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CADASTRAL STANDARDS REQUIRED
FOR THE
NATIONAL SPATIAL DATA INFRASTRUCTURE

A Thesis

Presented to

The Faculty of the Department of Geography

and Environmental Studies

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Matthew John Price

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ABSTRACT

CADASTRAL STANDARDS REQUIRED
FOR THE
NATIONAL SPATIAL DATA INFRASTRUCTURE

by Matthew John Price

This thesis addresses the need for cadastral data collection standards at the county level in the United States. One of the goals of the National Spatial Data Infrastructure (NSDI) is to develop a framework of data sets that includes a cadastral data layer. This framework will act as a foundation for numerous other data collection activities. The full utility of the framework will not be realized without a standardized cadastral data layer.

This research outlines the development of cadastral data collection standards that were required for the creation of the United States Public Land Survey System (USPLSS). The similarity between the NSDI and USPLSS is examined, and the need for a cadastral data collection standard for the successful development of the NSDI cadastral data layer is defined. Components of a cadastral data collection standard are developed along with supporting standards for cadastral data layers created and maintained by county governments within the United States that are to become part of the NSDI framework.

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INTRODUCTION

Advances in computer technology have led to an increase in the use and value of geospatial data. Geospatial data can be used to represent spatial features on or near the surface of the earth such as property lines, buildings, oil wells or wildlife habitats. Geospatial data includes data types such as paper maps as well as digital map data. Geospatial data has become a valuable tool to help promote economic development and improve our ability to manage capital, natural resources, and the environment.

Modern technology permits improved collection, utilization, and distribution of geospatial data. The Global Positioning System (GPS) provides a means to rapidly collect accurate geospatial data. The emergence of desktop Geographic Information Systems (GIS) provides a means to fully utilize and analyze geospatial data. The Internet provides a means to effectively distribute and share geospatial data. With these developing tools come new tasks and responsibilities, one of which is to develop and maintain standards for providers and users of geospatial data.

Standards

Standards are present everywhere in our lives. Standards for water quality, units of measure, and communication make it possible to exist in our modern society. Another set of standards, those for information interchange, are becoming critically important.

Spatial Data Transfer Standards (SDTS) for the National Spatial Data Infrastructure (NSDI) are being developed in various categories pertaining to the development, automation, and interchange of geospatial data. Content and quality standards for geospatial data are being developed for the NSDI to insure that geospatial data contains consistent and accurate information. There are many benefits associated with standards for geospatial data. Standards are a mechanism for providing a better understanding of geospatial data. The ability to collect and store geospatial data has increased at a rapid rate. At the same time, organizing geospatial data and preventing duplication of effort has become a formidable challenge. Standards are a means to improve the reliability, manageability, and value of geospatial data. Standards for geospatial data are needed to help promote the sharing of information between all levels of providers and users of geospatial data.

National Spatial Data Infrastructure

The National Performance Review recommended that the executive branch of the federal government develop a coordinated National Spatial Data Infrastructure (NSDI) to support public and private applications of geospatial data in cooperation with state, local, and tribal governments and the private sector.

> "On April 11, 1994, President Clinton issued an executive order calling for the establishment of a National Spatial Data Infrastructure (NSDI) from which all levels of government would benefit" (Clinton, 1994).

The NSDI is a framework for communication between producers and users of geospatial data. The NSDI is built upon data, standards, technology, and most importantly people. The main goal of the NSDI is to provide the means for efficient and reliable electronic communication of geospatial data. Other goals of the NSDI include developing a geospatial data clearinghouse, developing geospatial data standards, and expediting the creation of crucial geospatial data sets.

The NSDI is the means to assemble geographic information that describe the positions and attributes of features and phenomena on the earth. The infrastructure will include the materials, technology, and human resources necessary to collect, process, store, and distribute geographic information to meet a wide variety of needs. Some of the major areas that will be impacted by the NSDI will be transportation, community development, agriculture, emergency response, environmental management, and information technology.

Strategies to build the NSDI include establishing forums for communication, facilitating access to data, building the framework data sets and developing educational programs. The NSDI will build a common ground for fostering partnerships for data sharing among all levels of government, the private sector, and academia.

Basic Framework

One of the major components of the NSDI currently under development is a basic framework of digital geospatial data to act as a foundation for numerous other data collection activities. The framework will be a consistent geospatial data set that will provide users with a geospatial foundation to compile thematic data sets and attach attribute information. The information content of the framework will include geodetic control, digital orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral data. Other components of the framework include standards to facilitate data collection, documentation, and data transfer as well as the means to search, query, find, access, and use geospatial data. This framework will help the geospatial data community at the federal, regional, state, and local levels to produce and maintain commonly needed themes.

The framework development needs to be a coordinated effort much like more commonly understood infrastructure types such as interstate highways, water canals, airports, and cellular communication networks. Developing these infrastructure systems to stand the test of time and to provide users with the means to function effectively in society requires a considerable effort. The same can be said of developing our digital geospatial data infrastructure. The NSDI will be a tool used to manage and model real world conditions in a digital format. The NSDI should be viewed as an important addition to our country's existing infrastructure.

One of the critical parts of the basic framework for the NSDI is the cadastral data layer. A cadastral data layer generally consists of a digital map which contains property lines with data linkages to tabular data that describe interests in real property. A cadastral framework will be difficult to develop and maintain due to the high cost associated with creating and maintaining a data set that requires such a high level of spatial accuracy.

Cadastral Standards

A variety of definitions exist for the purpose of a cadastral data layer. One is that it is a tool for displaying lines of ownership as accurately as possible. Another is that a cadastral data layer is used as a background reference for other data sets that exist in the system and that the precise representation of ownership is not important. The reality is that currently most cadastral data layers fall somewhere in between these two interpretations. Problems arise when developers or end users do not have a clear understanding of the intent and the accuracy of the cadastral data layer.

The Federal Geographic Data Committee (FGDC), Cadastral Subcommittee, Technical Advisory Group is in the process of developing Cadastral Standards for the NSDI. There are four main components that may comprise the Cadastral Standards. These include a Cadastral Data Content Standard, Collection Standard, Metadata Standard, and a Transfer Standard.

Of these four components, the collection standard poses a difficult problem from a development point of view. The Cadastral Data Content Standard provides the data linkages and common definitions for the information stored in tabular databases. The Metadata Standard details the procedures for recording the lineage and development of the geospatial data, and the Spatial Data Transfer Standard (SDTS) defines the data transfer format. The need and practicality of a collection standard for survey methodology, equipment, accuracy, and classification schemes for the NSDI cadastral data framework are not yet confirmed.

Research Question

The question is whether the need exists for a collection standard pertaining to the method of collecting the cadastral data and a quality standard specifying the end results. The Cadastral Data Content Standard has been developed to add value to public data by creating common file formats, defining file contents, and common definitions of entities and their attributes. Is there also an opportunity to add value to cadastral data by developing a standard that includes collection methodology, quality standards, and classification schemes?

Many local and county governments are in the early stages of developing cadastral data layers, and this provides the opportunity to move forward in a coordinated effort to develop and adopt uniform collection and accuracy standards for cadastral data. Collection standards could be developed that would specify the methods used to gather cadastral data and the resulting accuracy of the cadastral data for generating coordinates for property corners and property lines that will become part of the cadastral framework for the NSDI. Standards for the format of cadastral data that is collected and submitted by private surveyors at the county level could be developed. Classification schemes based on the quality of the coordinate values displayed in a GIS based on collection methods and accuracy could be developed. The question is does the need for collection standards exist, and is it practical to develop collection and accuracy standards for the cadastral framework of the NSDI.

Collection, accuracy, and classification standards for cadastral data would improve the quality of the land information systems of the future. The Cadastral Data Content Standard provides the means of inclusion of all information regarding the legal aspects of real property. A collection standard would be a means of quality control and classification for the geospatial data that represents the rights and interests in real property.

