Using LiDAR, Aerial Photography, and Geospatial Technologies to Reveal and Understand Past Landscapes in Four West Central Missouri Counties

BY

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Chapter 1: Introduction

This dissertation focuses on Hugh Prince's (1969) principle of using the present (in this case as seen through remotely sensed imagery) to understand the past via relict features. I propose studying ghost towns, cemeteries, and abandoned railroads via NAIP (National Agriculture Imagery Program) and LiDAR (Light Detection And Ranging) imagery. The remnants of ghost towns, cemeteries, and abandoned railroads ("relict features") often manifest themselves in surface spatial patterns and terrain deformation. Ghost towns are common throughout the United States, and railroads redefined the urban and small-town landscape of the central United States, replacing or modifying previous patterns (Hudson, 1985). The United States railroad network reached its zenith in 1916 and since has been in serious decline in terms of mileage (Hiss, 1997). Cemeteries are ubiquitous across the United States and the Geographic Names Information System (GNIS) database offers a listing for many, but not all, cemeteries.

Ghost Towns

The study of ghost towns is common, with several articles and many books on the subject. Fitzgerald (1988) defined a ghost town as a town that has seen a 2/3 decline in population and/or a 2/3 decline of its business district; an additional consideration in his definition was the potential for a town to come back within the next 20 years. He noted that there are approximately 6,000 ghost towns in Kansas alone and many more nationally. It is worth noting that many of the leading researchers on ghost towns offer definitions that include a number of towns that still have inhabitants and some current activities. Fitzgerald (2009) divided ghost towns into eight categories: boomtowns, agricultural towns, mining towns, trail towns and railheads, annexation and paper towns, county seats, free-state/pro-slavery towns, and miscellaneous towns. Boomtowns came primarily from rapid growth via artificial means, typically growing rapidly and dying just as rapidly. Agricultural towns had economies based on local agriculture, with relatively small populations, and saw their fortunes rise and fall with the local agricultural economy. Often without solid transportation linkages, agriculture towns passed from existence with the consolidation of agriculture. Mining towns shared the boom and bust cycle of boomtowns; however, their boom and bust was dependent on the fate of mines and quarries. Decreases in prices of the natural resources extracted, areas with cheaper mine operation costs, and depletion of the natural resource often led to the end of mining towns. Trail towns and railheads share a history of being towns that prospered with transportation and passed from being when the transportation shifted. Annexation and paper towns actually are two different categories that Fitzgerald lumped together. Paper towns were towns that were platted (plats are surveys to establish boundaries and lay off lots of towns, which are filed with a county's court) but that never physically existed - little if any construction in the platted area took place. Often paper towns were moneymaking schemes by individuals not living in the area. Annexed towns once existed independently but were later annexed by larger, nearby municipalities. Fitzgerald's county seats category is for towns that declined or disappeared after the county seat was lost to another town. Free-state/pro-slavery towns fit into the larger scope of towns destroyed via war or political means. Miscellaneous towns function as a catch-all category that includes towns destroyed by natural disaster (flood, tornados, etc.) or ecological disasters such as Picher, Oklahoma, contaminated by tailings from lead and zinc mining.

Abandoned Railroads

Fitzgerald (1994), Baker (1991), and Morris (1980) discussed the role of railroads in the creation and destruction of towns. In the nineteenth century, an American town's ability to gain linkage to a railroad, and the longevity of the railroad, often determined a town's success or failure (Fitzgerald, 1988). Railroads often redefined the urban landscape of a state, sometimes creating ghost towns out of towns bypassed by the railroad (Hudson, 1985). After a peak of approximately 254,000 miles of railroads in 1916, totals fell to between 70,000 and 75,000 miles by 1995 (Hiss, 1997). Hiss stated there were nearly 179,000 miles of abandoned railroads in the United States in 1997. At present, there is no national database of historic railroads and after repeated mergers, records have often been lost or forgotten. However, the rise of the rails-to-trails movement has encouraged better documentation of historic rail lines so that landholders know the potential for conversion of nearby lines.

Cemeteries

Baker (1991) and Fitzgerald (1994) both noted that one of the most frequent remnants of a ghost town is a cemetery. Cemeteries are common cultural remnants throughout the landscape where humans have lived. Often, documentation exists in county cemetery books not readily available to the public. The GNIS database offers a partial listing of cemeteries in the United States, but this documentation is incomplete, with many cemeteries forgotten. However, there are researchers interested in different aspects of cemeteries and burials. Deetz (1996) investigated the morphology of gravestones during the American Colonial period. Reeder et al. (2004) utilized ground penetrating radar (GPR) to 122 (additional) suspected gravesites at Qumran, Israel, that offered no surface expression. Other researchers have been interested in burial mounds throughout various locations in the world. Trier et al. (2008) applied high-resolution satellite imagery to the identification of burial mounds. They suggested that the application of LiDAR to such a scenario has been underexplored. Crutchley (2006) did attempt to apply LiDAR to the Barlings Abby Barrow Cemetery in Lincolnshire, England. However, even with a 20-times exaggeration, most of the barrows were not clear.

Remote Sensing and Relict Features

Remote sensing offers a researcher the ability to see landscapes from different perspectives and at different scales, and evolving sensor technology provides greater spatial, spectral, temporal, and radiometric resolution, offering greater capabilities for studying past landscapes. Historically, remote sensing studies of the Central United States have focused primarily on agriculture and land cover/land use mapping. However, little research applying remote sensing to understanding past landscapes in this region of the country exists. A great deal is known about past cultures of the United States but what remnant features remain and what do they tell us? Utilizing remote sensing is an excellent way to apply technological means to answer cultural questions about the historical landscape of the central United States.

High spatial resolution is particularly beneficial for the detection of relict features still visible on the ground. Visual interpretation of NAIP imagery is useful for identifying relict features as the spatial resolution is one meter, imagery is free, it is georeferenced, and its imagery catalogue dates back to 2003 (United States Department of Agriculture, 2008). Thornton et al. (2006) found that QuickBird imagery (0.6 meter resolution) works well for mapping rural land cover features including hedgerows and trees - both are often remaining relict features in ghost settlements. Comfort et al. (2000) used satellite imagery, KVR-1000, Corona, and SPOT

(Satellite Pour l'Observation de la Terre) to examine historic routes and the historic city of Zeugma, Turkey (currently under excavation).

However, not every feature is easily visible from high spatial resolution imagery from multispectral sensors or aerial photographs. Processed LiDAR imagery offers excellent elevation data and may reveal features not easily detected via high spatial resolution multispectral imagery or air photos. The vertical accuracy of LiDAR typically ranges from .5 to 15 centimeters (Corns and Shaw, 2009). Post-processed LiDAR imagery removes vegetation, and due to superior vertical accuracy, may reveal relict features not otherwise easily detectable. The availability of digital technology (cameras, GPS units, etc.), digital maps, plentiful remotely sensed data, and user-friendly geographic information systems (GIS) software makes this the time to investigate relict features upon the landscape before the remnant traces become too faint to detect.

Research Questions

The overriding direction of this dissertation is the use of remote sensing to aid our understanding of past landscapes. In addition, I focused on the examination of imagery representation of relict features on the LiDAR and NAIP imagery as opposed to historical aerial photographs and topographic maps. Many studies using remote sensing for agriculture and land use/land cover mapping exist for the central United States. Researchers also know a great deal about the recent past of cultures but few geographic studies have focused on using remote sensing to interpret remaining relict features of these cultural landscapes.

The specific research questions for this study relate to the use of remote sensing technology and imagery as applied to the cultural landscape.

1) What can remote sensing help us to learn about the historical cultural landscape of the area?

- Will LiDAR and NAIP help to confirm what was depicted on plat books and GNIS?
- Will LiDAR and NAIP reveal features not appearing on historic plat books and GNIS?

2) If relict features are visible on the ground, which ones are detectable via various remote sensing means?

- Which sensor or sensors (LiDAR or NAIP) will reveal which categories of relict features (ghost towns, cemeteries, railroads, and their components) more readily?
- Will overlaying imagery (NAIP overlaid onto LiDAR) increase the ease of relict feature detection?

3) Will LiDAR's vertical accuracy be sufficient to detect relict features not revealed by NAIP imagery?

- Will detection of relict features lying in open areas such as grasslands or crop fields differ from those under tree canopies?
- Does age of a relict feature affect sensor detection of the feature?

Dissertation Overview

The remainder of this dissertation is divided into chapters covering the Literature Review (Chapter 2), Study Area (Chapter 3), Methods (Chapter 4), Results and Discussion (Chapter 5), Conclusions (Chapter 6), and an Epilogue (Chapter 7). In addition, there are chapters for the References (Chapter 8), Tables (Chapter 9), Figures (Chapter 10), and Appendices. The literature review (Chapter 2) provides an overview of literature relevant to the study of relict features, landscape, remote sensing for relict features, LiDAR, and Historical Geographic Information

Systems. This chapter provides previous research as a conceptual framework to move forward with this dissertation.

Chapter 3, Study Area, offers an in-depth description of the study area. The study area consists of four counties in West Central Missouri: Carroll, Chariton, Lafayette, and Saline. For each of the counties, a general physiographic description is presented. The next section of Chapter 3, Ghost Towns, focuses on in-depth histories of the 20 ghost towns discussed in this study, with five ghost towns in Carroll County, five in Chariton County, four in Lafayette County, and six in Saline County. Following the section on ghost towns is a section discussing the eight abandoned railroads found in the study area. Five cemeteries in each county are discussed in depth in the final section of the chapter

Chapter 4, Methods, further explains the concepts, data, and the design and procedures used. By combining historical data, remotely sensed data, and GIS data, a geographer can create a modern GIS representation of the location and distribution of historical cultural features. Schuppert and Dix (2009) suggested using GIS to recreate historic cultural landscapes and they found GIS to be the only convenient way for dealing with historical maps. Historical data for this study came from historical county plat books from the 1870s to the 1910s. County plat books are public records that contain maps, plats, and copies of recorded that were produced approximately every 20 years and include information regarding ghost towns and abandoned railroads, while the GNIS database was used for information regarding cemeteries. The University of Missouri and the Missouri Spatial Data Information Service provided the GIS data and remotely sensed images. The section on Design and Procedure, discusses the acquisition of historical plat book information (via photocopies and digital photography) and the georeferencing of the historical maps. Putting historical map data into a digital format made it possible to overlay the historical data on the remotely sensed imagery, which facilitated visual inspection and interpretation in a historical-geographical context. Quantitative analysis was performed for three different parts of the study: an independent samples t-test for statistical significance to compare RMS errors between georectified digital photographs and scans from historical plat books; a dependent samples *t*-test for statistical significance to determine if one form of imagery reveals more historical roads than the other; and a Pearson R Correlation between approximate death date of a town and remaining historical roads.

Chapter 5, Results and Discussion, addresses the results of the six research questions and includes a discussion of their significance. The presentation of results consists primarily of reporting of relict features in the form of descriptions, counts of features, and images showing the remains. The *Conclusion*, Chapter 6, discusses what was learned in this study, Potential Limitations, Significance to Other Research Areas, and Future Research Directions. In the Epilogue, Chapter 7, is a discussion of flooding along the Missouri River that led to further destruction of a number of relict features during the time the research and writing of this dissertation took place. The remaining chapters - References (Chapter 8), Tables (Chapter 9), Figures (Chapter 10), and Appendices - complete the dissertation.

This dissertation reaches beyond basic documentation of relict features to contribute to the democratizing of data. Information gathered here is available via .kml format to empower and to stimulate future citizen mapping attempts. Data regarding abandoned railroads will be contributed to the website AbandonedRails.com for public consumption. By sharing the knowledge gained via the internet, this dissertation will help to encourage public contribution to knowledge. Democratizing of knowledge leads to a more thorough understanding, stronger databases, and increased public input.

Chapter 2: Literature Review

This review covers a range of topics regarding the application of geospatial technology to the study of relict features. The first section discusses the history of the Study of Relict Features; brief conceptual history of relict features is presented, followed by a number of studies that analyze relict features. The second section, Landscapes, discusses the changing definition of landscape as a unit of analysis in geography and differing methods for landscape interpretation. The third section focuses on Cultural Landscapes of the Central United Sates, including a discussion of various cultural landscape studies throughout the region. In the fourth section, the history of Relict Features and Remote Sensing is discussed, which transitions into the fifth section on Geoarchaeology and Remote Sensing. This fifth section discusses the rise of remote sensing technology for geoarchaeology from the 1980s to the present. The sixth section, LiDAR, offers a definition of that sensor and discusses applications of the technology for landscapes and cultural geography. An in-depth discussion of Historical GIS in the seventh section concludes the literature review. Within that section, the birth and the rise of HGIS as a research area is first examined, followed by Urban HGIS, which looks at many different scales of landscapes from individual cities to the national level; Quantitative Studies of Single Points in Time, where articles are presented that challenge traditional orthodoxies and help to uncover new data about limited area; Changes over Space and Time, that discusses a number of different HGIS studies that utilize GIS as a way to accommodate the complexity of data and to allow for easier methods of data analysis; Qualitative Analysis, which discusses literature regarding the application of HGIS to research outside of the common quantitative bounds of GIS; Theoretical and Conceptual Concerns, a discussion of both historical and modern concerns; HGIS Today, which offers a contemporary view of HGIS from Anne Kelly Knowles and other leading HGIS authors and a final section, HGIS in this Dissertation, discusses how this dissertation utilizes HGIS concepts.

Study of Relict Features

Geography has a history of interest in relict features. Carl Sauer introduced the concept of relict features in his 1925 article, "The Morphology of Landscape," and later put forth a call for renewed emphasis on historical geography in his "Foreword to Historical Geography" (1941). Sauer (1925) viewed geography as "based on the reality of the union of physical and cultural elements of the landscape" (p. 29); integral to his view of geography was "a succession of these [cultural] landscapes with a succession of cultures" (p. 37). He stated, "We are interested in that part of the areal scene which concerns us as human beings because we are part of it, living with it, are limited by it, and modifying it" (p. 29). Clearly, human modification of landscapes played an important role to Sauer. He further stated, "The cultural landscape then is subject to change either by the development of a culture or by a replacement of cultures" (p. 37). The latter is of interest, as relict features may remain even after the replacement of one culture by another.

