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# Investigating Historic Parcel Changes to Understand Land Use Trends

## A Methodology and Application for the San Pedro River Watershed

RESEARCH AND DEVELOPMENT

# Investigating Historic Parcel Changes to Understand Land Use Trends

## Methodology and Application for the San Pedro River Watershed

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## Notice

This report has been peer reviewed by the U.S. Environmental Protection Agency Office of Research and Development and the USDA Agricultural Research Service and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation by EPA nor USDA/ARS for use.

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# Acronyms and Abbreviations

| | |
|---|---|
| **AGWA** | Automated Geospatial Watershed Assessment |
| **APN** | Assessor Parcel Number |
| **BLM** | U.S. Bureau of Land Management |
| **CFR** | Code of Federal Regulations |
| **EPA** | U.S. Environmental Protection Agency |
| **GIS** | Geographic Information System |
| **HD** | Housing Density |
| **ICLUS** | Integrated Climate and Land Use Scenarios |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IT** | Information Technology |
| **MGD** | Million Gallons a Day |
| **MSS** | Multi-spectral Scanner (Landsat) |
| **NEPA** | National Environmental Policy Act |
| **NHD** | National Hydrology Dataset (USGS) |
| **PLSS** | Public Land Survey System |
| **SPRNCA** | San Pedro Riparian National Conservation Area |
| **SRES** | Special Report on Emissions Scenarios |
| **STORET** | Storage and Retrieval Database |
| **SWAT** | Soil and Water Assessment Tool |
| **TANA** | TeleAtlas of North America |
| **TM** | Thematic Mapper (Landsat) |
| **USGS** | U.S. Geological Survey |
| **USPP** | Upper San Pedro Partnership |
| **WWTF** | Wastewater Treatment Facility |

## Abstract

Long-term land use and land cover change, and the associated impacts, pose critical challenges to sustaining healthy communities and ecosystems. In this study, a methodology was developed to use parcel data to evaluate land use trends in southeast Arizona's San Pedro River Watershed. Changes to parcel size are examined decade by decade, for two intervals: from 1882 to 2012, and from 1971 to 2012. Graphs are used to depict decadal parcel trends for both intervals. Parcel density maps additionally illustrate decadal trends for the 1971 to 2012 interval. The parcel density maps and graphs employ housing density categories developed by the Environmental Protection Agency's Integrated Climate and Land Use Scenarios project. The purpose of this study is to 1) improve and describe a methodology for evaluating land use trends using parcel data; 2) display land use trends in a portion of the San Pedro Watershed using parcel data; and 3) discuss the implications of the analysis for evaluating environmental impacts with modeling tools and for assessing indirect effects as required by the National Environmental Policy Act.

## Introduction

The San Pedro River is considered one of the last free flowing, undammed rivers in the American Southwest; it flows intermittently between two deserts and through two countries (Figure 1), supporting tremendous biodiversity and providing an important stopover along the central migratory flyway. Changes to ground- and surface water quality and quantity on both sides of the border have raised serious concerns about watershed sustainability. A particular focus in the Upper San Pedro River Watershed is long-term water supply reliability and impacts to the country's first National Riparian Conservation Area, the San Pedro Riparian National Conservation Area (SPRNCA). Despite pioneering water management approaches and collaborative partnerships, "the overall situation in the regional aquifer is not improving; rather, it continues to get worse" (USPP 2011).

The impact of urbanization on the San Pedro River watershed is a significant driver of declining water quality and quantity (Nie et al. 2011). Yet, few researchers have analyzed the area's changing urban landscape. The purpose of this study is not only to show land use trends in a portion of the San Pedro River Watershed, but also to improve and describe a methodology that could be used to chronicle growth-induced land use change in watersheds across the country.

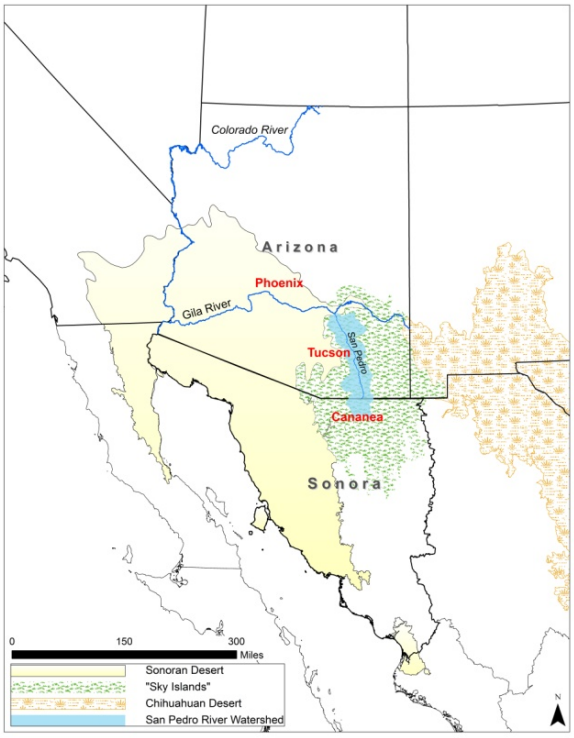



Figure 1: The San Pedro River flows 230 km (~142 mi) from its headwaters in Cananea, Sonora, Mexico to its confluence with the Gila River in Arizona. The watershed is within the Madrean Archipelago, also known as "Sky Islands." This area is one of the most biologically diverse in the world (Koprowski 2005, Skroch 2009). The geographic convergence of two major mountain ranges (the Rocky and the Sierra Madre) and two vast deserts form the foundation for ecological interactions found nowhere else (Skroch 2009). Hydrology data from USGS NHD; Administrative boundaries from AZTANA; Ecoregions from NHEERL; Mexican hydrology data and administrative boundaries from Kepner et al. 2003.

Land use change can have devastating impacts on the landscape. The consequences of human modification of the Earth's surface for extraction of natural resources, agricultural production, and urbanization may even rival those that are anticipated via climate change (Vitousek 1994, Vorosmarty et al. 2000, Chapin et al. 2002, DeFries and Eshleman 2004, Brauman et al. 2007, Whitehead et al. 2009).

Understanding and mitigating the consequences of future land use change require knowledge of past trends and impacts. Historic reference conditions can provide resource-managers with baseline "snap shots" capable of informing and directing the management and implementation of present day projects and planning. Evaluating management decisions using only current conditions belies potential impacts (Covington and Moore 1992). Without knowledge of past projects and their consequences, how can we evaluate whether present management will lead to significant environmental impacts in the future?

Preferably, reference conditions would be based on undisturbed environments. However, most environments have been impacted and modified by both modern and aboriginal humans (Swanson et al., 1993). Arguably, all environments could be described as "disturbed" or "produced nature" (Smith 1996). It is less important that a reference condition be "pristine" than that it be simply available and that subsequent changes to that baseline can be evaluated using consistent and measurable criteria.

Comparing conditions across large landscapes and assessing cumulative environmental impacts over time has been challenging. Before the launch of remote sensing satellites in the early 1970s, past and present conditions could be compared using archival literature and photography. Since then, remote imagery has increasingly been used to chronicle change. Despite certain limitations, both datasets have been used to produce compelling analyses of landscape change in the arid Southwest.

Vegetation change in the American West has been a subject of concern throughout the twentieth century (Humphrey 1958, Hastings and Turner 1965, Branson 1985, Grover and Musick 1990, Bahre 1991, Bahre and Shelton 1993, and Turner et al. 2003). Most of the evidence for vegetation change is provided from a series of matched photographs - a method called repeat photography - beginning in the late 1800s and early 1900s (Figure 2). However, there are serious drawbacks in using this technique to assign change over this period of history.

Figure 2: Landscape change from perennial grassland to mesquite woodland in a semi-arid rangeland (Santa Rita Mountains south of Tucson, Arizona) from 1903 (left) and 1941 (right) (from Kepner et al. 2002)

As some authors, e.g. Bahre (1991), point out, the field of view in older photographs is usually oblique and covers little total area, which limits their usefulness in determining change in plant occurrence over large regional areas. Secondly, the historic photographic series are usually separated by large periods of time, often captured more than a decade after the sites were first disturbed by human activity. Lastly, repeat photography has largely been used for qualitative comparisons and little progress has been made in quantifying and characterizing change using this dataset. Although several studies have addressed specific aspects of vegetation change in the Southwest, few have attempted to synthesize the cumulative impacts over large regional or watershed areas.

Important advances in the integration of remote imagery, computer processing, and spatial analysis technologies have been coupled to landscape ecology theory to study the distribution patterns of communities and ecosystems (Kepner et al. 2000 and 2002). Landsat imagery, for example, has been used to evaluate the human and environmental processes affecting distribution patterns over time (Figure 3). The combination of these technologies contributes to our ability to characterize large areas; it also provides predictive models for alternative future scenarios, which can lead to a more robust comparative analysis of impacts relative to alternative courses of management action (Kepner et al. 2004).

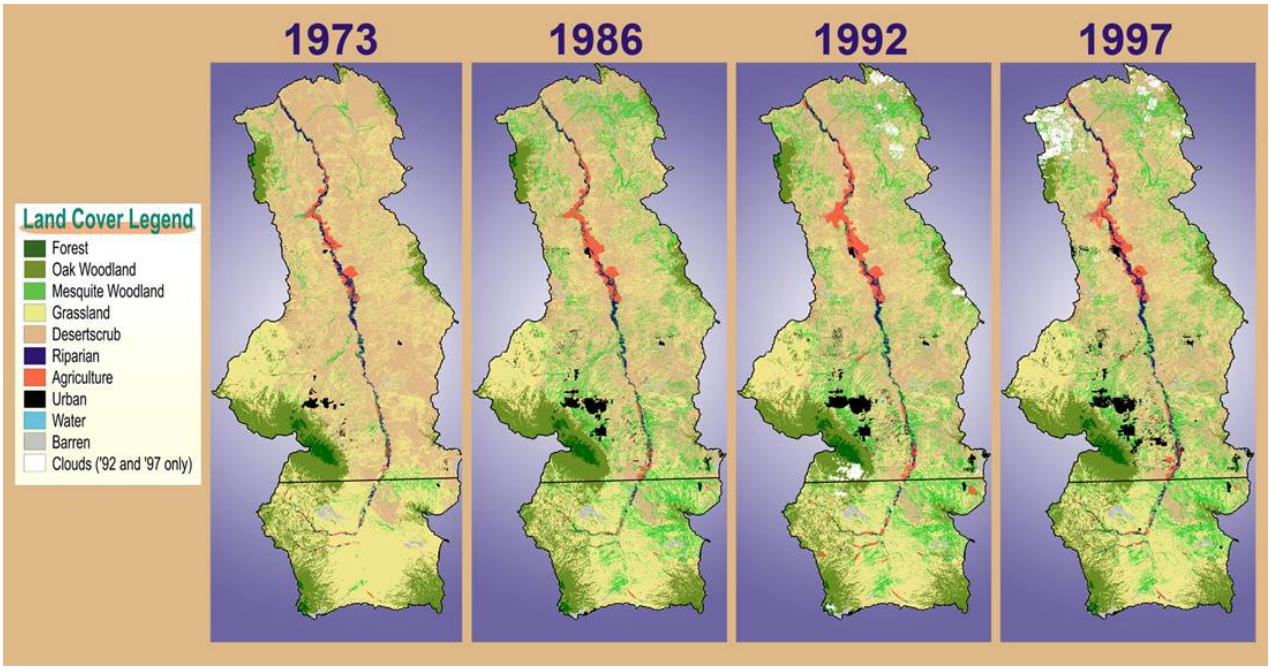



Figure 3: Land cover in the Upper San Pedro Watershed using Landsat MSS and TM (Kepner et al. 2002)

There are limits, however, to how much change can be detected employing remote imagery and spatial analysis technologies. For example, satellite images vary in scale related to pixel size and spectral resolution, which can complicate the generation of cohesive and comprehensive mosaics. Furthermore, their availability is limited. For instance, the earliest Landsat imagery dates back only to 1972.

Archival ownership records also provide information for understanding reference conditions, and may help facilitate the analysis of photographs and satellite images. While such records - notably county Treasurer and Assessor documents - may be limited as well, our research suggests property records (i.e., parcel data) may nonetheless provide important insight into historic land use trends, fill data gaps, and corroborate the findings of other change-detection methodologies.

For the purpose of this report, the results are restricted to a portion of the Upper San Pedro River Watershed that was studied by William R. Rodgers, a University of Arizona graduate student in the mid-1960s. Our study area encompasses the same rectangular section of the watershed Rodgers defined as the Upper San Pedro River Valley and mapped using the Public Land Survey System (PLSS) (Figure 4).

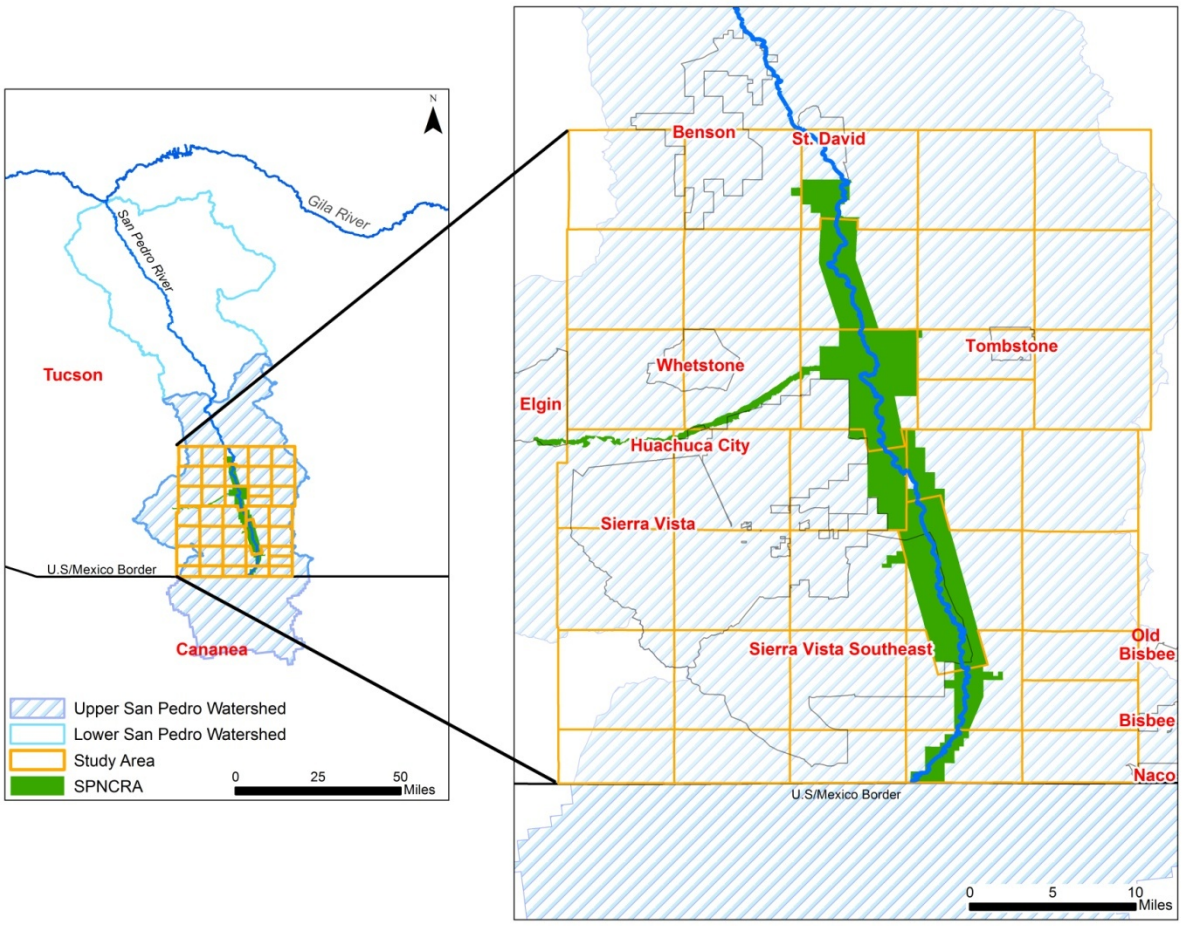



Figure 4: Location Map of the Study Area. The study area was defined using the Public Land Survey System (PLSS); the grid shows historic township boundaries. Also shown is the San Pedro Riparian National Conservation Area (SPRNCA). Administered by the U.S. Bureau of Land Management (BLM), SPRNCA protects approximately 64 km (~40 mi) of the river corridor. Hydrology data from USGS NHD; Administrative boundaries from AZTANA; PLSS boundaries from Cochise County; SPNCRA boundaries from Kepner et al. 2003.

## Methods

At the age of 55, Brigadier General William M. Rodgers retired from the Army and enrolled in the Geography program at the University of Arizona. In 1965, Rodgers submitted his thesis, titled “Historical Land Occupance of the Upper San Pedro River Valley Since 1870.” The study relied heavily on documents provided by the Cochise County Treasurer and Assessor. Rodgers described using Tax Rolls from 1882 through 1964 to analyze the changing extent, number, and acreage of parcels, decade by decade. He drew detailed landholding maps using the Public Land Survey System (PLSS). Figure 5 shows the 1900 and the 1964 landholding maps from Rodgers’ study. In Figure 5, the diagonal lines show how much of each section and how many of a Township’s 36 640-acre sections were occupied for each of the years examined.

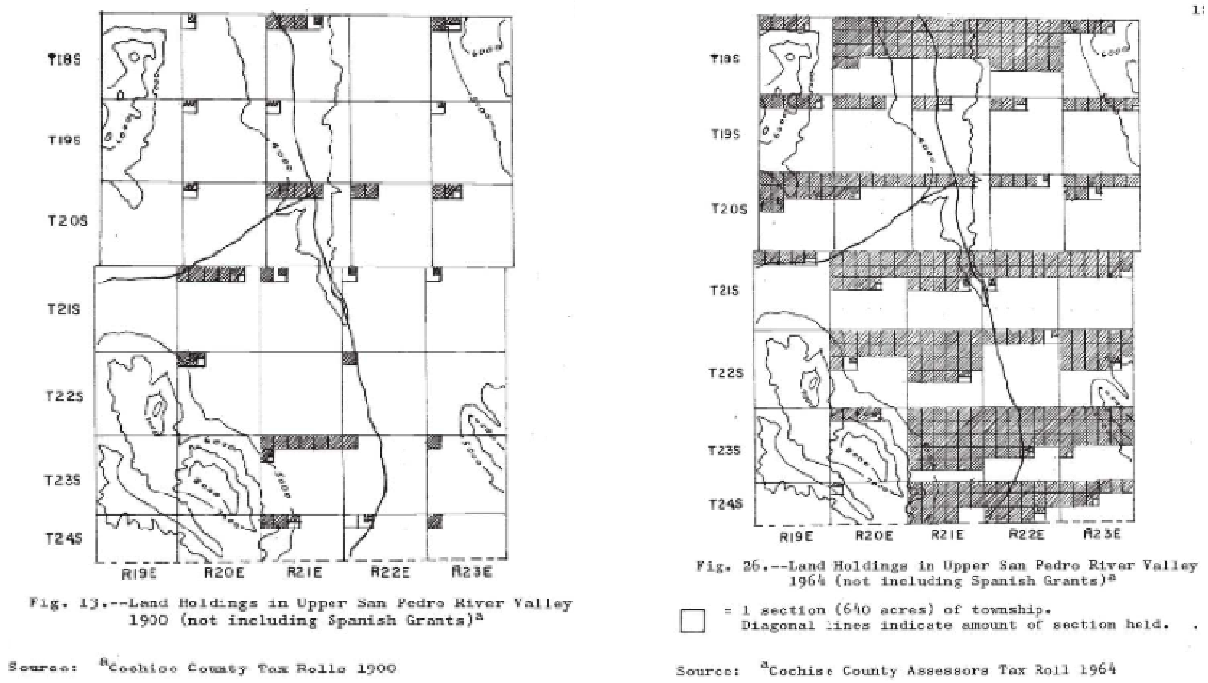
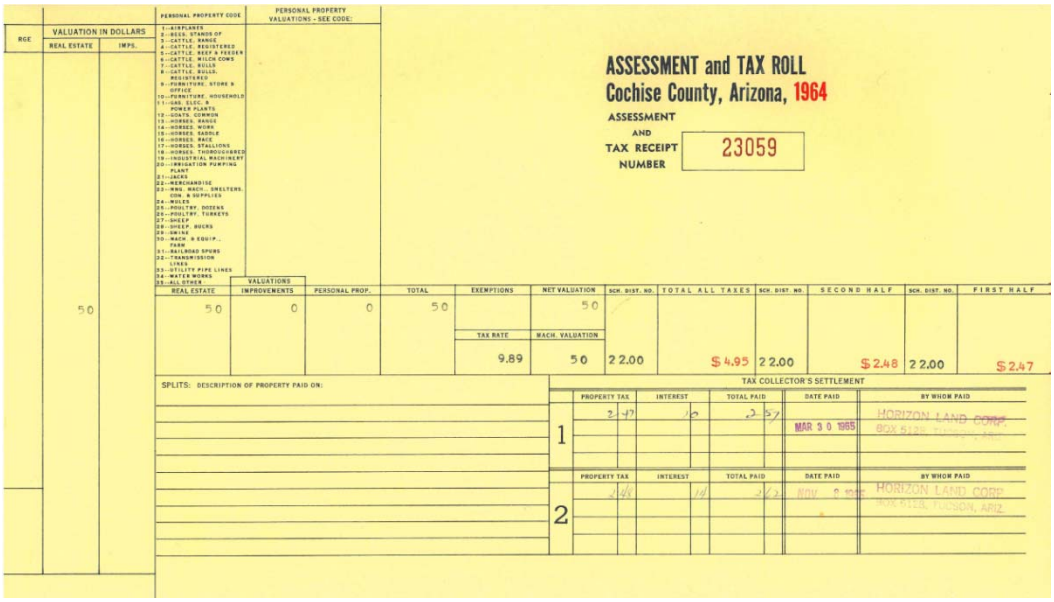



Figure 5: Landholdings in Upper San Pedro River Valley, 1900 and 1964 (Rodgers 1965)

The historic tax rolls are stored in large binders, organized by year and, from 1935 to 1970, by Tax Roll Number, which is also referred to as the Assessment Number. For example, the 1964 Tax Roll binder “35015 - 35441” contains all tax records with assessment numbers ranging from 35015 through 35441. Before 1935, the Tax Roll was organized by year and, alphabetically, by owner last name. Today, the binders are stored in the Cochise County Archives (Figure 6).

Figure 6: Cochise County Archives space savers (left) and the row containing the 1964 Tax Roll binders (right)

Each Tax Roll record provides an assessment number, the name and address of the owner, the taxes due, and, sometimes, the property's legal description, acreage, and location, defined using PLSS coordinates (e.g., Township 21, Range 22, southeast quarter of section 35) (Figure 7).



