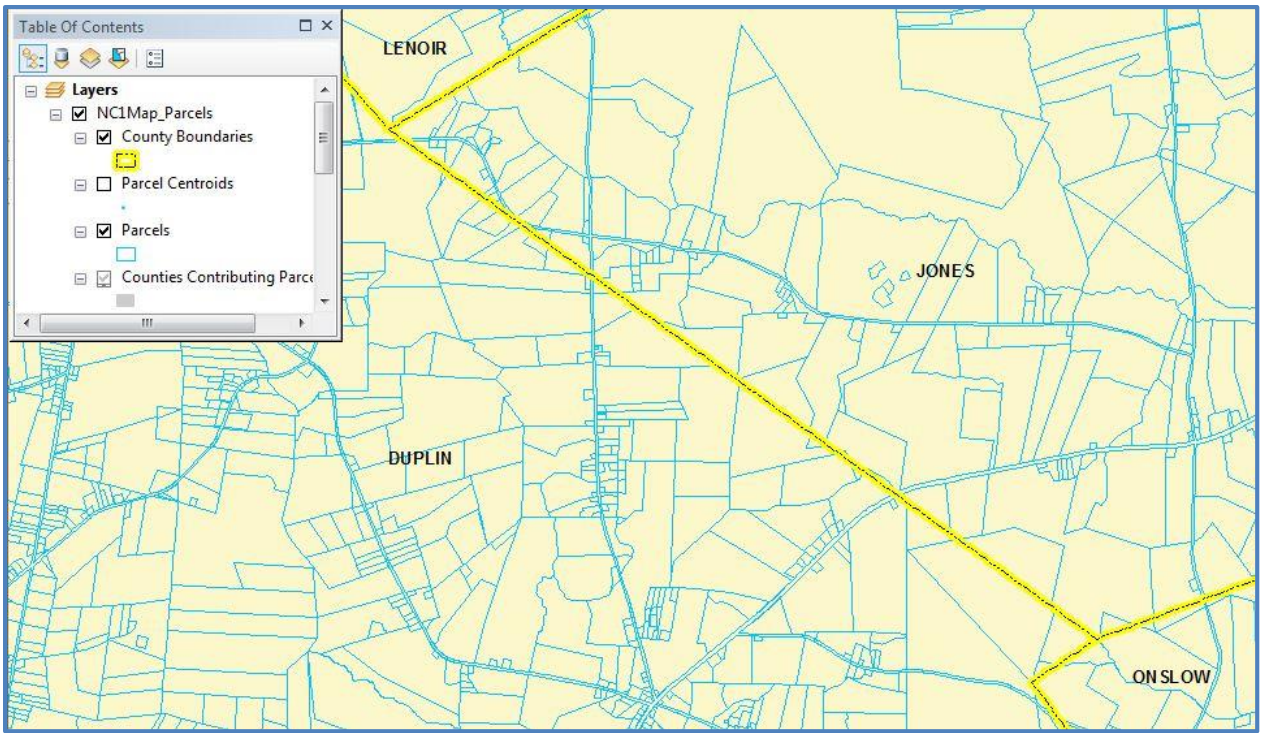

North Carolina Integrated Cadastral Data Exchange
Final Technical Report

The US Environmental Protection Agency awarded a grant to North Carolina to create and demonstrate the value of the "North Carolina Integrated Cadastral Data Exchange." The Project Team has developed a "Transformer" that is a set of online applications that provide a web based approach for submittal, transformation, integration, and publication of the parcel data from county and Tribal sources. This report is the Final Report of this project.

North Carolina Integrated Cadastral Data Exchange
Final Report

June 6, 2014

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Eastern Band of Cherokee Indians (Grant Partner)

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Fairview Industries, Inc. (Subcontractor)
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State Agencies: NC Department of the Secretary of State, NC Department of Transportation, NC Department of Public Safety, NC Department of Environment and Natural Resources, and NC Department of Revenue (technical assistance and advice)

US Environmental Protection Agency, Environmental Information Exchange Network (Grantor)
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North Carolina Geographic Information Coordinating Council, Statewide Mapping Advisory Committee, Working Group for Seamless Parcels (Project Initiation, Stakeholder Representation, Technical Advice, and Oversight)

*See Acknowledgements for more information and lists of participants.

Executive Summary

The US Environmental Protection Agency awarded a grant to North Carolina to create and demonstrate the value of the "North Carolina Integrated Cadastral Data Exchange." The Project Team has developed a "Transformer" that is a set of online applications that provide a web based approach for submittal, transformation, integration, and publication of the parcel data from county and Tribal sources.

The "Transformer" applications enable NC county geospatial data producers to:

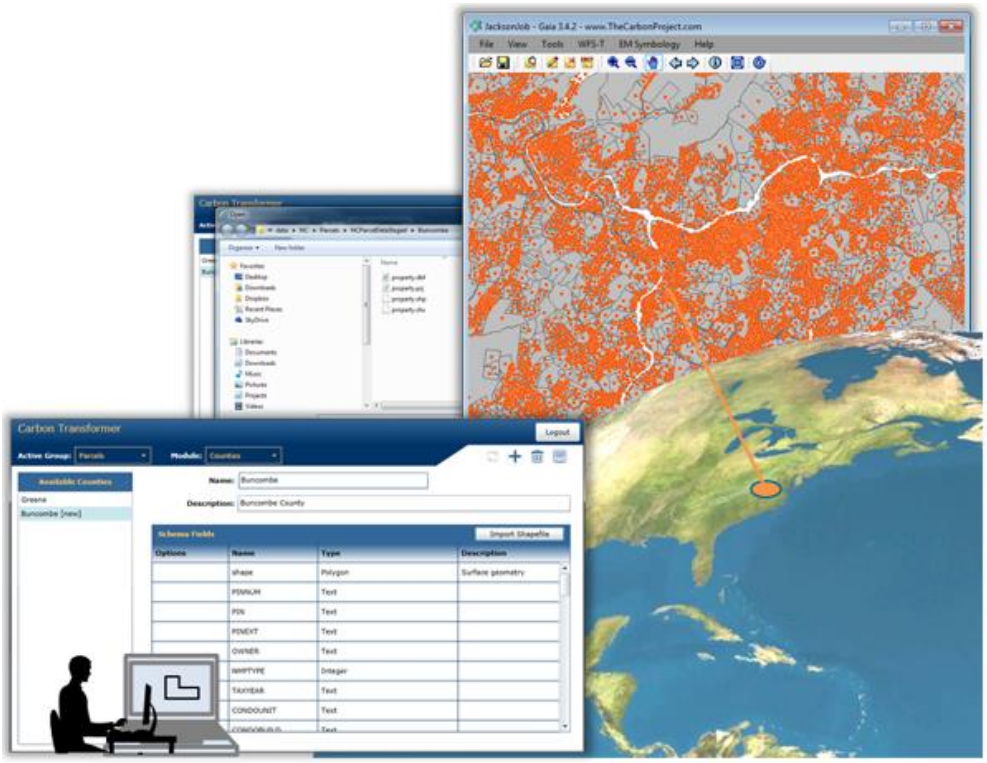
1) Log in to an authenticated web interface using North Carolina Identity Management (NCID) for security.
2) Use a custom interactive web interface to upload a county's parcel polygons with parcel data attributes (fields as published by county data managers) and view the fields.
3) Interactively match ("transform") a county's specific source parcel data attributes to a standard set of specific parcel data attributes (Master Schema).
4) Interactively submit a "job" that creates a zip file with original and transformed parcel data for a county (with geometry "as is" from the source), metadata and an error log file.
5) The job processing also generates a point file from parcel polygons with standardized attributes assigned to the points. The alogorithum assures that the point is inside the parcel polygon. The point file is iuseful in identifying any polygon errors and is valuable for viewing and querying multiple county data sets more quickly in web browsers and in GIS desktop software.
6) "Publish" web services in multiple formats for access from the US EPA Exchange Network and for access from the NC OneMap Geospatial Portal for discovery and use outside of the Exchange Network.
7) Repeat the transformation operation at a future date, using the initial (or latest) translation model ("transforms") in the interactive interface to confirm or correct the matches and "publish" the current data
8) Download "job" packages for any counties that have been transformed to the standard set of fields.

The applications enable national geospatial data consumers in the US EPA Exchange Network to:

1) Log in to an authenticated web interface managed and secured by US EPA Exchange Network.
2) Discover and gain access to web services representing standardized NC parcel data through the Network.

This approach to integrating parcel data is applicable to other geospatial datasets where local governments are authoritative sources, data fields are not standard, and potential benefits are compelling. The same approach as the one for parcels will apply as illustrated in the graphic below—data managers access a cloud-based application using a web browser and local authoritative data, use tools to transform the source data to the target master schema, and publish boundaries, lines, and/or points for consumption as web services in open data and popular formats for wide application.

This report is intended to document the project for US EPA Exchange Network, serve as a reference for North Carolina in expanding the content and participation and sustaining the tools, and inform other states working on similar statewide geospatial data initiatives.



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1. Project Description

1.1 GICC Initiative

The Integrated Cadastral Data Exchange is a project that will inform enterprise solutions for compilation, integration and sharing of statewide geospatial datasets. The NC Geographic Information Coordinating Council (GICC) identified priority datasets to serve to the public through the *NC OneMap* Geospatial Portal. Among those priority datasets, four in particular—roads, parcels, structure footprints and addresses—rely heavily on local government data creation, publication, and sharing. Within the state geospatial coordination structure, the Statewide Mapping Advisory Committee's Working Group for Seamless Parcels developed a proposal for cadastral data (tax parcel boundaries and polygons and associated information) that had statewide implications. On behalf of the Working Group for Seamless Parcels, the Department of Environment and Natural Resources submitted a grant proposal to the US EPA's Environmental Information Exchange Network in 2009.

1.2 EPA Assistance Award

US Environmental Protection Agency awarded a competitive assistance grant (83431001) to North Carolina in 2009. EPA awarded the grant to the NC Department of Environment and Natural Resources (DENR), but the department lost key personnel before a project could begin. The NC State Chief Information Officer and the Center for Geographic Information and Analysis (CGIA) submitted a proposal to transfer the grant to CGIA, and EPA made the transfer in August 2012. The Eastern Band of the Cherokee Indians (EBCI) continued as a project partner to extend the concepts and tools to Tribal Land.

1.3 Project Approach

The project approach is described by business issues, business goals, and a project strategy.

Business Issues

The business factors that led to the proposal of an Integrated Cadastral Data Exchange:

1. Among the GICC's top priority datasets to serve through the NC OneMap Geospatial Portal, cadastral data lacks a statewide dataset. To meet GICC requirements, statewide datasets must be consistent, complete, current and well documented.
2. State, regional, federal, and tribal government users and private business users of cadastral data individually collect, transform, and integrate county cadastral datasets for multi-county information and analysis.
3. Data sharing among public agencies is limited by currency, consistency, and the lack of an accessible statewide resource, resulting in duplication of effort by users as well as redundant provision of copies of data by county data producers.

4. Only 41 of 100 counties offer free downloadable tax parcel datasets for GIS users; an efficient, practical method for obtaining parcel data from all counties would benefit GIS users.
5. Counties follow state specifications for creating property boundaries and creating unique identifiers. In many cases, the property boundaries are maintained separately from the associated tax records, requiring queries and exports from a Computer Assisted Mass Appraisal (CAMA) system to join property attributes to the boundaries. The result is variability from county to county in the cadastral data fields published as geospatial data, particularly in field naming and selection of fields to publish.
6. Tribal Land boundaries related to lands of the Eastern Band of the Cherokee Indians have different attribution than county cadastral data, creating an additional challenge for an integrated dataset.
7. Analysis of cadastral data by state, regional and federal government users relies on current (within 6 to 12 months) property boundaries, and cross-jurisdictional consistency in associated information about ownership type (e.g., private, state, local, federal), land area, and land use to name a few of the attributes.
8. Analysis by private businesses and individuals may have a multi-county focus, and there are some use cases that rely on cross-jurisdictional consistency in associated information about property ownership, area, structures, and land use.
9. US EPA and its state partners will benefit from applications that integrate geospatial data into the Environmental Information Exchange Network. In particular, geospatial data for regulated facilities can benefit from and analysis of and reference to cadastral data.

Business Goals

The business goals address nine business issues.

1. Demonstrate that a statewide collection of cadastral data has the potential to achieve completeness, consistency, and currency.
2. Reduce the time spent by multiple state agencies in obtaining region-wide or statewide county cadastral data.
3. Create a readily accessible tool for sharing multi-county cadastral data among public agencies to reduce time spent requesting and processing cadastral data, and to reduce time spent by county data managers in furnishing copies of cadastral data.
4. Make cadastral data accessible through online tools from more of NC's 100 counties.
5. Demonstrate to county cadastral data managers that publishing a dataset to a common set of attributes will benefit many of the county's data constituents.
6. Demonstrate to Tribal Land data managers that transforming data to a common set of attributes will benefit users of Tribal Land data.
7. Provide current, consistent, multi-county cadastral datasets to government data users to support a variety of business needs.
8. Demonstrate that a collection of cadastral data can meet business needs of private users related to multi-county information and analysis.

9. Demonstrate the applicability of geospatial data to the Environmental Information Exchange Network.

Strategy

This project was intended to demonstrate full functionality for a significant portion of North Carolina (25 of 100 county parcel data sources). The elements of the project strategy:

- Establish a standard data schema for integrating a collection of county cadastral data in North Carolina. Include provision for inclusion of Tribal and Indian lands of the Eastern Band of the Cherokee Indians.
- Develop web tools for local government and Tribal geospatial data managers that will enable easy transformation of county tax parcel data to a common data model (not changing local databases, but matching county data fields to desired fields).
- Create easy-to-use web tools for uploading transformed county datasets to a cadastral database. In parallel, create easy-to-use web tools for uploading transformed Tribal datasets to a boundary database intended for the secure EPA Exchange Network.
- Create new data flows in the Environmental Information Exchange Network nodes, consistent with Network guidelines, to enable seamless cadastral data sharing between local, regional, state, Tribal, and Federal agencies.
- Provide web interfaces to deliver downloadable seamless parcel data interactive Exchange Network services and for GIS software (geospatial portal).
- Develop capability to convert data uploads to both multi-jurisdictional areas (polygons) and points (center of parcel) to support multiple business processes.
- Test the tools through participation by 25 county GIS operations (transformation and uploading) and project stakeholders (data sharing and data analysis). Test tools developed for EBCI.
- Evaluate the data model, tools for data transformation, and tools for data sharing in terms of quality, reliability, applicability, and costs. Evaluate the practical applicability of the tools and techniques to other priority datasets (e.g., roads, addresses, governmental boundaries). Evaluate the quality of the participation and resulting datasets.
- Make recommendations for applying, modifying, adopting, or transitioning the tools and techniques based on the evaluation, lessons learned, alternative tools, the context of other priority datasets.

2. Project Goals and Outcomes - Summary of Accomplishments

2.1 Develop state IT procurement documents and project plan, initiate procurement, and award contract.

Outputs:

Project Initiation, Project Management, Project Team, Stakeholders, Project Plan, contract for application development.

Scheduled date: November 2012

Completion date: December 11, 2012 - Project Initiation Approved
February 4, 2013 - RFP Issued
March 28, 2013 - Proposal Evaluation Completed
May 31, 2013 - Contract issued

Outcomes:

Project has identified dedicated staff. State procurement rules have been applied and are being followed. The project plan is guiding the procurement, and a well-qualified application development team was selected.

2.2 Develop Detailed Project Plan and Design

Outputs:

Detailed requirements and technical architecture system design

Scheduled date: December 2012

Completion date: July 2013

Outcomes:

A detailed project plan is guiding the development.

2.3 Develop GML schemas

Outputs:

Shape file models, GML schemas, Master Schema Core Parcel Data Element Definitions (see Appendix A), and WFS API for data exchange

Scheduled date: April 2013

Completion date: July 2013

Outcomes:

A master schema for polygon and point datasets and GML aligned with Federal standards and North Carolina specifications is completed.

2.4 Develop Geospatial Database

Outputs:

Complete geospatial database design to support data transformation, data exchange, and data access.