Attempting to apply a rigorous collection standard to every measurement of property corners in the United States would not be practical. Certain property corners and monuments could be held to a standard. Examples of such points are section corners, land grant corners, major street intersections, exteriors of major subdivisions, and other points of historical relevance. To determine if there is a need for collection, accuracy, and classification standards and whether such standards would add value to the NSDI's cadastral framework the following three factors will be examined:

1) The historical development of collection, accuracy, and classification standards in the United States Public Land Survey System.
2) Requirements for county level cadastral data collection standards to support the NSDI cadastral data framework development.
3) Additional standards needed for NSDI cadastral data framework development.

Historical Development Of Collection and Accuracy Standards

A parallel can be drawn between the lack of uniform standards at the county level in all states with regard to content, collection, submission, and display of cadastral data, and the lack of uniform standards for cadastral data that existed in the early colonial period of the United States. The development of the Public Land Survey System (PLSS) data collection methodology and accuracy standards evolved over two centuries. The strength of our current land registration system is based on an extended coordinated effort to maintain and develop these standards. A brief description and examination of the historical development of accuracies regarding the positioning of boundaries in the United States PLSS will be included in the second chapter.

Requirements for a Cadastral Data Collection Standard

Several of the problems of developing and enforcing a collection standard such as current equipment, current procedures, data formats, and costs are defined. Collection, accuracy, and classification standards that are currently in place are examined and evaluated for their ability to become a national standard. A list of possible elements that would comprise a classification scheme is developed in the third chapter.

Additional Standards Needed for NSDI Framework Development

An examination of the Cadastral Data Content Standard will provide insight into the potential to add value to public data by local governments who standardize the databases that contain cadastral information. The Cadastral Data Content Standards address the content of the tabular data that will be linked to the geospatial data that delineates parcel boundaries. The Cadastral Data Content Standard does not provide for a means to insure the accuracy of the geospatial data or a means to classify the geospatial data based on the collection methods used to gather the data. Collection and accuracy standards used in conjunction with the Cadastral Data Content Standard will add value to the cadastral framework of the NSDI by insuring that both the geospatial and attribute data are correct and reliable. A brief introduction to the Cadastral Data Content Standard for the NSDI will be included in the fourth chapter.

Summary

One of the goals of the NSDI is to insure consistent development of framework data sets. Standards for cadastral data collection, accuracy, and classification must be adopted at the county level to reach this goal. To identify the need for cadastral data collection standards the development of collection standards within the Public Land Survey System will be evaluated. This will provide historical perspective on the impacts of standards developed to date. Existing standards will be reviewed to get a better understanding of what would comprise the elements of a collection standard at the county level, and additional requirements for standard implementation will be reviewed to verify the need for cadastral data collection standards.

Chapter 2

HISTORICAL DEVELOPMENT OF CADASTRAL STANDARDS

The development of survey methodology and accuracy standards in the United States Public Land Survey System (PLSS) took over two centuries of refinement. As the tools and technology became available, new methods were adopted and stricter accuracies were required. Developing uniform procedures and requirements for the PLSS increased the value and worth of the public lands by minimizing vague boundaries and overlapping descriptions and created a consistent land registration system. The PLSS has been developed over time with great effort and by many people with varying skills and resources. Collection standards for cadastral data were developed over time and were a critical component in improving the quality and reliability of cadastral information that became part of the PLSS.

A parallel exists between the situation that existed in the American Colonies prior to the turn of the 19th century and the present situation that exits at the county level in the United States. In both of these cadastral systems, *uniform* standards with regards to the content and accuracy of cadastral data are absent. This is not to say that standards did not, or do not exist. This only points to the fact that *uniform* standards did not exist in the early colonial period just as they are absent at the county level today. This analogy is drawn to show the importance of having uniform cadastral standards throughout the United States at the county level.

The Act of May 20, 1785 began the systematic settlement of the western frontier. This coordinated effort that began over 200 years ago created a systematic and methodical procedure for disposing of the public lands. Opportunities exist today to develop a systematic and methodical procedure for building the digital cadastral framework for the NSDI at the county level in the United States.

Early Cadastral Systems - Pre 1785

The methods for settlement and land registration of the early American land owner varied greatly from colony to colony. In some areas there were patterns of settlement that resulted from the development of a community center. In other areas there was a completely random pattern of settlement. The early colonies did not have a uniform method for the disposal of land by the sovereign. This generally led to overlapping land grants or patents. There was no common size or shape of the tracts of land. Property lines were not surveyed before settlement occurred. This generally led to uncertain and vague property lines, and also made it nearly impossible to keep or maintain current land records with regards to location and ownership of real property. This led to inconsistencies in colonial territory that eventually became the states and counties. These inconsistencies were mostly errors in the quantity of land in a particular state or county. As time went by some states and counties found they had more land than on record while others found they had less land than on record.

The methods for keeping land records in the early colonial period were not sufficient to support the rapidly growing number of land transactions that were occurring.

> "In general these inadequacies included (1) vague and indefinite delineation of boundaries, such that they could not be identified on the ground, (2) overlapping grant descriptions and (3) a lack of systematized and efficient registration procedures so that accurate and up-to-date records of land ownership could not be kept" (McEntyre, 1985, p. 29).

The original colonist, realizing that troubles lay ahead, took measures to develop a uniform procedure for disposing of the unsettled western territory in the United States. In 1784 Thomas Jefferson was appointed chairman of a committee charged with preparing a standardized system for disposing of the public domain.

The Ordinance of May 20,1785

The first formal step towards developing a standardized cadastral system was taken May 20, 1785. The Continental Congress passed an ordinance titled "An Ordinance for Ascertaining the Mode of Locating and Disposing of Lands in the Western Territory." This was the beginning of the Public Land Survey System (PLSS). The ordinance of 1785 required that land would be divided into townships six miles square, and that these townships be divided into 36 lots (now called sections) of one square mile. The ordinance of 1785 also required that the township boundaries were to be marked every mile. Interior township lot (section) corners were not surveyed in the field, they were protracted. Protraction established lot (section) corners based on the intersection of lines from the exterior monuments that were set every mile on the township boundary. Physical monuments were not set to mark the location of the protracted corners. The ordinance of 1785 required that property be surveyed before it was sold and that the owner receive a written certificate (deed) proving ownership.

The ordinance of 1785 did not specify surveying procedures or methodology. Equipment was not mentioned except that direction would be measured with a magnetic compass and that a chain would be used for measuring distance. Standards for accuracy, direction, distance or mathematical closure of the townships or sections were not included. There was no method for dealing with random or systematic errors that occurred in the measurement process.

There was an inconsistency in the ordinance of 1785 that would become apparent. Requiring Townships to be six miles square was not practical because of the use of the magnetic compass. This requirement also did not account for the convergence of the Meridians.

The Act of 1785 laid the groundwork for what became the most sophisticated public land system the world has seen, but there was still work to be done. From 1788 to 1973 cadastral data collection standards were developed to improve to the quality of the PLSS. The PLSS benefited from standards developed in the following five categories: 1) Data Submission Formats, 2) Survey Equipment, 3) Survey Methodology, 4) Data Accuracy, and 5) Classification Schemes.

PLSS Data Submission Formats

The ordinance of 1788 required surveyors to create maps and field notes of the surveys conducted. These maps and field notes were to be submitted to the Board of the Treasury. This was the beginning of establishing standards for data submission formats.

In 1815 Edward Tiffin compiled a set of general instructions for deputy surveyors that were presented in three parts: "Instructions for Subdividing Townships", "General Instructions", and "Methods for Calculating or Placing the Errors in the Northern and Western Tier". Tiffin's instructions described in detail the format and content for field notes. Tiffin's instructions also described the mapping scale (1 inch to 2640 feet), medium, and layout of the survey plats that were to be submitted to the General Land Office.