In "Relict Landscapes" (1969), Hugh Prince expanded upon Carl Sauer's original concept of relict features. Regarding them, he stated, "All features in the present landscape are relict features, survivals from some past period. Constant reference to past events is necessary to understand how they came to occupy their present positions, but not all past events are equally important" (p. 29). Prince discussed two different approaches to studying relict features, "using the present as a key to understanding the past, and the past as a key to understanding the present" (p. 29). However, Prince noted that Sauer took a narrower view of relict features, with the surviving institutions representing conditions that were once dominant but that have subsided into the background. Prince further defined relict features by stating, “In the framework of the present-day economic and social geography of an area, relict features are those that cause friction. They are obsolete and resist change” (p. 30). Beds of railroads, cemeteries, and ghost towns are an excellent fit to this definition. Prince reminded the geographer of the importance of fieldwork when saying, “Field observations raise and may resolve questions upon which documents are silent” (p. 29). In addition, he suggested that “reconstruction of the past from the present, by what Maitland called ‘the retrogressive method,’ proceeds from the better known to the lesser known” (p. 29). He suggested that some relict features may eventually attain fame, “Relict features may also be preserved as monuments or outdoor museums of past cultures such as Stonehenge and the Acropolis, or places of period charm such as Bath and New Orleans (p.30).” Cemeteries work well into this schema.

Lowenthal (1975) examined the relict past and its present place in both landscape and memory. Describing the human desire for the past, he stated, “Nowadays the terrible future gains on us; we look back to old familiar landscapes in the fear that the comforts of the past may be vanishing before our eyes” (p. 1). Mass production of past imitations and keepsakes help to support Lowenthal’s case for the interest and importance of the past. In support, he stated, “Indeed, the tangible links that bind us to history defy enumeration” (p. 5). Lowenthal believed that humans have an almost innate need for past landscapes to cope with current landscapes. “We need the past, in any case, to cope with present landscapes” (p. 5). In addition, “The tangible past affects people most in their everyday surroundings” (p. 8). His work attempts “to show why we need tangible evidence of the past, the forms our need takes, and some consequences for landscapes and townscapes, relic and artifact” (p. 5). However, Lowenthal reminded the reader, “it is not simply nostalgia that makes the past so powerful. Hindsight and overview enable us to comprehend past environments in ways that elude us when we deal with the shifting present" (p. 7). Lowenthal also cautioned the reader, "relics we see need not be historically true or accurate; they need only convince us that we are connected with something that really did happen in the past" (p. 11-12). In addition, "Because we feel that old things should look old, we may forget that they originally looked new" (p. 26). Lowenthal offered two key thoughts on the importance of relict features. "Through awareness of the past, we learn to remake ourselves" (p. 24). "The past is also an elusive realm that we experience only fleetingly" (p. 25).

Raitz (1994) also showed a keen interest in relict features in his work on route geography and two edited volumes on *The National Road* (Raitz, 1996a; Raitz 1996b). He continued his interest in historic roads via academic articles discussing the history and legacy of routes in the Kentucky Bluegrass region (Raitz and O'Malley, 2005; Raitz and O'Malley 2007).

Landscape

Landscape may refer to the appearance of an area, the arrangement of objects that produce a particular appearance, and an area itself (Johnston et al., 2000). Warf (2006) suggested that the English word landscape has two meanings that are both complementary and contradictory: human shaping of a particular territorial space (i.e. the earth's surface) and visual or mental images of that specific space (easily understood at a glance). The two different definitions entered into the English language via different routes and eventually melded into the multidimensional word we have today. By the Middle Ages, the term Landscape (landskipe or landscaef) referred to land under the control of a lord or land inhabited by a specific group of people (Mikesell, 1968; Warf, 2006). Under the influence of Dutch painters during the 17th century, landscape came to refer to the appearance of an area and the representation of scenery.

Warf (2006) stated that, to the Dutch, landscape referred "to the look or appearance of the land, especially in paintings of the rural scene" (p. 75). By 1630, landscapes referred to paintings and large-scale rural vistas of towns, fields, woods, and church steeples that inspired the emerging English merchant class (Warf, 2006). During the late 1800s, universities in France and Germany began a scholarly tradition of examining the relationship between the natural environment and human interactions. German geographers called this new area of study *landscape science*, as geography was more interested in the forms of landscapes in specific areas. The early German landscape scientists attempted to scientifically study regions, settlements, village types, and agricultural systems. Johnston et al. (2000) stated that by the latter nineteenth century the basic form of the contemporary definition came into being, "a portion of land or territory which the eye can comprehend in a single view, including all objects so seen, especially in its pictorial aspect" (p. 420-430).

Carl Sauer formally introduced the term landscape in his landmark article "Morphology of Landscape" (1925), cited earlier. The article drew from the German geographers Passarger and Schlüter and their concept of landschaft (Johnston et al., 2000). The study of landschaft was interested in the forms of landscapes in a region and the schemes that were proposed to allow clarification of landscapes and their elements, to provide standardized procedures for analysis. Schemes allowed for distinguishing between natural and cultural landscapes, thereby recognizing human agency. Sauer's concept of landscape functioned as an alternative to the then common concept of environmental determinism (Johnston et al., 2000). Sauer viewed landscape as more than an attractive view - it was not merely a picture, vista, or a painting (Warf, 2006). Rather, Sauer viewed landscape as an area or region that was a product of natural elements that include climate, soil, plant life, and animal life, as well as the cultural attributes of population, economics, housing, and communication. The landscape approach attempted to describe the interrelations between humans and the environment, downplaying the subjective aspects of landscape, and focused on landscape as an objective area of study through scientific observation (Johnston et al., 2000). Sauer (1925) did mention the subjective; however, he stressed the use of scientific observation as the true method of landscape study. According to Johnston et al. (2000), Sauer's position was "that geographers should proceed genetically and trace the development of natural landscape into a cultural landscape" (p. 430). However, Sauer realized that was often impossible because human intervention radically altered the natural landscape, making reconstruction nearly impossible.

The formal birth of cultural geography and the study of cultural landscapes had its origins with Carl Sauer and the Berkeley School (Pitzl, 2004). The school encouraged direct field observations of cultural responses to environmental imprints left upon a landscape. In general, the creation of a cultural landscape takes time and is also created as transportation networks develop (Pitzel, 2004). Developed countries often see landscapes heavily influenced by dense networks of surficial transportation including railroads, interstate highways, and local level highways. Railroads, in particular, have historically been an important part of shaping the landscapes of countries. In developing countries, surficial transportation networks are less effective but still represent part of the cultural landscape. During this early period of American geography, Hartshorne (1939) defined cultural landscapes as being "restricted pieces of land" (p. 65). Warf (2006) cited Wilber Zelinsky's correlation of town design in the Pennsylvanian Cultural Area and Fred Kniffen's study of vernacular architectural spread as examples of the Berkeley School's interest in landscape. Landscape studies can include such additional topics as food preference, agricultural practices, settlement patterns, building types, building materials, and land division systems (such as the long lot system used by the French).

Following the Berkeley School, during the 1950s, English historian W. G. Hoskins and the American geographer (although educated in Europe) J. B. Jackson greatly influenced the study of landscape (Johnston et al., 2000). In 1951, Jackson founded Landscapes (a magazine) and from there went on to write a number of articles and books on landscapes. Since the 1960s, much of the intellectual context of landscape studies can be traced back to Jackson. Warf (2006) stated that Jackson defined landscape as, "a portion of the earth's surface that can be comprehended at a glance" (p. 75).

Jackson's "Metamorphosis" (1972) discussed the American cultural landscape via the death of the small town. Through the unique pattern of small towns found in the American South and Midwest, Jackson celebrated the common in the American landscape. He suggested that overexposure to the small town can lead to sensitivity to even the smallest change between towns. This sensitivity leads to an awareness of reading landscapes, the ability to notice minor differences in small towns. Jackson also discussed that the examination of architectural ruins, and the material culture of a town is important for reading and understanding a landscape. He indicated that the decline of towns is often not rapid; rather, it is the end of a long continuum that led toward death. Of particular interest to Jackson was the death of the second and third floors in the buildings of small-town downtowns. Jackson saw the eventual outcome of small town death as the destruction of the vertical development in favor of horizontal development. He concludes with the suggestion that to understand the changing landscape of the United States, one must admit that the United States is unique and does not share the same cultural landscape as Europe.

Discovering the Vernacular Landscape (1986) is a collection of Jackson's essays that discuss landscapes of the United States. In his first chapter, Jackson delved into the etymology of the word landscape itself. He presented diverging ideas about the definition of the word landscape followed by defining the boundaries of a landscape. A brief history of roads also was given with an interesting note that, historically, roads often would avoid small towns, a practice not unlike those engaged in by railroads in the United States. Furthermore, he noted that roads in the western two-thirds of the United States often follow the outlines of the public land survey system (PLSS) and, while country roads are costly to maintain, in the survival of such roads is the survival of those who refuse to migrate to urban areas, a symbol of our shared past.

Jackson (1986) pointed out that landscapes may not always be immediately visible. Often, researchers are blinded by the filters through which they view life and it is important, when viewing a landscape, to see it through other lenses. Deconstruction of landscapes is an additional challenge; how does one break apart a landscape to see important elements individually? One can also examine how the individual elements create a whole. Jackson attempted to deconstruct the small town and suggested a population threshold of 10,000 for viability. Jackson discussed the reason for placement of county seats on the Plains - ease of access for everyone from the far reaches of the county led to rulings for centering of county seats.

The tradition laid out by Jackson expands the dialogue about landscape beyond geography to include historians, architects, anthropologists, social theorists, and literary critics (Warf, 2006). Donald Meinig edited a volume entitled *The Interpretation of Ordinary Landscapes* (1979) which included landscape essays from Peirce Lewis, David Lowenthal, Donald Meinig, David Sopher, and Yi-Fu Tuan (Johnston et al., 2000). Although the work did not break new ground, it summarized the state of landscape studies at the time. Lowenthal (1986) found landscape to be “all-embracing – it includes virtually everything around us” (p. 1). However, Tuan (Meinig, 1979) viewed landscape as based on imagination, representation, or sensory perception of land: “an image, a construct of the mind, a feeling” (p. 89). Lewis (Meinig, 1979) saw landscape as an object of perception, meaning almost everything one sees when going outside. Meinig (1979) viewed landscape as “composed not only of what lies before our eyes but what lies within our heads” (33-34). Duncan and Duncan (2009) noted that Stephen Daniels shares Meinig’s view that landscape is both material and ideological.

During the 1980s and 1990s, several new developments in conjunction with the new cultural geography took place. Much of the new cultural geography draws upon European and British social and cultural theory, with a great deal of recent human geography examining the relationship between the built environment and the media outlets that depict the built environment (Warf, 2006). Material cultural landscapes remain a vital subject for historical geographers, but more geographers are creating new areas of research by tracing the iconography of historic events (Warf, 2006). Warf stated, “Drawing from visual cultural studies and on the theoretical perspectives of postmodernism, this work examines landscape as a cultural image, a pictorial way of representing, ordering, or symbolizing the world” (p. 215). Representations of a particular landscape may come in many different forms that include: travel narratives, photographs, maps, and paintings. Dennis Cosgrove was a champion of this when he characterized landscape as not being an object or a geographic area, rather a form of seeing (Warf, 2006). Warf (2006) said of Cosgrove’s view of landscape, that it was “a pictorial means of representing or structuring the world” (p. 77).

However, connections to the older landscape traditions remain, although an emphasis is placed on social and cultural theory as applied to landscape interpretation. A premium is placed upon showing how landscape is important to social, cultural, and political systems. Cosgrove and Daniels (1989) discussed landscape in Marxist terms, where the duplicity of landscape (deceitfulness of a casually observed landscape) is demonstrated by the lack of coherency and timelessness. Don Mitchell (1996) shared a similar view that even if a landscape appears beautiful, it can lie and hide deep, harsh social and labor conditions that brought about the current landscape. David Harvey (1985, 1989) discussed Marxist interpretation of landscapes of cities as a common theme in a number of his writings. Harvey's work also has ventured into postmodernism, particularly in *The Urbanization of Capital* (1985). Other geographers interested in landscapes and postmodern geography include Edward Soja (1989, 1992), Mike Davis (1990), Elizabeth Wilson (1991), and Michael Sorkin (1992).

A number of geographers have continued in this tradition, capitalizing on diverse studies that emphasize communicative and representational aspects of landscape that include methodological sources, art history, and poststructuralist notions as important parts of cultural ecology (Warf, 2006). Mona Domosh (1996) discussed how upper class leaders of New York and Boston envisioned the urban culture in divergent ways with varying representation and materials unique to each city. However, countries may possess certain landscapes that are thought of as more symbolic than are individual cities within the country (Warf, 2006). David Matless (1998) discussed the entwined and underlying relationships between landscapes and English identity as powerful social interests and historical factors. These factors, according to Matless, constructed a natural sense of rootedness of the English in both soil and land.

Another view of landscape has come from feminist scholars, including Gillian Rose who objected to landscapes as having inherently masculine overtones (Warf, 2006). Vera Norwood and Janice Monk's edited book *The Desert is No Lady* (1997) stated that a consideration of landscape is to understand gender, in addition to race, ethnicity, class, and sexuality. Delores Hayden (2004) discussed the history of American suburbanization with a discussion of the interplay between built and natural environment and showed that the resulting landscapes affected almost every aspect of modern American life. Hayden's account of suburbanization is in stark contrast to the previous studies and accounts that focused on changes in transportation networks and technology. James Duncan and Nancy Duncan (2003) focused on being suspicious of the visual appearance of a landscape but not for methodological or theoretical reasons. Rather, Duncan and Duncan focused on environmental aspects of aesthetics of suburban New York which illustrated that the physical presentation of landscape carries a range of markers for both inclusion and exclusion.

Landscape is a dynamic and growing area in many fields of study and definitions and theoretical underpinnings of landscape are varying and far-flung. The new cultural geography has built upon older concepts of landscape, carrying the term to new and broader horizons. As discussed, the concept of landscape is fluid and still a matter of discussion in the literature, both historically and currently.