ASSESSMENT and TAX ROLL
Cochise County, Arizona, 1964
ASSESSMENT AND TAX RECEIPT NUMBER 23059

| RGE | VALUATION IN DOLLARS REAL ESTATE | IMPS. | PERSONAL PROPERTY CODE | PERSONAL PROPERTY VALUATIONS - SEE CODE: |
|---|---|---|---|---|
| | 50 | | | |

| VALUATIONS REAL ESTATE | IMPROVEMENTS | PERSONAL PROP. | TOTAL | EXEMPTIONS | NET VALUATION | SCH. DIST. NO. | TOTAL ALL TAXES | SCH. DIST. NO. | SECOND HALF | SCH. DIST. NO. | FIRST HALF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 0 | 0 | 50 | | 50 | | | | | | |
| | | | | TAX RATE | MACH. VALUATION | | | | | | |
| | | | | 9.89 | 50 | 22.00 | $4.95 | 22.00 | $2.48 | 22.00 | $2.47 |

SPLITS: DESCRIPTION OF PROPERTY PAID ON:

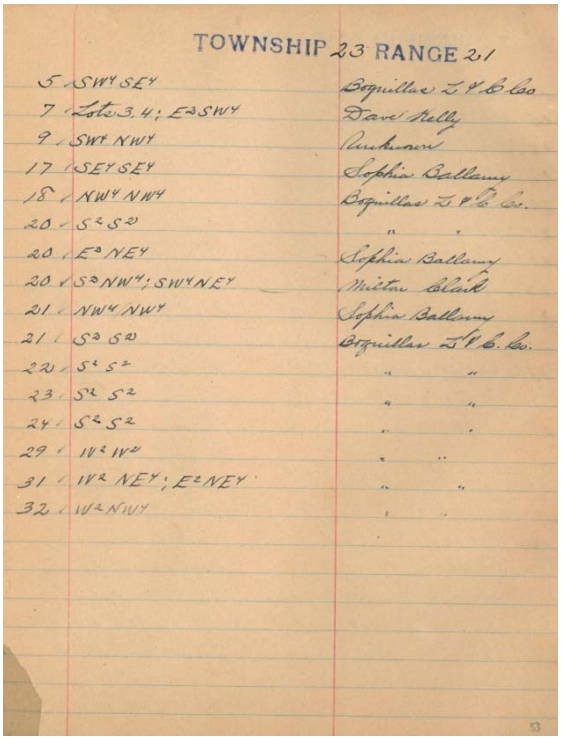
TAX COLLECTOR'S SETTLEMENT

| | PROPERTY TAX | INTEREST | TOTAL PAID | DATE PAID | BY WHOM PAID |
|---|---|---|---|---|---|
| 1 | 2.47 | | 2.47 | MAR 30 1965 | HORIZON LAND CORP. BOX 5126, TUCSON, ARIZ. |
| 2 | 2.47 | | 2.47 | NOV 8 1965 | HORIZON LAND CORP. BOX 5126, TUCSON, ARIZ. |

Figure 7: Scanned Image of 1964 County Assessor Tax Roll Record (Courtesy of Cochise County Archives, 2012)

If a property spanned multiple sections in multiple townships and/or ranges, the Tax Roll record - if complete - would list the acreage owned within each area (e.g. Township 21, Range 22, southeast corner of section 32, 160 acres; Township 22, Range 22, northern half of the northwest quarter of section 2, 80 acres). Rodgers was interested only in properties within the Upper San Pedro Valley, which he defined as Townships 18 through 24 and Ranges 19 through 23 (Figures 4 and 5). As the Tax Roll was not organized geographically and as many of the Tax Roll records had missing and/or incomplete acreage and location information, it seems more than likely Rodgers would have also relied on County plat books.

The County's oldest plat book dates from 1913, and the most recent from 1964. The plat books were organized by Township, Range, and Section. The properties within a given section were listed one by one and included only two additional pieces of information: who owned it and its acreage (Figure 8). There is no unique assessment number associated with each entry in the plat books. Rodgers would have needed to take great care in identifying an individual property. Since large properties consisted of land in multiple sections, ranges, and/or townships, the owner's name would appear multiple times in the plat books. Once Rodgers knew who occupied land in his study area, he would have been able to track that individual down in the Tax Roll and then accurately describe the acreage of a single property.



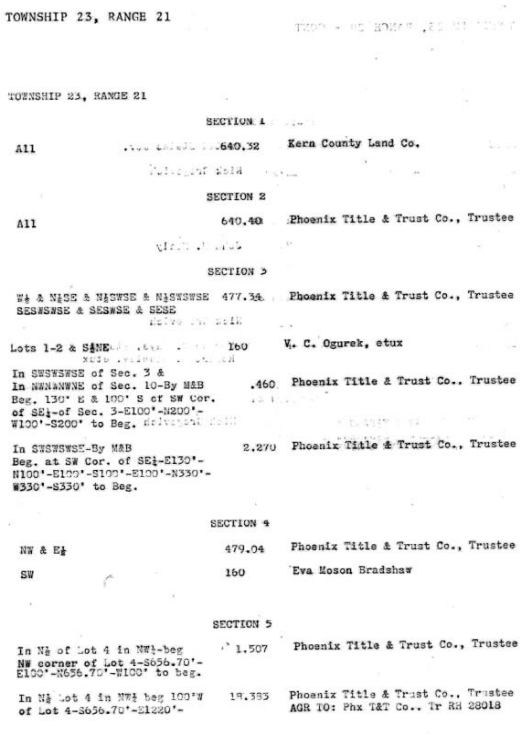




Figure 8: Scanned Plat Books entries showing landholdings in Township 23, Range 21 in 1913 (left image) and 1964 (right image) (Courtesy of Cochise County Archives, 2012)

Examining holdings in 1940, 1950, and 1964 would have required an additional step because, from 1935 to 1970, the Tax Rolls were organized by assessment number, not by owner name. In order to connect a property owner to a specific piece of property during those years, Rodgers likely referenced the "alpha indices," which are organized alphabetically by owner last name (Figure 9). Adjacent to the owner name, the alpha index lists the unique assessment number associated with that person's property. By referencing a given year's alpha index, Rodgers could have tracked down a Tax Roll record using the assessment number. To examine parcels in 1940, he may have done this as many as 325 times; for the year 1964, as many as 831 times. He did not describe his methods in detail, and they remain an impressive mystery - particularly for those years that lack plat books (before 1913) and Tax Roll binders (before 1886).

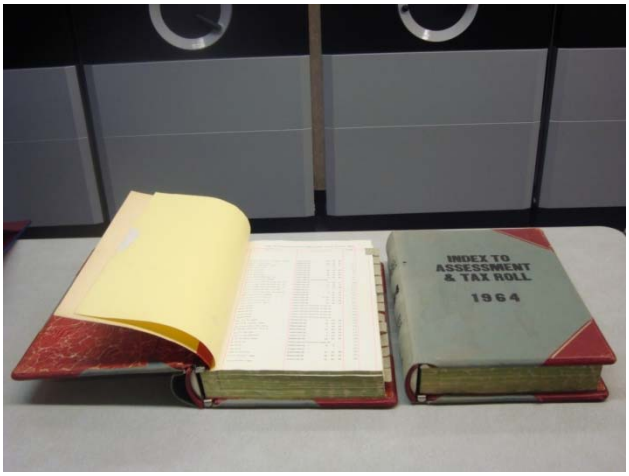



Figure 9: 1964 Alpha Index to Assessment and Tax Roll

However he obtained the data, the result was an analysis of the changing number and size of properties over an 80-year period. Rodgers not only described where people settled within the watershed, but how large those settlements were. The acreage of a property can provide insight into how the land was used, especially when coupled with additional data. For example, Rodgers also documented the changing cattle population decade by decade. To analyze the changing trends in the size of landholdings, he grouped properties into four categories: 0 - 159 acres, 160 - 319 acres, 320 - 999 acres, and 1000 acres and up.

These size categories not only refer to the PLSS (i.e., a 640-acre section divided by 4 equals 160 acres), but probably to the Homestead Acts. The original 1862 Act granted 160 acres, or a quarter of a section. Later iterations increased the allotted acreages. The 1909 amendment, for example, increased the size of homesteads to 320 acres in western (i.e. arid) states (BLM 2013). For each year he examined, Rodgers counted the number of landholdings within each category, calculated their sum acreage, determined what percentage of all holdings the sum acreage represented, and, lastly, established the average property size in each category. Figure 10 shows the tables and hand drawn pie charts for the years 1940, 1950, and 1964.

TABLE IV

CATEGORIES OF LAND HOLDINGS IN UPPER SAN PEDRO RIVER VALLEY BY NUMBER, ACREAGE, PERCENTAGE OF TOTAL HOLDINGS, AND AVERAGE SIZE 1930-1964[a]

| Year | Acreage of holdings | No. | Acreage | % of all holdings | Average size of holdings in acres |
|---|---|---|---|---|---|
| 1940 | 0-159 | 123 | 10,127 | 4.1 | 81 |
| | 160-319 | 71 | 13,820 | 7.2 | 194 |
| | 320-999 | 100 | 46,180 | 24.0 | 462 |
| | 1000+ | 28 | 122,137 | 50.9 | 4,362 |
| | Sp Grants | 3 | 51,572 | 21.5 | |
| | Total | 325 | 243,836 | | |
| 1950 | 0-159 | 244 | 7,593 | 2.7 | 31 |
| | 160-319 | 47 | 8,383 | 3.5 | 178 |
| | 320-999 | 65 | 31,644 | 14.7 | 579 |
| | 1000+ | 40 | 151,409 | 59.0 | 3,785 |
| | Sp Grants | 3 | 51,572 | 20.1 | |
| | Total | 399 | 256,601 | | |
| 1964 | 0-159 | 674 | 14,297 | 5.1 | 21 |
| | 160-319 | 73 | 14,672 | 5.2 | 201 |
| | 320-999 | 47 | 26,660 | 9.5 | 567 |
| | 1000+ | 34 | 175,188 | 62.0 | 5,153 |
| | Sp Grants | 3 | 51,572 | 18.2 | |
| | Total | 831 | 282,389 | | |

Source: [a]Cochise County Tax Rolls 1940-1950, Assessors Tax Roll 1964

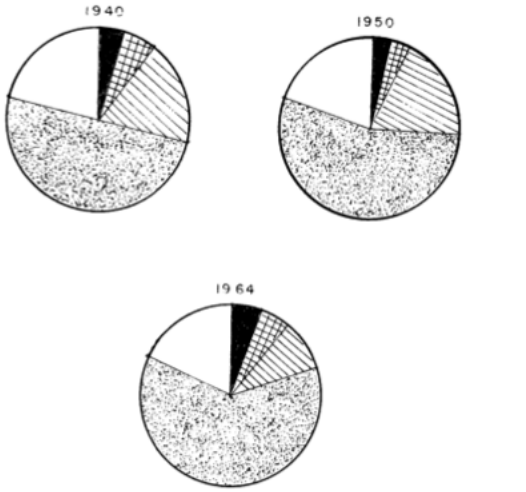



Fig. 28.--Privately Owned Land in Upper San Pedro River Valley by Size of Holdings 1940-1964[a]

Source: [a]Cochise County Tax Rolls 1940-1950, Assessors Tax Roll 1964

Figure 10: 1940, 1950, and 1964 summary of acreage changes in Upper San Pedro River Valley (Rodgers 1965)

The number of properties (column 3, i.e. the column with the heading “No.,” in Figure 10) does not represent the total number of landholdings within the watershed during that time; rather, it appears to be the sample size Rodgers used. His thesis is quiet on this matter. The difficulty in establishing every unique property’s location and size likely prevented Rodgers from obtaining the true total. He calculated “percentage of all holdings” (column 5) using “Total Acreage” (column 4, last rows for each year examined). The pie charts at right display this calculation. For example, in 1964, the properties greater in size than 1,000 acres covered a cumulative acreage of 175,188; the total acreage of all properties at that time was 282,389; the “percentage of all holdings” for properties of that size was 62%, i.e. (175,188/282,389)*100.

Today, the Cochise County Information Technology (IT) Department has mapped each property using customized Geographic Information System (GIS) software, thus simplifying the tasks of displaying, querying, and analyzing land use trends. The IT Department provided the authors with a geodatabase that contained property information for the entire county. The geodatabase included the precise geographic location and size of each landholding. With this information, all properties within the study area, i.e., all those properties with their “centroid” within Townships 18S though 24S, and Ranges 19E through 23E, could be identified. Figure 11 shows the landholdings within the study area for the year 2012. Including public and mining land, there are 37,360 individual parcels.

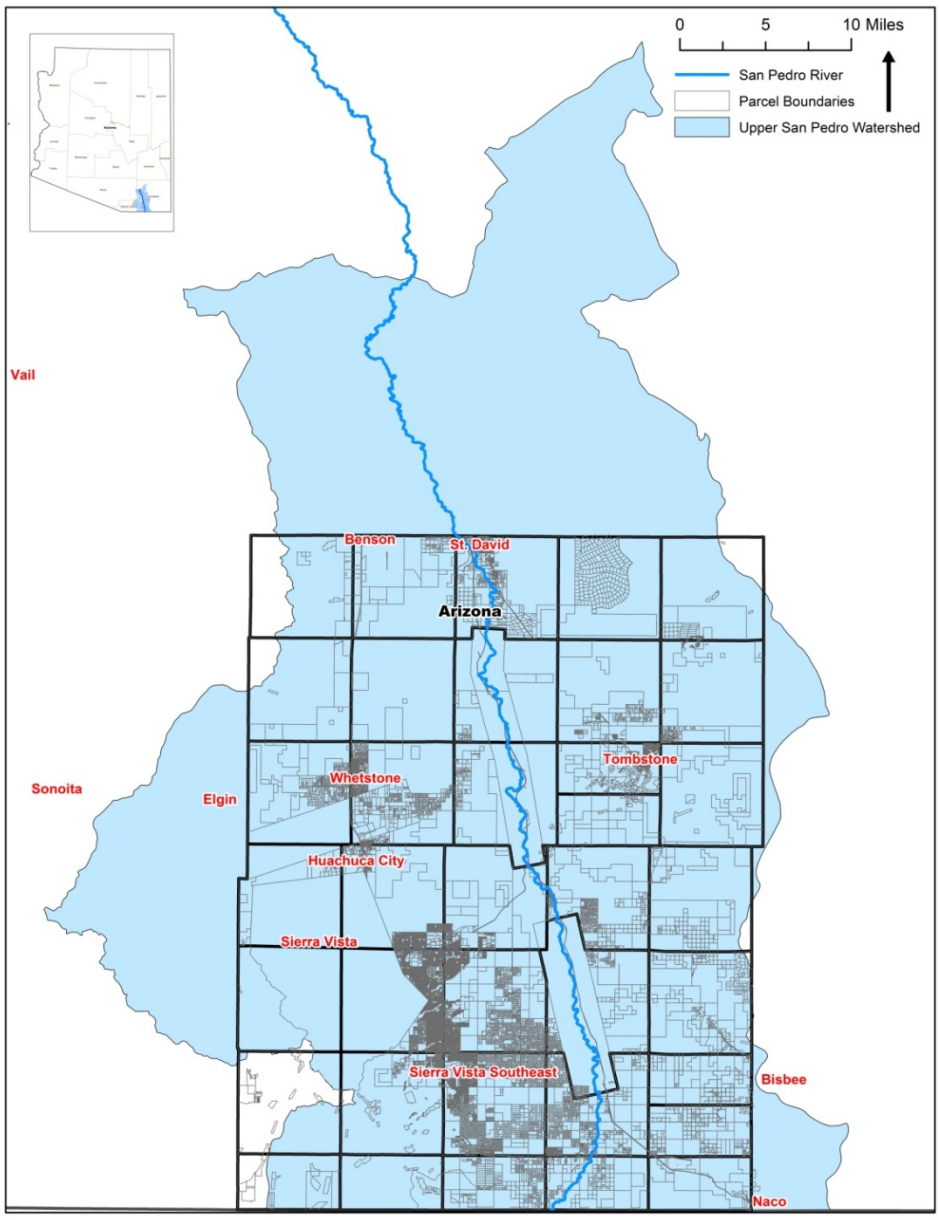



Figure 11: Parcels within the Study Area, 2012. Parcel data provided by Cochise County IT department; Hydrology data from USGS NHD

In order to complete the survey that Rodgers began, the same analysis was performed for the 2012 data. The 37,360 parcels were grouped into the four size categories. The number of parcels within each category were counted, the sum acreage calculated, the percentage of all holdings determined, and the average property size established (Table 1). Rather than, as Rodgers did, calculate "percentage of all holdings" using "Total Acreage," "Number of Holdings" was used instead. Figure 12 displays the results of those calculations for 1940, 1950, 1964 and 2012. With the goal of continuing Rodgers' decade-by-decade analysis, the authors sought to additionally obtain parcel data for 2001, 1991, 1981 and 1971. However, the parcel record for those decades was not available in the same format as the record for 2012. 2011 marked the first year the County mapped all parcels using GIS software. To analyze the previous decades and map the changes, an alternative approach was needed.

**Categories of Land Holdings in Upper San Pedro River Valley by Number, Acreage, Percentage of Total Holdings, and Average Size in 2012.**

| *Acreage of Holdings* | *Number of Holdings* | *Total Acreage* | *% of all holdings* | *Average size (ac)* |
|---|---|---|---|---|
| **0-159** | 36,891 | 142,231 | 98.74% | 3.86 |
| **160-319** | 170 | 36,489 | 0.46% | 214.64 |
| **320-999** | 209 | 110,499 | 0.56% | 532.78 |
| **1000+** | 90 | 464,278 | 0.24% | 5,158.65 |
| **Total** | 37,360 | | 100% | |

Table 1: 2012 Land Holdings Analysis (Data Courtesy of Cochise County IT Department, 2012)

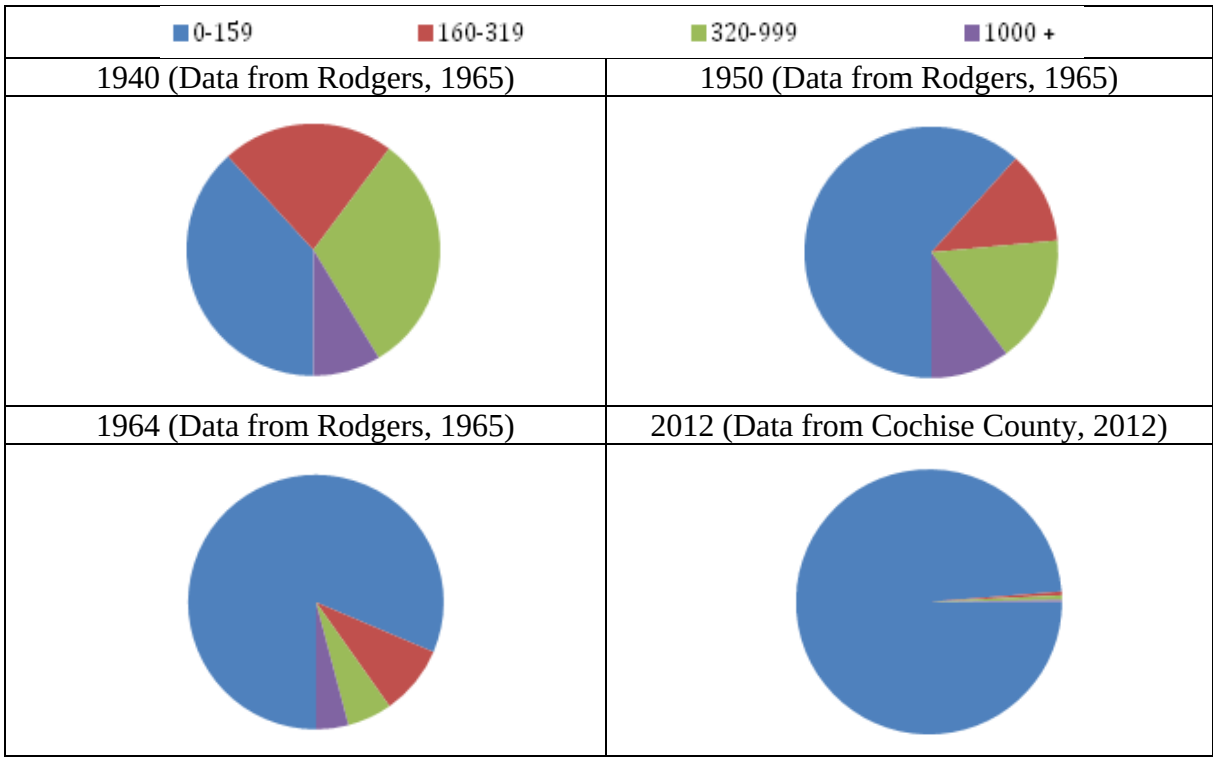



Figure 12: Percentage of all holdings using "Total Acreage" for 1940, 1950, 1964 and 2012. For example, in 2012, there were 90 properties as large as 1,000 acres or more, and a total of 37,360 properties: (90 /37,360)*100 = 0.24%.

By 1965, each record in the Cochise County Tax Roll possessed two unique identifiers: the assessment number and an Assessor Parcel Number (APN). The APN is a unique identification number used in a system of tracking parcels called an "Assessor Map-based" system. Under this system, the assessment map itself is incorporated into the parcel identifier (IAAO 2012). The parcel identifier (e.g. the APN) refers to three units. For Cochise County, these three units are the book, the map, and the parcel number. Within the study area, each "book" possesses a unique three-digit number (e.g. 101, 102); generally its area coincides with old PLSS designations, often covering the same area as two or more townships. To identify which books fall within the study area, Microsoft Excel's MID function was used to isolate the first three characters of every unique property's APN in the 2012 dataset. Excel's "remove duplicates" function then revealed the unique numbers. Excluding mining parcels, there are 17 books.

Within each book are multiple "maps," which represent a smaller geographic area and possess a unique two-digit number, 1 through 99. Combining the "book" number with a "map" number gives the "book-map" number. There are a total of 541 book-maps within the study area (Appendix A). However, parcel data were not collected for every book-map, for several reasons, including that some book-maps lie within federal or state lands that do not contain private, non-mining parcels. For example, the Coronado National Forest and the U.S. Army's Fort Huachuca together encompass over four dozen book-maps (Appendix C). Furthermore, parcel data were not collected from the same number of book-maps every year. In 1971, parcel data were collected from 325 book-maps; from 398 in 1981; from 415 in 1991; from 420 in 2001; and from 427 book-maps in 2012. This is because not all book-maps have always contained parcels. As the number of housing developments increased, so did the number of book-maps containing private, non-mining parcels (Appendix B).

Finally, the "parcel number" refers to a specific piece of real property within a book-map. A parcel number is generally a three-digit number (e.g. 001). If the property has been subdivided multiple times, a letter may be added (e.g. 001A or 001B). A typical APN would be "10101001" (i.e., Book 101, Map 01, Parcel number 001). While the Tax Roll began including the APN in 1965, it wasn't until 1971 that it began to be organized by the APN rather than the assessment number. For example, the 1971 Tax Roll binder "101-01-001 to 106-39-149" contains all tax records for parcels 10101001 through 10639149. In other words, in 1971, the County began organizing the parcel records geographically. Each book and book-map refer to a specific area (Figure 13). Some books are not shown in Figure 13 because the study area contains relatively small portions of their area not visible at the map's resolution.

