CONSTRUCTING A DIGITAL LAND RECORD SYSTEM

A Thesis

by

BRYAN S. GILLIS

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This thesis meets the standards for scope and quality of
Texas A&M University-Corpus Christi and is hereby approved.

Richard Smith, PhD Co-Chair	Tianxing Chu, PhD Co-Chair
Catherine Rudowsky, PhD Committee Member	Philippe Tissot, PhD Committee Member

August 2019

ABSTRACT

Land records represent the legal bindings of a person to their property and assist in the execution of property ownership. Protecting these documents and adopting a clear system to manage them should be a priority to every private citizen with interest in real property in the United States. Unfortunately, existing land record systems have become dated and fail to protect land records and offer little-to-no transparency or accessibility. Fortunately, more modern digital land record systems are being developed to combat these issues.

When constructing a digital land record system, it is necessary to (1) identify the economic and functional value of using digital land record systems for a government entity, (2) establish procedures for the digitization of physical land record systems, and (3) provide digital land record system examples that meet the base needs of a land administration system with public access that follows both geospatial data and digital library standards.

This thesis evaluates the needs of a successful digital land record system and outlines the development and capabilities of BandoCat, a modern digital land record system project at the Conrad Blucher Institute for Surveying and Science (CBI) at Texas A&M University – Corpus Christi. This thesis will assess the current state of land record systems in the United States and highlight the current inefficiencies and issues existing in these systems, thereby necessitating the development of BandoCat as a modern solution. The design of modern land record systems is founded in the standards of digital libraries. These digital libraries serve as long-term data stewards and provide well-developed standards which land record systems can leverage. This thesis details the parameters of BandoCat, how it leverages digital library standards, its modern features (such as georectification and adherence to metadata standards), and how modern land record systems (such as BandoCat) address current digital land record systems' shortcomings, facilitate easier

access for stakeholders, easier system interoperability, and visualization of land records information.

It is the hopes of the author that this thesis will serve as a guide to improving the state of land record systems in the United States. Through the combination of the modern digital land record systems, such as BandoCat, with a consistent and interoperable design, the state of land administration can be vastly improved. The procedures and methodology created by the author provide a baseline for improving land record systems, and the BandoCat system developed by the Spatial {Query} Lab provides a software to begin the transition from physical to digital land record systems.

DEDICATION

This thesis is dedicated to the people to the Spatial {Query} Lab and the Conrad Blucher Institute for their hard work and dedication to the projects and science that made this thesis a possibility.

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I would like to thank Richard Smith and Seneca Holland for your inspiration and dedication to my education and for giving me the courage and mentorship needed to become the director of the Spatial {Query} Lab. I'd also like to thank my committee members Dr. Chu, Dr. Tissot, and Dr. Rudowsky for their guidance, support, and understanding throughout the course of this research.

Thanks also to my wonderful wife Melanie for supporting me and encouraging me to continue during my moments of weakness during this thesis, I love you.

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CHAPTER I: INTRODUCTION

In most courthouses across the United States, land records are limited to physical records. Computer indexing is common, but it does not include digital copies of the land records. These same systems are also limited to transcribed versions of historic registries. *Modernizing American Land Records: Order Upon Chaos* (Epstein, 2014) outlines the problems revolving around the land record system in the United States, and even includes some valuable input and approaches to solving these issues. This thesis provides a general procedure for land administrators to follow when identifying how to best modernize land record collections.

The current state of the decentralized land record system in the United States presents a unique set of challenges to land administration. Land records are primarily decentralized within the United States and will be expanded upon in Chapter II. Land records represent the legal bindings of a person to their property and assist in the execution of property ownership. The decentralization of the land record system in the United States causes inconsistencies and confusion among its citizens in regards to property boundaries, and makes land records administration more burdensome and costly. Attempts to resolve these issues have largely failed due in part to the lack of funds and clear direction by the United States government (E. Grant, 2005). These inconsistencies have resulted in a patchwork of systems at local levels which are incompatible with each other. Additionally, many systems at local levels are operated and maintained by private entities (such as title companies and real estate organizations), thereby introducing data silos, uncommunicative proprietary systems, and lack of transparency.

This thesis analyzes the current and historic situation and background of land records in the United States and presents BandoCat as a modern solution to these issues. This thesis begins with a discussion of stakeholders and how they interact through the functionality of a digital land record system. Chapter II discusses the purpose and relationship between cadastre and land record systems, details the overarching authorities responsible for land records in the United States, and describes how survey methods effect land record system management. Chapter III provides an overview of digital libraries and how they provide a baseline for digital land record systems through proven structure. Chapter IV provides an overview of the primary functionality of a modern digital land record system. Chapter V details the procedures and workflows of BandoCat. Chapter VI provides a conclusion of the materials presented in this thesis and provides avenues for future work.

1.1 Background

To begin, we must understand what land records are. Land records are documents that reflect what is known about areas of land and its resources. These records come in many forms, more familiar ones being maps, deeds, survey reports, means, and bills-of-sale. In essence, land records are the metadata of land as it is the actual information contained in these records that can include, but is not limited to: location, size, grantor and grantee history, mineral rights, liens, and property restrictions. There are many stakeholders in a land record system, such as: county clerks, tax assessors, real estate companies, title companies, land surveyors, judicial courts, landowners, non-landowners, as well as any other interested parties.

County clerks are often charged with the responsibilities of recording and maintaining archives of land records. Unfortunately, because of the decentralization of land records in the United States and lack of strong guidance and oversight, not every county requires the same level of documentation and almost no two counties will store their records in the same way (Texas, 1876). Other major issues at the county-level include the lack of digital records, the lack of document control, and lack of online public access.

Tax assessors use land records to identify property values. In order to uniquely identify every parcel in the United States, the federal government mandates the assignment of a unique parcel identification number (PIN) making it the ideal attribute to assign to every single land record in order to improve organization and clarity of spatial location of land records nationally. Most county tax assessor offices have established geographic information systems (GIS) for tracking properties within their jurisdictions and within their system, use PINs to uniquely identify parcels. Not all stakeholders have adopted the use of PINs, which is unfortunate, because the use of PINs would allow for the interoperability between stakeholder systems.

Licensed land surveyors are subject matter experts of land and land information who identify real property on the ground. Surveyors recover boundary evidence through their field work and court room research. When surveyors complete a survey, they only file what is required by the county clerks, which, unfortunately, often does not require complete records that are critical to maintaining a complete land record system. Another issue involving the surveyor is that records are typically not tied to PINs because the county clerks do not require it. In relation to land records, this leads to unorganized and inconsistent land record systems.

Real estate and title companies represent the largest users and creators of land records. Title companies are responsible for handling land transactions in most cases. Real estate companies have created a system known as the multiple listing service (MLS) to aid in the listing and advertising of real property. This system is privately used by realtors and their current clients. On the client end, it is similar to public systems like Zillow and HomeFinder. On the realtor-end, the system includes more up-to-date information concerning properties on the market. The MLS system is dependent on the information volunteered by private real estate companies concerning properties in their area of operation. These systems will often incorporate the use of PINs tying the availability of properties to the same system established by tax offices. Even though MLS is a paid service, it is dependent on information sourced from real estate agents.

The last interested party discussed is the landowner. The landowner is the individual(s), or organization, that has rights to a property. Additionally, interests also extend beyond surface rights as mineral, groundwater, sub-surface, and liens are all examples of different interests that landowners can have on a single piece of property. Because records are not always linked between systems (as discussed above), a potential landowner could be misled and not know what they would own at the end of a land transaction. A diligent surveyor would do their best to compile as much information as they can about a property intended for sale, however, the current land system in the United States makes this difficult. Many surveyors and real estate agents will downplay the necessity for such in-depth research and place the burden of record finding on title companies or even potential landowners themselves. Unfortunately, title companies are not actually liable for their work which is why they sell title insurance. If there was a modern land record system that was tied to stakeholder systems utilizing PINs, it would remove the need for title insurance, reduce the cost of real estate transactions, and strengthen the confidence of the accuracy of land records across the nation.

CHAPTER II: CADASTRE & LAND RECORD SYSTEMS

In any land system, a cadastre is the information about land. Ownership, tax assessments, liens, and interests should all be included in a cadastre to assist with the proper management of land with respect to all stakeholders. Understanding the complex relationships associated with a piece of land is essential to the dynamic and fast-paced environment in which land transfers occur in the United States.

A land record system is composed of land parcel and cadastre information. In today's industry, the land record system is usually in the form of a geographic information system, or, more specifically, a digital land record system. The digital land record system could replace the necessity of paper indexes tracking physical records at various locations. This paves the way for the digital accessibility of land records, improving access to land information.

2.1 Decentralization of Land Administration

The first official cadastre in the United States wasn't established until the Northwest Territories were surveyed in 1784 (Jefferson, 1784). This expansion into the Ohio River Valley initiated Thomas Jefferson's U.S. Public Land Survey System, which is controlled today by the Bureau of Land Management. This system contains the basic spatial information about land within US states and territories except for Texas, where their information is limited to federal lands within the state.

However, the responsibility of recording and management of additional land information, such as tax data, ownership, and interests, is left to the State in which the properties fall. There is not always consistent recording formats or linkable information between jurisdictional systems (Grant, 2005). These inconsistencies have resulted in an undue burden on the judicial system to sort out disagreements about property boundaries and ownership of land between stakeholders (Linkous et al., 2018). This burden also comes with a fiscal cost to the taxpayers who are expected to fund the courts.

This decentralization of land administration also creates inconsistencies between regulatory bodies and creates an unequal ability to resolve issues (Grant, 2005). A smaller government will not have the resources to fund the initial development of a state-of-the-art digital land records system, especially in comparison to a larger municipality's capability. We typically see this in Texas where more populous counties have professionally constructed land record systems compared to more rural counties (Moss, 1998). As an example of this disparity, Harris County offers a sophisticated GIS as part of their digital land record system that utilizes a map viewer or traditional search to locate parcels within its jurisdiction and returns results immediately as seen in Figure 1 below. In contrast, Childress County Appraisal District requires an interested party to know specifics of a property (as shown in Figure 2) in order to submit a request for information that requires a paid county employee to fulfil the request. Even still, both systems lack the connection between property searches and the recovery of complete land records (at a minimum: plats, deeds, bills-of-sale) in a digital format (Grant, 2005). Both counties would still require an interested party to either arrive in person to the County Courthouse in order to obtain additional land records or pay a third-party company to recover the land records.

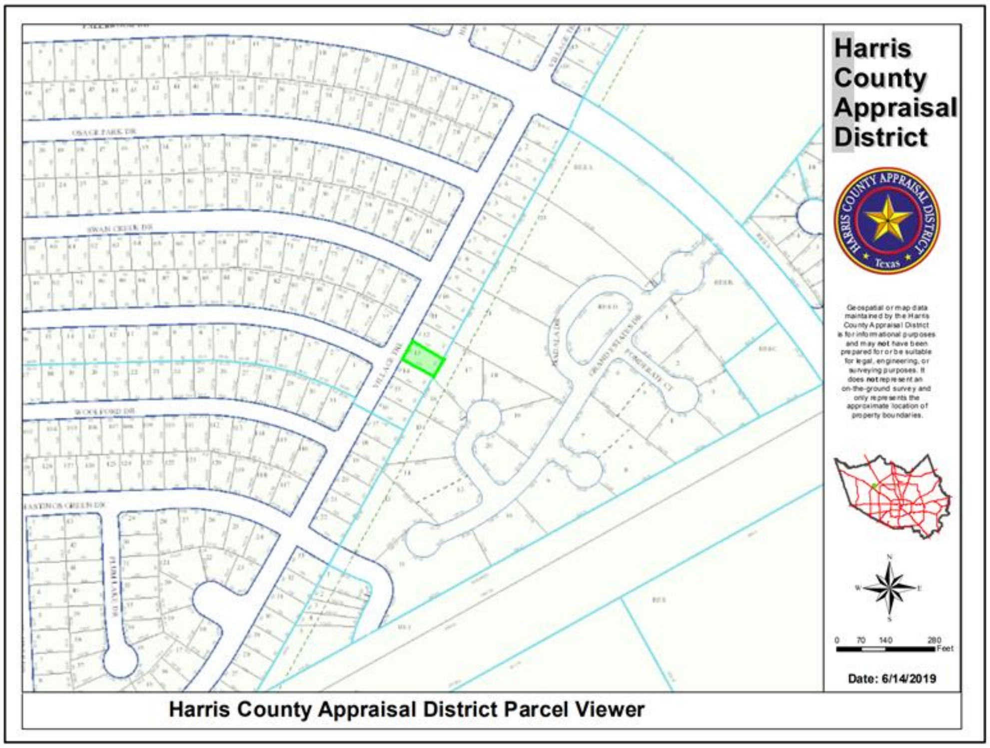


Figure 1: Example of Generated Land Record from Harris County Appraisal District

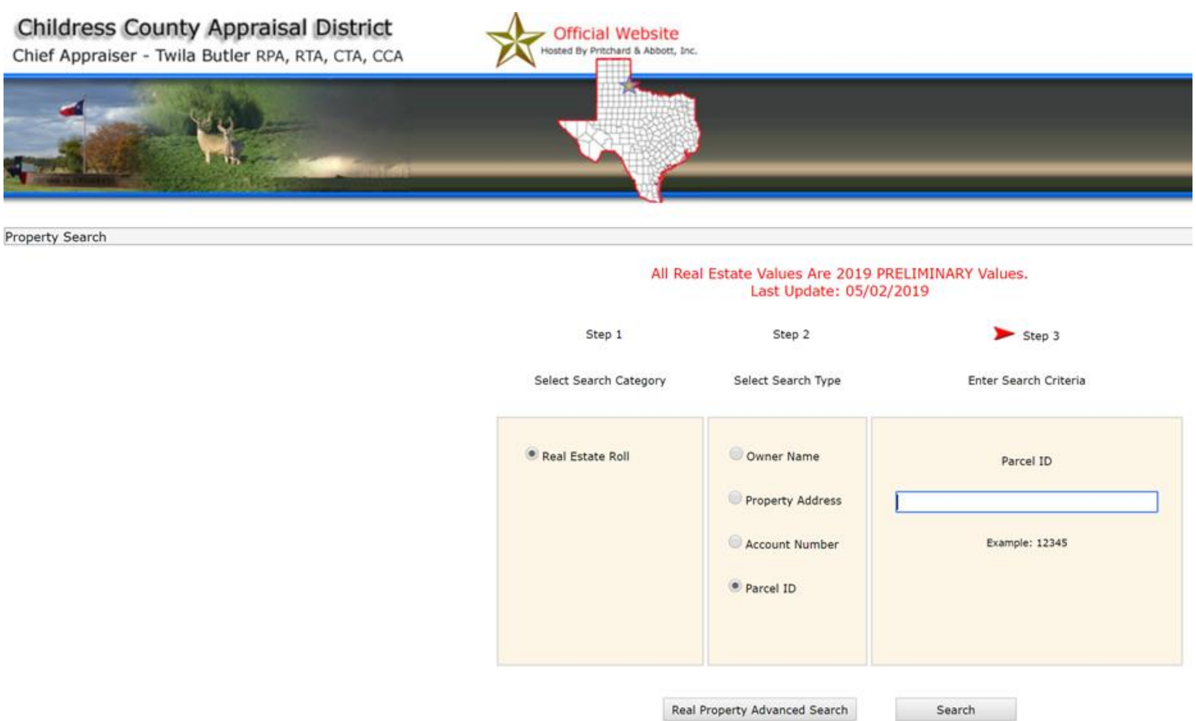


Figure 2: Screenshot of Childress County Appraisal District Record Request Form

2.2 Land Administration

While land record systems make the administration of land easier, centralizing land record systems does not equate the centralization of land administration. The function of land administration is to facilitate the process of determining, recording and disseminating information about ownership, value and use of land and its associated resources (Williamson, 2010).

While decentralization of land administration is a cause for many land issues faced in the United States today, centralization at the national level could be just as troublesome. Each U.S. state controls their own land laws. This has resulted in the unique practices of professions such as surveying, real estate, and title companies in each state. Upending a state's right to govern its own land would be a political catastrophe at the least. Therefore, land administration and regulation of land records should reside at the state level to better serve their citizens.

In many states, the state government already is responsible for land administration, but the responsibility is often delegated down to the county level. This was acceptable prior to the computer age, when land records were physically indexed and stored in county archives or courthouses. The computer age brought with it the ability to improve this system through centralization at the state level.

2.2.1 Public Land Survey System

The public land survey system uses a grid system to divide land within a state. The system utilizes 36 square mile grids identified with townships and ranges. The townships represent north or south location from the grid point-of-beginning. Ranges represent east or west location from the grid point-of-beginning. The location identified by the township and range is called a parcel. Each parcel is 1 square mile, or 640 acres. These parcels are further broken up into subdivisions of one-half or one-quarter as displayed in **Error! Reference source not found.**.

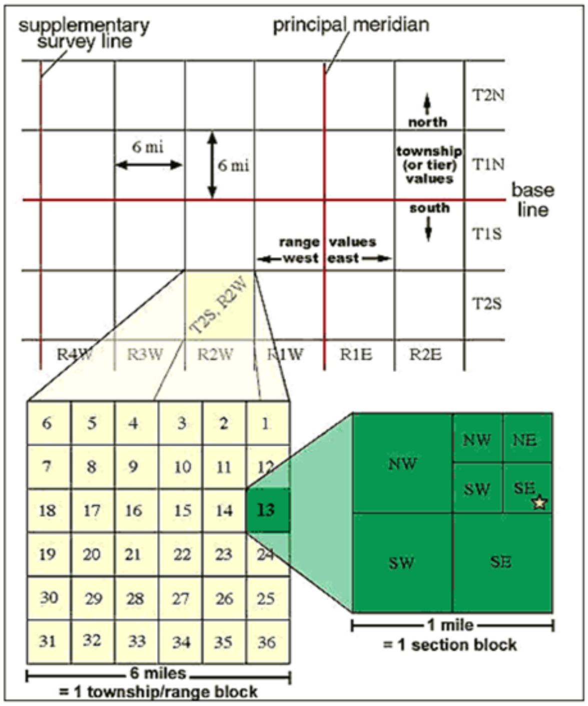


Figure 3: Overview of Public Land Survey System Design (Vasiley, 2014)

2.2.2 Metes & Bounds

When the American Colonies were established, real property was defined through the metes and bounds system. This system described land through an identifiable point-of-beginning that would follow an azimuth, or line, to another identifiable point. Whether that point was another monument or simply just a distance along that azimuth was defined by the surveyor. This method is shown in Figure 4.

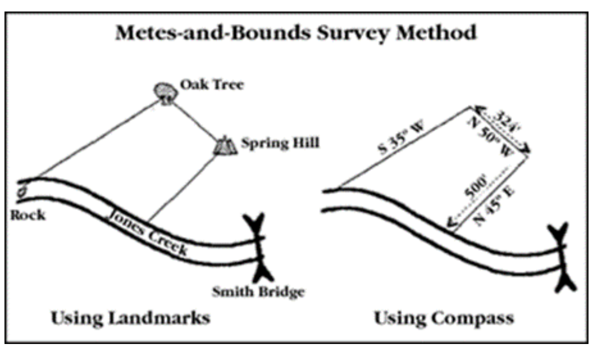


Figure 4: Example of Metes-and-Bounds Survey Method (King, 2012)

2.2.3 Bureau of Land Management

The Bureau of Land Management (BLM) was established in 1946 after the General Land Office of the United States and United States Grazing Service were combined to encompass the regulation of federal lands. The BLM is responsible for acquiring (with the exception of the State of Texas) and managing federal lands across the nation. BLM presence is more noticeable in Western states where land was acquired before these territories became states (as seen in **Error! Reference source not found.**).