Scheduled date: May 2013

Completion date: July 2013

Outcomes:

Documentation and scripts for creating and populating a geospatial database completed.

2.5 Design, Develop, Test, and Apply a Data Transformation Web Application

Outputs:

Web interface for data providers that will serve as a transformation service, and will track and post transformed data, sustain and maintain translation models, and provide access to transformed datasets.

Scheduled Date: September-November 2013

Completion Date: First Iteration - September 2013
Fully functional Transformer version - January 2014

Outcomes:

Web tools for data providers that standardizes locally sourced and tribally sourced data sets, maintains a record of the transformation of the data on an attribute-by-attribute basis, allows for the maintenance of the Master Schema and locally provided lookup tables and local data structure documentation, and provides access to data through job results that contain the original provided data, transformed or standardized data in polygon and point format and a metadata record for the standardized data.

2.6 Design, Develop, Test and Apply Web Service for Data Flow

Outputs:

Exchange Network REST endpoint for Web Features Services for parcel data from 25 sample NC counties and EBCI.

Scheduled Date: November 2013

Completion Date: Generated and tested Web Feature Services for data flow January 2014
Registered with Exchange Network Discovery Services (ENDS) March 2014

Outcomes:

Data providers have service interfaces for data flow and the project demonstrates the ability to share parcel data within the Exchange Network.

Reusable software applications and services available for use by other states and tribes, and recommendations for statewide solutions.

2.7 Develop Training Materials and Workshops

Outputs:

Training for a large sample of NC counties and EBCI for using the transformation tool for provision of parcel data.

Documented data flows and tools in a Quick Start Guide (see Appendix B).

Scheduled Date: January 2014

Completion Date: March 2014

Outcomes:

Engaged and trained local government and Tribal data providers as well state agency level experts to support and encourage local providers.

2.8 Integrate System Components

Integrate the completed components and business processes, test, accept, and document the solutions.

Outputs:

Test Plan with test results, analysis of the quality of participation, data flows, data content. Demonstration of integrated components of data flows from data providers to the Exchange Network and to access by non-node NC users.

Scheduled Date: January - February 2014

Completion Date: NC Staff tested Transformer - January 2014
All Test Plan elements completed March 2014

Outcomes:

Thoroughly tested and evaluated data flow, back-end database, web interfaces, translation tools and models, and EN REST endpoint. Documented and demonstrated solutions are complete.

2.9 Close the Project

Final edits to documents, packaging applications, evaluations, and final reports to NC and EPA

Outputs:

Final project files and documentation.

Scheduled Date: April 2014

Completion date: May 2014

Outcomes:

Reusable software applications and services available for use by other states and tribes, practices available for other states or datasets, and recommendations for statewide solutions.

3. Quality Assurance Measures

3.1 Develop state IT procurement documents and project plan, initiate procurement, and award contract

NC Enterprise Project Management Office (EPMO) provides oversight and quality assurance to the planning and design process, including the procurement process for a vendor for application development. Description of quality assurance activities:
http://www.epmo.scio.nc.gov/services/qualityAssurance.aspx
Outcomes:

Planning and Design completed 7/29/13. Vendor procurement was successful, under budget, and consistent with all stated requirements.
Contract executed May 30, 2013.

3.2 Develop Detailed Project Plan and Design

EPMO quality assurance includes project workflow gate review to verify that the project is planned and organized for success prior to approval to move to application development. Review is by state-level personnel including technical architecture system design reviewers and the SCIO.
Outcomes:

Gate 2 approval (9/25/13)
Gate 3 approval (4/28/13)

3.3 Develop GML schemas

Project Team will verify that the outputs conform to Open Geospatial Consortium standard formats for geospatial schemas, data and services. http://schemas.opengis.net/
Outcome:

Verified July 2013

Project Team will verify that comparable items in GML schemas are consistent with the core cadastral publication standard by the Cadastral Subcommittee of the Federal Geographic Data Committee, CADNSDI Publication Standard Version 2 (10/1/2012):
http://www.nationalcad.org/showdocs.asp?docid=1171&navsrc=Standards&navsrc2=
Outcomes:

The core data content was verified by comparison with the FGDC Cadastral Core Parcel Standard and was found to be in 100% compliance with the Cadastral Standard (August 2013)

Project team will verify that WFS conforms with the OGC standard:
http://www.opengeospatial.org/standards/wfs#downloads
Outcomes:
The output of the project is in conformance with WFS 1.1. and with the EN REST Guidance.

3.4 Develop Geospatial Database

The project team will verify that the database meets technical requirements, includes the required schema (based on the project's Core Parcel Data Element Definitions (Appendix A) for standard fields), and is documented to an extent that would enable replication.

Outcomes:

The database schema is consistent with the Core Parcel Data Element Definitions and was demonstrated for Buncombe County (August 2013).

Database content: The source geospatial datasets are created, maintained, and published by NC county agencies (and Tribal entities) as authoritative representations of property boundaries and associated descriptors. This project will accept the county and Tribal geospatial datasets "as is" and translate the attributes to a common schema. The geometry (property boundaries) will not be edited in the transformation process.

Outcomes:

Datasets were obtained and prepared for translation in "cross-walk" files; source and target fields reviewed and verified by CGIA (September 2013).

3.5 Design, Develop, Test, and Apply a Data Transformation Web Application

CGIA will register in ENDS and RCS and will research and monitor the content to assure that the selected Vendor reuses applicable EN nodes, data flows, services and IT resources for this project.

Outcomes:

CGIA registered with EPA and monitored the content of ENDS and RCS.

The Vendor will perform system integration testing. The Project Team, with support of the Vendor, will conduct acceptance testing for the components of the technical solution.

Outcomes:

System integration testing, testing of all components, and acceptance testing were completed in March 2014.

The Project Team will validate the metadata records based on FGDC standards and validation tools. http://www.fgdc.gov/metadata

Outcomes:

Metadata records for single counties and multi-county collections were validated successfully by CGIA (January 2014)

The Project Team will use copies of county parcel data for a sample of counties to verify that data and services produced by the project tools are complete (all county land is represented), have logical consistency, and have parcel identification numbers that match corresponding numbers in data published by the counties.

Outcomes:
The Project Team completed quality assurance for all 25 counties and the lands of the Eastern Band of Cherokee Indians.

To verify successful matching of selected source fields to schema fields, the Project Team will apply the cadastral output of the transformation tool to a set of tests including the following:

- Examine the sorted attribute table to verify the County FIPS value and CNTYNAME are correct for all records, by county.
- Select records where PARVAL > (LANDVAL+IMPROVVAL) to identify potential mismatch of source field to schema field (logically, total value should not exceed the sum of the land value and improvement value).
- Select records where STRUCT< > "" and IMPROVVAL = 0 to identify any inconsistent records (if a structure is on the property, there should be improvement value).
- Examine the attribute table sorted by LANDVAL to identify outliers (records with no land value and records with the highest land value) and verify that outliers appear to be valid by researching parcels on the corresponding county online map viewer/look-up tool if available.

Outcomes:

A custom program was developed to test the first 5 counties. These identified variables were tested for these five counties. The routines developed for the five county testing was used in ArcGIS for the remaining 20 counties. Quality reports were reviewed after each county was run and updates were made to the transformer and the county was re-run if needed. Data content issues were conveyed to the county.

The Vendor will register in ENDS and RCS, and will research and the content to assure reuse of applicable EN nodes, data flows, services and IT resources for this project.
Outcomes:

The Carbon Project, Inc. registered the EN REST endpoint successfully in ENDS.
CGIA registered XML schema and multi-county geospatial metadata with RCS.

The Vendor will perform system integration testing. The Project Team, with support of the Vendor, will conduct acceptance testing for the components of the technical solution, including verification that Nodes and Plug-ins meet Network Node Specifications and utilization of the Exchange Network Node Test Site.
Outcomes:

Integration testing was successful as documented in the Test Plan. The Project Team tested and accepted the applications, web services, and datasets, including the EN REST WFS.

3.6 Design, Develop, Test, and Apply Plug-in Web Service for Data Flow

Outcomes:

The Carbon Project designed, developed, tested, and applied the EN REST WFS, developed in conformance with the new EN REST Guidance (released January 2013), completed in February 2014. The XML Schema is attached as Appendix C.

3.7 Develop Training Materials and Workshops

Before and after training for data providers, the Project Team will engage the NC GIS coordination structure to assure that the training content is clearly presented, applicable, and valuable to county and Tribal data providers. This process will include the Working Group for Seamless Parcels and the NC Property Mappers Association.

Outcomes:

The Quick Start Guide, available online from the Transformer home page, presents step-by-step content to guide data sharing and transformation. Hands-on training of members of the Project Team (to train the trainer), a webinar for local government data producers, and presentations at four land records workshops were completed before the end of the grant project.

3.8 Integrate System Components

The Vendor will perform system integration testing. The Project Team, with support from the Vendor, will conduct acceptance testing for the components of the technical solution.

Outcome:

The Carbon Project, Inc. completed all Test Plan elements successfully (March 2014).

The Project Team will use copies of county parcel data for a sample of counties to verify that data and services produced by the project tools are complete (all county land is represented), have logical consistency, and have parcel identification numbers that match corresponding numbers in data published by the counties.

Outcome:

The Project Team applied quality assurance steps for all 25 counties and the Eastern Band of Cherokee Indians (February 2014)

The Project Team will do periodic tests after a cycle of data updates by data producers to assure that the tools and data flows are working as expected and to take corrective actions with the project Vendor.

Outcomes:

The Project Team applied quality assurance steps to Henderson County's second submission and verified successful transformation and data products (February 2014).

3.9 Close the Project

For registration of tools and services in ENDS, the Project Team and Vendor will collaborate (as applicable to this project) to create records, containing relevant metadata and descriptions, for all new Exchange Network nodes, data flows, and services (related to data flows) developed for this project; and create a record, containing relevant metadata and descriptions, for all new IT resources in ENDS (including where applicable XML schema, software tools, web services not related to data flows, SOAP or REST, widget tools, programming code, and code libraries).
Outcomes:
The Carbon Project, Inc. successfully registered the EN REST endpoint in ENDS. The XML Schema was completed (attached). Metadata records are included in each Job zip package. CGIA closed out the project in the North Carolina Enterprise Project Portfolio Management system.

4. EPA Exchange Network

4.1 Reuse of Existing Exchange Network Tools and Services

Outcomes:
The Carbon Project successfully registered the new EN REST endpoint in ENDS through ENDS.
The Reusable Component Services referred to ENDS for registration, also.
CGIA added the XML schema and metadata to RCS.

4.2 Registration of New Exchange Network Resources

Outcomes:

> The Carbon Project successfully registered the new EN REST endpoint in ENDS through ENDS. The Reusable Component Services referred to ENDS for registration, also.

5. Evaluation of the Project with respect to a statewide dataset

The NC Integrated Cadastral Data Exchange project was funded by US Environmental Protection Agency Exchange Network Grant 83431001. The EPA grant narrative stated:

> "During the two-year project, a private application developer under contract will be responsible for hosting files relating to application development, uploaded datasets, processed datasets, and online applications. After an evaluation of the pilot project by CGIA and its collaborators, if the project meets expectations and satisfies requirements for a statewide dataset for land parcels, a portion of the project budget is allocated to transfer the applications and data to CGIA/ITS and/or collaborating state agencies."

The Project Team evaluated project elements and concluded that the project achieved its objectives, delivered the expected online functionality, and delivered data products on time. The project met expectations and satisfied requirements for a statewide parcel dataset.

The Project Team identified 11 topics as the most important to evaluate.

5.1 Participation by Data Producers

The Project Team identified 11 topics as the most important to evaluate regarding participation by data producers to share and transform source data to standard data, including technical assistance by the Project Team.

1. Quality of Participation of Data Providers

All 25 participating counties plus the Eastern Band of Cherokee Indians published parcel data and shared files with the Project Team. The participants are displayed in Figure 1.

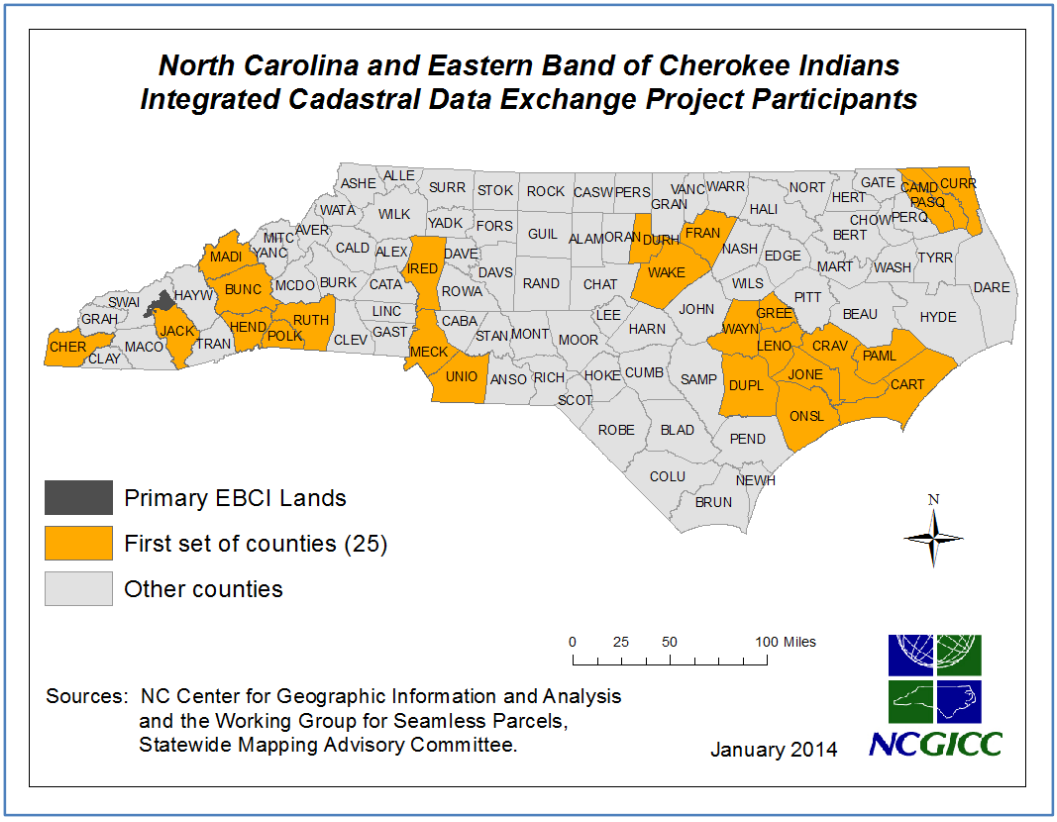


Figure 1. Participating Counties and Tribes in the Project

Ten of the participating counties provide free downloadable parcel data. The other 15 participating counties made data available at no charge. Of those 15, five counties have a policy of charging a fee for copies of parcel data; the project team was not charged and was granted permission to publish standardized data for those counties. Among the highest quality data providers was Pam Carver of Henderson County, co-chair of the Working Group for seamless parcels. The project team worked closely with Pam to specify a crosswalk from her source data to the target Master Schema. Similarly, David Wyatt of the Eastern Band of Cherokee Indians refined and published a parcel dataset to meet the needs of the project. Sol Wuensch of Craven County took extra time to assure complete content for his county crosswalk.

About half of the 25 pilot counties participated in a webinar on March 6, 2014 for training in the Transformer application.

Many of the 25 data providers were active in NC's geographic information coordination structure through the project period to add quality to participation. Members of the Working Group for Seamless Parcels included data contributors Pam Carver of Henderson County, Eric John of Wake County, Lucy Cardwell of Currituck County, and David Wyatt of the Eastern Band of Cherokee Indians. Members of the Local Government Committee included data contributors Julie Stamper of Pasquotank County and Lucy Cardwell.