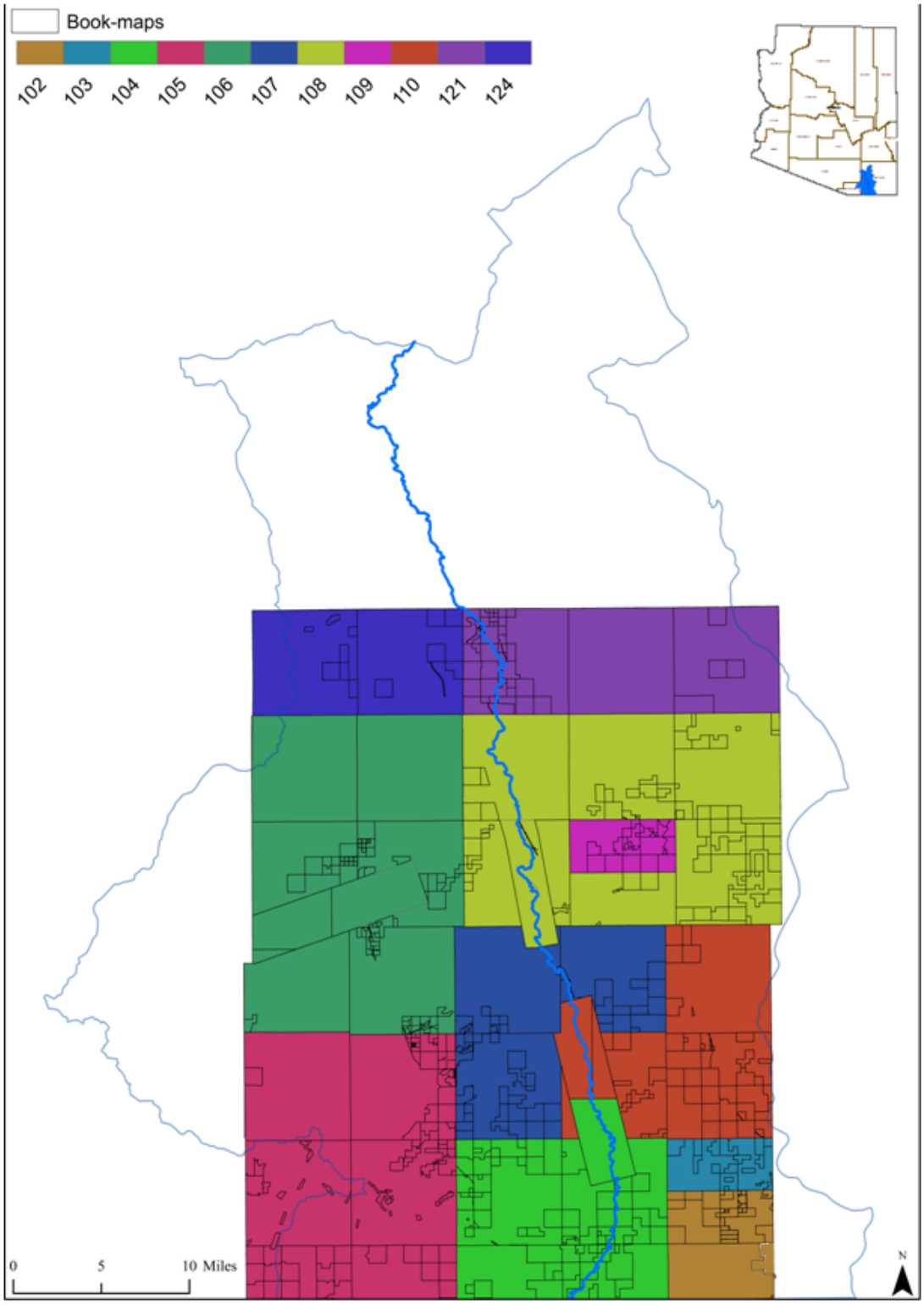



Figure 13: Books and Book-Maps in the Study Area (Book-Map data provided by Cochise County IT department; Hydrology data from USGS NHD)

With improved mapping technologies and the County's use of more modern book keeping procedures, the acreage analysis Rodgers made for 1882 through 1964 could be completed for 1971 through 2012. Additionally, detailed maps illustrating parcel density trends could be constructed. To analyze and display parcel density in the study area, the changing number of private, non-mining parcels within relevant book-maps for one year of each decade were tracked. The first dataset is from 1971, as it marked the first year the Tax Roll was organized by APN, and the remaining datasets are from the subsequent decades (1981, 1991, 2001, and 2012).

Collecting data for 1971, 1981, and 1991 required tracking not just the APN, but also the antiquated assessment number. While the assessment number assigned to a unique property changes every year and while it does not include geographic information, following the assessment numbers proved to be useful. Assessment numbers advance numerically. The first tax record within the first Tax Roll binder for any given year is "1" and each record follows in succession. To count the number of parcels within a particular book-map, one must note the assessment number at the beginning of a book-map (e.g. 1621 for book-map 10201 in the year 1971), flip through the Tax Roll binder's pages, note the last number (e.g. 1628), and calculate the difference (for this example, 8). In this way, the changing number of parcels within particular book-maps for the years 1971, 1981, and 1991 were tracked. Figure 14 shows a segment of the first page of the 1971 Tax Roll record. Appendix D provides examples of multiple records for 1971, 1981, and 1991.

To obtain acreage data the years 1971, 1981, and 1991, unique parcels were randomly selected from the dataset. Microsoft Excel's RandBetween function was used to generate the random sample of assessment numbers for properties within the study area. Those particular properties were located in Tax Roll binders, and their parcel size recorded. This was done for 1% of parcels for each year: In 1971, 99 of 9,035 parcels were sampled; in 1981, 183 of 18,016 parcels were sampled; and in 1991, 228 of 22,786 were sampled. For properties within subdivisions, the acreage was almost always omitted from the Tax Roll. For these properties, parcel size was assumed to be a generous 0.25 acres, which is the size of a "suburban" housing unit, as defined by the Integrated Climate and Land Use Scenarios (ICLUS) (USEPA 2009).

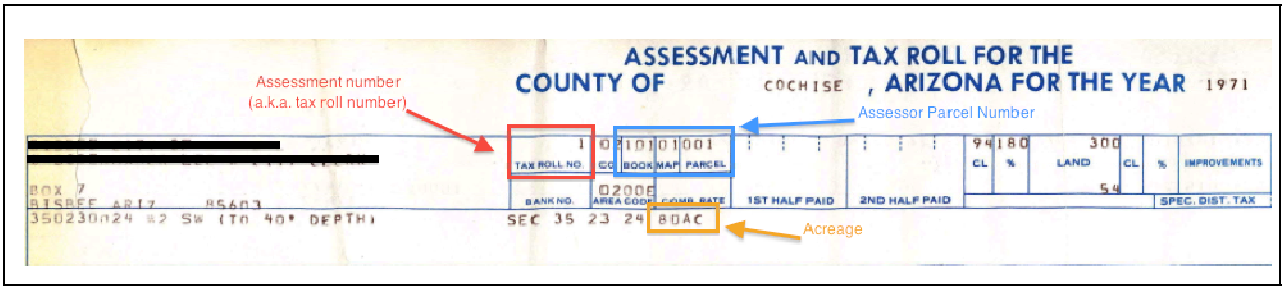



Figure 14: Segment of scanned 1971 Tax Roll Record (Courtesy of Cochise County Archives, 2012). Identifying annotations added.

The County began maintaining the Tax Rolls electronically in 1996. The IT Department was easily able to provide a spreadsheet listing all the properties within the study area for the year 2001. There were 29,319 private, non-mining parcels. However, obtaining the acreage information for those properties was not as easy. The legal descriptions were missing. The County compared the 2001 list of parcels to a 2002 list. Where APNs matched, the parcel size from the 2002 data was ascribed to the 2001 data. Using this method, the County extracted acreage data from the legal descriptions of over 10,000 parcels.

As with the Tax Roll records from 1971, 1981, and 1991, the 2001/2002 records for properties within subdivisions almost always lacked acreage information. The 2012 data were used to determine the acreage of parcels within subdivisions. Where the APNs matched, the 2012 subdivision acreage was ascribed to the 2001 parcels. For the remaining properties within subdivisions, parcel size was assumed to be 0.25 acres. Eventually, nearly 97% (or 28,308) of the parcels in the 2001 dataset were assigned acreage.

Having determined the number and sizes of parcels throughout the study area and within particular book-maps for 1971 through 2012, the acreage analysis not only picked-up where Rodgers left-off but could also be incorporated into to more contemporary investigations, such as ICLUS. The four acreage categories used in the Rodgers study reflect the splitting and combining of original homesteads, and the regional shift from a largely rural and agricultural to a more suburban and service-based community and economy. Examining land use trends using ICLUS Housing Density (HD) categories further refined the analysis, and expanded its utility.

The ICLUS project dataset has been identified as ideal for projecting watershed-wide development into the future because its national-scale HD scenarios are consistent with the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (Nakicenovic and Swart, 2000) greenhouse gas emissions storylines. ICLUS uses four categories for HD representing rural, exurban, suburban, and urban land uses (Bierwagen et al. 2010; USEPA 2009; USEPA 2010).

| Density Category | Acres Per Housing Unit | Housing Units Per Acre | Hectares Per Housing Unit | Housing Units Per Hectare |
|---|---|---|---|---|
| Urban | <0.25 | >4 | <0.1 | >10 |
| Suburban | 0.25-2 | 0.5-4 | 0.1-0.81 | 1.23-10 |
| Exurban | 2-40 | 0.025-0.5 | 0.81-16.19 | 0.06-1.23 |
| Rural | >40 | <0.025 | >16.19 | <0.06 |

Table 2: Explanation of ICLUS Housing Density (HD) Categories. ICLUS uses changes in HD to project changes in impervious surface cover, which can be used to examine impacts to water quality.

Decade-by-decade parcel data were analyzed using the ICLUS HD categories to create maps illustrating parcel concentration changes over time. The Cochise County book-map dataset included book-map area in square meters. The area of each book-map was converted to acres, and then divided by the number of parcels within that particular book-map. For each decade, the book-maps were then classified as urban (less than 0.25 acres/parcel), suburban (0.25-2 acres/parcel), exurban (2-40 acres/parcel), or rural (more than 40 acres per parcel), resulting in five distinct maps (Figures 20-24). For book-maps with no associated private, non-mining parcel data (e.g., Fort Huachuca, the Coronado National Forest, book-maps encompassing undeveloped land, etc.), the number of parcels per acre was assumed to be zero, i.e., rural because those book-maps contained fewer than 0.025 housing units per acre.

## Results

Between 1971 and 2012, the number of private, non-mining parcels within the study area increased from 9,035 to 36,511. The overall change increased consistently from 1971 to 2012, with a rate of 657 parcels per year (dashed line in Figure 15). However, the decadal change had a different trend. The rate of increase was the highest between 1971 and 1981 (898 parcels/year), lower but still high between from 1981to1991 and from 1991to 2001 (477 and 653 parcels/year, respectively), and an increasing but smaller rate from 2001 to 2012 (654 parcels/year). Between 1971 and 2012, the average parcel size dropped from 37.98 to 8.01 acres.

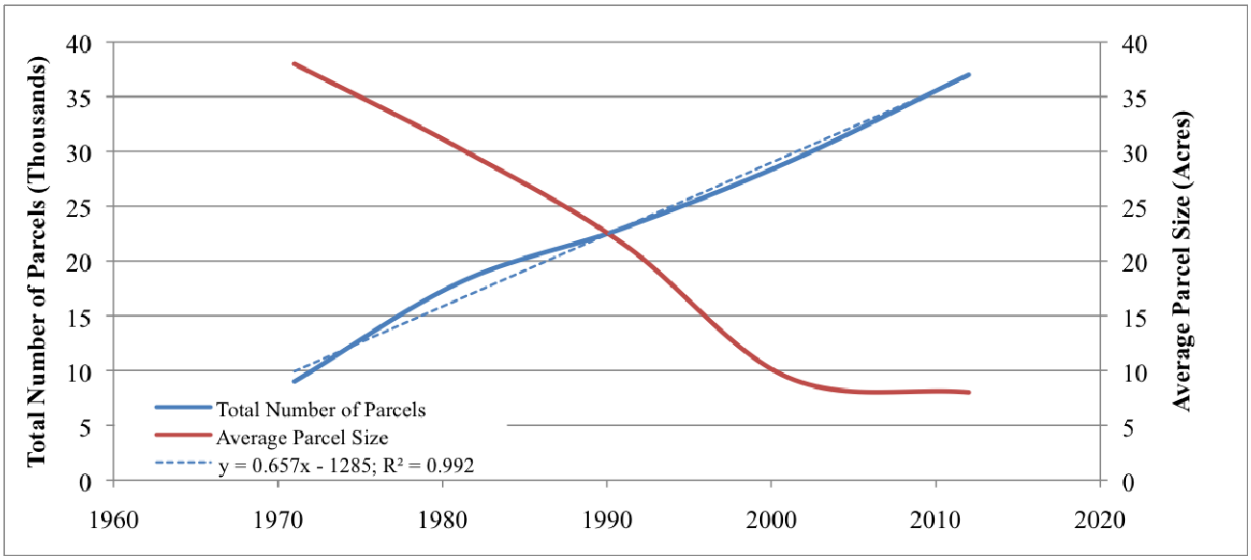



Figure 15: Decadal Changes in Total Number of Parcels and Average Parcel Size for 1971-2012

Parcels with an area of 159 acres or less increased by almost 10% over the 41-years, representing nearly 99% of all parcels by 2012 (Figure 12; Figure 16). Figure 16 incorporates data from the Rodgers study to show acreage trends over the last 130 years. Between 1882 and 2012, the number of parcels with an area of 159 acres or less jumped from 16.98% to 98.74%; parcels with an area between 160 and 319 acres dropped from 71.70% to 0.47%.

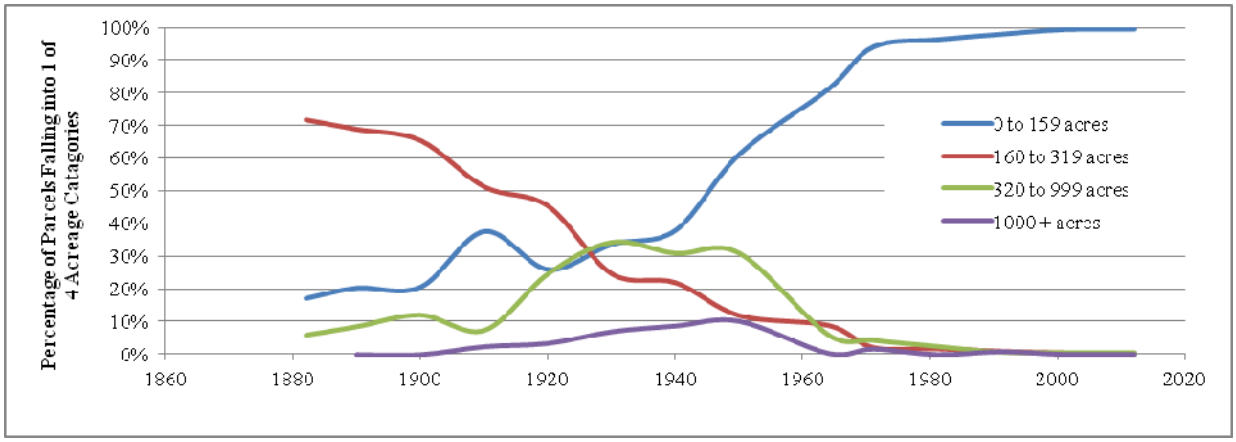



Figure 16: Decadal Trends Using Rodgers Acreage Categories: 1882 - 2012.

Using the ICLUS housing unit sizes to analyze parcel data between 1971 and 2012 provides greater insight into land use changes. Over the course of 41 years, the number of "urban" parcels increased by over 36%, while parcels in all other acreage categories decreased: "suburban" parcels by ~15%, "exurban" by ~8%, and "rural" parcels by ~10%. Figure 17 shows these acreage trends graphically. Table 3 details the percentage of parcels falling into the ICLUS housing unit categories for each decade.

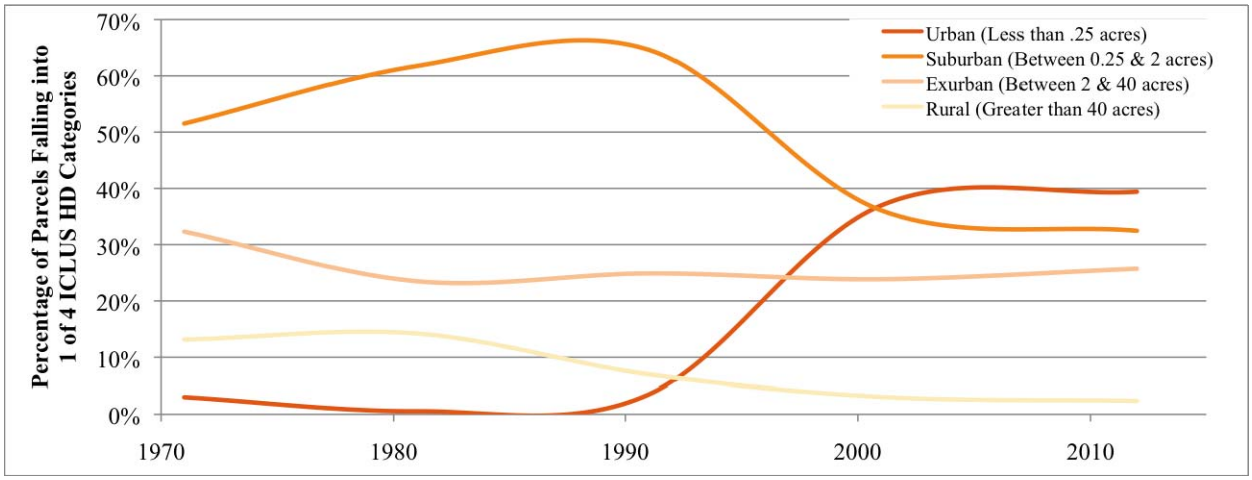



Figure 17: Decadal Acreage Trends Using ICLUS Housing Density Categories, 1971 - 2012.

| Year | Urban (Less than 0.25 acres) | Suburban (Between 0.25 & 2 acres) | Exurban (Between 2 & 40 acres) | Rural (Greater than 40 acres) | Parcel Sample Size | Total Number of Parcels |
|---|---|---|---|---|---|---|
| **1971** | 3.03% | 51.52% | 32.32% | 13.13% | 99 | 9,035 |
| **1981** | 0.55% | 61.75% | 23.50% | 14.21% | 183 | 18,016 |
| **1991** | 3.49% | 64.63% | 24.89% | 6.99% | 229 | 22,786 |
| **2001** | 36.96% | 36.10% | 23.86% | 3.08% | 28,200 | 29,319 |
| **2012** | 39.41% | 32.47% | 25.73% | 2.39% | 36,511 | 36,511* |

Table 3: Decadal Acreage Trends Using ICLUS HD Categories, 1971 - 2012. (*Note: Of the 37,360 parcels within the study area (Figure 11), 849 were public and/or mining parcels and therefore excluded from the ICLUS analysis).

As explained in the methods section, only the 2012 dataset included geographic information for each parcel. Mapping changes over time required tracking the changing number of parcels within individual book-maps. Figures 18 and 19 show decadal book-maps trends between 1971 and 2012. Table 4 details the number and percentage of book-maps falling into the ICLUS HD categories for each decade. Over the course of 41 years, the area of land classified as "urban" increased by 2.82%, the area classified as "suburban" by 8.35%, and the area classified as "exurban" by 11.95%. The area of land classified as "rural" decreased by 23.13%.

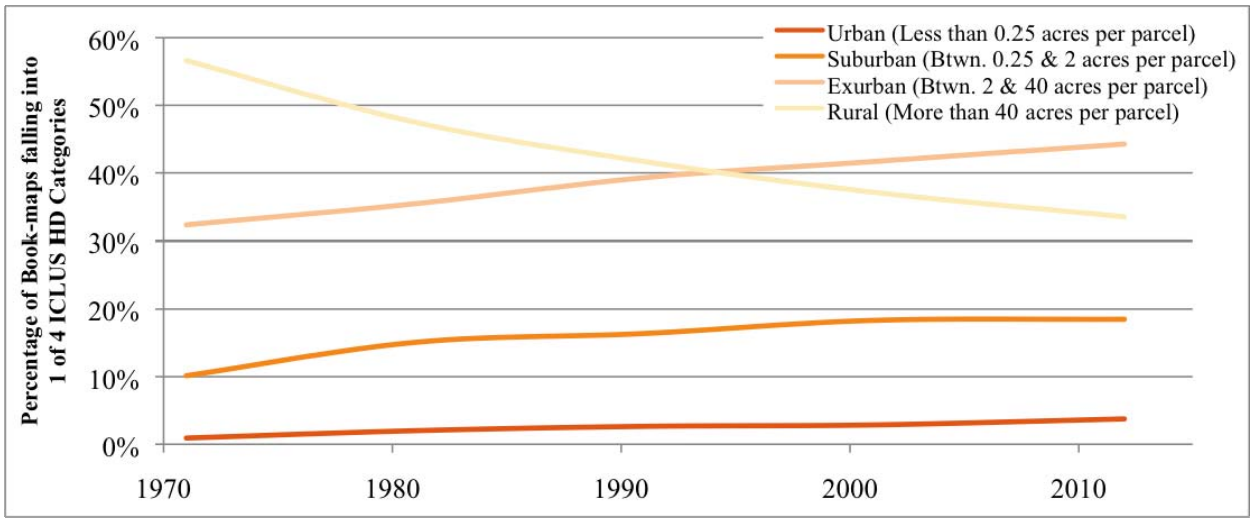



Figure 18: Decadal Book-Map Trends, 1971 - 2012 (Changing Percentage).