Uniform submission formats improved the quality of the PLSS by creating a central repository of land information that was uniform in content. This created consistency across the western frontier and aided in relocating monuments in the field by providing a consistent storage format for cadastral data.

PLSS Survey Equipment

The act of May 18, 1796 was the beginning of a standard development for survey equipment. It prescribed a chain two perches long (1 perch = 16.5 feet) which should be subdivided into 25 equal links. One link equals 0.66 feet.

The first written instructions were issued in 1804 by Jared Mansfield. Mansfield's instructions were general in nature and described the instrument and chain to be used. Tiffin's general instructions of 1815 for deputy surveyors called for a good compass of "Rittenhouse" construction. This was the first standard for survey instruments in the PLSS. The instructions called for a two pole chain of fifty links that had to be adjusted to a standard chain that was stored in the Surveyor General's office.

In 1833 additional instructions were issued by the Surveyor General that required the compass be checked against a standard compass in the Surveyor General's office. The instructions of 1833 required that the chain used be made of "good iron wire" and that the handles be constructed of brass and at least 1/4" in diameter. They also required that a standard chain was to be issued to the deputies and that the chain used in the field was to be compared and adjusted to the standard chain every other day.

The instructions of 1850 called for the use of Burts Solar Compass which was a instrument that could be used to precisely measure true (astronomic) north.

The manual issued in 1890 had stricter requirements for survey instruments and required that Polaris (the north star) be observed at the beginning of each survey. The use of the magnetic needle was restricted to subdividing townships and meandering (measuring water boundaries).

The next manual was printed in 1930. This manual restricted the use of a magnetic needle for determining direction. The manual requested that a record of the type of equipment used and the method used to determine azimuths be included in the field notes.

The development of standards for equipment within the PLSS improved the quality of the measurements by making sure that the latest technology was employed during the collection of cadastral data.

PLSS Survey Methodology

Tiffin's 1815 general instructions described procedures for measuring true horizontal distances instead of just laying the chain on the sloping ground. The instructions required that certain lines be run according to true (astronomic) north. They also described methods for subdividing townships and marking PLSS corners.

In the 1833 instructions methods for measuring declination (difference between astronomic north and magnetic north) of the compass were included. The instructions of 1850 called for a minimum requirement that the variation (declination) of the needle be checked every mile. This one mile minimum increased the requirement from the instructions of 1833 which was every twelve miles. The instructions of 1850 introduced stadia as an alternative method for measuring distance across difficult terrain or to inaccessible points. Stadia measurement is based on trigonometry and included having marks on the lens of the instrument. The instructions were the first to describe methods for dealing with the convergence of the meridians.

In 1855 the first "Manual of Instructions" was printed and distributed. It was similar in content to the instructions of 1850 but contained more guidance on survey methodology. The manual of 1902 required that every clear night a Polaris observation was required. The manual also required that chainmen be instructed on the proper methods for chaining over sloping or mountainous terrain.

The development of survey methodology with the PLSS improved the quality of cadastral data by refining the procedures for collecting cadastral data.

PLSS Data Accuracy

Tiffin's 1815 instructions introduced specifications for accuracy in direction and distance. Tiffin's instructions did not specify the error allowed in closure.

The 1843 instructions to deputy surveyors of the State of Arkansas set closing limits by limiting the error allowed in closure. The closure allowed for township lines was 5 chains (330 feet) or an accuracy of approximately 1:384. This is not very accurate by today's standards but was one of the first attempts at setting closing standards.

The 1855 manual was the first to limit or describe a tolerance to the length of line measured. The manual required that section lines running east and west be within 100 links (66 feet) of 80 chains (one mile). Specifications for accuracy in direction and mathematical closure were not mentioned in the manual of 1855.

The manual of 1881 entitled " Instructions of the Commissioner of the General Land Office to the Surveyors General of the United States Relative to the Survey of the Public Lands and Private Land Claims" was the first to have a separate section dedicated to the accuracy of surveys. The section was titled "Prescribed Limits for Closing and Length of Lines in Certain Cases".

The manual of 1894 added more detail to the survey procedures and additional accuracy requirements. The manual was the first to require that the true bearing between a latitudinal section line and the south boundary of the range line could not exceed 21 minutes of arc. This was the first manual to describe a detailed specification for accuracy in direction.

The 1930 manual had specifications for rectangularity that called for all lines in a section to be within 21 minutes of cardinal and that the allowable tolerance in measurement was to be within 560 links (369.6 feet) in a mile. The manual also had specifications for closure that called for boundaries to close within an accuracy of 1:452.

The reliability of the PLSS was greatly increased by developing accuracy standards for cadastral data.

PLSS Classification Schemes

The 1947 manual of instructions included a table that classified the acceptable limits of closure based on the difficulty of the terrain encountered. The manual stated that "Good Judgement" called for compiling with the closures listed in Figure 2-1.

The development of this classification scheme took the difficulty of obtaining the measurement information into account and improved the efficiency of the PLSS cadastral data collection efforts. A classification scheme for cadastral data does not exist at the county level in the United States. The NSDI will be developed over time and will contain large amounts of data compiled from sources that vary in content and accuracy.

Figure 2-1. Good Judgement Closures.

Character of Country: Basic Economic Value.	Average Closures in Latitude and Departure per Square Mile, Quarted as a Tolerance in the Direction and Length of line per mile; accurate to be attained in at least 2/3 of the Survey.	Limit of Tolerance in the Closure and in the Direction and Length of Line per Mile; Not to Be Exceeded nor Be approached in Excess of 1/3 of the Survey.	Closure Limits when Expressed by the Usual Fraction and by Linear Ratio.	
Class E	25 links 6.2 links, 2'40"	50 links 12.5 links, 5'20"	1/905 1:1280	1/452 1:640
Class D:	16 links 4.0 links, 1"40"	25 links 6.2 links, 2'40"	1/1414 1:2000	1/905 1:1280
Class C:	8 links 2.0 links, 0'50"	16 links 4.0 links, 1'40"	1/2828 1:4000	1/1414 1:2000

Class E:
Extremely rough mountainous land, heavily timbered, dense undergrowth, exceptionally difficult to survey, value chiefly for grazing, timber, recreation, reclamation reservoirs, wildlife preserves, etc.

Class D:
Rough mountainous land, scattering timber, considerable undergrowth value chiefly for grazing, timber, recreation, reclamation reservoirs, wildlife preserves, etc.

Class C:
Valuable mineral deposits, improved or cultivated lands, reclaimed agricultural lands, small tract areas; other areas where this accuracy can be attained at reasonable cost.

A classification scheme would provide end users with the information needed to determine the fitness of use of cadastral data by classifying the data based on its submission format, equipment, methodology, and accuracy. A classification scheme must be adopted at the county level to support the NSDI goal of consistent cadastral data across the country.

The 1973 Manual of Instructions

The manual of 1973 entitled "Manual of Instructions for the Survey of the Public Lands of the United States, 1973" is the most current manual. The 1973 manual included additional methods for measuring distances such as the use of multiple chains (steel tapes), stadia, subtense bar, traversing, triangulation, electronic telemetry, and photogrammetry. The instructions set the limit of closure for sections at 25 links (16.5 feet), and a township was to close within 150 links (99 feet).

The development of collection and accuracy standards in the PLSS was a long process that increased the reliability of the land records system in the United States. As new technology emerged it was incorporated into the methodology used to collect and classify cadastral data. Without the benefits of a coordinated effort to dispose of the public lands there would have been a heavy burden placed on our modern society in the form of inconsistent land grants.

Settling the Digital Frontier

We are embarking on settling the digital frontier, and there are many challenges to face and problems that need to be overcome. The settling of the digital frontier can be thought of in the same way as the settlement of the early American frontier. Settlement has begun in the more populated areas, but there is still a lot of wilderness out there. The early American frontier had large areas of unsettled territory. There was an uncertainty as to the quality and amount of land that existed in the early American frontier. In the same fashion, there is a large portion of the digital frontier that has not been settled with regards to cadastral data. Future generations may look back on our current time period in the same way that we see the original colonists.