Cultural Landscapes of the Central United States

A large body of literature focusing on cultural landscapes of the central United States exists. Hudson (1988) studied the places of origin of settlers to the central United States, (Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, Iowa, Michigan, Wisconsin, Minnesota, North

Dakota, and South Dakota) based on the 1880 census. Also, Hudson (1973) discussed homesteading expansion in two counties in the Dakotas from 1870 to 1910. Hewes and Frandson (1952) studied usage of prairie soils before and after drainage in Story County, Iowa during the homesteading period. Hudson (1979, 1985) focused on the railroad and its re-creation of the urban landscape in North Dakota. Shortridge (2004) also acknowledged the omnipresence of railroads along with other factors in the creation of the modern Kansas urban landscape. Brown (1948) looked in-depth at promotional imagery of Minnesota to entice settlement, including steamboat travel, agriculture, immigrant settlement, and railroad influences. McIntosh (1976) used land entry and land patent information from the original Land Office Tract Books to investigate and map the settlement of the Sand Hills region of Nebraska. Jordan (1964) discussed preference for settlement of forested areas versus prairies in 24 sites in Indiana, Illinois, Michigan, and Wisconsin.

Another view of historical cultural landscapes in the central U.S. relates to the impacts of immigrants. Hudson (1976) discussed the immigration of Canadians, Germans, Scandinavians, and the existing American population that settled North Dakota. Knowles (1997) offered an in-depth analysis of the settlement, land preferences, economy, and industry of Welsh immigrants to Ohio. Hume (2004) studied the urban settlement of Belgian immigrants to the Indiana rust belt. Lewis (1965) focused on the migration of African Americans and their impact on changing politics in Flint, Michigan from 1932 to 1962. Crisler (1948) used politics and immigration as a primary means to define a cultural region within Missouri.

Cultural geographers have used a number of other approaches to understand the historical and cultural landscapes of the central United States. Jordan (1963) took a decidedly material culture view of Texas by studying windmills, which are common throughout the central United

States. Marshall (1979) explored meat preservation techniques that were unique in Missouri in the Little Dixie region. Hurt (1992) and Jordan (1969, 1977) discussed agricultural techniques and practices as a part of the cultural landscape. Sauer (1920) looked at economic issues facing the Ozark Highlands, which also influenced the cultural landscape, and Hudson (1973) used statistics to model settlement distribution of suburbs in Illinois, Missouri, Iowa, Wisconsin, and Minnesota.

Remote Sensing and Relict Features

Remote sensing is important for investigating relict features, as it offers a different way of viewing the landscape. Campbell (2008) pointed out the advantages of the overhead perspective of remotely sensed images while at the same time cautioning about potential confusion caused by unfamiliar scales and resolutions. Cronin's "Northern Visions: Aerial Surveying and the Canadian Mining Industry, 1919-1928," (2007) discussed early era use of aerial photography for survey and identification of mineral deposits on the Canadian Shield. Bocking (2009) discussed the rise and development of aerial photography in Canada during the Cold War for topographic mapping and glacial mapping in "A Disciplined Geography: Aviation, Science, and the Cold War in Northern Canada, 1945–1960."

Having high spatial resolution is critical for the identification of smaller ground objects. Hawbaker et al. (2006) used aerial photography to map road changes for five different dates from 1937 to 1999 to measure change in habitat patch size. Kavzoglu et al. (2009) found that IKONOS (1 meter resolution) imagery is useful to determine the need for road resurfacing and rehabilitation in Istanbul, Turkey. Asphalt pixels from IKONOS imagery indicate road deformations are most common where vehicles reduce or increase speed rapidly or where vehicles have stopped. Hakeem and Raju (2009) found that by using high spatial resolution imagery (IKONOS), it is possible to create an accurate inventory of water storage tanks in Tamil Nadu, demonstrating that even small features are detectable with high-resolution imagery.

Geoarchaeology and Remote Sensing

Geoarcheologists and anthropologists are interested in using remote sensing to learn about relict features as well. Butzer (1982) defined geoarchaeology as a field that combines research in archeology with methods and concepts borrowed from earth sciences. Reeder et al. (2004) demonstrated this by combining human geographers, physical geographers, geologists, geomorphologists, Biblical scholars, historians, photographers, and geophysicists along with archeologists for a multidisciplinary research approach when studying the Khirbet Qumran archeological site in Israel. Lucas et al. (2005) noted that traditionally, there are three major limitations when identifying archeological sites: sites must be small enough for visualization and interpretation of visible remains; they must be visible and recognizable despite subsequent human activities; and despite weathering and erosion, the sites should be recognizable. Remote sensing can help to overcome these limitations.

Researchers recognize that remote sensing can greatly benefit both anthropology and geoarchaeology. Banks (1995) at the Second United Nations Educational, Scientific and Cultural Organization (UNESCO) International Expert Meeting sought to apply remote sensing to identify, study, and preserve ancient cultures around the world. He suggested a collaborative research team comprised of archeologists, ethnographers, cultural ecologists, environmental studies scientists, and remote sensing scientists for further study of remote sensing along the Silk Road. Lasaponara and Masini (2006) found that QuickBird imagery (0.6 meter spatial resolution) was useful for identification and spatial characterization of archaeological sites and detection of surface anomalies indicating buried archeological remains. Panchromatic images from QuickBird proved useful in the test case (in the south of Italy) for site planning prior to excavation and for increased information regarding the historic site. Bassani et al. (2009) used Multispectral Infrared and Visible Imaging Spectrometer (MIVIS) remotely sensed data to perform preliminary analysis of subsurface remains of archaeological areas cheaply and effectively. The research indicated that remote sensing is a powerful tool for examining the landscape for relict features.

Wilson (2000) suggested that rapid advancements in remote sensing technology have altered the way people view the earth. St. Joseph (1996) mentioned that for nearly 100 years aerial reconnaissance and photography from aircraft have provided valuable data for archeologists. Bewley (2003) stated, “Aerial photography for archeology has been developing its approaches and techniques over the past 100 years so that it now integrates the results of reconnaissance with extensive interpretative and analytical surveys” (p. 273). For example, researchers used maps and records from the English Heritage’s National Mapping Programme (NMP) to further the understanding of the past human settlement of England on multiple scale levels. NMPs goal is to increase knowledge and understanding of past human settlement by a synthesis of archeological sites and landscapes via remotely sensed imagery. “Developments in photography, cameras and aircrafts in the First World War accelerated the use of aerial photography and there was one man in particular, O.G.S. Crawford, who pioneered the technique for archaeology” (p. 274-275). Bewley specifically discussed how aerial reconnaissance of the Cherwell Valley markedly increased the number of known sites and transformed the knowledge of Iron Age settlements in Southern England. Advancements in satellite imagery have led some to have concerns about the continued viability of aerial photography. Kvamme (2005) discussed the development and use of terrestrial remote sensing, aerial remote sensing, and aerial photography. He argued that satellite remote sensing offers the advantage of seeing large areas rapidly for a relatively low cost. Remote sensing allows researchers to find features not easily seen from the surface, map the features precisely, and offer clues to their interpretations based on distribution, form, and context.

Remote Sensing in Archaeology (Wiseman and El-Baz, 2007) invited articles from authors in archeology and other fields. These interdisciplinary views show the importance of remote sensing in modern archeology. Evans and Farr (2007) discussed using Shuttle Radar Topography Mission (SRTM) digital elevation data to complement other existing data. Landscape re-creation becomes a possibility with higher quality digital elevation models (DEMs) that cover a majority of the earth. The authors found that "recent literature point to the potential of developing mitigation strategies for archeological and cultural heritage sites based on systematically acquired InSAR data" (p. 99). Fowler Jr. et al. (2007) quoted Carl Sauer's "The Morphology of Landscape" when discussing a landscape of conquest at Ciudad Vieja, El Salvador. Campana and Francovich (2007) found that QuickBird imagery is effective for finding castle ruins.

LiDAR

LiDAR is an acronym for light detection and ranging and it is an active system (Lillesand et al., 2004) that works by sending laser pulses of light directed toward a surface and measuring the time it takes the pulses to return. One unique aspect of LiDAR is that it produces multiple returns. Initial returns, called first returns, produce data regarding the top of canopies and other aspects of the natural and built landscapes. Last returns, the final returns to the sensor after penetrating the vegetation canopy, generally reflect the bare earth minus vegetation. The use of LiDAR for accurate terrain elevation measurement began in the late 1970s.

Ackerman (1999) documented airborne laser scanning for the creation of digital terrain models (DTMs) and surface models dating back to NASA concepts in the 1970s and 1980s in the United States and Canada. In 2005, Bewley et al. discussed the history of remote sensing for archeological research and the movement toward the usage of LiDAR. Crutchley (2006) suggested at a North Atlantic Treaty Organization (NATO) sponsored workshop in 2000 that LiDAR would have application in aerial archaeology research. Many early LiDAR researchers realized LiDAR's value to measure the elevation of terrain (Wehr and Lohr, 1999; Jensen, 2000; Holden et al., 2002; Bewley et al., 2005; Crutchley, 2006; Gallagher, 2007). Holden et al. (2002) believed that recent developments with airborne digital surveying for environmental mapping would inaugurate a new era for discovering and recording archaeological sites via multispectral sensors and LiDAR.

In a key study, Devereux et al. (2005) stated that, for over 50 years, oblique aerial photography was a mainstay of aerial reconnaissance for archeology. However, they noted that if lighting conditions and sun elevation are not at optimal levels, subtle ground markings might not be apparent. In addition, tree canopies hide other archeological features. They further noted that detection and mapping of archeological sites via aerial photography is among the oldest and most fruitful branches of remote sensing. However, even with ideal conditions, when soil moisture differences are at their maximum and when sun elevation is low in the sky, there is no guarantee that all features will be visible on aerial photography. Surveys conducted at different dates may reveal different features. Woodlands can hide even large archeological features from the camera lens, and completing a field study for such an area using multiple dates of photography would be expensive, laborious, and time consuming. As a result, archeological knowledge of sites under forested areas is less extensive than for agricultural areas. High resolution DEMs from LiDAR may help to overcome some of the limitations of standard aerial photography. LiDAR, in conjunction with hill shading, enables detection of variation in the elevation and direction of the illumination source for more effective feature detection. Results of Devereux et al's (2005) study indicated that LiDAR, "is extremely good at revealing even very subtle linear features. This is because the human eye has the capacity to filter discontinuities in such features caused by noise and lack of laser penetration" (p. 685). In addition to castle ramparts, Devereux et al. mention lynchets (a bank of earth that builds up on the downward slope of a ploughed field) and the open field system (under which a manor or village controlled several large fields that were farmed in strips by individual families) as good examples of features that are still detectable by LiDAR.

Hyyppa et al. (2000) found DTMs derived from laser scanning to be extremely accurate, and offering the possibility for generating three-dimensional (3D) height models of forested areas. Corns and Shaw (2009) discussed the use of LiDAR to produce three-dimensional models and ortho-images of earthwork monuments and surrounding archeological landscapes. Sensor accuracy of one centimeter in the study allowed for three-dimensional model creation of three sites when using helicopter based LiDAR. However, Corns and Shaw (2009) mention that the limitations of LiDAR data may vary between an accuracy of .5 centimeters and 15 centimeters depending on the sensor.

Many additional archeologists and geoarcheologists have realized the value of LiDAR for the detection of vertical archeological remains under vegetation (Devereux et al., 2005; Devereux et al., 2008; Doneus and Briese, 2006; Risbol et al., 2006; Sittler and Schellberg, 2006;

Crow et al., 2007). Other geoarcheologists have used LiDAR for both evaluation and prospecting (Brunning and Far-Cox, 2005; Challis, 2005; Challis, 2006; Challis et al., 2006; Carey et al., 2006; Jones et al., 2007). In addition, other geoarcheologists have used LiDAR to prospect for new sites and to define historical environments (Holden et al., 2002; Bewley, 2003; Crutchley, 2006).

Bewley et al. (2005) believed that "Lidar has the potential to radically transform our future understanding and management of the historic environment" (p. 636). Their research utilized both aerial photography and LiDAR, operating under the assumption that LiDAR would reveal few relict features not appearing on the NMP Survey. However, LiDAR helped to identify additional sites and improve positional accuracy, and sites thought previously ploughed under still appeared. In conclusion, they stated, "The composition of management plans and conservation plans, in particular, are enriched by lidar information and the facility for demonstrating the historic assets of landscapes in a highly accessible manner is of the greatest value to resource managers" (p. 645). Sittler (2004) agreed that LiDAR mapping has the potential to increase scientific knowledge of historic landscapes. Research by Sittler focused on depicting and assessing furrows and fossilized ridges in woodlands near Rastatt, Germany. The corrugated fields, with altimetric differences between 30 and 80 cm, resulted from medieval cultivation practices; those relict features survive, allowing one to understand how the medieval countryside worked. "Because traditional aerial photography is limited by the inability of optical sensors to collect information from beneath tree canopies, the purpose here was to test application prospects of the altimetry laser scanning (Lidar technology) for elevation data capture and for detecting and modeling terrain structure of ridge and furrow" (p. 258). LiDAR holds great promise for archeology as it may allow for greater assessment of archeological remains obscured by woodland areas. “Aerial photography does not reveal any microrelief patterns, but the DTM clearly shows the typical corrugated surface topography of the ridge and furrow” (p. 259).

Crutchley (2006) discovered using LiDAR is effective for the detection of cemetery stones in England. Upstanding (vertical) monuments appeared readily on LiDAR; however, earthen work borrows did not appear on the imagery. Crutchley’s strategy was to use multiple resources, as LiDAR alone has the potential to mislead researchers unfamiliar with a particular landscape and he cautioned against its use as the sole basis for landscape interpretation. Even with his reservations, Crutchley stated, “Lidar data are an important new source of information for surveying targeted at the historic environment and has the potential to provide major benefits to those carrying out such work” (p. 256-257).

Gallagher and Josephs (2008) applied LiDAR to cultural resources. They noted that beginning in the mid-1990s, LiDAR has proven successful in Europe for the identification of archeological sites concealed by dense vegetation or disturbances on the surface. LiDAR’s ability to see through vegetation allows for the identification of cultural features before typical fieldwork begins; aids in developing a more efficient survey strategy; and allows for a safer, more efficient, and more cost effective research design. Of the 32 features detected by LiDAR in their study, only 14 had appeared on previous documents. “Of the remaining 14 features, seven were confirmed in the field as being cultural features and were recorded for the first time as a result of this investigation” (p. 187). Results of the study supported using LiDAR as a viable method for detecting cultural resources, specifically in heavily forested areas. However, the authors noted that LiDAR should be part of a comprehensive research stratagem that incorporates laboratory, field, and archival research to create a comprehensive interpretation of the archeological record.

