A. System

1. Name of system and ESIG™ category

Name: CropScape

ESIG™ category: Single Process Systems

2. Authorization Letter

USDA

United States Department of Agriculture
National Agricultural Statistics Service
Research and Development Division

April 8, 2014

To Whom It May Concern:

I am writing this letter to authorize Dr. Zhengwei Yang, an IT Specialist with USDA National Agricultural Statistics Service (NASS), Research and Development Division to nominate our agency's web-based geospatial application CropScape as a candidate for the prestigious 2014 Urban and Regional Information Systems Association (URISA) Exemplary Systems in Government (ESIG) Award in the category of Single Process Systems. Dr. Yang will prepare, collect, and submit all required documents.

NASS has been producing a yearly Cropland Data Layer (CDL) product based on mid-resolution satellite data and high quality ground truth since 1997. This agricultural geospatial data has been providing crop and other non-crop land cover classification information encompassing the entire contiguous U.S. (CONUS) annually since 2008. It has been extensively used by policy and decision makers, scientists, researchers, educators, and farm producers for land cover monitoring, agricultural sustainability, biodiversity, crop acreage estimation, and extreme events such as flooding, drought and hail storm assessment. To further facilitate CDL data access and applications, NASS in cooperation with the Center for Spatial Information Science and Systems at George Mason University developed the geospatial web application aptly named CropScape, which offered many tools and web services for interactive visualization, data dissemination, geospatial queries, statistical analysis, change analysis, automated map creation without the need for specialized expertise, GIS software or high-end computers. CropScape is a well received by the agricultural community.

We look forward to a favorable decision on this nomination.

Sincerely,
p.p.
James M. Harris
NASS
Director, Methodology Division
for
Linda Young
Chief Mathematical Statistician & Director
Research and Development Division
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3. Summary

The Cropland Data Layer (CDL) is a land cover product depicting detailed field-level information on crop and non-crop categories and locations covering the contiguous United States (CONUS). This valuable geospatial data offers independent statistical estimates of crop acreage throughout the growing season, thereby improving agricultural statistics by reducing estimate error and serves as an important input in the official statistical reporting process. The CDL was previously disseminated to end users via paper thematic maps, CD/DVD media, or HTTP/FTP links from the National Agricultural Statistics Service (NASS) website or USDA Geospatial Data Gateway. To exploit the CDL data for an area of interest such as a county, geospatial data processing had to be performed on the original files using traditional desktop GIS software. The entire process required GIS software and expertise, was time consuming, and served as an access barrier to the farming community. Those traditional distribution channels greatly limited the effectiveness and efficiency for CDL data publishing, open access, visualization, dissemination, and usage and could not meet the growing needs from the community.

In cooperation with Center for Spatial Information Science and Systems (CSISS) of George Mason University, NASS developed CropScape (http://nassgeodata.gmu.edu/CropScape) to provide users with useful functions for online visualization, geospatial navigation and querying, reformatting and transformation, delineation of area of interest, on-the-fly data analysis, on-demand data processing and dissemination, thematic map creation, etc, in an online environment. CropScape revolutionizes the traditional CDL data distribution channels. It helps users avoid the burden of installing geospatial visualization and analytical software or tools, and opens access to visualize, retrieve, and analyze the CDL data at any geographic level through an intuitive user interface. CropScape also offers interoperable and standard-compliant Web services that can be integrated in scientific workflows to accomplish specific tasks or be consumed over the Web to create value-added new geospatial applications. CropScape not only greatly saves the expense of printing and shipping media and facilitates low carbon geospatial cropland content delivery but also significantly improves the efficiency and effectiveness for agricultural stakeholder related decision support.

Since it was released, CropScape has been extensively used by policy and decision makers, scientists, educators, researchers, and farm producers on issues like food security, land-cover change, pesticide control, agricultural sustainability, bio-energy crop inventory, hazards assessment, climate variability and so on. According to Google Analytics statistics, over **110,000** users from more than **120** countries have visited this Web application. CropScape was listed as one of the "highlights of Agency Open Government IT Accomplishments that improve citizen engagement" in the Office of Management and Budget's FY 2011 Report to Congress on the Implementation of The E-Government Act of 2002. CropScape has been utilized as one of the federal geospatial data sources in GIS courses by educators at institutions such as University of Alabama in Huntsville, Eastern Illinois University, University of Hawaii, and George Mason University. Moreover, CropScape has been recommended as a geospatial data resource by the libraries of many universities.