The settling of the digital frontier will require a similar effort to what was required to create the PLSS. In order to build a digital cadastral infrastructure there will need to be a coordinated effort. We must also realize that building it may span several decades and that it will require a large amount resources and will present unique challenges.

Many of the Geographic Information Systems that exist today at the county level contain a cadastral data layer, but there is no uniform method for referencing the source data such as the record of survey or the deed. There is no uniform structure for the tabular data base design and data linkages. There are no uniform collection, accuracy or classification standards. This situation is not necessarily negative at the local level, but it impedes the flow of communication by limiting the ability to easily transfer cadastral data from city to county and county to state and so on. It is still unsettled.

Cadastral Data Collection Standards must be developed and adopted at the county level to aid current and future development of the NSDI cadastral data framework. Cadastral data collection standards in conjunction with cadastral data content standards will insure the definite delineation of boundaries, such that they could be identified on the ground. Standards will augment data collection and compilation efforts with procedures to handle inconsistent record data. Standards will also provide a systematic and efficient registration process so that accurate and up-to-date records of landownership can be kept and accessed by the general public. The same effort that went into developing cadastral data collection standards for the PLSS must be applied to NSDI cadastral data framework development to reach the NSDI goals of consistent and accurate cadastral data.

Chapter 3

CADASTRAL DATA COLLECTION STANDARDS

The absence of nation-wide cadastral data collection standards at the county level has produced cadastral data that varies in content and accuracy based on its geographic location. The National Spatial Data Infrastructure (NSDI) is attempting to establish a common framework of cadastral data across the United States. Local surveyors' efforts could contribute to the development of this cadastral framework. This goal will only be reached with cadastral data collection standards that are uniform across the country.

The Federal Geographic Data Committee Subcommittee on Cadastral Data has been working on the development of a set of cadastral data content standards since 1994. The early drafts of the standard (April 1994 and September 1995) contained data content and collection standards. The collection standards focused largely on retrieving and processing record information and did not address the future development and support of a cadastral framework.

County level cadastral data collection standards to support the NSDI should consist of the following:

1) Digital Data Submission Formats
2) Survey Equipment
3) Survey Methodology
4) Data accuracy
5) Classification Schemes

Digital Data Submission Formats

Having common digital submission format requirements at the county level will eliminate duplication of effort, improve data quality, and reduce the time required to build the cadastral framework for the NSDI.

Each state currently is responsible for establishing requirements for records of survey and parcel maps submitted to the county surveyors. In California the standards for the format of records of survey submitted to the county surveyors office can be found in section 8763 of the California Land Surveyors Act. It states:

> "The record of survey shall be a map, legibly drawn, printed, or reproduced by a process guaranteeing a permanent record in blackon tracing cloth, or polyester base film, 18 by 26 inches or 460 by 660 millimeters. If ink is used on polyester base film, the ink surface shall be coated with a suitable substance to assure permanent legibility. A marginal line shall be drawn completely around each sheet leaving an entirely blank margin of one inch or 025 millimeters" (CLSA, 1995, p. 508).

Nothing is mentioned regarding the submission of data in digital format. In one county that does not have requirements for submitting tract maps in digital format the process for collecting, submitting, and indexing cadastral data is as follows: A private surveyor completes a survey and through electronic data collection produces a digital tract map that they must then print on Mylar to submit to the county surveyor. The county surveyor checks the record of survey and if accepted for compliance with the state statutes, it is recorded at the county recorder's office. The mapping department then takes the hard copy and draws the map on a Computer Aided Drafting (CAD) system using coordinate geometry to calculate the coordinate values of the property corners and the bearing and distance of the lines. Then the data is compiled to conform with the format of the assessor's maps and printed. The hard copy map is then placed in the appropriate assessor's book.

Developing standards for the digital submission of these parcel maps and record of survey to comply with the assessor's book format could cut out duplication of effort and supply the counties and public with a superior product. The digital maps would still need to be checked with conformance with the State Code, but recording and indexing a digital map should take far less time and effort than using coordinate geometry and CAD to generate coordinate values. The format of the digital data could be as simple as a common text file with information such as the point number, coordinate values, type of monument, positional accuracy statement, and a description of the equipment and procedures used to record the measurements.

Digital submission requirements at the county level would establish a consistent data format for cadastral data across the nation. This would also insure that the cadastral data collected by both the public and private sector could be incorporated into the NSDI cadastral framework.

Survey Equipment

Surveying equipment refers to the survey instrumentation used to collect cadastral data. The type and quality of survey equipment used to collect cadastral data has a direct impact on the quality and reliability of the information. Currently there is no method to capture information regarding the type of equipment used during a field survey which would be a key component of a classification scheme.

A large disparity exists in the quality of surveying equipment used to capture cadastral data. The quality of survey equipment varies when it comes to price. The equipment employed by the everyday surveyor has changed drastically in the last twenty years. The use of electronic total stations with electronic data collectors has become increasingly common place. The quality of survey instrumentation is based on the minimum seconds of arc in angle measurements and part per million for the distance measurements.

The use of the Global Positioning System (GPS) in property surveys is not commonly practiced, but this is mainly due to the cost of this technology. As the cost drops its use will most likely increase.

The method by which cadastral data has been recorded is on paper maps with bearings and distances marked on lines that represent property locations. When these maps are converted to digital format there will be problems differentiating between errors caused by quality of equipment and errors contained within the public record.

Cadastral data is not currently being classified based on the equipment used to collect the data. Forcing a certain type or quality of survey equipment would not be practical. Requiring documentation on the survey equipment used during the survey would be practical. This data is usually recorded in the surveyor's field notes but not passed along with the recorded maps.

Survey Methodology

Survey methodology refers to the techniques used to collect measurements in the field and the procedures for generating coordinates from these measurements. The methodologies employed to collect cadastral data and generate coordinate values has a direct impact on the quality and reliability of the information.

Having a common survey methodology for terrestrial procedures for making field ties to property corners and the type of survey adjustments used to disperse the error would aid in the classification of survey data. Some examples of standard survey methodology would be requiring certain types of monuments to be tied from two locations or having a certain number of field ties to control of a certain order.

Developing a standard survey methodology would be very difficult due to the nature of collecting information regarding property line location. Gathering measurements to determine property locations requires a different approach for each situation. In some cases safety is a factor, in others the physical terrain can make following a cook book approach to collecting survey information impossible.

Building the cadastral framework for the NSDI requires adopting a standard survey methodology and a means to document variances from the standard.

Accuracy

The accuracy of cadastral data is largely influenced by the equipment and survey methodology employed to collect the cadastral data. Accuracy standards will insure the quality of the NSDI cadastral framework by establishing a minimum acceptance criteria for data to be included.

The Federal Geographic Data Committee has prepared a Geospatial Positioning Accuracy Standard. The Geospatial Positioning Accuracy Standards have provisions for classifying the positional accuracy of a geodetic networks based on the 95 percent confidence interval produced by the survey adjustment (Figure 3-1).

Figure 3-1. FGDC Geospatial Positioning Accuracy Standards.

Accuracy Classification	95-Percent Confidence
1-Millimeter	0.001 meters
2-Millimeter	0.002 "
5-Millimeter	0.005 "
1-Centimeter	0.010 "
2-Centimeter	0.020 "
5-Centimeter	0.050 "
1-Decimeter	0.100 "

Survey adjustments produce an error ellipse that represents the confidence interval of the positional accuracy of the coordinate values. No uniform system is used to classify the positional accuracy of coordinate values that represent cadastral data based on the 95 percent confidence interval of the survey adjustment.

Adopting the FGDC Geospatial Positioning Accuracy Standards for cadastral data and setting a minimum confidence interval would increase the reliability and insure consistency within the cadastral framework of the NSDI.