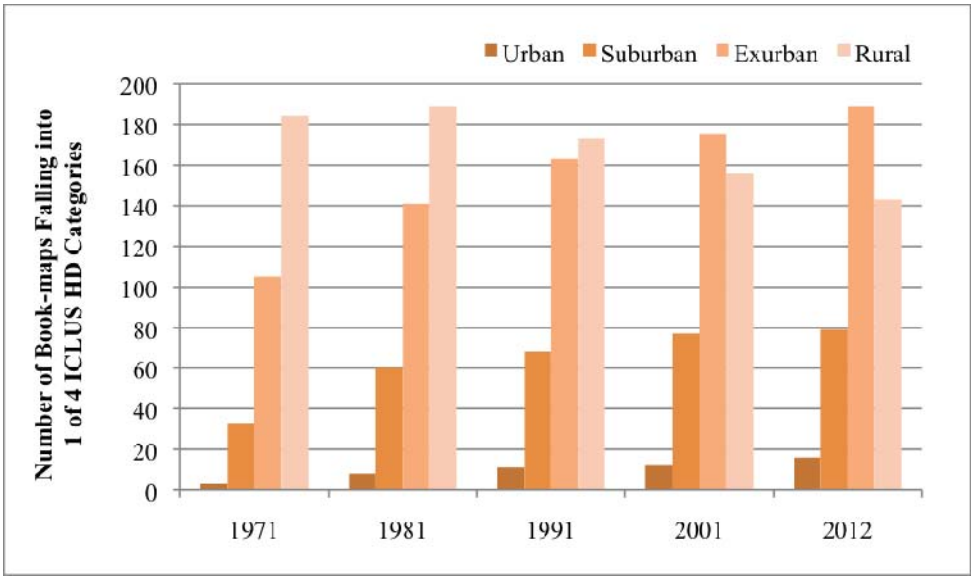



Figure 19: Decadal Book-Map Trends, 1971 - 2012 (Changing Number).

| | Urban | | Suburban | | Exurban | | Rural | | Total Number of Book-Maps |
|---|---|---|---|---|---|---|---|---|---|
| | Number of Book-Maps | Percentage of Total | Number of Book-Maps | Percentage of Total | Number of Book-Maps | Percentage of Total | Number of Book-Maps | Percentage of Total | |
| 1971 | 3 | 0.92% | 33 | 10.15% | 105 | 32.31% | 184 | 56.62% | 325 |
| 1981 | 8 | 2.01% | 60 | 15.08% | 141 | 35.43% | 189 | 47.49% | 398 |
| 1991 | 11 | 2.65% | 68 | 16.39% | 163 | 39.28% | 173 | 41.69% | 415 |
| 2001 | 12 | 2.86% | 77 | 18.33% | 175 | 41.67% | 156 | 37.14% | 420 |
| 2012 | 16 | 3.75% | 79 | 18.50% | 189 | 44.26% | 143 | 33.49% | 427 |

Table 4: Number and Percentage of Book-Maps Falling into ICLUS HD Categories, 1971 - 2012.

Figures 20 through 24 show land use in the study area for the years 1971, 1981, 1991, 2001, and 2012. The most significant changes occurred in and around established communities. The land use in and around the communities of Tombstone, Bisbee, and Huachuca City changed at a

notable pace. For example, the number of parcels within the City of Tombstone's boundaries increased by 194% while the land designated as rural decreased by 100%. Change was most pronounced in the central southwestern portion of the study area, near Fort Huachuca and Sierra Vista. For example, the number of parcels in Sierra Vista's unincorporated counterpart, Sierra Vista Southeast, increased by 550% while the area classified as rural decreased by 70.84%. Figure 25 shows detailed maps of Sierra Vista Southeast and Tombstone in 1971 and 2012.

Esparza and Carruthers (2000) have also noted the growth and changing land use in and around Sierra Vista. This pattern of growth, particularly in regard to its accompanying increase in water consumption, agitates many. The concern that a rapidly increasing population could destructively deplete water resources has been repeatedly expressed (American Rivers 1999, Arias 2000, Browning-Aiken et al 2004, Bredehoeft et al. 1999, Pool and Coes 1999, West and Vásquez-León 2008, USPP 2010, and many others), and periodically litigated – e.g., a 1990s suit against a U.S. Fish and Wildlife Service non-jeopardy decision, a 2002 suit against Fort Huachuca's planned expansion (CBD 2013), and a recently filed Superior Court suit seeking to overturn a state ruling that permitted a new 6,900-home development in Sierra Vista (Davis 2013).

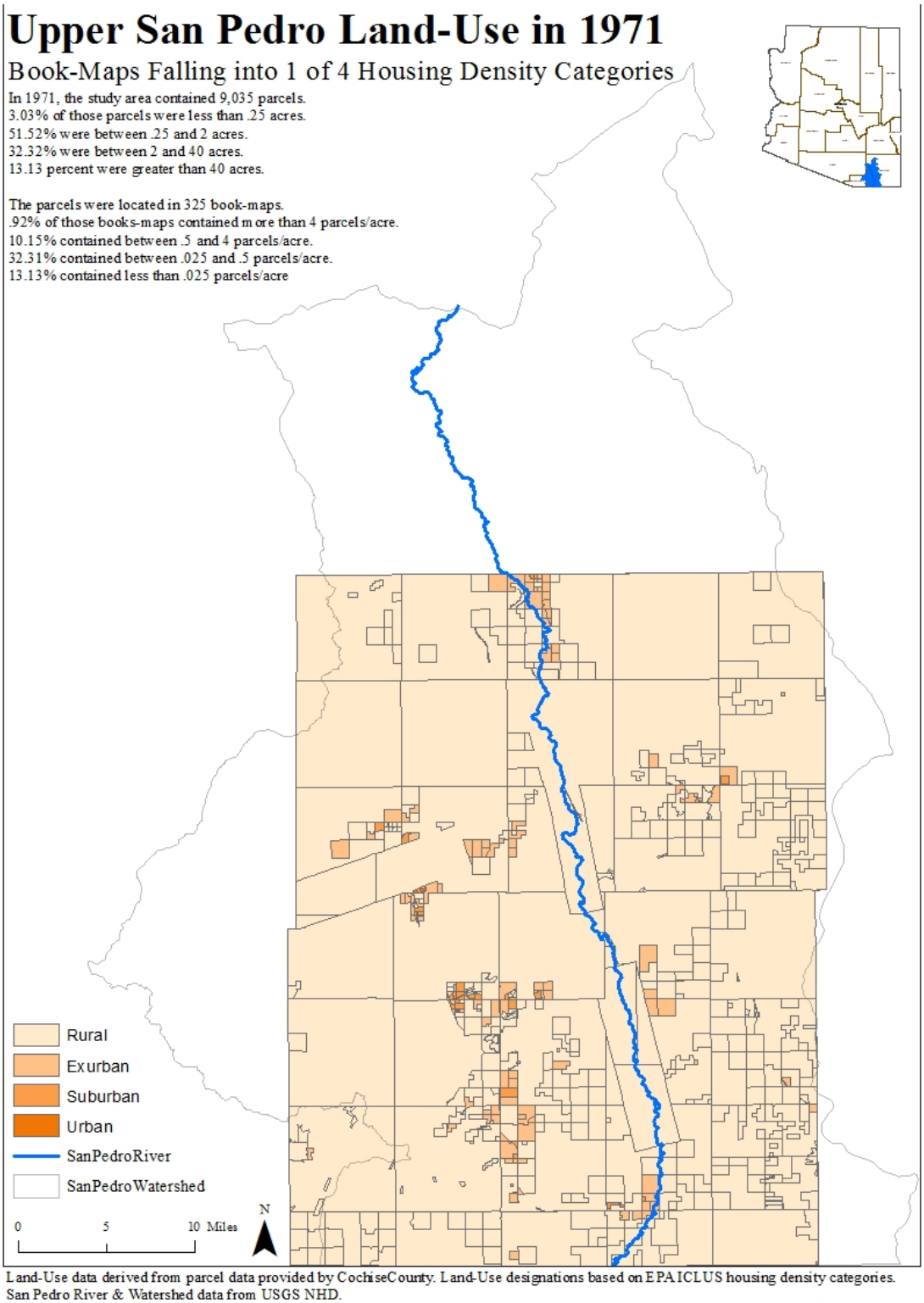



Figure 20: Upper San Pedro Land Use, 1971

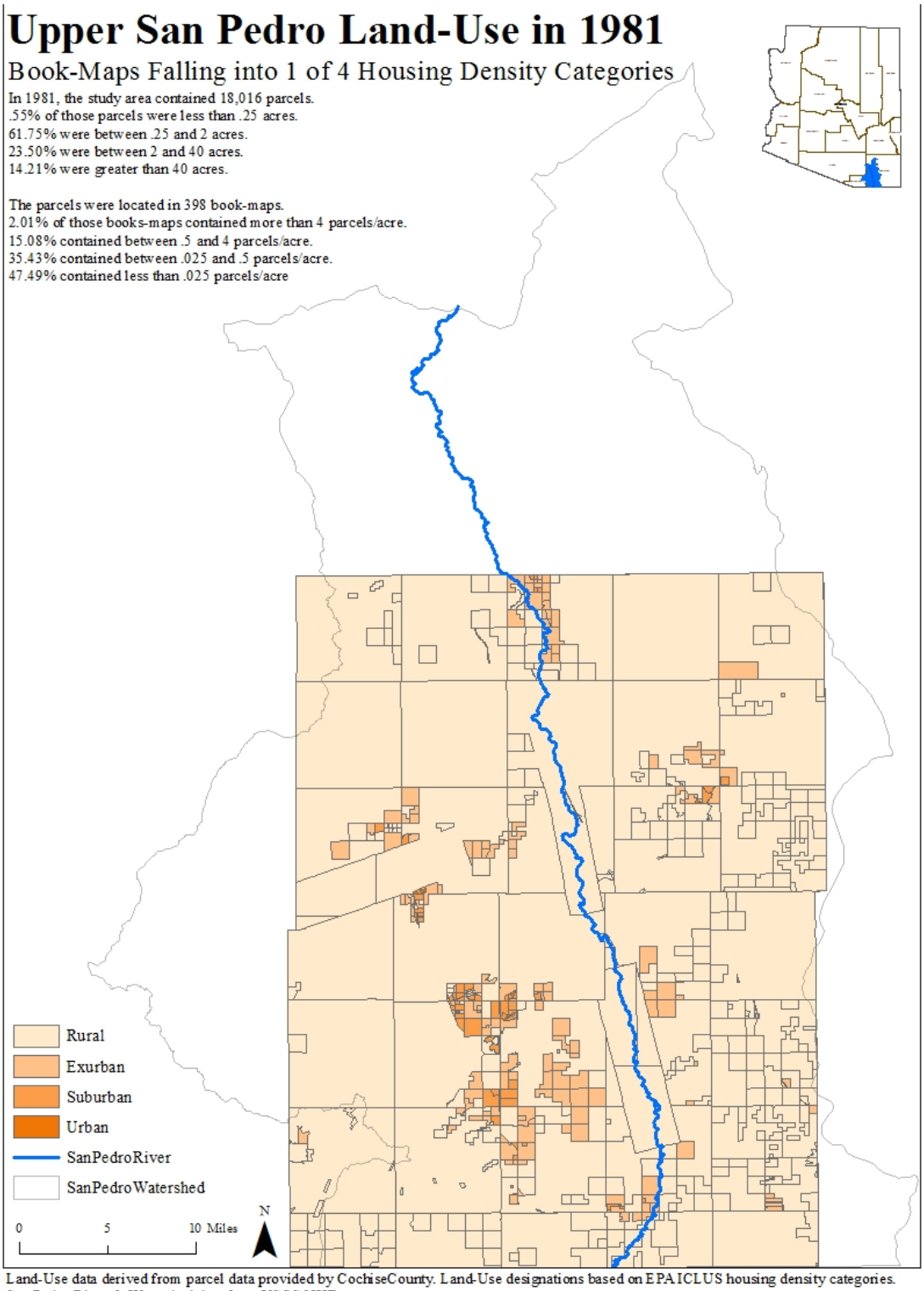



Figure 21: Upper San Pedro Land Use, 1981

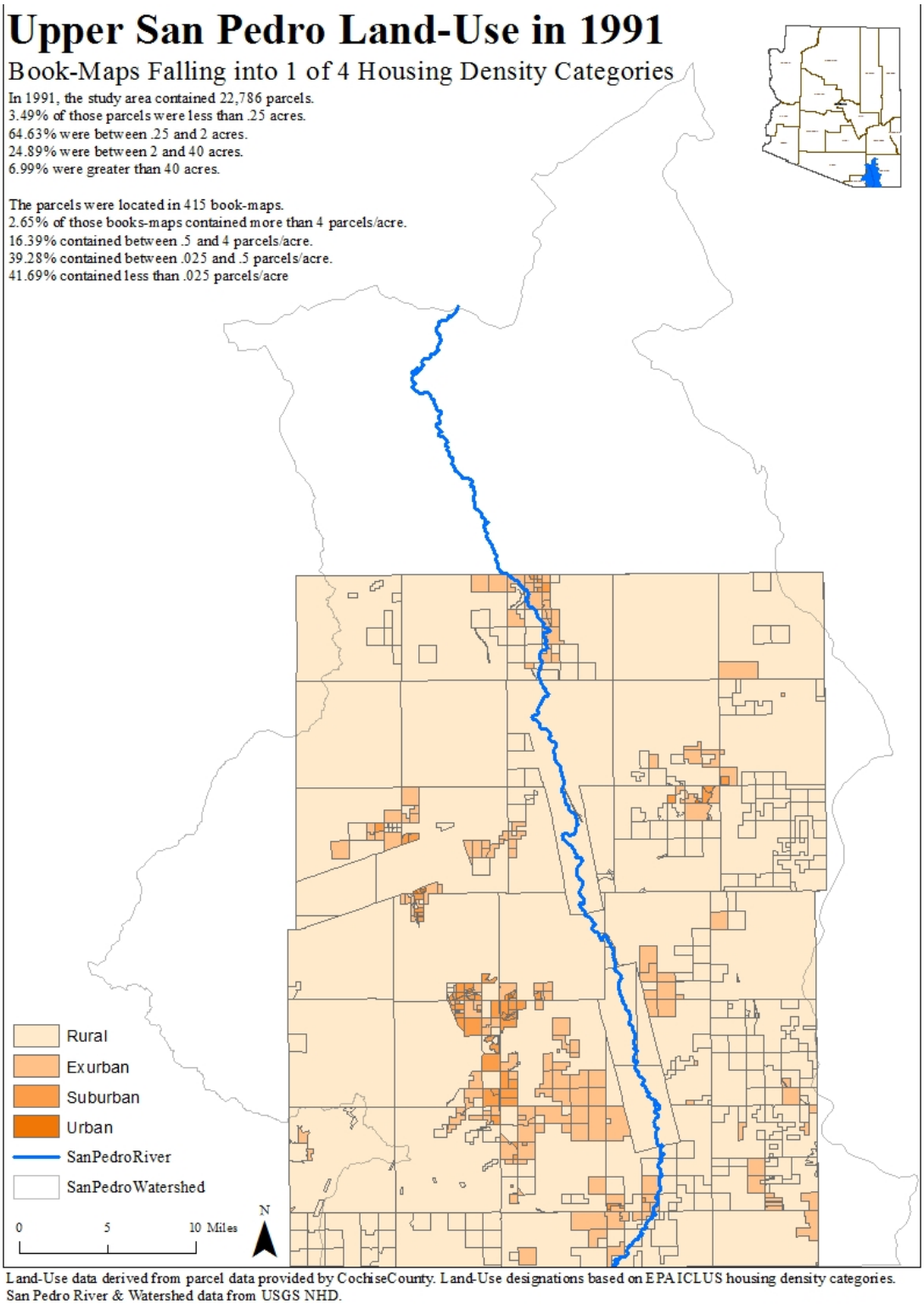



Figure 22: Upper San Pedro Land Use, 1991

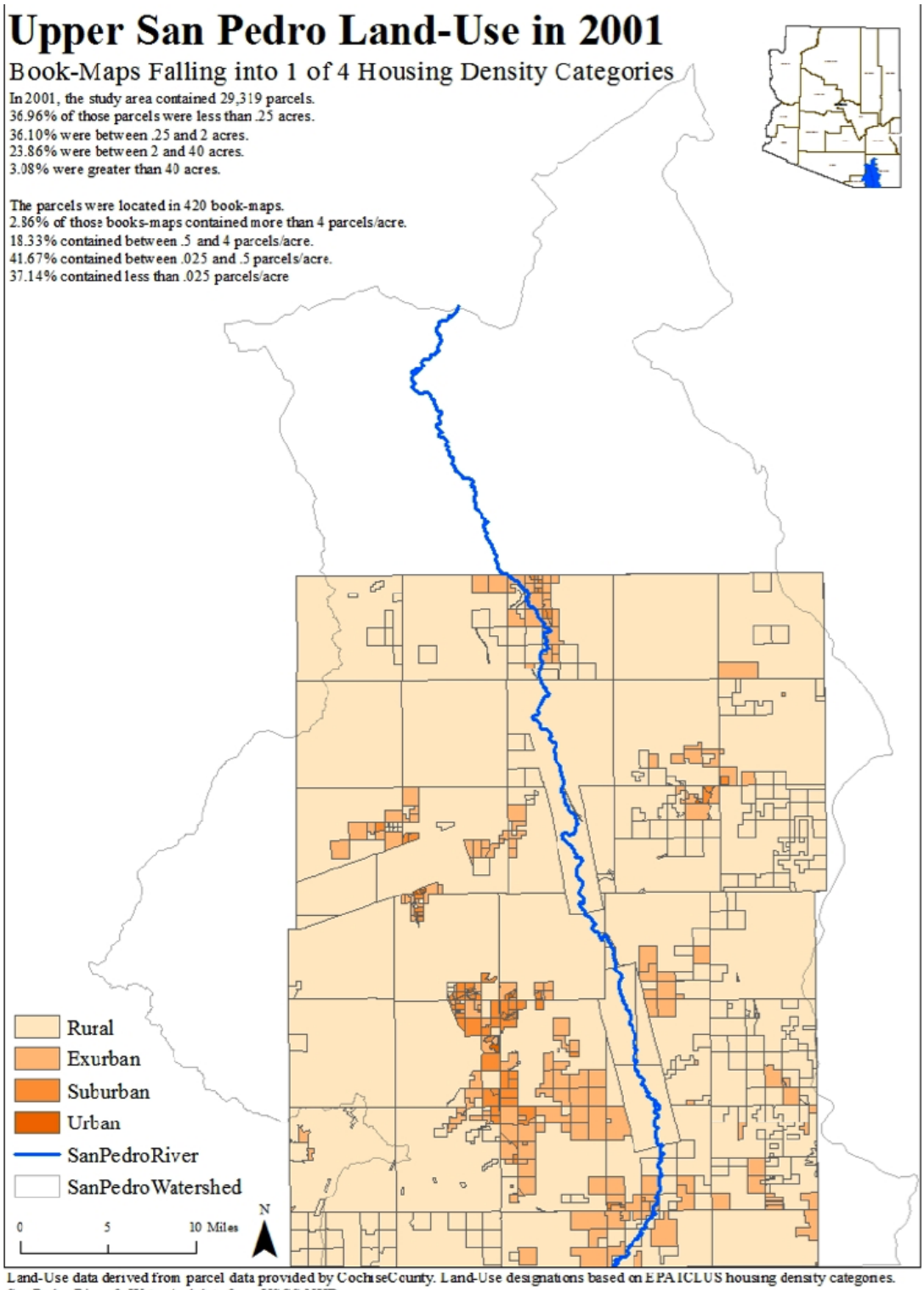



Figure 23: Upper San Pedro Land Use, 2001

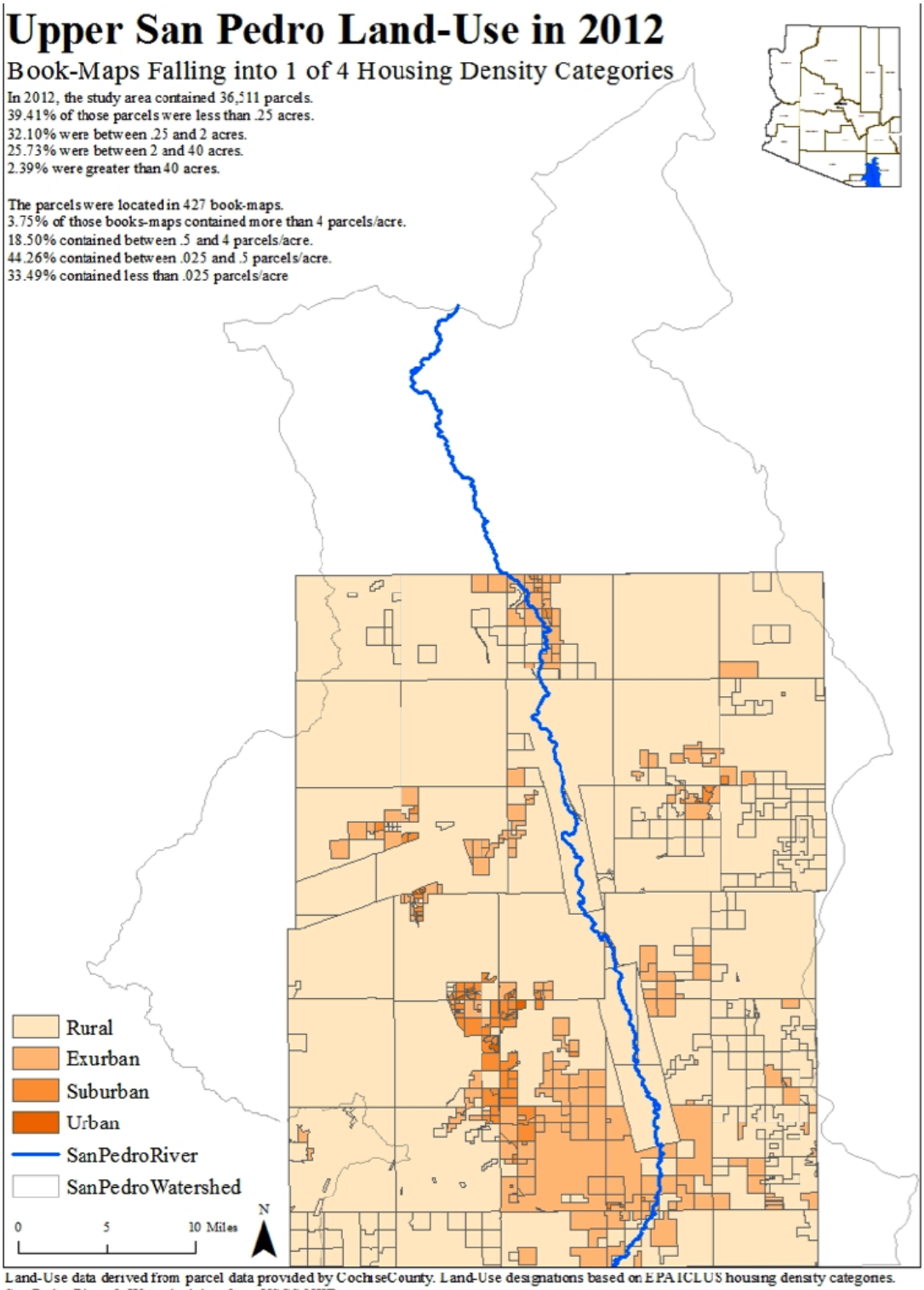
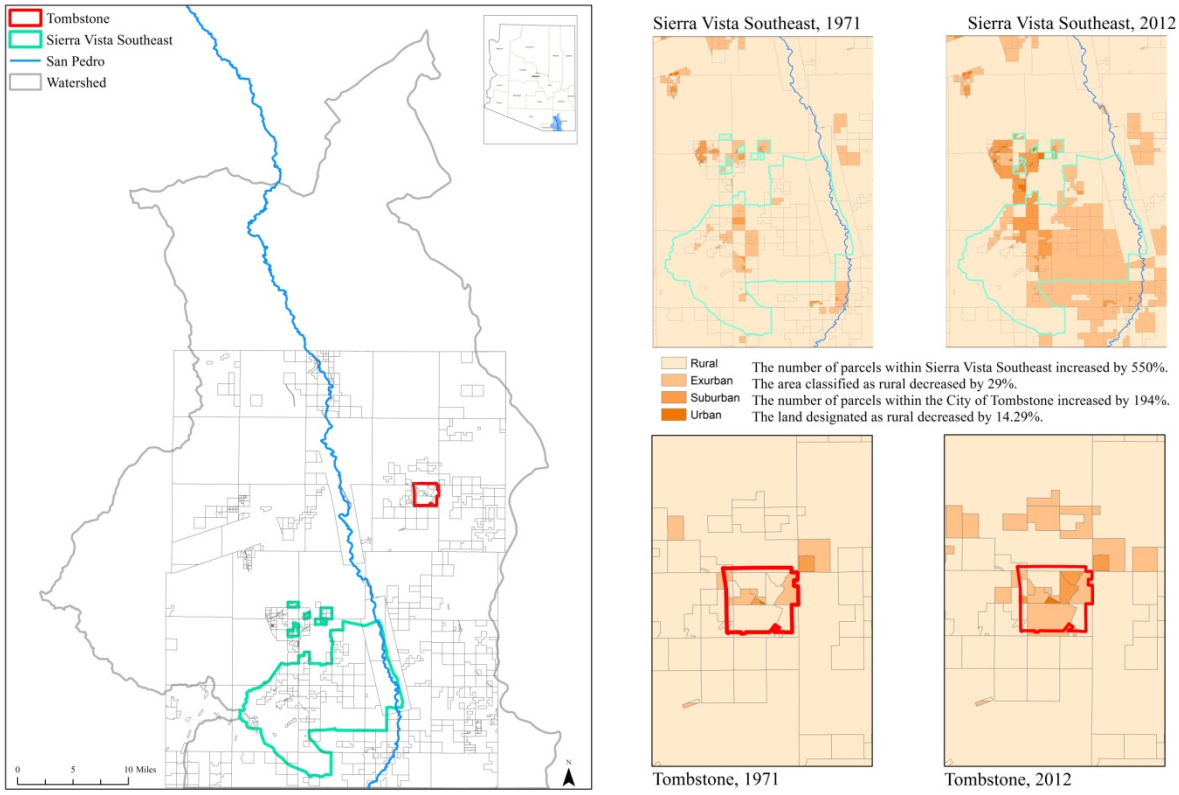



