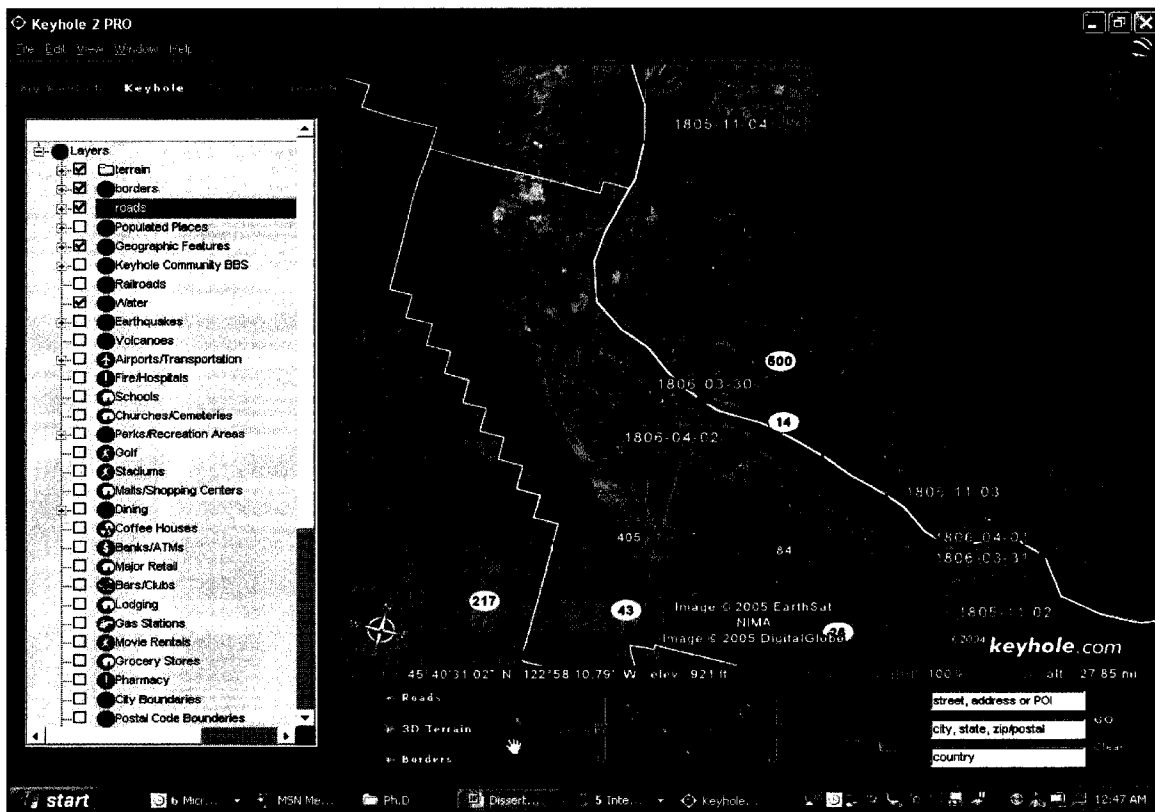


Figure 33. Keyhole zoom of Lewis and Clark campsites, high-resolution imagery (NGA and DigitalGlobe), and ancillary geospatial data for the Portland, Oregon region.

⁴⁶ The entire Keyhole demonstration can be requested from the author as a .kml file. The entire .kml file, developed for this research, has been provided as Appendix E. The KML properties can be modified, depending upon the schema definitions, to alter the appearance and character of the data display with the Keyhole client application. Moreover, the KML are easily distributable owing to size, and are actively being shared globally through BBS systems, and used within the intelligence community. On-going operations involve consumption and visualization of the geodatabase within Keyhole using ArcEngine development tools, as well as the ability for Keyhole to be a spatial search tool.

Indeed, as illustrated below in Appendix E, the KML for the Geosystem data as visualized represents an additional language for sharing and communicating the geospatial historical geography of the Lewis and Clark Trail. Moving beyond ArcXML, KML represents an easily distributable language for geographical communication. The entire KML file for the Lower Columbia River Geosystem is a mere 83 KB. Such extensibility can be easily shared, consumed, parsed, and visualized in a variety of client tools designed to read to KML. Interestingly, ArcXML, KML, and other XML-based extensive languages serve as the basis for a next-generation language – ontological mark-up language: OML.⁴⁷

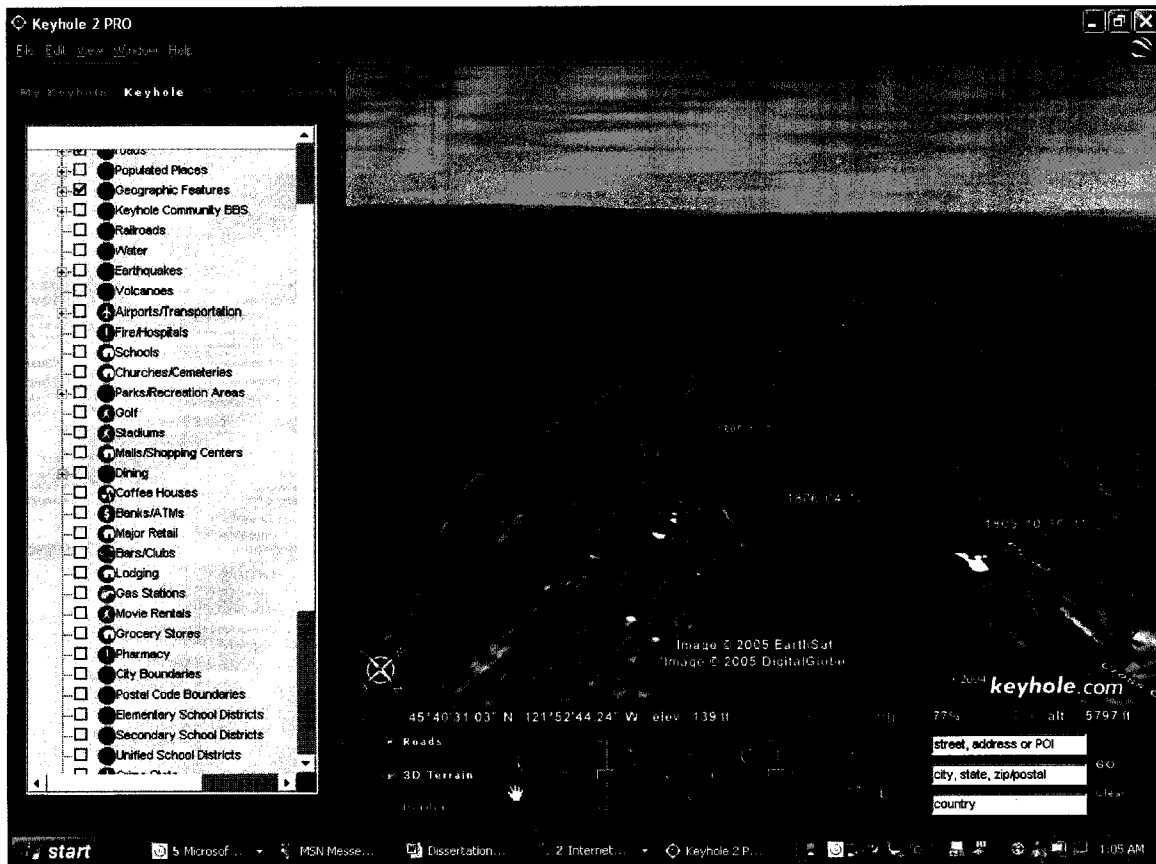


Figure 34. Perspective, rotated view of Columbia Gorge section of The Lower Columbia River, showing Lewis and Clark campsites and other geographical data.

⁴⁷ <http://www.ontologos.org/CKML/CKML%200.2.html>

Funded as a DARPA-based experiment, OML may represent the future of the Geosystem. Ontological data are “smart” or “intelligent” data in so far as data can be described as such. This means that semantic characteristics are assigned to the data beyond the extensibility or description of the data. XML, an extensible language, provides descriptive characteristics that can be parsed to invoke certain characteristics. Ontological data provides opportunities to associate behaviors and inherent geospatial characteristics, such as self-positioning, dynamic geospatial recombination, automated routines for calling services and applications, and a variety of security permissions. As the Geosystem progresses, the goal is to extend the dynamic, distributed, and intelligent nature of the data and create additional interactive, immersive mechanisms by which the geospatial Web services can be produced and consumed.

Indeed, the natural extension and ultimate objective of the Lewis and Clark Geosystem would be to convert and develop all of the spatial data sets within a Web-based, 3D, fly-through environment for extensive data visualization. The penultimate experience, which is theoretically possible, would be to move toward a shared environment wherein multiple users could be interactively participating in the geospatial environment as autonomous, yet connected agents. Typically described as a shared “gaming environment,” this would move beyond the existing *status quo*. As opposed to users of the Geosystem individually and independently interacting with relatively static geospatial representations of key historical geographical vector and raster data sets, the interactive Geosystem would be designed as an interactive cyber-landscape or “cyberscape”.⁴⁸

⁴⁸ Cyberscape is a term developed by the author to describe the metaphysical fabric of the geospatial historical geography of the Geosystem in future iterations. A cyberscape combines the digital

Contrary to existing gaming environments that present advanced visualization, the Geosystem as cyberscape would incorporate investigative, analytical tools directly into the experience. The geodatabases, which currently serve as the basis for the Geosystem, would be dynamically available for query and spatial functions. This would allow the participants to simulate cyberscape processes, investigate patterns, and literally interact with the change of function as a result of spatial-temporal dynamics ongoing across the cyberscape matrix.⁴⁹ Conceptually, the user moves phenomenologically from being outside the data *to being literally within the data*. This transform, while remaining technically challenging, would revolutionize the previously discussed cognitive processes associated with a geospatial historical geography (cyberscape).

The significance of this research rests somewhere between the proverbial “cutting-edge” and “bleeding-edge” of practical applications and advanced geospatial research. However, as noted, very real companies are currently making billion-dollar investments in building and delivering exactly these types of solutions. The author has been privileged recently to be able to participate in these levels of discussion, attempting to lay out a migrational pathway for the next-phase evolution of this Geosystem into a fully distributed, immersive, geospatially accurate experience. Just as it was improbable

fabric of cyberspace with the geography of place. The goal is to push *simulacra* further toward a “real” representation of the landscape. As noted, future evolutions of distributed GIS can be conceived as forming the foundation of multiple cyberscapes that serve as the foundation for past, present, and future exploration of geospatial information. As a Microsoft Research Fellow, the author is currently exploring the convergence of Microsoft Flight-Sim, the X-Box platform, and Web-based applications as a potential cyberscape environment for the Geosystem.