Classification Scheme

The benefits of classifying coordinates would be far reaching and would aid in developing an understanding of various sources and quality of data used to construct the NSDI cadastral framework.

The American Land Title Association (ALTA) has developed a broad classification scheme that includes four classes of surveys: Urban, Suburban, Rural, and Mountain/Marshland. Within this classification the required methodology and accuracy are derived based on the class of survey. Adopting the ALTA survey classification scheme at the county level addresses the problems of standardized equipment and methodology.

The County's Role

The majority of the cadastral systems at the county level in the United States are based on hardcopy tract maps and records of survey which are submitted on Mylar or a comparable medium. Some counties have begun scanning these maps into document management systems and developing databases that consists of scanned deeds. Counties have also began developing sophisticated cadastral systems that include developing cadastral data layers. The county conducts office checks and sometimes field checks of survey data submitted by private surveyors. The county acts as the main repository for the cadastral data, but the county does not contain all of the measurement information that is gathered by other entities. Counties must insure NSDI cadastral framework development by adopting and enforcing standards for cadastral data collection.

Need for Central Location of All Land Records.

The need to modernize land records systems has been identified since the early 1950's when McEntyre (1985) proposed a land records system that would merge the Public Land Survey System (PLSS) with the state plane coordinate system to develop a torrens system of land registration. One of the problems identified in the proposal was the lack of a central location of records that describe the ownership, position, and legal status of a parcel of land. For example, in California there are several other agencies besides the local county that maintain land record information. The list includes the United States Bureau of Land Management, Bureau of Indian Affairs, National Park Service, National Forest Service, Bureau of Reclamation, United States Lands Commission, United States Forest Service, California State Department of Forestry, California State Department of Parks, Department of Water Resources, local cities, utility companies, private surveying firms and land title companies.

> "The citizenry of a nation in the modern day world needs a data bank for land that includes (1) boundary descriptions that are accurate, intelligible, and mathematically verifiable, (2) a quality inventory concerning each parcel of described land.... (5) a flexible record system that allows desired land information to be filed and retrieved easily and efficiently" (McEntyre, 1985, p. 29).

Such a system can be developed based on a cadastral data layer. The development of the cadastral data layer at the county level must be a nationwide coordinated effort to maintain consistency of the land records systems from county to county and state to state.

Current Situation

The present situation in a majority of the western states is that the bulk of the cadastral data is stored at the local county. Methods for recording and storing cadastral information vary from county to county. There are no uniform submission formats for digital cadastral data. Much of the cadastral data is maintained on hardcopy maps in county map libraries. Retrieval of cadastral information is a time consuming task that requires compiling records such as deeds and maps from a variety of sources and locations. Data is collected through advanced techniques such as the Global Positioning System (GPS) and electronic survey equipment. The map data is then compiled with the help of Computer Aided Drafting (CAD) software and paper or Mylar maps are produced. The hardcopy maps are then taken to the county surveyor's office and checked and then placed in the hardcopy map library. The information regarding the collection methods are for the most part not included on the hardcopy maps. There are no uniform standards at the county level for the collection, classification, format, and accuracy of cadastral data within the United States. Most counties have no method for capturing cadastral data in digital form. Cadastral data in digital form could rapidly become part of the cadastral framework for the NSDI. Cadastral data and the methods used to capture the cadastral data need to be standardized at the county level to build the cadastral framework for the NSDI.

Summary

No uniform standards exist at the county level within the United States for digital submission, equipment, methodology, accuracy, and classification for cadastral data that will become part of the cadastral data framework for the NSDI. Of the five major problems facing cadastral data framework development, agreeing on a common digital submission format is the first that needs to be addressed. Requiring digital data submission would reduce the burden on local agencies trying to check, index, and create the digital cadastral framework.

To address equipment and methodology issues there needs to be a consensus with regards to a classification scheme for cadastral data quality at the county level. Classification schemes based on the positional accuracy of cadastral data would provide end users with a means to make sound judgements on data compiled from multiple sources. The development of the cadastral framework for the NSDI will not be possible without uniform cadastral data collection standards at the county level.

Chapter 4

ADDITIONAL STANDARDS REQUIRED FOR NSDI FRAMEWORK DEVELOPMENT

Additional standards for the basic components of a cadastral data layer are required to implement cadastral data collection standards at the county level. Currently, several definitions of what constitutes the basic components of a cadastral data layer exist. This precludes the ability of some counties to fully implement cadastral data collection standards. The counties must standardize on the basic components of a cadastral data layer to reach the NSDI goals of consistent cadastral data content and accuracy across the nation.

The document entitled Multi Purpose Land Information Systems: The Guidebook (MPLIS Guidebook) was used as a source along with Cadastral Standards for the National Spatial Data Infrastructure (Cadastral Data Content Standard) to identify what additional standards would be needed to support cadastral data collection standards. The following basic components of a cadastral data layer will need to be standardized to develop the NSDI cadastral data framework and to receive the benefits of cadastral data collection standards:

1) Geodetic Reference Systems
2) Parcel Level Data
3) The Geospatial Data Model
4) Thematic Attribute Data Content
5) Thematic Attribute Data Linkages

Geodetic Reference System

A Geodetic Reference System (GRS) was identified in the MPLIS Guidebook as a important foundation for a cadastral data layer. A GRS comprises permanent points, usually brass disks or steel rods that are mathematically tied to a common horizontal and vertical datum. The benefit of such a system is that data complied from various locations throughout the nation will be tied to a common horizontal datum which supports the NSDI goal of consistent data.

"The National Research Council (NRC) has recommended the use of State Plane Coordinate Systems for cadastral data in the United States because of the universality of the systems" (Stem & Young, 1989). Many of the maps that have been compiled in the past have been based on the North American Datum of 1927 (NAD27). The North American Datum of 1983 (NAD83), which is a better mathematical model of the earth surface, is replacing NAD27. According to the NRC, NAD83 should be used from the beginning of cadastral data layer development to avoid problems with coordinate transformations. A critical component of NSDI framework development is the use of a common GRS to establish both relative and absolute positions on the earth's surface.

Standardizing on the State Plane Coordinate Systems and NAD83 is the first step to establishing a uniform Geodetic Reference System for the NSDI cadastral data framework. The benefits of a standard GRS include the ability to reference cadastral data to a well established control system. All cadastral data collection activities will use the same coordinate system which will allow for compilation of data collected by different entities at different points in time. Adopting the State Plane Coordinate Systems and NAD83 will insure that cadastral data collected at the local level will fit into the NSDI cadastral data framework. This will also allow other data types that are tied to the common GRS to be accurately referenced to the cadastral data layer.

Parcel Level Data

No definition has been developed at the county level with regards to what parcel level data is required to make a cadastral data layer complete. Parcel level data includes information regarding the bearing and length of property lines, land use classification, and ownership rights and interests. These rights and interests can include ingress and egress, mineral rights, grazing rights or a variety of other uses of the land. "A parcel is an unambiguously defined unit of land within which a bundle of rights and interests are legally recognized in a community" (Epstien & Moyer, 1993, p. 13-2). The Cadastral Data Content Standards defines a parcel as "... a single cadastral unit, which is the spatial extent of the past, present, and future rights and interests in real property" (FGDC, 1996, p. 3-22).

The intended uses of parcel level data include indexing information about a parcel and visually displaying the relationships between the boundaries of several related parcels. What constitutes parcel level data within a cadastral data layer needs to be standardized at the county level to receive the benefits of cadastral data collection standards.

Parcel level data is currently compiled from a variety of sources including title records, assessment records, infrastructure records, land use and zoning regulation records, resource and environmental records, court records, and survey records. Often additional information must be gathered by field surveys. Having a standard definition of what constitutes parcel level data will allow local data collection and compilation efforts to be incorporated into the NSDI cadastral data framework.