2. Parcel Data Quality

The Project Team found that source parcel data quality was very good for the most part. There were some shortcomings identified by the Project Team. A goal is to resolve problems in the process of updating the 25 participating counties and engaging additional data providers in the future. The data issues found by the team:

- Datasets were not developed with the core parcel attributes in mind, therefore is takes some processing of the data to extract things like the presence of a structure on a property.
- Once the dataset is standardized, inconsistencies in the attribution within the datasets may be apparent. For example, one field might indicate a parcel is vacant but another field indicates building value associated with the parcel. The source of the difference may be multiple data systems tracking information or data flows that result in difference update schedules for some fields.
- Ascertaining the types of values in the datasets is a challenge. The source data dictionary may indicate that an attribute is the taxable value, but then properties that are clearly exempt will have a value for that attribute.
- Determining the type of owner (federal, state, county, local, private, non-profit, international, etc.) is very difficult. In a few cases the names could be sampled but in general just determining taxable versus non-taxable was challenging enough.
- The use of names in any field is problematic. For example the US Government as a landowner is listed and misspelled in a variety of ways, making it difficult to identify federal landowners in a data set. Similarly, attributes that contain the word Exempt were found to have a wide variety of misspellings.
- The use or non-use of leading spaces makes data querying difficult. For example in many counties the site address street direction was provided as “E” and as “ E” or as “E “. The hidden space in the data set makes concatenation difficult but also complicates data queries and standardization.
- Duplicate parcel numbers can arise from condominiums where the one parent parcel has many dependent parcels. In some cases uniqueness can be determined by appending an alternate parcel number or a suffix to the parcel number, but not always.
- In some instances, parcels are mapped as multiple polygons with a common parcel identification number, e.g., a forested parcel under single ownership divided by roads. The operation of joining a table exported from a computer assisted mass appraisal (CAMA) system to parcel geometry, based on parcel ID, can result in numeric fields that contain joined values representing the entire property for each of the polygon records that make up the full property. Users need to account for those records to avoid double counting items such as land value.
- Parcels should have parcel identification numbers from county sources except in rare instances where ownership is not known or in cases where assignment of the parcel number is still pending. Also, county parcel dataset may or may not include polygons representing transportation rights of way or natural features such as rivers.

Polygons that do not represent real property may not have parcel identification numbers and do not have meaningful parcel attributes.

3. Frequency of Data Submissions

The pilot project did not request multiple submissions from county data producers with the exception of Henderson County. After the first transformation, Pam Carver of Henderson published a second source parcel dataset with additional fields exported from Henderson County's computer assisted mass appraisal system (CAMA) to more fully populate the standard core fields. The Project Team considers annual updates essential and semi-annual updates preferred where practical. The system is designed so that data providers may update their source data and run transformation jobs at any time. Time stamping of resulting shapefiles keeps track of versions. Publication of web services can occur at any time. Similarly, update of the *NC OneMap* Database is designed to occur weekly to capture recent updated county datasets.

4. Time required by data providers

The first transformation of county data varied from about one hour to around three hours. Availability of a data dictionary or a metadata record saved time in specifying the field matching from source to master schema. Available look-up tables saved time, as well, for field involving codes and/or code descriptions. The specific publication details varied from county to county, explained in part by a wide variety of CAMA vendors and systems serving NC counties as indicated in Figure 2.

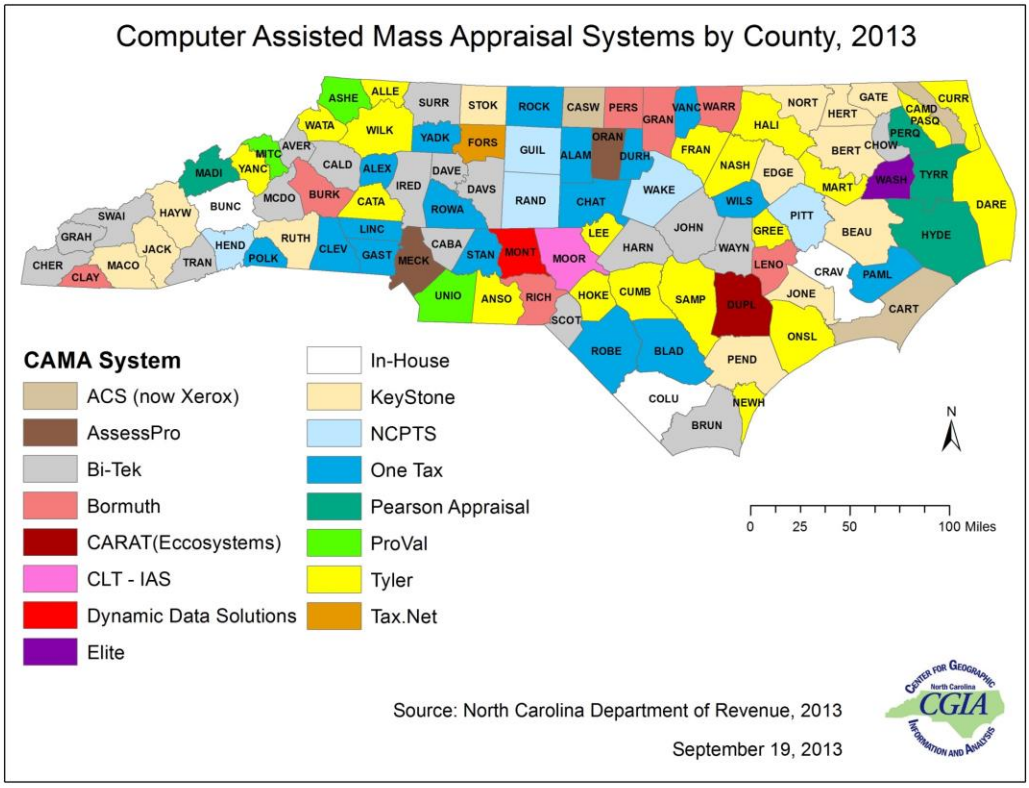


Figure 2. CAMA Systems by County Tax Department, 2013.

The 25 participating counties represented 12 of the 16 CAMA vendors, giving the project a realistic experience with a variety of tabular tax data attached to parcel boundaries. See Figure 3.

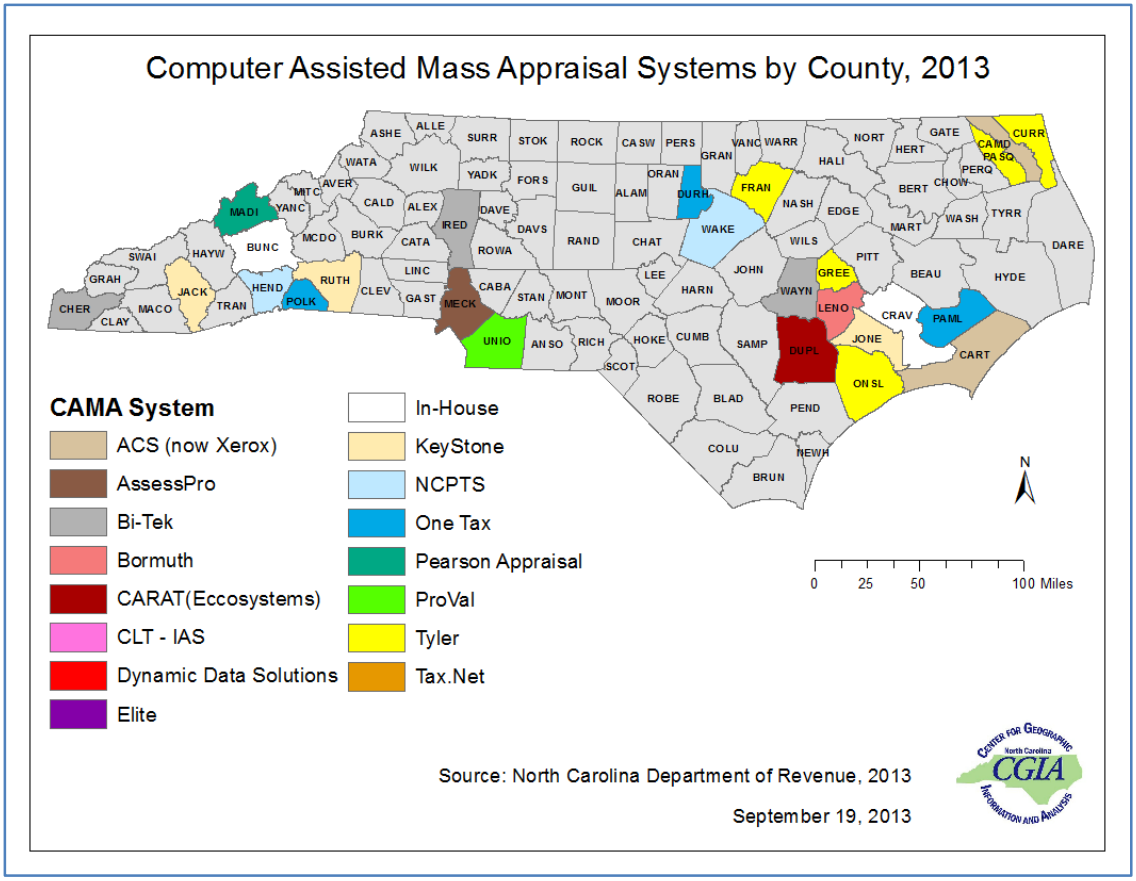


Figure 3. CAMA Systems among the Participating Counties

Regarding time and effort by local data providers, a concern expressed by members of the Project Team is that the process of getting, using, and maintaining an NCID may be burdensome to local government data managers. NCID worked very well for Project Team members who regularly use NCID and merely registered their NCID with the Transformer application. Testing by the team found that the process of creating an NCID account was efficient, and the process of registering an NCID with the application was simple. NCID passwords must be changed every 90 days, which may

5. Time Required by Project Team Consultation

Project team consultation was required for security measures (registration with NCID for authentication) and for orientation to the modules of the Transformer. The automated features of the Transformer, including auto population of some of the fields, saved time for data producers and the project team. Some of the field transforms require guidance from the Project Team, particularly where the matching of source fields to target fields is not one-to-one and where business rules need careful attention. Tools for guidance are the Quick Start document and the NCID/Registration guide produced by the Project Team.

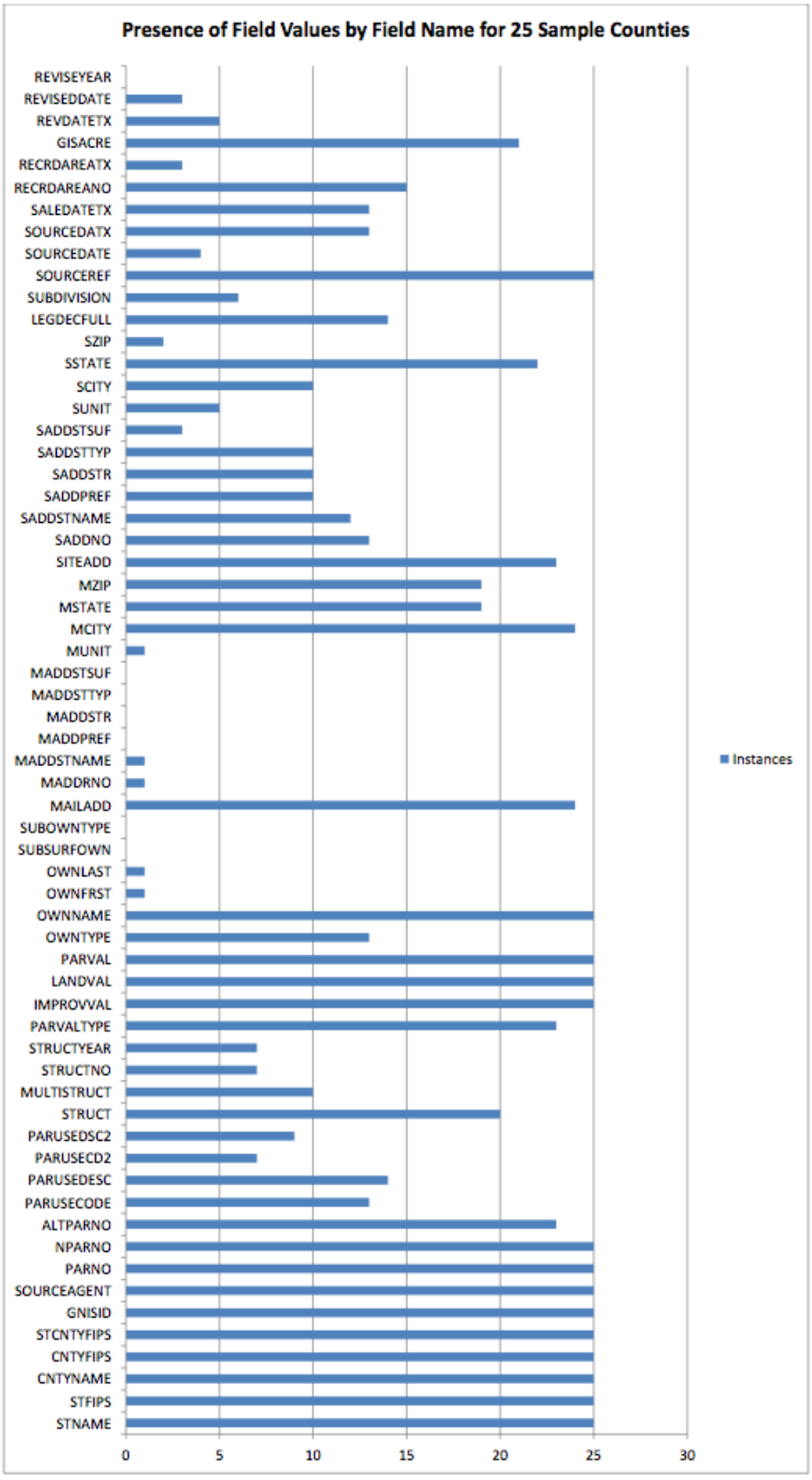
6. Identification of Potential Benefits to Data Providers and Data Consumers

Outreach by the Project Team, using NC's geographic information coordination structure and project team engagement with professional organizations, led to discussions of potential benefits. Among data providers, the availability of new high quality web services makes application development in their jurisdictions more practical. Also, valid metadata records for standardized parcels are available where metadata has been scarce. Among data consumers, project discussions revealed instances of parcel data collection and integration by multiple public and private organizations and opportunities for collaboration and better use of staff resources. While county-specific parcel map viewers, containing the latest property information, will continue to be a prime source for real estate and legal data consumers, the state compilation and standardization enable convenient multi-county analysis and mapping.

7. Quality of Data and Identification of Gaps Using the Project Master Schema as a Standard

The parcel data quality is high in general, with some apparent anomalies and missing values. The 61 fields in the master schema had some missing values as displayed in Figure 4. The missing values are the result of either the local parcel data manager not publishing a particular field that could be exported from the computer assisted mass appraisal (CAMA) system or the CAMA not supporting data entry for a particular attribute or field (e.g., not supporting entry of the constituent parts of a mailing address).

The project team identified the 27 core standard fields that are most useful for queries, analysis, and mapping of parcels. The percent of counties with values in those 27 fields indicated values were present in most instances, as shown in Figure 5.