Figure 24: Upper San Pedro Land Use, 2012

## Land Use Change in Two Upper San Pedro Communities:

Sierra Vista Southeast and Tombstone, 1971 and 2012




Land Use data delivered from parcel data provided by Cochise County. Land use designations based on EPA ICLUS housing density categories. San Pedro River and Watershed data from USGS NHD. Arizona administrative boundaries from TANA

Figure 25: Land Use Changes in Sierra Vista Southeast and Tombstone, 1971 and 2012

## Discussion

Historic parcel data have been used to show land use trends in a portion of the Upper San Pedro River Watershed, and the methodology has been described. As a methodology for evaluating land use change, analyzing parcel data is promising but has serious limitations. Some challenges include:

- The difficulty in amassing representative historical acreage data;
- The discrepancy between what exists on paper versus reality, i.e., parcels that have been subdivided may not have been developed;
- The substantial amount of time needed to collect the data.

Incorporating findings from other change detection methodologies (such as archival photographs and remote imagery) could make historic parcel data analysis more accurate. Differences and similarities in findings could offer important insight into the efficacy of each approach, and provide more reliable reference conditions to use in environmental decision-making.

Despite its limitations, using historic parcel data to examine land use change can be quite useful. Pairing historic parcel data with other historic and localized parameters could allow environmental managers to qualify the relationship between changing land use and other environmental and cultural trends at the community scale. For example, if paired with demographic and water quality data, environmental managers could use unique and scaled historic baselines to calibrate planning tools designed to explore plausible future impacts of different scenarios to a specific watershed, or even specific areas within a watershed.

The Automated Geospatial Watershed Assessment (AGWA) tool has recently been used to characterize the hydrologic impacts of growth in the San Pedro River Watershed (Burns et al. 2013). However, rather than rely on historic population data unique to the watershed, the analysis drew from nation-wide population projections. Instead of using historic water quality data unique to the watershed, the analysis integrated the Soil Water Assessment Tool (SWAT) component of AGWA with national scenarios provided from ICLUS.

As they are available, incorporating historic data into AGWA could potentially provide more accurate and relevant projections for smaller scale analyses versus the basin scale as was reported by Nie et al. (2011). For example, between 1971 and 2012, the number of parcels in Tombstone increased 194%. The number of "urban" and "suburban" book-maps increased by 40% and 110%, respectively; and the number of "exurban" and "rural" book-maps decreased by 12.5% and 100%, respectively. In that same period, the population increased by 11% (U.S. Census Decennial, 1970 & 2010). Models used to forecast probable landscape changes could incorporate such trends.

Historic water quality data are available through EPA's STOrage and RETrieval (STORET) data "warehouse," a repository for water quality data, including biological, chemical, and physical parameters. Within two miles of Tombstone, there are ten monitoring stations with a combined 1,023 water quality records, the earliest dating from 1952 (EPA STORET 2012). These records might also reveal useful trends that could be incorporated into models such as the AGWA watershed modeling system.

Environmental managers could also use historic baselines, including the data generated from this study, to assess the impacts of projects. NEPA requires that the "indirect" effects of federally funded projects be analyzed and described in environmental documents, such as Environmental Assessments and Environmental Impact Statements. Federal regulations state that, "indirect effects may include growth inducing effects and other effects related to induced changes in the *pattern of land use*, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR § 1508.8(b)).

The lack of historic data often requires decision makers to assess a project's indirect effects without sufficient context or background. How well can a NEPA reviewer assess the growth-inducing impacts of, for example, a wastewater infrastructure expansion project without knowing the historic relationship between wastewater treatment capacity, population, land use, and other environmental parameters? Pairing historic parcel data and the resulting land use trends analysis with historic population and wastewater treatment capacity data could help evaluate an expansion project's potential impact on land use patterns.

The City of Sierra Vista provides an example. Between 1971 and 2012, the number of parcels in Sierra Vista (including Sierra Vista Southeast) increased ~549%, from 1,591 parcels to 10,327 parcels; the percentage of "urban" and "suburban" book-maps increased by ~800% and ~112%, respectively. The number of "exurban" and "rural" book-maps decreased by ~8% and ~75%, respectively. In that same period, the population increased by ~780% (U.S. Census Decennial, 1970 & 2010), and wastewater treatment capacity increased ~566%, from 0.6 million gallons a day (MGD) to 4 MGD (SEAGO 1978, 2012). Table 5 lists the decadal changes. Figures 26, 27, and 28 display the historic relationships graphically.

| Decade | Population of Sierra Vista | Number of parcels | Book-Maps % Urban | Book-Maps % Suburban | Book-Maps % Exurban | Book-Maps % Rural | Wastewater Capacity (MGD) |
|---|---|---|---|---|---|---|---|
| **1970** | 6,689 | 1,591 | 0.00% | 19.23% | 46.15% | 34.62% | .6 |
| **1980** | 24,937 | 3,909 | 3.36% | 30.25% | 48.74% | 17.65% | .6 |
| **1990** | 42,220 | 5,548 | 5.65% | 33.06% | 48.39% | 12.90% | 2.9 |
| **2000** | 52,123 | 8,406 | 6.40% | 38.40% | 45.60% | 9.60% | 4 |
| **2010** | 58,685 | 10,327 | 8.00% | 40.80% | 42.40% | 8.80% | 4 |

Table 5: Decadal Trends in Population, Parcels, Book-Maps, and WWTF capacity in Sierra Vista, AZ.

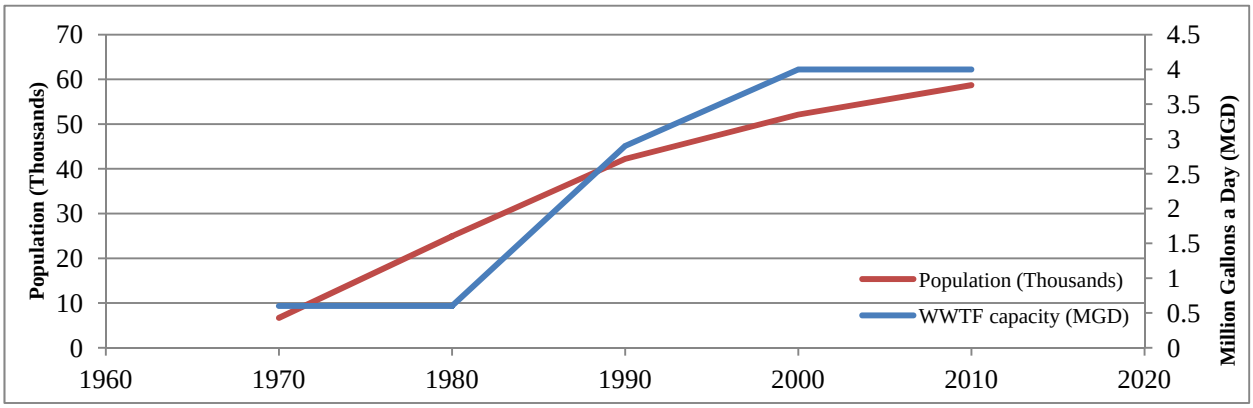



Figure 26: Population and Wastewater Treatment Facility (WWTF) Capacity in Sierra Vista, AZ: 1971 - 2012

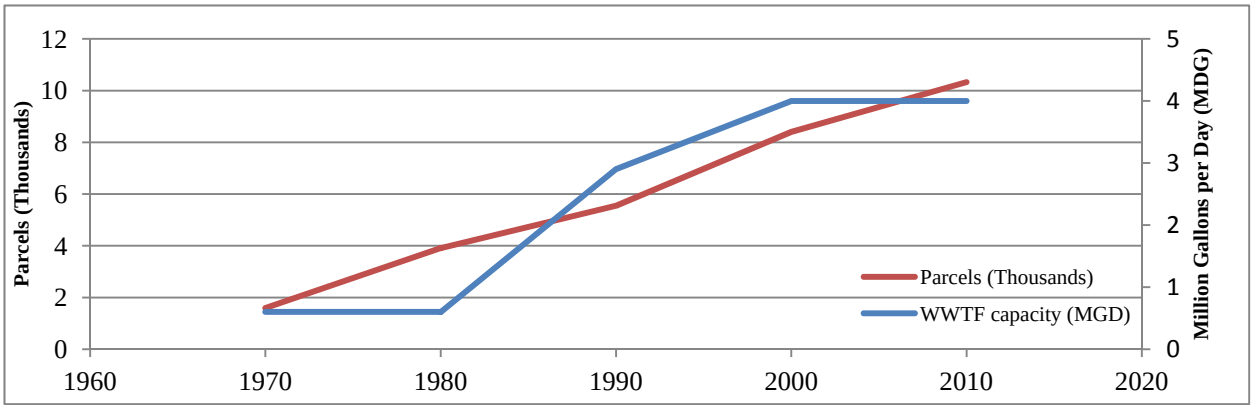



Figure 27: Number of Parcels and WWTF Capacity in Sierra Vista, AZ: 1971-2012

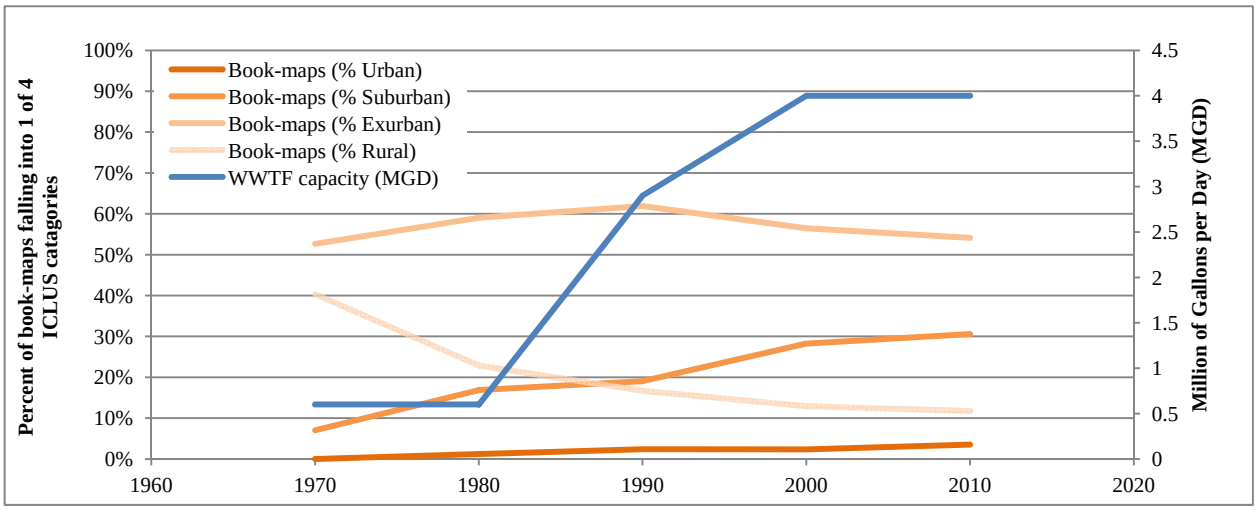



Figure 28: WWTF Capacity and Book-Maps in Sierra Vista, AZ: 1971-2012

Assuming the complex factors that affect everything from wastewater flow to subdivision development continue at the same rate as they did between 1971 through 2012, the trends displayed in Figures 26, 27, and 28 could be used to develop a scenario that projects how expanding Sierra Vista's WWTF would affect the area's pattern of land use[1].

The analysis suggests that for every increase of 1 MGD in Sierra Vista's wastewater treatment capacity, 1) the population would increase by nearly 13,000 people; 2) the number of parcels would increase by roughly 2,150 units; and 3) the land use would become roughly 1% more urban, 6% more suburban, and nearly 7% less rural. Using these assumptions, a NEPA reviewer analyzing the indirect effects of expanding Sierra Vista's WWTF from the current 4 MGD to a hypothetical 6 MGD could consider the addition of 26,000 more people, 4,300 more parcels, and a landscape that would become 2% more urban, 12% more suburban, and 14% less rural.

Determining whether or not these changes "significantly affect the pattern and type of land use…including altering the character of existing residential areas" (40 CFR § 6.207 (a)(3)(xi)) is, of course, a more complicated endeavor that would require additional information. But incorporating a future scenarios analysis into an indirect effects assessment could provide a more reliable basis from which to make predictions than the present approach, which has been criticized as inconsistent and imprecise (Mandelker 2010).

[1] *Many of the properties in Sierra Vista Southeast rely on private wells and septic systems. While the expansion of the Sierra Vista WWTF would not necessarily directly serve its unincorporated counterpart, the expanded capacity would accommodate a greater number of individuals and businesses within the facility's core service area. Growth in central Sierra Vista would very likely catalyze growth in Sierra Vista Southeast, the historical development of which has been tied to its incorporated neighbor.*

## Conclusion

"Upper San Pedro River Valley" parcel size and location trends between 1882 and 2012 were evaluated using 1) assessor records, and 2) the 1965 research completed by William M. Rodgers. Land use trends between 1971 and 2012 were produced using 1) assessor records, 2) the book-map geodatabase provided by Cochise County IT staff, and 3) EPA's ICLUS HD categories. ICLUS HD categories were used for a number of reasons, including their use in a similar EPA research effort (Burns et al. 2013), the relative simplicity of their reclassification to a product supported by modeling tools (e.g. AGWA), and the significant science behind the product (IPCC and SRES consistent storylines).

The analysis shows substantial land use change, particularly in and around Sierra Vista. However, the changes seem relatively minor compared to the linear increase in the total number of parcels and people. Perhaps this is because the watershed includes large amounts of land where development is either restricted or limited (Appendix C). The analysis, in other words, shows increased density. While typically indicative of a more sustainable community (Burchell and Mukherji 2003), population-driven urbanization could exhaust the one source of drinking water (the local aquifer) and the aquifer-dependent San Pedro River. There is particular concern over how new development could affect water rights the BLM holds to maintain flows through SPRNCA. This concern again emerged in the courts in May 2013 when the BLM filed suit to prevent the proposed 6,900-unit development in Sierra Vista (Davis 2013).

Evaluating the relationship between land use trends and water consumption patterns (i.e. changing number and capacity of wells, depth to aquifer levels, and river flow) could also help calibrate forecasting tools, inform indirect effect analyses, and generally help communities within the Upper San Pedro Watershed navigate contentious projects and environmental management quandaries. Such an analysis would benefit many communities in arid and semi-arid geographies. Rapidly rising populations place considerable pressure on finite water resources throughout the Southwest. Southwestern communities could greatly benefit from looking to their past to understand future impacts to water and other vital resources.

The methodology described could be applied well beyond the San Pedro. Communities across the Country - including the vast majority of municipalities within California, Arizona, New Jersey, New York, Virginia, and Nevada, as well as an unknown percentage of municipalities within Georgia, Kentucky, Maryland, and Vermont - have used the assessor map-based system (USDA 1979). While many of these communities have likely incorporated GIS to more reliably track parcels, it is also likely that today's parcel identification numbers reflect yesterday's map-based system and that the approach defined here could be widely replicated.

Alternative futures analyses allow us to consider various scenarios, and to develop strategies that better prepare society to confront the challenges ahead. In the face of climate change, economic instability, and resource scarcity, futures analyses can help protect our most vulnerable people and places. As possible, such analyses should be based on local historic trends. At the very least, the usefulness of present models should be judged by their ability to generate simulations that describe known historic conditions. As Richard Powers observed, "the simplest possible test for any futures game consist(s) in finding out whether it (can) predict the past."

# Appendix A: Books and Book-Maps within the Study Area

| 102 | 103 | 104 | | 105 | | 106 | | 107 | | 108 | 109 | 110 | 120 | 121 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10201 | 10337 | 10401 | 10454 | 10502 | 10553 | 10601 | 10655 | 10701 | 10765 | 10801 | 10901 | 11001 | 12031 | 12101 |
| 10202 | 10338 | 10402 | 10455 | 10503 | 10554 | 10602 | 10656 | 10713 | 10766 | 10806 | 10902 | 11003 | | 12102 |
| 10203 | 10339 | 10403 | 10456 | 10504 | 10556 | 10603 | 10657 | 10715 | 10767 | 10807 | 10903 | 11004 | | 12103 |
| 10204 | 10340 | 10404 | 10457 | 10505 | 10558 | 10604 | 10658 | 10716 | 10768 | 10808 | 10904 | 11005 | | 12104 |
| 10206 | 10341 | 10405 | 10458 | 10506 | 10559 | 10605 | 10659 | 10717 | 10769 | 10811 | 10905 | 11006 | | 12105 |
| 10207 | 10342 | 10406 | 10460 | 10507 | 10560 | 10606 | 10661 | 10718 | 10770 | 10812 | 10906 | 11009 | | 12106 |
| 10208 | 10343 | 10407 | 10461 | 10508 | 10564 | 10608 | 10662 | 10719 | 10771 | 10813 | 10907 | 11012 | | 12107 |
| 10209 | 10344 | 10408 | 10462 | 10509 | 10565 | 10609 | 10663 | 10720 | 10772 | 10814 | 10908 | 11013 | | 12108 |
| 10210 | 10346 | 10409 | 10463 | 10510 | 10566 | 10610 | 10664 | 10721 | 10773 | 10815 | 10909 | 11014 | | 12109 |
| 10211 | 10347 | 10410 | 10464 | 10511 | 10567 | 10611 | 10665 | 10722 | 10774 | 10816 | 10910 | 11016 | | 12110 |
| 10218 | 10348 | 10411 | 10465 | 10512 | 10568 | 10612 | 10666 | 10723 | 10775 | 10817 | 10911 | 11017 | | 12111 |
| 10221 | 10350 | 10412 | 10466 | 10513 | 10569 | 10615 | 10667 | 10724 | 10776 | 10818 | 10912 | 11018 | | 12112 |
| 10234 | 10351 | 10413 | 10467 | 10514 | 10570 | 10616 | 10668 | 10727 | 10777 | 10819 | 10913 | 11019 | | 12113 |
| 10235 | | 10414 | 10468 | 10515 | 10571 | 10617 | 10669 | 10728 | 10778 | 10820 | 10914 | 11020 | | 12114 |
| 10236 | | 10415 | 10469 | 10516 | 10573 | 10618 | 10670 | 10729 | 10779 | 10821 | 10915 | 11022 | | 12115 |
| 10259 | | 10416 | 10470 | 10517 | 10574 | 10619 | 10671 | 10730 | 10780 | 10822 | 10917 | 11023 | | 12116 |
| | | 10417 | 10473 | 10518 | 10575 | 10620 | 10672 | 10731 | 10781 | 10829 | 10918 | 11024 | | 12117 |
| | | 10418 | 10474 | 10519 | 10576 | 10621 | 10673 | 10733 | 10782 | 10830 | 10919 | 11025 | | 12118 |
| | | 10419 | 10475 | 10520 | 10577 | 10622 | 10674 | 10734 | 10783 | 10831 | 10921 | 11026 | | 12119 |
| | | 10420 | 10476 | 10521 | 10578 | 10623 | 10675 | 10736 | 10784 | 10832 | 10924 | 11027 | | 12120 |
| | | 10421 | 10477 | 10524 | 10583 | 10624 | 10677 | 10737 | | 10833 | 10925 | 11028 | | 12121 |
| | | 10422 | 10478 | 10525 | 10588 | 10625 | 10678 | 10738 | | 10836 | 10928 | 11029 | | 12122 |
| | | 10423 | 10479 | 10527 | 10589 | 10626 | | 10739 | | 10837 | 10930 | 11030 | | 12123 |
| | | 10424 | 10480 | 10528 | 10590 | 10627 | | 10740 | | 10838 | 10932 | 11031 | | 12125 |
| | | 10425 | 10481 | 10529 | 10591 | 10628 | | 10741 | | 10839 | 10933 | 11032 | | 12126 |
| | | 10426 | 10482 | 10530 | 10592 | 10629 | | 10742 | | 10840 | | 11033 | | 12127 |
| | | 10427 | 10483 | 10531 | 10593 | 10631 | | 10743 | | 10841 | | 11034 | | 12128 |
| | | 10431 | 10484 | 10533 | 10594 | 10632 | | 10744 | | 10844 | | 11035 | | 12129 |
| | | 10434 | 10485 | 10534 | 10595 | 10634 | | 10745 | | 10850 | | 11040 | | 12130 |
| | | 10437 | | 10535 | 10596 | 10635 | | 10746 | | 10853 | | 11041 | | 12131 |
| | | 10438 | | 10536 | 10597 | 10636 | | 10747 | | 10869 | | 11042 | | 12133 |
| | | 10439 | | 10537 | 10598 | 10639 | | 10748 | | 10876 | | 11043 | | 12134 |
| | | 10440 | | 10538 | 10599 | 10640 | | 10749 | | 10881 | | 11044 | | 12135 |
| | | 10441 | | 10539 | | 10641 | | 10750 | | 10882 | | 11045 | | 12136 |
| | | 10442 | | 10540 | | 10642 | | 10751 | | 10883 | | 11050 | | 12137 |
| | | 10443 | | 10541 | | 10643 | | 10752 | | | | 11051 | | 12139 |
| | | 10444 | | 10542 | | 10645 | | 10754 | | | | 11054 | | 12140 |
| | | 10445 | | 10543 | | 10646 | | 10755 | | | | 11055 | | 12141 |
| | | 10446 | | 10544 | | 10647 | | 10756 | | | | 11056 | | 12142 |
| | | 10447 | | 10546 | | 10648 | | 10758 | | | | 11057 | | 12143 |
| | | 10448 | | 10547 | | 10649 | | 10759 | | | | 11059 | | 12144 |
| | | 10449 | | 10548 | | 10650 | | 10760 | | | | 11060 | | 12146 |
| | | 10450 | | 10549 | | 10651 | | 10761 | | | | | | 12147 |
| | | 10451 | | 10550 | | 10652 | | 10762 | | | | | | 12149 |
| | | 10452 | | 10551 | | 10653 | | 10763 | | | | | | 12150 |
| | | 10453 | | 10552 | | 10654 | | 10764 | | | | | | 12151 |