⁴⁹ Intentionally, the evolution of the Geosystem as an immersively, interactive cyberscape was originally conceived by the author in the form of a proposal presented to the Human Interface Technology Laboratory (HITL) at the Washington Technology Center, The University of Washington as an interdisciplinary Ph.D. Conceived in 1991, the proposal hypothesized the creation of “A Virtual Historical Biogeographic World(s) as a Spatial-Temporal Machine.” Although this proposal was rejected, and the hardware, software, and programming resources would have been massive to build such as system, fourteen years later the advances in all physical parameters have been reduced and the theoretical objective is being slowly realized.

to conceive of the realization of the existing applications ten years ago, it is equally improbable to anticipate successful realization of the aforementioned cyberscapes as functional systems.

CONCLUSION

This geospatial historical geography of the Lewis and Clark Trail, defined as the Lewis and Clark Geosystem, represents a massive undertaking. Over the course of six years, the author has endeavored to create a series of interconnected geospatial Web services providing insight into the specific temporal and spatial components of the Lewis and Clark Trail geography. The Geosystem combines a rich and comprehensive series of interrelated geodatabases for a multi-scale descriptive geography of the Trail environs. Utilizing a series of interfaces and platforms with specific communication objectives and solutions, the intent was to build an operational “system of systems” that provides the basis for advanced geospatial communication: a geographic communication system (GCS).

In so far as the applications are all on-line and currently active, the validity and uniqueness of the Geosystem is best experienced within the media itself – *Web-based, interactive geospatial visualization*. Behind the applications and the specific educational and/or research focus, an extensive amount of time was dedicated to the collection, aggregation, and geodatabase design for the vast amounts of data maintained with the overarching system. Many of the data sets are entirely unique to the Geosystem.

Moreover, the creation and management of the code base behind the various geospatial Web services represents a monumental accomplishment in and of itself. The purpose of including the XML-based files (ArcXML v. 1.1) behind the primary components of the Geosystem was to document this work and describe the level of complexity associated with both XML and the database structure behind the applications.

As is well known, all geospatial analysis and visualization is dependent upon the quality and availability of the data to tell a particular story. When one combines these traditional parameters with the deployment of the data across Web-based networks, the complexity of the Web services and the XML-based service structure is noteworthy.

The development, promulgation, and delivery of the various components of the Geosystem has occurred in significant phases as interconnected components. The development and delivery of the GOS Channel represents the highest possible point of publication for the Geosystem as a nationally recognized geospatial resource. At the time of its release, the Geosystem's consumption within the GOS Channel highlighted the successful completion of a complex, multiphased, interdisciplinary research project. Thus, the Geosystem represents significant achievement in three primary areas: 1) Lewis and Clark geospatial content development and database design; 2) design and implementation of interconnected and distributed geospatial Web services; and 3) the foundation for a subdiscipline within geography described as geospatial historical geography (advanced cyberscape phenomenology).

Geospatial historical geography articulates a descriptive, interdisciplinary approach to geographical understanding emphasizing geospatial information technology and historical geography. It is more than GIS – Geographic Information Systems. Geospatial historical geography defines a new metaframework for the historical spatial and temporal analysis of landscapes. It emphasizes understanding, quantifying, and visualizing geospatial information as it pertains to specific historical geographies. This metaframework also emphasizes the specific, emergent technologies designed to provide a basis for the exploration of the geospatial thematics. The geospatial IT element

provides a new methodology and series of tools for describing and exploring historical landscapes from a dynamic, interactive level of experience. *The Geosystem, if nothing else, represents a singular achievement in the proof of distributed geospatial applications designed to provide a multifaceted examination of a continental phenomena represented by the Lewis and Clark Expedition.* The Geosystem also extends the envelop in what was theoretically possible from a systems perspective and proves the value of a distributed geographical application.

It should be noted that this project could, but did not, benefit from a model or framework for adoption. The Geosystem had to be designed and delivered as an original statement from concept to actualization through the integration of both advanced geospatial techniques and content. The emphasis should be placed on the design, architecture, and delivery of the Geosystem as a functional platform for the geospatial historical geography of the Lewis and Clark Trail. The Geosystem is a means to an end, as opposed to an end in itself. As individual components have been completed and deployed, the author was able to achieve positive movement toward the end objective of federal recognition and global viewing. Each chapter of this document, combined with the delivery of the Web service languages, encapsulates the services and the interconnection of the individual elements. The true value, and defensible nature of the project, is firmly grounded in the applications themselves. As the applications are explored as interrelated and interconnected extrapolations of the Lewis and Clark Trail, the Geosystem is greater than the sum of its parts.

As more advanced geospatial analytical tools are deployed across distributed networks as server-based functions, the Geosystem could be re-imagined as a framework

for heterogeneous analysis. Currently, the majority of the interactivity is based upon sophisticated ASP.NET calls to the geodatabase and the return of specific records, services, or expert-based content through project collaboration with Lewis and Clark scholars. However, unless the Web services *per se* are consumed into sophisticated thick-client applications, data analytics are limited. The Geosystem, as such, is more of a descriptive, experiential tool designed to stimulate dialogue on key geospatial thematics presented across continental, regional, and local scales. The objective of this research was not to focus upon the analysis of the geospatial content, but rather, the design, development, and delivery of the Geosystem itself. This was a key decision.

As a distributed set of applications, the underlying desire was to create a connected context for historical geographical investigations. Distribution, in a sense, connotes connectivity – the ability to harness geospatial data resources through a series of interoperable relationships between physically distinct data repositories or Web services. One of the more challenging aspects of historical geography, including the Lewis and Clark saga, is the ability to find and utilize both spatial and non-spatial information in a timely and cost-effective manner. So many lines of investigation require access to data resources that remain disconnected from a viable, discoverable network.

The connectivity of the Geosystem provides a means to access and visualize information that heretofore was simply not digitally viable. In so far as information is not accessible or connected, the value of this information is limited. Metaphorically, the Geosystem serves as an interconnected, dynamic repository of seemingly unrelated elements of historical geography. The value of these resources, when harvested into a usable and accessible set of services, increases dramatically. The value is expressed in

the stimulation of dialogue, research-based inquiry, and general public education. Given the fact that the combined resources of the Geosystem receive in excess of 30-40,000 unique visits per month, the Geosystem is delivering a valuable educational tool to a global audience.

The Lewis and Clark Geosystem, as an expression of geospatial historical geography, can be understood as a complex tool. In the etymological root of the word technology, we find the ancient Greek word *tekne*. *Tekne* means tool. A tool, by definition, is something one uses to assist in the implementation or realization of a concept or idea. We use tools as a means to an end. In so far as geospatial historical geography is about creating and developing analytical frameworks and systems for analyzing particular landscape-based phenomena, the Lewis and Clark Geosystem must be seen as an experiential, descriptive tool. The Geosystem is a means to end. It was designed as an elaborate gateway to the Lewis and Clark Trail. It is a gateway with multiple interconnecting branches that reveal a variety of patterns and processes across a spatio-temporal metaframework.

It is the sincere hope of the author that the Lewis and Clark Geosystem will continue to provide value in understanding the geographical significance of the Lewis and Clark Trail. It is gratifying that the Geosystem has been recognized by the USGS as an “outstanding contribution” to the science of Lewis and Clark scholarship, and the author intends to pursue the evolution of the tools and the existing geodatabases as our society begins to examine our past to better understand our future environmental choices.⁵⁰

⁵⁰ Geological Society of America Conference, USGS Pardee Symposium, November 2003: “The Science of the Lewis and Clark Trail.”

APPENDIX A:
MACRO-SCALE BIOGEOGRAPHY ARXML FILE

>>>>>

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<SCREEN dpi="96" />

</ENVIRONMENT>

<MAP>

<PROPERTIES>

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<MAPUNITS units="meters" />

<FILTERCOORDSYS id="102039" />

<FEATURECOORDSYS id="102039" />

</PROPERTIES>

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<SHAPEWORKSPACE name="shp_ws-60" directory="D:\DATA\Albers\Vector" />

<SHAPEWORKSPACE name="shp_ws-0" directory="I:\mobot_species" />

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fillcolor="0,92,230" boundarycaptype="round" boundarycolor="132,94,205" />
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</LAYER>
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  <DATASET name="TEMP0304" type="polygon" workspace="shp_ws-34" />
  <COORDSYS id="102039" />
  <VALUEMAPRENDERER lookupfield="DEG_F">
    <EXACT value="A &lt; 20.0" label="A &lt; 20.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="232,219,255" boundarycaptype="round" boundarycolor="102,102,255" />
    </EXACT>
    <EXACT value="B 20.0 - 32.0" label="B 20.0 - 32.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="66,77,168" boundarycaptype="round" boundarycolor="117,98,230" />
    </EXACT>
    <EXACT value="C 32.1 - 40.0" label="C 32.1 - 40.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,92,230" boundarycaptype="round" boundarycolor="132,94,205" />
    </EXACT>
    <EXACT value="D 40.1 - 50.0" label="D 40.1 - 50.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="147,89,180" />

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</EXACT>

<EXACT value="E 50.1 - 60.0" label="E 50.1 - 60.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="190,232,255" boundarycaptype="round" boundarycolor="162,85,155" />

</EXACT>

<EXACT value="F 60.1 - 70.0" label="F 60.1 - 70.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="233,255,190" boundarycaptype="round" boundarycolor="177,81,130" />

</EXACT>

<EXACT value="G 70.1 - 80.0" label="G 70.1 - 80.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,255,115" boundarycaptype="round" boundarycolor="192,76,105" />

</EXACT>

<EXACT value="H 80.1 - 90.0" label="H 80.1 - 90.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,126,46" boundarycaptype="round" boundarycolor="207,72,80" />

</EXACT>

<EXACT value="I &gt; 90.0" label="I &gt; 90.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,0,0" boundarycaptype="round" boundarycolor="222,68,55" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Temp March" visible="false" id="14">

  <DATASET name="TEMP0303" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="DEG_F">

    <EXACT value="A &lt; 20.0" label="A &lt; 20.0">

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<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="232,219,255" boundarycaptype="round" boundarycolor="102,102,255" />
</EXACT>
<EXACT value="B 20.0 - 32.0" label="B 20.0 - 32.0">
<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="66,77,168" boundarycaptype="round" boundarycolor="117,98,230" />
</EXACT>
<EXACT value="C 32.1 - 40.0" label="C 32.1 - 40.0">
<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,92,230" boundarycaptype="round" boundarycolor="132,94,205" />
</EXACT>
<EXACT value="D 40.1 - 50.0" label="D 40.1 - 50.0">
<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="147,89,180" />
</EXACT>
<EXACT value="E 50.1 - 60.0" label="E 50.1 - 60.0">
<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="190,232,255" boundarycaptype="round" boundarycolor="162,85,155" />
</EXACT>
<EXACT value="F 60.1 - 70.0" label="F 60.1 - 70.0">
<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="233,255,190" boundarycaptype="round" boundarycolor="177,81,130" />
</EXACT>
<EXACT value="G 70.1 - 80.0" label="G 70.1 - 80.0">
<SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,255,115" boundarycaptype="round" boundarycolor="192,76,105" />
</EXACT>
<EXACT value="H 80.1 - 90.0" label="H 80.1 - 90.0">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,126,46" boundarycaptype="round" boundarycolor="207,72,80" />
  </EXACT>
  <EXACT value="I &gt; 90.0" label="I &gt; 90.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,0,0" boundarycaptype="round" boundarycolor="222,68,55" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Temp February" visible="false" id="15">
  <DATASET name="TEMP0302" type="polygon" workspace="shp_ws-34" />
  <COORDSYS id="102039" />
  <VALUEMAPRENDERER lookupfield="DEG_F">
    <EXACT value="A &lt; 20.0" label="A &lt; 20.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="232,219,255" boundarycaptype="round" boundarycolor="102,102,255" />
    </EXACT>
    <EXACT value="B 20.0 - 32.0" label="B 20.0 - 32.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="66,77,168" boundarycaptype="round" boundarycolor="117,98,230" />
    </EXACT>
    <EXACT value="C 32.1 - 40.0" label="C 32.1 - 40.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,92,230" boundarycaptype="round" boundarycolor="132,94,205" />
    </EXACT>
    <EXACT value="D 40.1 - 50.0" label="D 40.1 - 50.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="147,89,180" />