Challis et al. (2008) compared an inventory of relict features found by LiDAR to an existing record of the historical environment. “Then a selected number of aerial photographs were used to assess the extent to which lidar might improve on the record collected from a more conventional survey, using only aerial photography” (p. 1057). When comparing the LiDAR imagery and the historic environmental record, 84.4% of the relict features appearing on the LiDAR imagery were not in the historical environmental record. The researchers discovered, “An added advantage of lidar over photography is that it may be manipulated to show three dimensional images, contour maps, and profiles” (p. 1060). Conclusions indicated that “lidar offers considerable potential for the enhancement of historic records in landscapes dominated by upstanding earthwork remains” (p. 1060). In addition, the researchers found that while aerial photography offers reliable data for identifying features on the landscape, LiDAR detected additional sites that were not visible with aerial photography.

Harmon et al. (2006) discussed using LiDAR data for the creation of topographic maps that have greater 3D precision than offered by conventional maps. In addition, these new 3D maps may offer greater spatial accuracy. LiDAR imagery has the potential for revealing archeological deposits that go unnoticed when using standard discovery methods. Not all major surface features comprising a landscape are visible during surface reconnaissance and the spatial Gestalt does not readily appear through common field methods. Harmon et al. stated that LiDAR and GIS offer the ability to visualize landscapes both qualitatively and orthographically, enabling analysis of the entire site. Three-dimensional landscapes created via LiDAR allow for visualization of built landscapes, structures, and other cultural features of interest to an archaeologist. Photogrammetric stereo pairs and LiDAR complement each other for investigating buildings, as LiDAR provides more accurate vertical elevations (z dimension) while aerial photography may provide more accurate x, y dimension data. Aerial photography captures break lines, including building edges, with greater accuracy than LiDAR. Harmon et al. (2006) suggested combining built forms including terraces, paths, beds, lines, ponds, outbuildings, and other markers to create a view of the cultural landscape. "Such cultural landscapes, often defined as an area that has been transformed by human action, the boundaries of which are definable by sight, are usually intermediate scale phenomena, larger and more complex than the site as traditionally defined, but much smaller in area than the physiographic or cultural regions that often comprise the study areas for GIS-enabled analyses of archaeological sensitivity, settlement pattern, or other cultural systems" (p. 653).

Lucas et al. (2005) proposed an ambitious study to attempt to determine where the Roanoke colonists settled after the abandonment of the colony. Initially, the research team utilized Interferometric Synthetic Aperture Radar (InSAR) for penetration of vegetative canopies. However, a spatial resolution of 30 meters, as used in this study, is insufficient for the detection of many discrete cultural features. LiDAR with a spatial resolution that is frequently better than one meter, offers a better alternative, even with questions of statistical uncertainties when applied to small areas. "Patterns of sites that may not be noticed or understood at ground level may be viewed at another perspective. Subtle variations in the soil color, in the density, height, or types of vegetation, or patterns of shadows may give suggestions to the underlying buried features" (p. 2). By combining historical data, maps, and remote sensing the researchers hoped to locate where colonists fled after the abandonment of Roanoke.

Historical GIS

The 1998 and 1999 meetings of the Social Science History Association (SSHA) were abuzz with the new concept of historical GIS (HGIS) (Knowles, 2000). In particular, the 1998 SSHA meeting in Chicago was a watershed moment as many researchers had previously been unaware of others using the same methodology. Interest from this initial meeting generated a second, larger meeting in 1999 that included more research than the previous conference. In addition, many of the practical, theoretical and substantive issues important in early HGIS came from papers presented and discussions conducted at these first two conferences.

Knowles (2000) suggested in a special issue of *Social Science History*, for which she authored the introduction, the beginning of a movement toward HGIS as a mainstream research area. She hoped the special issue would convey the varied nature of HGIS, the potential of HGIS to expand the scope of social science history, its utility to find new answers to historical questions, and difficulties researchers face when applying GIS to their own studies. HGIS extends quantification and systematic empirical analysis to questions, scales, and evidence rarely considered by historians. HGIS is much like other kinds of GIS in structure with the key difference that source data typically include archival data that have to be converted to digital format. Building digital spatial databases is key in the creation of opportunities for GIS analyses of the past, especially in urban, transportation, business, and environmental history.

HGIS offers a wealth of possibilities for adding to the current literature of historical and cultural geographies. The concept of HGIS can be traced back to several antecedents that utilized the geographical perspective to analyze history (Knowles, 2008a). One of the earliest was the French Annales School. The school's strongest geographical trait was its treatment of region and place as subjects. Members of the school mapped history in a metaphorical sense via the combination of economy, culture, and political history in layers analogous to layers of a map (Knowles, 2008a). In addition, they were more interested in the function of the physical environment than a majority of the historians of the time. Geohistoire, as conceptualized by Fernand Braudel, is the understanding of both the spatial and environmental contexts of human activities and the mapping of such activities. American historical geography also has played a role in the intellectual development of HGIS. As noted earlier, Carl Sauer (1941) put forth the call to historical geography in his AAG presidential address. Another iconic figure in historical geography is Donald Meinig. Knowles (2008a) suggests that Meinig may be the best known historical geographer among historians due to his massive, four-volume series *The Shaping of America* (Meinig, 1986; Meinig 1992; Meinig, 1995; Meinig, 2004).

Paul Carter (1987) introduced the term spatial history and the term now serves as an umbrella concept for studies that examine the human experience in the frame of both physical and social space (Knowles, 2008a). Spatial history treats the concept of mapping as somewhat metaphorical, applying meaning based on hierarchies that structure social relations via the accessibility of a place by a class of individuals. Books and journals are the common place for the publication of spatial histories (Knowles, 2008a); whereas visual history and digital history are fields of research that typically publish through web-based media, devoting a great deal of space to imagery. Digital historians wish to engage and encourage readers via evidence to draw their own conclusions (Knowles, 2008a). This approach borrows from post-modernism and was applied by Knowles herself (2008b) in her study of “What Could Lee See at Gettysburg.” Knowles’ work began as an attempt to make primary documents accessible but along the way, the potential for the utilization of GIS emerged.

Ell and Gregory (2001) identified HGIS as a rapidly developing area of research. There are specific benefits of applying GIS in historical research. Each row of attribute data is linked to a coordinate-based representation of the object's location; thus, apparently incompatible datasets can be integrated simply through their location in space. The key to GIS utilization by historians is that source material can be placed in both space and time. Within the parameters suggested by Ell and Gregory (2001), data can be either qualitative, quantitative, or a mixture of the two; while the choice of approach lies with the researchers, not the software. Three advantages of GIS listed by Ell and Gregory (2001) are the ability to explore spatial patterns visually, the ability to integrate disparate datasets using location, and the ability to analyze data spatially. These three advantages allow researchers to handle data that contains a locational component in more powerful and sophisticated ways than was previously possible. This has led to a rekindling of interest in the importance of location in historical research as historians begin to use the potential offered by GIS.

Historically, the adoption of GIS by historians has been relatively slow (Ell and Gregory, 2001). Practical reasons for this include: GIS software is relatively expensive; there is still a steep learning curve associated with it; and GIS datasets are expensive and time-consuming to create. Additional factors include the fact that historians may not immediately see the advantages of using a spatial approach in their research and the fact that the origins of GIS lie in a more quantitative, scientific academic discipline.

However, there has been some clear movement in breaching this divide led first by historical geographers but spreading into mainstream history. The year 2000 saw the first special issue of a mainstream journal devoted to HGIS (Knowles, 2000), an increase in presentations at the Association of American Geographers (AAG), and the ground breaking book *Past Time, Past*

Place: GIS for History (Knowles, 2002a). Gregory et al. (2003) state that spatial information has been under-utilized by historians in the past and that GIS offers the opportunity to remedy this oversight. They suggest three key advantages of GIS: it provides new approaches for discovering and managing historical sources through the explicit expression of location; GIS's visualization abilities create a new medium for publishing historical data and substantive works of historical scholarship; and GIS offers new analytical methodologies that explicitly incorporate location.

In addition, Ell and Gregory (2001) discussed the growth of GIS beyond history with the Electronic Cultural Atlas Initiative (ECAI), an international collaborative organization based at the University of California, Berkeley. ECAI attempts to bring together historians, curators, and librarians from all parts of the discipline together with experts in database design, networking, and geographical information systems to promote best use of geographical information (Lancaster and Bodenhamer, 2002). Healey and Stamp (2000) discuss the fact that databases are substantial works of scholarship in their own right. Ell and Gregory (2001) also discuss the underlying theme that the use of GIS must build on the traditions of historical scholarship and be aimed at solving substantive issues rather than merely offering technological fixes.

Gregory and Healey (2007) took a look back across a decade of HGIS and into the field's current state. During the previous decade, the new field of HGIS had become an accepted and evolving part of both quantitative and qualitative research in historical geography. At the time the article was written, Gregory and Healey (2007) identified three common themes in HGIS: the creation and dissemination of historical GIS databases, the use of GIS to perform quantitative and qualitative analyses, and the underlying conceptual issues that underpin GIS. Although, the concept of HGIS began in the more quantitative ends of the discipline it has grown to encompass qualitative research as well.

Critical to the implementation of HGIS is the realization that GIS is more than mapping. The creation and maintenance of databases is vital in the implementation of HGIS across disciplines; building databases has long been recognized as the most time-consuming and costly stage of a GIS project. HGIS databases are rarely a simple digital facsimile of a single source. Instead they take data from multiple sources, integrate them in a manner that is sympathetic to the sources' limitations, and create metadata and documentation to record the sources and standards used. Gregory and Healey (2007) state that electronic databases are far more useful than their paper counterparts; however, it is harder for them to gain academic standing and for their creators to receive due recognition. Recognition of the problem is needed to continue the creation of databases and those databases as intellectual property. Dissemination is important for the furthering of HGIS and the Internet is the key for sharing historical databases. Specific examples of important online map collections include the Sydney Time Map Project (Wilson, 2001), David Rumsey Historical Map Collection, Alexandria Digital Library, and the Perseus Project. Gregory and Healey (2007) suggest the spread of HGIS beyond just historical geography will bring increased awareness of the importance of geography to historians.

Padilla (2008) discussed how HGIS is a subfield of historical geography that has allowed for the resurgence of geography, the reinvention of maps, and the vindication of geography. With the capability of GIS for spatial analysis, GIS can reveal patterns and relationships among data that are not readily apparent in spreadsheets or other statistical packages. By combining GIS and temporal data, a researcher can visualize urban growth, environmental change, weather patterns, and other social and scientific changes. HGIS also offers a new way to visualize and analyze population movement, distribution of wealth, and location of infrastructure. In addition, HGIS can help expand the spatial analysis of historical materials by collating and mapping historical data derived from many different kinds of historical resources such as letters, diaries, sketches, census data, and voting records. Padilla (2008) mentioned the creation of a number of current national HGIS digital archives and other digital archives. The Great Britain Historical Geographical Information System (GBHGIS) is a digital collection that shows the change over time within British regions, including census reports from 1801 to 2001, historical gazetteers, travelers' stories, and historical maps. Gregory et al. (2002) discussed the creation of the GBHGIS. Data for the GBHGIS project included records and censuses from the early 19th century to the 1970s and changing administrative boundaries from 1840 to 1973. Maps were combined with text sources in order to give exact dates of change. China Historical GIS was being developed by Harvard University and Fudan University (China) in 2001 with a database of places and administrative units in China, from 222 BC to 1911 AD. The National Historical Geographic Information System is a system for displaying and analyzing census tracts and tract changes in the US which can be viewed as maps or reports. In Canada, the History of the Book contains bibliographic, geographic, and biographical data regarding Canada's print culture from the 16th century through the 21st century. Currently, the History of the Book contains more text than GIS. Archeologists are also creating HGIS databases for archeological excavation sites in numerous locations. Padilla (2008) suggests future research in HGIS will embrace environmental history for urban and conservation planning, enabling historians, geographers, civil engineers, architects, and others to study urban changes through time in order to plan for further urbanization.

Bailey and Schick (2009) conceptualized HGIS as a field of study that encompasses what remains today or what had previously occurred with an approach that can borrow from both spatial and temporal perspectives. Almost every static or dynamic feature, phenomenon, or trend has a locational and historical component related to it. After generations of research that primarily focused on a history of the wealthy and powerful, social historians are beginning to reimage the lives of those who left few records. Historians have begun to broaden their scope to include more geographically influenced fields of study, including regional and environmental history. Improvements in GIS technology have facilitated the ability to analyze change over time and space, fostering the convergence of the two disciplines. Knowles (2002b) stated "Geography is the study of spatial differentiation, history the study of temporal differentiation. Historical GIS provides the tools to combine them to study patterns of change over space and time" (p. xii). Historical research regarding the ordinary person requires the ability to synthesize processes in dynamic and nonlinear ways and to accomplish synthesizing processes in dynamic and nonlinear ways; it is required to manage large arrays of both data and variables (Gregory, 2002). In addition to written documents, historical maps record locational attributes, fundamental for the reconstruction of historical settings, and the maps show data not commonly found in other written sources (i.e. boundaries, landscape features, etc.) or that have been destroyed via the progression of time and development (Rumsey and Williams, 2002). The capability of GIS to manage, analyze, and visually display spatially referenced data has led to the software being embraced by historians and students alike (Bailey and Schick, 2009).

Development of GIS has coincided with the digital information revolution which involved digital translation, manipulation, and dissemination of data (Goodchild, 1992). The capability of GIS for digital manipulation of spatial data enabled researchers to build on the quantitative revolution and, some believe, transcend the quantitative revolution by adding visual intuition that can be gained from spatial display (Bailey and Schick, 2009). Essentially, GIS extended quantitative analysis by allowing for a more intuitive approach through presentation of patterns via maps and other graphic media. Schuurman (2004) stated, “One of the chief virtues of GIS is that it allows the visualization of spatial data as well as providing a means of utilizing fuzzy data. Although quantitative science prefers clear and precise ‘facts,’ GIS provides a way to include data that is not pristine. It presents geographers with ways to visualize spatial arrangements and, in the process, recovers intuition from the wasteheap to which it was relegated during the quantitative revolution” (p. 7). Human interpretation of visual imagery helped to generate meaning from data by conveying data in a graphic form from which spatial patterns can be derived (Bailey and Schick, 2009). The visualization component of GIS helps it surpass many boundaries posed by conventional analyses.