# Appendix B: Changing Number of Parcels within Study Area Book-Maps

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10201 | 8 | 17 | 22 | 25 | 26 |
| 10202 | 1 | 5 | 5 | 5 | 7 |
| 10203 | 1 | 7 | 7 | 7 | 10 |
| 10204 | 0 | 6 | 10 | 11 | 14 |
| 10206 | 1 | 1 | 1 | 1 | 1 |
| 10207 | 0 | 0 | 5 | 5 | 3 |
| 10208 | 0 | 3 | 4 | 5 | 6 |
| 10209 | 0 | 3 | 5 | 5 | 9 |
| 10210 | 0 | 16 | 26 | 34 | 31 |
| 10211 | 1 | 11 | 14 | 19 | 48 |
| 10218 | 0 | 8 | 19 | 21 | 24 |
| 10221 | 0 | 13 | 18 | 23 | 23 |
| 10234 | 11 | 14 | 19 | 20 | 45 |
| 10235 | 3 | 4 | 6 | 7 | 1 |
| 10236 | 14 | 21 | 24 | 29 | 2 |
| 10259 | 0 | 0 | 13 | 15 | 28 |
| 10337 | 3 | 8 | 18 | 19 | 21 |
| 10338 | 1 | 3 | 3 | 3 | 3 |
| 10339 | 4 | 5 | 6 | 9 | 11 |
| 10340 | 1 | 1 | 1 | 1 | 1 |
| 10341 | 1 | 1 | 1 | 1 | 1 |
| 10342 | 0 | 2 | 2 | 2 | 2 |
| 10343 | 1 | 12 | 13 | 13 | 13 |
| 10344 | 0 | 4 | 6 | 6 | 6 |
| 10346 | 0 | 1 | 1 | 1 | 1 |
| 10347 | 0 | 2 | 4 | 5 | 5 |
| 10348 | 0 | 1 | 6 | 6 | 6 |
| 10350 | 1 | 1 | 1 | 1 | 4 |
| 10351 | 2 | 8 | 10 | 10 | 15 |
| 10401 | 0 | 18 | 15 | 289 | 395 |
| 10402 | 14 | 21 | 29 | 285 | 373 |
| 10403 | 46 | 52 | 52 | 66 | 72 |
| 10404 | 6 | 6 | 12 | 222 | 227 |
| 10405 | 1 | 10 | 12 | 95 | 106 |
| 10406 | 3 | 14 | 25 | 34 | 35 |
| 10407 | 102 | 110 | 162 | 298 | 402 |
| 10408 | 5 | 34 | 150 | 222 | 247 |
| 10409 | 21 | 49 | 58 | 115 | 126 |
| 10410 | 104 | 105 | 109 | 109 | 107 |
| 10411 | 0 | 16 | 26 | 50 | 85 |
| 10412 | 17 | 18 | 21 | 23 | 27 |
| 10413 | 18 | 23 | 23 | 35 | 18 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10414 | 21 | 28 | 31 | 33 | 36 |
| 10415 | 27 | 43 | 76 | 74 | 75 |
| 10416 | 10 | 10 | 16 | 24 | 27 |
| 10417 | 1 | 2 | 2 | 65 | 137 |
| 10418 | 1 | 2 | 2 | 81 | 149 |
| 10419 | 6 | 7 | 7 | 7 | 8 |
| 10420 | 17 | 25 | 31 | 29 | 30 |
| 10421 | 17 | 25 | 26 | 27 | 27 |
| 10422 | 8 | 10 | 11 | 16 | 16 |
| 10423 | 29 | 47 | 47 | 43 | 42 |
| 10424 | 0 | 0 | 0 | 16 | 259 |
| 10427 | 5 | 15 | 25 | 224 | 473 |
| 10431 | 0 | 17 | 76 | 220 | 271 |
| 10434 | 2 | 7 | 8 | 8 | 13 |
| 10437 | 3 | 3 | 5 | 7 | 8 |
| 10438 | 2 | 6 | 5 | 7 | 11 |
| 10439 | 2 | 2 | 2 | 2 | 11 |
| 10440 | 1 | 1 | 8 | 15 | 14 |
| 10441 | 9 | 9 | 14 | 15 | 18 |
| 10442 | 33 | 61 | 67 | 81 | 99 |
| 10443 | 1 | 8 | 9 | 72 | 94 |
| 10444 | 3 | 17 | 37 | 80 | 106 |
| 10445 | 6 | 8 | 10 | 15 | 25 |
| 10446 | 366 | 359 | 357 | 343 | 336 |
| 10447 | 6 | 9 | 9 | 29 | 43 |
| 10448 | 9 | 10 | 19 | 24 | 27 |
| 10449 | 124 | 122 | 121 | 90 | 82 |
| 10450 | 9 | 12 | 11 | 11 | 29 |
| 10451 | 7 | 6 | 7 | 7 | 13 |
| 10452 | 3 | 4 | 5 | 5 | 6 |
| 10453 | 1 | 1 | 1 | 24 | 42 |
| 10454 | 8 | 10 | 85 | 122 | 138 |
| 10455 | 7 | 7 | 47 | 79 | 137 |
| 10456 | 3 | 15 | 14 | 14 | 15 |
| 10457 | 0 | 0 | 0 | 5 | 5 |
| 10458 | 0 | 80 | 82 | 82 | 83 |
| 10460 | 2 | 14 | 18 | 20 | 20 |
| 10461 | 6 | 2 | 2 | 2 | 2 |
| 10462 | 3 | 5 | 7 | 12 | 15 |
| 10463 | 1 | 3 | 4 | 5 | 5 |
| 10464 | 13 | 17 | 17 | 18 | 20 |
| 10465 | 3 | 3 | 3 | 4 | 6 |
| 10466 | 12 | 14 | 14 | 14 | 13 |
| 10467 | 5 | 6 | 6 | 7 | 10 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10468 | 4 | 10 | 22 | 23 | 26 |
| 10469 | 3 | 3 | 3 | 3 | 3 |
| 10470 | 2 | 3 | 3 | 3 | 3 |
| 10473 | 1 | 1 | 1 | 1 | 1 |
| 10474 | 2 | 3 | 22 | 33 | 38 |
| 10475 | 0 | 46 | 66 | 77 | 83 |
| 10476 | 0 | 24 | 183 | 236 | 217 |
| 10477 | 0 | 64 | 76 | 106 | 87 |
| 10478 | 0 | 24 | 31 | 34 | 34 |
| 10479 | 0 | 0 | 18 | 45 | 67 |
| 10480 | 0 | 0 | 28 | 42 | 83 |
| 10481 | 0 | 0 | 5 | 7 | 7 |
| 10482 | 0 | 16 | 179 | 187 | 258 |
| 10483 | 0 | 16 | 12 | 12 | 15 |
| 10484 | 0 | 0 | 36 | 67 | 95 |
| 10485 | 0 | 0 | 33 | 35 | 36 |
| 10502 | 1 | 1 | 1 | 1 | 1 |
| 10503 | 4 | 7 | 5 | 45 | 646 |
| 10504 | 422 | 481 | 501 | 500 | 502 |
| 10505 | 81 | 414 | 555 | 562 | 578 |
| 10506 | 2 | 22 | 32 | 46 | 53 |
| 10507 | 15 | 25 | 43 | 51 | 57 |
| 10508 | 3 | 2 | 6 | 6 | 7 |
| 10509 | 9 | 51 | 57 | 57 | 58 |
| 10510 | 37 | 39 | 43 | 42 | 43 |
| 10511 | 15 | 15 | 16 | 16 | 16 |
| 10512 | 23 | 24 | 26 | 26 | 28 |
| 10513 | 110 | 110 | 111 | 111 | 111 |
| 10514 | 100 | 202 | 259 | 205 | 207 |
| 10515 | 2 | 140 | 143 | 143 | 329 |
| 10516 | 5 | 48 | 51 | 339 | 967 |
| 10517 | 0 | 66 | 102 | 102 | 100 |
| 10518 | 0 | 47 | 96 | 160 | 168 |
| 10519 | 1 | 1 | 1 | 1 | 1 |
| 10520 | 1 | 34 | 111 | 159 | 170 |
| 10521 | 1 | 3 | 3 | 3 | 4 |
| 10524 | 1 | 1 | 1 | 1 | 1 |
| 10525 | 4 | 11 | 12 | 13 | 13 |
| 10527 | 1 | 1 | 1 | 1 | 1 |
| 10528 | 4 | 3 | 6 | 6 | 6 |
| 10529 | 131 | 130 | 130 | 111 | 104 |
| 10530 | 5 | 7 | 7 | 8 | 10 |
| 10531 | 1 | 1 | 1 | 1 | 1 |
| 10533 | 1 | 1 | 1 | 1 | 1 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10534 | 1 | 1 | 1 | 1 | 1 |
| 10535 | 1 | 2 | 2 | 2 | 2 |
| 10536 | 1 | 4 | 4 | 4 | 4 |
| 10537 | 9 | 14 | 20 | 29 | 37 |
| 10538 | 7 | 9 | 10 | 20 | 67 |
| 10539 | 56 | 69 | 78 | 87 | 105 |
| 10540 | 24 | 31 | 62 | 81 | 96 |
| 10541 | 1 | 5 | 15 | 38 | 50 |
| 10542 | 5 | 5 | 7 | 17 | 27 |
| 10543 | 3 | 5 | 5 | 6 | 6 |
| 10544 | 1 | 1 | 1 | 1 | 1 |
| 10546 | 6 | 10 | 12 | 17 | 22 |
| 10547 | 1 | 1 | 1 | 1 | 1 |
| 10548 | 3 | 7 | 9 | 9 | 10 |
| 10549 | 2 | 1 | 1 | 1 | 1 |
| 10550 | 1 | 1 | 1 | 8 | 8 |
| 10551 | 8 | 10 | 12 | 12 | 13 |
| 10552 | 4 | 14 | 13 | 13 | 14 |
| 10553 | 2 | 2 | 2 | 2 | 2 |
| 10554 | 1 | 1 | 1 | 1 | 6 |
| 10556 | 0 | 161 | 160 | 160 | 160 |
| 10558 | 4 | 4 | 4 | 4 | 12 |
| 10559 | 0 | 1 | 1 | 1 | 1 |
| 10560 | 1 | 0 | 0 | 0 | 1 |
| 10564 | 1 | 1 | 1 | 1 | 1 |
| 10565 | 0 | 0 | 0 | 0 | 1 |
| 10566 | 0 | 0 | 0 | 0 | 1 |
| 10567 | 1 | 1 | 1 | 1 | 1 |
| 10568 | 3 | 3 | 3 | 3 | 3 |
| 10569 | 2 | 2 | 2 | 2 | 2 |
| 10570 | 2 | 2 | 2 | 2 | 2 |
| 10571 | 1 | 1 | 1 | 1 | 1 |
| 10572 | 0 | 0 | 0 | 1 | 1 |
| 10573 | 1 | 1 | 1 | 1 | 1 |
| 10574 | 1 | 1 | 1 | 1 | 1 |
| 10575 | 1 | 1 | 1 | 1 | 1 |
| 10576 | 1 | 1 | 1 | 1 | 1 |
| 10577 | 1 | 1 | 1 | 1 | 1 |
| 10578 | 1 | 1 | 1 | 1 | 1 |
| 10583 | 1 | 1 | 1 | 1 | 1 |
| 10588 | 0 | 272 | 272 | 272 | 263 |
| 10589 | 59 | 58 | 56 | 54 | 58 |
| 10590 | 24 | 35 | 34 | 35 | 35 |
| 10591 | 41 | 159 | 157 | 155 | 155 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10592 | 3 | 516 | 861 | 896 | 882 |
| 10593 | 0 | 74 | 72 | 72 | 68 |
| 10594 | 0 | 277 | 277 | 273 | 275 |
| 10595 | 0 | 0 | 390 | 875 | 989 |
| 10596 | 0 | 1 | 3 | 105 | 659 |
| 10597 | 0 | 278 | 352 | 798 | 819 |
| 10598 | 0 | 265 | 321 | 390 | 395 |
| 10599 | 0 | 209 | 290 | 473 | 473 |
| 10601 | 6 | 6 | 6 | 6 | 7 |
| 10602 | 3 | 3 | 3 | 3 | 6 |
| 10603 | 6 | 10 | 11 | 30 | 117 |
| 10604 | 156 | 151 | 149 | 148 | 157 |
| 10605 | 36 | 47 | 51 | 62 | 63 |
| 10606 | 94 | 31 | 47 | 58 | 75 |
| 10608 | 4 | 15 | 24 | 36 | 37 |
| 10609 | 3 | 38 | 38 | 65 | 66 |
| 10610 | 4 | 3 | 4 | 3 | 2 |
| 10611 | 2 | 3 | 5 | 7 | 8 |
| 10612 | 2 | 3 | 10 | 19 | 25 |
| 10615 | 7 | 11 | 9 | 15 | 293 |
| 10616 | 2 | 50 | 64 | 122 | 130 |
| 10617 | 3 | 21 | 23 | 28 | 56 |
| 10618 | 12 | 22 | 24 | 65 | 84 |
| 10619 | 24 | 29 | 35 | 39 | 42 |
| 10620 | 48 | 48 | 46 | 44 | 44 |
| 10621 | 196 | 198 | 195 | 185 | 184 |
| 10622 | 96 | 96 | 96 | 95 | 95 |
| 10623 | 0 | 0 | 12 | 17 | 19 |
| 10624 | 157 | 177 | 182 | 183 | 192 |
| 10625 | 65 | 75 | 84 | 116 | 134 |
| 10626 | 36 | 38 | 41 | 40 | 41 |
| 10627 | 51 | 50 | 54 | 57 | 59 |
| 10628 | 9 | 10 | 11 | 11 | 14 |
| 10629 | 0 | 129 | 122 | 103 | 97 |
| 10631 | 10 | 10 | 13 | 15 | 16 |
| 10632 | 0 | 51 | 4 | 4 | 4 |
| 10634 | 32 | 34 | 41 | 43 | 47 |
| 10635 | 9 | 9 | 13 | 14 | 21 |
| 10636 | 3 | 3 | 3 | 3 | 4 |
| 10639 | 210 | 208 | 193 | 178 | 170 |
| 10640 | 0 | 60 | 61 | 58 | 58 |
| 10641 | 4 | 4 | 5 | 9 | 24 |
| 10642 | 2 | 2 | 3 | 7 | 7 |
| 10643 | 0 | 0 | 0 | 18 | 31 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10645 | 2 | 2 | 2 | 3 | 2 |
| 10646 | 5 | 8 | 11 | 34 | 41 |
| 10647 | 44 | 59 | 132 | 77 | 96 |
| 10648 | 154 | 158 | 159 | 161 | 164 |
| 10649 | 62 | 70 | 69 | 76 | 78 |
| 10650 | 0 | 41 | 104 | 159 | 159 |
| 10651 | 81 | 115 | 117 | 118 | 127 |
| 10652 | 1 | 1 | 1 | 2 | 4 |
| 10653 | 4 | 5 | 3 | 4 | 4 |
| 10654 | 4 | 4 | 6 | 17 | 28 |
| 10655 | 2 | 3 | 3 | 3 | 2 |
| 10656 | 133 | 191 | 192 | 196 | 202 |
| 10657 | 18 | 23 | 24 | 18 | 16 |
| 10658 | 34 | 35 | 36 | 132 | 132 |
| 10659 | 0 | 108 | 108 | 108 | 108 |
| 10661 | 21 | 24 | 25 | 27 | 28 |
| 10662 | 81 | 71 | 81 | 82 | 85 |
| 10663 | 0 | 361 | 360 | 408 | 410 |
| 10664 | 108 | 108 | 108 | 108 | 108 |
| 10665 | 27 | 30 | 40 | 40 | 41 |
| 10666 | 0 | 123 | 122 | 122 | 123 |
| 10667 | 11 | 13 | 23 | 24 | 24 |
| 10668 | 295 | 297 | 296 | 298 | 295 |
| 10669 | 342 | 391 | 450 | 527 | 527 |
| 10670 | 137 | 138 | 138 | 138 | 221 |
| 10671 | 238 | 246 | 247 | 249 | 250 |
| 10672 | 2 | 9 | 11 | 72 | 595 |
| 10673 | 12 | 25 | 33 | 35 | 38 |
| 10674 | 181 | 178 | 178 | 178 | 180 |
| 10675 | 113 | 115 | 124 | 125 | 172 |
| 10677 | 0 | 80 | 80 | 80 | 80 |
| 10678 | 0 | 0 | 148 | 152 | 152 |
| 10701 | 7 | 13 | 8 | 15 | 226 |
| 10713 | 0 | 0 | 2 | 68 | 8 |
| 10715 | 0 | 37 | 104 | 119 | 126 |
| 10716 | 12 | 23 | 46 | 76 | 107 |
| 10717 | 110 | 110 | 111 | 110 | 111 |
| 10718 | 0 | 1 | 49 | 49 | 49 |
| 10719 | 12 | 23 | 29 | 34 | 35 |
| 10720 | 8 | 18 | 23 | 38 | 43 |
| 10721 | 12 | 18 | 19 | 22 | 24 |
| 10722 | 127 | 155 | 152 | 162 | 164 |
| 10723 | 28 | 29 | 39 | 39 | 49 |
| 10724 | 33 | 8 | 10 | 10 | 12 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10727 | 2 | 2 | 2 | 2 | 11 |
| 10728 | 0 | 0 | 2 | 2 | 6 |
| 10729 | 10 | 13 | 14 | 15 | 16 |
| 10730 | 0 | 0 | 0 | 0 | 2 |
| 10731 | 13 | 27 | 27 | 27 | 27 |
| 10733 | 176 | 176 | 176 | 176 | 176 |
| 10734 | 0 | 0 | 1 | 8 | 14 |
| 10736 | 0 | 162 | 240 | 243 | 245 |
| 10737 | 69 | 72 | 76 | 136 | 139 |
| 10738 | 7 | 7 | 7 | 7 | 7 |
| 10739 | 9 | 12 | 13 | 20 | 24 |
| 10740 | 5 | 8 | 9 | 16 | 27 |
| 10741 | 0 | 7 | 7 | 7 | 7 |
| 10742 | 7 | 7 | 16 | 20 | 21 |
| 10743 | 2 | 2 | 36 | 68 | 85 |
| 10744 | 8 | 12 | 16 | 21 | 28 |
| 10745 | 0 | 23 | 24 | 18 | 18 |
| 10746 | 0 | 8 | 8 | 9 | 10 |
| 10747 | 42 | 29 | 28 | 27 | 53 |
| 10748 | 4 | 7 | 14 | 378 | 190 |
| 10749 | 0 | 0 | 174 | 290 | 951 |
| 10750 | 173 | 205 | 208 | 208 | 215 |
| 10751 | 69 | 329 | 345 | 414 | 421 |
| 10752 | 11 | 24 | 43 | 90 | 114 |
| 10754 | 0 | 17 | 27 | 36 | 42 |
| 10755 | 0 | 9 | 20 | 46 | 63 |
| 10756 | 3 | 15 | 33 | 57 | 352 |
| 10758 | 1 | 8 | 14 | 17 | 29 |
| 10759 | 13 | 42 | 47 | 55 | 65 |
| 10760 | 0 | 14 | 15 | 60 | 78 |
| 10761 | 2 | 12 | 58 | 83 | 99 |
| 10762 | 0 | 48 | 63 | 86 | 99 |
| 10763 | 0 | 46 | 50 | 63 | 99 |
| 10764 | 0 | 22 | 30 | 41 | 46 |
| 10765 | 0 | 0 | 0 | 0 | 119 |
| 10766 | 99 | 144 | 177 | 222 | 226 |
| 10767 | 140 | 183 | 204 | 214 | 222 |
| 10768 | 245 | 291 | 292 | 298 | 299 |
| 10769 | 53 | 84 | 93 | 103 | 124 |
| 10770 | 0 | 9 | 22 | 29 | 40 |
| 10771 | 0 | 153 | 146 | 145 | 145 |
| 10772 | 1 | 64 | 107 | 116 | 119 |
| 10773 | 0 | 107 | 163 | 161 | 163 |
| 10774 | 0 | 145 | 145 | 144 | 144 |