Presence of Field Values by Field Name for 25 Sample Counties
REVISEYEAR
REVISEDDATE
REVDATETX
GISACRE
RECRDAREATX
RECRDAREANO
SALEDATETX
SOURCEDATX
SOURCEDATE
SOURCEREF
SUBDIVISION
LEGDECFULL
SZIP
SSTATE
SCITY
SUNIT
SADDSTSUF
SADDSTTYP
SADDSTR
SADDPREF
SADDSTNAME
SADDNO
SITEADD
MZIP
MSTATE
MCITY
MUNIT
MADDSTSUF
MADDSTTYP
MADDSTR
MADDPREF
MADDSTNAME
MADDRNO
MAILADD
SUBOWNTYPE
SUBSURFOWN
OWNLAST
OWNFRST
OWNNAME
OWNTYPE
PARVAL
LANDVAL
IMPROVVAL
PARVALTYPE
STRUCTYEAR
STRUCTNO
MULTISTRUCT
STRUCT
PARUSEDSC2
PARUSECD2
PARUSEDESC
PARUSECODE
ALTPARNO
NPARNO
PARNO
SOURCEAGENT
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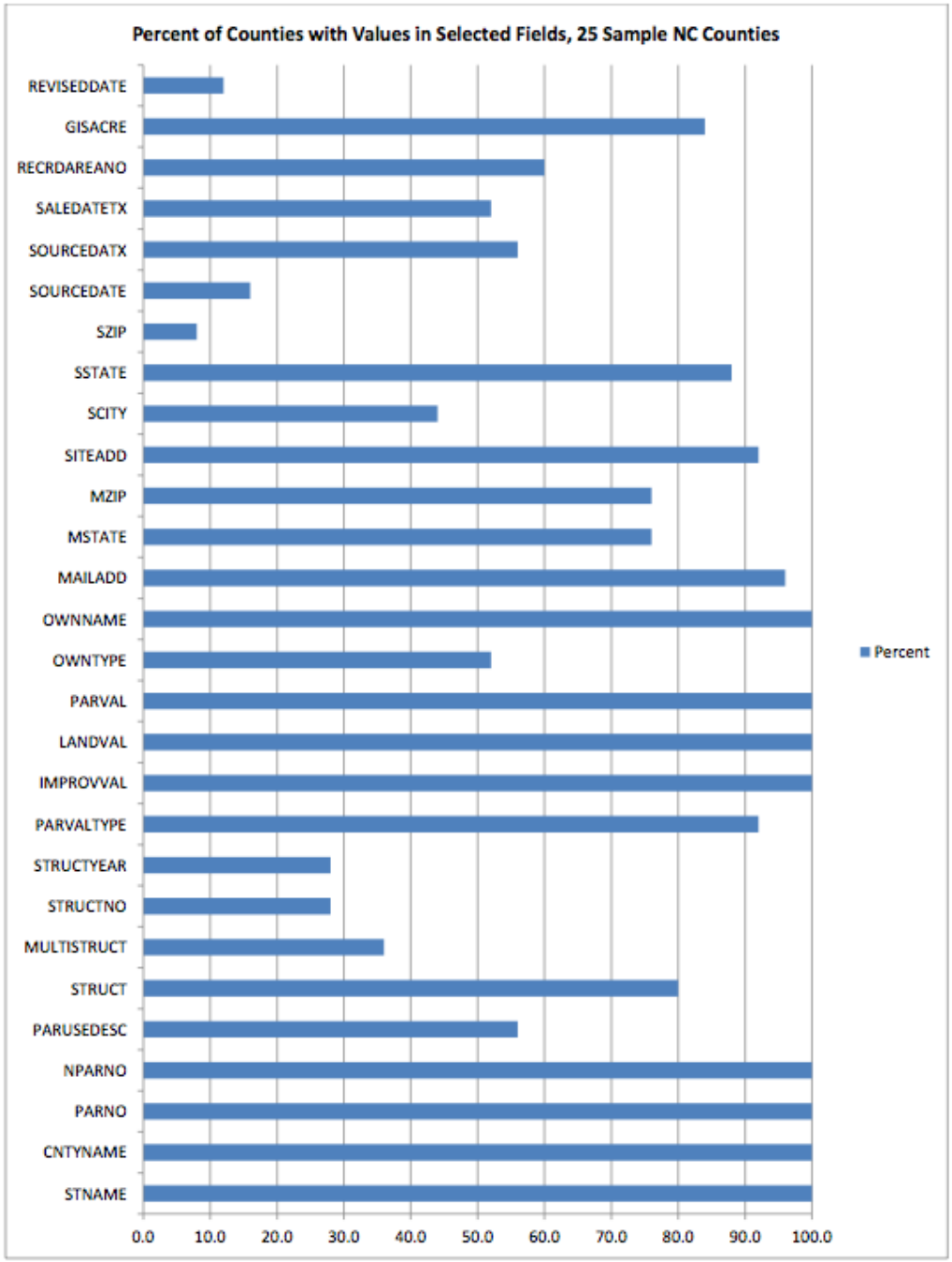
10
15
20
25
30
Instances



8. Adding County Datasets to the Transformer

The Project Team recommends a combination of (1) engaging county parcel data managers to use the NC Parcel Data Transformer directly (with technical support from the team) and (2) assisting county parcel data managers with field transforms to support participation and quality. The first approach is practical for many counties, and even more practical after the first

set of field transforms and completion of a job package for a county. Subsequent updates take a few minutes if source field names are the same as the previous source file. Even a few changes in field transforms do not take more than a few minutes.

NCDOT had a collection of county parcel data that was valuable for quality control purposes to be sure that translated datasets are complete (polygons and points) and that parcel identification numbers match in the transformed results and the NCDOT base. For simplifying field translation in the second and subsequent rounds of parcel data upload and translation, the Project Team found that the most suitable source dataset for the first round is one from the county (authoritative) source. The first iteration will be time consuming as the source fields are matched to target fields, but subsequent iterations will employ the saved translation model that will not need more field matching except for any fields that have been changed in or added to the source data.

The Master Schema (Core Parcel Data Element Definitions (Appendix A) for the project) served the project team well. Hands-on experience with the NC data from sample counties revealed that a few minor edits were warranted to assure the practicality of the standard core attributes for parcels.

9. Quality Assurance

The Project Team found that quality assurance steps applied to the output of a job were effective in identifying a few minor flaws in field transforms. Flaws were much less frequent for counties where source files were well documented with field definitions. The quality assurance report prepared for EPA proved to be useful guide for checking the parcel data products.

10. Monitoring Participation

The Project Team will need to monitor the frequency of county uploads and transformations to meet currency goals. The Team has a goal of at least once a year, with twice preferred. The jobs generated by counties can be published at any time and with greater frequency if desired. The *NC OneMap* Database will be refreshed on a weekly basis to integrate new or updated county datasets in standard format. The Project Team will need to understand county parcel data update cycles to set expectations and communicate effectively with county data managers.

11. Applicability to Other Priority Geospatial Data

The Carbon Project, Inc. demonstrated the addition of a second Transformer group for North Carolina, representing governmental unit boundaries. The Carbon Project, Inc., completed a similar project for the Eastern Carolina Council under a grant from the Federal Geographic Data Committee that implemented an online tool for transforming street centerlines to a standardized set of attributes. The Transformer tools, focused on applying a Master Schema to uploaded polygons or lines, are relevant for address points where source files are likely to have a variety of fields and field names association with address locations.

5.2 Non-EPA Network Users

Share Data with Non-Node Data Consumers

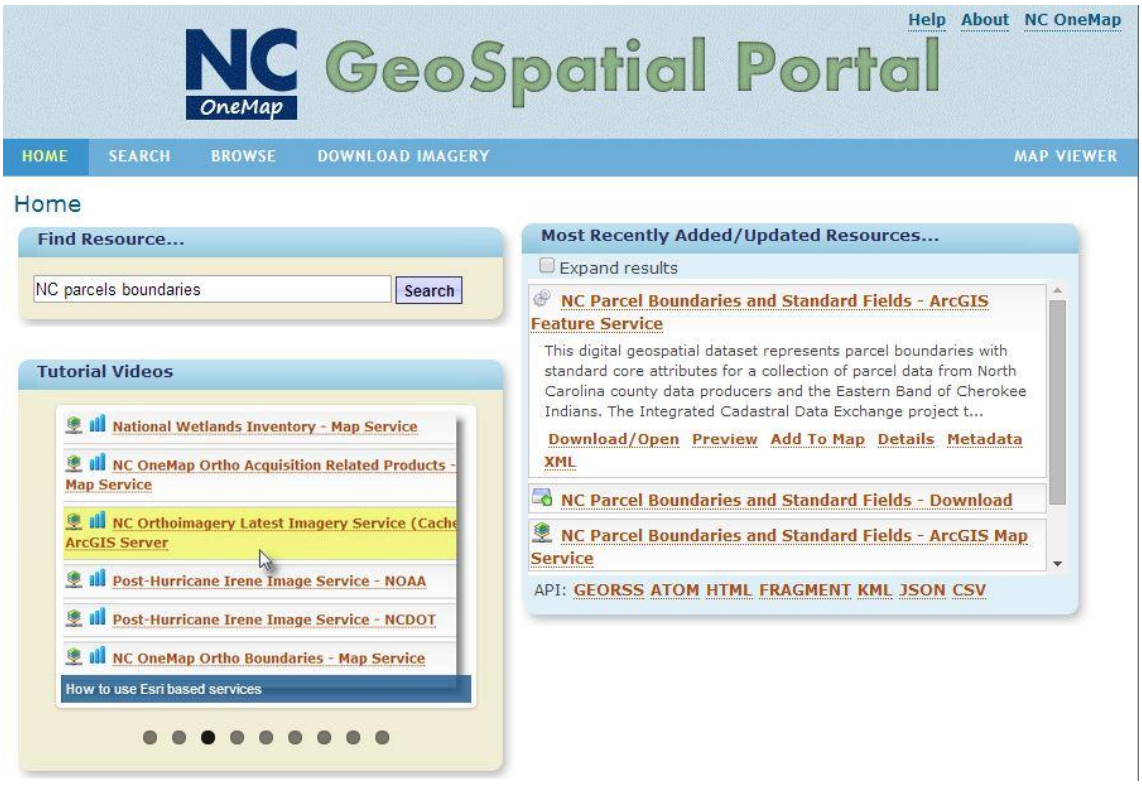
CGIA proposed and implemented a complementary data sharing solution for parcel data consumers outside of the Exchange Network to expand the reach of the Network. CGIA took advantage of the *NC OneMap* Geospatial Portal and *NC OneMap* database to generate web services and downloadable datasets for public discovery and access. See Figure xx. Applying ArcGIS Server, CGIA published Esri REST map services and feature services, as well as Web Map Services (WMS). Like the EN REST WFS, formats supported include JSON and GML. For convenient access users of ArcGIS Online for Organizations (AGOL), CGIA added the REST services to AGOL for discovery and access.

CGIA's role in accomplishing data sharing for non-node, non-authenticated data consumers has three facets:

Data download -- CGIA will ingest data from the Transformer on a routine basis and create data (zip packages by county) for download from CGIA map servers.

Services -- CGIA supports interoperability by generating additional web services (including WMS and REST) that do not require an Interoperability Extension for ArcGIS Server).

Data discovery – the *NC OneMap* Geospatial Portal enables users to discover parcel web services.



5.3 Project Performance Metrics

Several key metrics were developed to understand measureable benefits including workflow improvements, data quality improvements, and user access improvements. The improvements were measured against desktop and existing processes.

5.3.1 Workflow Improvements

In North Carolina, most GIS users in state and local agencies use Esri software tools for geospatial data management and processing. The effort to standardize parcel data is typically done in an ArcGIS desktop environment utilizing both ArcMap and ArcCatalog. The desktop processing steps might typically be as follows.

Desktop Standardization Process - Summary of Processing Steps

- ***Receive Source Data:*** Receive county parcel source data.
- ***Review Source Data:*** Review the data in ArcMap or ArcCatalog. ArcMap makes it possible to look at the table(s) simultaneously with the parcel polygon data to identify obvious gaps or other spatial issues.
    - ArcCatalog provides tools to review file layout and
    - ArcCatalog can be launched from ArcMap and vice versa. Arc Toolbox is available as needed in both ArcCatalog and ArcMap.

- Some processors may prefer to work in Access™ or other database formats but the spatial characteristics of the data improve data quality review and may assist in queries and searches.

- ***Data Crosswalk:*** Appendix D illustrates a sample crosswalk between Madison County NC provided data and the standardized data. The crosswalk can be a lengthy process and involves comparing county provided data attributes to the required standardized data and verifying the existence of standard attributes, and the processing required to establish a standard attribute.
- ***Change Detection of Previously Acquired Data:*** If the data has been previously standardized and a crosswalk document is available, compare the new source data to the crosswalk document. Identify any changes in the data and update the crosswalk document as needed.

  .*1.* ***Key elements*** *to review*
  - Source data file names, number of files and process dates
  - Number of parcels and data records
  - Note table name changes
  - Note field name changes
  - Verify field mapping compatibility for size/type
  - Verify data content – which fields (or part or combination of fields) will populate standard fields.
  - Review against imagery for alignment of structures and other features and boundaries, checking for source data coordinate system changes.

  .2. ***Note changes*** by updating the transforms.
- ***Verification and Formatting***

  .1. ***Working File:*** After the initial review of the source data, import the source data into a personal geodatabase (or file geodatabase) named "***COUNTYNAME***_*WORKING*". Create the working feature classes in the geodatabase.

  .2. ***Necessary Fields Only:*** When importing the source files into the personal geodatabase, take this opportunity to import only the fields needed so the resultant feature class is not cluttered with unneeded data.
  - Joins work better when the source files are in a personal geodatabase. Shapefiles often cause processing time limitations and incomplete joins.
  - ArcGIS version 10 file geodatabases increase the speed of processing as well as provide attribute indexes on fields to be used in joins.
- ***Joins:*** Create joins after all source files are imported into a working geodatabase or in a compatible Esri format.
  - If there are multiple tables begin with the table that has the fields that other tables are to be joined to (i.e. assessor file might hold parcel use codes that are needed to match to the use code look up table).
  - It may be helpful to also join an empty template dataset to the parcel data so the template will have an exact copy of all of the needed fields to be populated.
- ***Create New Working Feature Classes:*** After each join export the resulting feature class to a new feature class. Stacking joins decreases performance dramatically. This performance

problem can also be reduced if the fields being joined are indexed using the "Add Attribute Index tool" prior to the join.

- ***Verify Feature Class Attributes:*** After joins are completed and a full working feature class with all needed source fields are available to populate the target CADNSDI Standard feature class, conduct another review of the data set.
    - Do any of the fields need to be calculated to comply with the standard? For example: owner name or addresses may be a concatenation of several fields.
- ***Calculate Fields***
    - ***Field Calculations:*** Perform all calculations in the working feature class. This will typically require adding fields with standard name and format to the working feature class. If the join to a template dataset (Step 6) was conducted, these fields will already exist.
    - ***Field Names:*** Name all working or calculated fields the same as the target field name so when loading data into the standard feature class the load is mapped one to one.
    - ***Convert Number Types:*** Some of the calculations are transforming a double value field to a long. These can be done using either a temporary field or using an explicitly defined function for the conversion, i.e., int(<input double>). This had been addressed and fixed in CadNSDI version 2.
    - ***Beware of Bugs in ArcGIS:*** Note that earlier service packs of ArcGIS version 10 have some performance bugs, so if a tool function is used, verify that it produced the desired results before proceeding.
- ***Document calculations:*** Calculated field expressions are documented in the crosswalk documentation.

The source "working" feature class is now complete and is ready to be loaded into a CADNSDI Standard Feature Class

- ***Update Crosswalk Document:*** Update the new crosswalk document including notes on processing changes, parcel and structure counts, data providers, and attribute summary.
- ***Create Standardized Geodatabase***
  .1. ***Create Geodatabase:*** Open ArcCatalog and create new geodatabase
  .2. ***Name Geodatabase:*** Name according to the standard naming convention.
- ***Create Geodatabase Feature Class Parcel Polygons:*** Create a new feature class within the geodatabase using ArcCatalog. The feature class for the core parcel polygons has the same name as the geodatabase. If parcel points are available and not parcel polygons, add "Pts" at the end of the feature class name
- ***Coordinate System:*** Check coordinate system of the source County parcel feature class and the new target County parcel feature class; verify that all of the spatial data projection and extents are the same.
- ***Load Data into Feature Class:*** Using the "Data load" function in ArcCatalog (right click on the empty dataset), load the source data into empty target feature class in mapping the

fields according to the crosswalk document. If the names from the source feature class are different than the standard field names the matching of fields is done one-by-one.

- ***Validate Data:*** Validate all fields and naming conventions and validate that all data records have been loaded.