Urban HGIS

With large populations and often with documents and records spanning decades to centuries, cities are an ideal topic of study for HGIS. In addition, as centers of commerce, transportation linkages often converge in urban areas, so a better understanding of historical urban areas can help one understand broader economic pattern and transportation patterns. GIS is an important tool for understanding these networks and their patterns on the landscape.

In an early study, Siebert (2000) created a comprehensive GIS database of the major features of Tokyo from the 19th century to the present. Data in Siebert’s study included physical landscapes, administrative boundaries, data from population and economic censuses, information about commercial and industrial activities, information on the growth of the road and rail networks, and information about land ownership. Another early study was Wilson’s (2001) creation of the Sydney TimeMap. Wilson focused on museum artifacts, locating them in space by complementing artifacts with a series of maps of the development of the city from the very early days of European settlement to the present. In addition, a wide range of primarily qualitative data from a variety of different sources was integrated, allowing the research to explore the development of Sydney from Aboriginal times to the present. At the core of the research was a spatio-temporal browser that allowed fragmented sources to be located in both time and space. The spatial framework used was based on a series of maps of Sydney dating from 1788 to 1998 that allowed users to chart the growth of the city and other information (paintings, engravings, and photos).

Great Britain has been the focus of a significant amount of HGIS development. Dorling et al. (2000) studied the health effects of poverty in London from 1896 to 1991. HGIS provided new insight into geographical change in ways that may help answer unresolved questions and ask entirely new questions using the census and similar sources to explore change over time. The study compared poverty in late Victorian London, as measured by Charles Booth, with 1991 mortality patterns. GIS allowed researchers to compare the modern ward-level data with the areas used by Booth. Results indicated that the areas with highest poverty rates from a century ago still have the highest poverty rates today and still have the highest mortality rates from many diseases. Dorling et al. (2000) stated that the continuing poverty shows characteristics of the areas have remained rather consistent over time and that area types are closely associated with the mortality characteristics of their inhabitants. Orford et al. (2002) expanded upon Dorling et al. (2000) (of which Orford was a coauthor) and focused specifically on Charles Booth's poverty maps of London in the late 19th century. Gregory and Healey (2007) examined how HGIS could be used for structuring, mapping, and analyzing local historical geographies as opposed to those at a national level. Localized HGIS databases are quicker and cheaper to build than national systems and allow researchers to move more quickly from the database creation phase of the project to the dissemination and analysis phases.

St-Hilaire et al. (2010) discussed the Canadian Century Research Infrastructure (CCRI) and its intention to create historical data sets from the 1911-1951 Canadian Census manuscripts. The CCRI integrates as much geographical information as the census can provide and offers users with additional resources to map some data and the divided results. For spatial processing polygon files were created for almost 32,000 subdivisions and managed via a geodatabase. St-Hilaire et al. (2010) also discussed some challenges associated with the CCRI and provided a discussion of limitations and the technical framework of the geographical components.

Hillier (2010) discussed how urban and planning historians have a long-standing interest in spatial topics that include migration, segregation, gentrification, and urbanization. Historical maps often serve as a source of information for urban planners, but GIS is underutilized for analysis of spatial patterns. He asserts that GIS is rarely employed by urban planners and historians, as many are not comfortable with quantitative methods and have limited training and experience with GIS. Hillier (2010) suggested that GIS can uniquely inform urban historical researchers by highlighting the underlying spatial processes in ways that can refine and challenge many of the commonly held urban historical narratives. GIS also offers the ability to highlight several characteristics of a particular location, highlighted by the re-creation of W. E. B. Du Bois 1896 map of social class in Philadelphia's seventh ward. In addition, Hillier also offered advice on overcoming existing barriers with HGIS as applied to urban and planning history. Advice included the creation of databases of digitized Sanborn maps, telephone directories, house sales data, and additional government records for construction of map layers of businesses, industry, and residences for temporal narratives. An additional suggestion for future research was the creation of a series of comparative spatial-temporal analyses of population movement for a more detailed understating of decline of a geographic area.

Quantitative Studies of Single Snapshots in Time

Gregory and Healey (2007) suggest that one major area of data analysis with GIS is quantitative studies of single points in time. This type of research expands HGIS into realm of challenging traditional orthodoxies and finding new data about a limited area. Pearson and Collier (1998, 2002) used GIS to study the tithe survey, investigating agricultural productivity in Wales during the mid 19th century. The tithe survey provides a detailed inventory of each field in a parish including ownership, the occupier when the field was tenanted, crop type, and the rateable value of the field. Pearson and Collier used the tithe survey in conjunction with modern GIS data that provided information on the physical characteristics of each field, including relief, slope, and aspect. Statistics showed that while many of the variations in agricultural productivity were explained by physical characteristics of the field, owners and tenants both had significant impact, with tenants seeming to have had a larger impact than owners.

Hillier (2002, 2003) investigated mortgage redlining in Philadelphia, PA during the Great Depression of the 1930s. In 1933, the Home Owners' Loan Corporation (HOLC) helped home owners and mortgage lenders by making low interest loans to cover defaulted mortgages. The HOLC divided cities by perceived risk of lending; areas perceived as highest risk by the HOLC were marked with redlines; containing large African American and Jewish American populations. Previous researchers have shown that redlined areas were doomed to decline due to the difficulty in obtaining mortgages in those areas. Hillier tested this by using GIS to integrate data from a sample of individual mortgages via data from a 1934 property survey and the 1940 census. Results indicated that areas of highest African American populations were more likely to be redlined than other areas, but contradicted the idea that once an area was redlined it was difficult to get a mortgage. Mortgages in African American areas had only slightly higher interest rates than other areas.

Harris (2002) used GIS to ask new questions about archeology by creating a virtual world and a digital terrain model. Through GIS, Harris created a landscape and vegetation cover around a burial mound in Ohio that represented the period before European settlement and subsequent urbanization. GIS allowed for the exploration of the significance of the mound on the landscape as it would have appeared to contemporary observers.

Knowles (2008b) investigated the Civil War battle of Gettysburg. She created a digital terrain model from historic topographic surveys from 1874 and then created a viewshed to analyze what an observer could have seen from different vantage points on the battlefield. Results from the viewshed analysis suggested that a blocked line of sight might have influenced key moments in the battle and that General Robert E. Lee could not see the Union troops at the disastrous Pickett's Charge.

Dobbs (2009) discussed how the United States Southern back-country underwent a radical transformation in terms of rapid settlement by Europeans and a period of intense urbanization during the mid-1740s to the mid-1760s. During this period the population increased from a few hundred to over 40,000 due in large part to land grants. This was in contrast to many other parts of the United States South where urbanization and town building tended to lag. Dobbs specifically examined the North Carolina Piedmont, using GIS to analyze both spatial and temporal patterns (via kernel density and a series of maps) in the 18^{th} century land grants of the region and their relationship to the development of towns. Results from the study suggest that the initial conditions, including the presence of indigenous landscape features, are important factors in the understanding of town formation in the backcountry. GIS made it possible for a number of different approaches to be utilized that previously would have been much harder due to their labor-intensive nature.

Changes over Space and Time

Gregory and Healey (2007) state that, “In many cases, historical GIS will be required to explore how geographical change over time occurred” (p. 645). In the past, this has been made difficult both by complexity of data and problematic data analysis. GIS offers a way to mitigate the complexity of data and provide potentially easier methods for data analysis. In this respect, GIS has revolutionized research regarding changes over space and time.

Skinner et al. (2000) discussed Chinese fertility transition though time and regional space in regard to the Chinese government’s one-child program. They performed an analysis of fertility rates in China from the 1960s through the 1990s, making use of familiar geographic concepts. Central place theory was used to divide China into what Skinner et al. (2000) termed Hierarchical Regional Space (HRS), subdividing places into eight-level urban-rural hierarchies based on information about settlement size, industrial structure, etc. In addition they also created a seven-level core-periphery hierarchy based on a variety of socio-economic indicators. The methodology allowed the researchers to allocate the data from each place to a location on a matrix that they simplified to divide every place into one of eight categories from inner-core urban areas to far-periphery rural areas. An analysis of geographic variation of fertility over time is now possible, utilizing non-contiguous regions rather than a focus on individual administrative regions.

Diamond and Bodenhamer (2001) examined the commonly held notion that white flight led to the exodus of many Protestant churches from the inner city. They explored the effects of white flight from the center of American cities on the religious geography of Indianapolis, Indiana. GIS was used to track changes in church locations and the changing ethnic composition for tracts in Indianapolis. There was some evidence for churches moving along with population shift; however, it was not as widespread as previously thought.

Gregory et al. (2001) examined inequality in England and Wales. Variables in the study were infant mortality, overcrowded housing, and unskilled workers from the 1890s, 1930s, 1950s, and 1990s, and they explored how patterns of these variables change once all of the data have been interpolated onto 1890s registration districts. Results showed that inequality among the areas containing population declines appears to have risen over the 20th century for all three of these variables, and that the increase has been most pronounced since the 1950s.

Cunfer (2002, 2005) examined the Dust Bowl on the Great Plains during the Great Depression. Traditionally, the dust storms in the mid 1930s on the Great Plains have been attributed to over-cultivation of unsuitable soils that led to the depletion of top soils by high winds, thereby placing the blame for the Dust Bowl on intensive agricultural practices by farmers that had been driven by market forces. Cunfer (2002, 2005) pointed out that historic studies only investigated two counties in the center of the Dust Bowl region during the New Deal period, the peak era of dust storms. Cunfer's study investigated 280 counties in the Great Plains by using annual agricultural and environmental data for a period beginning prior to the mid 1930s. His research showed that dust storms were far more common in the region than previously acknowledged and that the link between agriculture and dust storms was not overly strong. Drought in the mid 1930s seemed to be a far more significant factor than was intensive tillage practices. Studying a larger area over a longer period of time as opposed to individual county studies allowed for an effective challenge to an accepted historical interpretation.

De Moor and Wiedemann (2003) attempted to reconstruct Belgian territorial divisions and their hierarchy. The goal of the research initially was to create a HGIS for Beligium. However, De Moor and Wiedemann discovered a number of problems caused by the country's complex administrative structure which changed and developed over time. The research led to the development of a model for historical GIS design that is applicable for all but the most complex structures. De Moor and Wiedemann (2003) demonstrated the value of incorporating a mixture of quantitative and qualitative attribute data into the system and suggested research issues that the GIS and attribute data can address.

Gregory and Ell (2005) analyzed spatio-temporal changes by utilizing HGIS for understanding population changes during the Great Irish Potato Famine. The research continued Gregory's research exploring the potential for using areal interpolation in combination with several spatial analysis techniques to examine population change after the Irish Potato Famine. Gregory and Ell showed the potential of GIS techniques to further explore geographical and temporal variations in large quantitative datasets.

Knowles and Healey (2006) studied, via a GIS based analysis, Pennsylvanian's iron industry throughout much of the 19th century. They reexamined long-standing problems in the understanding of the development of the US antebellum iron industry by building a historical GIS of ironworks during the middle 19th century. Data for the study came from Lesley's 1859 Directory, county histories, and historical mapping. A spatiotemporal analysis allowed for detailed, substantive conclusions to be drawn about the adoption of mineral fuel technologies in blast furnaces, the influence of transportation costs on supply and demand in regionally segmented iron markets, and the relationship between regional patterns of investment in the iron industry, transportation developments, business cycle changes and national tariff policy.

Boeckel and Otterstrom (2009) used GIS and statistics to examine the sex ratios of the United States between 1790 and 1910 to determine if men actually outnumbered women on the American Frontier. They combined United States Census data with historically digitized county maps for calculation of male-to-female sex ratio and density of settlement. Sex ratios were analyzed using basic descriptive statistics, analysis of variance (ANOVA), and comparison historical maps. Results indicated that male-female ratios on the American Frontier were high throughout the study era and significantly differed in more densely populated areas. As Boeckel and Otterstrom hypothesized, men did significantly outnumber women in frontier counties. Sex ratios also declined as population density increased though each decade of the study. However, frontier areas consistently had high male-female sex ratios in 1910, showing an ongoing demographic difference between lightly settled and urbanized counties.

Historical maps of the Negev Desert were used by Levin et al. (2010) to observe patterns of settlement, agricultural history, indigenous peoples, and determining the legal geography of land ownership. During the mid 19th century European powers recognized the area as having great geopolitical importance, so numerous surveys and mapping efforts were carried out. Levin et al. utilized 375 historical maps that covered parts or all of the Negev from 1799 to 1948. Scanned and georectified maps were imported into GIS to enable a quantitative analysis of accuracy and to reveal new insights regarding settlement and the sedentarization process. The median error of maps based on explorer's notes during most of the 19th century was several kilometers. Later, the various Palestine Exploration Fund maps (1872-1890) produced maps having errors of several hundred meters, and British maps from the First World War and the

British Mandatory Survey of Palestine contained errors well below 100 meters. Detailed analysis of the maps allowed for the researchers to delineate boundaries between cultivated lands and the desert, the birth of new settlements, and quantification of the sedentarization process of the Bedouin people.

McLeman et al. (2010) described their development of a GIS-derived model of historical drought and population in western Canada. The model was designed to support qualitative field work regarding drought adaptation and migration. This GIS model combined both digitized census data and newly modeled historical climate data (on a $10km^2$ grid cell scale) for hotspot analysis, where historical declines in rural populations might be associated with long periods of low precipitation and high temperatures. Results of the study indicated that the model is promising for expanding and refining GIS-based models of historical human-climate interactions to offer support for qualitative research. In addition, the model offers the potential to serve as a stepping stone toward forecasting areas of future risk for drought-related migrations in dry environments.

Qualitative Analysis

GIS originated in the quantitative realm; however, developments in database technology now allow for the extension of GIS for qualitative analysis (Gregory and Healey, 2007). Today, GIS is effectively used with qualitative data including texts, imagery, sound, and video. The studies discussed in this section show that GIS need not be solely a quantitative technology but can offer a geographic framework for virtually any approach within historical research where geography is a component. The body of literature in this area is small but growing.