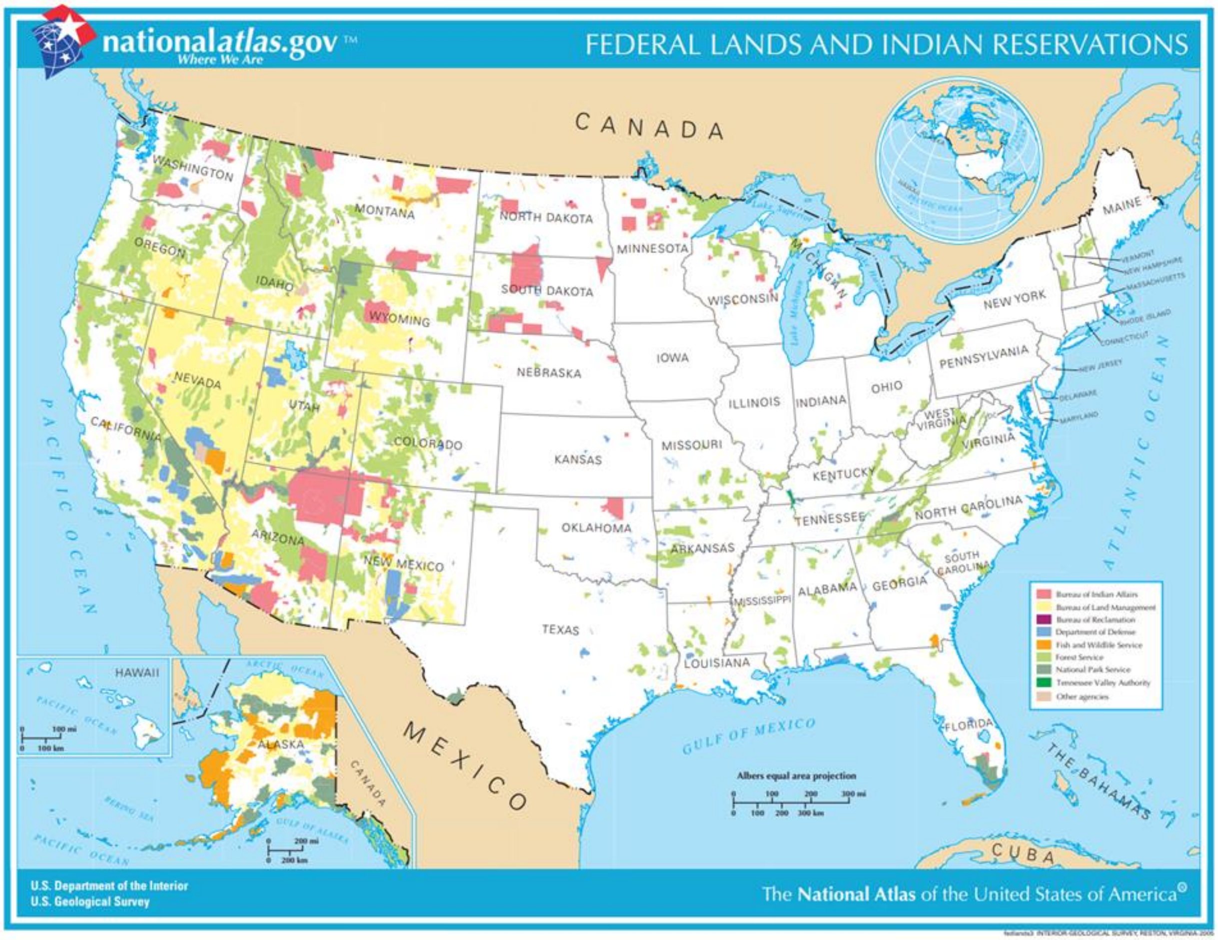


Figure 5: Map of Federal Lands Maintained by the Bureau of Land Management (National Atlas, 2005)

2.2.4 Texas General Land Office

The Texas General Land Office's (TGLO) core mission is the management of Texas state lands and mineral-right properties totaling 32,000 square miles as of 2017 as shown in Figure 6

(Aldon, 2017). Included in that portfolio are the beaches, bays, estuaries, and other submerged lands out to 10.3 miles in the Gulf of Mexico, institutional acreage, grazing lands in West Texas, and timberlands in East Texas. In managing that property, the TGLO issues oil and gas leases and surface leases and sells state land (Texas General Land Office, 2019).

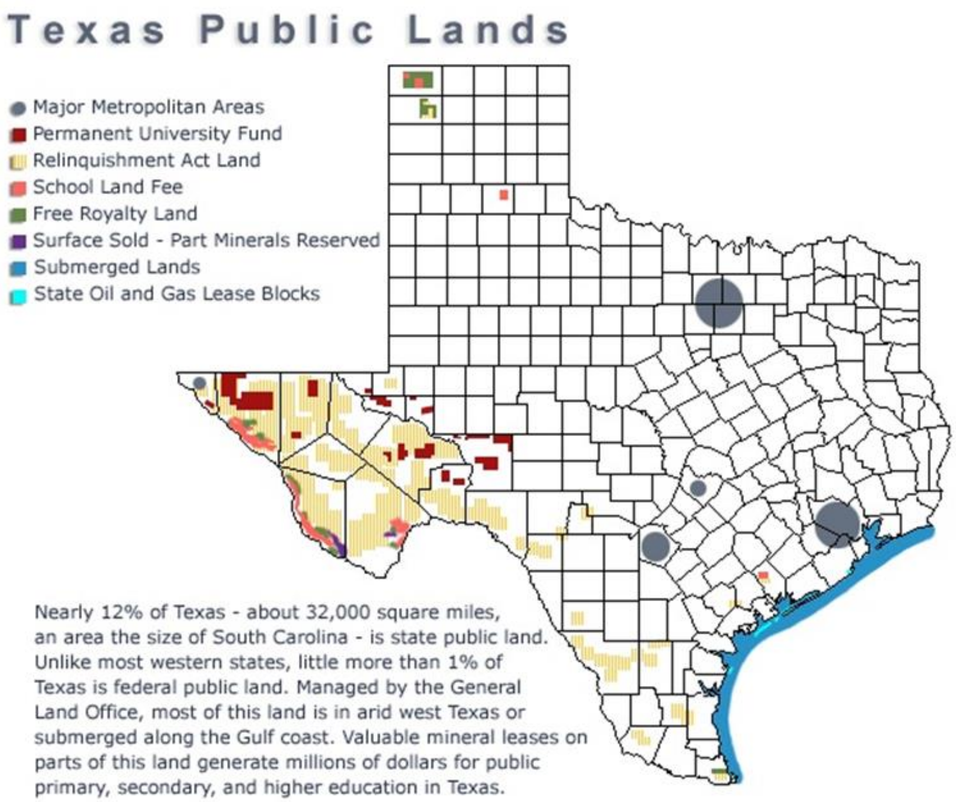


Figure 6: Map of Texas Public Lands Maintained by the Texas General Land Office (Aldon, 2017)

2.3 When to Adopt a Digital Land Record System

A difficult issue to address is when to adopt a digital land record system that fits an authority's existing cadastre or when it would be more appropriate for a governmental entity to start from scratch and redesign a cadastre around a new digital land record system. Unfortunately, the answer to this comes at a case-by-case situation depending on the current land administration climate and traditions for that nation. Not every sovereignty has a well-designed cadastre, and many sovereignties don't even have consistent cadastre structures among their jurisdictions, such as the United States of America (Lee, 2018).

When an existing cadastre is well designed, it is ideal to build a land record system around it that will create a homogeneous system. This will avoid the large costs of re-surveying and re-issuing title to existing landowners. However, when the cadastre is inconsistent and in need of vast improvements an entirely new system may be preferable.

2.4 Examples

A brief example of why there is no straight answer would be an assessment of the cadastre systems of the State of Texas in the United States and the country of Scotland. Each example has an existing system rife with problems, legal, and otherwise.

2.4.1 Texas Land Systems

Texas' 254 counties and general land office each follow a similar structure that dates back to the Stephen F. Austin land grant in 1823 when Texas was still a province of Mexico. Land grants issued from all 6 sovereignties of Texas were upheld, despite the vast differences in land grant rules. Figure 7 shows an example of Spanish land grants in South Texas, which include several different types of land grants issued by the Spanish Crown. Today, a statewide digital land record system could be designed to fit all jurisdictions with minimal anomalies because these land grants have been upheld to date. The continuity of land history makes Texas ideal for building a digital land record system around their current cadastre system.

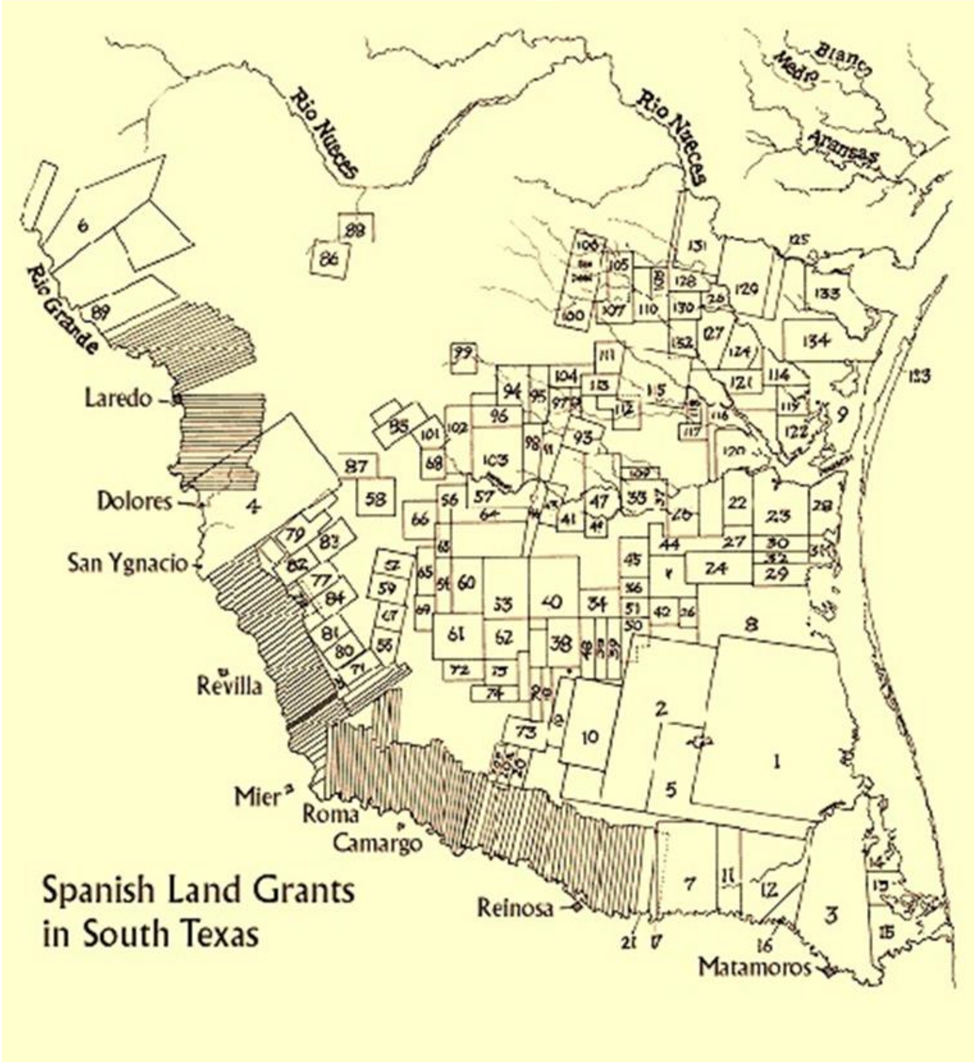


Figure 7: Map Showing an Example of Land Grants in South Texas (Texas Beyond History)

2.4.2 Scotland Land Systems

The Scottish Land administration system represents an opposite case study. The Registers of Scotland currently manage several cadastre, including the 1617 Register to Sasine which is the oldest land record still in use (Reid, 2015). Scotland is also going through land reform, in which the public is demanding a unified land record system which provides better public access (Lovett, 2018). The fact that the Scotland Land administration is already going through a total reform (it currently is moving from feudalism to a free real market) makes it an ideal case for implementing a new cadastre that better fits an original digital land record system (Reid, 2015). With the new reform, interested stakeholders are able to easily acquire land records (such as shown in Figure 8) from the Land Register of Scotland website.

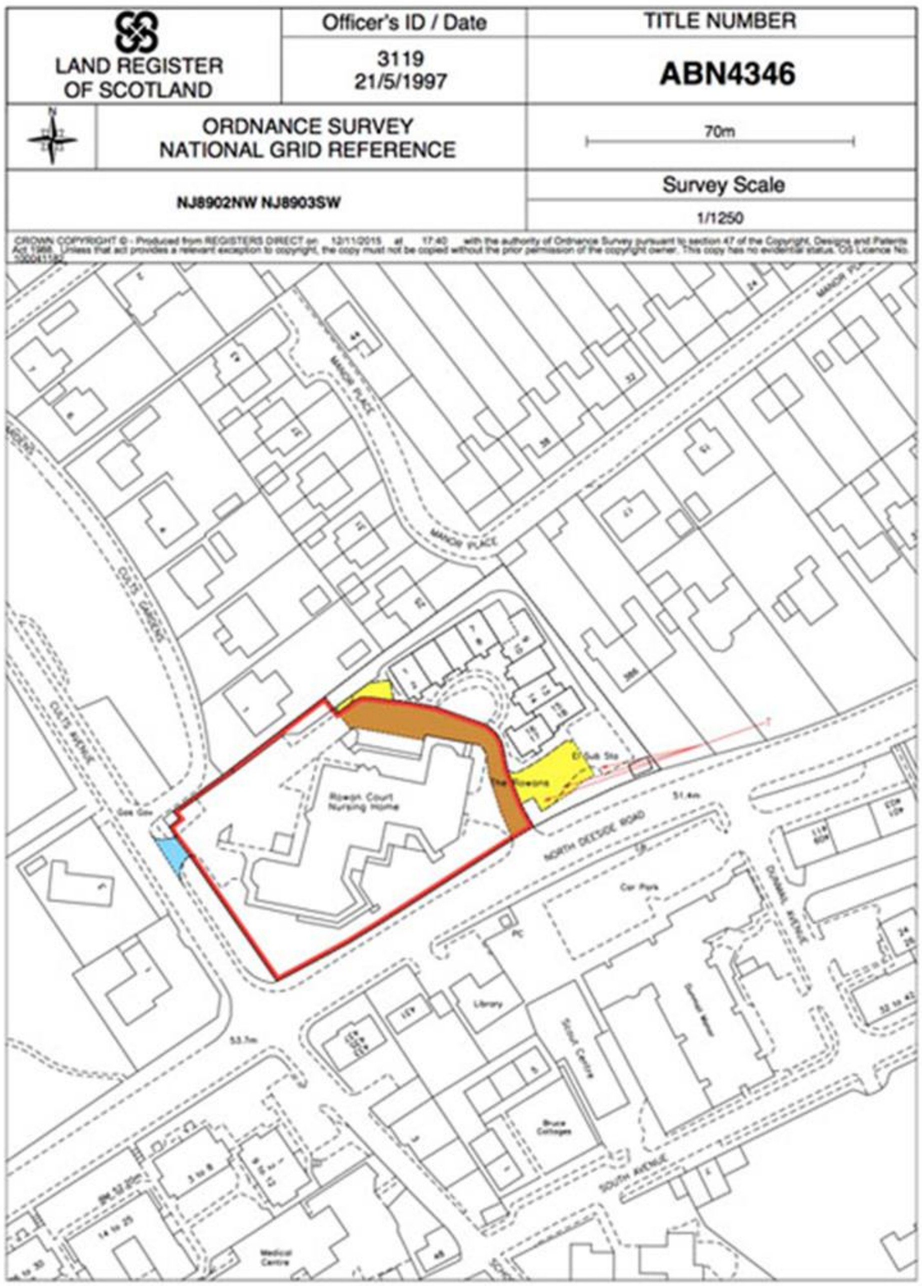


Figure 8: Map Showing Property Location from Scotland's Reformed Land Register

CHAPTER III: DIGITAL LIBRARIES

The design of modern land record systems are founded in the standards of digital libraries. These digital libraries serve as long-term data stewards and provide well-developed standards which land record systems can leverage. Digital land record systems are an applied tool for progressing land administration and gaining access to records in real time for validated sources. However, digital land record systems do more than just provide a tool. At present, they allow for the preservation of information that otherwise would be stored in physical formats subject to corrosion and loss. Digital land record systems present us with an opportunity to create digital libraries that preserve and archive our land history. This chapter will first examine the relationship between digital libraries and digital land record systems and then identify the key concepts of digital libraries as they relate to digital land record systems.

3.1 Digital Library vs Digital Land Record System

The establishment of best-practices and archival standards when constructing a digital land record system prevents the necessity of developing two separate systems to support a single cadastre. Current partnerships between the Conrad Blucher Institute and the Mary and Jeff Bell Library on the BandoCat project have shown that including library scientists at the inception of a digital land record system will improve the overall functionality and sustainability of that system. Additionally, the establishment of best-practices and archival standards allow for a single system that services historic as well as current land records. This is necessitated by the inherit differences between temporal overlap of records of the same property.

When BandoCat was developed, it was initially intended to be a cataloging tool and allowed for the generation of metadata for maps within the Blucher Survey Collection. Since its creation, BandoCat has become more than just a cataloging tool. Today, BandoCat has the capability to catalog, georectify, compile, transcribe, query, and publish scanned land records into what is becoming a digital land record system of historical survey data concerning South Texas. So, because the digital land records are all historical and currently stored in a physical library, a redesign of BandoCat's back-end was required to meet the standards and criteria of a digital library (Nguyen, 2017).

BandoCat was redesigned to adhere to standards such as those set by the Digital Libraries Federation (2019) which has established minimum benchmarks and standards of practice for digital libraries. Minimum benchmarks begin with the scanning procedures. They help to identify what documents should be scanned at what resolution, into what file type, at what scale, and what color. These benchmarks focus on traditional types of documents found in the library such as books, journals, pictures and microfilm. While some of these types of documents exist in land record collections, they do not specifically address all the unique types of documents in any given land record collection. This means that there is a necessity for established minimum benchmarks concerning land records.

3.2 Key Concepts of Digital Libraries

This section briefly introduces the key concepts of a digital land record system following digital library standards.

Resources are a basic element of a digital land record system. They are the generic containers that store data. At its most fundamental level, a resource has an identifier, a location, a collection pointer, an owner, access control information, and contents and attributes as defined in its schema. Resources are stored as XML documents, which will be discussed further in Chapter V.

Schemas are used to define the internal structure of resources. Every resource requires a schema. Resources with the same schema are instances of the schema, in which case, the schema plays the role of a Class in the Object-Oriented model. Schemas are not user-consumable data but are meant to be used by the digital record system or other applications to interpret the contents of resources. Schemas are part of the system, but they will be exposed to external applications in the form of URLs for information exchange purposes (Lim et al, 2002).

In order to organize the various resources, users can define layers that contain a collection of resources. These resources may or may not be of the same type. A resource may belong to different layers if its access control information, as specified by its owner, allows it to be shared.

In addition, resources typically are not used in isolation but as part of a larger task. The concept of a project is introduced to provide a higher level of abstraction and is used to define the collection of layers used for a task. Under one project, multiple layers can be defined. Each project will have one or more core layers, which serve as the spatial context for the whole project. A layer can only be owned and modified by one project but may be made available to other projects through replication. This is visualized in Figure 9.

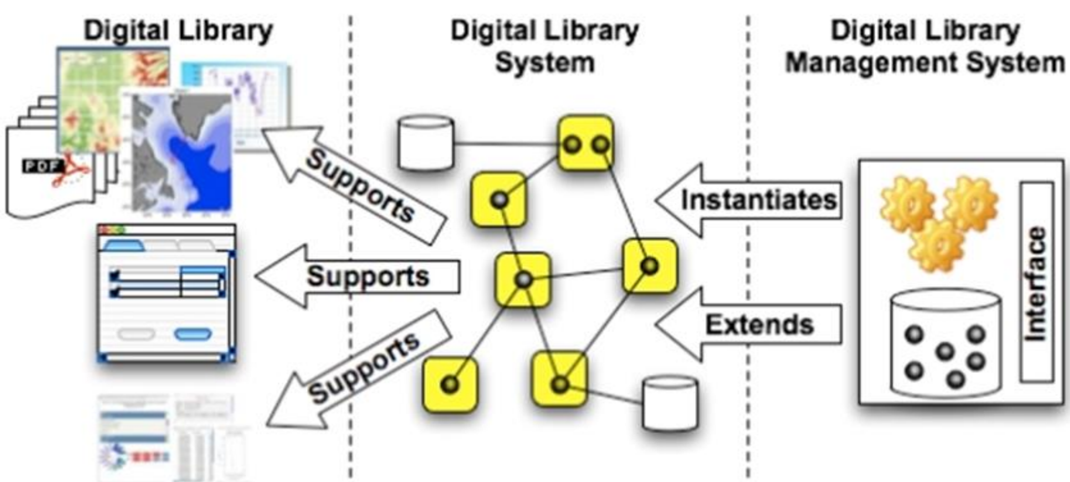


Figure 9: Example Schema Design Behind a Digital Library (Candela et al., 2007)

3.3 Architecture

Digital libraries are created for the purpose of building upon work being done in the information and data management area and to provide an effective means to distribute learning resources to its users (Trivedi, 2010). In the specific case of digital land record systems, this means the management, population, and presentation of complete land records. There are two parts of a digital library architecture: document management and document population.

Document management is the process of managing and maintaining records within a digital library. Digital libraries allow for the management of documents across multiple projects or resources. This approach to document management provides compartmentalization of records by storing records in the most appropriate schema (Figure 10). The interconnecting nature of these resources and projects improves the indexing of records allowing documents to be tagged as related, or in the case of land records, within a defined proximity.