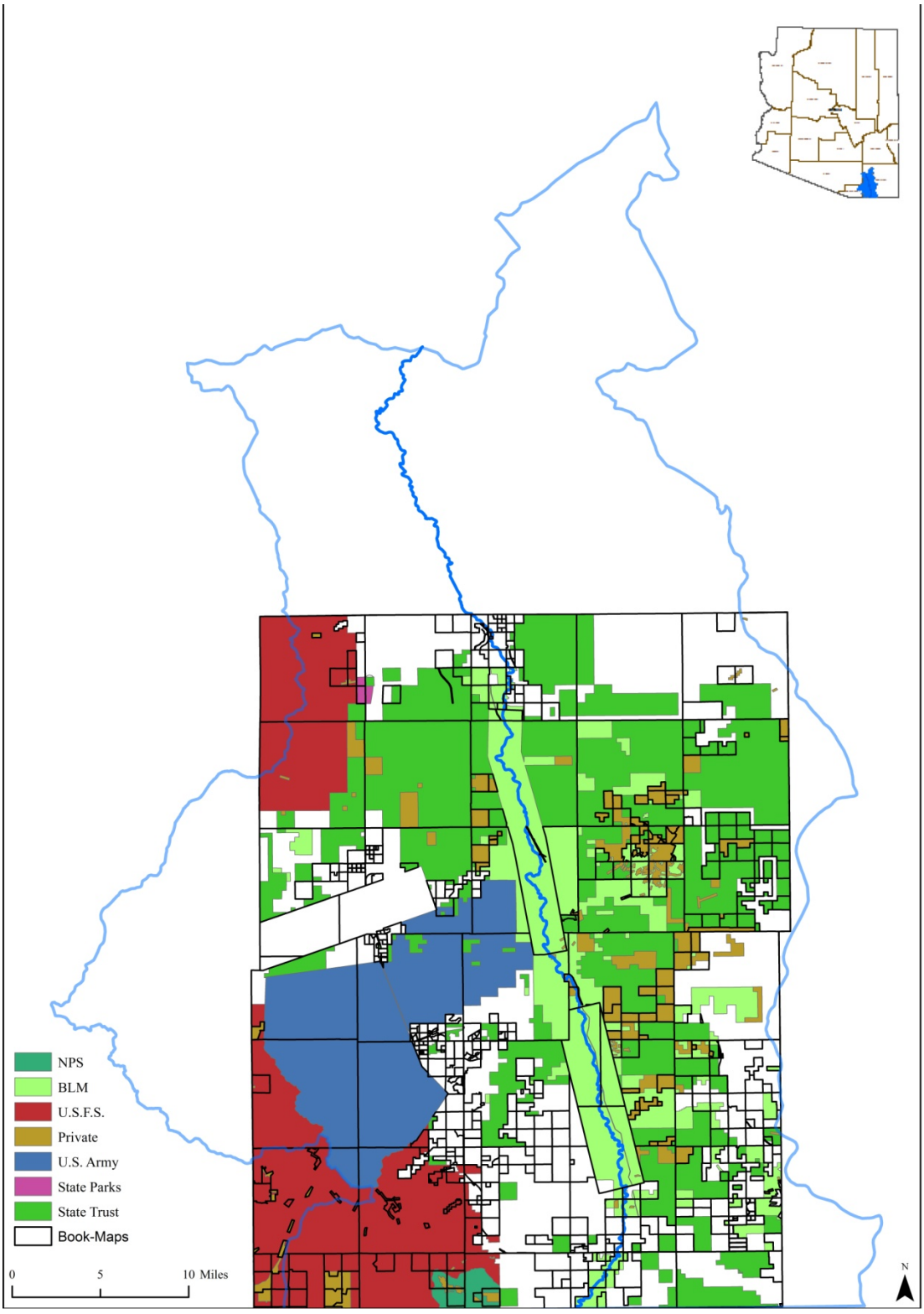
| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10775 | 0 | 44 | 59 | 83 | 89 |
| 10776 | 0 | 133 | 124 | 124 | 124 |
| 10777 | 0 | 173 | 155 | 155 | 156 |
| 10778 | 0 | 51 | 423 | 819 | 876 |
| 10779 | 0 | 219 | 219 | 219 | 220 |
| 10780 | 0 | 1 | 1 | 1 | 1 |
| 10781 | 0 | 2 | 0 | 0 | 1 |
| 10782 | 0 | 117 | 117 | 117 | 117 |
| 10783 | 0 | 124 | 124 | 124 | 124 |
| 10784 | 0 | 178 | 178 | 178 | 178 |
| 10801 | 3 | 4 | 4 | 4 | 12 |
| 10806 | 4 | 3 | 3 | 3 | 3 |
| 10807 | 1 | 2 | 2 | 2 | 1 |
| 10808 | 10 | 10 | 10 | 11 | 48 |
| 10811 | 0 | 12 | 14 | 19 | 19 |
| 10812 | 0 | 30 | 36 | 37 | 40 |
| 10813 | 0 | 17 | 17 | 35 | 37 |
| 10814 | 0 | 1 | 4 | 23 | 31 |
| 10815 | 65 | 66 | 65 | 73 | 76 |
| 10816 | 4 | 5 | 6 | 6 | 9 |
| 10817 | 1 | 1 | 1 | 1 | 28 |
| 10818 | 5 | 4 | 4 | 6 | 8 |
| 10819 | 2 | 2 | 2 | 2 | 4 |
| 10820 | 2 | 7 | 11 | 10 | 75 |
| 10821 | 2 | 2 | 2 | 2 | 2 |
| 10822 | 1 | 1 | 1 | 1 | 1 |
| 10829 | 1 | 1 | 1 | 1 | 1 |
| 10830 | 1 | 3 | 3 | 3 | 3 |
| 10831 | 27 | 67 | 76 | 99 | 112 |
| 10832 | 91 | 89 | 86 | 83 | 85 |
| 10833 | 0 | 0 | 0 | 10 | 17 |
| 10836 | 3 | 3 | 3 | 3 | 6 |
| 10837 | 2 | 2 | 3 | 3 | 5 |
| 10838 | 8 | 11 | 11 | 31 | 60 |
| 10839 | 13 | 21 | 22 | 23 | 27 |
| 10840 | 6 | 13 | 13 | 15 | 15 |
| 10841 | 11 | 13 | 13 | 18 | 18 |
| 10844 | 1 | 1 | 1 | 1 | 1 |
| 10850 | 1 | 1 | 1 | 1 | 1 |
| 10853 | 9 | 11 | 13 | 14 | 19 |
| 10869 | 2 | 2 | 2 | 2 | 2 |
| 10876 | 0 | 1 | 1 | 1 | 1 |
| 10881 | 42 | 42 | 42 | 42 | 42 |
| 10882 | 0 | 0 | 0 | 0 | 1 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 10883 | 0 | 0 | 0 | 0 | 4 |
| 10901 | 7 | 4 | 4 | 4 | 11 |
| 10902 | 0 | 2 | 2 | 3 | 5 |
| 10903 | 4 | 5 | 10 | 12 | 25 |
| 10904 | 28 | 32 | 38 | 39 | 39 |
| 10905 | 31 | 38 | 38 | 40 | 43 |
| 10906 | 21 | 23 | 23 | 16 | 20 |
| 10907 | 55 | 60 | 64 | 64 | 73 |
| 10908 | 36 | 41 | 40 | 41 | 43 |
| 10909 | 45 | 55 | 60 | 58 | 58 |
| 10910 | 154 | 174 | 179 | 179 | 192 |
| 10911 | 111 | 133 | 143 | 140 | 141 |
| 10912 | 91 | 96 | 98 | 93 | 118 |
| 10913 | 96 | 98 | 98 | 100 | 105 |
| 10914 | 43 | 46 | 43 | 41 | 42 |
| 10915 | 94 | 94 | 92 | 90 | 86 |
| 10917 | 8 | 9 | 10 | 9 | 11 |
| 10918 | 3 | 3 | 93 | 3 | 6 |
| 10919 | 5 | 10 | 10 | 10 | 21 |
| 10921 | 0 | 398 | 400 | 392 | 378 |
| 10924 | 0 | 0 | 0 | 0 | 3 |
| 10925 | 7 | 13 | 24 | 25 | 36 |
| 10928 | 0 | 1 | 1 | 1 | 1 |
| 10930 | 0 | 1 | 1 | 10 | 10 |
| 10932 | 0 | 160 | 159 | 160 | 158 |
| 10933 | 0 | 263 | 258 | 258 | 221 |
| 11001 | 5 | 11 | 15 | 14 | 15 |
| 11003 | 2 | 2 | 2 | 2 | 2 |
| 11004 | 7 | 7 | 7 | 9 | 18 |
| 11005 | 2 | 2 | 93 | 2 | 6 |
| 11006 | 2 | 2 | 2 | 2 | 2 |
| 11009 | 0 | 0 | 2 | 2 | 2 |
| 11012 | 0 | 0 | 7 | 9 | 9 |
| 11013 | 0 | 0 | 10 | 10 | 11 |
| 11014 | 0 | 0 | 7 | 9 | 11 |
| 11016 | 0 | 0 | 8 | 8 | 8 |
| 11017 | 0 | 0 | 24 | 25 | 29 |
| 11018 | 4 | 6 | 7 | 18 | 146 |
| 11019 | 31 | 31 | 31 | 31 | 31 |
| 11020 | 36 | 36 | 36 | 34 | 31 |
| 11022 | 1 | 3 | 5 | 5 | 5 |
| 11023 | 1 | 1 | 1 | 7 | 8 |
| 11024 | 1 | 1 | 1 | 1 | 1 |
| 11025 | 1 | 2 | 2 | 2 | 2 |

| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 11026 | 1 | 1 | 1 | 1 | 1 |
| 11027 | 1 | 2 | 2 | 2 | 2 |
| 11028 | 1 | 3 | 3 | 3 | 3 |
| 11029 | 2 | 2 | 4 | 2 | 4 |
| 11030 | 2 | 5 | 17 | 19 | 57 |
| 11031 | 0 | 0 | 0 | 8 | 9 |
| 11032 | 0 | 0 | 0 | 22 | 26 |
| 11033 | 1 | 1 | 2 | 7 | 7 |
| 11034 | 1 | 2 | 7 | 7 | 7 |
| 11035 | 1 | 1 | 2 | 3 | 3 |
| 11040 | 1 | 1 | 1 | 1 | 1 |
| 11041 | 2 | 4 | 4 | 4 | 5 |
| 11042 | 1 | 2 | 2 | 2 | 2 |
| 11043 | 1 | 1 | 1 | 1 | 1 |
| 11044 | 4 | 4 | 4 | 7 | 11 |
| 11045 | 4 | 4 | 4 | 6 | 7 |
| 11050 | 4 | 5 | 8 | 10 | 14 |
| 11051 | 2 | 3 | 14 | 18 | 28 |
| 11054 | 2 | 2 | 2 | 2 | 2 |
| 11055 | 1 | 1 | 1 | 1 | 1 |
| 11056 | 3 | 3 | 4 | 4 | 4 |
| 11057 | 12 | 13 | 17 | 19 | 20 |
| 11059 | 0 | 2 | 2 | 2 | 3 |
| 11060 | 0 | 0 | 0 | 10 | 6 |
| 12031 | 0 | 0 | 0 | 235 | 25 |
| 12101 | 2 | 3 | 6 | 43 | 55 |
| 12102 | 1 | 2 | 3 | 5 | 9 |
| 12103 | 4 | 5 | 8 | 13 | 12 |
| 12104 | 5 | 17 | 131 | 31 | 34 |
| 12105 | 14 | 14 | 17 | 18 | 18 |
| 12106 | 23 | 45 | 48 | 48 | 56 |
| 12107 | 3 | 6 | 6 | 7 | 6 |
| 12108 | 14 | 16 | 19 | 25 | 25 |
| 12109 | 10 | 12 | 16 | 16 | 17 |
| 12110 | 31 | 36 | 36 | 37 | 28 |
| 12111 | 9 | 16 | 18 | 20 | 18 |
| 12112 | 2 | 3 | 5 | 8 | 8 |
| 12113 | 14 | 21 | 18 | 23 | 23 |
| 12114 | 15 | 25 | 29 | 32 | 30 |
| 12115 | 18 | 40 | 45 | 76 | 89 |
| 12116 | 1 | 1 | 2 | 2 | 7 |
| 12117 | 27 | 34 | 30 | 40 | 43 |
| 12118 | 14 | 52 | 51 | 49 | 50 |
| 12119 | 12 | 16 | 15 | 18 | 23 |

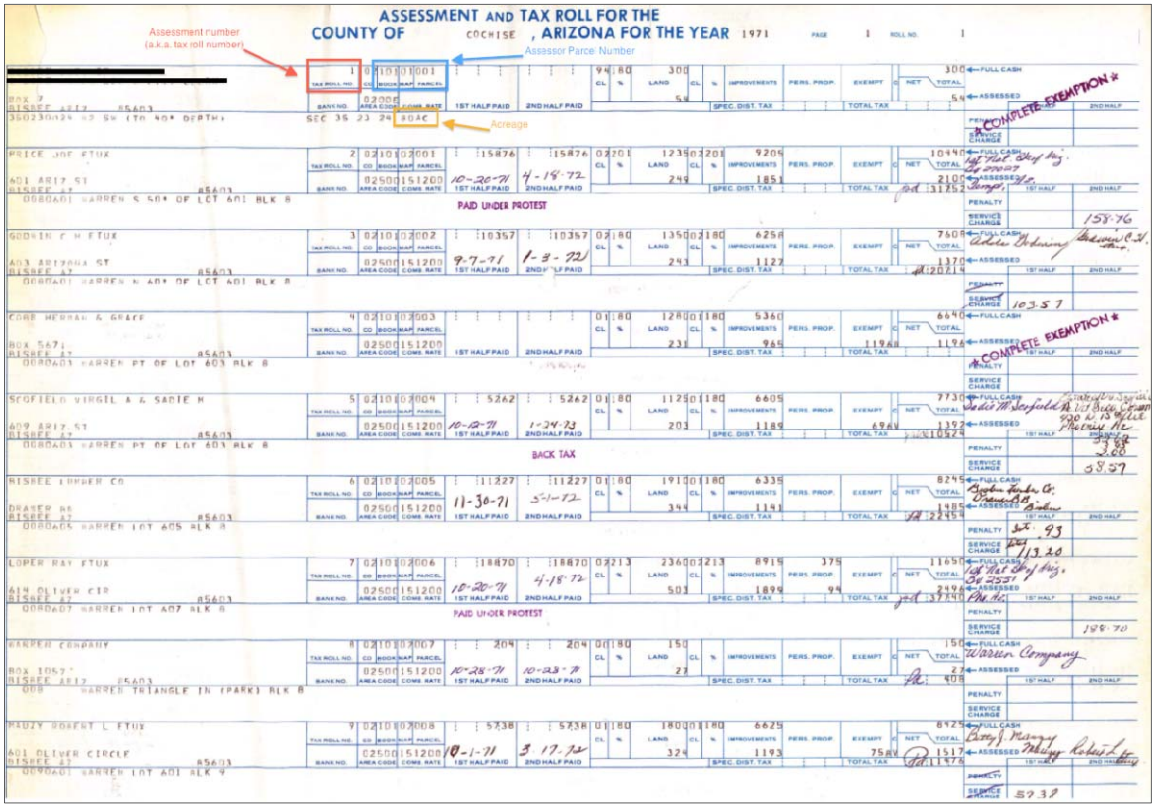
| Book-Map | 1971 (# of parcels) | 1981 (# of parcels) | 1991 (# of parcels) | 2001 (# of parcels) | 2012 (# of parcels) |
|---|---|---|---|---|---|
| 12120 | 1 | 13 | 25 | 28 | 33 |
| 12121 | 13 | 44 | 69 | 91 | 90 |
| 12122 | 7 | 13 | 20 | 20 | 26 |
| 12124 | 4 | | 8 | | |
| 12123 | 2 | 4 | 4 | 37 | 47 |
| 12125 | 6 | 15 | 14 | 17 | 19 |
| 12126 | 2 | 2 | 2 | 2 | 1 |
| 12127 | 4 | 4 | 4 | 4 | 7 |
| 12128 | 11 | 16 | 23 | 34 | 40 |
| 12129 | 0 | 0 | 16 | 16 | 16 |
| 12130 | 0 | 0 | 12 | 12 | 12 |
| 12131 | 4 | 4 | 12 | 4 | 4 |
| 12133 | 5 | 5 | 4 | 6 | 7 |
| 12134 | 2 | 3 | 3 | 4 | 4 |
| 12135 | 7 | 8 | 8 | 10 | 10 |
| 12136 | 10 | 14 | 13 | 16 | 22 |
| 12137 | 2 | 2 | 4 | 4 | 6 |
| 12139 | 1 | 1 | 4 | 4 | 5 |
| 12140 | 2 | 2 | 2 | 2 | 3 |
| 12141 | 1 | 2 | 4 | 4 | 9 |
| 12142 | 1 | 3 | 3 | 3 | 3 |
| 12143 | 1 | 1 | 15 | 1 | 1 |
| 12144 | 1 | 2 | 12 | 1 | 1 |
| 12146 | 1 | 1 | 1 | 169 | 170 |
| 12147 | 2 | 2 | 2 | 2 | 76 |
| 12149 | 1 | 1 | 1 | 1 | 1 |
| 12150 | 2 | 2 | 2 | 2 | 2 |
| 12151 | 0 | 40 | 41 | 41 | 39 |
| 12425 | 0 | 16 | 18 | 31 | 44 |
| 12431 | 3 | 3 | 3 | 5 | 6 |
| 12432 | 1 | 1 | 1 | 1 | 1 |
| 12434 | 1 | 1 | 1 | 1 | 2 |
| 12435 | 2 | 2 | 2 | 2 | 2 |
| 12436 | 0 | 0 | 0 | 0 | 2 |
| 12439 | 2 | 2 | 2 | 2 | 2 |
| 12440 | 10 | 10 | 9 | 27 | 28 |
| 12441 | 29 | 14 | 24 | 29 | 33 |
| 12445 | 0 | 0 | 4 | 4 | 4 |

# Appendix C: Land Jurisdiction in Study Area

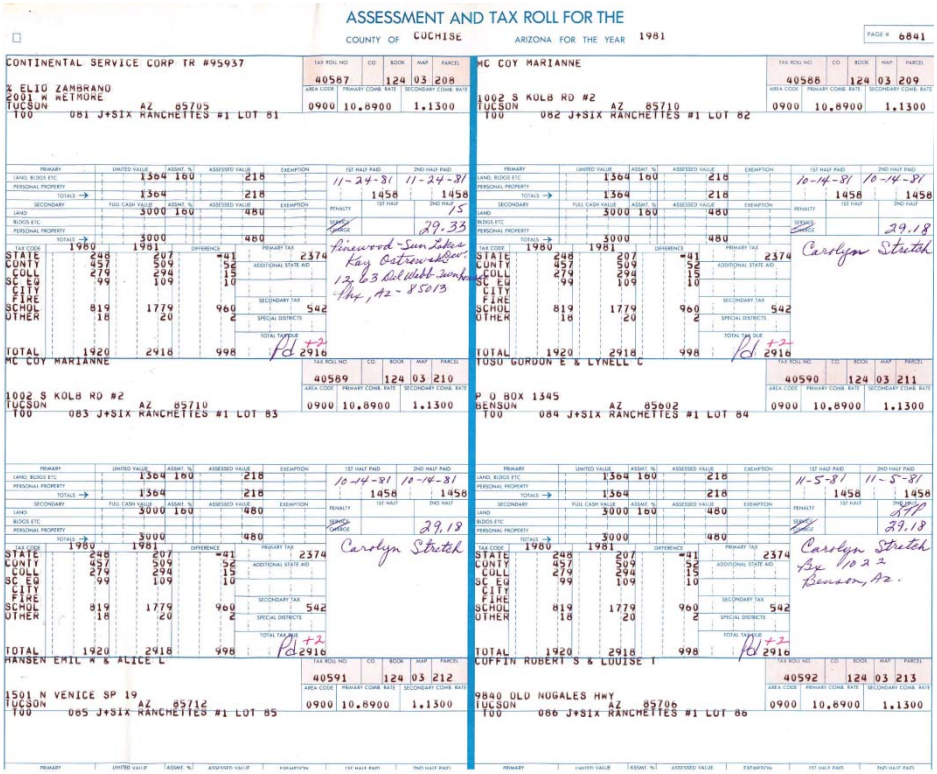



Land Jurisdiction and book-map data provided by Cochise County. San Pedro River and Watershed data from USGS NHD.

# Appendix D: Example Tax Roll Records for 1971, 1981 and 1991




Scanned 1971 Tax Roll Record (Courtesy of Cochise County Archives, 2012).