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</EXACT>

<EXACT value="E 50.1 - 60.0" label="E 50.1 - 60.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="190,232,255" boundarycaptype="round" boundarycolor="162,85,155" />

</EXACT>

<EXACT value="F 60.1 - 70.0" label="F 60.1 - 70.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="233,255,190" boundarycaptype="round" boundarycolor="177,81,130" />

</EXACT>

<EXACT value="G 70.1 - 80.0" label="G 70.1 - 80.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,255,115" boundarycaptype="round" boundarycolor="192,76,105" />

</EXACT>

<EXACT value="H 80.1 - 90.0" label="H 80.1 - 90.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,126,46" boundarycaptype="round" boundarycolor="207,72,80" />

</EXACT>

<EXACT value="I &gt; 90.0" label="I &gt; 90.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,0,0" boundarycaptype="round" boundarycolor="222,68,55" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Temp January" visible="false" id="16">

  <DATASET name="TEMP0301" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="DEG_F">

    <EXACT value="A &lt; 20.0" label="A &lt; 20.0">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="232,219,255" boundarycaptype="round" boundarycolor="102,102,255" />
  </EXACT>
  <EXACT value="B 20.0 - 32.0" label="B 20.0 - 32.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="66,77,168" boundarycaptype="round" boundarycolor="117,98,230" />
  </EXACT>
  <EXACT value="C 32.1 - 40.0" label="C 32.1 - 40.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,92,230" boundarycaptype="round" boundarycolor="132,94,205" />
  </EXACT>
  <EXACT value="D 40.1 - 50.0" label="D 40.1 - 50.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="147,89,180" />
  </EXACT>
  <EXACT value="E 50.1 - 60.0" label="E 50.1 - 60.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="190,232,255" boundarycaptype="round" boundarycolor="162,85,155" />
  </EXACT>
  <EXACT value="F 60.1 - 70.0" label="F 60.1 - 70.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="233,255,190" boundarycaptype="round" boundarycolor="177,81,130" />
  </EXACT>
  <EXACT value="G 70.1 - 80.0" label="G 70.1 - 80.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,255,115" boundarycaptype="round" boundarycolor="192,76,105" />
  </EXACT>
  <EXACT value="H 80.1 - 90.0" label="H 80.1 - 90.0">

```

```

    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,126,46" boundarycaptype="round" boundarycolor="207,72,80" />
    </EXACT>
    <EXACT value="I &gt; 90.0" label="I &gt; 90.0">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,0,0" boundarycaptype="round" boundarycolor="222,68,55" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Precip December" visible="false" id="18">
    <DATASET name="PREC0112" type="polygon" workspace="shp_ws-34" />
    <COORDSYS id="102039" />
    <VALUEMAPRENDERER lookupfield="INCHES">
    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />

```

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</EXACT>

<EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />

</EXACT>

<EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />

</EXACT>

<EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />

</EXACT>

<EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />

</EXACT>

<EXACT value="I &gt; 20.00" label="I &gt; 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip November" visible="false" id="19">

  <DATASET name="PREC0111" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
    </EXACT>
    <EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
    </EXACT>
    <EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
    </EXACT>
    <EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
    </EXACT>
    <EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
  </EXACT>
  <EXACT value="I &gt; 20.00" label="I &gt; 20.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Precip October" visible="false" id="20">
  <DATASET name="PREC0110" type="polygon" workspace="shp_ws-34" />
  <COORDSYS id="102039" />
  <VALUEMAPRENDERER lookupfield="INCHES">
    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />

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</EXACT>

<EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />

</EXACT>

<EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />

</EXACT>

<EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />

</EXACT>

<EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />

</EXACT>

<EXACT value="I &gt; 20.00" label="I &gt; 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip September" visible="false" id="21">

  <DATASET name="PREC0109" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
  </EXACT>
  <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
  </EXACT>
  <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
  </EXACT>
  <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
  </EXACT>
  <EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
  </EXACT>
  <EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
  </EXACT>
  <EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
  </EXACT>
  <EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
    </EXACT>
    <EXACT value="I &gt; 20.00" label="I &gt; 20.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Precip August" visible="false" id="22">
    <DATASET name="PREC0108" type="polygon" workspace="shp_ws-34" />
    <COORDSYS id="102039" />
    <VALUEMAPRENDERER lookupfield="INCHES">
    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />

```

```

</EXACT>

<EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />

</EXACT>

<EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />

</EXACT>

<EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />

</EXACT>

<EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />

</EXACT>

<EXACT value="I &gt; 20.00" label="I &gt; 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip July" visible="false" id="23">

  <DATASET name="PREC0107" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
  </EXACT>
  <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
  </EXACT>
  <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
  </EXACT>
  <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
  </EXACT>
  <EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
  </EXACT>
  <EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
  </EXACT>
  <EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
  </EXACT>
  <EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
  </EXACT>
  <EXACT value="I &gt; 20.00" label="I &gt; 20.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Precip June" visible="false" id="24">
  <DATASET name="PREC0106" type="polygon" workspace="shp_ws-34" />
  <COORDSYS id="102039" />
  <VALUEMAPRENDERER lookupfield="INCHES">
    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />

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</EXACT>

<EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />

</EXACT>

<EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />

</EXACT>

<EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />

</EXACT>

<EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />

</EXACT>

<EXACT value="I &gt; 20.00" label="I &gt; 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip May" visible="false" id="25">

  <DATASET name="PREC0105" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
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  <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
  </EXACT>
  <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
  </EXACT>
  <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
  </EXACT>
  <EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
  </EXACT>
  <EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
  </EXACT>
  <EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
  </EXACT>
  <EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
    </EXACT>
    <EXACT value="I &gt; 20.00" label="I &gt; 20.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Precip April" visible="false" id="26">
    <DATASET name="PREC0104" type="polygon" workspace="shp_ws-34" />
    <COORDSYS id="102039" />
    <VALUEMAPRENDERER lookupfield="INCHES">
    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />

```

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</EXACT>

<EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />

</EXACT>

<EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />

</EXACT>

<EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />

</EXACT>

<EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />

</EXACT>

<EXACT value="I &gt; 20.00" label="I &gt; 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip March" visible="false" id="27">