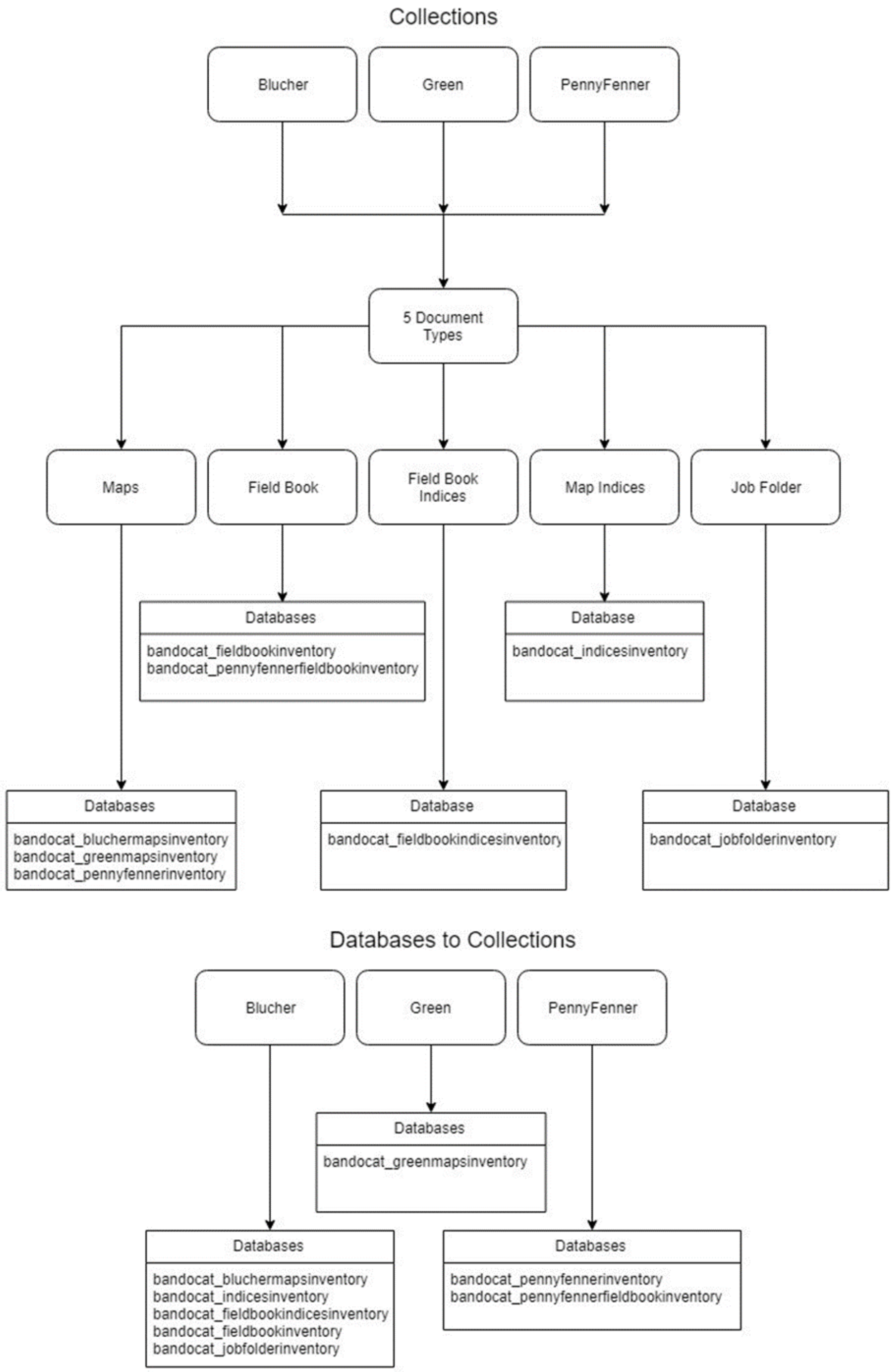


Figure 10: BandoCat Database Schema

The second function of digital library architecture is document population. Document population is the generation of metadata for that document. A benefit of document population is the improved ability to locate resources within a digital library.

As an example of the implementation of digital library architecture for land records of the Blucher Collection, using BandoCat, the collection is treated as a project and the document types are treated as resources. Currently, the project has resources defined as maps, field books, job files, and indices. To populate a resource in the project, BandoCat utilizes forms that upload the record in a .tiff format and create metadata for the record. Each resource has a unique form to capture the necessary metadata for that record. Figure 11 shows BandoCat's schema for the map resource.

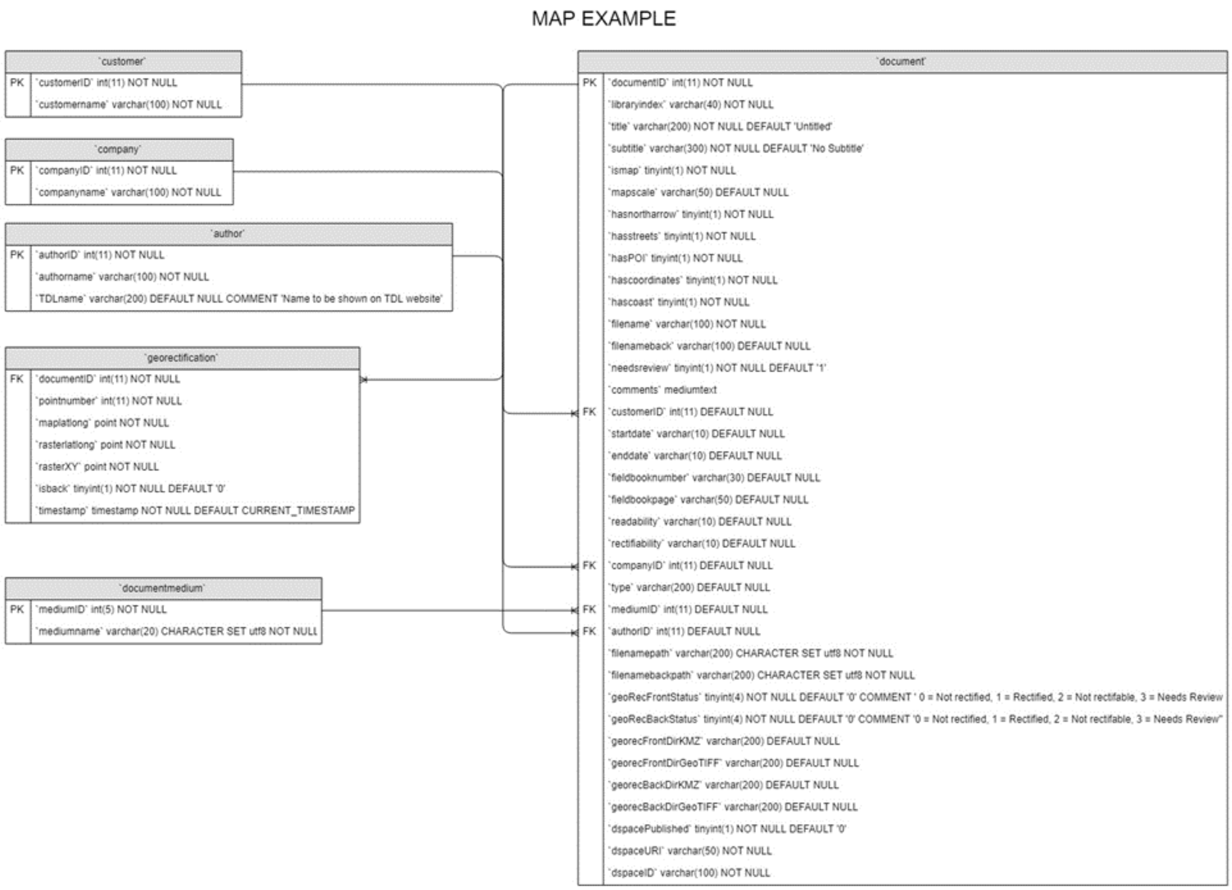


Figure 11: BandoCat Resource Schema

Each cataloging form directs records into the associated resource table, automatically organizing records in the digital library. Once a record is stored with required metadata, it becomes available for the georectification process (which will be discussed in Chapter IV) and is indexed. The georectification process will further populate the digital library with georectified and georeferenced maps when possible and appropriate. By georectifying and georeferencing those records will become available for use in a spatial search engine.

3.4 Record Visualization

A difference between classic digital libraries and what is available today is the ability to access information based on spatial attributes. Digital libraries, such as Google, gives users the ability to search for resources based on location or type through an integrated user interface. Google Maps is a popular example of spatial record visualization because the interface provides search returns via a list and corresponding spatial locations, as shown in Figure 12.

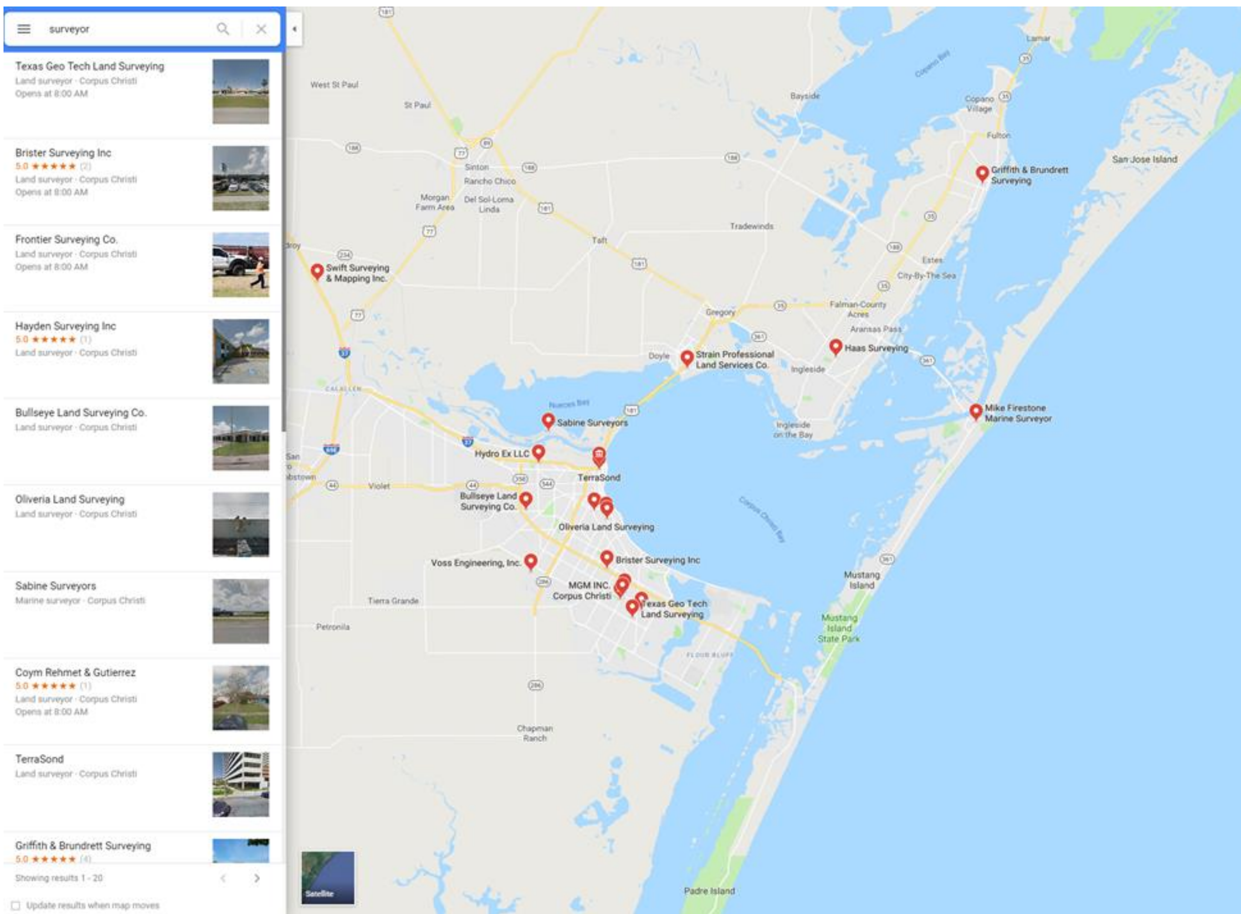


Figure 12: Screenshot of Google Maps Search Interface (Google Maps, 2019)

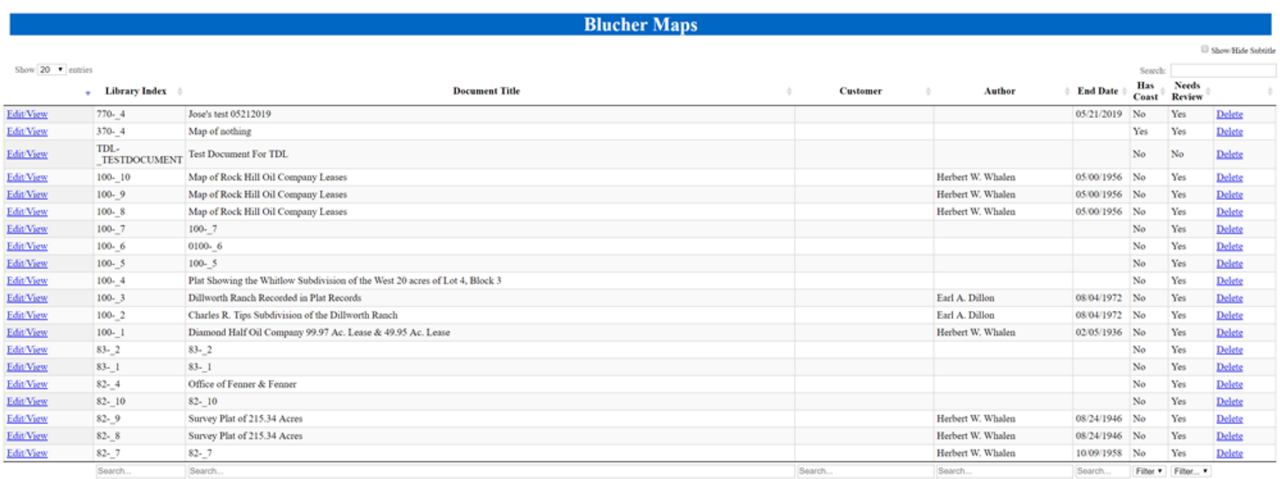
For the purpose of a digital land record system, it is important to have both a spatial search and a classic index search as the spatial search allows the user to exploit the spatial attributes of records within the library and the indexed search provides users with a more familiar search return user interface. Each return gives way to additional search tools and functions as discussed in the following sub-sections.

3.4.1 Spatial Search

The ability to find information based on spatial extent versus specific query inputs has revolutionized search engines (Bone, 2015). This revolutionary feature gives users the ability to know *where* they are seeking information from, in addition to *what* they are seeking. Regarding land records, this gives users the ability to more adequately conduct land record research as land records are inherently spatial.

3.4.2 Index Search

An indexed search is a traditional search of records within a digital library. It allows for the filtering and sorting of records based on returns from keywords and content. In the case of digital land record systems, the metadata is the driver of what is searched and will often have a spreadsheet-like user interface as seen in Figure 13 below.



Blucher Maps

Show Hide Subtitle

Show 20 entries

Search:

	Library Index	Document Title	Customer	Author	End Date	Has Coast	Needs Review	
Edit/View	770-_4	Jose's test 05212019			05/21/2019	No	Yes	Delete
Edit/View	370-_4	Map of nothing				Yes	Yes	Delete
Edit/View	TDL-_TESTDOCUMENT	Test Document For TDL				No	No	Delete
Edit/View	100-_10	Map of Rock Hill Oil Company Leases		Herbert W. Whalen	05/00/1956	No	Yes	Delete
Edit/View	100-_9	Map of Rock Hill Oil Company Leases		Herbert W. Whalen	05/00/1956	No	Yes	Delete
Edit/View	100-_8	Map of Rock Hill Oil Company Leases		Herbert W. Whalen	05/00/1956	No	Yes	Delete
Edit/View	100-_7	100-_7				No	Yes	Delete
Edit/View	100-_6	0100-_6				No	Yes	Delete
Edit/View	100-_5	100-_5				No	Yes	Delete
Edit/View	100-_4	Plat Showing the Whitlow Subdivision of the West 20 acres of Lot 4, Block 3				No	Yes	Delete
Edit/View	100-_3	Dillworth Ranch Recorded in Plat Records		Earl A. Dillon	08/04/1972	No	Yes	Delete
Edit/View	100-_2	Charles R. Tips Subdivision of the Dillworth Ranch		Earl A. Dillon	08/04/1972	No	Yes	Delete
Edit/View	100-_1	Diamond Half Oil Company 99.97 Ac. Lease & 49.95 Ac. Lease		Herbert W. Whalen	02/05/1936	No	Yes	Delete
Edit/View	83-_2	83-_2				No	Yes	Delete
Edit/View	83-_1	83-_1				No	Yes	Delete
Edit/View	82-_4	Office of Fenner & Fenner				No	Yes	Delete
Edit/View	82-_10	82-_10				No	Yes	Delete
Edit/View	82-_9	Survey Plat of 215.34 Acres		Herbert W. Whalen	08/24/1946	No	Yes	Delete
Edit/View	82-_8	Survey Plat of 215.34 Acres		Herbert W. Whalen	08/24/1946	No	Yes	Delete
Edit/View	82-_7	82-_7		Herbert W. Whalen	10/09/1958	No	Yes	Delete
	Search...	Search...	Search...	Search...	Search...	Filter	Filter...	

Figure 13: BandoCat's Index Search with Column Filters

3.4.3 Search Synchronization

A key to document visualization is to have synchronization between both spatial and indexed search results (Lim et al, 2002). The Google Maps example in Figure 12 above shows an ideal user interface that supports both search types simultaneously. However, in the case of digital land records, a more complex interface that offers better filtering would be preferred. Land records require a nuanced spatial search due to the specific requirements of professionals seeking related legal records. It is common for land records to rely on information contained in nearby related records that may provide additional information not recorded in the initially discovered record. As Tobler (1970) once stated, “Everything is related to everything else, but near things are more related than distant things.” The real estate industry has already provided many examples of successfully synchronized search interfaces. Figure 14 displays an example of an integrated search from Zillow.

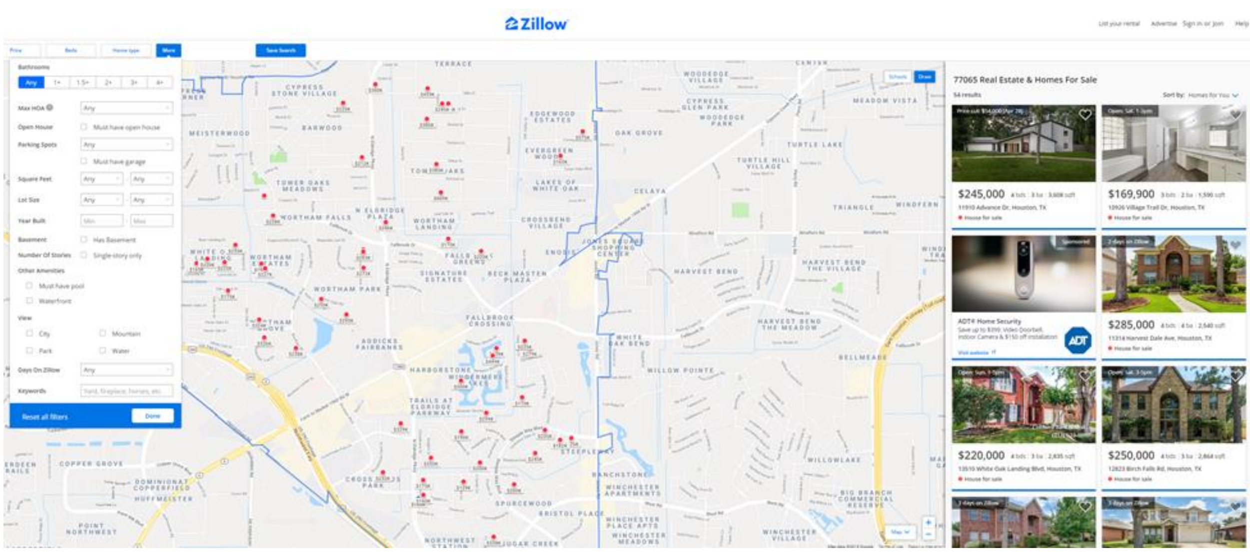


Figure 14: Zillow's Integrated Spatial and Indexed Search Interface with Filters (Zillow, 2019)

Zillow allows users to search by location on a map, limiting results based on the extent of a defined spatial filter. On the right-hand side, there are previews of indexed search returns, and on the left-hand side is the ability to apply specific filters.

CHAPTER IV: MODERN DIGITAL LAND RECORD SYSTEM FUNCTIONALITY

Modern digital land records systems should include numerous functions. This chapter will focus on three critical functions (georectification, georeferencing, and metadata) to define what a modern digital land record system should include.

4.1 Georectification

Georectification provides a spatial component to physical records that do not have associated CAD or GIS files (Liu et. al., 2018). Georectification requires the matching of points between a physical record and a known coordinate system on Earth, referred to as a control point. A digital land record system would ideally have a complete GIS built-in that provides a map viewer for the data, but if digital drawing or similar files do not exist, these georectified documents provide a best second choice (Sengupta et. al., 2016). Another benefit of georectified historic data is that geospatial techniques can be used to match historic data to current land systems, if they exist (Liu et. al., 2018). This will tie historic data to current GIS datasets, thereby allowing for records to be identified via spatial search.

Georectification of land records improves the content of a digital land record system. The georectification can be accomplished either as a built-in feature or a standalone process within another program. The benefit of a built-in georectification tool is the option to open up georectification to users of the digital land record system instead of requiring the user to purchase or install specialized software. As land records are commonly used by professionals in the fulfilment of their jobs, this option could encourage crowd-sourcing the georectification of data.

BandoCat uses a built-in georectification tool for users to identify control points and perform coordinate transformations on reviewed land records in the system. Control points are saved after the transformation as part of the metadata so that subsequent georectification adjustments can be done if necessary. Transformations result in the generation of geospatial features (such as boundaries and centroids) for each georectified map. The generation of these features are necessary for the spatial search (as described in Chapter III).

Many standalone options for georectification are available in either commercial or free and open-source GIS software. Esri's ArcGIS Desktop and ArcGIS Pro (as shown in Figure 15) are the most ubiquitous commercial software options. Along with user friendly tools, these software come with extensive documentation and training from Esri and provide users with direct support.