ASSESSMENT AND TAX ROLL FOR THE

COUNTY OF COCHISE ARIZONA FOR THE YEAR 1981

PAGE # 6841

CONTINENTAL SERVICE CORP TR #95937
% ELIO ZAMBRANO
2001 N HETMORE
TUCSON AZ 85703
T00 081 J+SIX RANCHETTES #1 LOT 81
TAX ROLL NO. 40587 CO. BOOK 124 MAP 03 PARCEL 208
AREA CODE 0900 PRIMARY COMB. RATE 10.8900 SECONDARY COMB. RATE 1.1300
PRIMARY LAND, BLDGS ETC 1364 160 218
PERSONAL PROPERTY
TOTALS → 1364 218
SECONDARY LAND 3000 160 480
BLDGS ETC
PERSONAL PROPERTY
TOTALS → 3000 480
1980 1981 DIFFERENCE PRIMARY TAX
STATE 248 207 -41 2374
CUNTY 457 509 52
COLL 279 294 15
SC ED 99 109 10
CITY
FIRE
SCHOL 819 1779 960 542
OTHER 18 20 2
TOTAL 1920 2918 998 2916
1ST HALF PAID 11-24-81 1458
2ND HALF PAID 11-24-81 1458
PENALTY
SEWER CHARGE 29.33
Pd +2

MC COY MARIANNE
1002 S KOLB RD #2
TUCSON AZ 85710
T00 082 J+SIX RANCHETTES #1 LOT 82
TAX ROLL NO. 40588 CO. BOOK 124 MAP 03 PARCEL 209
AREA CODE 0900 PRIMARY COMB. RATE 10.8900 SECONDARY COMB. RATE 1.1300
PRIMARY LAND, BLDGS ETC 1364 160 218
PERSONAL PROPERTY
TOTALS → 1364 218
SECONDARY LAND 3000 160 480
BLDGS ETC
PERSONAL PROPERTY
TOTALS → 3000 480
1980 1981 DIFFERENCE PRIMARY TAX
STATE 248 207 -41 2374
CUNTY 457 509 52
COLL 279 294 15
SC ED 99 109 10
CITY
FIRE
SCHOL 819 1779 960 542
OTHER 18 20 2
TOTAL 1920 2918 998 2916
1ST HALF PAID 10-14-81 1458
2ND HALF PAID 10-14-81 1458
PENALTY
SEWER CHARGE 29.18
Carolyn Stretch
Pd +2

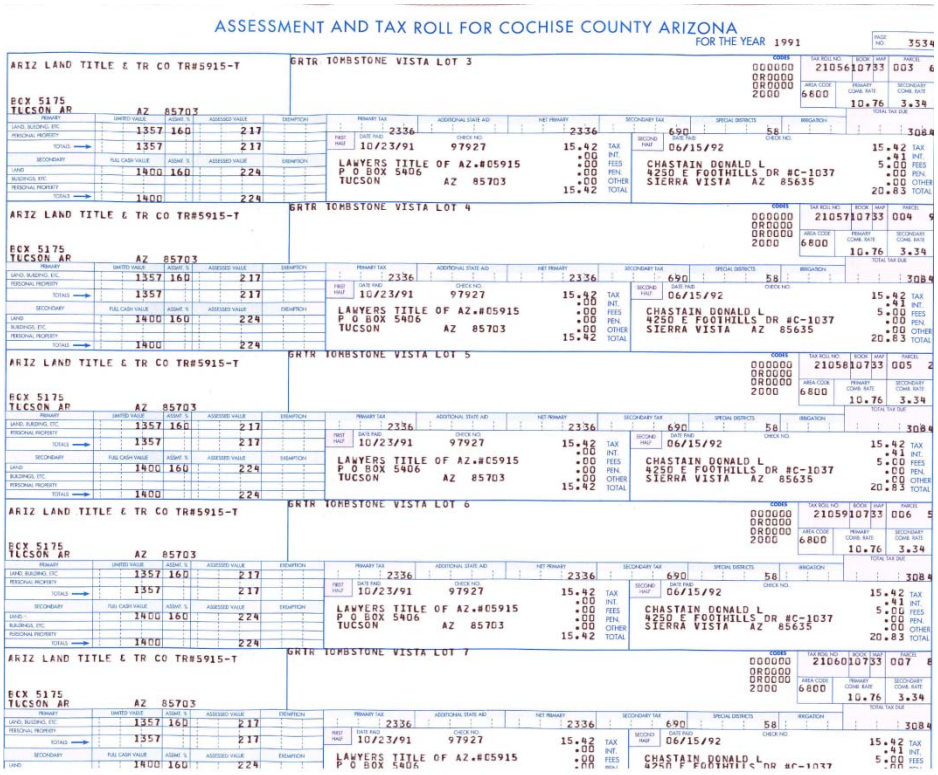
MC COY MARIANNE
1002 S KOLB RD #2
TUCSON AZ 85710
T00 083 J+SIX RANCHETTES #1 LOT 83
TAX ROLL NO. 40589 CO. BOOK 124 MAP 03 PARCEL 210
AREA CODE 0900 PRIMARY COMB. RATE 10.8900 SECONDARY COMB. RATE 1.1300
PRIMARY LAND, BLDGS ETC 1364 160 218
PERSONAL PROPERTY
TOTALS → 1364 218
SECONDARY LAND 3000 160 480
BLDGS ETC
PERSONAL PROPERTY
TOTALS → 3000 480
1980 1981 DIFFERENCE PRIMARY TAX
STATE 248 207 -41 2374
CUNTY 457 509 52
COLL 279 294 15
SC ED 99 109 10
CITY
FIRE
SCHOL 819 1779 960 542
OTHER 18 20 2
TOTAL 1920 2918 998 2916
1ST HALF PAID 10-14-81 1458
2ND HALF PAID 10-14-81 1458
PENALTY
SEWER CHARGE 29.18
Carolyn Stretch
Pd +2

TUSU GORDON E & LYNELL C
P O BOX 1345
BENSON AZ 85602
T00 084 J+SIX RANCHETTES #1 LOT 84
TAX ROLL NO. 40590 CO. BOOK 124 MAP 03 PARCEL 211
AREA CODE 0900 PRIMARY COMB. RATE 10.8900 SECONDARY COMB. RATE 1.1300
PRIMARY LAND, BLDGS ETC 1364 160 218
PERSONAL PROPERTY
TOTALS → 1364 218
SECONDARY LAND 3000 160 480
BLDGS ETC
PERSONAL PROPERTY
TOTALS → 3000 480
1980 1981 DIFFERENCE PRIMARY TAX
STATE 248 207 -41 2374
CUNTY 457 509 52
COLL 279 294 15
SC ED 99 109 10
CITY
FIRE
SCHOL 819 1779 960 542
OTHER 18 20 2
TOTAL 1920 2918 998 2916
1ST HALF PAID 11-5-81 1458
2ND HALF PAID 11-5-81 1458
PENALTY
SEWER CHARGE 29.18
Carolyn Stretch
Box 1022
Benson, Az.
Pd +2

HANSEN EMIL M & ALICE L
1501 N VENICE SP 19
TUCSON AZ 85712
T00 085 J+SIX RANCHETTES #1 LOT 85
TAX ROLL NO. 40591 CO. BOOK 124 MAP 03 PARCEL 212
AREA CODE 0900 PRIMARY COMB. RATE 10.8900 SECONDARY COMB. RATE 1.1300

COFFIN ROBERT S & LOUISE T
9840 OLD NOGALES HWY
TUCSON AZ 85706
T00 086 J+SIX RANCHETTES #1 LOT 86
TAX ROLL NO. 40592 CO. BOOK 124 MAP 03 PARCEL 213
AREA CODE 0900 PRIMARY COMB. RATE 10.8900 SECONDARY COMB. RATE 1.1300

Scanned 1981 Tax Roll Record (Courtesy of Cochise County Archives, 2012).



ASSESSMENT AND TAX ROLL FOR COCHISE COUNTY ARIZONA

FOR THE YEAR 1991

PAGE NO. 3534

ARIZ LAND TITLE & TR CO TR#5915-T
BOX 5175
TUCSON AR 85703
GRTR TOMBSTONE VISTA LOT 3
CODES 000000 ORDOOO ORDOOO 2000
TAX ROLL NO. 21056 BOOK 10 MAP 733 PARCEL 003
AREA CODE 6600 PRIMARY COMB. RATE 10.76 SECONDARY COMB. RATE 3.34
TOTAL TAX DUE 3084
PRIMARY LAND, BUILDING, ETC 1357 160 217
PERSONAL PROPERTY
TOTALS → 1357 217
SECONDARY LAND 1400 160 224
BUILDINGS, ETC
PERSONAL PROPERTY
TOTALS → 1400 224
PRIMARY TAX 2336 ADDITIONAL STATE AID NET PRIMARY 2336 SECONDARY TAX 690 SPECIAL DISTRICTS 58 IRRIGATION
FIRST HALF DATE PAID 10/23/91 CHECK NO. 97927 15.42 TAX .00 INT. .00 FEES .00 PEN. .00 OTHER 15.42 TOTAL
LAWYERS TITLE OF AZ.#C5915
P O BOX 5406
TUCSON AZ 85703
SECOND HALF DATE PAID 06/15/92 CHECK NO.
CHASTAIN DONALD L
4250 E FOOTHILLS DR #C-1037
SIERRA VISTA AZ 85635
15.42 TAX .41 INT. 5.00 FEES .00 PEN. .00 OTHER 20.83 TOTAL

ARIZ LAND TITLE & TR CO TR#5915-T
BOX 5175
TUCSON AR 85703
GRTR TOMBSTONE VISTA LOT 4
CODES 000000 ORDOOO ORDOOO 2000
TAX ROLL NO. 21057 BOOK 10 MAP 733 PARCEL 004
AREA CODE 6600 PRIMARY COMB. RATE 10.76 SECONDARY COMB. RATE 3.34
TOTAL TAX DUE 3084
PRIMARY LAND, BUILDING, ETC 1357 160 217
PERSONAL PROPERTY
TOTALS → 1357 217
SECONDARY LAND 1400 160 224
BUILDINGS, ETC
PERSONAL PROPERTY
TOTALS → 1400 224
PRIMARY TAX 2336 ADDITIONAL STATE AID NET PRIMARY 2336 SECONDARY TAX 690 SPECIAL DISTRICTS 58 IRRIGATION
FIRST HALF DATE PAID 10/23/91 CHECK NO. 97927 15.42 TAX .00 INT. .00 FEES .00 PEN. .00 OTHER 15.42 TOTAL
LAWYERS TITLE OF AZ.#C5915
P O BOX 5406
TUCSON AZ 85703
SECOND HALF DATE PAID 06/15/92 CHECK NO.
CHASTAIN DONALD L
4250 E FOOTHILLS DR #C-1037
SIERRA VISTA AZ 85635
15.42 TAX .41 INT. 5.00 FEES .00 PEN. .00 OTHER 20.83 TOTAL

ARIZ LAND TITLE & TR CO TR#5915-T
BOX 5175
TUCSON AR 85703
GRTR TOMBSTONE VISTA LOT 5
CODES 000000 ORDOOO ORDOOO 2000
TAX ROLL NO. 21058 BOOK 10 MAP 733 PARCEL 005
AREA CODE 6600 PRIMARY COMB. RATE 10.76 SECONDARY COMB. RATE 3.34
TOTAL TAX DUE 3084
PRIMARY LAND, BUILDING, ETC 1357 160 217
PERSONAL PROPERTY
TOTALS → 1357 217
SECONDARY LAND 1400 160 224
BUILDINGS, ETC
PERSONAL PROPERTY
TOTALS → 1400 224
PRIMARY TAX 2336 ADDITIONAL STATE AID NET PRIMARY 2336 SECONDARY TAX 690 SPECIAL DISTRICTS 58 IRRIGATION
FIRST HALF DATE PAID 10/23/91 CHECK NO. 97927 15.42 TAX .00 INT. .00 FEES .00 PEN. .00 OTHER 15.42 TOTAL
LAWYERS TITLE OF AZ.#C5915
P O BOX 5406
TUCSON AZ 85703
SECOND HALF DATE PAID 06/15/92 CHECK NO.
CHASTAIN DONALD L
4250 E FOOTHILLS DR #C-1037
SIERRA VISTA AZ 85635
15.42 TAX .41 INT. 5.00 FEES .00 PEN. .00 OTHER 20.83 TOTAL

ARIZ LAND TITLE & TR CO TR#5915-T
BOX 5175
TUCSON AR 85703
GRTR TOMBSTONE VISTA LOT 6
CODES 000000 ORDOOO ORDOOO 2000
TAX ROLL NO. 21059 BOOK 10 MAP 733 PARCEL 006
AREA CODE 6600 PRIMARY COMB. RATE 10.76 SECONDARY COMB. RATE 3.34
TOTAL TAX DUE 3084
PRIMARY LAND, BUILDING, ETC 1357 160 217
PERSONAL PROPERTY
TOTALS → 1357 217
SECONDARY LAND 1400 160 224
BUILDINGS, ETC
PERSONAL PROPERTY
TOTALS → 1400 224
PRIMARY TAX 2336 ADDITIONAL STATE AID NET PRIMARY 2336 SECONDARY TAX 690 SPECIAL DISTRICTS 58 IRRIGATION
FIRST HALF DATE PAID 10/23/91 CHECK NO. 97927 15.42 TAX .00 INT. .00 FEES .00 PEN. .00 OTHER 15.42 TOTAL
LAWYERS TITLE OF AZ.#C5915
P O BOX 5406
TUCSON AZ 85703
SECOND HALF DATE PAID 06/15/92 CHECK NO.
CHASTAIN DONALD L
4250 E FOOTHILLS DR #C-1037
SIERRA VISTA AZ 85635
15.42 TAX .41 INT. 5.00 FEES .00 PEN. .00 OTHER 20.83 TOTAL

ARIZ LAND TITLE & TR CO TR#5915-T
BOX 5175
TUCSON AR 85703
GRTR TOMBSTONE VISTA LOT 7
CODES 000000 ORDOOO ORDOOO 2000
TAX ROLL NO. 21060 BOOK 10 MAP 733 PARCEL 007
AREA CODE 6600 PRIMARY COMB. RATE 10.76 SECONDARY COMB. RATE 3.34
TOTAL TAX DUE 3084
PRIMARY LAND, BUILDING, ETC 1357 160 217
PERSONAL PROPERTY
TOTALS → 1357 217
SECONDARY LAND 1400 160 224
PRIMARY TAX 2336 ADDITIONAL STATE AID NET PRIMARY 2336 SECONDARY TAX 690 SPECIAL DISTRICTS 58 IRRIGATION
FIRST HALF DATE PAID 10/23/91 CHECK NO. 97927 15.42 TAX .00 INT. .00 FEES
LAWYERS TITLE OF AZ.#C5915
P O BOX 5406
SECOND HALF DATE PAID 06/15/92
CHASTAIN DONALD L
15.42 TAX .41 INT. 5.00 FEES

Scanned 1991 Tax Roll Record (Courtesy of Cochise County Archives, 2012).

## References


American Rivers. 1999. America's Most Endangered Rivers of 1999. http://www.americanrivers.org/our-work/protecting-rivers/endangered-rivers/background/past-reports.html (Last accessed May 16 2011).

Arias, H. M. 2000. International Groundwaters: The Upper San Pedro River Basin *Case*. *Natural Resources Journal*. 40: 199-221.

Bahre, C.J. 1991. *Legacy of Change: Historic Human Impact on Vegetation in the Arizona Borderlands*. Tucson, AZ: University of Arizona Press.

Bahre, C. J. and M. L. Shelton. 1993. Historic vegetation change, mesquite increases, and climate in southeastern Arizona. *Journal of Biogeography* 20:489-504.

Bureau of Land Management (BLM). 2013. Homesteading Timeline. www.blm.gov/pgdata/etc/medialib/blm/wo/Law_Enforcement/nlcs/education__interpretation/homestead_graphics0.Par.57736.File.dat/Expanded%20Homestead%20Timeline%20final.pdf (Last accessed May 25 2013).

Bierwagen, B. G., D. M. Theobald, C. R. Pyke, A. Choate, P. Groth, J. V. Thomas, and P. Morefield. 2010. National Housing and Impervious Surface Scenarios for Integrated Climate Impact Assessments. *Proceedings of the National Academy of Sciences of the United States of America*. Vol. 107, No. 49 20887-20892.

Branson, F. A. 1985. Vegetation changes on western rangelands. Society for Range Management.

Brauman, K. A., G. C. Daily, T. K. Duarte, and H. A. Mooney. 2007. The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. *Annual Review of Environmental Resources* 32:67–98.

Browning-Aiken, A., H. Richter, D. C. Goodrich, B. Strain, and R. Varady. 2004. Upper San Pedro Basin: Fostering Collaborative Binational Watershed Management. *International Journal of Water Resources Development* 20 (3): 353-367.

Burchell, R. W. and S. Mukherji. 2003. Conventional development versus managed growth: the costs of sprawl. *American Journal of Public Health* 93(9), 1534-1540.

Burns, I. S., W. G. Kepner, D. P. Sidman, D. C. Goodrich, L. R. Guertin, L. R. Levick, W. Yee, M. Scianni, C. S. Meek, and J. B. Vollmer. 2013. *Assessing Hydrologic Impacts of Future Land Cover Change Scenarios in the San Pedro River (U.S./Mexico).* EPA/600/R-13/074; ARS/294076. U.S. Environmental Protection Agency, Office of Research and Development, Las Vegas, NV.

Center for Biological Diversity/CBD. 2013. San Pedro River: Action Timeline. www.biologicaldiversity.org/programs/public_lands/rivers/san_pedro_river/action_timeline.html (Last Accessed July 2 2013).

Chapin, F. S., P. A. Matson, and H. A. and Mooney. 2002. *Principles of Terrestrial Ecosystem Ecology*. New York, NY: Springer Science.

Bredehoeft, J., R. Lacewell, J. Price, H. Arias, J. Stromberg, and G. Thomas. 1999. *Ribbon of Life: An Agenda for Preserving Transboundary Migratory Bird Habitat on the Upper San Pedro River*. Commission for Environmental Cooperation, Montréal, Qué.

Covington, W. W. and M. M. Moore. 1992. Postsettlement Changes in Natural Fire Regimes: Implications for Restoration of Old-growth Ponderosa Pine Forests. In *Old-growth forests in the Southwest and Rocky Mountain Regions*, eds. Kaufmann, M. R., W. H. Moir, and R. L. Bassett. United States Department of Agriculture (USDA)/ United States Forest Service (USFS), Fort Collins, CO.

Davis, Tony. 2013. Dispute looms in Sierra Vista over housing vs. water rights. *Arizona Daily Star*. http://azstarnet.com/mobi/business/article_03a3c62f-ad96-5c64-a5c0-5983e55b88ad.html (Last accessed July 2 2013).

DeFries, R. S., and K. N. Eshleman. 2004. Land-use Change and Hydrologic Processes: A Major Focus for the Future. *Hydrological Processes* 18(11): 2183-2186.

Esparza, A. X. and Carruthers, J. I. 2000. Land Use Planning the Exurbanization in the Rural Mountain West: Evidence from Arizona. *Journal of Planning Education and Research* 20: 23-36.

Grover, H. D. and H. B. Musick. 1990. Shrubland Encroachment in Southern New Mexico, U.S.A.: an Analysis of Desertification Processes in the American Southwest. *Climatic Change* 17:305-330.

Hastings, J. R., & R. M. Turner. 1965. *The Changing Mile: An Ecological Study of Vegetation Change with Time in Her Lower Mile of An Arid and Semi-arid Region*. Tucson, AZ: University of Arizona Press.

Humphrey, R. R.1958. The desert grassland a history of vegetational change and an analysis of causes. *The Botanical Review* 24(4), 193-252.

International Association of Assessing Officers/IAAO. 2012. *Standard on Digital Cadastral Maps and Parcel Identifiers*. www.iaao.org/uploads/Standard_Digital_Cadastral_Mapping.pdf (Last accessed on July 9 2013)

Kepner, W. G., D. J. Semmens, D. T. Heggem, E. J. Evanson, C. M. Edmonds, S. N. Scott, D. W. and Ebert. 2003. *The San Pedro River Geo-data Browser and Assessment Tools*. EPA/600/C-03/008; ARS/152432. U.S. Environmental Protection Agency, Office of Research and Development, Las Vegas, NV.

Kepner, W. G., C. J. Watts, C. M. Edmonds, J. K. Maingi, S. E. Marsh, and G. Luna. 2000. A Landscape Approach for Detecting and Evaluating Change in a Semi-arid Environment. *Journal of Environmental Monitoring and Assessment* 64, No. 1: 179-195.

Kepner, W.G., C. M. Edmonds, and C. J. Watts. 2002. Remote Sensing and Geographic Information Systems for Decision Analysis in Public Resource Administration: A Case Study of 25 Years of Landscape Change in a Southwestern Watershed. EPA/600/R-02/039. U.S. Environmental Protection Agency, Office of Research and Development, Las Vegas, NV.

Kepner, W. G., D. J. Semmens, S. D. Bassett, D. A. Mouat, and D. C. Goodrich. 2004. Scenario Analysis for the San Pedro River, Analyzing Hydrological Consequences of a Future Environment. *Journal of Environmental Monitoring and Assessment* 94:115–127.

Koprowski, J. L., A. J. Edelman, B. S. Pasch, and D. C. Buecher. 2005. *A dearth of data on the mammals of the Madrean Archipelago: what we think we know and what we actually do know*. USDA Forest Service proceedings RMRS-P-36, 412-415.

Mandelker, D. R. 2010. National Environmental Policy Act: A Review of Its Experience and Problems. *The Washington University Journal of Law and Policy* 32: 293-312

Nakicenovic, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, and Z. Dadi. 2000. *Special report on emissions scenarios: a special report of Working Group III of the Intergovernmental Panel on Climate Change* (No. PNNL-SA-39650). Pacific Northwest National Laboratory, Richland, WA (US), Environmental Molecular Sciences Laboratory (US).

National Health and Environmental Effects Research Laboratory (NHEERL). 2013. *Level III Ecoregions of North America.* U.S. Environmental Protection Agency, Office of Research & Development (ORD).

Nie, W., Yuan, Y., Kepner, W., Nash, M. S., Jackson, M., & Erickson, C. 2011. Assessing impacts of Land-use and Land-cover changes on hydrology for the upper San Pedro watershed. *Journal of Hydrology* 407(1): 105-114.

40 C.F.R § 15808.8 (b). Indirect effects. 1970.

40 C.F.R § 6.207 (a)(3)(xi) Environmental Impact Statements. 1970.

Pool, D. R., & A. L. Coes. 1999. *Hydrogeologic investigations of the Sierra Vista subwatershed of the upper San Pedro basin, Cochise County, southeast Arizona*. US Geological Survey.

Powers, R. 2002. *Plowing the dark*. Random House.

Rodgers, W. M. 1965. *Historical land occupance of the upper San Pedro River Valley since 1870.* University of Arizona.

Skroch, M. 2009. Sky Islands of North America: A Globally Unique and Threatened Inland Archipelago. *Journal of Wilderness* 15(1): 9.

Swanson, F. J., J. A. Jones, D. A. Wallin, and J. H. Cissel. 1993. Natural Variability-Implications for Ecosystem Management. In *Eastside forest ecosystem health assessment, Vol. II, Ecosystem management: principles and applications*, eds. Jensen, M.E. and P.S. Bourgeron. USDA/USFS, Missoula, MT.

Smith, N. 1996. The Production of Nature. *FutureNatural: Nature, science, culture* 35-54.

Southeastern Arizona Governments Association/SEAGO. 1978. *Section 208 Water Quality Management Plan.*

SEAGO. *2012. Section 208 Water Quality Management Plan*. http://seago.org/?q=2011-wqmp-update (Last accessed July 9 2013).

Turner, R. M., R. H. Webb, J. E. Bowers, and J. R. Hastings. 2003. *The Changing Mile Revisited: An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semiarid Region*. Tucson, AZ: University of Arizona Press.

U.S Census. 1970. The Decennial Censuses for Arizona. www.census.gov/prod/www/decennial.html (Last accessed June 5 2013).

U.S Census. 2010. The Decennial Censuses for Arizona. www.census.gov/prod/www/decennial.html (Last accessed June 5 2013).

U.S. Environmental Protection Agency (EPA). 2009. *Land-Use Scenarios: National-Scale Housing-Density Scenarios Consistent with Climate Change Storylines*. EPA/600/R-08/076F. U.S. Environmental Protection Agency, Global Change Research Program, National Center for Environmental Assessment, Washington, DC.

U.S. Environmental Protection Agency. 2010. *ICLUS V1.3 User's Manual: ARCGIS Tools for Modeling US Housing Density Growth*. EPA/600/R-09/143F . U.S. Environmental Protection Agency, Global Change Research Program, National Center for Environmental Assessment, Washington, DC.

U.S. Environmental Protection Agency STOrage and RETrieval (STORET). 2012. HUC 15050202. http://www.epa.gov/storet/. (Last accessed July 9 2013).

Vitousek, P. M. 1994. Beyond global warming: Ecology and global change. *Ecology* 75(7):1861–1876.

Vörösmarty, J., P. Green, J. Salisbury, and R. B. Lammers. 2000. Global water resources: vulnerability from climate change and population growth. *Science* 289, 284–288.

West, C. T. and M. Vásquez-León. 2008. Misreading the Arizona landscape: Reframing analyses of environmental degradation in southeastern Arizona. *Human Organization* 67(4), 373-383.

Whitehead, P. G., R. L.Wilby, R. W. Battarbee, M. Kernan, and A.J. Wade. 2009. A Review of the Potential Impacts of Climate Change on Surface Water Quality. *Hydrological Sciences* 54(1), 101–123.

United States Department of Agriculture/USDA. 1979. *Monitoring Foreign Ownership of U.S. Real Estate: A Report to the Congress, Vol. 2.*

Upper San Pedro River Partnership. (2011). *Water Management of the Regional Aquifer in the Sierra Vista Subwatershed, Arizona - 2011 Report to Congress.* U.S. Department of the Interior, Washington, DC.

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