Standard Parcel Data set is now complete

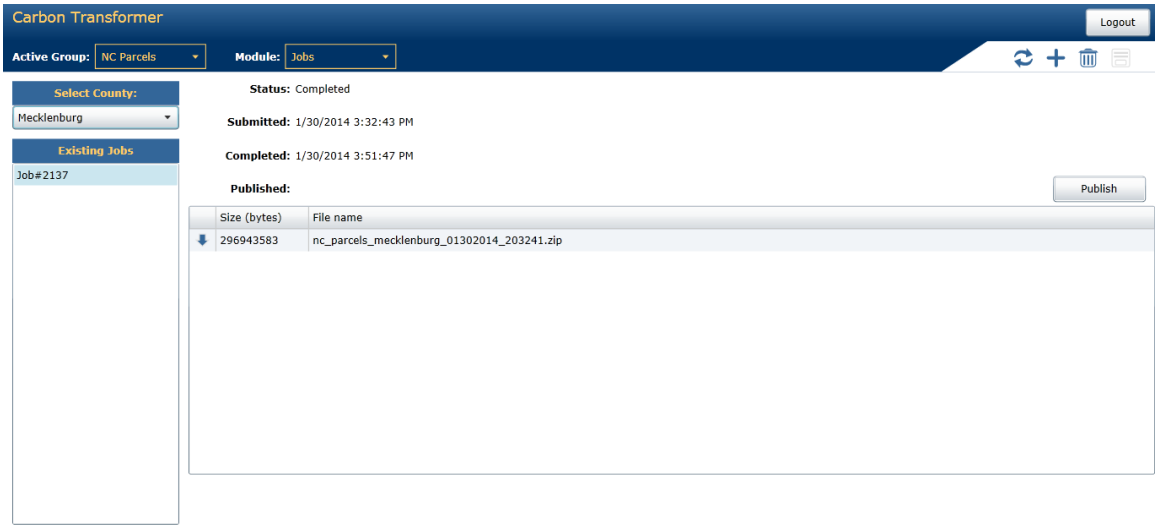
In comparison, the steps to create standardized parcel data using the NC Parcel Data Transformer are the following.

Transform Engine Process

- ***Receive Source Data:*** Receive county parcel source data.
- ***Review Source Data:*** Review the data in ArcMap or ArcCatalog. ArcMap makes it possible to look at the table(s) simultaneously with the parcel polygon data to identify obvious gaps or other spatial issues.
    - ArcCatalog provides tools to review file layout and
    - ArcCatalog can be launched from ArcMap and vice versa. Arc Toolbox is available as needed in both ArcCatalog and ArcMap.
    - Some processors may prefer to work in Access™ or other database formats but the spatial characteristics of the data improve data quality review and may assist in queries and searches.
- ***Data Crosswalk:*** Appendix D illustrates a sample crosswalk between Madison County NC provided data and the standardized data. The crosswalk can be a lengthy process and involves comparing county provided data attributes to the required standardized data and verifying the existence of standard attributes, and the processing required to establish a standard attribute.
- ***Change Detection of Previously Acquired Data:*** If the data has been previously standardized and a transform is available, compare the new source data to the existing transforms. Identify any changes in the data and update the transforms.
- ***Run Test Transform -*** Select the number of records to review in the test and compare the original data set to the standardized data, check for error log notes. If necessary update transforms and rerun.
- ***Run Transformation***

Standard Parcel Data set is now complete

Note that the transformer approach is not only fewer steps but it also produces an error log, metadata for the standardized data sets (see Appendix E), and point and polygon data files.



Measureable Improvements

- The number of steps required from beginning to end is greatly reduced, thus reducing the chance for error.
- The transforms are saved and are easily reused with the transformer, reducing the "next" time processing time.
- The creation of the parcel points occurs as part of the transformation. In ArcMap, parcels with bad geometry will stop the point creation process making it difficult and time consuming to complete the point generation. The transformer reports errors but continues to process until all possible polygons have a parcel point or a report as to why the point could not be computed.
- The time required for the desktop processing varies from about 3 hours at the very best to as much as 8 hours per county. On average it is about 4 to 4 ½ hours per county. The transformer completes this process with the generation of metadata and the error log in anywhere from 30 minutes to 1 ½ hours with a typical county taking about 1 hour from beginning to end the first time and about 15 minutes for subsequent runs.

5.3.2 Data Quality Improvements

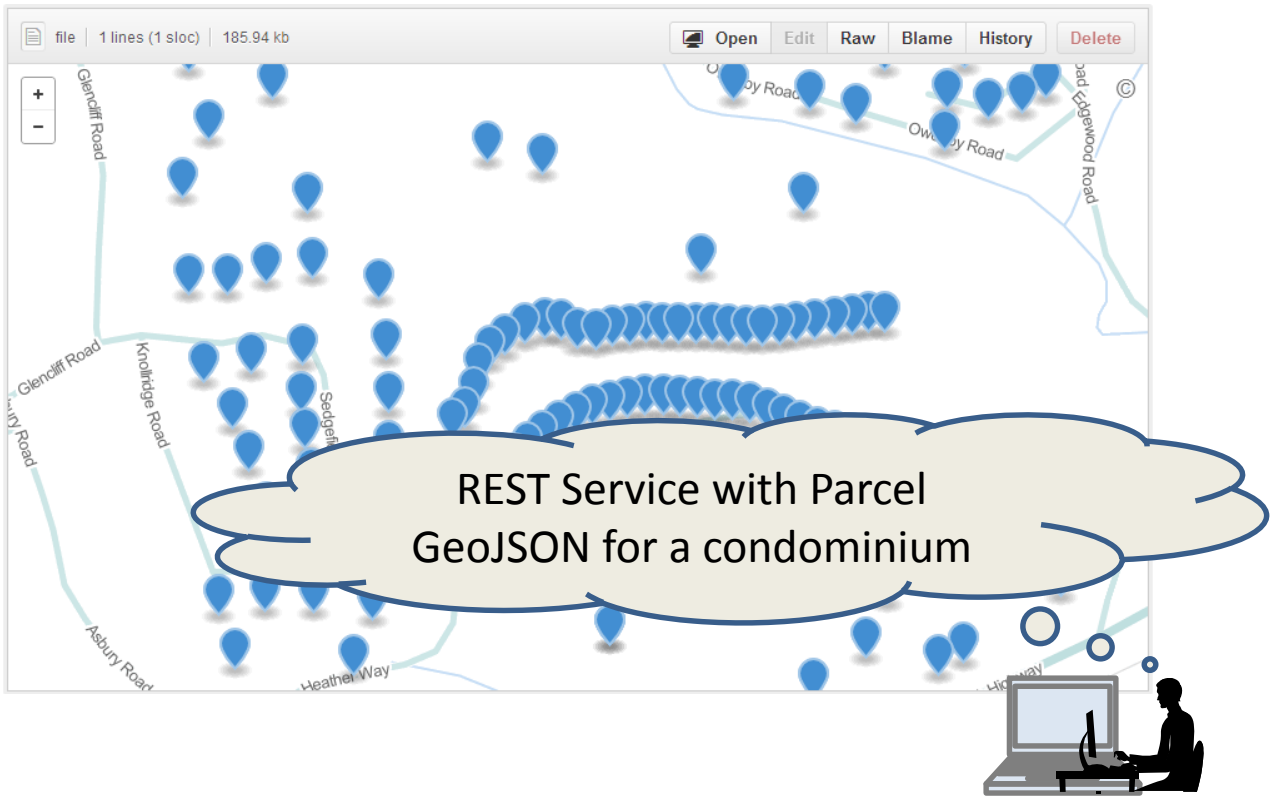
The standardized data represents an improved data quality because the data content is more readily understood and consumable by applications. The field names are the same across county boundaries and coded values are translated to their text or descriptive content, making it easier to understand and apply the data.

Additionally the transform errors help the data producer understand where data improvements could be made or where corrections to the data would improve data quality.

5.3.3 User Access Improvements

The current access to parcel data is county-by-county, requiring a statewide data user to make 100 data requests, which can take several weeks to complete. Data may be proved in many forms including GIS data with related tables, shape files, geodatabase, and other formats. In some cases data can be downloaded but in other cases there must be a data request and a physical format, such as CD or DVD may be needed.

Having all of the available parcel data at a single source makes access immediate and in a consistent and standard form and format.



5.4 Realizing Benefits

5.4.1 Data Producers

The benefits to the data producers for the data sets provided are (1) to provide a review of data quality, (2) to provide metadata documentation of the standardized data set, and (3) to provide an archive of the source and standardized data as required by North Carolina State Statute. The data quality review included a check of the geometry through the generation of a parcel polygon point. If a parcel point could not be generated from the parcel polygon the polygon was identified as a polygon in need of geometry repair. The attribute quality check looked at the field length, for example did the owner name extend beyond 200 characters, which may not

have been an error but would be an indication to the data producer that the field was truncated in the standardized data, and field type verification, for example if a field was supposed to be a date field but could not be transformed to a date this was flagged in the error report.

Other benefits included increasing the cooperation, communication, and collaboration among the North Carolina parcel data producers, and identifying areas where future standardization within local data sets would benefit other programs. For example, standardizing the identification of exempt properties would increase compliance with the North Carolina Department of Revenue AV50 filing requirements. In the long run this will reduce the level of effort by the local entities to comply with state reporting requirements and increase the re-usability of the data for statewide analysis.

5.4.2 Data Consumers and Consumer Data and Process Needs

The benefits and uses for the standardized parcel data grew continually throughout the project. To summarize and capture some of the uses and benefits for the data, the following table was developed that summarizes the key indexing and query fields used by various applications and a summary of the uses.

The example query is used to identify "essential core attributes" and also to summarize some of the identified uses or applications for the data set.

Example Query	Statistics	Display	Purpose	Analysis
Select parcels where STRUCT = 'Y'	Count	Selected points over base map	Look for magnitude and clusters of properties with structures (e.g., to identify areas to prioritize for defense against a wildfire).	Point density; count within an area of interest; count within a distance of an event (e.g. wildfire).
Select parcels where MULTISTRUCT = 'Y'	Count	Selected points over base map	Housing analysis that includes apartments and condominiums.	Point density; count within an area of interest
Select parcels where STRUCTNO > 0 (or MULTISTRUCT = 'Y')	Count and sum	Selected points over base map	Useful in analysis of housing stock and related purposes relating to demographics, public health, and education to name a few.	Number of structures in area of interest; count within a distance of an event.

Example Query	Statistics	Display	Purpose	Analysis
Select parcels where STRUCTNO > 0 and IMPROVVAL > $2,500	Count of parcels; sum of parcels; sum of IMPROVVAL	Selected points or polygons over base map	Useful in analysis of buildings (excluding out-buildings or minor structures).	Number of structures in area of interest; count within a distance of an event.
Select parcels where STRUCTYEAR < 1996	Count of parcels; sum of IMPROVVAL	Selected polygons over base map and thematic layers such as flood hazard areas	Useful for identifying structures built before a year of interest (e.g., beginning of a flood insurance program) for purposes of natural hazard mitigation and other planning applications.	Selected polygons intersecting flood hazard areas.
Within an area of interest, select parcels where STRUCTYEAR > 2011	Count of parcels, sum of IMPROVVAL, mean IMPPROVAL	Display with jurisdictional boundaries such as school districts	Public school planning where new homes are related to enrollment projections.	Select subset; select residential parcels based on PARUSDESC, SUBDIVISION, or other local data that indicate residential use.
Select parcels where IMPROVVAL < $2,500	Count of parcels; sum of GIS ACRES	Selected polygons over base map	Identify vacant land (excepting minor structures) for economic development purposes; dollar threshold varies.	Polygons intersecting an area of interest or within a specified distance of an interstate highway interchange.
Select parcels where PARVAL < LANDVAL + IMPROVVAL	Count of parcels; sum of GISACRES	Selected polygons over base map and thematic layers such as military flight training routes.	In some but not all counties, parcels with “Present Use Value” may have a PARVAL that meets this condition. The purpose is to identify lands in farm and/or forest production to map “working lands.”	Creation of subset for planning, e.g., farmland preservation, or selection of “working land” polygons intersecting military flight training routes.

Example Query	Statistics	Display	Purpose	Analysis
Select parcels where GISACRES > 15	Count of parcels; sum of GISACRES	Display polygons on base map with streams, land cover, and other environmental features	Land conservation planning; recreation planning (e.g., state park land); water quality analysis; natural heritage area analysis	Select polygons intersecting or within a distance of environmental features of interest
Select parcels in an impact area defined by users (may include parts of multiple counties)	Count of parcels; sum of LANDVAL; sum of IMPROVVAL	Display on base map with county boundaries and municipal boundaries for reference	Damage assessment after a natural hazard event; public health analysis; wildland fire response	Select polygons intersecting an impact area
Derive ownership and other property attributes for properties where environmentally regulated facilities are located.	Sum of GISACRES for selected polygons	Display with vectors such as streams and/or roads	Monitoring regulated facilities such as septic systems that are tied to property; emergency response where owner notification is urgent	Join polygon attributes to facility points (join by location, point in polygon) and analyze joined table. Prepare a join table to join to parcels in area of interest and derive a subset of parcels that take on facility attributes.
Within an area of interest, select parcels where STRUCTYEAR > 2011	Count of parcels, sum of IMPROVVAL, mean IMPPROVAL	Display with jurisdictional boundaries such as school districts	Public school planning where new homes are related to enrollment projections.	Select subset; select residential parcels based on PARUSDESC, SUBDIVISION, or other local data that indicate residential use.
Within a jurisdiction of interest, select parcels where SALEDATETX > date of interest	Sum of LANDVAL, IMPROVVAL, PARVAL; SUM of STRUCTNO	Display over base map	Public school planning where home sales are related to enrollment projections	Select subset; select residential parcels based on PARUSDESC, SUBDIVISION, or other local data that indicate residential use.

Example Query	Statistics	Display	Purpose	Analysis
Land value per acre calculated	Sum of LANDVAL; mean LANDVAL	Display parcels symbolized by value per acre	Commercial and residential development; environmental analysis	Calculate a new field LANDVAL/GISACRES
Building value per acre calculated	Sum of IMPROVVAL; mean IMRPOVVAL	Display parcels symbolized by value per acre	Commercial and residential redevelopment; natural hazard mitigation; housing analysis	Calculate a new field IMPROVVAL/GISACRES
Future 1(when more counties have values for PARUSECD and PARUSEDESC that are consistently classified): select parcels by land use type	Count of parcels and sum of GISACRES by land use type of interest	Display over orthoimagery or slope (elevation) raster; display with streams and other base map layers	Economic development, working lands analysis, land under military air training routes, wildlife habitat assessment, recreation planning, land conservation planning, natural hazard mitigation planning, housing analysis	Select by PARUSECD in an area of interest
Future 2 (when more counties have values for OWNTYPE that are consistently classified): select parcels by owner type	Count of parcels and sum of GIS ACRES by owner type	Display with base map layers	Planning purposes where plans and policies differ by ownership type (e.g., hazard mitigation strategies for local government and state government properties versus strategies related to privately owned property).	Select by OWNTYPE in an area of interest

After release of the EN WFS REST and REST services from *NC OneMap*, the Project Team prepared examples of using web services in desktop GIS. In the first example, a parcel web service from *NC OneMap* is displayed with a transportation feature (NC Railroad Company line along Church Street in Cary) in the vicinity of the boundary between Wake and Durham Counties. See Figure 1. The fields describing this selected property and fields for parcels in the adjoining counties are the same, enabling analysis and consistent mapping.