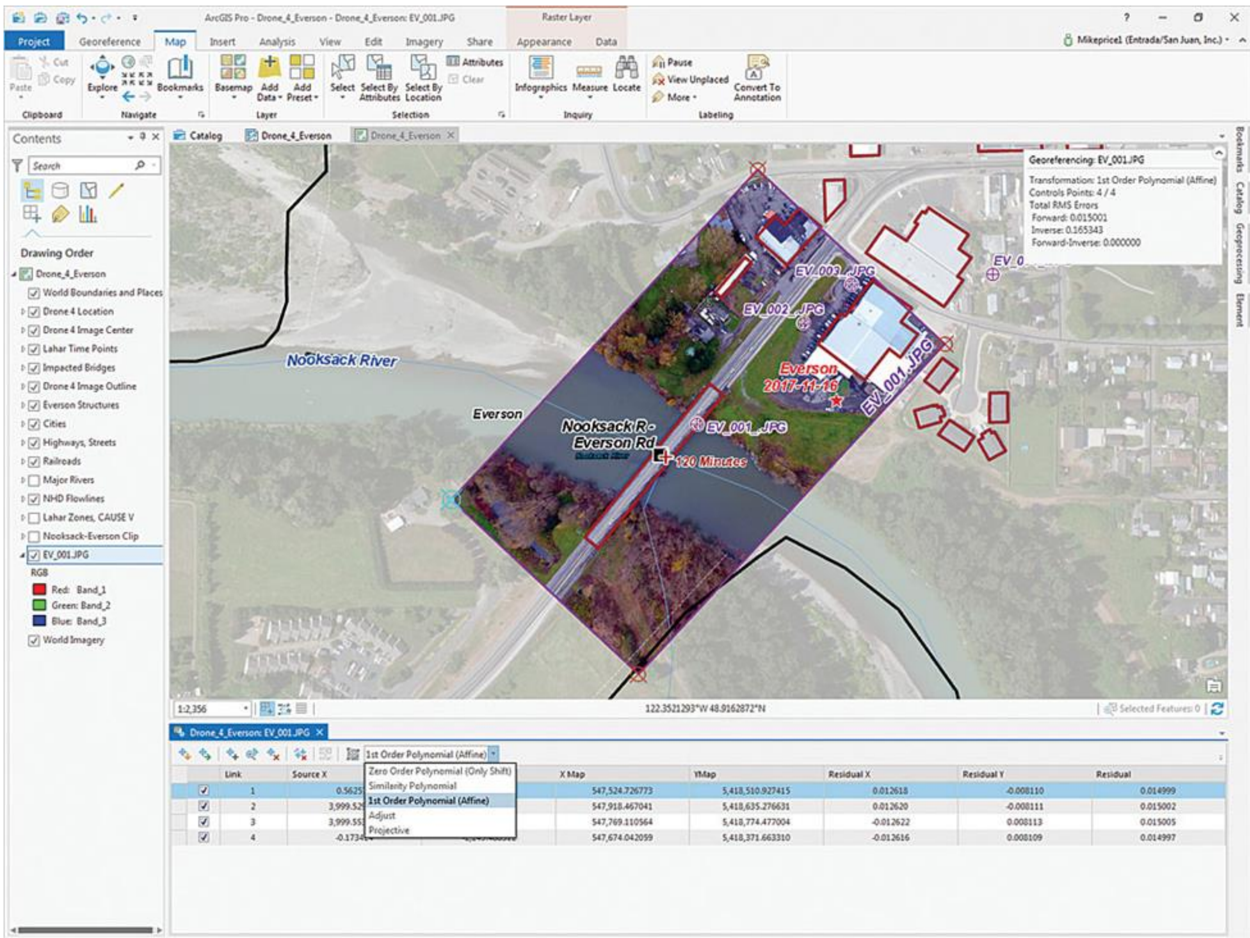


Figure 15: Example of ArcGIS Pro Showing Georectification Results

An ubiquitous free and open-source software for georectification is QGIS. QGIS offers georectification tools similar to Esri's software (as shown in Figure 16). As QGIS is a free and open-source software, there is large community support as well as extensive crowdsourced documentation and tutorials from the QGIS user community.

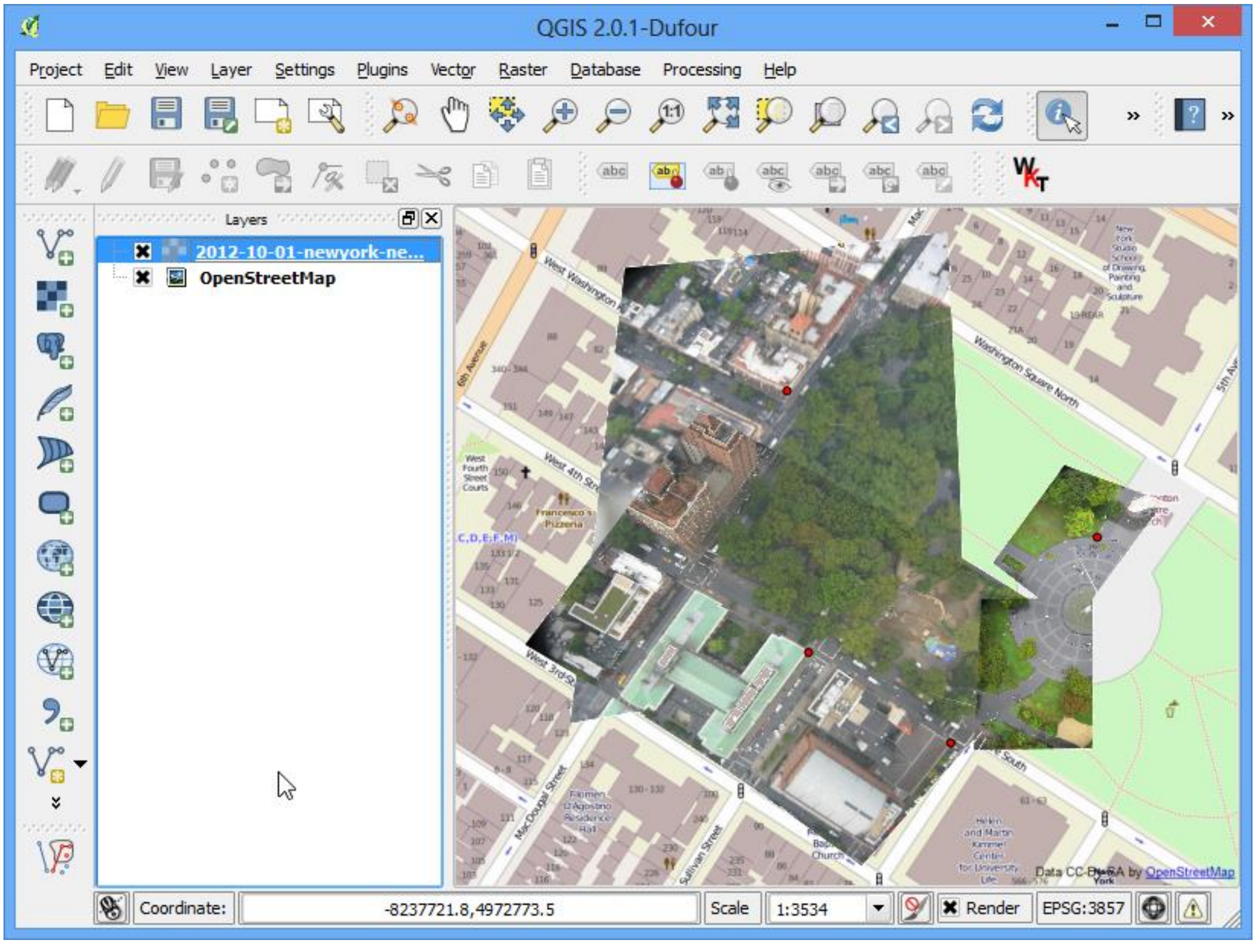


Figure 16: Example QGIS 2.0.1 Showing Georectification Results

4.2 Assessing Positional Accuracy During Georectification

Selecting ground control points on historical maps can be difficult as features may have changed since the map was created (as shown in Figure 17). The process is completely human driven as feature matching is not consistent with historic maps or imagery (Sengupta et al., 2016). The proprietary nature of the land surveying industry also reduces the ability to select better ground control points. In most cases, a 'best-fit' approach will be utilized.

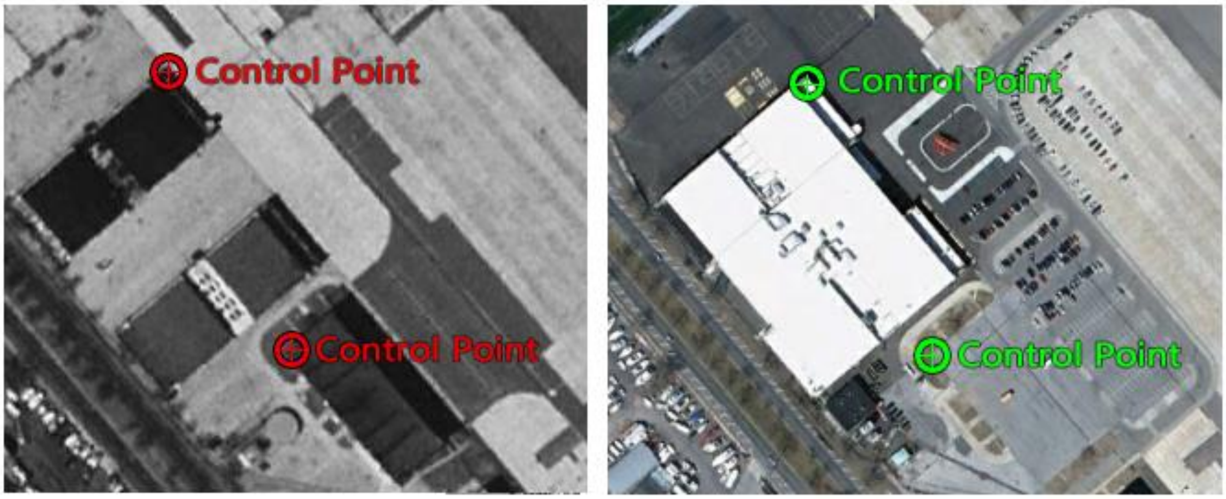


Figure 17: Example of GCP Selection Between a Known Point (right) and the Location of an Unrectified Image (left)

Positional accuracy is how closely a coordinate description of features compare to their actual location. Positional accuracy is one of the most important parameters to determine the geometric quality of a digital dataset (Positional Accuracy Handbook, 1999) because georectified records may be used for spatial search and analysis. An improperly georectified image can result in erroneous search and analysis results. Therefore, root mean square error (RMSE) information should be evaluated to ensure it meets the project's tolerance of 95% confidence for each matched control point during the georectification process and stored as part of the records metadata.

4.3 Georeferencing

Georeferencing is the process of assigning a single spatial point that connects a physical record to a known location. That location will allow an un-georectifiable record to still be associated with a spatial location for use by a spatial search. Records which are not inherently spatial (field books, logs, job files) are considered un-rectifiable. There is also the possibility that a map or aerial image does not have sufficient information in order to rectify it and will be marked as un-rectifiable as well.

4.4 Metadata

Metadata is the data about data. When metadata records are formatted to a common standard, it facilitates the location and readability of the metadata by both humans and machines (FGDC, 2019). Providing accurate and consistent metadata for documents within a digital land record system is fundamental to the value and integrity of the system. This metadata also provides the information that makes the databases searchable. A digital land record system may contain thousands and thousands of documents (for example, BandoCat already houses over a hundred thousand documents) so searchable metadata is crucial to any large land record system. There are many metadata standards, however, Dublin Core and ISO set minimum standards that all modern land record systems should meet.

The BandoCat cataloging process includes the uploading records, data entry, and review of records being added to the system. Currently there are four document types being added to BandoCat: maps, field books, job files, and indices. Map cataloging primarily focuses on general map information such as the map title, scale, date, record location, and client/author information. The map cataloging process also collects true/false information of map features that aid in the georectification process. Field book cataloging captures job numbers, crew members, and dates. Field book catalog entries are also indexed so that they can be compiled and converted to complete PDF books at a later point. Job files cataloging focuses on identifying the content of each document, such as calculation page, part of a legal description, a small sketch, or other similar file. Like field books, job files are later compiled into PDFs according to their job folder. Indices are cataloged similarly with the follow-on step, in which the contents are completely transcribed. The benefit of transcribing the indices is that they can be used as a bridge to connect all resources in a project.

Because of the importance of these land records, as well as the volume of records, it is important to establish a QA/QC system (Liu et al, 2018). As part of the catalog process, there should be a "needs review" field that denotes whether a document's metadata has been reviewed yet or not. Supervisors should be granted authority to review metadata and mark them as reviewed. In an effort to identify sources of cataloging errors, personnel information should be stored during the catalog process and is only viewable by supervisors. The QA/QC process and recording of personnel information linked to record entry helps supervisors target sources of data entry errors for remedial training. Another benefit of this QA/QC system is that additional tasks such as georectification and publishing are not available for a document until it has been reviewed.

4.4.1 Dublin Core Compliant Metadata

The Dublin Core Metadata Initiative (DCMI) is an organization supporting innovation in metadata design and best practices across the metadata ecology. The DCMI supports shared innovation in metadata design and best practices across a broad range of purposes and business models (DCMI, 2019). DCMI is an ideal format for organizing multiple land record metadata designs. As discussed in Chapter II, a digital land record system may be part of a complete overhaul of an authority's cadastral system. Therefore, DCMI provides a least-cost approach to a new system that can integrate legacy data (Trilles et al, 2017).

4.4.2 ISO-compliant metadata

When digital land record systems adopt ISO compliant formats at it provides identical formats to users of other systems. The need for consistency is reiterated in Chapters II and III in order to provide a consistent design across decentralized land administration authorities. Several ISO metadata standards are now endorsed by the FGDC and federal agencies and National Spatial

Data Infrastructure (NSDI) Stakeholders are encouraged to make the transition to ISO metadata (FGDC, 2019).

4.5 Metadata Implementation

Metadata should be queried and constructed directly from the digital land record systems internal catalog (Giuliani et al., 2016). In the case of the BandoCat, metadata is generated during the catalog process and then converted into a DCMI/ISO compliant format so that it can be published into other systems. This approach ensures that documents in our digital land record system can be converted, to a certain degree, into a new system.

CHAPTER V: BLUCHER LAND RECORD PROJECT

The Blucher Land Record Project was initially a map scanning project with the goal of creating digital copies of maps in the Blucher Collection at the Mary and Jeff Bell library. The financial sponsorship allowed for the evolution of the project beyond the original scope of the project and it eventually became a digital land record system by the name of BandoCat. BandoCat is the primary example of a digital land record system for this thesis as it was developed in parallel with the standards emphasized in earlier chapters. The following section outlines the process and workflows of the project that have resulted in one of the largest digital land record collections in South Texas with over one-hundred thousand land records processed to date.

According to Epstein and Niemann (2014), land records can be modernized following the following five steps: (1) scanning of records, (2) cataloging of records, (3) georeferencing/georectifying, (4) identifying related records, and (5) setting up a public release. These five steps are fundamental to modernizing land record collection and constructing a digital land record system. While there are only five steps, this process can be quite lengthy depending on land record conditions, the number of records that need to be digitized, and the availability if resources and funding. Regardless, these steps have been tried and proven effective as part of an ongoing project to digitize hundreds of thousands of land records stored in the archives at Texas A&M University – Corpus Christi.

5.1 Process

Using the scanning projects from Spatial {Query} Lab and Mary and Jeff Bell Library, this thesis identifies successful structures used for the Blucher Collection that include: preparations of documents, the establishment of archival standards, the development of a database that fits the collection, the cataloging process (metadata), the value of georectification, and publishing the data to intended users. These steps are necessary as the foundation of a digital land record system will define the adaptability of the system throughout time. Before we could begin working on structure, we first needed to prepare and treat land records. Land records may be stored in many different formats and the Blucher project has seen everything from rotting boxes in store units to ideal preservation in climate-controlled map cases.

5.1.1 Equipment

The Spatial {Query} Lab has five document scanners currently in use: (1) Paradigm Image Pro Gx42 Pass-through Large Format Scanner, (2) EPSON Expression XL 10 series flatbed scanners, (1) BookEye 4 Book Scanner, and (1) Epson Perfection V600 professional scanner. These scanners give the ability to scan large maps, traditional land record documents, and microfilm/microfiche. There is also 1 GIS Server, a Dell PowerEdge R710 with Intel Xeon x5560 (16 CPUs). 32GB RAM. 5TB HDD space.

5.1.2 Preparation

The process of preparing records begins with an initial assessment of the records. As part of the preparation process, the presence of hazardous materials such as mold or rusted metals is identified. If these materials are found, these records are separated and set aside for treatment. The rest of the records typically move into a rehydration stage. Historic land records often become brittle after being stored in sub-par conditions for many years. Simply unrolling a map can cause its disintegration and loss of information. Rehydration methods vary depending on the need as some records require full rehydration and others only need spot treatment.

Full rehydration is performed using two bins, a large one and a small one. The larger bin is partially filled with steaming water. The record is then placed inside the smaller bin which is set into the larger bin. Next, a lid is placed on the larger bin, trapping the steam inside the bins. This steam is then absorbed by the record, rehydrating it throughout. The process takes approximately one hour per map. Spot treatment will utilize a steam pen which can be used for treating small areas and creases. When documents have folds that have been dehydrated, the risk of sections breaking off at the folds' crease is increased. Spot treatment helps circumvent this risk and can even remove minor creases all together. The process is done in an open-air environment, unlike the full rehydration method.

Once records have been separated and treated, the organization of the records for long-term storage can begin. Long-term storage methods can vary depending on space. The project has utilized flat, vertical, and rolled map storage, shelving and filing for additional land records such as job files and field books. How a record is stored greatly depends on its condition post-treatment. Some land records will always be in fragile condition as a result of age or lack-of-care prior to the archival process, but these records are still very valuable as they will hold legal precedence in a court of law. In the pursuit of information integrity and protection of property records, every original land record needs to be stored in a method that will preserve it. Once records have been stored and organized according to archival standards, the development of a digital land record system can begin.

Understanding the structure of the cadastre to be made digital and whether said structure is going to be replicated is the next step in developing a digital land record system. In the case of the Blucher Map Collection, it was initially identified that job numbers and map file names would serve as our ideal naming convention and aimed to replicate the Blucher structure. This process included long, inconsistent naming conventions that only reflected information tied to individual maps. The naming convention also included special characters, which was later identified as a poor-practice for digital archiving. The Blucher project eventually uncovered survey notes, field books, and indices that tied the entire land record collection together. This prompted the restructuring of the database along with improved naming conventions.

BandoCat is now able to link related records based on relationships defined in the indices. What this means is that if you are viewing a map of a subdivision in Corpus Christi, you will also be able to see any other land records that are attached to that job or map. Because the Blucher Survey Collection did have a well-organized land record structure, it was worthwhile to redesign our digital land record system around it, as opposed to changing the structure of the collection. When dealing with historic collections versus living ones, it is likely more ideal to fit our digital land record system to it, so that it preserves the history.

5.2 Scanning Workflows

The scanning workflows detail the procedures used at Spatial {Query} Lab for the processing of physical records prior to their addition to the BandoCat Land Record System. Scanning records is the first step in the process of converting physical land records to a digital format. Making land records not only allows us to populate our digital land records system, it also doubles as a preservation effort of the physical records. Preserving the physical records must be a priority because in the case of a legal dispute, the original physical record will always hold weight over a digital copy. Appendix A through C provides the specific workflows for scanning maps, land records, and field books.

5.3 Cataloging Workflows

With records now scanned and ready for processing into the land record system, the cataloging process can begin. The cataloging process is the capture of important information from the physical records. Basic information to catalog includes titles, dates, and authors. Because these are land records, it is also valuable to capture information such as field book records, client data, scale, and record types (map, plat, blueprint, etc...). These fields represent ideal options to include in advanced searches. Structured query language is used to communicate between the projects and drives the search tools, as well as a few other administrative features.

Other information captured during the catalog process helps with another feature of the digital land record system, georectification. This additional information includes the cataloging of true-false document features such as: is it a map, coast, north arrow, roads, points of interests, and needs review. The needs review field aids with the QA/QC process and is used as a check before documents are available in certain tools, such as georectification and publishing.

5.3.1 Maps

The form shown in Figure 18 represents all of the information that is captured when adding a scanned map to BandoCat. The *Library Index* field is a non-editable field that is automatically populated based on the file name of the *Front Scan*. Document titles and subtitles are copied directly from the map being cataloged. If there is no title given, the cataloger will use the *Library Index* as the document title and leave the subtitle blank. For most maps, there will only be one date present. That date will be used as the end date. The true/false information (scale, north arrow, etc…) is determined by the cataloger and aides in the georectification process as described in Chapter IV. *Document Type* determines what type of map we are looking at (plat, preliminary survey, blueprint, etc...). *Document Medium* represents the material the map is produced on (cloth, tracing, blue paper, acid free paper, etc…) and will help archivists prepare long-term storage solutions for the record. *Readability* and *Rectifiability* fields are intended for ranking the difficulty of georectifying the record. When uploading front and backs of scans, an automatic check will be run to ensure that files selected for back scans are appropriately named as a pair to the front scan. This prevents a potential human error in selecting the wrong file. The *Comments* section represents a catch-all field that gives the cataloger the ability to include any other information that may be important for future users to have at-a-glance in the metadata. Because every map is unique, this gives the ability to include un-common, but important, information in the metadata.