4. Three Testimonials

Please check the attachment.

B. Jurisdiction

1. Name of jurisdiction

United States Department of Agriculture
National Agricultural Statistics Service

2. Population served by the agency

US farmers and users from agricultural industry, federal government agencies, state and local governments, international and domestic research and educational institutes, and nonprofit organizations.

3. Annual total budget for jurisdiction

Total NASS budget for 2014 is $159.6 million

4. Name, title and address of chief appointed official

Linda Young, PhD

Chief Mathematical Statistician and Director
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1400 Independence Ave., SW, Room 6054
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5. Name, title, address, telephone, FAX, and email for contact person for system

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C. System Design

1. What motivated the system development?

The Cropland Data Layer (CDL) was previously disseminated via paper thematic maps, CD/DVD media, or HTTP/FTP links of compressed files at the state level. Those traditional distribution channels could not meet the growing hands-on needs from the agricultural community, including on-demand CDL data access and queries, visualization, retrieval, analysis through common Web browsers, and standard Web geospatial services. The latest Web technologies and open geospatial data and processing standards enabled us to address these challenges by implementing a new geospatial application system.

2. What specific service or services was the system intended to improve?

CropScape was developed to improve geospatial CDL data dissemination, online access, geospatial navigation, visualization, statistical analysis, and cropland cover change analysis; and to further facilitate CDL data applications by empowering users in research, education, and agricultural decision making support. In addition, the new system was also designed to reduce NASS' operational costs by eliminating manual printing and media copying and shipping, and automating CDL map creation.

3. What, if any, unexpected benefits did you achieve?

Since CropScape was released, it was used extensively by users from government agencies, non-profit organizations, educational institutions, and industry in their applications and research. To our surprise, it was also broadly used by the general public as a citizen science tool to explore cropland interactively. For example, farmers used CDL thematic maps to document their land use. The Save Our Crops Coalition (SOCC) submitted an electronic comment to the U.S. Environmental Protections Agency (EPA) to prevent injury to non-target crops from exposure to 2,4-D and dicamba. In SOCC's submission, a CDL thematic map of a portion of Monroe County, Michigan, produced with CropScape, was used as a supporting example of a typical crop pattern (in this case, a tomato field surrounded by corn and soybean fields) in the Midwest to discuss the potential non-target plant damage caused by drift of dicamba.

4. What system design problems were encountered?

The major design problems included what kind of architecture should be adopted to preserve system scalability and interoperability while maintaining good system performance, and what kind of Web services have to be developed and implemented.

5. What differentiates this system from other similar systems?

Although many geospatial data portals have been built, the biggest difference between CropScape and others is that it is designed from the geospatial data and GIS analyst's perspective. The unique functions of CropScape include efficient GUI design and layout, and tools such as interactive image swiping to view land cover changes, multiple intuitive areas of interest queries, on-the-fly CDL data analysis down to the field level, on-demand CDL image printing, and supporting charts and tables. CropScape not only serves as a distribution portal of the CDL data, but also offers various online tools and web services for geospatial cropland information retrieving, processing, and consumption.

D. Implementation

1. What phases did you go through in developing the system?

In developing CropScape system, each phase of CropScape development, including:

- User requirement collection and analysis
- Defining system specifications
- System design
- Software development and integration
- Concurrent stress testing
- System deployment and maintenance
- Feedback and further enhancement
- Technical support

2. Were there any modifications to the original system design? Why? What?

Yes. In the original design, GeoServer was utilized to serve geospatial data layers as standard Web Map Service (WMS), Web Feature Service (WFS), and Web Coverage Service (WCS) services. It was found in the stress testing that the performance of GeoServer was not satisfactory and memory leaks occurred when handling large raster files, such as the CDL data. Therefore, MapServer was adopted for its performance and robustness. Moreover, the data server configuration was also adjusted from a single server to multiple servers for better performance.