Geospatial Data Model

A standard definition of the underlying geospatial data model for displaying parcel level data is critical to insure consistent representation of features such as property lines and corners within the NSDI cadastral data framework. Geospatial data are coordinate values that represent geometric shapes such as points, lines, and polygons. Geospatial data can be grouped into data base objects that model real world phenomenon. Information contained in geospatial database objects include the topological information that describes the adjacency of areas and the connections and intersections of lines.

The vector data model described in the MPLIS Guidebook fits best with cadastral data and should be adopted as the data model to support NSDI cadastral data framework development. The geospatial database objects that make up the vector profile fit well with parcel level data. Of the seven major geospatial data base objects within the vector profile, five have a parcel data equivalent (Figure 4-1).

Figure 4-1. A General Description of the Vector Data Model.

Geospatial Data Base Objects		
OBJECT	**DESCRIPTION**	**PARCEL EQUIVALENT**
Points	X,Y,Z Coordinates	No Parcel Equivalent
Arcs (line segments)	Set of Connected Points	Property Lines
Nodes	Topological Junctions such as Intersections and Endpoints of Lines (X,Y,Z Coordinates)	Property Corners
Links	Set of Nodes Connected by Lines	Property Line with Angle Points
Chain	Sequence of Connected Points/Segments with Nodes at Each End	No parcel Equivalent
Ring	A Closed Chain or a Set of a Series of Closed Chains	Parcel Boundary
Polygon	The interior of a ring	Parcel Area

Arcs are comprised of a set of connected points. These arcs can be represented as property lines with thematic attributes describing their length and direction which corresponds to the distance and bearing recorded on parcel maps. Nodes are located at the intersections and endpoints of lines and can represent property corners and angle points in property lines. Rings and polygons consist of a closed set of arcs that create a polygon that represents the parcel boundary and area.

Adopting the vector data model for NSDI cadastral data framework development would standardize geospatial database objects that represent parcel level data within a cadastral data layer. Having a standard definition of the underlying geospatial data model will allow local cadastral data collection efforts to be incorporated into the NSDI cadastral data framework. Collection standards for NSDI cadastral data framework will not be practical without a standard definition of the underlying geospatial data model.

Thematic Attribute Data Content

Entities are features or phenomenon that occur in the world. Thematic attribute data describe and differentiate entities. A parcel of land is an entity. It exists in the real world, and to differentiate it from other parcels unique attributes are associated with it. Parcel attributtes can include a parcel number, zip code, land use classification, and street address.

Thematic attribute data consists of qualities and quantities. Thematic databases consist of fields and records which contain numbers and alpha-numeric text that describe the attribute data about an entity in the real world or a geospatial database object that represents a real world entity (Figure 4-2).

Figure 4-2. Thematic Data Base.

Thematic Data				
	APN	ZipCode	LandUse	Address
FUNCTION	(Primary Key)	(Foreign Key)	Text	Text
RECORD1	304-34-222	95008	Vacant	123 1st St.
RECORD2	444-09-887	95008	Parks	1 S. Main St.

Standards for the thematic attribute data content stored in databases that are linked to the geospatial data base objects will provide consistent information to end users of a cadastral data layer. Consistent NSDI cadastral data framework development can be achieved by adopting standards for thematic attribute data content.

Cadastral Data Content Standard

The Cadastral Data Content Standard is a guideline for the content and data linkages of a cadastral data layer. "The Cadastral Data Content Standard forms the basis for automating the legal elements of cadastral data found in public records" (FGDC 1996, p. 1-3). There is no attempt to place limits on the information that can be included in a cadastral data layer within the standard. The Cadastral Data Content Standard describes the format, order, and domain of attributes values for cadastral entities. The goals of the Cadastral Data Content Standards are to facilitate the automation of land records, and to maximize data sharing while minimizing the duplication of effort between all levels of users and providers of cadastral data.

The Cadastral Data Content Standard requires the following four attributes be used to describe and differentiate a parcel: 1) Parcel ID, 2) Parcel Type, 3) Parcel Name, and 4) Parcel Local Label.

The Parcel ID is the primary key for the parcel within the database. The Parcel Type refers to zoning or the land use of the parcel. The Standards contain a list of values that may be included in the Parcel Type Field. For example, "Coal Reserve", "Conservation Area" or "Easement" would be placed in this field. The Parcel Name is an identifying name for a parcel. This field can include a project number or any other identifier for a parcel. The Geographic Names Information System (GNIS) contains names for Federal installations which can be placed in the Parcel Name field. The Parcel Local Label refers to a number or text that local governments use to identify a parcel for administrative purposes such as an Assessors Parcel Number (APN).

Adopting the Cadastral Data Content Standards for cadastral data will establish a method to incorporate consistent thematic attribute data content during cadastral data collection and compilation efforts. Cadastral data collection standards will not be practical without standards for thematic attribute data content.

Thematic Attribute Data Linkages

Cadastral Data Content Standard describes thematic attribute data linkages as a means of combing and cross referencing separate databases by common elements. A data linkage is a reference from one data group to another. Data linkages exist between geospatial and thematic databases as well as between different thematic databases. The Cadastral Data Content Standard recommends that a data linkage be bi-directional. This allows for accessing geospatial information in a thematic database and thematic information from a graphical display.