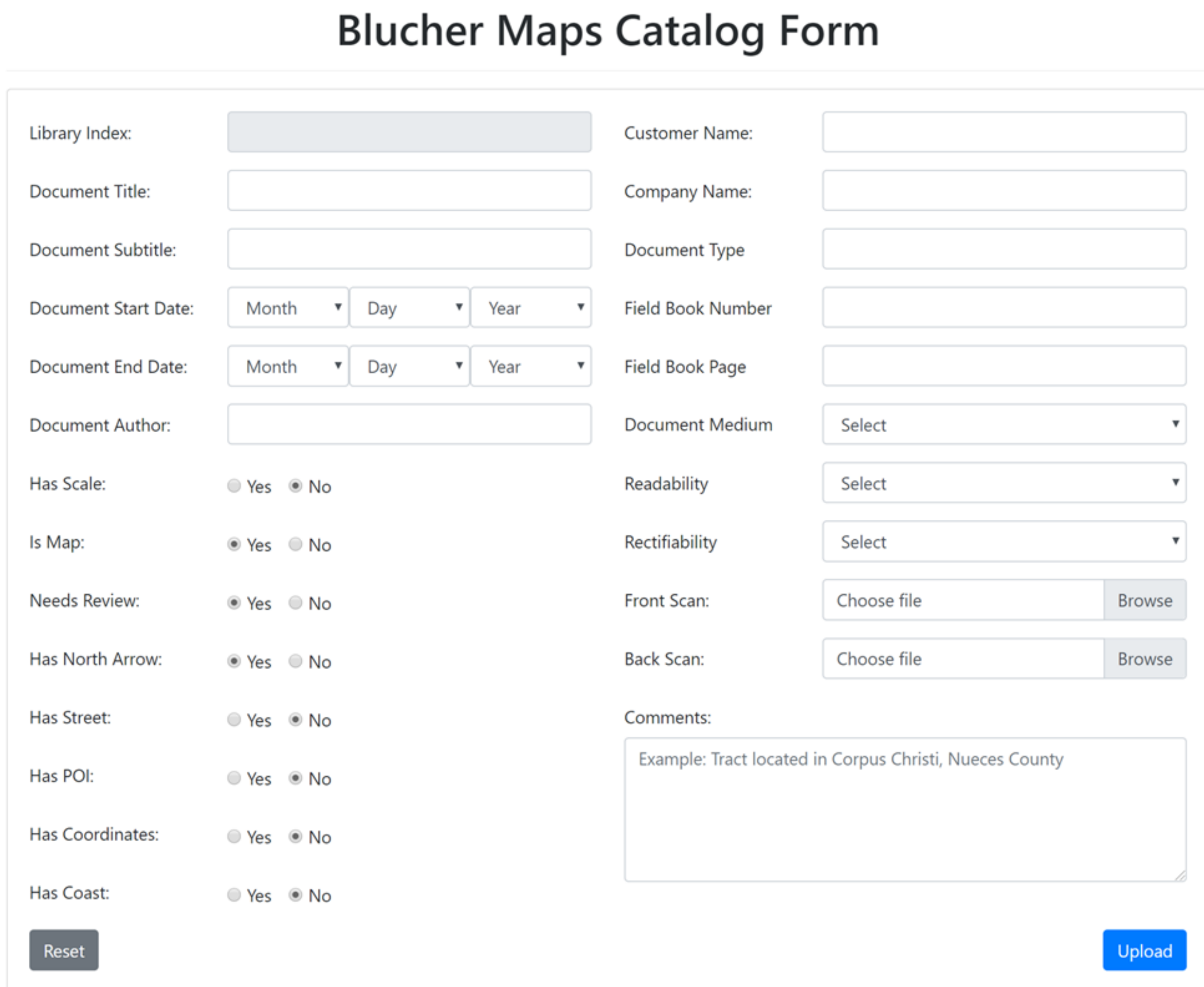


Figure 18: Map Catalog Form on BandoCat

5.3.2 Land Records

Cataloging land records differs from maps as there are fewer fields to catalog. Land records are not georectifiable as they, typically, provide further explanation and insight into the process of surveying and processing data for map creation. *Document titles* are determined the same as maps. These records present the possibility of multiple *authors*, therefore the form (shown in Figure 19) allows for the inclusion of multiple authors. Unique to these land records is the possibility of sub folders. As the current goal of the project is to preserve existing structure where possible, the original filing system is maintained, subfoldering included. The c*lassification* field gives the cataloger the option to determine the type of land record being cataloged (i.e. legal document, sketch, draft, correspondence, etc…). Additional fields for *classification* and *subfolder comments* are present in case a further explanation is necessary.

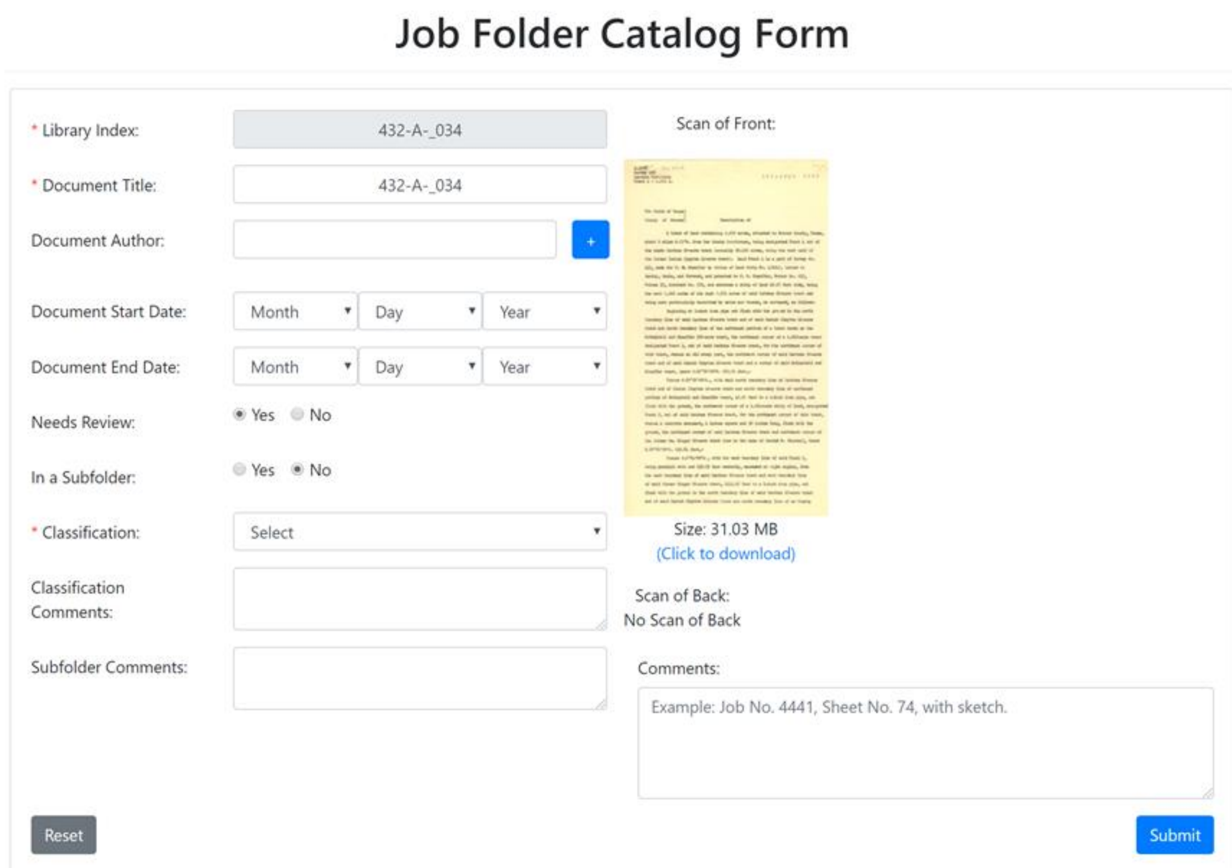


Figure 19: Job Folder Catalog Form on BandoCat

5.3.3 Field Books

Lastly, we have the field book catalog form shown in Figure 20. In order to maintain the chronological order of each field book page, all pages are uploaded to a staging location on BandoCat prior to cataloging. This approach gives catalogers the ability to quickly catalog field book pages in order. Due to the repetitive nature of information in field books, the form will copy input from a completed form to the next one. Carrying the input forward increases cataloging rates as well as maintains exact input for repeat information on field book pages. Field books also introduce *Job Number, Job Title,* and *Indexed Page* fields. This information is primarily drawn from the field books table of contents. Including this information on each page's metadata allows for the creation of more organized PDF books later in the publishing process, which will be described in section 5.5 of this chapter. *Field Book Author* represents the surveyor responsible for the field book and *Field Crew Member(s)* represents the individuals that aided the surveyor with the data collection.

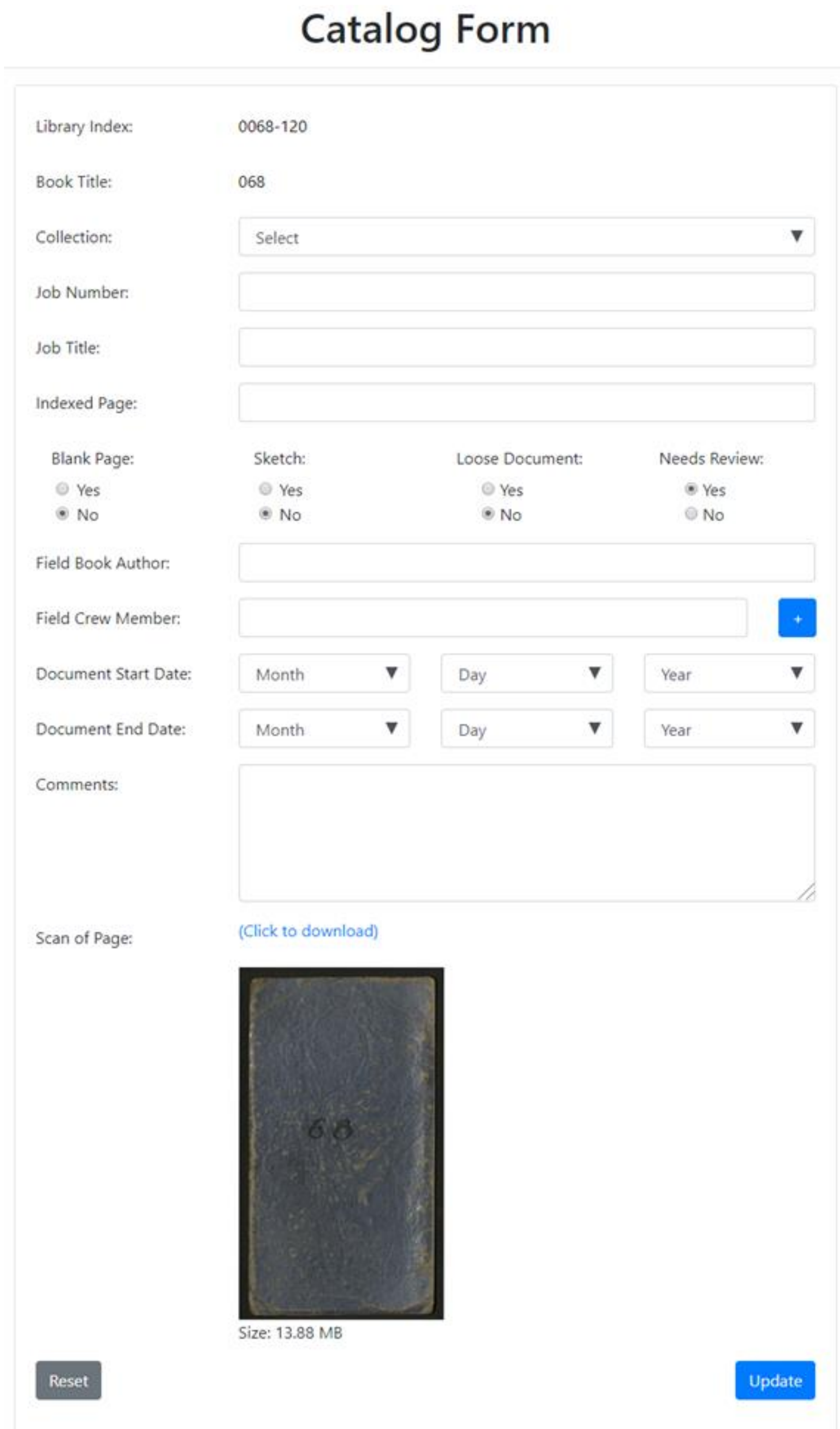


Figure 20: Field Book Catalog Form on BandoCat

5.4 Georectifcation Workflow

BandoCat has a built in georectification tool that uses Leaflet and OpenStreet Maps to allow users to perform coordinate transformations on land records, as shown in Appendix D. Georectified maps enrich the digital land record system in a way that benefits surveyors and the general public. Many of these historic maps were not drawn with the intention of public use, so being able to locate them on a projected coordinate system provides a sense of reality to the maps. Users are able to see, in software like Google Earth, where these maps are located on the earth. This also improves the values of these land records to the surveying community, so that when they are planning a retracement of one on the surveys in the digital land record system, they can have an idea of what to expect on the ground, as well as a starting place to search for their point-of-beginning.

5.5 Publishing Workflow

The last major task of constructing a digital land record system is developing a plan to publish that data to a public front end. Currently, BandoCat only provides public access via the Texas Digital Library. As seen by Figure 21, the publishing process is one of the most controlled and reviewed processes once these records are published to the Texas Digital Library. The published records can be used and cited by the public for use in research and legal cases. Once published, individual land records must be maintained online, necessitating reliability. A digital land record system is expected to be available, whether via public access or by other requests.

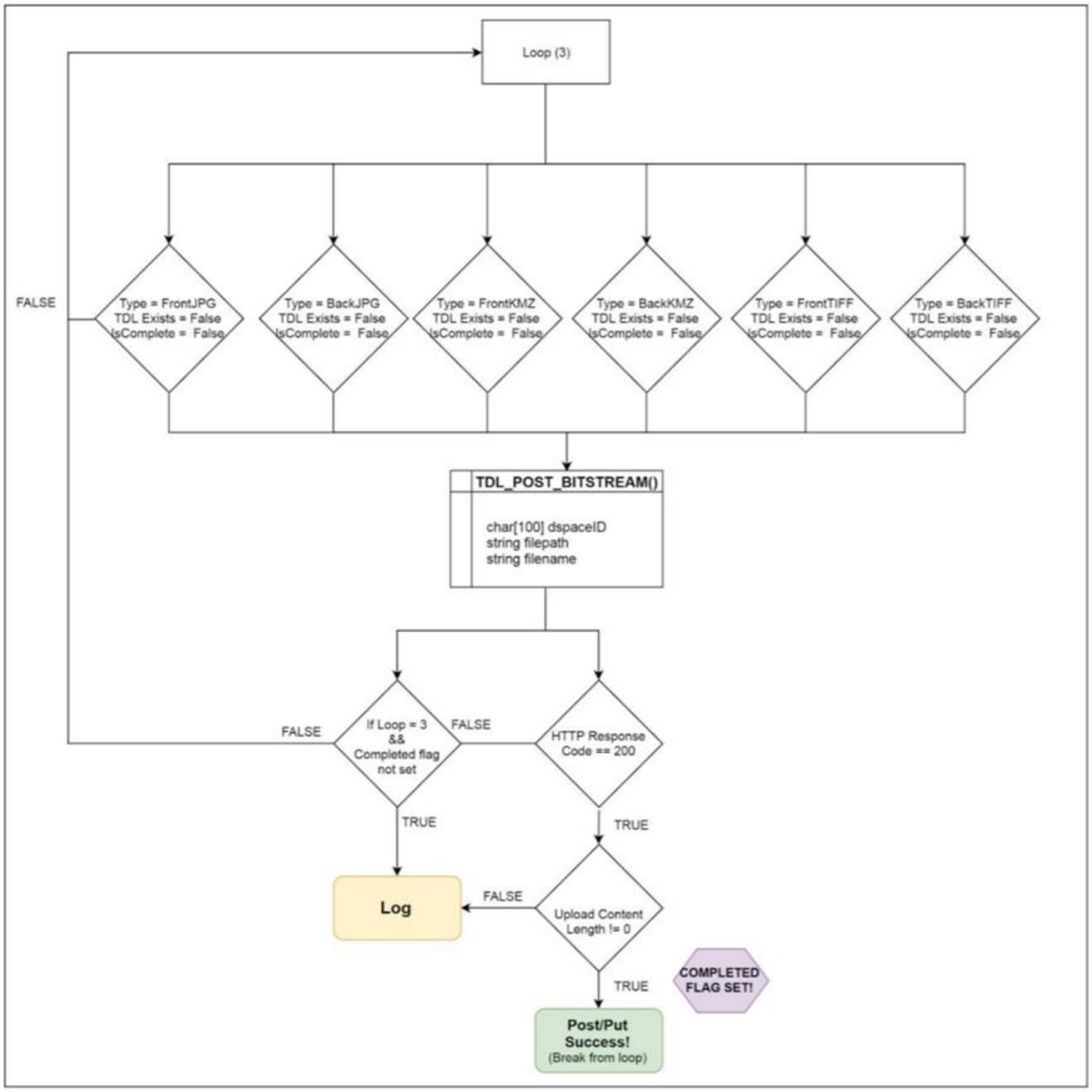


Figure 21: Publishing Documents to TDL Workflow (Allred, 2018)

CHAPTER VI: CONCLUSION

This thesis provided a detailed, example driven design for constructing a modern digital land record system, an assessment of multiple cadastre systems and how they benefit from modern digital land record systems, and the establishment of metadata and library archival standards. The BandoCat system featured within this thesis was presented as a model modern digital land record system. The BandoCat source code is freely available on GitHub (https://github.com/spatial-query-lab/Bandocat) as an open-source software and was developed by the Spatial {Query} Lab. Additionally, this thesis identified the economic and functional value of using digital land record systems, such as BandoCat, for various stakeholders. With its established procedures for the digitization of physical land record systems, it provides for the construction of a modern digital land record system which meets the base needs of stakeholders, providing public access and following both geospatial data and digital library standards.

With BandoCat already available as an open-source software, its adoption could very well include implementation into municipal and county governments with an interest in managing land records. Such governments could include Nueces County, where discussions toward a county level GIS or land management system have already begun. Additionally, the interoperability between BandoCat and private stakeholders, such as, but not limited to, title companies and survey companies, would be a natural fit.

In conclusion, BandoCat provides a modern solution to land record management systems, resulting in protected land records (thereby protecting property ownership), increasing the transparency and accessibility of land records, and potentially decreasing economic expenditures.

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LIST OF APPENDICES

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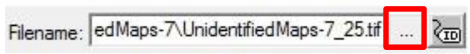
Appendix A: Map Scanning Procedures

Step 1: Cleaning Scanner

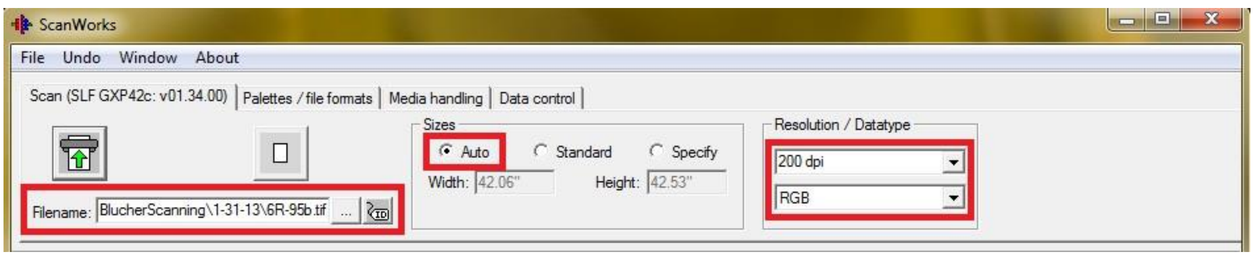
1. Before turning on the scanner, the scanner must be inspected for dirt and debris. Open the lift of the scanner by pressing the raised buttons on each side of the scanner. Using a flashlight, inspect the glass for smudges or scratches.
    - If the glass is clean, close the lift and wipe down the exterior of the scanner with a clean cloth (orange). Be sure to wipe the back of the scanner were the map leaves the scanner and moves on to the holding surface. Clean the holding surface (top of map case) of any excess dust.
    - If the glass needs to be cleaned, use a clean cloth (white) and glass cleaner to gently wipe away the debris from the glass. **IMPORTANT**: <u>Never</u> spray the glass cleaner directly on the glass. Spray the glass cleaner on the cloth then gently wipe across the glass surface. Finally, use a clean dry cloth to remove excess glass cleaner and any remaining residue from the scanner.
    - Scanner lift is properly closed when two loud clicks are heard.
2. Turn on the scanner (ON/OFF switch is located on the bottom back of the scanner near the right side). The scanner display screen will display the message “Initializing”. Only after the scanner displays “**READY**”, can the scanning program be opened.

Step 2: Scanner Startup

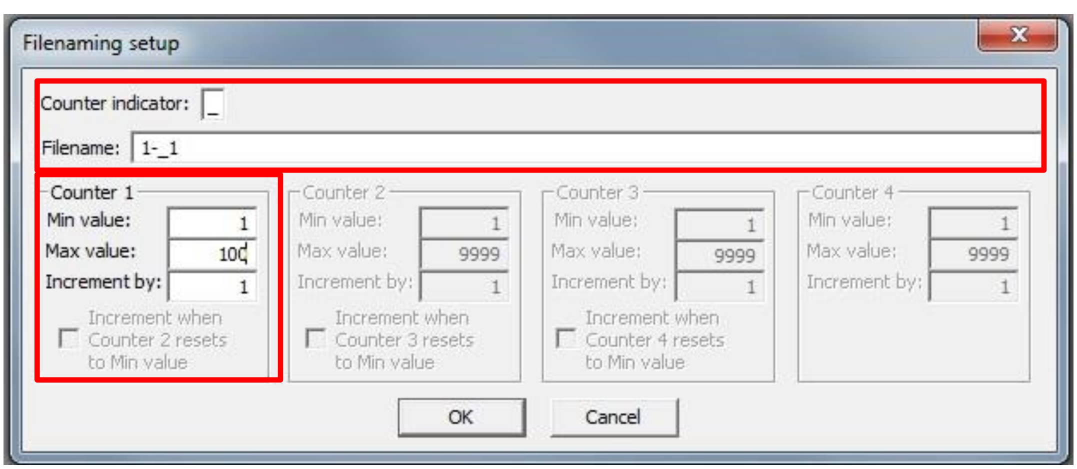
1. Fill out Map Scanning Log.
    a. Extra copies can be printed from Map Scanning Log PDF.
2. Open the *Scanworks 2.4.7.3* program located on the desktop.
3. On the desktop, open Documents and then the *Scanworks*.

4. Create a new folder with the map folder as the name.
5. Use the Window Browse button to navigate to the appropriate map folder that was just created. 