Ray (2002) discussed the Salem Witchcraft Trials of 1692, mapping accusers and accused using data consisting of images, documents, and maps. Contemporary sources were paramount for the study. Historically, Boyer and Nissenbaum (1974) had argued that the village was split by social and economic pressures, the accused being found in the east and their accusers to the west. Ray (2009) located more individuals than did Boyer and Nissenbaum, who found a blurred geographical separation between the accusers and the accused. In addition, Ray mapped taxation and church attendance, showing that neither of the resulting patterns shows the clear split suggested by Boyer and Nissenbaum (1974).

Sheehan-Dean (2002) and Thomas and Ayers (2003) discussed the Valley of the Shadow Project, life in a northern (Pennsylvania) and a southern (Virginia) community before and after the Civil War via an archive of letters, newspapers, churches, census records, speeches, and diaries. As a digital archive, the Valley of the Shadow Project provided detailed comparisons between Franklin County, Pennsylvania and Augusta County, Virginia. The researchers questioned the commonly held concept that slavery made a profound difference between the North and the South. Previous studies had showed little difference between the two counties in terms of voting patterns, equality/distribution of wealth, employment, and related factors. Sheehan-Dean (2002) indicated that there were indeed clear differences between the two counties studied; however, the differences were relatively subtle. Thomas and Ayers (2003) reflected on the differences between the two sites in a paper examining the underlying causes of the Civil War. They argued that it was not a conflict between industrialized and urban modernity in the North and rural stagnation from the past in the South; rather, the Civil War was a clash between two thriving variants of modernity.

Fyfe et al. (2009) examined historical hotel guest registers to extract dates for mapping and analyzing patterns of visitors to commercial hotels in three small Central Pennsylvanian towns (Bradford, Buena Vista, and Roaring Spring) in the late 19th century. Data from hotel registers allowed for the simultaneous consideration of both spatial and temporal dimensions. The dimensions included periodicity of visitors, by day of the week or by season, and if whether different spatial patterns of the guest's hinterlands were aligned with occupation and different time intervals. Prior to the automobile era, guest registers showed both slow travel (often via horse and buggy) and linkages through railroad networks to distant places. Hotels near a rail station had an entirely different "guest-shed" than did those not near railroads, and hotels in a county seat reflected the influence of court sessions and county fairs.

Theoretical and Conceptual Concerns

Even with all of the advantages offered by GIS, there are still methodological, theoretical, and conceptual concerns, according to a number of researchers. In 1995, Unwin believed that GIS software was improving but pointed out that problems remained, as GIS was poor at handling uncertainty, incompleteness, inaccuracy and ambiguity in data, often termed as error. Knowles (2000) expressed concerns about converting paper maps based on unsystematic qualitative sources to digital format, while locating historical places in order to assign them the geographic coordinates needed for GIS. O'Sullivan (2005) highlighted additional concerns about the inadequacies of handling the time element in GIS and the lack of understanding of available methods by empirical researchers. Padilla (2008) mentioned a number of barriers still remaining for HGIS including unfamiliar sources (maps); creating or finding adequate historical base maps; difficulty in using GIS software for historical research; and some GIS software is not adequate for HGIS research, lacking the ability to perform temporal analysis. Healey and Stamp (2000) expressed concern at the lack of acknowledgment given to those creating HGIS databases as databases are substantial works of historical geographical scholarship in their own right.

Ell and Gregory (2001) believed the greatest challenge for HGIS was to develop new and unique methodologies. They suggested three areas to improve GIS that would foster the development of HGIS: better handling of uncertainty in data, enhanced functionality to handle change over time, and the need to develop new methodologies that will weaken some of the barriers between quantitative and qualitative scholarship. However, Gregory et al. (2003) identified three unique advantages when applying GIS for historical research. First, spatial data tells us where objects are located; this can be used to structure a database and to integrate seemingly incompatible data simply through where they are placed on the earth's surface. A second advantage is that GIS allows data to be visualized using maps and more advanced techniques such as animations and virtual landscapes. Finally, GIS enables unique forms of spatial analysis where the coordinate locations of the features under study are vital to the analysis. Gregory and Healey (2007) discussed three ways that uncertainty is dealt with in GIS: mathematical, representational, and documentary.

Gregory and Healey (2007) also discussed a wide range of topics with regard to advantages and limitations of GIS for application to historical research, pointing out, for example, that the development of practical applications of HGIS has taken place largely without reference to the theoretical literature on spatiotemporal GIS. MacEachren et al. (1999) stated that researchers associate visualization of the evolving geographic process as ubiquitous. Gregory and Healey (2007) stated that addressing some of the issues they raised has the potential to bring historical GIS from the far reaches of several disciplines into the forefront of empirical research in these areas, because of the potential for asking new substantive research questions or facilitating the re-examination of long-standing issues. Examples of bringing historical GIS to the forefront of diverse fields include multiple studies on railroads and economic growth (Fogel, 1964; Schwartz, 1999; and Healey and Stamp, 2000) and the examination of evolving relationships between immigration waves and the demographic structure of the United States. However, recent developments in both databases and GIS software (ArcGIS 9.2 [ESRI, 2007]) have helped to move technology past limitations of pre-relational and feature-oriented systems and in the direction of object-related databases and object-oriented GIS (Stonebaker et al., 1999).

HGIS Today

To define and discuss the current intellectual goals of HIGS, Knowles (2008a) suggests four different areas. First, geographical questions need to be an important factor in historical research. Previously, researchers often added geographical questions "midstream," and HGIS was not even considered during the research design. Second is making historians and other researchers aware that geographical information offers useful, historical information. If researchers from outside geography realize the importance of historical evidence contained in geographical information, the field will continue to blossom and new methodologies will be developed. Third, an analytical framework of a study deals with databases that contain both location and time for research structure and analysis. Finally, data will be produced in the form of maps, graphics, tables, and imagery. Maps are critical as they can show pattern change and development over time. Meeting these goals and standards is important for keeping HGIS relevant and attracting new researchers from diverse disciplines to the field.

Knowles (2008a) suggested that methodologies for HGIS fall into three broad research categories. First is the history of land use and spatial economy. Both historical geographers and environmental historians have been interested in land use and were among the first to realize the power of GIS in this area (Knowles, 2008a). Campbell began to use GIS in the early 1990s for mapping historical agriculture and land tenure in medieval England (Knowles, 2008a). Land records from 800 maps were converted into digital format for calculating sums, averages, and portions to create an understanding of the importance of crops and land tenure across the medieval landscape of England. In many ways this approach is a historical version of the modern land use/land cover (LULC) maps produced today but with a historical and temporal-longitudinal focus. Changes over time show patterns that might not be otherwise easily detectable. By mapping various economic activities and ways of life, researchers can better understand the spatial economy within a region or a place (Knowles, 2008a). The dynamic linkages from trade, migration, and war are spatial in many regards and are ripe for HGIS interpretation. Both moments in time and shifts in spatial relations can be assembled from fine data and aggregated for analysis at different temporal and geographical scales (Knowles, 2008a).

Knowles' second category is reconstructing past landscapes (Knowles, 2008a). Some researchers are interested in authenticity of a landscape while others prefer a computer animation reality. Sketch-up in Google Earth is a useful way to conceptualize this; some individuals wish to precisely recreate buildings while others are interested in just having a representation of a building. Knowles (2008a) suggests that this digital landscape re-creation can serve a purpose for scholars. GIS facilitates the ability to create digital landscapes for the study of urban morphology in a longitudinal sense. By overlaying archeological data, maps, and satellite imagery, the Nolli Map project is a good example of the power of reconstructing past landscapes (Knowles, 2008a).

Siebert (2000) undertook an ambitious approach when re-creating a spatial history of Edo era Tokyo. Going beyond just maps, Siebert focused on physical features, urban boundaries, administrative consolidation, population change, and the development of the railroad network after 1900. Other researchers focusing on local history utilizing historical plat maps, fire insurance maps, scans of newspapers, landownership data, and even historical photographs as digital base-maps for the recreation of historic city streets (Knowles, 2008a). Large-scale urban maps and street plans offer excellent historical information and backdrops for historical geovisualization of cities. Typically, maps influenced by either European or United States cartographic traditions are the easiest to georectify. Maps created in the "West" before 1750 and Asian maps well into the 19th century are difficult to georectify and may produce inaccurate spatial results. By adjusting transparency, a researcher can see a wide range of information depending on what raster layers they have added to a database. Often, this method can take years to create a database that yields meaningful data for analysis.

Knowles' (2008a) third area of methodology and research deals with infrastructure projects. Many of these projects come from a national level and focus on providing historical administrative boundaries. Creation of historical administrative boundaries is painstaking and time intensive (Knowles, 2008a). Often, these administrative boundaries are linked to demographic information from some form of national census. China, via their China Historical GIS database, is of particular interest as it is a well-developed example of an infrastructure project. Bol (2008) suggests that nodes and networks are superior to polygons when describing the hierarchical relationships that molded the religious history and administrative units of China. Climate change experts have created the Global Historical Cropland Cover dataset, using both historical records and satellite imagery to observe LULC change from 1700 to 1992 (Knowles, 2008a).

Knowles (2008a) suggests there are a number of current limitations with HGIS. Historians remain concerned about the intellectual merits of HGIS (Bodenhamer, 2008). "All of these elements – interdependency, narrative, and nuance, among others – predispose the historian to look askance at any method or tool that appears to reduce complex events to simple schemes" (p. 222). She points out that HGIS is currently thought of as being almost solely a quantitative field due to the basis for this being in map algebra (Knowles, 2008a). However, Knowles' own chapter "What Could Lee See at Gettysburg?" (2008b), itself, reaches beyond the quantitative and into the qualitative. Michael Goodchild (2008) suggests that GIS has evolved beyond just simple analysis of place and is capable of dealing with time better than many historians believe. Knowles (2008a) also states that HGIS lacks a body of literature for comparative studies, with many current studies focusing on only one site. Knowles also expressed concern about the lack training researchers are given regarding GIS. Without GIS being taught in a broader group of disciplines, many researchers will lack the technical skill to utilize GIS. In another vein, she notes that building large-scale HGIS databases is both expensive and time consuming (Knowles, 2008a). Often, it may take years for a particular HGIS database to reach a level from which results may be derived. The means for archiving data in a meaningful way are only beginning to be explored in the United States (Knowles, 2008a).

Current GIS software also poses concerns about limitations in HGIS. Knowles (2008a) suggests three topics software designers need to address to further facilitate the expansion of HGIS use by historians. First, cartographic representation of uncertainty is lacking. It is possible that cartographers could develop color pallets or symbol sets to represent uncertainties that are more easily understood by non-cartographers. However, this area needs a great deal more thought and standards need to be developed. Second, GIS software designers need to develop new ways of storing document sources, while tracking their usage in GIS. Currently, there is a poor architecture for linking data to external documents and text fields within GIS. Metadata is also difficult to create, is highly technical, and is not well suited for HGIS. Finally, GIS software needs to offer an easier method for the calculation and representation of change over time. Knowles (2008a) stated that the tools available in GIS software are modeled to represent longitudinal data for a unit area while Google Earth tools offer animation capabilities. Despite all of these concerns, the power of HGIS is tremendous and more researchers from diverse fields are realizing the advantages of the technology. Knowles et al. (2008) believe that because of advances in HGIS, “Whole chapters of will need to be rewritten or revised” (p. 272).

HGIS in this Dissertation

HGIS methodology plays a vital role in this research. As Knowles (2000) pointed out, HGIS is rapidly becoming a mainstream research area. As Ell and Gregory (2001) stated, HGIS offers the ability to visually analyze data and explore spatial patterns both of primary focus in this dissertation. A key concept in this research is that GIS serves as more than just an enhanced mode of mapping: the created databases serve as archives of information. Gregory and Healey (2007) discussed advantages of electronic databases as opposed to paper counterparts, with the internet being the key to distribute these electronic databases. Siebert (2000) also explored the creation of a database that included a number of historical features in much the same manner as this dissertation does. In addition, Gregory et al. (2002) discussed changing administrative boundaries, a concept used in this dissertation when mapping the historical boundaries of towns.

Another key concept from HGIS used in this dissertation is that of using HGIS to study what remains today of the past or what had previously occurred in the past, borrowing from both spatial and temporal perspectives (Bailey and Schick, 2009). Knowles (2002b) also confirmed this by stating, "Historical GIS provides tools that combine them [geography and history] to study patterns of change over time and space" (p. xii). Padilla (2008) discussed the ability of GIS to conduct spatial analysis to reveal patterns, an ongoing theme throughout this dissertation. Visual interpretation of data presented in graphic form is at the core of both HGIS (Bailey and Schick, 2009) and this study, as GIS allows for visualization that may overcome many boundaries posed by conventional analyses. In addition, Rumsey and Williams (2002) specifically state that locational attributes from historical maps are fundamental for the reconstruction of historical settings. This concept is at the core of the dissertation via the usage of plat maps to provide information regarding the reconstruction of the past. This study follows the research trend of looking past the history of wealth and power to attempt, through HGIS, to see what remains on the landscape from the common person.

Chapter 3: Study Area

The study area for this proposal consists of four counties in West Central Missouri (Figure 1): Carroll (Figure 2), Chariton (Figure 3), Lafayette (Figure 4), and Saline (Figure 5). The area of the four counties is approximately 2,873 square miles (Earngey, 1995). Also included are unused overlapping portions of several other counties, primarily Ray County. Selection of this area stems from several factors. Most important, the area is representative of much of the central United States, surviving historical plat books for documentation of relict features are available, and the study area is one of only four multiple county areas in the central United States where LiDAR is available. In addition, this area is reflective of much of the central United States in regard to the construction of railroads remaking the urban landscape (Shortridge, 2007). Furthermore, to date there has been little documentation of relict features in the area, and it is important to document the ghost towns, abandoned railroads, and cemeteries before their traces disappear. My personal knowledge of and experience in the area, being I am a native of Lafayette County, will be an advantage.