  <DATASET name="PREC0103" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
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  <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
  </EXACT>
  <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
  </EXACT>
  <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
  </EXACT>
  <EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
  </EXACT>
  <EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
  </EXACT>
  <EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
  </EXACT>
  <EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
  </EXACT>
  <EXACT value="I &gt; 20.00" label="I &gt; 20.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Precip February" visible="false" id="28">
  <DATASET name="PREC0102" type="polygon" workspace="shp_ws-34" />
  <COORDSYS id="102039" />
  <VALUEMAPRENDERER lookupfield="INCHES">
    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
    </EXACT>
    <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
    </EXACT>
    <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
    </EXACT>
    <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />

```

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</EXACT>

<EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />

</EXACT>

<EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />

</EXACT>

<EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />

</EXACT>

<EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />

</EXACT>

<EXACT value="I &gt; 20.00" label="I &gt; 20.00">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip January" visible="false" id="29">

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  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 0.51" label="A &lt; 0.51">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
  </EXACT>
  <EXACT value="B 0.51 - 1.00" label="B 0.51 - 1.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
  </EXACT>
  <EXACT value="C 1.01 - 1.50" label="C 1.01 - 1.50">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
  </EXACT>
  <EXACT value="D 1.51 - 2.00" label="D 1.51 - 2.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
  </EXACT>
  <EXACT value="E 2.01 - 3.00" label="E 2.01 - 3.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
  </EXACT>
  <EXACT value="F 3.01 - 5.00" label="F 3.01 - 5.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
  </EXACT>
  <EXACT value="G 5.01 - 10.00" label="G 5.01 - 10.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
  </EXACT>
  <EXACT value="H 10.01 - 20.00" label="H 10.01 - 20.00">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
  </EXACT>
  <EXACT value="I &gt; 20.00" label="I &gt; 20.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Temp Annual" visible="false" id="4">
  <DATASET name="TEMP0313" type="polygon" workspace="shp_ws-34" />
  <COORDSYS id="102039" />
  <VALUEMAPRENDERER lookupfield="DEG_F">
    <EXACT value="A &lt; 32.0" label="A &lt; 32.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="232,219,255" boundarycaptype="round" boundarycolor="102,102,255" />
    </EXACT>
    <EXACT value="B 32.0 - 40.0" label="B 32.0 - 40.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="66,77,168" boundarycaptype="round" boundarycolor="117,98,230" />
    </EXACT>
    <EXACT value="C 40.1 - 45.0" label="C 40.1 - 45.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,92,230" boundarycaptype="round" boundarycolor="132,94,205" />
    </EXACT>
    <EXACT value="D 45.1 - 50.0" label="D 45.1 - 50.0">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="147,89,180" />

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</EXACT>

<EXACT value="E 50.1 - 55.0" label="E 50.1 - 55.0">

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fillcolor="190,232,255" boundarycaptype="round" boundarycolor="162,85,155" />

</EXACT>

<EXACT value="F 55.1 - 60.0" label="F 55.1 - 60.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="233,255,190" boundarycaptype="round" boundarycolor="177,81,130" />

</EXACT>

<EXACT value="G 60.1 - 65.0" label="G 60.1 - 65.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,255,115" boundarycaptype="round" boundarycolor="192,76,105" />

</EXACT>

<EXACT value="H 65.1 - 70.0" label="H 65.1 - 70.0">

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fillcolor="255,126,46" boundarycaptype="round" boundarycolor="207,72,80" />

</EXACT>

<EXACT value="I &gt; 70.0" label="I &gt; 70.0">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,0,0" boundarycaptype="round" boundarycolor="222,68,55" />

</EXACT>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Precip Annual" visible="false" id="17">

  <DATASET name="PREC0113" type="polygon" workspace="shp_ws-34" />

  <COORDSYS id="102039" />

  <VALUEMAPRENDERER lookupfield="INCHES">

    <EXACT value="A &lt; 5.01" label="A &lt; 5.01">

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    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="255,210,127" boundarycaptype="round" boundarycolor="255,255,204" />
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  <EXACT value="B 5.01 - 12.00" label="B 5.01 - 12.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="254,255,115" boundarycaptype="round" boundarycolor="235,245,184" />
  </EXACT>
  <EXACT value="C 12.01 - 20.00" label="C 12.01 - 20.00">
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fillcolor="211,255,116" boundarycaptype="round" boundarycolor="215,235,164" />
  </EXACT>
  <EXACT value="D 20.01 - 30.00" label="D 20.01 - 30.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="162,255,116" boundarycaptype="round" boundarycolor="195,225,144" />
  </EXACT>
  <EXACT value="E 30.01 - 40.00" label="E 30.01 - 40.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="116,215,224" boundarycaptype="round" boundarycolor="175,215,124" />
  </EXACT>
  <EXACT value="F 40.01 - 50.00" label="F 40.01 - 50.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="114,223,254" boundarycaptype="round" boundarycolor="155,205,104" />
  </EXACT>
  <EXACT value="G 50.01 - 70.00" label="G 50.01 - 70.00">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="115,178,255" boundarycaptype="round" boundarycolor="135,195,84" />
  </EXACT>
  <EXACT value="H 70.01 - 100.00" label="H 70.01 - 100.00">

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        <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="0,91,231" boundarycaptype="round" boundarycolor="115,185,64" />
    </EXACT>
    <EXACT value="I &gt; 100.00" label="I &gt; 100.00">
        <SIMPLEPOLYGONSYMBOL boundarytransparency="0.0" filltransparency="0.7"
fillcolor="169,0,132" boundarycaptype="round" boundarycolor="95,175,44" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Botkin EcoRegions" visible="true" id="113">
    <DATASET name="Botkin3" type="polygon" workspace="shp_ws-60" />
    <GROUPRENDERER>
        <SIMPLERENDERER>
            <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.0"
boundarywidth="2" boundarycaptype="round" boundarycolor="245,201,62" />
        </SIMPLERENDERER>
        <SIMPLELABELRENDERER field="DESCR">
            <TEXTSYMBOL antialiasing="true" font="Arial" fontstyle="regular" fontsize="9"
fontcolor="50,10,0" glowing="188,188,188" />
        </SIMPLELABELRENDERER>
    </GROUPRENDERER>
</LAYER>
<LAYER type="featureclass" name="City" visible="true" id="30" maxscale="1:8000000">
    <DATASET name="Meanmotp" type="point" workspace="shp_ws-34" />
    <GROUPRENDERER>
        <SIMPLERENDERER>
            <SIMPLEMARKERSYMBOL type="square" width="4" />
        </SIMPLERENDERER>
    </GROUPRENDERER>
</LAYER>

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<SCALEDEPENDENTRENDERER lower="1:1" upper="1:8000000">
  <SIMPLELABELRENDERER field="MEAN_MONTH" labelpriorities="1,2,2,4,5,3,2,4">
    <TEXTSYMBOL antialiasing="true" font="Arial" fontstyle="bold" fontsize="12" />
  </SIMPLELABELRENDERER>
</SCALEDEPENDENTRENDERER>
</GROUPRENDERER>
</LAYER>
<LAYER type="featureclass" name="LouisianaPurchase" visible="false" id="2">
  <DATASET name="la_pur" type="polygon" workspace="shp_ws-60" />
  <COORDSYS id="102039" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
filltype="fdiagonal" fillcolor="27,127,127" boundarycaptype="round" />
  </SIMPLERENDERER>
</LAYER>
<LAYER type="featureclass" name="Lakes" visible="true" id="3" maxscale="1:10000000">
  <DATASET name="hydrogp020" type="polygon" workspace="shp_ws-60" />
  <COORDSYS id="102039" />
  <GROUPRENDERER>
    <VALUEMAPRENDERER lookupfield="FEATURE">
      <EXACT value="Bay or Estuary or Ocean" label="Bay or Estuary or Ocean">
        <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
fillcolor="132,190,254" boundarycaptype="round" boundarycolor="132,190,254" />
      </EXACT>
      <EXACT value="Glacier" label="Glacier">
        <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
fillcolor="255,255,255" boundarycaptype="round" boundarycolor="255,255,255" />
      </EXACT>
    </VALUEMAPRENDERER>
  </GROUPRENDERER>
</LAYER>

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<EXACT value="Lake" label="Lake">
  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
fillcolor="132,190,254" boundarycaptype="round" boundarycolor="132,190,254" />
</EXACT>
<EXACT value="Reservoir" label="Reservoir">
  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
fillcolor="132,190,254" boundarycaptype="round" boundarycolor="132,190,254" />
</EXACT>
<EXACT value="Reservoir Intermittent" label="Reservoir Intermittent">
  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
fillcolor="132,190,254" boundarycaptype="round" boundarycolor="132,190,254" />
</EXACT>
<EXACT value="Stream" label="Stream">
  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.7"
fillcolor="132,190,254" boundarycaptype="round" boundarycolor="204,255,255" />
</EXACT>
</VALUEMAPRENDERER>
<SCALEDEPENDENTRENDERER lower="1:1" upper="1:2000000">
  <SIMPLELABELRENDERER field="NAME">
    <TEXTSYMBOL antialiasing="true" font="Tempus Sans ITC" fontstyle="regular"
fontsize="14" fontcolor="0,0,255" />
  </SIMPLELABELRENDERER>
</SCALEDEPENDENTRENDERER>
</GROUPRENDERER>
</LAYER>
<LAYER type="featureclass" name="UrbanAreas" visible="true" id="35" maxscale="1:10000000">
  <DATASET name="urbanap020" type="polygon" workspace="shp_ws-60" />
  <COORDSYS id="102039" />

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<SIMPLERENDERER>
  <SIMPLEPOLYGONSYMBOL fillcolor="255,0,255" boundary="false" />
</SIMPLERENDERER>
</LAYER>
<LAYER type="featureclass" name="Streams" visible="true" id="32" maxscale="1:5000000">
  <DATASET name="hydrogl020" type="line" workspace="shp_ws-60" />
  <GROUPRENDERER>
    <SIMPLERENDERER>
      <SIMPLELINESYMBOL transparency="0.75" width="1" captype="round"
color="132,190,254" />
    </SIMPLERENDERER>
    <SCALEDEPENDENTRENDERER lower="1:1" upper="1:400000">
      <SIMPLELABELRENDERER field="NAME" linelabelposition="placeabove">
        <TEXTSYMBOL antialiasing="true" font="Tempus Sans ITC" fontstyle="regular"
fontsize="11" fontcolor="0,0,255" />
      </SIMPLELABELRENDERER>
    </SCALEDEPENDENTRENDERER>
  </GROUPRENDERER>
</LAYER>
<LAYER type="featureclass" name="StateBoundaries" visible="true" id="36">
  <DATASET name="states" type="polygon" workspace="shp_ws-60" />
  <COORDSYS id="102039" />
  <GROUPRENDERER>
    <SIMPLERENDERER>
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.0"
boundarywidth="2" boundarycaptype="round" boundarycolor="128,128,128" />
    </SIMPLERENDERER>
    <SCALEDEPENDENTRENDERER lower="1:10000000" upper="1:9223372036854775807">

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<SIMPLELABELRENDERER field="STATE_NAME">
  <TEXTSYMBOL antialiasing="true" font="Tempus Sans ITC" fontstyle="regular"
fontSize="12" />
</SIMPLELABELRENDERER>
</SCALEDEPENDENTRENDERER>
</GROUPRENDERER>
</LAYER>
<LAYER type="featureclass" name="Trail" visible="true" id="34">
  <DATASET name="route2" type="line" workspace="shp_ws-60" />
  <COORDSYS id="102039" />
  <SIMPLERENDERER>
    <SIMPLELINESYMBOL width="4" type="dash" captype="round" color="204,153,53" />
  </SIMPLERENDERER>
</LAYER>
<LAYER type="featureclass" name="Campsites" visible="true" id="33" maxscale="1:6000000">
  <DATASET name="campsites" type="point" workspace="shp_ws-60" />
  <COORDSYS id="102039" />
  <GROUPRENDERER>
    <SIMPLERENDERER>
      <RASTERMARKERSYMBOL url="Mobot/Images/North.gif"
image="D:\WebMap\MOBOT/Images\north.gif" />
    </SIMPLERENDERER>
    <SCALEDEPENDENTRENDERER lower="1:1" upper="1:1000000">
      <SIMPLELABELRENDERER field="TEXTDATE" labelpriorities="1,2,2,4,5,3,2,4">
        <TEXTSYMBOL antialiasing="true" font="Tempus Sans ITC" fontstyle="bold"
fontSize="11" fontcolor="204,153,0" glowing="255,255,255" />
      </SIMPLELABELRENDERER>
    </SCALEDEPENDENTRENDERER>
  </GROUPRENDERER>
</LAYER>

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    </GROUPRENDERER>

</LAYER>

<LAYER type="featureclass" name="Roads" visible="true" id="31" maxscale="1:1000000">
    <DATASET name="mjrrds" type="line" workspace="shp_ws-60" />
    <COORDSYS id="102039" />
    <SIMPLERENDERER>
        <SIMPLELINESYMBOL width="1" captype="round" />
    </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Highways" visible="true" id="38" maxscale="1:5000000">
    <DATASET name="majrdnet" type="line" workspace="shp_ws-60" />
    <COORDSYS id="102039" />
    <GROUPRENDERER>
        <SIMPLERENDERER>
            <SIMPLELINESYMBOL width="2" captype="round" color="255,0,0" />
        </SIMPLERENDERER>
        <SIMPLELABELRENDERER field="SIGN1" linelabelposition="placeontop">
            <SHIELDSYMBOL antialiasing="true" font="Arial" fontstyle="regular" fontsize="8"
type="usroad" minsize="2" />
        </SIMPLELABELRENDERER>
    </GROUPRENDERER>
</LAYER>

<LAYER type="featureclass" name="Interstate" visible="true" id="39" maxscale="1:10000000">
    <DATASET name="intrstat" type="line" workspace="shp_ws-60" />
    <COORDSYS id="102039" />
    <GROUPRENDERER>
        <SIMPLERENDERER>
            <SIMPLELINESYMBOL width="3" captype="round" color="0,153,0" />
        </SIMPLERENDERER>
    </GROUPRENDERER>
</LAYER>

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</SIMPLERENDERER>

<SIMPLELABELRENDERER field="NAME" linelabelposition="placeontop">
  <SHIELDSYMBOL antialiasing="true" font="Arial" fontstyle="regular" fontsize="8"
fontcolor="255,255,255" type="interstate" minsize="2" />
  </SIMPLELABELRENDERER>
</GROUPRENDERER>
</LAYER>
<LAYER type="featureclass" name="aech_occ_i_pl" visible="false" id="40">
<DATASET name="aech_occ_i_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="anti_amer_pl" visible="false" id="41">
<DATASET name="anti_amer_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="aplo_rufa_pl" visible="false" id="42">

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<DATASET name="aplo_rufa_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="ayth_coll_pl" visible="false" id="43">
<DATASET name="ayth_coll_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="bona_umbe_pl" visible="false" id="44">
<DATASET name="bona_umbe_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>

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</LAYER>

<LAYER type="featureclass" name="calc_mcco_pl" visible="false" id="45">
<DATASET name="calc_mcco_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="cani_latr_pl" visible="false" id="46">
<DATASET name="cani_latr_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="cani_lupu_pl" visible="false" id="47">
<DATASET name="cani_lupu_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

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```

    </EXACT>

  </VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="card_tris_pl" visible="false" id="48">
<DATASET name="card_tris_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="cast_cana_pl" visible="false" id="49">
<DATASET name="cast_cana_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="cato_semi_pl" visible="false" id="50">
<DATASET name="cato_semi_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">

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        <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="cent_urop_pl" visible="false" id="51">
<DATASET name="cent_urop_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
        <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="cerv_elap_pl" visible="false" id="52">
<DATASET name="cerv_elap_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
        <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="chor_mino_pl" visible="false" id="53">
<DATASET name="chor_mino_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />

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<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="cola_aura_pl" visible="false" id="54">
<DATASET name="cola_aura_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="corv_caur_pl" visible="false" id="55">
<DATASET name="corv_caur_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="corv_cora_pl" visible="false" id="56">

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<DATASET name="corv_cora_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="cyan_stel_pl" visible="false" id="57">
<DATASET name="cyan_stel_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="cygn_colu_pl" visible="false" id="58">
<DATASET name="cygn_colu_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
  <EXACT value="1" label="1">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>

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</LAYER>

<LAYER type="featureclass" name="cyno_ludo_pl" visible="false" id="59">
<DATASET name="cyno_ludo_pl" type="polygon" workspace="shp_ws-0" />
  <COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="dend_obsc_pl" visible="false" id="60">
<DATASET name="dend_obsc_pl" type="polygon" workspace="shp_ws-0" />
  <COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="dryo_pile_pl" visible="false" id="61">
<DATASET name="dryo_pile_pl" type="polygon" workspace="shp_ws-0" />
  <COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

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    </EXACT>

  </VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="erem_alpe_pl" visible="false" id="62">
<DATASET name="erem_alpe_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="eret_dors_pl" visible="false" id="63">
<DATASET name="eret_dors_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="euph_cyan_pl" visible="false" id="64">
<DATASET name="euph_cyan_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">

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    <SIMPLEPOLYGONS YMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
    </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="falc_cana_pl" visible="false" id="65">
<DATASET name="falc_cana_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
        <SIMPLEPOLYGONS YMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
        </EXACT>
        </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="gymn_cyan_pl" visible="false" id="66">
<DATASET name="gymn_cyan_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
        <SIMPLEPOLYGONS YMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
        </EXACT>
        </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="lani_ludo_pl" visible="false" id="67">
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<COORDSYS id="4326" />

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<VALUEMAPRENDERER lookupfield="PRESENCE">
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  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="laru_glau1_pl" visible="false" id="68">
<DATASET name="laru_glau1_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="laru_occi_pl" visible="false" id="69">
<DATASET name="laru_occi_pl" type="polygon" workspace="shp_ws-0" />
<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="laru_phil_pl" visible="false" id="70">

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<DATASET name="laru_phil_pl" type="polygon" workspace="shp_ws-0" />
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  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="lepu_town_pl" visible="false" id="71">
  <DATASET name="lepu_town_pl" type="polygon" workspace="shp_ws-0" />
  <COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="lynx_rufu_pl" visible="false" id="72">
  <DATASET name="lynx_rufu_pl" type="polygon" workspace="shp_ws-0" />
  <COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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  </VALUEMAPRENDERER>

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</LAYER>

<LAYER type="featureclass" name="marm_flav_pl" visible="false" id="73">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="meph_meph_pl" visible="false" id="75">
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<COORDSYS id="4326" />
<VALUEMAPRENDERER lookupfield="PRESENCE">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

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    </EXACT>

    </VALUEMAPRENDERER>

</LAYER>

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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
        </EXACT>
    </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="neot_flor_pl" visible="false" id="77">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</LAYER>

<LAYER type="featureclass" name="nuci_colu_pl" visible="false" id="78">
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    <VALUEMAPRENDERER lookupfield="PRESENCE">
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        <SIMPLEPOLYGONS YMBOL boundarytransparency="1.0" filltransparency="0.3"
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<LAYER type="featureclass" name="nume_amer_pl" visible="false" id="79">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</VALUEMAPRENDERER>
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<LAYER type="featureclass" name="odoc_hemi_pl" visible="false" id="80">
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<COORDSYS id="4326" />

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<LAYER type="featureclass" name="oreo_pict_pl" visible="false" id="82">
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  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="ovis_cana_pl" visible="false" id="83">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="peri_cana_pl" visible="false" id="84">

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<DATASET name="peri_cana_pl" type="polygon" workspace="shp_ws-0" />
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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<LAYER type="featureclass" name="phal_auri_pl" visible="false" id="85">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</LAYER>
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</VALUEMAPRENDERER>

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</LAYER>
<LAYER type="featureclass" name="pica_huds_pl" visible="false" id="87">
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</LAYER>
<LAYER type="featureclass" name="pico_vill_pl" visible="false" id="88">
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<LAYER type="featureclass" name="pira_ludo_pl" visible="false" id="89">
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<EXACT value="1" label="1">
<SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
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```

    </EXACT>

    </VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="podi_gris_pl" visible="false" id="90">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="proc_loto_pl" visible="false" id="91">
<DATASET name="proc_loto_pl" type="polygon" workspace="shp_ws-0" />
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="puma_conc_pl" visible="false" id="92">
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        <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
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    </EXACT>
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</LAYER>
<LAYER type="featureclass" name="sciu_gris_pl" visible="false" id="94">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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<LAYER type="featureclass" name="sela_plat_pl" visible="false" id="95">
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  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="sper_colu_pl" visible="false" id="96">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="sper_trid_pl" visible="false" id="97">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="ster_anti_pl" visible="false" id="98">

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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</LAYER>
<LAYER type="featureclass" name="ster_fors_pl" visible="false" id="99">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="stur_negl_pl" visible="false" id="100">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</VALUEMAPRENDERER>

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</LAYER>

<LAYER type="featureclass" name="tami_doug_pl" visible="false" id="101">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="tami_huds_pl" visible="false" id="102">
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  <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="tami_town_pl" visible="false" id="103">
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  <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
  </EXACT>
</VALUEMAPRENDERER>
</LAYER>

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    </EXACT>

    </VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="taxi_taxu_pl" visible="false" id="104">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
        </EXACT>
    </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="thom_talp_pl" visible="false" id="105">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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</LAYER>

<LAYER type="featureclass" name="trog_trog_pl" visible="false" id="106">
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        <EXACT value="1" label="1">

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        <SIMPLEPOLYGONS YMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
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        </VALUEMAPRENDERER>
    </LAYER>
    <LAYER type="featureclass" name="tymp_phas_pl" visible="false" id="107">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
    </VALUEMAPRENDERER>
    </LAYER>
    <LAYER type="featureclass" name="ursu_arct_pl" visible="false" id="108">
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    <COORDSYS id="4326" />
    <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
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fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
    </VALUEMAPRENDERER>
    </LAYER>
    <LAYER type="featureclass" name="vulp_velo_pl" visible="false" id="109">
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    <COORDSYS id="4326" />

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<COORDSYS id="4326" />
  <VALUEMAPRENDERER lookupfield="PRESENCE">
    <EXACT value="1" label="1">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.3"
fillcolor="204,255,204" boundarycaptype="round" boundarycolor="204,255,204" />
    </EXACT>
  </VALUEMAPRENDERER>
</LAYER>
</MAP>
</CONFIG>
</ARCXML>