6. Then, check the settings for filename/file location, size, resolution/data type, and number incrementor.
   a. Filename: explained below in Step 4: Document Title Procedure
   b. Size: **Auto** radio button selected
   c. Resolution/ Data type: **200dpi RGB**



   d. Number incrementor: Click the ID button and make sure that the counter indicator is an underscore ("_"), that the max value is 100, and the numbers are being incremented by 1.



***IMPORTANT**: Make sure to check the mapNumber when the incrementor hits the number 10. For some reason, *Scanworks* is notorious for adding obscure characters to the name.

Step 3: Preparing Document for Scanning

1. Scanner is on and in the "Ready" mode. *Scanworks* program running with all settings checked. Review Equipment Procedures for questions about scanner or scanning program.
2. Unlock map case and clean the top of the map case of any dust or debris. Use the orange dusting cloth to wipe the surface of the map case.
3. Place the map to be scanned on the surface of the map case. Using a paint brush, sweep the map of clean of dust or loose materials. Be sure to thoroughly clean both sides of the map before scanning.
    a. Whenever a cloth is dirty, place it beside the scanning computer. If almost all the cloths are dirty, the scan lead will take them home to be washed in the washing machine.
    b. Periodically dust out the paint brush to remove collected dust. If the brush becomes matted from use and dust, wash out the brush with water and baby shampoo. Let the brush air dry before resuming use.

Step 4: Document Title Procedure

1. Documents without a dash in their folder name:

    <folderName>-_*<mapNumber>*

    Ex: CQ-_16

    If the document includes a back:

<folderName>-_<mapNumber><(back)>

Ex: CQ-_16(back)

2. Documents without a dash in their folder name containing a job number:

<folderName>-_<mapNumber>,<jobNumber>

Ex: CQ-_17,J-3473

If the document includes a back:

<folderName>-_<mapNumber>,<jobNumber><(back)>

Ex: CQ-_17,J-3473(back)

***IMPORTANT:** When any documents without a dash in their folder name are uploaded into the database the dash is ALWAYS removed in the library index.

3. Documents with a dash in their folder name:

<folderName>_<mapNumber>

Ex: CR-1_14

If the document includes a back:

<folderName>_<mapNumber><(back)>

Ex: CR-1_14(back)

4. Documents with a dash in their folder name containing a job number:

<folderName>_<mapNumber>,<jobNumber>

Ex: DE-2_72,No.876

Ex: DB-3_14,1051-C

If the document includes a back:

<folderName>-_<mapNumber>,<jobNumber><(back)>

Ex: DE-2_72,No.876(back)

5. Documents with subfolders.

   a. Subfolders are any series of documents that are paper clipped, stapled, or taped together.

   <folderName>-_<mapNumber>.<subfolderNumber>

   Ex: CH-_1.30

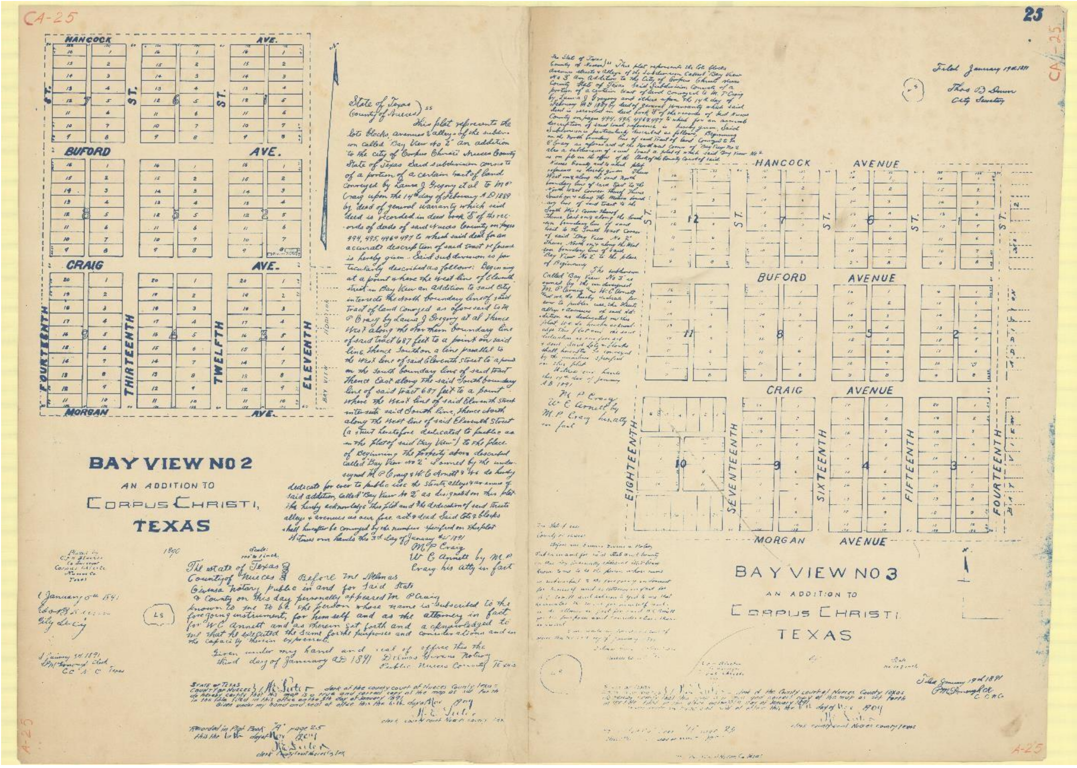
If the document includes a back:

<folderName>-_<mapNumber>.<subfolderNumber><(back)>

Ex: CH-_1.30(back)

*If the document includes a jobNumber, add the jobNumber after the subfolderNumber separated by a coma (Ex: CO-_13.1,No.286)

6. Documents that contain multiple drawings



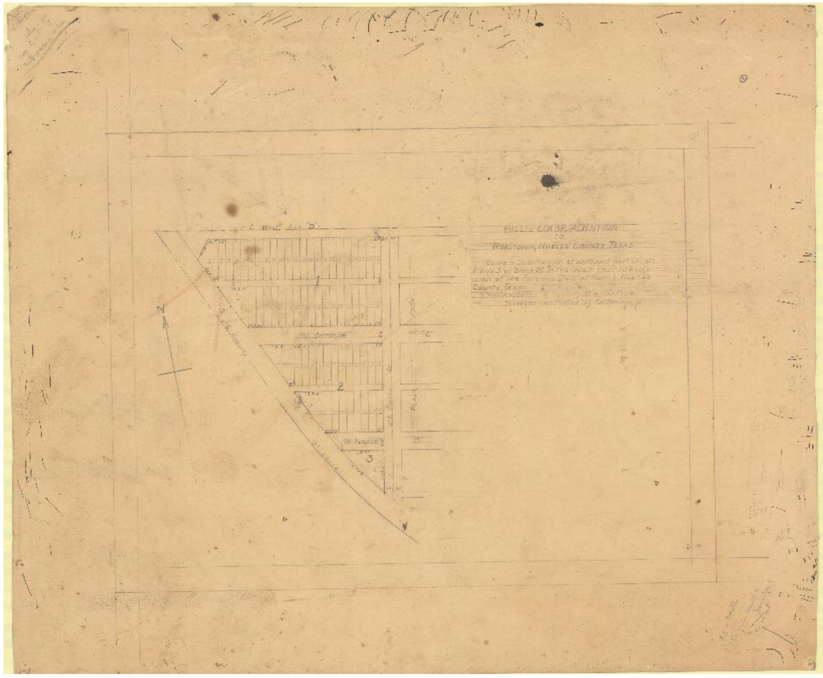
*Some documents contain a right and left side or bottom and top.

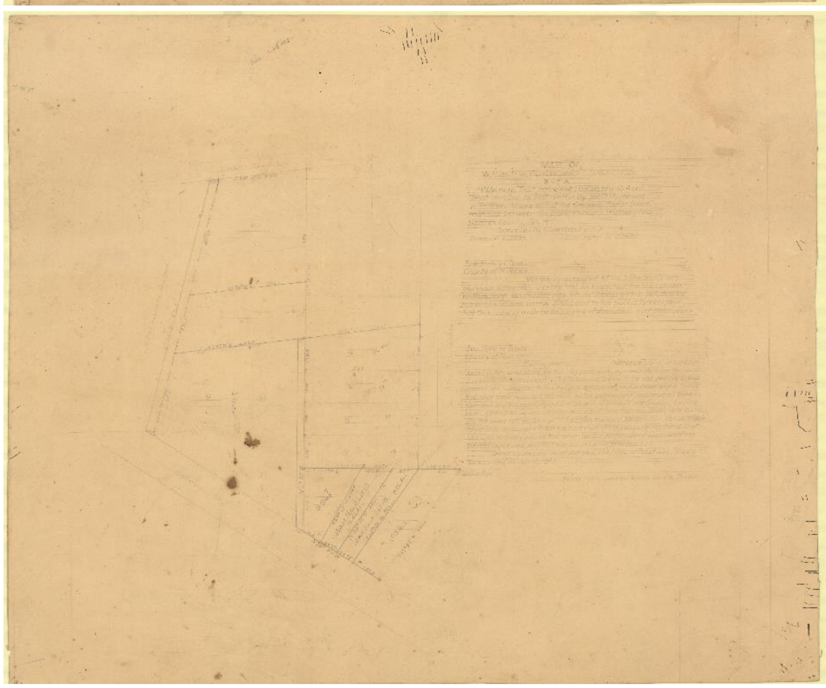
<folderName>-_<mapNumber><(sideOfDocument)>

Ex: CA-25(right) and CA-25(left)

Ex: AMFrench-2_10,5-A-15(bottom) and AMFrench-2_10,5-A-15(top)

7. Documents with a different map on the back





<folderName>-_<mapNumber>.<(sideOfDocument)>

Ex: CWHomeyer-_4.A and CWHomeyer-_4.B

*"A" indicates the front of the document and "B" represents the back.

2. Job numbers are typically (but not always) hand-written in the corners of a map. The can either be a "J" number, "No." number, or a series of numbers and letters separated by dashes.

Step 5: Scanning Document

1. After completing Step 3: Preparing Document for Scanning, approach the scanner, place the map near the far-right justified line. Once the sensors pick up the map, the scanner will load the map into position. Try to load the map as straight as possible, but this is not always possible. The map will typically load better if the longest side of the map is fed into the scanner. **<u>IMPORTANT</u>**: Maps that are particularly delicate (frayed edges, large tears, or with a large amount of tape) should be placed inside of the Mylar plastic sleeves before being inserted into the scanner.

    *Sometimes it works best to feed the Mylar plastic sleeves into the scanner first before placing the map inside.

    *Consult Mylar Procedures for more details.

2. Once the map has been loaded, return to the computer and confirm that the scan will be saved in the correct folder and with the correct file name. (Drop down menu located in the upper left-hand corner of the *Scanworks* program)

3. Press the green arrow button in the top left corner of program to begin the scan. Watch the map carefully as it travels through the scanner and onto the holding surface. **<u>IMPORTANT</u>:** If for any reason the scanning process needs to be stopped in the middle of a scan, press the <u>CANCEL</u> button located on the scanner below the display screen. If the scanning process

has been stopped, the up and down arrow buttons on the scanner can be used to manually remove the map from the scanner.

4. If there is a secondary map or any form of notations on the reverse side of the map, repeat steps 4-7 for the reverse side of the map. This image should be saved following the title procedures in Step 4: Document Title Procedures.

Step 6: Editing Documents

1. When the entire document has been scanned, inspect the image for any blemishes. Depending on the severity of any blemishes located on the image, a second scan may be necessary to replace the current image. If the flaw is minor, the image can be saved by selecting the floppy disk button. If the document needs to be rescanned, select the trash can button to delete the image.
    a. If the image is deleted, try rescanning the document in a different direction to prevent the blemishes from occurring.

        *Blemishes usually occur due to scratches on the glass or tape residue.

2. If the scan is satisfactory, crop  and rotate  the image as necessary in *ScanWorks*.

    *Note: *Scanworks* frequently will duplicate edges of an image when it is rotated within *Scanworks*. Thus, it is advisable to rotate the image in Windows Photo Viewer.

3. Save image.

a. If the image is saved without being cropped, open the image in Windows Photo Viewer, click open Microsoft Office, and edit the image there.

4. Open saved image (stored in the *ScanWorks* folder, under the map folder's name) and check for any blemishes, duplication, or folds that inhibits reading the document.

Step 7: Returning Documents

1. Once the document is scanned and checked for blemishes, flip map over and place face down inside the top map case drawer.
2. After scanning ten maps, clean the glass of dust and residue.
    a. Begin by closing the *Scanworks* program (the program will freeze once the scanner is switched off for cleaning).
        i. **IMPORTANT**: Turn off the scanner before cleaning. If the sensors on the scanner are activated while cleaning the cloth may get caught in the rollers.
    b. Proceed to clean the scanner glass as indicated in Step 1: Cleaning Scanner.
3. To continue scanning, turn on the scanner and wait until "Ready" is displayed by the scanner to open the *Scanworks* program and begin the process again.
4. Once a folder is completely scanned, flip over all documents stored in the top map drawer, place the folder back into its appropriate storing place, and put a sticky note on the front of the map drawer indicating which folder(s) have been completely scanned.
5. After scanning is complete for the day, be sure to copy all scanned images onto the external hard dive of the collection being worked on (Blucher HDD, Green Collection

HDD, or White Map Cases). The folders are organized by map folder; copy scanned images into appropriate folder.

6. Turn off, clean, and replace protective cover over scanner and holding surface.
7. Finally, lock the map case by threading the chains through the handles on the drawers and latch lock.

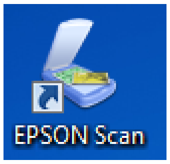
Appendix B: Job File Scanning Procedure

Step 1: Cleaning Scanner

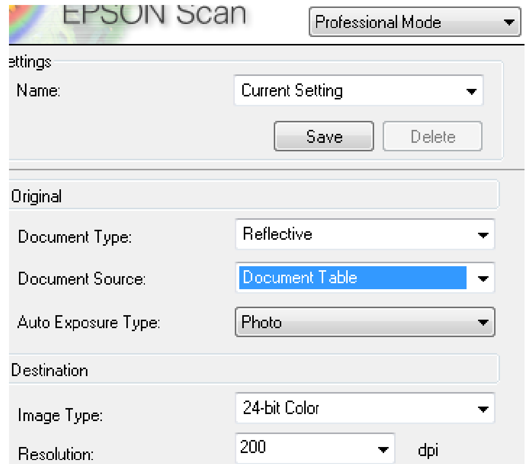
1. Ensure the EPSON scanner is powered off.
2. Using a clean cloth, wipe down the exterior of the scanner removing all dust particles from the outside of the scanner.
3. Open the scanner.
4. Using a flashlight, inspect the glass surface for dust and debris.
5. Douse a clean cloth with two sprays of lens cleaner away from the scanner. *Do not spray the scanner directly.*
6. Wipe the scanner's glass surface with the doused cloth, removing all dust and debris.
7. If a film or any residue is left on the glass surface by the lens cleaner, use a dry cloth to wipe it off.

Step 2: Scanner Startup

1. Power on the Epson scanner with the button on the lower left of the front of the scanner.
2. On the desktop, double-click the EPSON icon to launch the scanning software.



3. Ensure the scanning settings are as follows:
   a. Mode: **Professional Mode**
   b. Document Type: **Reflective**
   c. Auto Exposure Type: **Photo**
   d. Image Type: **24-bit color**
   e. Resolution: **200 dpi**



Step 3: Preparing Document for Scanning

1. Take the first envelope behind the divider in the crate and place it on the desk.
2. Open the envelope and carefully remove its contents onto the desk, ensuring that the order of the documents is preserved.
3. The first document of every envelope will be a scanned document; this document is a copy of the original job folder.
4. Using the brush, lightly brush the documents, removing dust and debris. Always brush towards the edge of the desk so that dust and debris will fall off the desk. Workspace is confined and brushing back and forth will only push dust into the air to settle back down onto your documents.
5. Once the document has been cleaned, ensure Step 1 has been completed.

Step 4: Document Titling Procedure

1. The base titling format for job folder covers is as follows:

<envelope name><->(envelope)_<back>

a. *<envelope name>* refers to the identifying name on the outside of the manila folder the documents are stored in.

b. <-> a dash is **only** placed when there is not an existing dash in the envelope name.

c. *(envelope)* identifies the scanned document as the job folder cover in our database and must be present, **including** parenthesis.

d. *<back>* identifies the scanned document as a back in our database and must be present when appropriate, **excluding** brackets.

    i. When a back is present, the document name must be changed manually because the software does not allow alpha characters after the numeric number is assigned.

e. The scanning software will always assign a numeric value to scanned documents You must manually remove the number at the end of the scanned job folder document and reset the counter to 001.

2. The base titling format for job folder documents is as follows:

<envelope name><->_<document number>.<subfolder document number>.<sub-subfolder document number>_<back>

a. *<envelope name>* refers to the identifying name on the outside of the manila folder the documents are stored in.

b. <-> a dash is **only** placed when there is not an existing dash in the envelope name.

c. *<document number>* is an assigned number that identifies the document's place in the envelope starting with 001 as the first document following the copied job folder at the top of the document.

d. *<subfolder document number>* is **only** assigned when a group of documents are bound together.

   i. Methods of binding can include: staple, paperclip, envelope, paper binding.

   ii. The binding object will only be scanned if it contains information. (e.g. envelopes with addresses, names, or calculations or paper bindings with titles or reference numbers.)

   iii. Scanning software does not support this titling format, document names must be formatted manually.

e. *<sub-subfolder document number>* is **only** assigned when a group of documents are bound within an already bound group of documents. Binding methods are the same as subfolder documents.

   i. Scanning software does not support this titling format, document names must be formatted manually.

f. *<back>* identifies the scanned document as a back in our database and must be present when appropriate, **excluding** brackets.

   i. When a back is present, the document name must be changed manually because the software does not allow alpha characters after the numeric number is assigned.

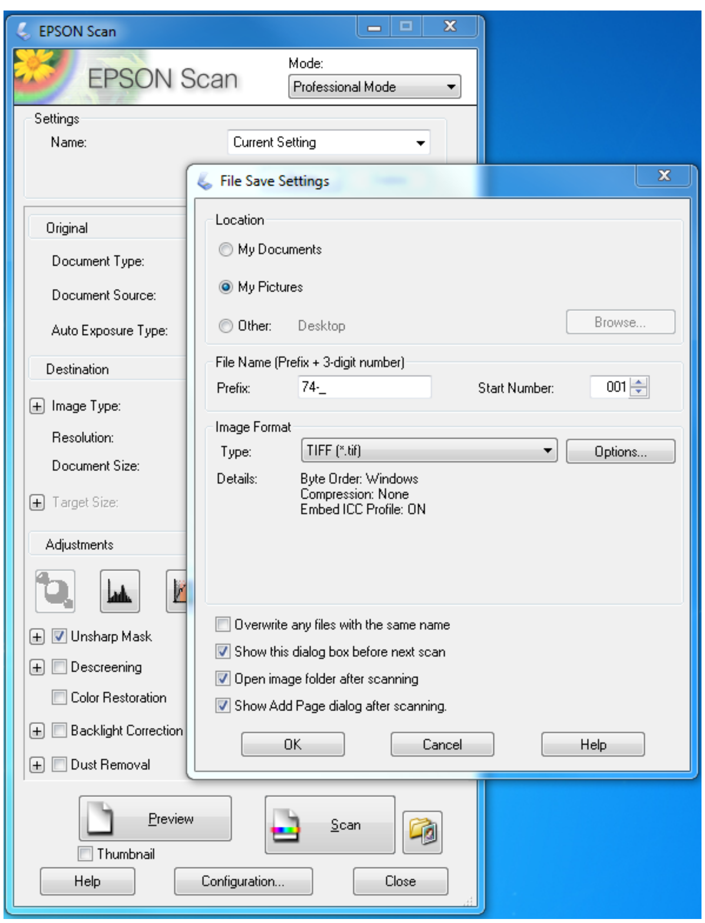
3. If a document does not have a value for a field then it will not be present in the document name. For instance, if a document is the 5^{th} document of folder 16-H it will be titled *16-H_005*, but if it was the 10^{th} subfolder document of the 5^{th} document in folder 16-H it would be titled *16-H_005.10*

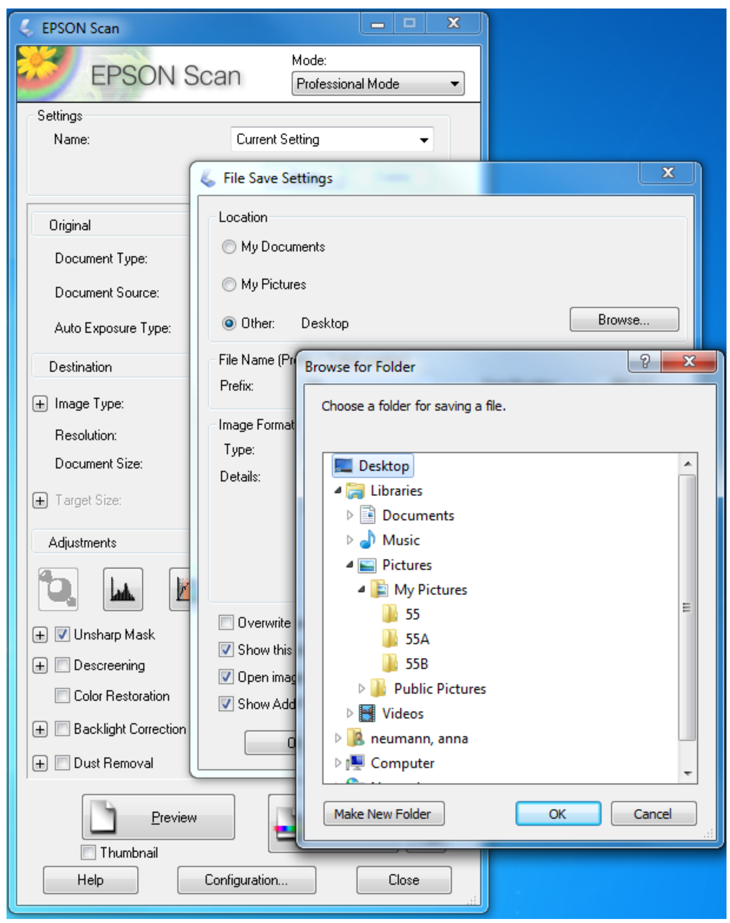
4. All documents will have at minimum an envelope name and document number.