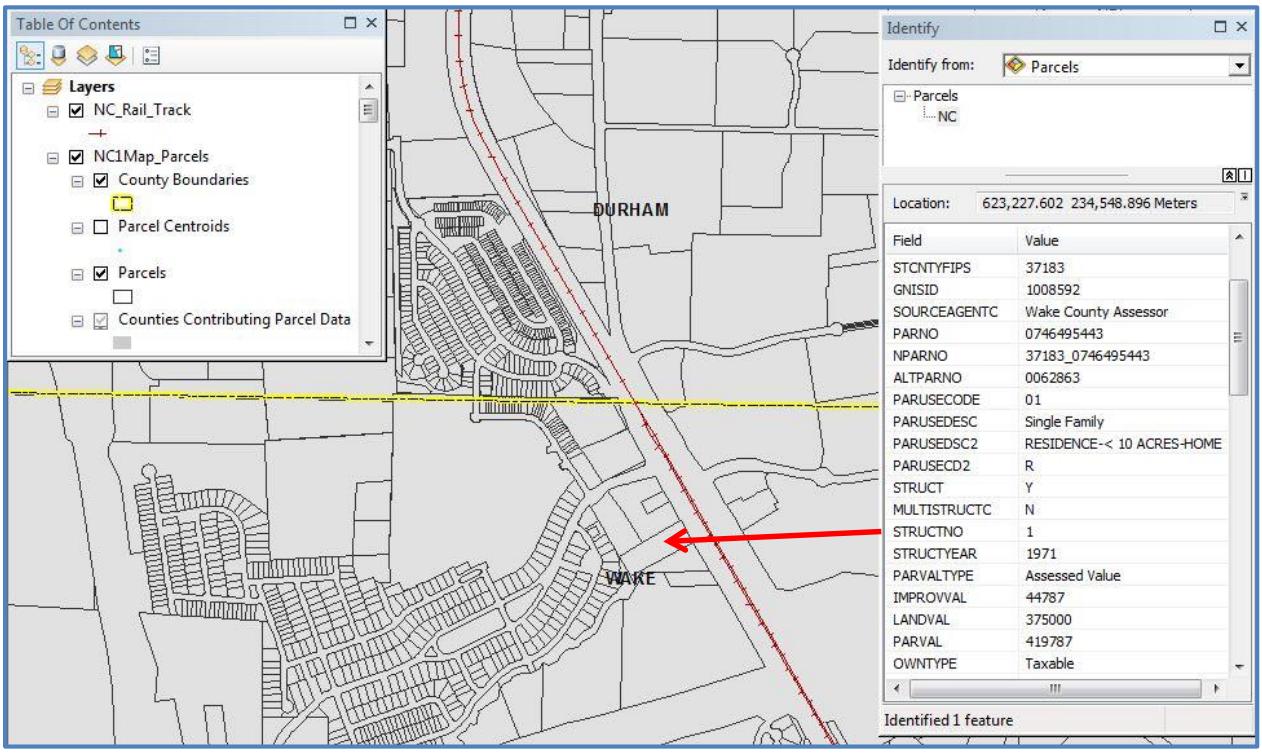


Figure 4. NC Parcel Data Example, Selected Parcel, Wake County

In a second example, an economic development agent, using base map web services from *NC OneMap,* can narrow a search for suitable sites and spend less time on site visits. In Figure 2, statewide 2010 orthoimagery, 4-foot elevation contours, and parcel boundaries provide a quick look at a selected parcel on the boundary of Wake and Johnston counties.

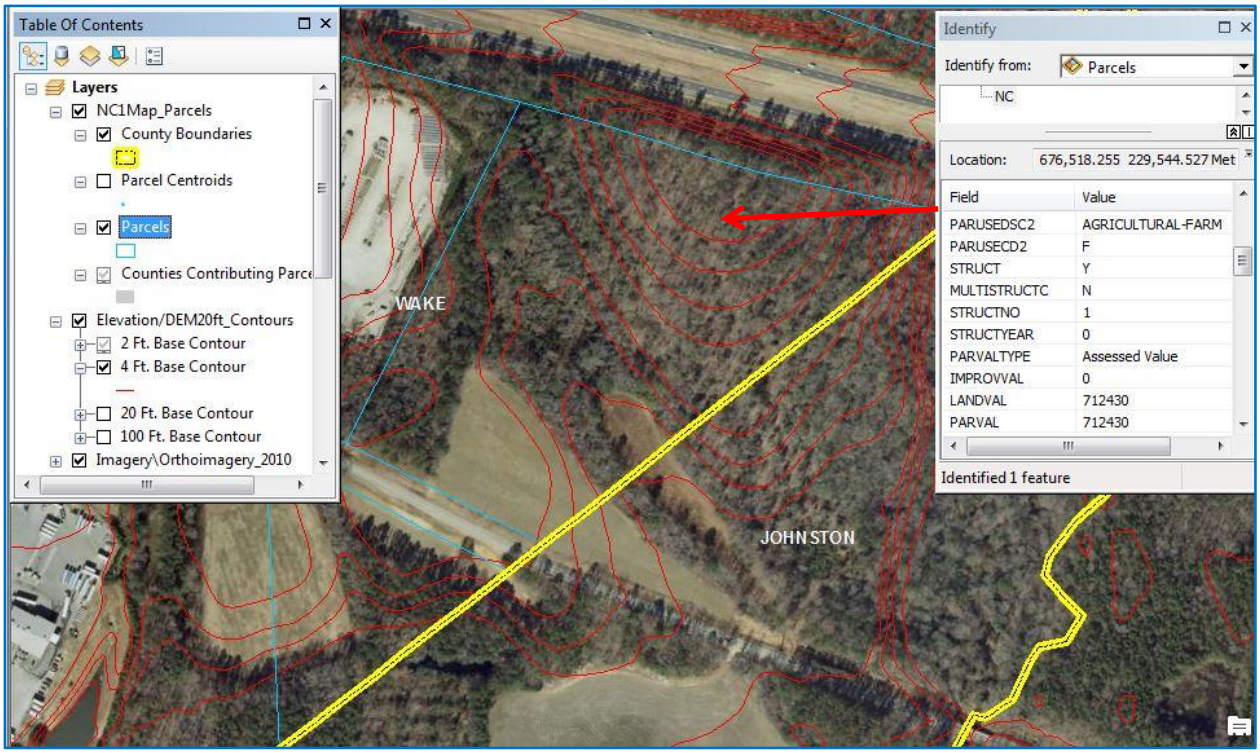


Figure 5. Example of Base Map Datasets Applied to Economic Development Business Process

With the exception of parcels (currently one-fourth of the state completed by this project), high priority statewide datasets in North Carolina are complete and in the process of updates and improvements to better support data consumers across the state.

To address growing interest in cloud-based geographic information solutions among State Government GIS Users in North Carolina where an Enterprise License Agreement with Esri includes ArcGIS Online for Organizations, the project team demonstrated the utility of REST map services generated from ArcGIS Server.

CGIA tested the NC OneMap parcels map service using North Carolina's ArcGIS Online for Organizations account. The following steps were successful.

- Add NC OneMap parcels map service to North Carolina's ArcGIS Online account (Figure 6)

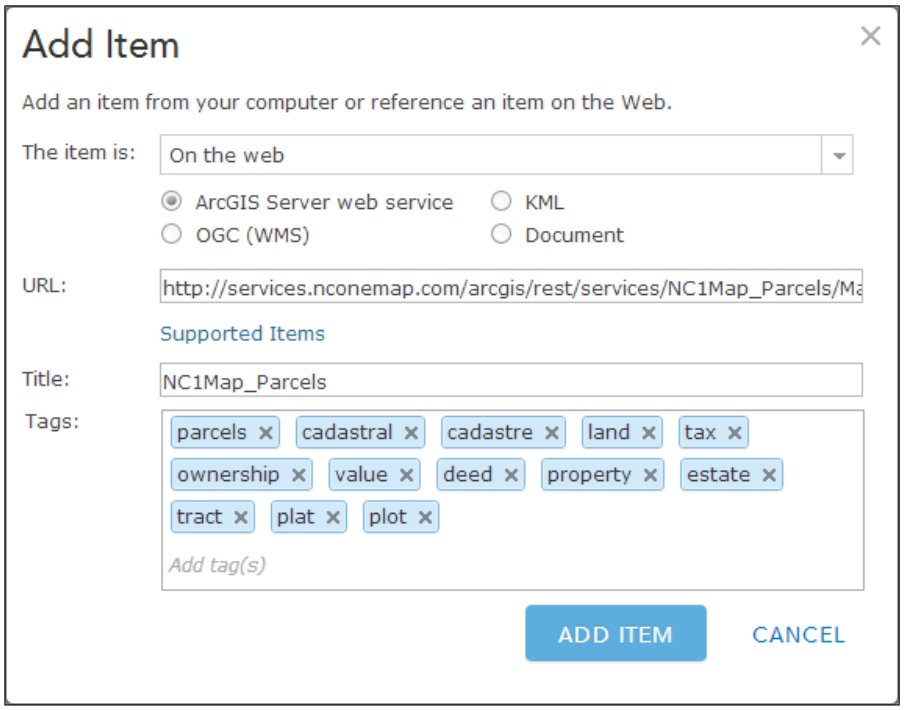


Figure 6. Add ArcGIS Server Web Service to ArcGIS Online

The addition was successful as displayed in Figure 7.

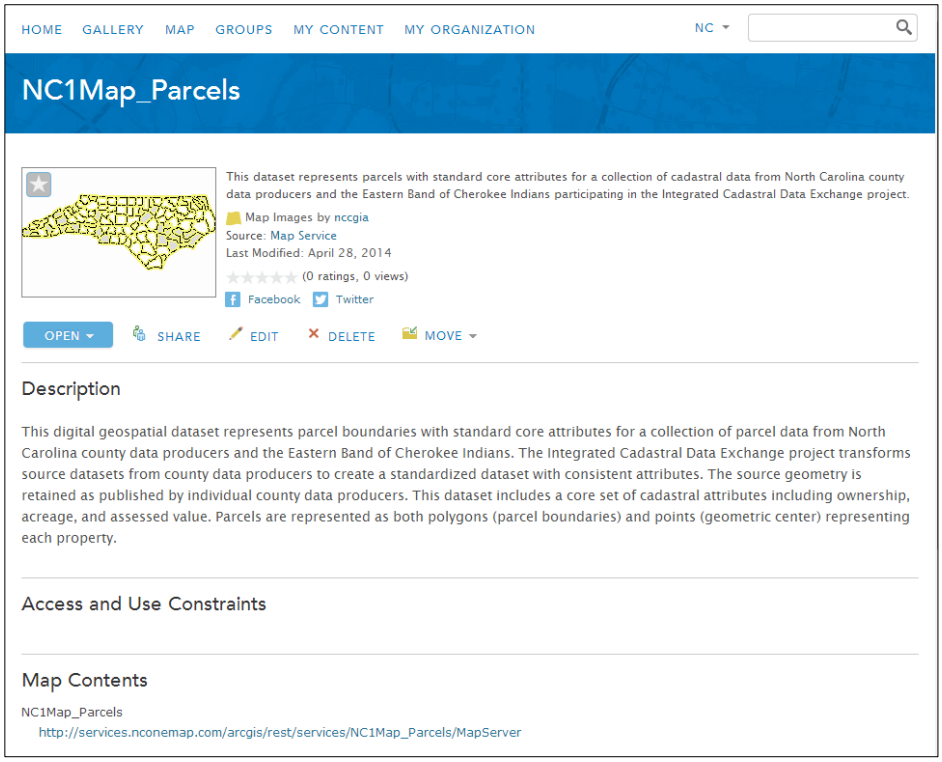


Figure 7. Parcels Map Service Description in ArcGIS Online

- Display the NC OneMap parcels map service in an ArcGIS Online map (Figures 8 and 9)

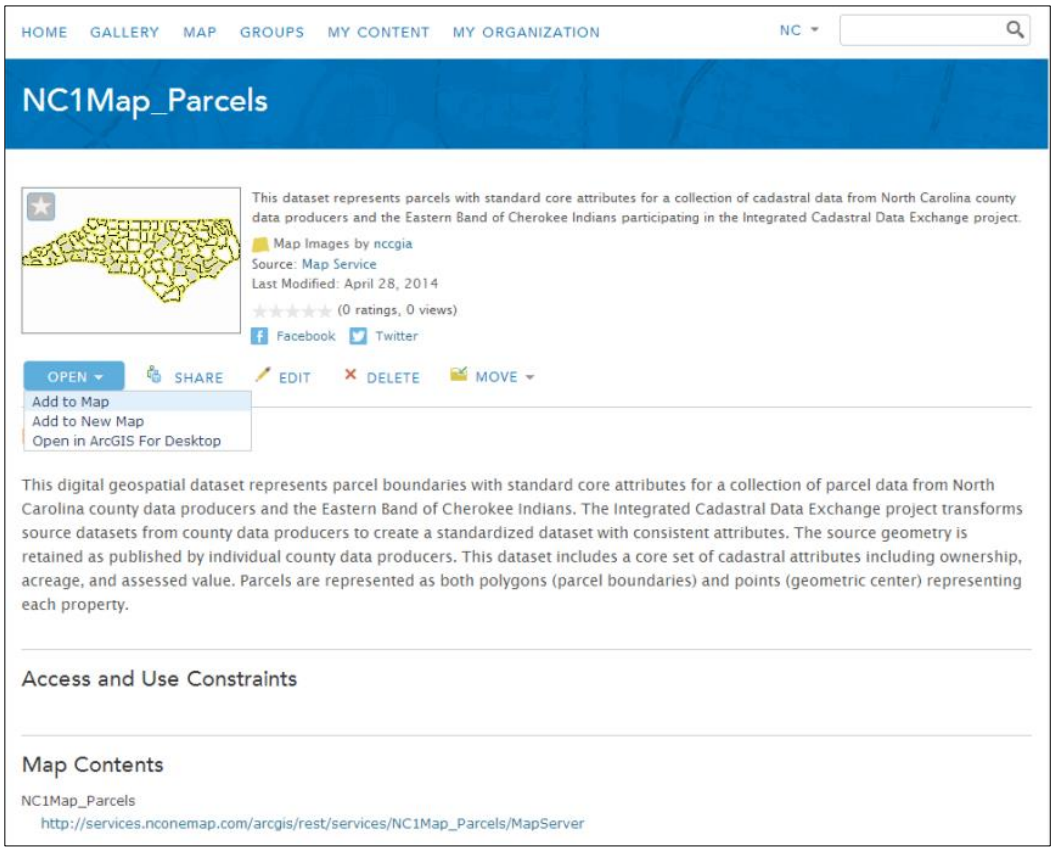


Figure 8. Select the Add to Map Function in ArcGIS Online

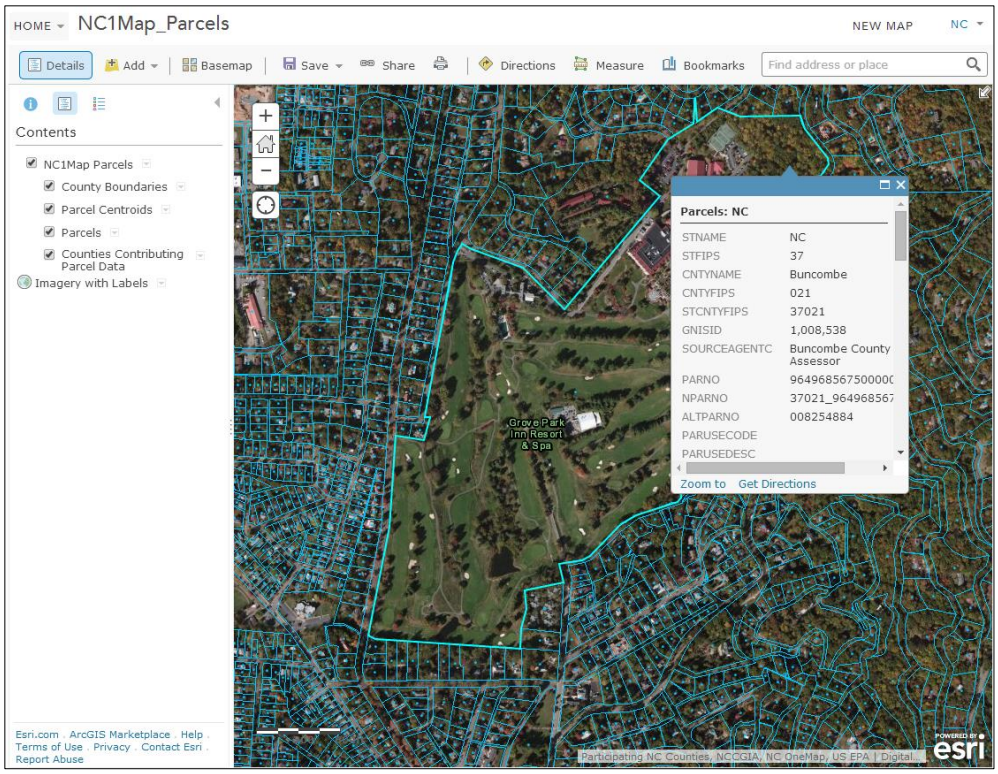


Figure 9. Example of NC Parcels Displayed in a Map in ArcGIS Online

Access Parcel Data as an ArcGIS Online Service

CGIA tested NC Parcel data as an ArcGIS Online Service in desktop GIS (ArcMap). The following steps were successful.