```

APPENDIX B:
REGIONAL AND MICRO SCALE ARXML FOR LOWER COLUMBIA RIVER
WEB MAPPING APPLICATION: HISTORICAL CARTOGRAPHY IMS
SERVICE AND PRIMARY IMS SERVICE.

```
<?xml version="1.0" encoding="UTF-8"?>
```

```
<ARXML version="1.1">
```

```
<CONFIG>
```

```
<ENVIRONMENT>
```

```
<LOCALE country="US" language="en" variant="" />
```

```
<UIFONT color="0,0,0" name="dialog" size="12" style="regular" />
```

```
<SCREEN dpi="96" />
```

```
</ENVIRONMENT>
```

```
<MAP>
```

```
<PROPERTIES>
```

```
<ENVELOPE minx="403386.38069151924" miny="5010415.408511595"  
maxx="650157.0455819332" maxy="5178751.6436694" name="Initial_Extent" />
```

```
<MAPUNITS units="meters" />
```

```
</PROPERTIES>
```

```
<WORKSPACES>
```

```
<IMAGEWORKSPACE directory="H:\usfws\raster\dem" name="jai_ws-36" />
```

```
<SHAPEWORKSPACE name="shp_ws-37" directory="H:\usfws\shapefile" />
```

```
</WORKSPACES>
```

```
<LAYER type="image" name="mapdem_utm10.img" visible="true" id="9">
```

```
<DATASET name="mapdem_utm10.img" type="image" workspace="jai_ws-36" />
```

```
</LAYER>
```

```

<LAYER type="featureclass" name="1936_landcover" visible="false" id="10">
  <DATASET name="1936_landcover" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="HVEG36_NAM">
    <EXACT value="Agricultural Zone" label="Agricultural Zone">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="229,161,0" boundarycaptype="round" boundarycolor="229,161,0" />
    </EXACT>
    <EXACT value="Balsam Fir-Mtn Hem-Upper Slope Types, Large" label="Balsam Fir-Mtn
Hem-Upper Slope Types, Large">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="240,230,140" boundarycaptype="round" boundarycolor="240,230,140" />
    </EXACT>
    <EXACT value="Balsam Fir-Mtn Hem-Upper Slope Types, Small" label="Balsam Fir-Mtn
Hem-Upper Slope Types, Small">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="172,150,172" boundarycaptype="round" boundarycolor="172,150,172" />
    </EXACT>
    <EXACT value="Cedar-Redwood, Large" label="Cedar-Redwood, Large">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="205,155,29" boundarycaptype="round" boundarycolor="205,155,29" />
    </EXACT>
    <EXACT value="Deforested Burns" label="Deforested Burns">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="139,69,19" boundarycaptype="round" boundarycolor="139,69,19" />
    </EXACT>
    <EXACT value="Douglas Fir, Large Second Growth" label="Douglas Fir, Large Second
Growth">