Step 5: Scanning Document

1. Place the cleaned document face-down on the scanner.
2. Close the scanner lid.
3. On the scanning software, click the scan button.

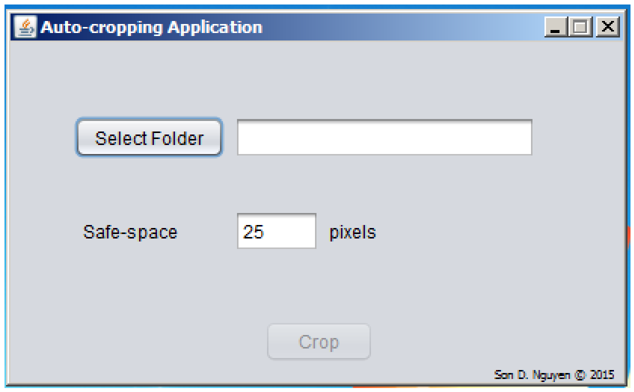
4. In the following window prompt, chose these settings:
   a. Location: Select **Other**, click **Browse,** and navigate to the index folder.
      i. Note: We want to have all the documents and maps from one folder to be in the same folder in the computer.
   b. File Name: input the name of file with correct formatting from Step 4.
   c. Image Format Type: **TIFF**



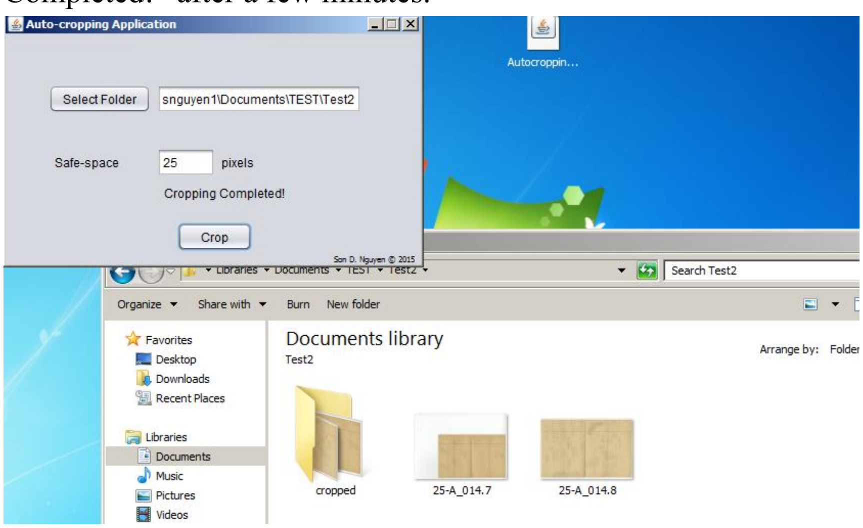


Step 6: Editing Documents

1. Scanning software does not allow cropping, so job folder documents will need to be edited using the Auto-Cropping application and/or Microsoft Office.
    a. Auto-Cropping Application:
        i. Make sure all image files have .tiff extension and the image name doesn't have spaces.



        ii. Open Auto-cropping application, set safe-space to 25 pixels (default).
        iii. Choose "Select Folder" and select one folder that has uncropped maps. Click "Open".
        iv. Click "Crop" and the application will display the message "Cropping Completed!" after a few minutes.



        v. All the cropped maps are stored in the "cropped" folder inside the selected folder.

vi. Go to “cropped” folder and check whether the maps are cropped correctly or not.

vii. If a map was not cropped correctly, delete the cropped image and crop the image manually with Microsoft Office Picture Manager. The cropped image will always be saved in the “cropped” folder.

viii. Note:

- ImageMagick software and Java Runtime Environment (JRE) are needed to run this application.
- Autocropping, ImageMagick & JRE can be downloaded from “Utilities” on the Job Folder homepage.

b. Microsoft Office Procedure:

i. Open document with Microsoft Office.

ii. Click on edit picture (top toolbar)

iii. Select crop (right toolbar)

iv. Crop image leaving a small margin around the image.

v. Click ‘OK’

vi. Rotate the image if needed

vii. Zoom in to check the details

viii. Save cropped image

Step 7: Returning Documents

1. When finished with all the documents, turn them over so that they are in the original order, and carefully place them back into the job envelope.

a. Avoid disheveled piles when returning documents. If the stack is not neat, edges can get caught on the manila envelope and potentially damage the documents.
b. Separate the documents into smaller stacks if necessary. Ensure original order is preserved.

2. After scanning is complete for the day, be sure to copy all scanned documents onto the Job Folder external hard drive.

Notes

- When a larger map or any document that doesn't fit the small scanner is encountered, scan it in the large scanner, then move back to the computer connected to the small scanner and put it on the document stack, preserving original order.
- If the maps or documents are in poor shape, Audrey will not give them to us. Instead, there will be a note inside the envelope with the information about the maps or other documents that belong to this envelope. Please DO scan this note as if it were a document!
- Be very careful with tracing and other field notes paper. Brush them carefully. We might need to use a flat spatula and a piece of rigid paper or plastic to move the maps or documents from the desk to the scanner and back.
- After every 10 scans, inspect and clean the scanner glass following the procedures outlined in step 1.
- Do not use gloves with any job folder documents or maps.
- Stop and call the Library if there is a special case, complication, or question on how to handle, scan, or catalog a map or document.

Appendix C: Field Book Scanning Procedure

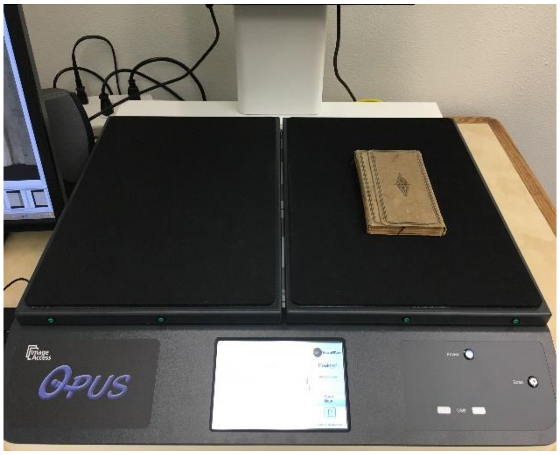
General Setup

1. Turn on the BookEye 4 scanner by holding the power button down for three seconds.
    a. The scanner will make a beeping noise when turning on
2. Open the Opus FreeFlow scanning software
    a. The BookEye 4 scanner must be turned on and fully loaded before opening scanning software
    b. The software will automatically open previous project

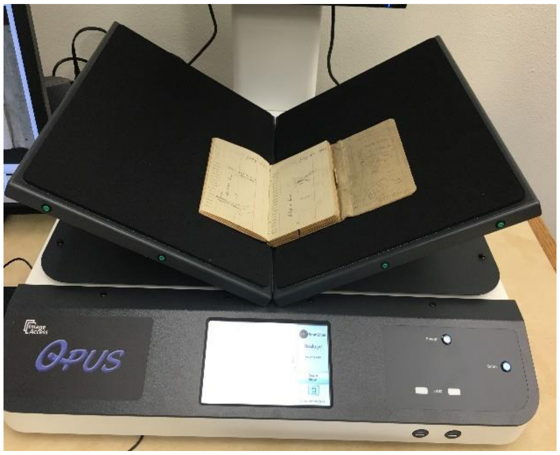
BookEye 4 V.2 Hardware Overview

The BookEye 4 V.2 scanner can be used in several different scan modes. The scan modes we will use are flat and "V" or book mode. Below are photos showing the scanner set in the two different modes. To change the scanner from flat to "V" mode, the user must lift the scan platform from the side and set the collapsible leg against the notch to hold the plate in place. To lower the platform, lift the plate slightly and release the collapsible leg, then lower gently back to flat position.

FLAT MODE



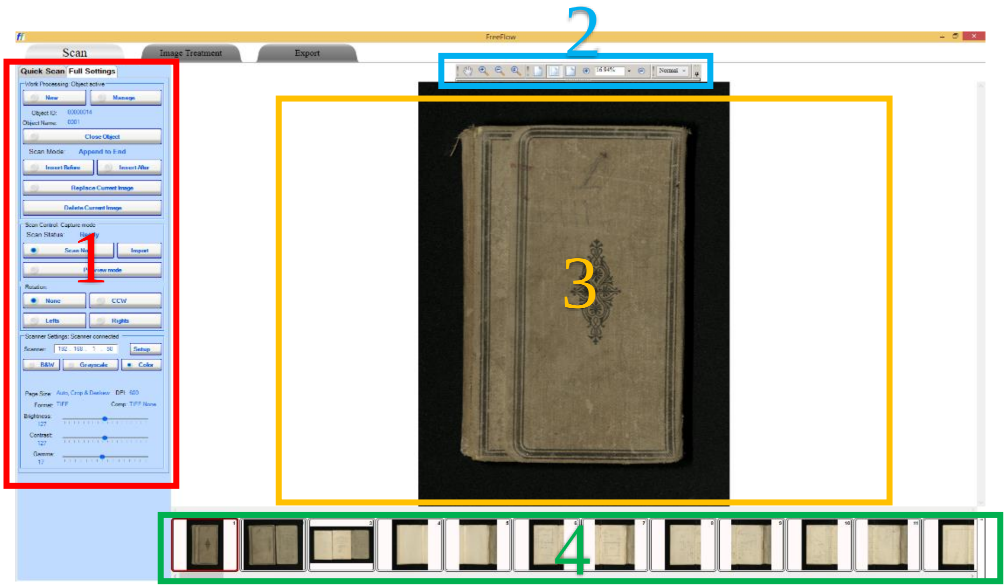
"V" MODE



A scan can be initiated by pressing the scan button on the base of the BookEye 4 scanner, by pressing any of the green buttons located at the edge of the scanner bed plates, or by stepping on the scan pedal located on the floor below the scanner. The scan buttons on the scanner are highlighted in red below.

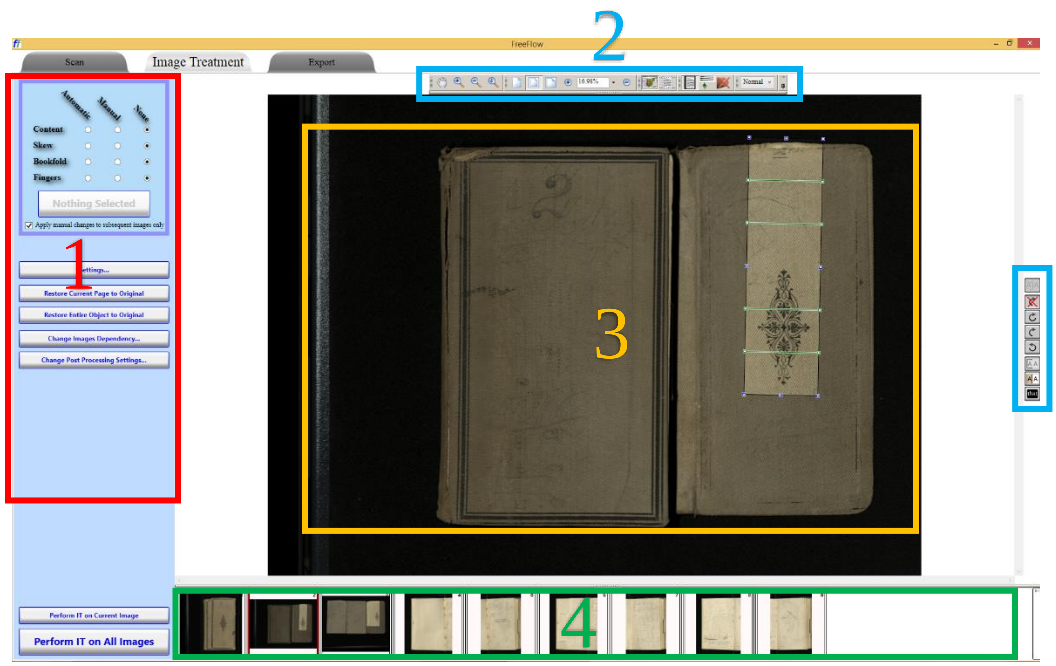
<u>Opus FreeFlow V.4 Software Overview</u>

The Opus FreeFlow software has three main workspaces for the user to work in while using the software. The three interfaces, denoted by tabs at the top of the screen, allow the user to use different functions of the software. The three tabs are Scanning, Image Treatment, and Export. The active tab is lighter in color than the inactive tabs. Click on the desired tab to activate it. The software automatically opens in the **Scan** tab. The **Scan** tab interface is divided into four areas.



1. The **control panel**, located along the left side of the screen, allows the user to select between two different control settings, **Quick Scan** and **Full Settings**. These options are chosen by selecting one of the two tabs at the top of the control panel.
2. The **image preview toolbar**, located at the top center of the screen, allows the user to control the image preview settings. The user can pan, zoom in or out, view the image at full size, fit the image to the screen, etc.
3. The **current image preview** is located in the center of the screen.
4. The **thumbnail preview scroll bar**, located at the bottom of the screen, allows the user to quickly move between different images.

The **Image Treatment** tab is very similar to the scan tab in layout, but this interface has additional tools that allows for automatic or manual changes to be made to the images.



1. The **control panel**, located along the left side of the screen, allows the user to select between automatic or manual image processing. For our purposes we will leave all of these settings at the default location of "None".
2. The **image preview toolbar**, located at the top center of the screen, allows the user to control the image preview settings. The user can pan, zoom in or out, view the image at full size, fit the image to the screen,etc. In addition to the basic image preview control available on the Scan Tab, this tool bar now includes manual image treatment tools.

a. b. c. d. e.

   a. Click to toggle between dependent and independent images.
   b. Click to make the two pages on the current image the same Clip size. This enables the user to create exactly the same image size of the selected images, eliminating 'flutter' or 'stutter' when viewing multiple images in a 'film strip' style viewer

c. Click to activate the manual Content Location and Deskew functions. This enables the user to adjust the size and/or skew of a page.

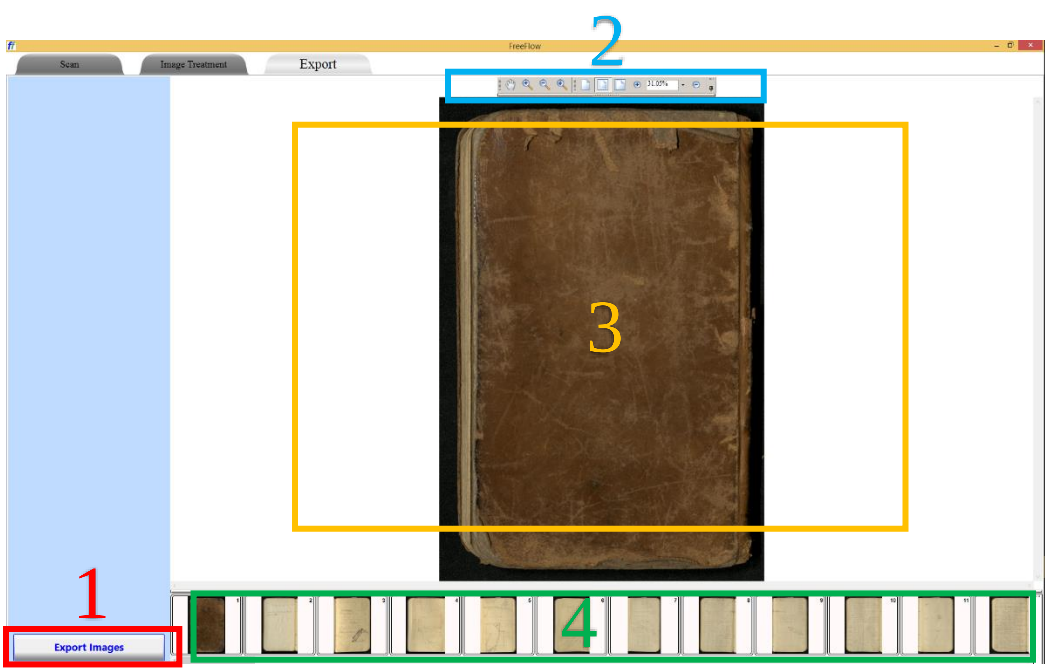
d. Click to activate the manual Curvature Correction function. This enables the user to adjust the image so the curvature is eliminated.

e. Click this to activate the manual Finger or Artifact Removal function. This enables the user to remove artifacts of all types.

3. The **current image preview** is located in the center of the screen.

4. The **thumbnail preview scroll bar**, located at the bottom of the screen, allows the user to quickly move between different images.

The **Export** tab interface has several functions including exporting the images to a directory. One of the precursors to exporting an image is the conversion of the raw image to a derivative



format meeting its intended purpose. Like other processes, the Export tab may be accessed at any time.

1. Upon clicking the **Export Images** button, the user will be presented with the Derivative Settings window. In this window, the user can select the format file of the derivatives or final output, save or load a template, select the path where the derivatives will be stored, and specify the name of the derivative files.
2. The **image preview toolbar**, located at the top center of the screen, allows the user to control the image preview settings. The user can pan, zoom in or out, view the image at full size, fit the image to the screen, etc.
3. The **current image preview** is located in the center of the screen.
4. The **thumbnail preview scroll bar**, located at the bottom of the screen, allows the user to quickly move between different images.

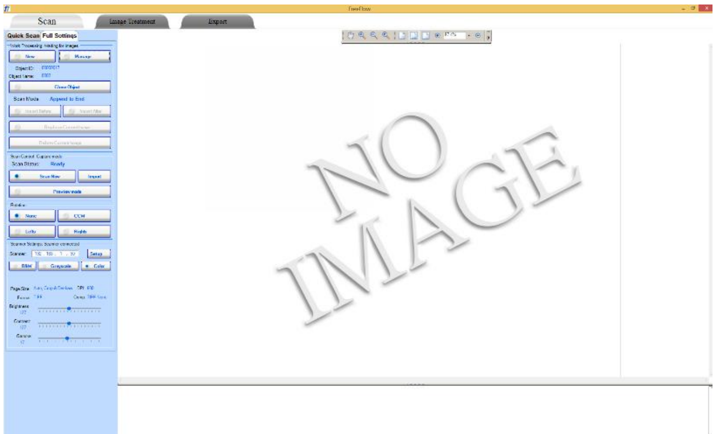
Begin New Project in Opus FreeFlow Software

1. Select the **Scan** tab at the top of the screen.
2. Directly beneath the Scan tab, in the control panel, select **Full Settings** tab
3. Select the **New** button
4. Define Opus Object dialog box will appear. Fill in box as follows:
    a. Project: *Field Book* _ _ _ _ (*four digit number indicating field book numbers. EX: field book number 23 would be "0023")*
    b. Object Type: *select "book" from drop down menu*
    c. Object Name: *four digit number indicating field book numbers. EX: field book number 23 would be "0023"*
    d. Description:
    e. Author:
    f. Publication:

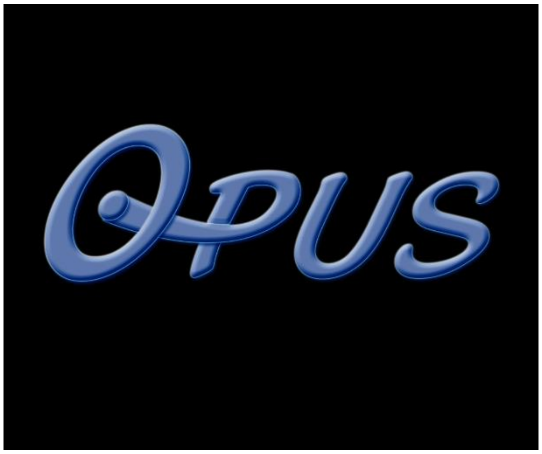
5. Select **OK**

    a. The software will now display “No Image” at the center of the screen.

Monitor 1



Monitor 2



Scanning a Field Book

1. Select **Setup**, Advanced Scanner Setup Dialog box will appear
2. If scanning front or back cover of field book, follow steps below and then proceed to step four. If scanning the pages inside of field book, skip directly to step three.
    a. Hardware Setup
        i. Scanner should be set in flat position
        ii. Place the field book on the right portion of the scanner bed
    b. Software Setup
        i. Select **Load Setting from Template** button
        ii. Select “Front_Back_Covers.bin” file
        iii. Select **Open** button
        iv. Select **OK** button to apply loaded scanner setup template
3. If scanning pages inside of field book, select Load Setting from Template button
    a. Hardware Setup

i. Scanner should be set in “V” position

ii. Place the open field book in the “V” cradle with spine at the bottom of the cradle.

b. Software Setup

i. Select **Load Setting from Template** button

ii. Select “InsideFieldBook.bin” file

iii. Select **Open** button

iv. Select **OK** button to apply loaded scanner setup template

4. Select **Scan Now** button or press any of the physical buttons located on the scanner to begin the scan of the field book.

NOTE: While using Split Pages template, the Scan Now button must be pressed a second time after the scan is complete to display both halves of field book. The left page of the book will be displayed initially, and the right page of the book will be displayed after the scan button is pressed a second time.