E. Organizational Impact

1. What user community does the system serve and how?

CropScape mainly serves the American agricultural community and the GIS community as a Web portal and a service provider of open access, visualization, query, retrieval, and analysis of the CDL data and other geospatial data layers. CropScape also serves the user communities world-wide user, including the international community (about 120 countries), federal, state and local governments, research institutions, universities, financial companies, etc., through its common Web browser client and web services. We receive frequent queries as to what other countries have developed a cropland monitoring system such as this, and our response is this is one of a kind.

2. What are the ultimate decisions/operations/services being affected? If appropriate, provide a few examples including, but not limited to: screen input/output forms, paper products, or other descriptive graphics.

CropScape revolutionizes the traditional CDL data distribution channels, and greatly improves CDL data publishing, accessing, dissemination and applications. It provides operations of cropland information query, customization and retrieval, statistics and reporting, change analysis, and thematic map creation. Those operations can be easily integrated with other web-based geospatial applications, and be composed with other Web services to accomplish customer-specified tasks. CropScape has been utilized in the agricultural related research fields, such as pesticide control, land cover monitoring, biomass monitoring, crop rotation, bioenergy crop inventory, and carbon accounting. A few examples are given below:

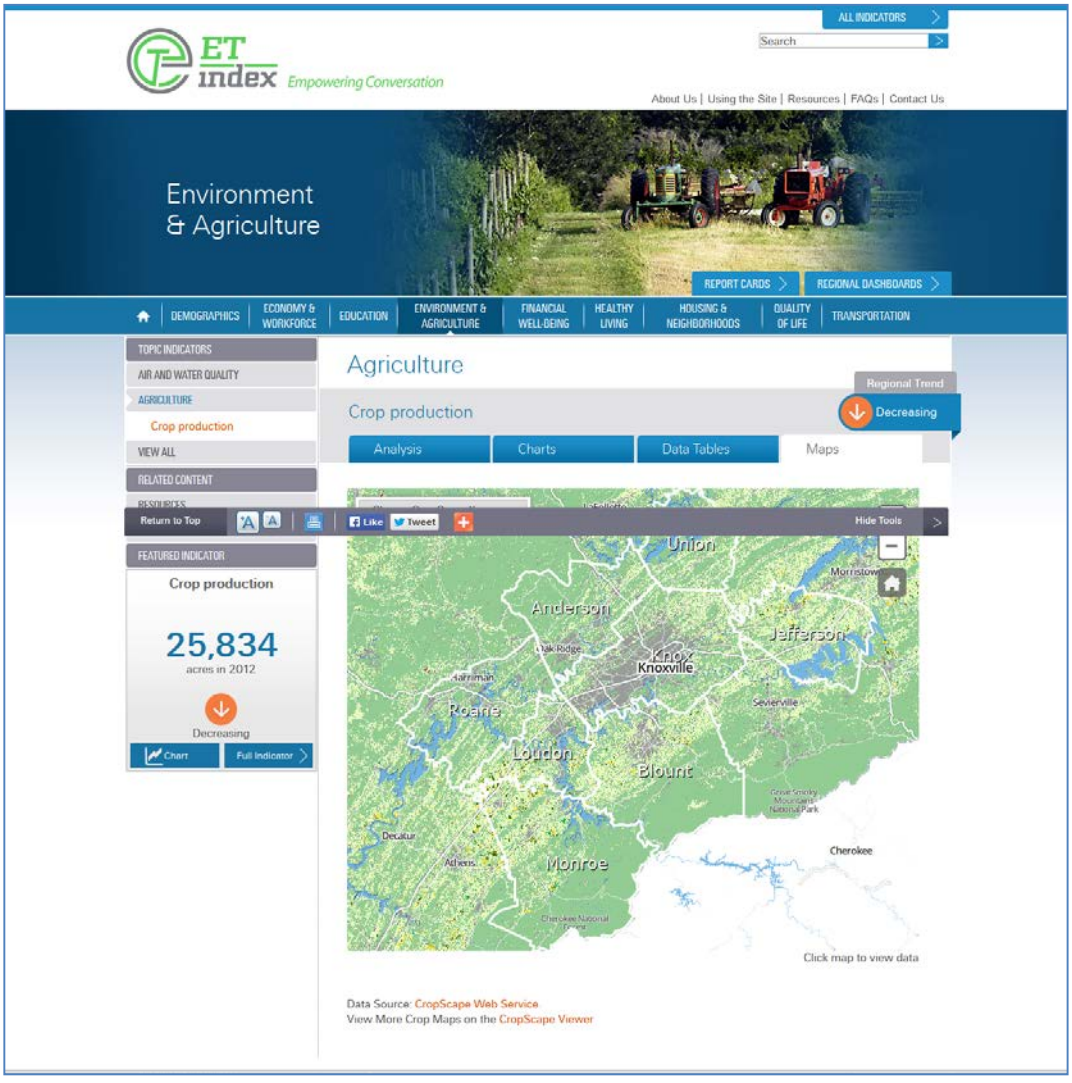


Figure 1 CropScape's application in the Plan East Tennessee

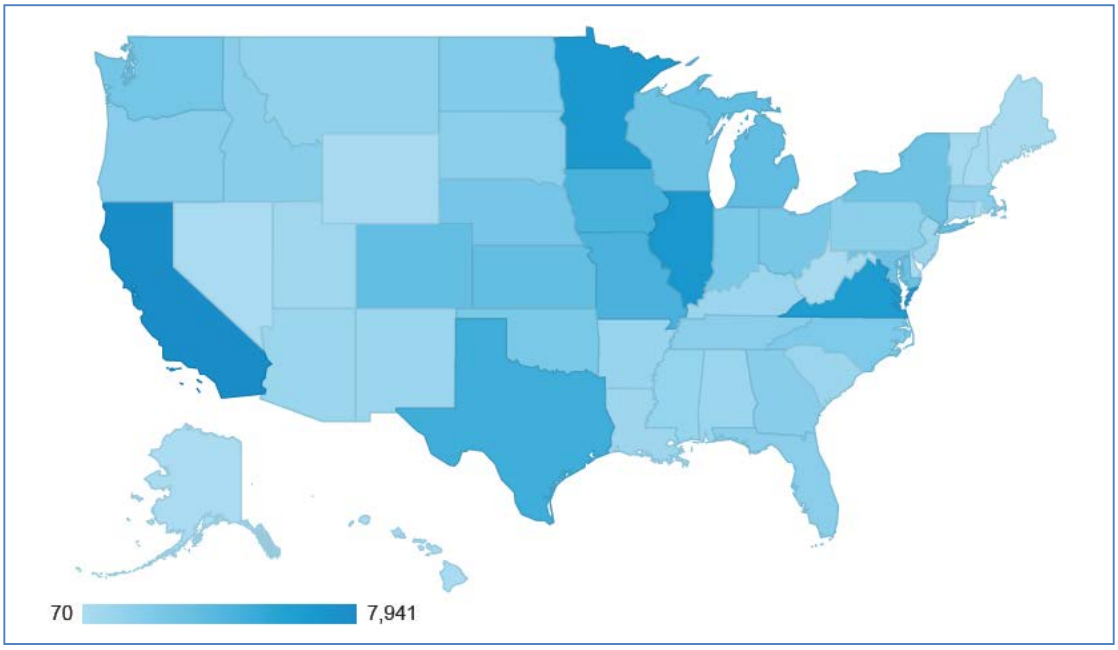
(1) In the Plan East Tennessee project (see details in the User Testimonial 1), the CDL WMS layers, statistical results, and query service were leveraged in a five-county (Anderson, Blount, Knox, Loudon, and Union) regional plan. A Web map application (http://www.etindex.org/) was constructed to integrate the CDL layers, cropland information with other social, economic, and natural resources layers together. A screenshot is shown as Figure 1.

(2) Wisconsin Department of Natural Resources created automated tools for summarizing a CDL raster block into a flat raster of summarized crop rotations (see details in the User Testimonial 2). These crop rotations from the CropScape Web service helped them understand the types of agricultural management that are being practiced. These web services eliminate the need for their users to manually download and process datasets, which is resource intensive and cumbersome.

(3) Researchers at the Agricultural System Research Unit of USDA Agricultural Research Service (ARS) requested to integrate crop statistical information with other inputs in a Web-service based tool to detect crop rotation patterns over years in several ecosystem response units (ERUs). The crop information was extracted from CropScape Web services, and then inserted into the input files of their AgroEcoSystem-Watershed (AgES-W) model. Details can be found in User Testimonial 3.