The general physiography of Lafayette, Saline, Carroll, and Chariton Counties is representative of much of the central United States. Lafayette County is primarily prairie with some rolling hills (Earngey, 1995). However, there are steep hills along an anticline in the southwest corner, and along the Missouri River in the north are bottomlands and bluffs. Rafferty (1982) defined Lafayette County as being in the Osage Cuestas of Missouri, split between the dissected till plains (northeast) and the Osage Plains (southwest). Saline County features high, rolling prairies along with broad floodplains along water bodies. Rafferty (1982) also defined Saline County as being in the Osage Cuestas of Missouri, also part of the dissected till plains. Carroll County contains rolling hills from glaciations with wide floodplains along the Missouri

River on the southern edge of the county (Earngey, 1995). Rafferty (1982) defined Carroll County as being in the west central loess hills of Missouri, part of the dissected till plains. Chariton County is varied, with the central and eastern portions of the county sloping north-south with steep-sided, closely spaced hills; bottom-land; and rolling prairies (Earngey, 1995). The western section of the county tends to have gently rolling uplands. Rafferty (1982) defined Chariton County as being in the west central loess hills of Missouri.

All four of the study counties (Lafayette, Saline Carroll, and Chariton) have surviving plat books from the 19th century. Many other counties' records have been destroyed due to courthouse fires, so plat books are not always accessible (Earngey, 1995). Chariton County's courthouse was destroyed by fire in 1973; however, the courthouse was under renovation at the time so the records were safely stored elsewhere. Existing plat books are important as they show precise locations of platted towns, rail lines, and locations of cemeteries. Because they were based on land surveys, plat books are easily matched to modern data for exact site checking of relict features. This study spans the timeframe from Missouri statehood (1821) to the present day, viewing what relict features remain from the period in question.

The availability of LiDAR in the central United States is extremely limited. At present, there are only four areas of LiDAR acquisition in the central United States larger than two counties. Iowa recently completed acquiring LiDAR for the entire state (University of Northern Iowa, 2009). The next largest area consists of multiple counties in North Dakota, South Dakota, and Minnesota (Figure 6). In Kansas, at the time of this writing, there were 19 counties with LiDAR coverage (Kansas Data Access & Support Center, 2012). Missouri is the fourth area with four counties of LiDAR imagery.

In this study, I focus on three different categories of relict features: ghost towns, abandoned railroads, and cemeteries. I selected 20 ghost towns (five in Carroll County, five in Chariton County, four in Lafayette County, and six in Saline County) of the 49 platted (Moser, 1981), eight abandoned railroads, and 20 cemeteries (five per county) of the 112 appearing in the GNIS database (however, 231 cemeteries appear in modern county plat books). Distribution of selected ghost towns attempted to cover both elevated and flood-prone regions of the counties; all abandoned railroads in the four-county area were included, and cemetery distribution attempted to balance both large and small cemeteries in both rural and urban settings.

The remainder of this chapter is dedicated to discussion of specific sites included within this dissertation. In the first section, descriptions of the individual ghost towns are grouped by county, and a brief historical sketch of each town is presented. Historical sketches of ghost towns offer detailed information about their history, lifespan, and demise. Discussion of the history of abandoned railroads comprises the second section. Information regarding abandoned railroads includes founding date, various operators of the railroad, and approximate timeframe when operations ceased. The final section discusses individual cemeteries, grouped by county. Approximate founding dates and general histories for each cemetery are provided.

Ghost Towns

Carroll County

Coloma

Mathew B. Mullens filed a plat on March 2, 1858 for the town of Coloma on the eastern half of the southwest quarter of Section 3, Township 55 North, and Range 23 West (Figures 7-8) (Moser, 1981). In 1861, a post office opened in the town with the name Coloma (Schultz, 1982).

At the town's peak there were two general stores, a millinery shop, a blacksmith shop, drugstore, school, post office, and a number of churches (*Carroll County*, 1968). After the railroad bypassed Coloma by approximately two miles to the south in 1884, the town began a slow decline. In 1907, the post office closed (Schultz, 1982) but the Coloma Store remained until 1955 (*Carroll County*, 1968). By 1968, only a garage and gas station remained; both since have ceased operating. Today, several old buildings remain along with a few occupied homes along state supplemental route Z (Figures 9-10).

Miami Station

During 1868 and 1869 the Wabash Railroad built a line though the area and as Saline County (directly across the Missouri River) had no railroad, a station to act as a shipping port on the Carroll County side was an appealing business venture (Moser, 1981). William Darr filed a plat for a town called Miami Station on June 1, 1869 located on the northeast quarter of the southeast quarter of Section 4, Township 42 North, and Range 21 West (Figures 11-12) (*Carroll County*, 1968). The name Miami Station came from the town of Miami, directly across the river in Saline County (Moser, 1981). From 1910 to 1923, the site had numerous businesses, 15 homes, and a population near 100 (*Carroll County*, 1968). However, a fire in December of 1923 destroyed much of the business district. Businesses did rebuild but at a smaller scale and in 1930 mail, freight, express, and passenger service at the Miami Station depot (for Miami across the river) were discontinued. During a flood in 1927, much of the farmland south and east of Miami Station was destroyed. Homes from the surrounding flooded areas were moved into town, giving a short increase in population. During the 1940s the depot and elevators were torn down, and the flood of 1947 added to the decline. A flood in 1950 did further damage and a major flood in 1951 saw water four feet deep in the town. Due to the flood, the post office closed in 1951, never to reopen. The Wabash railroad closed the railroad depot permanently on April 30, 1953. A few businesses reopened and some of the population returned, only to be dispersed again during the flood of 1967, which left only one occupied home. Today, much of the area is open farm land with a couple of homes remaining near the end of state supplemental route V (Figures 13-14).

Miles Point

Originally known as Shanghai, Miles Point was the early shipping center for western Carroll County (*Carroll County*, 1968). The name Shanghai likely came from the Shanghai chickens shipped from the site. Jonathan Miles filed a plat on January 1, 1855 for a town called Miles Point (Figures 15-16) (Moser, 1981). Capitalizing on the existing river trade, Miles Point was located only 600 feet from the Missouri River. The opening of a post office in 1858 ensured the name Miles Point would continue (Schultz, 1982). Steamships on the Missouri River often stopped at Miles Point to take on wood for fuel from local lumberyards before coal became the primary fuel (*Carroll County*, 1968). At the town's zenith there were big warehouses for the storage of cotton, tobacco, hemp, and flax. In 1868, the Northern Missouri Railroad bypassed Miles Point almost five miles to the north (the town of Norborne was founded near that point). These two factors, combined with the continual flooding of the townsite and declining river transportation, led to a slow decline of Miles Point. In 1903, the post office closed and the town passed from existence (Schultz, 1982). Today, only one home and two barns remain along a gravel road in the floodplain (Figures 17-18).

Plymouth

James Flash platted the town of Plymouth on August 2, 1881 in the southwest quarter of Section 3, Township 55 North, and Range 25 West (Figures 19-20) (*Carroll County*, 1968). The post office in the town had opened earlier, in 1877 (Schultz, 1982), and the first store opened in

1880 (*Carroll County*, 1968). In 1881, the population was 21 (*History of Carroll*, 1881). By 1900 the town had a drug-store, two goods stores, a harness shop, a blacksmiths shop, a skating rink, and a Lodge Hall. Located at a distance from railroads, Plymouth survived longer than many other rural towns in Carroll County; however, in 1908 the post office closed (Schultz, 1982). The first of the two goods stores closed in 1917 and the other store closed in 1956, sealing the fate of the town (*Carroll County*, 1968).Today, only a few homes and an abandoned church remain at the intersection of state supplemental route D, state supplemental route N, and county road 110 (a gravel road) (Figures 21-22).

Wakenda

Barton Bates, the president of the North Missouri Railroad Company, filed a plat in the name of Eugene City on June 18, 1869 (*Carroll County*, 1968). The plat shows the town on the southern portion of the eastern half of the southwest quarter of Section 16, Township 52 North, and Range 22 West (Figures 23-24). Daniel Cary had donated the land for the town site in advance of the coming railroad. A post office in the town opened under the name of Eugene City in 1869 and continued with that name until 1876 (Schultz, 1982) when the name of the post office changed to Wakenda, reflecting the name of both a local creek and the township (Moser, 1981). Supposedly, the term Wakenda is a Native American word meaning “God’s river.”

By 1910, the town was a thriving business and agricultural location, having a population of 400 (*Carroll County*, 1968). Saturdays were often busy with horses and buggies lining the streets as farmers came to town for trade and band concerts. However, flooding was a constant concern for the town and destruction from floods was a regular occurrence. During a flood in 1947, the Wabash Railroad embankment prevented the flooding of the town. However, in 1951, a massive flood nearly destroyed it. At the zenith of the flood, both the residential and commercial districts of the town were covered with six feet of water. In October 1966, the Wabash Railroad station closed, dealing Wakenda another severe blow. Fears of another flood in 1967 caused half of the town's population to leave and by 1968 and the population fell to 149. The 1970s and 1980s saw continuing population decline; however, it was the 1990s that finally signaled the death of Wakenda. A marker at the townsite (Figure 25) tells of the destruction from back to back floods in 1993 and 1994, followed by the death knell, a tornado, that destroyed most of what remained in 1995 (*Saline County Historical*, 2002). The post office, one of the last remnants of the town, closed in 1995 (Forte, 2011). Today, grain elevators, some supporting buildings, and one home remains along state supplemental route B (Figures 26-27).

Chariton County

<u>*Cunningham*</u>

Eziah McLilly, in advance of the Brunswick and Chillicothe Railroad, platted the town of Cunningham in 1870 (Figures 28-29) (Gehrig and Smith, 1923). A saloon was the first business in the town and the Cunningham post office opened in 1871 (Schultz, 1982). Cunningham continued to grow and in 1874 the town had one church and a population of about 200 (Moser, 1981). Though the town was thriving, the Burlington Railroad decided to bypass Cunningham with their new line in 1882 (Gehrig and Smith, 1923). Cunningham either could not or refused to raise funds to convince the Burlington Railroad to come one mile south and save the town, and the railroad bypassed the town by one mile (Gehrig and Smith, 1923). The summer of 1882 saw the birth of Sumner and the new town's founding meant the death of Cunningham. While the struggle was bitter, businesses left Cunningham for Sumner along with the town's churches, and the Wabash Railroad moved their depot from Cunningham to Sumner. The last remaining vestiges of the town were the school (which also served Sumner) which lasted into the early 20th century (Gehrig and Smith, 1923) and the Cunningham post office that closed in 1910 (Schultz, 1982). Moser (1981) mentions that there was a population of 40 in 1974 and the town continued to decline since. Today, there are just a few homes along state supplemental route RA and a few gravel roads that lead into the Swan Lake National Wildlife Refuge (Figures 30-31).

Mendon (Old Mendon)

Before the actual town was platted, there was a settlement at the site known as Salt Creek as early as 1865 (Gehrig and Smith, 1923). The original town of Mendon was platted in 1871 by Christopher Shupe and rapidly became a local center of trade (Figures 32-33). A post office opened in 1872 and the future seemed bright (Schultz, 1982). However, the survey for the Atchison, Topeka, and Santa Fe Railroad bypassed the town by a mile and citizens became uneasy (Gehrig and Smith, 1923). In 1886 it became apparent that the current town would be bypassed and a new town would be founded along the railroad. During 1887 and 1888, rails were laid out and the new town of Mendon was born. Shortly thereafter, the post office along with all businesses and the population of the old town moved to the new town. Today, a remaining part of the old town is the Mendon Cemetery that lies along a gravel road (Figure 34).

Shannondale

Shannondale was platted in 1874 by Charles Shannon as the Keokuk and Kansas City Railroad was being built through the area (Figures 35-36) (Adams, 1928). The town was also known as Shannon and its post office opened in 1884 (Schultz, 1982). Shannondale's post office closed in 1915, the railroad (owned by the Wabash Railroad) ceased operations in 1942 (Weaver, 2010), and the town passed from being. Today, state highway 5 runs perpendicular to the abandoned railroad tracks with a few homes lying along the former city streets that are now gravel and dirt roads (Figures 37-39).

Triplett

In 1870, the Brunswick and Chillicothe Railroad platted the town of Triplett, as the railroad desired a station in the area (Figures 40-41) (Gehrig and Smith, 1923). The town derived its name from the town's founder, John E. M. Triplett and he built the first house in the town. Five years later, a post office of the same name opened (Schultz, 1982). The town grew well and in 1881 was incorporated as a city; by 1923 it had a population of nearly 400 (Gehrig and Smith, 1923). However, with consolidation of agriculture and rural to urban movement, Triplett declined during the 20th century. Passenger train service ended during the 20th century and the railroad through the town ceased operation as well. In 2001, the post office closed, signaling an end to Triplett as a town (Forte, 2011). Today, a number of homes remain in various states of disrepair along a number of former city streets (gravel) and state supplemental routes M and Z (Figures 42-45).

Wien

In 1873, a post office known as Wien opened in Chariton County at the site of the current town (Schultz, 1982). A town plat for Mount St. Mary's was filed in 1877 and both names were used for the town for a period (Figures 46-47) (Gehrig and Smith, 1923).Wien was built around a large German Catholic church (the source of the name Mount St. Mary's) and a large German settlement. No railroad ever entered the town but it remained as an ethnic community. A rural community focused on immigrants and a church, Wien slowly passed from being during the 20th century. The post office closed in 1903 but some businesses held on longer (Schultz, 1982). Today, a few homes (Figure 48), the old commercial district (consisting of a very few buildings) (figure 49), and the Mount St. Mary's Church (Figure 50) remain along gravel streets and state highway 129.

Lafayette County

Berlin

The Town of Berlin was originally platted on March 7, 1854 by half brothers Joseph O. Shelby and Howard H. Gratz (Figures 51-52) (Young, 1910). A post office opened in the town under the name of Berlin in 1857 (Schultz, 1982). Bryan (1998a) listed the postmasters of Berlin as: William B. Carpenter beginning June 29, 1857; William W. Gantry beginning March 27, 1858; and Thomas A. Ogden beginning May 31, 1859. Ogden was the final postmaster at Berlin. Prior to the Civil War, Berlin had grown to have a lumber mill, a hotel, two general stores, a school, a blacksmith shop, and a hemp factory (Bryan, 1998a). Berlin was where the song *Put on Your Old Gray Bonnet* was written. The story is that the composer, a young man standing on the boat dock at Berlin on a Sunday morning, was watching people go ashore and preparing to go to church when the song came to him while watching the scene.