- Access the NC OneMap parcels map service in a non-node application (e.g., ArcMap), display over an imagery service, and check the layer properties. See Figure 10.

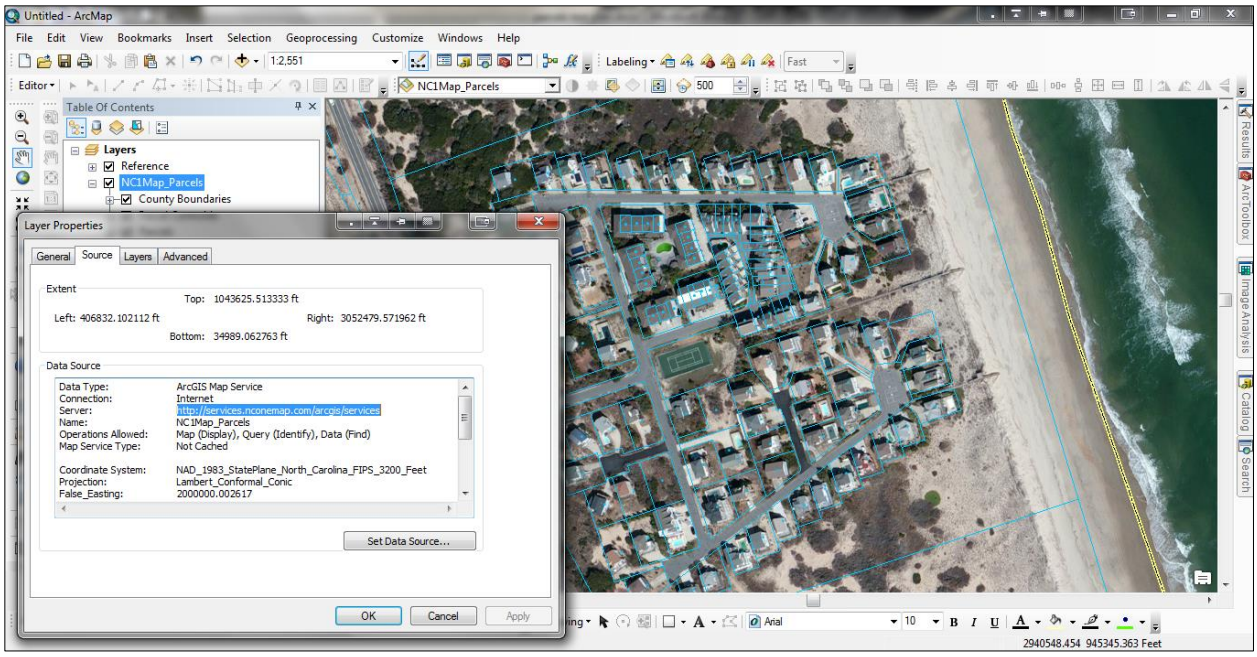


Figure 10. Example of NC Parcels Map Service from ArcGIS Online Displayed in ArcMap

5.5 Applicability to Other States

The NC Parcel Transformer and Master Schema are suitable for application with parcel datasets in other states. A project imperative was to develop a Master Schema consistent with the Federal Geographic Data Committee core parcel content standard and applicable to use cases nationwide.

Specifically, the Master Schema includes fields for the state FIPS code, state and county FIPS codes combined, the county GNIS Identifier, and a generated nationally unique parcel identification number equal to the source unique parcel identification number with the state and county FIPS codes added to the beginning of the source parcel identification number (e.g., 37081_123456789012 for state 37, county 081, and source parcel number 123456789012). Those fields are populated from a lookup table based on the county name, reducing data entry errors and assuring the information is included. Master Schema fields for site address include a defaulted value for state abbreviation. The Master Schema fields for property descriptors (e.g., land value, presence of structure, area, etc.) are applicable in other states as core standard fields. The lookup tables would need to be updated to accommodate municipal or other local government parcel data providers. This may require an added field for municipal FIPS for example.

Populating the standard fields in any state is constrained only by the specific parcel data fields that source data managers are willing and able to share and publish. The approach of the NC Parcel Transformer is to accept parcel geometry "as is," an approach that is not affected by state-specific parcel boundary anomalies and discrepancies. Source data managers remain responsible for resolving inconsistencies between and within source jurisdictions.

6. Lessons Learned

6.1 Tracking stakeholders

County data managers are essential contacts for developing quality content for integrated parcel data. CGIA maintained a database for contacts that proved valuable in data sharing and communication with GIS managers. The list of contacts on the *NC OneMap* and GICC websites would be more valuable if it were generated dynamically for the database, which it is not currently. The Land Records Management Program also maintains a list of land records managers and property mappers that is valuable for questions about Computer Assisted Mass Appraisal and access to local data dictionaries.

6.2 Presentations

The Project Team confirmed through multiple presentations that engaging project stakeholders at their meetings is most effective in reaching more people, responding to questions, and conveying the information. The team presentation led by Nancy von Meyer at a meeting of the North Carolina Property Mappers Association was a prime example. Sample presentations are included in Appendix F.

6.3 Hands-On Sessions

Stakeholders learn best when they can operate the software - webinars or hands-on sessions are most effective. The concept of training the trainers worked well for staff of the Land Records Management Program, CGIA, and NCDOT.

6.4 Source Data Availability and Quality

The Project Team found the following:

- Data was not developed with the core attributes in mind, therefore is takes some processing of the data to, for example, determine if a property has a structure on it.
- Once the data fields are standardized, the Project Team found inconsistencies in the attribution within the data sets. For example, one source field might indicate a parcel is vacant but there is a building value associated with the parcel. It appears that either two systems may be tracking information or one attribute is updated and the other dependent attributes are not updated.
- Ascertaining the types of values in the data sets is a challenge. The data dictionary may indicate that an attribute is the taxable value, but then properties that are clearly exempt will have a value for that attribute.
- Determining the type of owner (federal, state, county, local, private, non-profit, international, etc.) is very difficult. In a few cases the names could be sampled but in general just determining taxable versus non-taxable was challenging enough.
- The use of names in any field is problematic. For example the US Government as a landowner is listed and misspelled in a variety of ways, making it difficult to identify

federal landowners in a data set. Similarly attributes that contain the word "Exempt" were found to have a wide variety of misspellings.

- The use or non-use of leading spaces makes data querying difficult. For example in many counties the site address street direction was provided as "E" and as " E" or as "E ". The hidden space in the data set makes concatenation difficult but also complicates data queries and standardization.
- Duplicate parcel numbers can arise from condominiums where the one parent parcel has many dependent parcels. In some cases uniqueness can be determined by appending an alternate parcel number or a suffix to the parcel number, but not always.
- In some instances, parcels are mapped as multiple polygons with a common parcel identification number, e.g., a forested parcel under single ownership divided by roads. The operation of joining a table exported from a computer assisted mass appraisal system to parcel geometry, based on parcel ID, can result in numeric fields that contain joined values representing the entire property for each of the polygon records that make up the full property. Users need to account for those records to avoid double counting items such as land value.

6.5 Technology

The Project Team found the following regarding technology:

- An FTP Site for Source Data was valuable in getting started.
- The Transformer is very powerful but the use of the transforms needs to be clearly explained and may be better illustrated with videos or hands on sessions.
- It may be more efficient to have a state agency or a series of state agencies develop the initial transforms for each county and have the counties run their data through the standardization but not have to learn and build the transformations.
- The data flow needs to be clearly articulated in the architecture. The standardized data is exposed through REST and WFS services and then consumed by the EPA Network as well as the NC One Map. Depending on the specific formats and interoperability, web services can be consumed using GIS software including ArcGIS desktop, ArcGIS Online, and ArcExplorer (Esri software), computer aided design software, or Google viewers to name some of the most common.

Regarding security, ITS Security recommended the North Carolina Identification System (NCID) as the security solution for user authentication. Inside the Transformer, security measures assigned roles to registered, authenticated users at three levels: system administrators, group (i.e., parcels) administrator for approving accounts, and users (i.e., county and tribal data contributors). The Project Team expressed concern that most local government users have no experience with NCID, may find registration to be time consuming, and would be required to update NCID password every 90 days. Development and implementation of NCID for the Transformer was challenging even with timely and effective technical support from NCID. For State agency users, NCID was very convenient for registration with the application and login.

6.6 Project Management

CGIA managed the grant project through the North Carolina Enterprise Project Management Office's Project Portfolio Management system. Lessons learned in project management were the following.

Business Case

Based on advice from the North Carolina Office of State Budget and Management, the business case needed to be more specific in how the tool and products will create tangible benefits to data consumers. Time-savings for GIS staff are not sufficient as benefits. The Project Team described and illustrated cases where the products will provide consistent, complete, reliable visual reference for emergency response, economic development and other consumer business processes. The following two examples supplemented the original business case.

1. Example of Building Value in a Sample Wildfire Impact Area

The benefits of complete, consistent, current, reliable geospatial data for parcels (property boundaries and value information) to emergency management are difficult to measure because of the unpredictablilty of natural disasters. Nonetheless, to put the total cost of ownership for the NC Integrated Cadastral Data Exchange ($1.2 million) in context, consider a selection of 17 parcels in western Henderson County near forested areas. See Figure 11. The total assessed building value for those 17 properties (all with building value greater than $1,000) is $1.3 million (Henderson County 2013). In the event of a wildfire approaching those properties, if well informed fire fighters had a parcel dataset for the area (and for the adjacent counties) to quickly display properties with buildings, damage to the buildings might be prevented. For the 17 properties alone, property damage avoided would exceed the cost of the project.

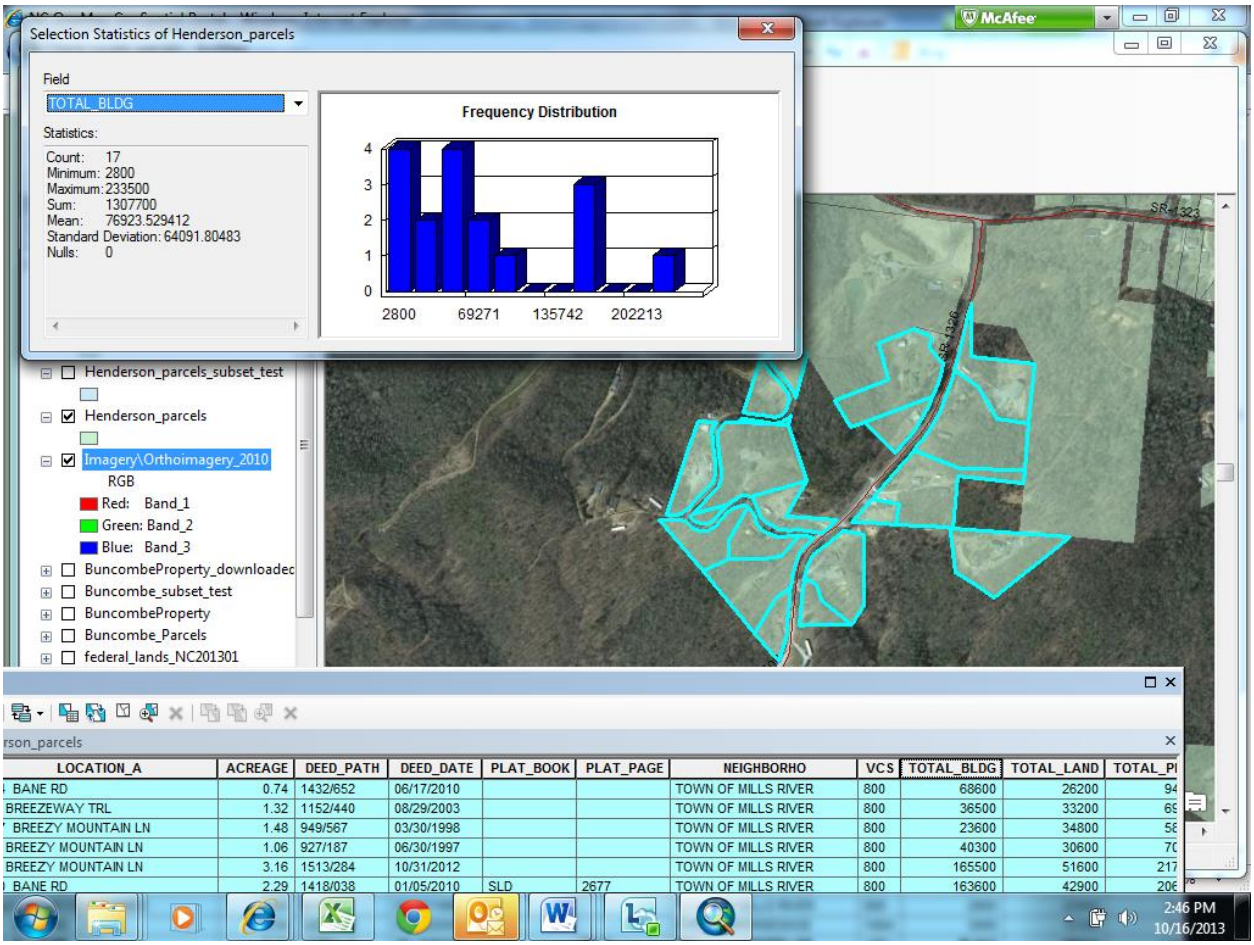


Figure 11. Selected properties in western Henderson County, NC as a Sample Impact Area. The green shaded land parcels have building value over $1,000. The blue outlined parcels (17 properties) were selected as an example of parcels with buildings near a forested area. If these properties were threatened with a wildfire, well-informed fire fighters, with a display like this to identify properties with buildings in harm's way, could prevent property damage. The building value on the 17 selected properties sums to $1.3 million, or about $100,000 more than the total cost of ownership for the project to develop statewide integrated parcel data.

2. Scenarios that Illustrate Benefits of Accessible Integrated Parcel Data for North Carolina

Property boundaries, ownership, value of structures, and other descriptions of what is on the ground are invaluable in emergency preparation, response, recovery, and hazard mitigation planning. The NC Integrated Cadastral Data Exchange project will produce parcel data (property boundaries and related property information) compiled from county data producers, integrated in a standard format, and published as downloadable data and as web services, readily accessible to users of geographic information systems in State agencies. The integrated data will support emergency operations and planning in ways that save time, property and even lives.

This project uses a collaborative approach to enable county data producers to share authoritative parcel data with a central database from which standardized geospatial information is accessible to data users. The products will benefit State agencies in business processes related to emergency preparation, response, recovery and mitigation planning. Staff supporting those processes will expend less time on acquiring and processing the county-

produced parcel data for multi-county applications, and spend more time focused on applying the data in situations where timely response is essential. Staff will more effectively inform plans and operations with maps based on current, complete, consistent parcel data that reveal patterns of properties with structures, viewed in the context of impact areas relating to emergency events.

For example, three emergency scenarios take advantage of multi-county, standardized, accessible parcel data to save time, money and even lives.

Scenario 1: Hurricane Response and Recovery
A hurricane hits eastern North Carolina and knocks out electric power service in four counties; heavy rain and storm surge create flood conditions that damage homes and businesses and prevent county information technology staff from getting to work. County parcel data would inform emergency response and recovery operations, but county servers are down in the impact area. Accessibility of integrated parcel data from servers outside of the impact area enable staff of NC Emergency Management and other agencies to produce timely information to (1) display the extent of the hurricane impact to the Governor and emergency managers, (2) estimate damage (with information about owner type, land value, building value, land use) to inform disaster relief and recovery. Having the data processed, standardized and accessible in advance saves valuable time and enables emergency managers and geographic information specialists to focus on emergency communications, response logistics, and custom mapping. The pre-processing need not be done by multiple agencies, just once by the Integrated Cadastral Data Exchange project.