```

```

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,251,195" boundarycaptype="round" boundarycolor="255,251,195" />
  </EXACT>
  <EXACT value="Douglas Fir, Old Growth" label="Douglas Fir, Old Growth">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="189,176,86" boundarycaptype="round" boundarycolor="189,176,86" />
  </EXACT>
  <EXACT value="Douglas Fir, Seedling-Sapling-Pole" label="Douglas Fir, Seedling-Sapling-
Pole">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="220,206,219" boundarycaptype="round" boundarycolor="220,206,219" />
  </EXACT>
  <EXACT value="Douglas Fir, Small Second Growth" label="Douglas Fir, Small Second
Growth">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="167,175,94" boundarycaptype="round" boundarycolor="167,175,94" />
  </EXACT>
  <EXACT value="Hardwood, Alder-Ash-Maple" label="Hardwood, Alder-Ash-Maple">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="192,101,73" boundarycaptype="round" boundarycolor="192,101,73" />
  </EXACT>
  <EXACT value="Hardwood, Oak-Madrone" label="Hardwood, Oak-Madrone">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="139,105,20" boundarycaptype="round" boundarycolor="139,105,20" />
  </EXACT>
  <EXACT value="Lodgepole Pine" label="Lodgepole Pine">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="192,144,88" boundarycaptype="round" boundarycolor="192,144,88" />

```

```

</EXACT>

<EXACT value="Non-Forest" label="Non-Forest">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="254,234,198" boundarycaptype="round" boundarycolor="254,234,198" />

</EXACT>

<EXACT value="Non-restocked Cutover" label="Non-restocked Cutover">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="177,186,132" boundarycaptype="round" boundarycolor="177,186,132" />

</EXACT>

<EXACT value="Pine Mix, Large" label="Pine Mix, Large">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="105,139,105" boundarycaptype="round" boundarycolor="105,139,105" />

</EXACT>

<EXACT value="Pine Mix, Small" label="Pine Mix, Small">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="166,182,85" boundarycaptype="round" boundarycolor="166,182,85" />

</EXACT>

<EXACT value="Ponderosa Pine, Large" label="Ponderosa Pine, Large">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="139,139,0" boundarycaptype="round" boundarycolor="139,139,0" />

</EXACT>

<EXACT value="Ponderosa Pine, Seedling-Sapling-Pole" label="Ponderosa Pine, Seedling-
Sapling-Pole">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="189,183,107" boundarycaptype="round" boundarycolor="189,183,107" />

</EXACT>

<EXACT value="Ponderosa Pine, Small" label="Ponderosa Pine, Small">

```

```

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="247,211,179" boundarycaptype="round" boundarycolor="247,211,179" />
  </EXACT>
  <EXACT value="Pure Ponderosa Pine, Large" label="Pure Ponderosa Pine, Large">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="219,103,0" boundarycaptype="round" boundarycolor="219,103,0" />
  </EXACT>
  <EXACT value="Recent Cutover" label="Recent Cutover">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,199,174" boundarycaptype="round" boundarycolor="255,199,174" />
  </EXACT>
  <EXACT value="Spruce-Hemlock, Large" label="Spruce-Hemlock, Large">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,215,0" boundarycaptype="round" boundarycolor="255,215,0" />
  </EXACT>
  <EXACT value="Spruce-Hemlock-Cedar, Small" label="Spruce-Hemlock-Cedar, Small">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="247,181,103" boundarycaptype="round" boundarycolor="247,181,103" />
  </EXACT>
  <EXACT value="Subalpine and Non-commercial" label="Subalpine and Non-commercial">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="115,131,37" boundarycaptype="round" boundarycolor="115,131,37" />
  </EXACT>
  <EXACT value="Water" label="Water">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="0,0,153" boundarycaptype="round" boundarycolor="0,0,153" />
  </EXACT>
</VALUEMAPRENDERER>

```



```

</LAYER>

<LAYER type="featureclass" name="1860 County Population" visible="false" id="8">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="POP_1860">
    <RANGE lower="0.0" upper="1417.6" label="Less than 1417.6">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="1417.6" upper="2835.2" label="1417.6 - 2835.2">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,176,6" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="2835.2" upper="4252.7999" label="2835.2 - 4252.7999">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,151,13" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="4252.7999" upper="5670.4" label="4252.7999 - 5670.4">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,127,20" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="5670.4" upper="7088.01" label="5670.4 - 7088.01">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,102,27" boundarycaptype="round" />
    </RANGE>
  </VALUEMAPRENDERER>
</LAYER>

<LAYER type="featureclass" name="1880 County Population" visible="false" id="11">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />

```

```

<VALUEMAPRENDERER lookupfield="POP_1880">
  <RANGE lower="0" upper="5041" label="Less than 5041">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="5041" upper="10082" label="5041 - 10082">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="252,177,9" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="10082" upper="15122" label="10082 - 15122">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="249,154,19" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="15122" upper="20163" label="15122 - 20163">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="246,130,29" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="20163" upper="25204" label="20163 - 25204">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="243,107,39" boundarycaptype="round" />
  </RANGE>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="1900 County Population" visible="false" id="17">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="POP_1900">
    <RANGE lower="0.0" upper="20633.4" label="Less than 20633.4">

```

```

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="20633.4" upper="41266.8" label="20633.4 - 41266.8">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,181,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="41266.8" upper="61900.2" label="41266.8 - 61900.2">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,162,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="61900.2" upper="82533.6" label="61900.2 - 82533.6">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,143,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="82533.6" upper="103167.01" label="82533.6 - 103167.01">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,124,0" boundarycaptype="round" />
  </RANGE>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="1920 County Population" visible="false" id="18">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="POP_1920">
    <RANGE lower="2357.0" upper="57065.2" label="Less than 57065.2">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
    </RANGE>

```

```

    <RANGE lower="57065.2" upper="111773.4" label="57065.2 - 111773.4">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,171,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="111773.4" upper="166481.5999" label="111773.4 - 166481.5999">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,141,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="166481.5999" upper="221189.8" label="166481.5999 - 221189.8">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,111,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="221189.8" upper="275898.01" label="221189.8 - 275898.01">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,81,0" boundarycaptype="round" />
    </RANGE>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="1940 County Population" visible="false" id="16">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="POP_1940">
    <RANGE lower="4286.0" upper="74448.6" label="Less than 74448.6">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="74448.6" upper="144611.2" label="74448.6 - 144611.2">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,177,0" boundarycaptype="round" />

```

```

</RANGE>

<RANGE lower="144611.2" upper="214773.8" label="144611.2 - 214773.8">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,153,0" boundarycaptype="round" />

</RANGE>

<RANGE lower="214773.8" upper="284936.4" label="214773.8 - 284936.4">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,129,0" boundarycaptype="round" />

</RANGE>

<RANGE lower="284936.4" upper="355099.01" label="284936.4 - 355099.01">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,105,0" boundarycaptype="round" />

</RANGE>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="1960 County Population" visible="false" id="15">

  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />

  <VALUEMAPRENDERER lookupfield="POP_1960">

    <RANGE lower="3426.0" upper="107303.4" label="Less than 107303.4">

      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />

    </RANGE>

    <RANGE lower="107303.4" upper="211180.8" label="107303.4 - 211180.8">

      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,171,0" boundarycaptype="round" />

    </RANGE>

    <RANGE lower="211180.8" upper="315058.1999" label="211180.8 - 315058.1999">

```

```

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,141,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="315058.1999" upper="418935.6" label="315058.1999 - 418935.6">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,111,0" boundarycaptype="round" />
  </RANGE>
  <RANGE lower="418935.6" upper="522813.01" label="418935.6 - 522813.01">
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,81,0" boundarycaptype="round" />
  </RANGE>
</VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="1980 County Population" visible="false" id="14">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="POP_1980">
    <RANGE lower="3832.0" upper="115593.6" label="Less than 115593.6">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="115593.6" upper="227355.2" label="115593.6 - 227355.2">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,171,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="227355.2" upper="339116.8" label="227355.2 - 339116.8">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,141,0" boundarycaptype="round" />
    </RANGE>
  </VALUEMAPRENDERER>
</LAYER>

```

```

    <RANGE lower="339116.8" upper="450878.4" label="339116.8 - 450878.4">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,111,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="450878.4" upper="562640.01" label="450878.4 - 562640.01">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,81,0" boundarycaptype="round" />
    </RANGE>
  </VALUEMAPRENDERER>
</LAYER>
<LAYER type="featureclass" name="2000 County Population" visible="false" id="13">
  <DATASET name="county_pop_1860_2000" type="polygon" workspace="shp_ws-37" />
  <VALUEMAPRENDERER lookupfield="POP_2000">
    <RANGE lower="3824.0" upper="143223.2" label="Less than 143223.2">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,200,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="143223.2" upper="282622.4" label="143223.2 - 282622.4">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,171,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="282622.4" upper="422021.6" label="282622.4 - 422021.6">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,141,0" boundarycaptype="round" />
    </RANGE>
    <RANGE lower="422021.6" upper="561420.8" label="422021.6 - 561420.8">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,111,0" boundarycaptype="round" />
    </RANGE>
  </VALUEMAPRENDERER>
</LAYER>

```

```

</RANGE>

<RANGE lower="561420.8" upper="700820.01" label="561420.8 - 700820.01">

  <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="255,81,0" boundarycaptype="round" />

  </RANGE>

</VALUEMAPRENDERER>

</LAYER>

<LAYER type="featureclass" name="USFWS Refuge Boundaries" visible="true" id="2">

  <DATASET name="usfws_nwr_bndy" type="polygon" workspace="shp_ws-37" />

  <SIMPLERENDERER>

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="51,102,51" boundarywidth="2" boundarycaptype="round" boundarycolor="102,0,0" />

  </SIMPLERENDERER>

</LAYER>

<LAYER type="featureclass" name="Whitetail Deer Habitat - GAP Analysis" visible="false" id="3">

  <DATASET name="gap_whitetail_deer" type="polygon" workspace="shp_ws-37" />

  <SIMPLERENDERER>

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="102,102,0" boundarycaptype="round" />

  </SIMPLERENDERER>

</LAYER>

<LAYER type="featureclass" name="Sandhill Crane Habitat - GAP Analysis" visible="false" id="4">

  <DATASET name="gap_sandhill_crane" type="polygon" workspace="shp_ws-37" />

  <SIMPLERENDERER>

    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="102,102,102" boundarycaptype="round" boundarycolor="255,0,0" />

  </SIMPLERENDERER>

</LAYER>

```



```

<LAYER type="featureclass" name="River Otter Habitat - GAP Analysis" visible="false" id="5">
  <DATASET name="gap_riverotter" type="polygon" workspace="shp_ws-37" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="0,102,0" boundarycaptype="round" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Elk Habitat - GAP Analysis" visible="false" id="6">
  <DATASET name="gap_elk" type="polygon" workspace="shp_ws-37" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="51,51,0" boundarycaptype="round" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Bald Eagle Habitat - GAP Analysis" visible="false" id="7">
  <DATASET name="gap_baldeagle" type="polygon" workspace="shp_ws-37" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="204,204,0" boundarycaptype="round" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Lewis and Clark Campsites" visible="true" id="0">
  <DATASET name="lc_campsites" type="point" workspace="shp_ws-37" />
  <SIMPLERENDERER>
    <SIMPLEMARKERSYMBOL color="102,51,0" type="triangle" width="10" />
  </SIMPLERENDERER>
</LAYER>