3. What were the quantitative and qualitative impacts of the system?

CropScape delivers, for the first time, online geospatial CDL data access, navigation, query, visualization, and analysis using interactive maps in the public domain. CropScape has provided considerable public service to the US agricultural and scientific communities since its official release on January 10, 2011. By April 7, 2014, over 100,000 users have visited the website from federal, state, and local governments, companies, academic institutions, and non-profit organizations in the USA (as seen in Figure 2), and over 12,000 users from more than 120 countries have used CropScape. Over 200 GB of CDL data was downloaded in multiple ways by users each month. There is only one annual crop specific national land cover monitoring program in the world and CropScape facilitates data dissemination to the public in an efficient and effective manner.



(a)User Distribution

(b)Monthly Visits

Figure 2 CropScape Users Statistics

4. What effect has the system had on productivity?

CropScape not only greatly saves the cost of printing and shipping media and facilitates low carbon geospatial cropland information delivery for decision support, but it also significantly improves the efficiency and effectiveness for agricultural related decision support. CropScape's capability of generating standard state and county cropland maps and exporting maps to .pdf files greatly reduces NASS staff's burden of map production and helps NASS transition into an electronic-map era. The data dissemination through web services automates many third-party applications and operations, and thus improves users' productivity. In addition, the capability of exporting CDL data directly to Google Earth enriches the spectrum of users' geospatial toolboxes.

5. What, if any, other impacts has the system had?

CropScape also offers various Web services for users to discover, access, invoke, integrate, and execute remotely. The standards-based geospatial Web services

enable automated delivery of custom CDL products to our customers. Users can reuse, integrate, and execute CropScape Web services with distributed geospatial web services from different sources. One successful example is given as following:

- Bioenergy Knowledge Discovery Framework of U.S. Department of Energy (Bioenergy KDF, https://bioenergykdf.net/). Bioenergy KDF lists the CDL WMS service as one important supporting dataset in its land cover library so that the CDL layers can be loaded with other bio-energy layers for decision making support with regard to development options for biomass feedstock production and bio-refinery infrastructure.

6. How did the system change the way business is conducted with and/or service delivered to clients? Give specific examples comparing the old way with the new.

The CDL product was a content rich map product just waiting for the appropriate application to be created to deliver it to the masses; and this is an example of how CropScape fundamentally changed the way NASS disseminates geospatial data. Before CropScape was available, NASS disseminated CDL data by printing CDL data on paper thematic maps and then mailed to users per their request. Staff at NASS headquarters manually loaded the CDL data using GIS software such as ArcGIS Desktop, subset the CDL data using county boundaries, and created one CDL thematic map for each county, and/or printed in paper. This process was labor-intensive, inefficient, and dependent on commercial mapping software. With the Web thematic map creation service in CropScape, users could obtain on-demand CDL thematic maps for individual counties directly without the intermediate processing steps with traditional mapping software. The custom legend obtained is map-specific based on land cover abundances. Advanced users can specify the CDL data using county FIPS codes for batch tasks in their own programs to produce on-demand CDL thematic maps.

F. System Resources

1. What are the system's primary hardware components? Give a brief list or description of the hardware configuration supporting the system.

Two high performance servers were set up to support this Web application. Their basic configurations include:

- Processor: 2 Dual Intel i7 Processors
- Memory: 32 GB
- Hard Disk: 1 TB
- Video Card: support high resolution
- Network Card: 1000M

2. What are the system's primary software components? Describe the primary software and, if a commercial package, any customizations required for the system.

The primary components are shown in Figure 3.