5. Turn the page of the field book and repeat steps 2-4 until the end of the book.

Delete an Unsatisfactory Image

1. If an image needs to be rescanned, the user should first select the image thumbnail from the preview scroll bar at the bottom of the screen (area 4).
2. Select **Delete Current Image** button.
3. Repeat Scanning a Field Book procedures until successful scan is achieved.

Image Treatment

1. Select the **Image Treatment** tab at the top of the screen.

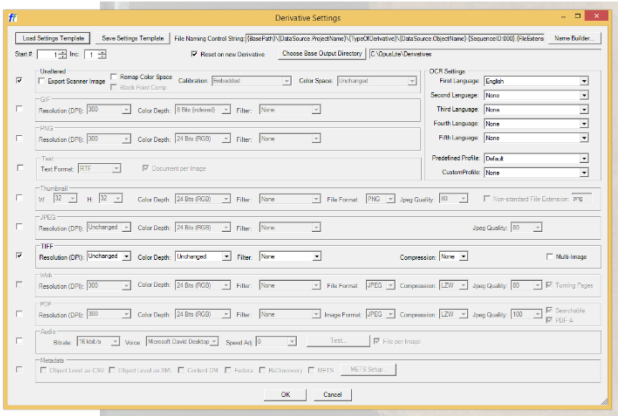
2. Using the thumbnail preview scroll bar at the bottom of the page, select the front cover image. 
3. Select the **Content Clip** button to manually adjust the clip area. The clip area box should now be highlighted.
4. Drag the corners of the highlighted box until the box is placed around the desired image.

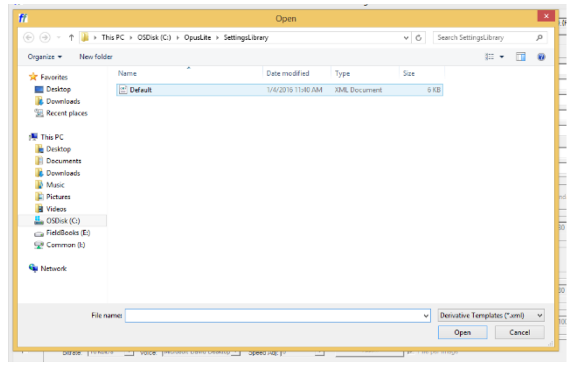
5. Select **Perform IT on Current Image** button. DO NOT select **Perform IT on All Images.** The software will automatically take the user to the Export tab.
6. Repeat steps 1-5 on the back-cover image. You should only need to perform Image Treatment on the first and last images (front and back cover).

<u>Exporting the Scanned Images</u>

1. Select the **Export** tab at the top of the screen.
2. Select the **Export Images** button at the bottom of the control panel. The Derivative Settings dialog box will appear.
3. Select **Load Settings Template** button.

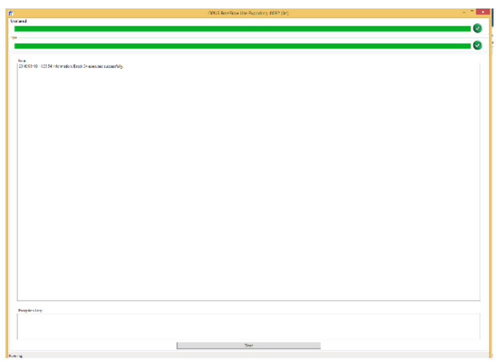
a. Choose **Default** file and select **Open** button.





4. An exporting progress screen will appear. The scanner and scanning software cannot be used while exporting is in progress.

5. Once the exporting process is complete, select **Close** button at the bottom of the progress screen.



<u>Save Images to Hard Drive</u>

1. Navigate to the export location. C:\OpusLite\Derivatives\Field Book ####

2. Select and COPY the TIFF and Unaltered folders as well as the **ObjectInfo** Excel document.

3. Open Field Books (I:) and paste items in appropriate folder.

Appendix D: Georectification Workflow

Georectification procedures:

1. To georectify a map in BandoCat:

    a. Log into BandoCat: http://cartogram.fw.tamucc.edu:81

    b. From the menu on the left of the screen, go to GeoRectification, select either Blucher Maps or Green Maps. This will open a Maps Georectification page. On this page, the maps may be sorted by selecting up or down arrows at the head of any column.

	Library Index	Document Title	Customer	End Date	Has Coast	Has POI	Rectifiability	GeoRec Front Status	GeoRec Back Status	GeoRectify
Edit/View	6R_65A	"Map C" of the Geo. H. Paul Subdivision of the Driscoll Ranch		01/00/1910	No	Yes	POOR	Rectified	Not Rectifiable	Front | Back
Edit/View	6R_62	Map of Lands from Alice and San Diego South		08/13/1909	No	Yes	GOOD	Rectified	Not Rectifiable	Front | Back
Edit/View	8_36.3	Webb County			No	Yes	GOOD	Rectified		Front
Edit/View	8_36.2	[Land Office Map List to Purchase Copies]			No	No	POOR	Not Rectifiable		Front
Edit/View	8_36.1	[Correspondence for Royalty Owners Service]		09/22/1965	No	No	POOR	Not Rectifiable		Front

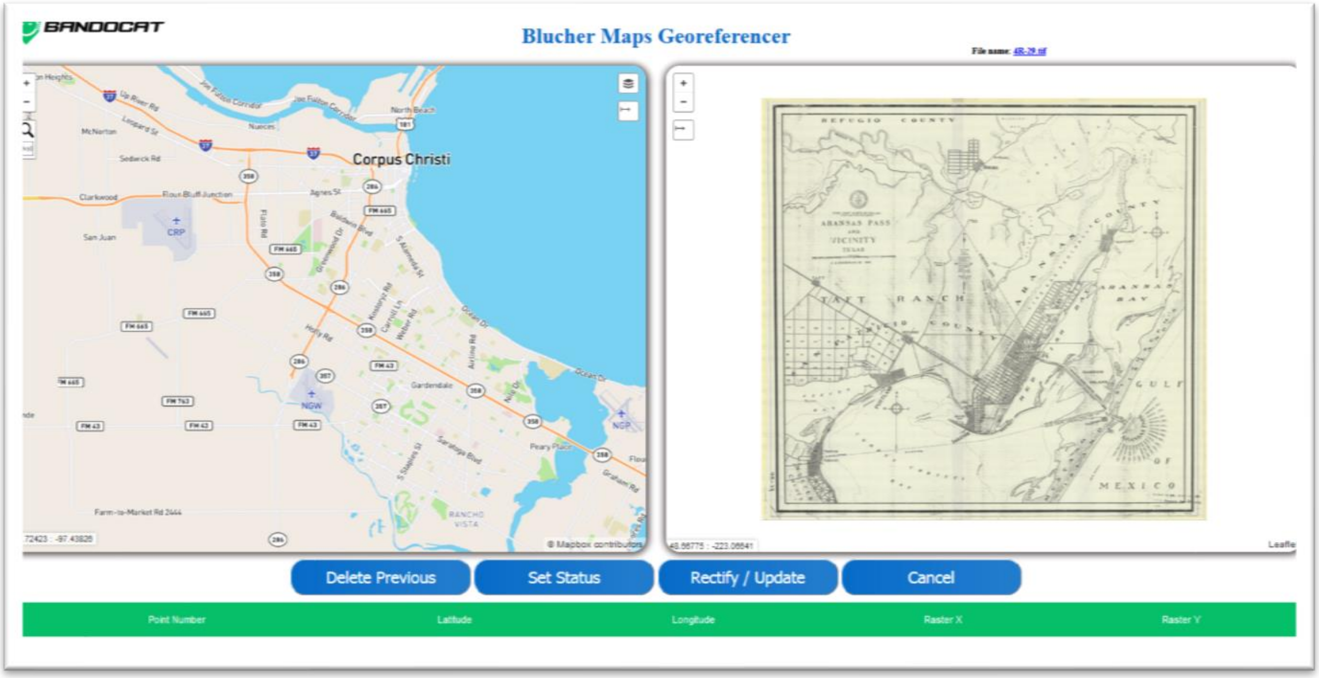
In the GeoRec Front Status and the GeoRec Back Status columns, the maps are labeled as: **Rectified, Not Rectified, Research Required, or Not Rectifiable**.

    c. At the bottom of the GeoRec Front Status column, select the dropdown box and choose **Not Rectified**.

    d. Choose a map to rectify by clicking on **Front** or **Back** in the Georectify column on the row of the map to be rectified. BandoCat will display a message that it is generating map tiles which will take a few moments.

After generating the tiles, BandoCat will open a new Map Georeferencer window with the base map in the left pane and the raster map in the right pane.

Note: If you do not see the new window, you may have popups blocked in your web browser. Disable popup blocking and repeat the above step.



Choose a base map type

There are two map types from which to choose in the base map window. To choose the map type, hover the mouse pointer over the Street/Satellite View icon at the top right of the screen. If details from a satellite image are useful, choose the Satellite view and add street information by checking the ESRI Transportation box. Street view offers a less cluttered map, which is useful for locating smaller towns, and street and railroad intersections.

To rectify the map, a minimum of three identifiable, corresponding points must be found and marked in each map. Street intersections, points of interest, structures, and stable natural features are typically good candidate points. Street intersections are the most common places to set a point marker, but depending on the scale of the map, identifiable land objects may be used. For example, in a map of the state of Texas, the western tip at El Paso, the corners of the panhandle, the intersection of the panhandle and the Red River, and the Rio Grande at the Gulf of Mexico may be used.

In addition to finding pairs of points on both maps, a good distribution of points is needed for a high-quality rectification. The figures below show an example of maps with poor and good point distribution. Sometimes it is not possible to have a good distribution of points, due to the nature of the location being mapped, however, a good distribution is always the goal, even if it takes additional time to determine points.

Figure 1: Example of Poor GCP Distribution (left) and Good GCP Distribution (right) on a Raster Map

e. Examine both maps to find suitable points.

   a. If you are unable to find suitable points then it is considered not rectifiable. Click the Set Status button located below the map panes. From the Update GeoRec Status drop down menu select **Not Rectifiable** then click Update. A popup window will display “Status updated successfully!” Click OK and the Georeferencer page will close. The maps status will be changed to **Not Rectifiable**.

b. If you are able to find suitable points, use the mouse crosshairs to mark the point in the raster pane by left-clicking the mouse, then mark the corresponding point in the base map pane by left-clicking the mouse.

f. Repeat the above step for the next pair of points. Each subsequent point must first be selected in the raster pane, then in the base map pane. As points are added to the panes, the point numbers are added at the bottom of your screen showing the Latitude, Longitude, Raster X, and Raster Y for each point.

g. If marker points are chosen by mistake, or do not work in the rectification, the Delete Previous button will remove marker points in order from the most recent point selected to the first point selected.

h. When all the points have been marked, with proper distribution, click the Rectify/Update button located below the map panes.

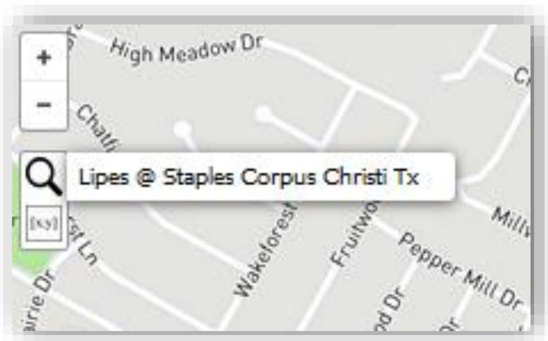
i. When the map is rectified successfully a "Success" window will pop up. Click the OK button to close the Maps Georeferencer window. Then click the F5 button on your keyboard to refresh the page. At this point the map will be changed from **Not Rectified** to **Rectified**.

Tools Available in BandoCat Georeferencer

BandoCat Georeferencer contains three tools aimed at assisting the user in finding locations (Address Locator Tool), entering coordinates (Coordinate Entry Tool), and measuring distances (Measurement Tool). This Appendix explains how to use each of these tools.

Address Locator Tool

The address locator may be used to help locate a street or intersection on the base map. Using @ between two street names will search for the intersection of those two streets. Adding the city and state will narrow the search. To execute the search, press Enter on the keyboard. The base map will zoom to the street/intersection, or the search tool will display a message saying that the address could not be found.

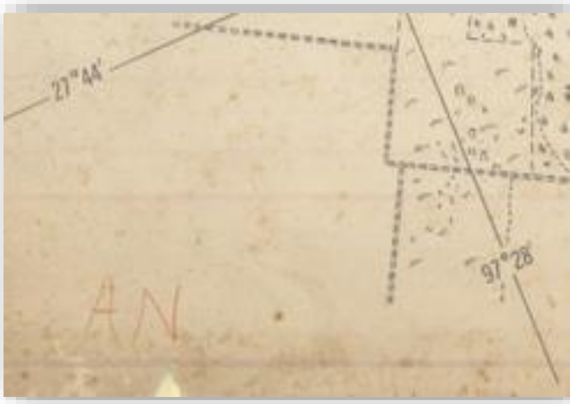


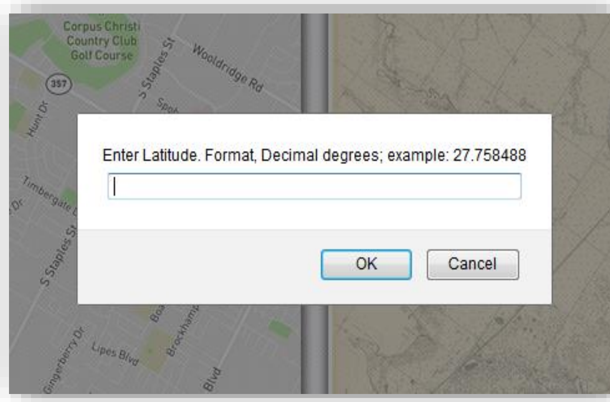
Coordinate Entry Tool

Raster maps with latitude and longitude coordinates may have their corresponding points entered in the base map by using the coordinate entry tool ([x,y] icon) at the upper left of the base map, below the street search magnifying glass tool. After selecting an intersecting latitude and longitude in the raster map, click on the [x,y] icon in the base map. A popup box will ask you for the Latitude and then the Longitude, both in decimal degrees.

If maps in the collection have lines of latitude and longitude, they will usually be in degrees and minutes, (ex. 27° 44”). Coordinates must be entered using decimal degrees.

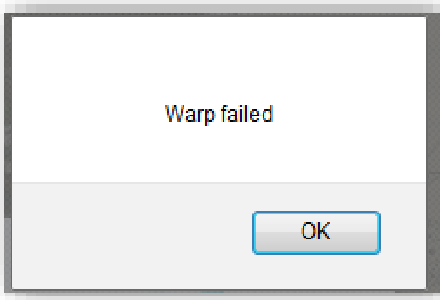
Note: In some cases, entering latitude and longitude coordinates does not work, in which case the point values for Raster X and Raster Y at the bottom of the screen will display undefined values.





Point Number	Latitude	Longitude	Raster X	Raster Y
1	28.033333	-97.083333	undefined	undefined

If you try to Rectify/Update after entering undefined values you will see “Warp Failed”, instead of “Success”. After clicking OK, the window will close and the map will remain **Not Rectified**.



Measurement Tool

Some maps do not have enough identifiable streets or intersections to place enough marker points for rectification. If there are bearings and distance on the raster map, the measurement tool enables the user to measure from a known point and add marking points on the base map by using the distance and bearings shown on the raster map.

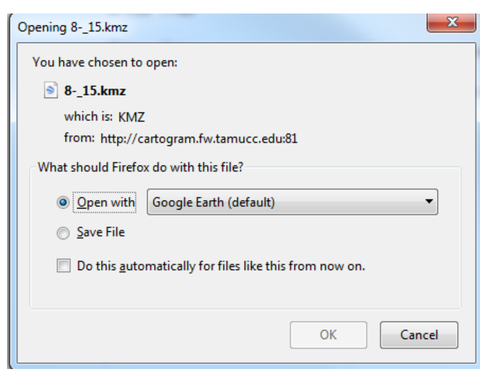
1. Enable the measurement tool by left-clicking on the measurement tool icon. The icon background will change to green, indicating that it is enabled.
2. With the measurement tool enabled, the user can left-click the mouse on the base map to select a beginning point, leaving a green node. As the crosshair moves across the screen, the distance and bearing from the beginning node is displayed next to the crosshair. Left-click a second time and the tool will leave an orange node and the distance and bearing between the two nodes. If you wish to continue to another point, the display box will include the bearing and distance from the last point, in black numbers, and the total distance from the beginning node in green numbers.
    a. **Note:** To make multiple measurements without turning the tool off, press the Escape key on the keyboard to leave each measurement, with a green to a red node, and its distances and bearings displayed on the screen.

3. Disable the tool by left-clicking on the measurement tool icon to stop measurements and clear the nodes from base map.

Quality Control – How to check the Georectification Quality

A check of the rectification can be made by opening the map in Google Earth.

1. From the Maps Georectification page click **Edit/View** in the first column of the map row of the map you wish to check. This opens the associated Maps Review Form page.
2. At the bottom of the Maps Review Form page click on **Front KMZ**. Make sure that Open with Google Earth is selected in the popup window, then click OK.



3. When Google Earth opens, the raster map should be overlaid, and rectified to, the Google Earth map. When finished viewing the map, close Google Earth and choose "Discard" from the pop-up window.

If the raster map does not align with the Google Earth map, there might be a problem with point distribution, a lack of sufficient points to rectify the map, or a simple blunder in placing the marker points.

1. To redo a rectified map:
   a. Return to the Maps Georectification page and select the map by clicking on **Front**, or **Back** in the Georectify column on the row of the map to be rectified.
   b. To try rectifying again, remove the marker points by using the Delete Previous button below the map panes to remove marker points in order from the most recent point selected.
   c. Begin again by selecting marker points.
   d. After the map has been rectified, check it again in Google Earth.
2. If there is still a problem or issue with the map rectification that cannot be solved:
   a. Return to the Maps Georectification page and select the map again by clicking on **Front**, or **Back** in the Georectify column on the row of the map to be rectified.
   b. Remove the marker points by using the Delete Previous button below the map panes to remove marker points until all of the points are removed from both the raster map and the base map.
   c. After the marker points are removed, click the Set Status button. If you are sure the map cannot be rectified, select **Not Rectifiable** from the drop-down menu and click the

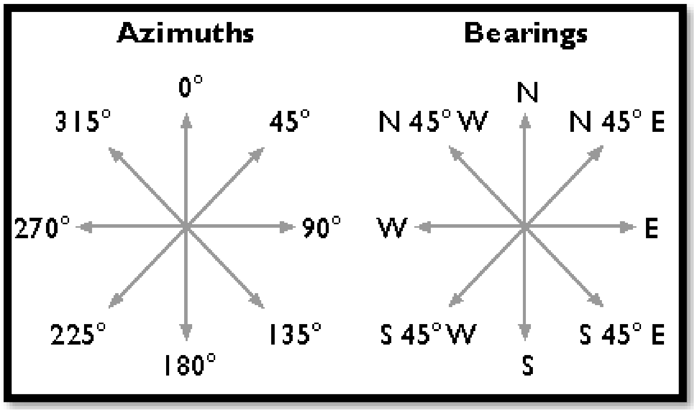
Update button. If there is still a possibility that the map can be rectified, select **Research Required**, from the drop-down menu then click the Update button.

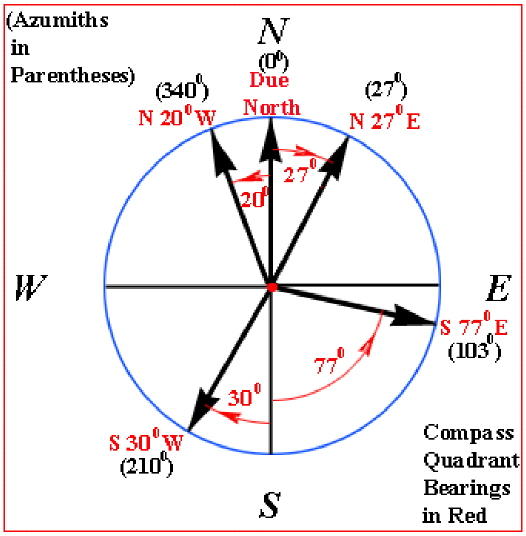
d. Click the F5 button on the keyboard to refresh the page.

e. Make a note of the library index of any map that has undefined raster points, Translate failed, or Warp failed, and notify your supervisor so it may be reviewed.

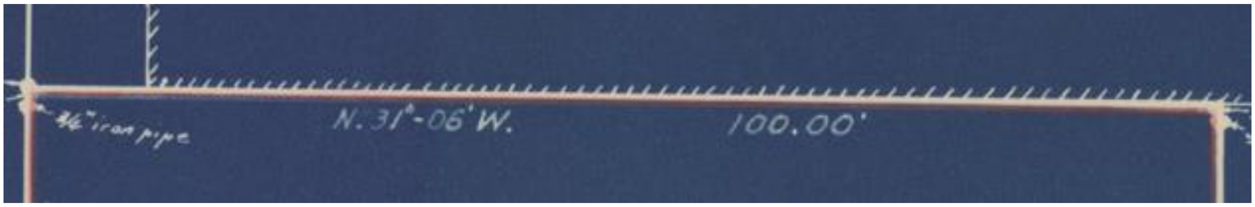
Bearings vs Azimuth

An azimuth is a horizontal angle measured clockwise from North, 0° to 360°. Southeast is written 135°. A bearing is described from North or South, with the angle to the West or East. An azimuth of 135° would be written as a bearing of S 45° E, which can be thought of as: from the south (180°), 45° east.





The collection maps measurements are usually given in Bearing and Distance, as in the example below.



Most distances are in feet, but others are in varas and will need to be converted before using the measurement tool. 1 vara = 33 1/3 inches. To convert varas to feet, take the varas and divide by 0.36.