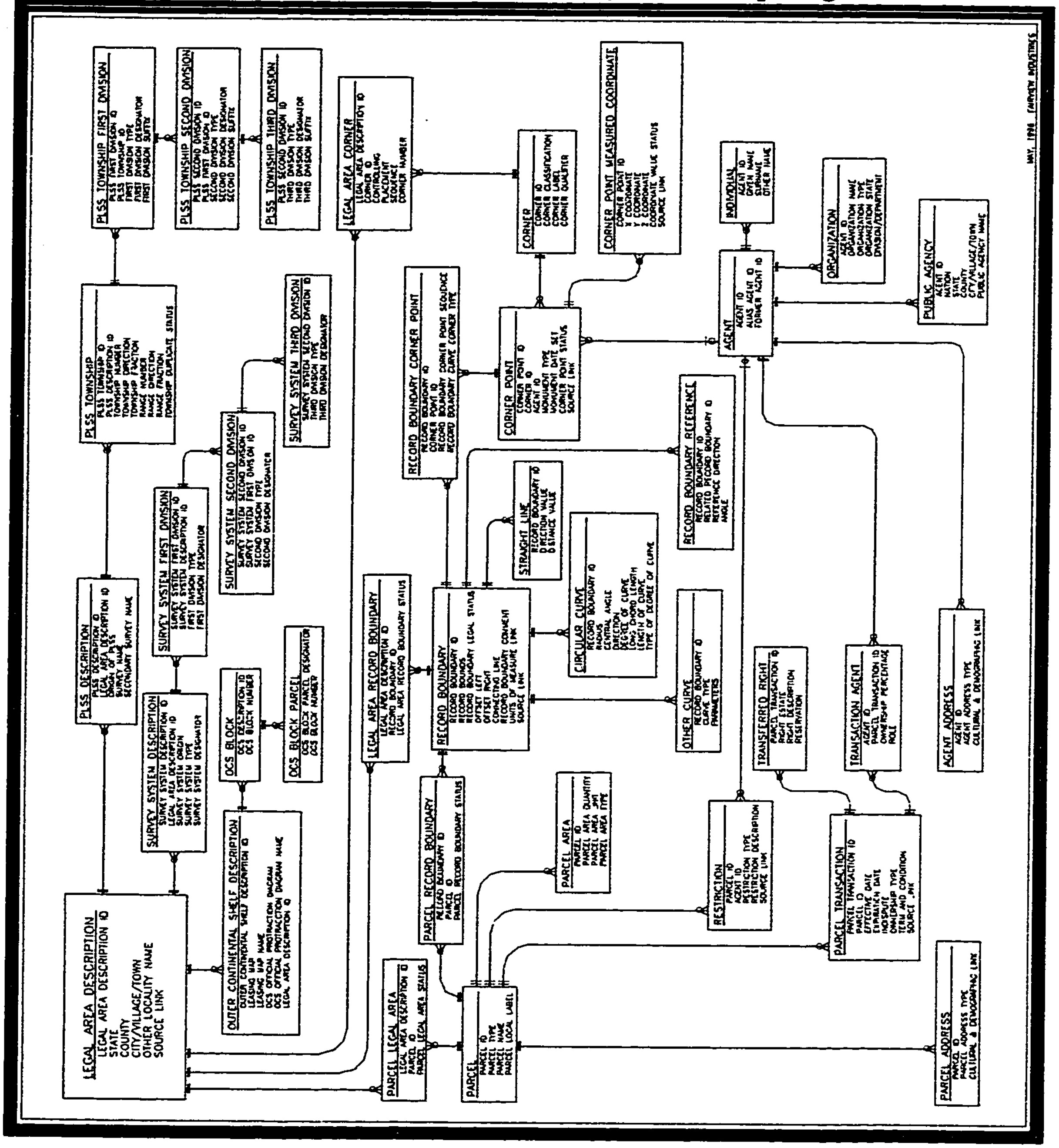
Entity Relationship Diagram

The Cadastral Data Content Standard shows the required entities, their attributes and the data linkages as an entity relationship diagram. "Entity relationship diagrams illustrate the entities, their attributes, and their associations" (FGDC, 1996, p. 2-1). The entity relationship diagram contains 38 entities and 176 attributes. Each entity is represented by a box with the name of the entity being underlined at the top of the list. Below the entity name is the list of the attributes that describe and differentiate the entity. Lines and symbols are used to describe the cardinality and associations between linked entities (Figure 4-3).

Cardinality

The lines that connect the boxes describe the cardinality of the relationships between the respective entities. Cardinality describes the number of occurrences of an entity with respect to a linked entity. At the end of each line there is a symbol that represents the number of possible occurrences of the entity with respect to the connected entities. All of the relationships except for two represent a "mandatory one" to an "optional many". What this means is that certain entities can only occur once while other entities may need to occur more than once. For example, a Parcel Entity can be linked to more than one Parcel Area Entity.

Figure 4-3. Cadastral Data Content Standard Entity Relationship Diagram.



One parcel can have several different areas within the database. One area may be for taxation purposes and only accurate to the nearest tenth of an acre. Another area may be referenced from a tract map and used for sales purposes. Another area may be generated from the state plane coordinate grid within a GIS. Each of the mentioned areas must be associated with only the one parcel that generated the area (Figure 4-3). This relationship is displayed by the line and symbols which connect the Parcel Entity to the Parcel Area Entity. The double line symbol on the line near the parcel entity represents a mandatory one relationship. At the end of the line near the Parcel Area Entity a circle and triangle represent an optional many relationship. The two exceptions to the mandatory one to optional many rule can be found on the line connecting the Corner Point Entity to the Agent Entity and the line connecting the Transaction Agent Entity to the Agent Entity. In these instances one agent may optionally be represented by the circle and line symbol near the Agent Entity. One method for linking tables that supports a "mandatory one" to "optional many" data linkage is to embed primary keys from one entity into a linked entity as a foreign key (Figures 4-4 & 4-5).

Figure 4-4. Parcel Entity.

PARCEL ENTITY				
	Parcel ID	*Parcel Type*	*Parcel Name*	*Parcel Local Label*
	(Primary Key)	(Text)	(Text)	(Text)
	1001	Park	Dune	455-23-001

Figure 4-5. Parcel Area Entity.

PARCEL AREA ENTITY				
	Parcel ID	*Parcel Area Quant.*	*Parcel Area Unit*	*Parcel Area Type*
	(Foreign Key)	(Numeric)	(Text)	(Text)
	1001	20.4352	Acres	Surveyed
	1001	19.00	Acres	Taxable
	1001	20.42	Acres	Computed

Figure 4-4 and 4-5 graphically portray the embedding of a foreign key from the Parcel Entity into the Parcel Area Entity. This allows three values to be associated with the primary key 1001.

Database keys are used to implement data linkages between geospatial and thematic (attribute) data bases. According to the Cadastral Data Content Standard each of the records in a thematic (attribute) file should: 1) be linked to the geospatial data in the same manner, using the same linkage strategy, 2) be uniformly formatted to support integration and aggregation of information, 3) all data objects (records) that need linkages should have linkages. The most common method for establishing data linkages is the use of primary keys.

Primary Keys

Primary keys can be sequential numeric integers that are assigned by a computer system to keep track of a data base record. Primary keys provide a one to one relationship. They also provide a direct means to access the data. Secondary keys are not unique and may retrieve more that one set of data. For example, an assessor's parcel number could be used as a primary key. When the parcel number is typed into the system, data about a unique parcel is retrieved. A secondary key could be the zip code of the parcel. When the zip code is entered in the system the parcel mentioned above will be recalled along with all the other parcels that fall in that zip code.

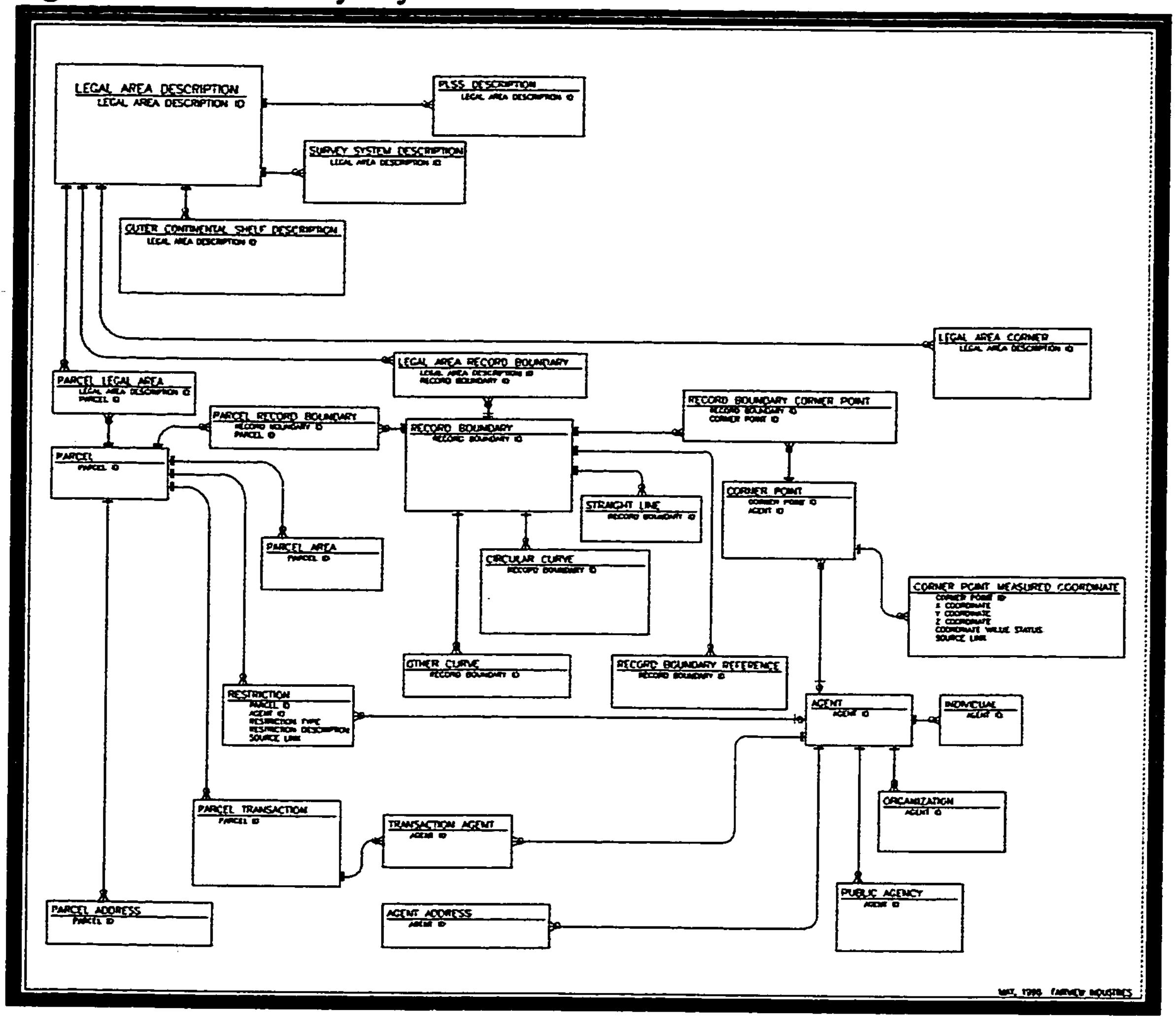
The Cadastral Data Content Standard contains fifteen entities with primary keys (Figure 4-6). These fifteen primary keys are embedded in other entities as foreign keys to form the "mandatory one" to "optional many" link.