```

```

<LAYER type="featureclass" name="Lewis & Clark Wildlife Observations" visible="true"
id="1">
  <DATASET name="lc_wildlife_observations" type="point" workspace="shp_ws-37" />
  <SIMPLERENDERER>
    <SIMPLEMARKERSYMBOL color="204,0,51" width="10" />
  </SIMPLERENDERER>
</LAYER>
</MAP>
</CONFIG>
</ARCXML>
<?xml version="1.0" encoding="UTF-8"?>
_____BREAK
<ARCXML version="1.1">
<CONFIG>
  <ENVIRONMENT>
    <LOCALE country="US" language="en" variant="" />
    <UIFONT color="0,0,0" name="SansSerif" size="12" style="regular" />
    <SCREEN dpi="72" />
  </ENVIRONMENT>
  <MAP>
    <PROPERTIES>
      <ENVELOPE minx="-0.00000000000005684342" miny="-370.90939597315435" maxx="612.0"
maxy="0.5" name="Initial_Extent" />
      <MAPUNITS units="meters" />
    </PROPERTIES>
    <WORKSPACES>
      <IMAGEWORKSPACE directory="//gcsdataserver1\data\usfws\Historical_Map_Images"
name="jai_ws-0" />

```

```

</WORKSPACES>

<LAYER type="image" name="1855_Oregon_Subsection.tif" visible="false" id="0">
    <DATASET name="1855_Oregon_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="Arrowsmith_1802_Subsection.tif" visible="false" id="1">
    <DATASET name="Arrowsmith_1802_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="western1854_Subsection.tif" visible="false" id="2">
    <DATASET name="western1854_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="wa1896_Subsection.tif" visible="false" id="3">
    <DATASET name="wa1896_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="puget1853_Subsection.tif" visible="false" id="4">
    <DATASET name="puget1853_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="nw1871_Subsection.tif" visible="false" id="5">
    <DATASET name="nw1871_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="bodega1792_Subsection.tif" visible="false" id="6">
    <DATASET name="bodega1792_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="Union_Pacific_Mid_19th_Subsection.tif" visible="false" id="7">
    <DATASET name="Union_Pacific_Mid_19th_Subsection.tif" type="image" workspace="jai_ws-
0" />
</LAYER>

<LAYER type="image" name="TransMs1854_Subsection.tif" visible="false" id="8">
    <DATASET name="TransMs1854_Subsection.tif" type="image" workspace="jai_ws-0" />

```

```

</LAYER>
<LAYER type="image" name="TransMS1902_Subsection.tif" visible="false" id="9">
  <DATASET name="TransMS1902_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="RussPO1802_Subsection.tif" visible="false" id="10">
  <DATASET name="RussPO1802_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="RussPO1775_Subsection.tif" visible="false" id="11">
  <DATASET name="RussPO1775_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="PO1766-1779_Subsection.tif" visible="false" id="12">
  <DATASET name="PO1766-1779_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="OR1880_Subsection.tif" visible="false" id="13">
  <DATASET name="OR1880_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="NorthPO1732_Subsection.tif" visible="false" id="14">
  <DATASET name="NorthPO1732_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="NWCo1871_Subsection.tif" visible="false" id="15">
  <DATASET name="NWCo1871_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="NPRR_1882_Subsection.tif" visible="false" id="16">
  <DATASET name="NPRR_1882_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>
<LAYER type="image" name="NAmKing1803_Subsection.tif" visible="false" id="17">
  <DATASET name="NAmKing1803_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

```

```

<LAYER type="image" name="NAml811_Subsection.tif" visible="false" id="18">
  <DATASET name="NAml811_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="NAml805_Subsection.tif" visible="false" id="19">
  <DATASET name="NAml805_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="NAml802_Subsection.tif" visible="false" id="20">
  <DATASET name="NAml802_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="NAml775_Subsection.tif" visible="false" id="21">
  <DATASET name="NAml775_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="NAml772_Subsection.tif" visible="false" id="22">
  <DATASET name="NAml772_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="NAml694_Subsection.tif" visible="false" id="23">
  <DATASET name="NAml694_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="NAml685_Subsection.tif" visible="false" id="24">
  <DATASET name="NAml685_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="Lewis1814_Subsection.tif" visible="false" id="25">
  <DATASET name="Lewis1814_Subsection.tif" type="image" workspace="jai_ws-0" />
</LAYER>

<LAYER type="image" name="Fremont_expedition_1842_Subsection.tif" visible="false" id="26">
  <DATASET name="Fremont_expedition_1842_Subsection.tif" type="image"
workspace="jai_ws-0" />
</LAYER>

```

</MAP>

</CONFIG>

</ARCXML>

APPENDIX C: GOS ARXML FILE

```
>>>>>>
<?xml version="1.0" encoding="UTF-8"?>
<ARXML version="1.1">
  <CONFIG>
    <ENVIRONMENT>
      <LOCALE country="US" language="en" variant="" />
      <UIFONT color="0,0,0" name="dialog" size="12" style="regular" />
      <SCREEN dpi="96" />
    </ENVIRONMENT>
    <MAP>
      <PROPERTIES>
        <ENVELOPE minx="-2536022.992555831" miny="92696.0" maxx="2852378.992555831"
maxy="3736196.0" name="Initial_Extent" />
        <MAPUNITS units="meters" />
      </PROPERTIES>
      <WORKSPACES>
        <IMAGEWORKSPACE directory="F:\LewisClark\Albers" name="jai_ws-100" />
        <SHAPEWORKSPACE name="shp_ws-102" directory="F:\LewisClark\Albers" />
      </WORKSPACES>
      <LAYER type="image" name="modis32day_composite_hillshade.img" visible="false" id="1">
        <DATASET name="modis32day_composite_hillshade.img" type="image" workspace="jai_ws-
100" />
      </LAYER>
      <LAYER type="image" name="modis_621_rgb.img" visible="true" id="0" minscale="1:1000000">
        <DATASET name="modis_621_rgb.img" type="image" workspace="jai_ws-100" />
      </LAYER>
```

```

<LAYER type="featureclass" name="States" visible="true" id="2">
  <DATASET name="states" type="polygon" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.0"
boundarycaptype="round" boundarycolor="255,255,0" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Louisiana Purchase Boundary" visible="true" id="3">
  <DATASET name="louisiana_purchase" type="polygon" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
filltype="bdiagonal" fillcolor="255,200,0" boundarycaptype="round" boundarycolor="255,0,0" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Water Bodies" visible="false" id="4">
  <DATASET name="hydroply" type="polygon" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="0,0,255" boundarycaptype="round" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Canada" visible="true" id="5">
  <DATASET name="canada" type="polygon" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.0"
boundarytype="dash" boundarycaptype="round" boundarycolor="51,102,51" />
  </SIMPLERENDERER>
</LAYER>

```



```

<LAYER type="featureclass" name="Mexico" visible="true" id="6">
  <DATASET name="MEXICO" type="polygon" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="0.0"
boundarytype="dash" boundarycaptype="round" boundarycolor="255,200,0" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Transportation" visible="false" id="7" maxscale="1:2000000">
  <DATASET name="roads" type="line" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLELINESYMBOL width="1" captype="round" color="102,51,0" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Primary Hydrology" visible="true" id="8"
minscale="1:3000000">
  <DATASET name="rivers" type="line" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLELINESYMBOL width="1" captype="round" color="0,0,255" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="Secondary Hydrology" visible="false" id="9"
maxscale="1:3400000">
  <DATASET name="hydroln" type="line" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLELINESYMBOL width="1" captype="round" color="0,0,255" />
  </SIMPLERENDERER>
</LAYER>

<LAYER type="featureclass" name="lc_tr_mid_arc" visible="true" id="11">

```

```

<DATASET name="lc_tr_mid_arc" type="line" workspace="shp_ws-102" />
<SIMPLERENDERER>
  <SIMPLELINESYMBOL width="2" captype="round" color="51,102,51" />
</SIMPLERENDERER>
</LAYER>
<LAYER type="featureclass" name="lc_tr_w_arc" visible="true" id="12">
  <DATASET name="lc_tr_w_arc" type="line" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLELINESYMBOL width="2" captype="round" color="27,227,27" />
  </SIMPLERENDERER>
</LAYER>
<LAYER type="featureclass" name="lc_fe_arc" visible="true" id="13">
  <DATASET name="lc_fe_arc" type="line" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLELINESYMBOL width="2" captype="round" color="255,200,0" />
  </SIMPLERENDERER>
</LAYER>
<LAYER type="featureclass" name="Lewis and Clark Campsites" visible="false" id="10">
  <DATASET name="lc_campsite" type="point" workspace="shp_ws-102" />
  <SIMPLERENDERER>
    <SIMPLEMARKERSYMBOL color="255,0,0" type="triangle" width="6" />
  </SIMPLERENDERER>
</LAYER>
</MAP>
</CONFIG>
</ARXML>

```

APPENDIX D:

GOS XML METADATA FOR CHANNEL PUBLICATION

>>>>>>

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 strict//EN">
```

```
<html><head>
```

```
<title>Lewis and Clark Geosystem</title>
```

```
<meta http-equiv="Content-Type" content="text/html;charset=UTF-8">
```

```
<link rel="stylesheet" href="/style/gos.css" type="text/css">
```

```
<script language="JavaScript">
```

```
<!--
```

```
function SymError()
```

```
{
```

```
    return true;
```

```
}
```

```
window.onerror = SymError;
```

```
var SymRealWinOpen = window.open;
```

```
function SymWinOpen(url, name, attributes)
```

```
{
```

```
    return (new Object());
```

```
}
```

```
window.open = SymWinOpen;
```

```
//-->
```

```
</script>
```

```
<script language="JavaScript" src="/js/cmn.js"></script>
```

```
<script language="JavaScript" type="text/JavaScript">
```

```
function vwMap(sServer,sService,isWMS) {
```

```
    if (window.opener && !window.opener.closed && window.opener.cmnViewMap)
```

```
        window.opener.cmnViewMap(sServer,sService,isWMS);
```

```
    else cmnViewMap(sServer,sService,isWMS);
```

```
}
```

```

</script>

</head>
<body>

<div class="searchHeader" title="geodata.gov: Your one stop for federal, state & local data">
  <h3>Details</h3>
</div>