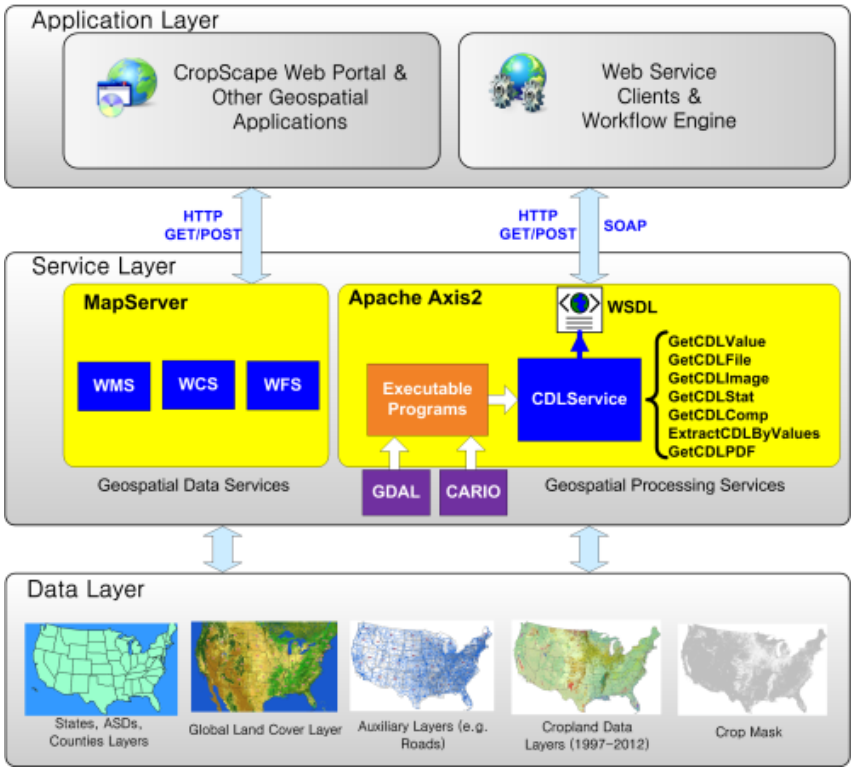


Figure 3. CropScape Components

- Web Server: Apache HTTP Server 2.2
- Application Server: Tomcat 6
- Web Service Engine: Apache Axis2
- Database: PostgreSQL 8
- Geospatial Library: GDAL 1.9 and it dependent packages
- Graphic Library: Cairo Graphics
- Web GIS: MapServer
- Browser Client: OpenLayers (Web mapping) and ExtJS (Graphic User Interface)

3. What data does the system work with? List and briefly describe the database(s).

CropScape utilizes the geospatial data layers as shown in Table 1.

TABLE 1 DATA LAYERS LIST

Type	Name	Description
Raster	CONUS CDLs	The annual CDL files for the CONUS from 1997 to 2013
	State CDLs	The available annual CDL files for each CONUS state
	Crop Mask	The crop mask file derived from the 1997–2013 CONUS CDL files
Vector	Boundaries	The boundary files of agricultural regions, states, ASDs, and counties for the whole CONUS and states, ASDs, and counties for each CONUS state1
	Roads	The national freeway system and regional major highways
	Waters	The rivers and lakes at the national and regional level

[1] Created from the latest 2013 TIGER/Line® Shapefiles (http://www.census.gov/geo/maps-data/data/tiger-line.html).

4. What staff resources were required to implement the system? (i.e., report approximate staff and consultant time as FTE's)

It took 2 FTEs 6 months to build the initial version of this system. After it was released, it took 2 FTEs 1.5 months to update the CDL data, enhance system functions, and provide customer technical support.

5. Comment on anything unusual about the resources used to develop your system, such as data, software, personnel and financing.

In CropScape, a geospatial web service named CDLService was developed to disseminate and analyze cropland and other land cover information within any given area of interest. One unusual issue, which was not expected, was the standard WCS GetCoverage request and WMS GetMap request returned only grid data or images within a specified spatial extent defined by a bounding rectangle. The study area in most cases, however, was normally an administrative or ecological region. Its boundary was usually not rectangular in shape. Therefore, for CDLService development, we specifically added specifications to support any shape of area of interest defined by FIPS or Agricultural Statistic District (ASD) code, bounding box, coordinates, or uploaded boundary file.

Another unusual thing was related to TIGER/Line® Shapefiles. The TIGER/Line® Shapefiles described too much boundary details to be effectively displayed in the CropScape browser client when selecting an administrative district (i.e., state) in some coastal areas. Therefore, a generalized version of those original Shapefiles with lots of details had to be used and be transformed to geography markup language (GML) files. The GML files were cached in one directory for displaying

only. The original high resolution Shapefiles were still used to clip the CDL data for more accurate boundary definition.