Figure 4-6. Primary Keys.

Entity	Primary Keys
Agent	Agent ID
Corner	Corner ID
Corner Point	Corner Point ID
Legal Area Description	Legal Area Description ID
Outer Continental Shelf Description	Outer Continental Shelf Description ID
Parcel	Parcel ID
Parcel Transaction	Parcel Transaction ID
Public Land Survey System Description	Public Land Survey System Description ID
Public Land Survey System Township	Public Land Survey System Township ID
Public Land Survey System Township First Division	Public Land Survey System Township First Division ID
Public Land Survey System Township Second Division	Public Land Survey System Township Second Division ID
Record Boundary	Record Boundary ID
Survey System Description	Survey System Description ID
Survey System First Division	Survey System First Division ID
Survey System Second Division	Survey System Second Division ID

Five of the fifteen primary keys link twenty-seven of the thirty eight entities (Figure 4-7).

Figure 4-7. Main Primary Keys.



The five main primary keys are: 1) Legal Area Description ID, 2) Parcel ID, 3) Record Boundary ID, 4) Agent ID, and 5) Corner Point ID.

The Legal Area Description ID is the primary key for the Legal Area Description Entity. "A Legal Area Description provides the structure for the delineation of areal extent of land or water" (FGDC, 1996, p. 3-14). The Legal Area Description ID is embedded in six other entities as foreign keys. The Legal Area Description Entity maintains the "mandatory one" relationship while the six entities with embedded foreign keys are optional and may occur more that once (optional many).

The Parcel ID is the primary key for the Parcel Entity. The Parcel ID is embedded in six other entities as a foreign key. The Parcel Entity maintains the "mandatory one" relationship while the six entities with embedded foreign keys are optional and may occur more than once (optional many).

The Record Boundary ID is the Primary Key for the Record Boundary Entity. "A Record Boundary is the linear feature that represents the edge of an areal feature, which may be a parcel or a legal area" (FGDC, 1996, p. 3-37). The Record Boundary ID is embedded in seven other entities as a foreign key. The Record Boundary Entity maintains the "mandatory one" relationship while the seven entities with embedded foreign keys are optional and may occur more than once (optional many).

The Agent ID is the primary key for the Agent Entity. "An agent is an individual, organization or public agency that holds rights, interests, or restrictions in land; holds or files land records, or has established a land description or monument" (FGDC, 1996, p. 3-4). The Agent ID is embedded in seven other entities as a foreign key. The Agent Entity maintains the "mandatory one" relationship while the seven entities with embedded foreign keys are optional and may occur more that once (optional many).

The Corner Point ID is the primary key for the Corner Point Entity. "A Corner

Point is a point which marks the ends of a Record Boundary or the extremities of a legal arear" (FDGC, 1996, p. 3-9). The Corner Point ID is embedded in two other entities. The Corner Point Entity maintains the "mandatory one" relationship while the seven entities with embedded foreign keys are optional and may occur more than once (optional many).

Benefits of Standardized Thematic Attribute Data Linkages

The standardization of database linkages at the county level would benefit all levels of users of cadastral information. Data collected locally could be used across jurisdictional boundaries which would save time and money. Standardized thematic attribute data linkages would insure that primary keys are established during data collection and compilation efforts. Standard database keys and a common parcel identifier system will be required to reach the full potential of the NSDI cadastral data framework.

Summary

Implementing cadastral data collection standards as part of the NSDI cadastral data framework will not be possible without a common definition of a cadastral data layer. The counties need to adopt standards for a cadastral data layer in addition to cadastral data collection standards to insure the development of the NSDI cadastral data framework. This includes adopting the State Plane Coordinate System as the geodetic reference system for cadastral data. A definition of what constitutes parcel level data must be developed. The vector geospatial data model must be adopted as the foundation for storing geospatial data that represents cadastral data. Adopting the Cadastral Data Content Standards will provide a means to standardize thematic attribute data content and thematic attribute data linkages.

Standards for a cadastral data layer will allow collection and compilation efforts to occur at different times and places with the final product being consistent in form and content. A standardized cadastral data layer would also allow data collected by local agencies to be used by all levels of government and the private sector. A standard definition of a cadastral data layer combined with cadastral data collection standards would insure the consistent development of the NSDI cadastral data framework.

Chapter 5

SUMMARY AND RECOMMENDATIONS

The National Spatial Data Infrastructure (NSDI) includes the standards, materials, technology, and the people necessary to acquire, process, store, and distribute the critical framework data sets for producers and users of geospatial data. Standards for the framework data sets will eliminate duplication of effort at all levels and supply end uses with quality products and information. The NSDI framework data sets include geodetic control, digital orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral data. Currently there is no intention to develop a collection standard for cadastral data that is to become part of the NSDI. Collection standards for the cadastral layer within the NSDI framework are critical for the successful implementation of the NSDI.

The development of collection and accuracy standards for cadastral data in the Public Land Survey System (PLSS) was a process that took over 200 years of refinement and increased the reliability of the land records system in the United States. There is a parallel between the lack of uniform standards in the early colonial system and the current lack of uniform cadastral standards at the county level.

Content and collection standards for cadastral data must be implemented and enforced at the county level in the United States. This will insure that the cadastral portion of the NSDI will be as successful in settling the digital frontier as the PLSS was in disposing of the lands in the western frontier.

A common framework of cadastral data across the United States will not be obtained with the absence of a nation-wide cadastral data collection standard at the county level. The absence of cadastral data collection standards has produced data that varies in content and accuracy based on its geographic location. A massive duplication of effort is taking place and no quality control process for developing cadastral data layers exist. To remedy this situation the counties must adopt and enforce a cadastral data collection standard that includes a standard for digital data submission formats. There needs to be minimum requirements for survey equipment and standard survey methodologies. Data accuracy classification schemes based on equipment and methodologies need to be employed during field collection activities and office compilation efforts.

Additional standards for the basic components of a cadastral data layer are required to implement cadastral data collection standards at the county level. Currently several definitions of what constitutes the basic components of a cadastral data layer exist. This precludes the ability of some counties to fully implement cadastral data collection standards. The counties must standardize on the basic components of a cadastral data layer to reach the NSDI goals of consistent cadastral data content and accuracy across the nation.

To reach the NSDI's goal of a common cadastral framework, a common geodetic reference system that is tied to the State Plain Coordinate System must be adopted as the coordinate system for cadastral data. Agreement needs to be reached on what constitutes the content of parcel level data. A standard geospatial data model needs to be identified and used as the basis for storing the geospatial data base objects. Standards for thematic attribute data content and thematic attribute data linkages must be adopted and enforced. The Cadastral Data Content Standard has been developed to provide a uniform system to establish the attributes that will be used as identifiers for primary keys in geospatial and thematic data bases. The adoption of the Cadastral Data Content Standard along with cadastral data collection standards at the county level would insure the successful implementation of the cadastral portion of the NSDI framework.

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