<div style="width: 750px; background-color: #FFFFFF;">
<h2 class="fullBar" style="margin-top: 0px;">Lewis and Clark Geosystem</h2>
<div class="searchResultsContent">
<p><h3 style="margin-left: 10px; color: #C51015; display: inline;">Content Citation</h3></p>
<div class="dataCategoryContent">
<p><h3>Content Title: </h3><a href="http://www.gcs-research.net/gos/mapindex.htm"
target="_blank">Lewis and Clark Geosystem</a></p>
<p><h3>Content Type: </h3>Live data & maps (Map Service)</p>
<p><h3>Publisher: </h3>GCS Research LLC</p>
<p><h3>Publication Date: </h3>20040222</p>
</div>
<br>
<p><h3 style="margin-left: 10px; color: #C51015; display: inline;">Content Description</h3></p>
<div class="dataCategoryContent">
<p><h3>Content Summary: </h3>The Lewis and Clark Geosystem is a collection of private, state, local
and federal data resources associated with the geography of the Lewis and Clark expedition (1803-1806).
Data has been compiled from key partners including NASA - John C. Stennis Space Center, Army Corps of
Engineers, the US Fish and Wildlife Service, the USGS, Montana Tech of The University of Montana, the
US Forest Service, and a collection of Lewis and Clark scholars. The Geosystem is intended for
educational and research purposes and its primary goal is to provide a Web-based geospatial system
wherein concepts of historical landscape change can be explored interactively through the Web.</p>
<p><h3>Content Purpose: </h3>The purpose of the Lewis and Clark Geosystem is to provide multiscale
and multitemporal examination of the geography of the Lewis and Clark Trail. Covering two hundred
years of change, 1803-1806, the purpose is to present a variety of spatial data, historical, ecological,
climatological, etc., in a way that allows for examination of historical landscape change as a result of
anthropogenic and non-anthropogenic effects. A second purpose is to explore the deployment and

```

networking of a variety of geospatial Web services that each provide unique geospatial data types of interest to the study of the geography of the Lewis and Clark Trail.</p>

<p><h3>Supplemental Information: </h3>The Lewis and Clark Geosystem, version 1.0, involves a variety of geospatial data from a variety of private, local, state, and federal partners, and has evolved over the past six years of collective effort. <http://www.gcs-research.net/gos/mapindex.htm>Data Themes include:Lewis and Clark Trail Line: East, Central, and Western Portions;Lewis and Clark Campsite Database: Courtesy of Dr. Robert Bergantino, Montana Tech of The University of Montana;NASA MODIS - SRTM Composite Digital Hillshade Relief;MODIS Image (Bands 6,2,1) RGB - 16 day composite;ESRI State Boundaries; Louisiana Territory Polygon, Courtesy of George Dailey, ESRI:Mexico and Canada National Boundaries, ESRI:Major Hydrological Units or Water Bodies, ESRI:1894 Missouri River Commission Maps, Courtesy of Army Corps of Engineers:Transportation: ESRI:Primary Hydrology, ESRI:Secondary Hydrology, ESRI:DigitalGlobe Quickbird Imagery (2003), NASA Scientific Data Purchase Program;</p></div>

<p><h3 style="margin-left:10px; color:#C51015; display:inline;">Time Period of Content</h3></p>

<div class="dataCategoryContent">

<p><h3>Beginning Date: </h3>1893</p>

<p><h3>Ending Date: </h3>2004</p>

</div>

<p><h3 style="margin-left:10px; color:#C51015; display:inline;">Content Status</h3></p>

<div class="dataCategoryContent">

<p><h3>Progress: </h3>Under Development</p>

<p><h3>Update Frequency: </h3>monthly</p>

</div>

<div class="channellImage"></div>

<p><h3 style="margin-left:10px; color:#C51015; display:inline;">Spatial Domain</h3></p>

<div class="dataCategoryContent">

<p><h3>West Coordinate: </h3>-125</p>

<p><h3>East Coordinate: </h3>-60</p>

<p><h3>North Coordinate: </h3>50</p>

<p><h3>South Coordinate: </h3>23</p>

</div>

<p><h3 style="margin-left:10px; color:#C51015; display:inline;">Content Keywords</h3></p>

<div class="dataCategoryContent">

<p><h3>Theme Keywords:

</h3>environment,Lewis,Clark,change,trail,history,imagery,Landsat,MODIS,Missouri River,Columbia River</p>

</div>

<p><h3 style="margin-left:10px; color:#C51015; display:inline;">Spatial Data Information</h3></p>

<div class="dataCategoryContent">

<p><h3>Data Type: </h3>vector, raster</p>

<p><h3>Data Format: </h3>image</p>

<p><h3>Data Projection: </h3>Albers Equal Area Conic</p>

<p><h3>Data Scale: </h3>1:1000000</p>

</div>

<p><h3 style="margin-left:10px; color:#C51015; display:inline;">Access and Usage Information</h3></p>

<div class="dataCategoryContent">

<p><h3>Access Constraints: </h3>For educational and research purposes only. Accessible as GCS Research Map Service</p>

<p><h3>Usage Constraints: </h3>For educational purposes only; not to be soled or redistributed in any way without writtten permission by GCS Research and/or its partners.</p>

<p><h3>Map Server: </h3>http://www.gcs-research.net/</p>

<p><h3>Map Service: </h3>gos</p>

<p>You may use the map server and map service information above to access the map service with your GIS tool or GIS application.</p>

</div>

<hr>

<div class="searchResultsButtons">

</div>

```
</div></div>
<form name="fSubmit" method="POST" action="/gos">
<input type="hidden" name="command" value="">
<input type="hidden" name="uuid" value="{72921745-6669-11D8-978B-080020ECC634}">
</form>
</body>
</html>
```

```
<script language="JavaScript">
<!--
var SymRealOnLoad;
var SymRealOnUnload;

function SymOnUnload()
{
    window.open = SymWinOpen;
    if(SymRealOnUnload != null)
        SymRealOnUnload();
}

function SymOnLoad()
{
    if(SymRealOnLoad != null)
        SymRealOnLoad();
    window.open = SymRealWinOpen;
    SymRealOnUnload = window.onunload;
    window.onunload = SymOnUnload;
}

SymRealOnLoad = window.onload;
window.onload = SymOnLoad;

//-->
</script>
```

Break

Lewis and Clark Geosystem

Identification Information:

Citation:

Citation Information:

Title: Lewis and Clark Geosystem

Online Linkage: <http://www.gcs-research.net/gos/mapindex.htm>

Originator: GCS Research LLC

Publication Date: 20040222

Publication Information:

Publication Place: Missoula, MT, USA

Publisher: GCS Research LLC

Geospatial Data Presentation Form: digital map

Edition: 1

Description:

Abstract: The Lewis and Clark Geosystem is a collection of private, state, local and federal data resources associated with the geography of the Lewis and Clark expedition (1803-1806). Data has been compiled from key partners including NASA - John C. Stennis Space Center, Army Corps of Engineers, the US Fish and Wildlife Service, the USGS, Montana Tech of The University of Montana, the US Forest Service, and a collection of Lewis and Clark scholars. The Geosystem is intended for educational and research purposes and its primary goal is to provide a Web-based geospatial system wherein concepts of historical landscape change can be explored interactively through the Web.

Purpose: The purpose of the Lewis and Clark Geosystem is to provide multiscale and multitemporal examination of the geography of the Lewis and Clark trail. Covering two hundred years of change, 1803-1806, the purpose is to present a variety of spatial data, historical, ecological, climatological, etc., in a way that allows for examination of historical landscape change as a result of anthropogenic and non-anthropogenic effects. A second purpose is to explore the deployment and networking of a variety of geospatial Web services that each provides unique geospatial data types of interest to the study of the geography of the Lewis and Clark Trail.

Supplemental Information: The Lewis and Clark Geosystem, version 1.0, involves a variety of geospatial data from a variety of private, local, state, and federal partners, and has evolved over the past six years of collective effort. <http://www.gcs-research.net/gos/mapindex.htm>Data Themes include:Lewis and Clark Trail Line: East, Central, and Western Portions;Lewis and Clark Campsite Database: Courtesy of Dr. Robert Bergantino, Montana Tech of The University of Montana;NASA MODIS - SRTM Composite Digital Hillshade Relief;MODIS Image (Bands 6,2,1) RGB - 16 day composite;ESRI State Boundaries; Louisiana Territory Polygon, Courtesy of George Dailey, ESRI;Mexico and Canada National Boundaries, ESRI;Major Hydrological Units or Water Bodies, ESRI;1894 Missouri River Commission Maps, Courtesy of Army Corps of Engineers;Transportation: ESRI;Primary Hydrology, ESRI;Secondary Hydrology, ESRI;DigitalGlobe Quickbird Imagery (2003), NASA Scientific Data Purchase Program;

Keywords:

Theme:

Theme Keyword: environment

Theme:

Theme Keyword: Lewis

Theme Keyword: Clark

Theme Keyword: change

Theme Keyword: trail

Theme Keyword: history

Theme Keyword: change

Theme Keyword: imagery

Theme Keyword: Landsat

Theme Keyword: MODIS

Theme Keyword: Missouri River

Theme Keyword: Columbia River

Point of Contact:

Contact Information:

Contact Person Primary:

Contact Person: Alex Philp

Contact Organization: GCS Research LLC

Contact Address:

(addrType):mailing

Address: 1121 East Broadway, Suite 113 Montana Technology Enterprise Center

City: Missoula

State or Province: MT

Postal Code: 59802

Country: US

Contact Electronic Mail Address: aphilp@gcs-research.com

Contact Voice Telephone: 406-532-3254

Contact Facsimile Telephone: 406-532-3255

Spatial Domain:

Bounding Coordinates:

West Bounding Coordinate: -125

East Bounding Coordinate: -60

North Bounding Coordinate: 50

South Bounding Coordinate: 23

Status:

Progress: Under Development

Maintenance and Update Frequency: monthly

Time Period of Content:

Currentness Reference: 2004

Time Period Information:

Range of Dates/Times:

Beginning Date: 1893

Ending Date: 2004

Access Constraints: For educational and research purposes only. Accessible as GCS Research Map Service

Use Constraints: For educational purposes only; not to be soled or redistributed in any way without written permission by GCS Research and/or its partners.

Data Quality Information:

Lineage:

Source Information:

Source Scale Denominator: 1000000

Spatial Data Organization Information:

Direct Spatial Reference Method: vector, raster

Spatial Reference Information:

Horizontal Coordinate System Definition:

Planar:

Map Projection:

Map Projection Name: Albers Equal Area Conic

Distribution Information:

Standard Order Process:

Digital Form:

Digital Transfer Information:

Format Name: image

Distributor:

Contact Information:

Contact Person Primary:

Contact Person: Alex Philp

Contact Organization: GCS Research LLC

Contact Address:

(addrType):physical, mailing

Address: 1121 East Broadway, Suite 113 Montana Technology Enterprise Center

City: Missoula

State or Province: MT

Postal Code: 59802

Country: US

Contact Electronic Mail Address: aphilp@gcs-research.com

Contact Voice Telephone: 406-532-3254

Contact Facsimile Telephone: 406-532-3255

Metadata Reference Information:

Metadata Date: 20040303

Metadata Reference Information:

*(metastdn):*FGDC

ESRI Metadata

Esri:

Server: <http://www.gcs-research.net/>

Service: gos

Service Type: image

Published Document ID: {72921745-6669-11D8-978B-080020ECC634}

Input Source: GeoData Online Form

Content Developer Type: Commercial

*(resourceType):*Live Data and Maps

GOS Metadata

GOS:

Rating: Primary

APPENDIX E:
GEOSYSTEM KML (KEYHOLE MARKUP LANGUAGE)
FOR LOWER COLUMBIA RIVER GEOSYSTEM WEB SERVICE

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