Scenario 2: Wildfire Response
A wildfire ignites and spreads quickly in western North Carolina in windy and dry conditions. The impact area covers parts of three counties. A single online source of parcel data for the multi-county impact area, with standardized information about land with buildings, enables the NC Forest Service and other wildfire responders to display vulnerable properties in forested areas and respond accordingly. Fire-fighting measures can save homes and even lives when timely information is available to inform ground operations.

Scenario 3: Animal Disease Outbreak Response
A communicable swine disease outbreak in the Piedmont affects livestock operations in parts of neighboring counties. The Department of Agriculture and Consumer Services maps the incidence of disease and applies parcel data and other geospatial data to define an area of risk around those facilities. Ready access to multi-county, standardized parcel data, recently integrated, enables emergency responders to focus on notification of animal operations and related trucking operations to contain the outbreak, reducing losses of livestock for the agricultural industry.

In addition to the three scenarios, integrated parcel data is beneficial for tasks that help mitigate damage and/or aid disaster recovery. Two examples:

a. Hazard Mitigation Planning

Effective hazard mitigation planning relies on property information in locations that are vulnerable to hurricane storm surge, flooding, wildfire, and other natural hazards. An accessible, integrated parcel dataset saves staff time in estimating potential property damage and potential savings from mitigation measures. Consistent, current, complete parcel data make a more convincing case for taking action to avoid damage, with potential savings for citizens and businesses.

b. Transportation Planning

An emergency event may include damage to roads and bridges. Disaster recovery may involve reconstruction in the same highway corridor or, in coastal areas, a modified route or new bridge location. Access to current, consistent parcel data informs highway plans and guides notification of property owners in project areas. Ready access to the data enables the Department of Transportation to focus on analysis of modified routes and production of timely maps to inform planners.

These examples represent a few of the practical applications of integrated parcel data that inform timely response, targeted recovery, effective planning, and public decisions that can save time, property and even lives. The NC Integrated Cadastral Data Exchange project will develop ways to efficiently transform parcel data to a consistent, multi-county dataset, and make it accessible and consumable online for these example applications and many more public and private business processes.

Project Management Process, Documentation and Communication

Time spent by the Project Team on details of the Request for Proposal proved valuable in the Project Team evaluation of proposals from multiple vendors. The Project Team reached agreement on a sound evaluation and selection of the application development vendor. The details of the vendor proposal, matching the level of detail in the RFP, served the Project Team well in tracking progress and providing timely review for modifications in the iterative development process.

Bi-weekly status meetings were valuable in keeping tasks on track and engaging project team members. Use of single points of contact for the vendor team and the project team held in most cases, to the benefit of project communication. Some direct contact between vendor team and project team members was valuable in several cases for problem resolution and/or technical explanations.

Completing the database design, finalizing the Master Schema for data, and transforming the 25 counties early in the project was valuable in testing and modifying the online Transformer application. Having the actual data in the tool and evaluating actual output helped keep on track the iterative development of the Transformer and the related generation of web services. The approach also helped the project achieve 25 percent completion to meet a provision of the grant agreement with US EPA in a timely way to justify and receive an essential 6-month extension.

The project team created valid geospatial metadata (Federal Geographic Data Committee, Content Standard for Digital Geospatial Metadata) for the integrated multi-county datasets (See Appendix E) and for individual counties where county names and dates are inserted in the data flow.

The Carbon Project's cloud hosted applications were deployed efficiently. Considering the limited CGIA staff time available for technical support to application development and database development, cloud hosting was convenient for the grant project.

The Project Team and the Vendor focused on project deliverables and produced iterations early enough in the project to enable modifications that improved the usability of the tools and datasets. The EN REST endpoint for the EPA Exchange Network took advantage of the latest Exchange Network REST Guidance (January 30, 2013) in consultation with an EPA network specialist. Attending and presenting at the EN 2014 Conference in February 2014 (Jeff Brown and Jeff Harrison) was valuable in confirming deliverables including the Transformer and the web services generated for EPA and non-EPA data consumers. See Appendix F.

Members of the Project Team (Nancy von Meyer, Pam Carver, and Tom Morgan) presented at the GIS/CAMA conference in Jacksonville, Florida (February 2014) and received valuable feedback from counterparts from around the nation.

The project team reported regularly to the NC Geographic Information Coordinating Council and its standing committees, including a presentation in Appendix F.

The user guides, hands-on training of members of the Project Team, webinar for county data managers, and presentations to land records workshops were comprehensive. A concern not foreseen when the grant proposal was submitted in 2009 and not modified in the project requirements: today's local government (data manager) audience may be more inclined to watch short online videos on using the Transformer than to read a user guide with the same content. The *NC OneMap* Geospatial Portal has had success with instructional videos for the statewide imagery project. Future work on integrated parcels may be able to utilize videos to advantage.

The US EPA grant that funded this project was an invaluable resource for advancing the goal of the NC Geographic Information Coordinating Council to develop and sustain a statewide parcel dataset for public access. The success of the online tool for transforming source data to standardized data and release of products for one-fourth of the state provides impetus for parcel data consuming organizations to support expanding and sustaining the resource. The end of the grant project also highlights the risk that potential partners among data consuming organizations will not support the operation and maintenance of the project soon enough to scale up the tool for statewide content and sustain participation and data sharing by data producers.

7. Sustaining the Applications and Data Sharing

The NC Integrated Cadastral Data Exchange project developed an online tool for compiling county geographic data for parcel boundaries. The tool, called the *NC Parcels Transformer*, translated parcel data for 25 counties into a single dataset with standard data fields for display and analysis across county boundaries. The grant project, funded by the US Environmental Protection Agency Exchange Network, created an efficient platform for expansion to a statewide parcel data resource. Transformed parcel data are accessible through the EPA Exchange Network as WFS REST services (http://ncservices.cloudapp.net/wfs/) and through the *NC OneMap* Geospatial Portal as web services and downloadable geographic data (http://data.nconemap.com).

The NC Center for Geographic Information and Analysis (CGIA) is coordinating an expansion of the NC Parcels dataset to a statewide resource that is maintained, documented, and published as web services and downloadable datasets. CGIA relies on the NC Geographic Information Coordinating Council (GICC) for organized collaboration for statewide programs and initiatives, standards, strategies, policies, and mutual benefits. Geographic information coordination is focused on essential base map datasets that are applied widely in public and private business processes, including orthoimagery, parcels, addresses, elevation, roads, and streams. CGIA's business need is to provide discovery and access to enterprise geospatial datasets, to the benefit of a wide range of public and private data consumers.

Options may include direct funding support from one or more state agencies, in-kind services from one or more agencies with experience in parcels and outreach to counties, and/or realization of public-private partnerships studied by the Council (http://www.ncgicc.org/CurrentActivities/PublicPrivatePartnerships.aspx).

Collaborators on the Project Team and/or in the state geographic information coordination structure include the Department of Transportation, the Land Records Management Program in the Department of the Secretary of State, the Department of Agriculture and Consumer Services, the Department of Public Safety's Floodplain Mapping Program, the State Center for Health Statistics in the Department of Health and Human Services, the Department of Commerce, the State Property Office in the Department of Administration, and the Department of Revenue.

8. Application Documentation

Application documentation includes technical architecture, data workflow, processing workflow, security, and WFS REST query guide.

- Architecture of the final system

  The Technical Architecture System Design is available on request.
- Data workflow

  The Test Plan including results illustration of the data workflow. See Appendix G.
- Processing workflow

  The Test Plan including results and illustration of the processing workflow. See Appendix G.
- Consumption tools and access points

  User authentication (for data submission and transformation) was accomplished by NCID. See the user registration guide attached as Appendix H.

  Use of the WFS REST endpoint is documented in the WFS REST Query Guide, attached as Appendix I.

  The XML Schema for WFS REST is attached as Appendix C. The XML Schema may be generated by opening this URL: http://ncservices.cloudapp.net/wfs/?service=WFS&version=1.1.0&request=DescribeFeatureType

9. Future and Ongoing Efforts

The project team identified efforts needing attention to sustain the tools and data.

- Review the availability of attributes in the initial data load. Does this represent all of the easily available data or can additional attribution be obtained from the counties without incurring added cost or hardship?
- Review the Master Schema.
  - Are there attributes that should be eliminated because they just are not available in NC data sets?
    - What is the storage and workload including sustainability issues related to having attributes that are not populated in the standardized data?
  - Should other attributes be added such as sale price, assessed value and taxable value as separate fields, and/or sale date in date format as well as text?
  - Should standards for relatable tables be developed and then linked to the Master Schema data through the keys contained in the Master data sets?
- Re-standardize the 25 pilot counties into a revised schema. This will involve updating the WFS as well as the schema.
  - If the Master Schema is kept as is and related tables are developed the re-standardization will not be necessary
- Obtain and standardize the data for the remaining 75 counties.

- Shapefiles performed well in the Transformer, even for the county with the most records (Mecklenburg). In the future, other formats may need to be explored in the context of growth in the number of parcel records in the most urbanized counties where subdivision of parcels may be significant.
- Review the potential to have a transformer for site addresses or to use existing site address standards and standardization procedures to provide a site address point with the parcel data. Discuss and review if site address should be captured with the parcel data or should it be generated and maintained independently and then combined with the parcel data, i.e., what is the most efficient workflow for capturing and maintaining accurate, current, and complete site address points for all types of property (commercial, residential, vacant?) in NC.
- Should site address data be resolved to street names? The street name in the standardized street centerline dataset should be the same as the street name in the site address files. How can consistency be achieved and maintained?
- What data may be needed internally in state agencies to serve agency business needs that can be linked to the standardized parcel data? Is all of the information needed for doing this linking provided and are the raw datasets to be linked available?
- Privacy issues - The assessment records identify the elderly and veteran real estate property tax deferments. But if the parcels with elderly or veteran tax deferments are published in an easily digestible format does this make these populations more susceptible to victimization and predatory scams? An effort to assist counties in compiling reports may have unintended consequences.
- Explore and document recommendations for long-term sustainability. Multiple state agencies have collected, compiled and used parcel data from multiple counties. They can benefit from a single reliable source of standardized parcel data.
- Governmental Units possibly including state, county, municipal, and taxing district polygons would be a good addition to the parcel datasets. This process would require developing an attribute standard for each of the administrative area types, and identify the best source for taxing district and municipal boundaries.

10. Acknowledgements

The North Carolina Integrated Cadastral Data Exchange Project is a collaborative project, supported by a grant awarded to the State of North Carolina and the Eastern Band of Cherokee Indians by the EPA Exchange Network (EPA Grant 83431001) and managed by the North Carolina Center for Geographic Information and Analysis (CGIA).

Successful collaboration relied on (1) the geographic information governance structure provided by the NC Geographic Information Coordinating Council and its standing committees and working groups, (2) a Vendor Team with specific expertise

and experience that won a competitive bid for application development and data development, (3) a project management structure through the NC Office of Information Technology, and (4) timely and effective grant administration by US EPA.

The State of North Carolina's Project Team, assembled from leaders and participants in the coordination structure, deserves recognition for developing project concepts, writing a successful competitive grant proposal, persisting in establishing a grant manager, and working hard to achieve the goals, objectives, and detailed elements of the project. The core team was comprised of Tom Morgan and John Bridgers (Land Records Management Program in the Department of the Secretary of State) and Pam Carver (Henderson County) the co-chairs of the Working Group for Seamless Parcels, John Farley (NC Department of Transportation GIS Unit), David Wyatt (Eastern Band of Cherokee Indians GIS Unit), and Jeff Brown (Center for Geographic Information and Analysis (CGIA)). Tim Johnson, CGIA Director, project sponsor for the Enterprise Project Management Office process, added guidance at key junctures. Jeff Brown, CGIA's Coordination Program Manager, served as Project Manager and Principal Investigator for the EPA grant project. He submitted monthly status reports to the Project Portfolio Management system, applied for approvals for project phases, prepared grant reports to US EPA, managed regular team meetings, tracked spending, monitored schedules and milestones, assisted with data quality assurance and component testing, and other project management tasks.

The Project Team was active and effective in providing technical advice and assistance during the project. The core members acknowledge the valuable contributions from the following team members: Chris Tilley and Emmanuel Matata (NCDOT GIS Unit), Hope Morgan (Department of Public Safety), David Baker (Department of Revenue), John Amoroso and Jeff Horton (Department of Environment and Natural Resources), Stan Duncan (Henderson County and Chair of the Geographic Information Coordinating Council), and David Giordano and Brett Spivey (CGIA, *NC OneMap* team).

The Vendor Team, led by the Carbon Project Inc., won a competitive bid for a contract with CGIA in the Office of Information Technology Services. Jeff Harrison was fully engaged and effective in managing the Vendor Team to achieve timely achievement of milestones and delivery of products. He more than met expectations for communication of progress and presentation of accomplishments. Mark Mattson provided technical expertise in application development, met the technical requirements, and accommodated the iterative development process in close collaboration with the Project Team. Nancy von Meyer, Fairview Industries, Inc., brought invaluable experience in cadastral data standards and parcel data application to the project. Her focused work on developing crosswalks between source fields and standard fields, applying the Transformer to source data, and assuring data quality were essential to project success. Her extensive documentation was vital for adding substance to the final report. Hays Lambert, Atlas Geographic

Data, Inc., applied his specific experience with North Carolina parcel data to assure quality and consistency in the data products.

The Project Team acknowledges the valuable advice and oversight in the project management process from the Office of Information Technology Services and State Approvers. Carolyn Whitlock's skillful project management assistance put the project on sound footing from Initiation through Planning and Development. Kathleen Crawford and Glenn Poplawski added timely advice. Project Management Advisor Alisa Cutler helped keep the project on course through its development phases. The Project Team appreciated the excellent service provided by Brent Roberts (NCID), Chip Moore's staff (security), Don Jerman (technical architecture system design review), Tim Lassiter (IT procurement), and Richard Bradford (legal advice).

The US EPA grant coordinator, Rock Taber, provided timely, concise, and effective guidance, advice, and assistance throughout the project, including valued support through years of post-award preparation before the project started. The process of award modification was very efficient and essential to project success. Grant administration tasks performed by Jennifer Brooks and Salena Reynolds were completed efficiently and accurately. In addition, technical advice from Kurt Rakouskas was instrumental in maintaining project momentum and getting the latest information from the Exchange Network.

North Carolina's coordination structure provided oversight and technical advice. The Project Team appreciated the many opportunities to present status and receive comments from the Geographic Information Coordinating Council (chaired by Dr. Lee Mandell until 2013 and by Mr. Stan Duncan currently), the Statewide Mapping Advisory Committee (chaired by Anne Payne until 2013 and by Ryan Draughn currently), the State Government User Committee (chaired by John Farley), and the Local Government Committee (chaired by Julie Stamper until 2013 and Kathryn Clifton currently). Foremost, the grant and the project would not have happened without the dedicated work of the Working Group for Seamless Parcels (co-chaired by Pam Carver and Tom Morgan). Members of the working group since 2008 have included John Bridgers, John Farley, David Giordano, David Wyatt, Julia Harrell (the conceptual designer and grant writer from the Department of Environment and Natural Resources), Alex Rickard and Patrick Flanagan (Eastern Carolina Council), Lucy Cardwell (Currituck County), Amy Durden (Elizabeth City), Eric John (Wake County), Christian Klaus (Department of Health and Human Services), Janet Lowe (NCDOT), Rich Elkins (Pitt County), Kevin Jamison (Jackson County), Steve Averett (Orange County), Holly Hixson (US Forest Service), and Joanna Pitsikoulis and David Cline (Census Bureau).

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Appendices

Appendix A - Master Schema - Core Parcel Data Element Definitions

Appendix B - Quick Start Guide (User Guide) for Transformer

Appendix C - XML Schema

Appendix D - Crosswalk Sample

Appendix E - Geospatial Metadata for Multi-County Standardized Parcel Data

Appendix F - Presentations to EN2014 and GICC

Appendix G - Test Plan

Appendix H - NCID Registration Guide

Appendix I - Web Feature Service Query Guide