On December 15, 1855 individuals from Kansas burned Shelby's and Gratz's sawmill in retaliation for a raid on Franklin, Kansas, that had been led by Shelby (Bryan, 1998a). The loss was estimated at $9,000 and the brothers had no insurance on the sawmill. In September of 1863, the steamboat *Marcella* was commandeered by about 60 partisan rangers (Confederate Guerillas) at Berlin Landing (Young, 1910). Passengers were robbed of $900, several cases of boots and shoes, and other clothing. After a search of the boat, four Union soldiers of the Missouri State Militia were discovered. Martin Fisher, Charles Wagoner, Edward Knobbs, and Chris Seely (all natives of Lexington) were taken a short distance into the woods, lined up, and fired upon.

Fisher, Knobbs, and Seely were killed. However, Wagoner was not hit and escaped into the woods.

Following the Civil War, Piper Chairs (a style of locally produced chair named for Mr. Piper) were a popular export of Berlin (Bryan, 1998a). Mr. Pipers produced the hickory chairs with woven split bottoms. Quality workmanship and materials led to a chair that was claimed to have lasted 60 to 100 years. Following Mr. Pipers a man by the name of Tiltion continued to make these chairs. However, the name Pipers was still associated with the chairs. In May of 1870, the home of Joseph O. Shelby burned to the ground while he was out of Berlin, possibly in either Lexington or Kansas City (Bryan, 1998a). It seems possible that this may have been arson; however, no one was ever charged. After this, the town declined rapidly and nothing was left by the 20th century. Today, the town site lies abandoned, inaccessible, along a private gravel road near an orchard.

Chapel Hill

The Ridings family acquired the area of Chapel Hill in 1837 (*The Continuing History*, 2002). At some point between 1839 and 1843, a small settlement began to grow (*History of Lafayette County*, 1881). A local spring known as Cool Spring likely drew people to the area and encouraged settlement. The crossing of two main stagecoach roads was another likely reason for additional settlement (*The Continuing History*, 2002). In 1839, a post office was established in the area under the name of Cool Springs (Schultz, 1982). Bryan (1994) indicates that settlement for a town likely began in 1843, and Archibald W. Ridings was likely the town founder. A change in postmaster precipitated a change of post office name to Harrisburg in 1844.

The town's eventual name came from Chapel Hill College (originally Chapel Hill Academy) founded about 1840 (Bryan, 1994). Chapel Hill College was unique in pre-Civil War Missouri in that it was co-educational and educated Hispanic and Native American students. Reflecting the popularity of the college, the post office officially changed its name to Chapel Hill in 1850. Chapel Hill was platted on March 26, 1857 (Young, 1910); however, Bryan (1994) suggests the incorporation date was May 26, 1857 (Figures 53-54). By 1860, there were approximately 20 families in Chapel Hill, constituting a population of 120 (Bryan, 1994).

Chapel Hill's decline began on March 26, 1863 when Chapel Hill College and most of the town was burned to the ground during the Civil War (Young, 1910). No effort to rebuild the college occurred during the remainder of the war and many of the students had moved on. Eventually, the town was rebuilt; however, another blow to Chapel Hill was the failure of the Lexington, Lake, and Gulf Railroad (Bryan, 1998b). The railroad was graded along most of its route, except at Chapel Hill. However, only a few rails were ever laid and those were at Lexington. With the eventual failure of the Lexington, Lake, and Gulf Railroad and with the Chicago and Alton Railroad passing well to the north, Chapel Hill began rapidly to decline (*The Continuing History*, 2002). Its 1876 population was 75 and by 1881 the population had fallen to about 50 (Bryan, 1994). From about 1885 to 1890, the population of Chapel Hill remained a steady 100. By 1893-1894, the population had plummeted to 60 and only a slight rebound to 73 was seen in 1908. Past this time, it seems the population continued to slowly decline and the post office closed in 1915 (Schultz, 1982). Today, several homes remain along state supplemental routes Z and HH (Figures 55-56).

Hodge

Young (1910) stated that Hodge (originally called Edward's Mill) was originally a boat landing. Edward's Mill was platted by W.C. Morris on March 31, 1888 with the coming of the Missouri Pacific Railroad (Figures 57-58). The railroad depot was known as Edwards Station. However, a post office opened in the town in 1888 under the name of Hodge (Schultz, 1982). At one point, Hodge had several businesses, yet was mostly a place where employees of the railroad lived (*The Continuing History*, 2002). By 1910, Hodge was listed as being a hamlet with no commercial importance (Young, 1910) and the post office closed in 1963 (Schultz, 1982). Today, there is little left at Hodge - only a few homes remain at the intersection of a gravel road, state supplemental route N, and the Union Pacific Railroad (Figure 59).

Mount Hope

Following the founding of the Hopewell Cumberland Presbyterian Church in 1850, a community began to form around the church (Figures 60-61) (Atchison, 1937). However, Young (1910) suggests the founding date of the Hopewell Cumberland Presbyterian Church was 1854. The area surrounding the town was called Mount Hope Prairie and was the name given to the post office after the name Hopewell was rejected by the postal authority in 1860 (Schultz, 1982). At the start of the Civil War, Mount Hope had two stores, owned respectively by W.K. McChesney and Mr. Kirkwood, and a blacksmith shop (Young, 1910). During the Civil War the post office was closed from 1861 to 1865 (Schultz, 1982) and the town was completely burned to the ground (Young, 1910). Following the Civil War, Mount Hope was rebuilt and the Hopewell Cumberland Presbyterian Church was rebuilt in 1867 (*History of Lafayette County*, 1881). The post office reopened in the name of Mount Hope during 1865 (Schultz, 1982).

The death of Mount Hope occurred in large part due to the failure of the Lexington, Lake, and Gulf Railroad in the late 1870s, combined with the Chicago and Alton Railroad bypassing Mount Hope by about four miles to the north (Bryan, 1998b). Odessa was founded along the new railroad and much of Mount Hope was moved there (Young, 1910). The Mount Hope post office was moved from Mount Hope to Odessa in 1879. In 1880, the Mount Hope Cumberland Presbyterian Church was disassembled and moved to the new town of Odessa. Today, only two homes remain at the site, which is along two gravel roads (Figure 62).

Saline County

Cambridge

After Old Jefferson (Jefferson) had been destroyed by a change in the course of the Missouri River, a settlement less than a mile south was born (*History of Saline*, 1967). Settlement of Cambridge began about 1845 but it was not platted until Frederick A. Brightwell filed a plat in 1848 (Figure 63-64) (*History of Saline County*, 1881). A post office in the town with the name Cambridge opened in 1845 (Schultz, 1982). Before the coming of the Chicago and Alton Railroad in 1878, Cambridge was a principal shipping point for Saline County (*History of Saline County*, 1881). A peak population of over approximately 450 was reached in 1876 (*History of Saline*, 1967). The town declined when the railroad bypassed it and the towns of Slater and Gilliam were created (*History of Saline County*, 1881). Many of the businesses were moved to Slater (where there was a railroad repair center). In addition, many people also left for nearby Gilliam (also located along the Chicago and Alton Railroad). The post office remained open until 1903 (Schultz, 1982) and today the abandoned site sits on a gravel road past the end of state supplemental route PP (Figures 65-66).

Elmwood

In 1867, R.F. Canterbury and Dr. George Hereford platted the town of Elmwood and six new homes were built (Figure 67) (*History of Saline*, 1967). However, the Elmwood post office had existed in the area since 1851 (Schultz, 1982). As an agricultural community, Elmwood had several churches, a local chapter of the Grange, and a few businesses (*History of Saline County*, 1881). Before the introduction of the temperance organization the Good Templars, it was said that the village of Elmwood sold more whiskey than other towns twice its size in Saline County. After their arrival however, the liquor dealers closed shop and there was no whiskey sold in the place from presumably 1879. Of the town in its declining years, Dr. Thomas Parks said "Nothing ever happens here" (*History of Saline*, 1967 p. 162). Elmwood's post office closed in 1907 (Schultz, 1982), and by 1967 there were no businesses or stores (*History of Saline*, 1967). Today a few homes remain along with an abandoned church along state supplemental route W (Figure 68).

Laynesville

In 1870, John Layne founded and platted the town on July 4, 1871 (Figures 69-70) (County deed mob 15, Page 311). A post office in the town opened in 1873 under the name Laynesville (Schultz, 1982). Located on the banks of the Missouri, Laynesville served as one of Saline County's heaviest shipping points (*History of Saline*, 1967). The town reached its peak in 1875 and then went into decline when Laynesville was bypassed by the railroads being built through the county. As a shipping and trade point, Laynesville could never overcome a lack of railroad connection and decline was rapid. Acceleration of the slow decay came to the town during a flood in 1881 when the Missouri River destroyed the town (*History of Saline County*, 1881). The post office would remain until 1903 but nothing was left of the town (Schultz, 1982).

Later floods completely changed the course of the Missouri River and today the site of Laynesville sits on the north bank of the Missouri River (*History of Saline*, 1967) in an inaccessible field in the Missouri River floodplains of Carroll County.

New Frankfort

Before its platting as a town, the area of New Frankfort was known as Gwinn Settlement for Bartholomew Gwinn who settled in the area in 1817 (*Saline County Historical*, 2002). The town of Frankfurt (later New Frankfort) was platted in 1858 by the Columbia City Building Association of Milwaukee, Wisconsin and contained 170 city blocks (Figures 71-72) (*History of Saline*, 1967). However, the men who actually founded the town were Mr. Kaul, Mr. Alexander, and Mr. Keye. Many of the early settlers of the town were Germans who immigrated to the United States and lived in New York before moving on to Milwaukee. Lots in New Frankfort were purchased sight-unseen, leading some to sell their lots after viewing them while others remained to build a town. New Frankfort was incorporated in 1859 with John Kepler as its first mayor. A post office opened in the town under the name New Frankfort in 1863 (Schultz, 1982). The post office closed on September 10th, 1864 as a result of the Civil War and reopened on April 8^{t}, 1865 (*History of Saline*, 1967). At the town's peak in the latter half of the 19th century, between 4,000 and 5,000 gallons of wine were made in the town.

New Frankfort's position on the Missouri River led many to believe that it was a prime spot for a railroad bridge (*History of Saline*, 1967). However, the Chicago and Alton Railroad bypassed the town to the southwest and the Missouri Pacific railroad preferred a line through the county seat of Marshall. In addition, much of the northern part of the town plat was covered by the Missouri River as it changed course through the years. As an ethnic enclave, the town survived well into the 20th century but slowly died. A small population of African Americans moved to the town but this gave only a temporary rise in population that would eventually pass as they moved away. The post office closed for good on September 5, 1905, the final store in the town burned to the ground in 1949, and the school closed in 1950. By 1967, there was a population of 31 and many of those citizens were elderly. Today, only a few homes remain at the site along several gravel roads and at the end of state supplemental route M (Figures 73-75).

Salina

The town of Salina was platted on June 15, 1849 (County deed book N; Page 207; Plat, Plat Disc). Little is actually known about the town as no mention is made of it in any of the county histories. According to Schultz (1982), there was never a post office under the name of Salina in Saline County. A plat and location for the town appear in the 1876 Saline County Plat Book and the town had six blocks, lying against the Missouri River (Figures 76-77). Salina was within one mile of another ghost town, Doylstown/Commons, which also was located on the Missouri River. It is not clear whether there was ever a town at the site or if Salina was a "paper town", one platted but never actually built. If it was a town, it was likely intended as a shipping port and had a short life. Today, the former town site is inaccessible, sitting on a partially forested bank above the former site of the Missouri River, overlooking a large area of crop fields.

Saline City

Before a town existed at the site, Native Americans referred to the high bluff above the Missouri River as Little Arrow Rock. Rufus Bigelow cleared the town site in 1858 and Col. George W. Allen platted the town the same year, naming the town Saline City (Figures 78-79) (*History of Saline County*, 1881). A post office was issued under the name of Saline City in 1869 but it closed the following year (Schultz, 1982). A new post office, this time under the name of Little Rock was issued in 1878 (Schultz, 1982). The post office was originally requested to be named Saline City; however, there was already a post office under that name in Missouri so the name reverted to a form of the Native American traditional name (*History of Saline County*, 1881). Sitting on a high bluff above the Missouri River, the town became a shipping port with a dock below the town directly on the river. In 1881 the town's port was considered an advantageous port on the Missouri River and the port shipped a large volume of goods. However, the Chicago and Alton Railroad bypassed the town by six miles to the north in the late 1870s and the ensuing drop in river shipping led to decline (*History of Saline*, 1967). The town's post office closed in 1907 (Schultz, 1982) and the town continued to decline with only two homes left in the area today. Much of the former town site consists of abandoned homes in either pasture land or forested areas overlooking the Missouri River floodplain (Figures 80-83).

Abandoned Railroads

Carroll County

Chicago, Burlington, and Quincy Railroad

The Chicago, Burlington, and Quincy Railroad was built through Carroll County in 1884 and along the track was the newly platted town of Bogard (Bogard Missouri, 1985). The southern terminus of the railroad was the Atchison, Topeka, and Santa Fe Railroad at the county seat of Carrollton. By 1896, the railroad was renamed the Chicago, Burlington, and Kansas City Railroad. A 1914 plat map of Carroll County shows that the railroad had expanded to the west, north of Bogard, making the portion from the split to Carrollton only a trunk line as opposed to the main line now extending toward Kansas City. By 1914 the railroad was owned by the Burlington Northern Railroad. Rafferty (1981) indicates that the railroad was active in 1970;

however, the line closed and all of the rails were removed in 1981 (Figure 84) (Bogard Missouri, 1985).

Chariton County

Brunswick, Chillicothe, and Omaha Railroad

The Brunswick, Chillicothe, and Omaha Railroad began building through Chariton County in 1870, platting along the way the towns of Cunningham and Triplett. The terminus of the railroad was just west of Brunswick at the St. Louis, Kansas City, and Northern Railroad. Later, the Wabash Railroad bought the line and it was a part of the Wabash High Line (Moser, 1981). Rafferty (1981) indicates that the railroad was active in 1970 but the line has since closed (Figure 85).

Keokuk and Kansas City Railroad

The Keokuk and Kansas City Railroad was built as a branch line south from Salisbury to Glasgow, Howard County in 1873. Founded along the new railroad were the towns of Shannondale and Forest Green (Moser, 1981). Plat maps from 1897 and 1915 list the railroad as being a part of the Wabash Railroad. The line was abandoned in 1942 (Weaver, 2010) and Rafferty (1981) confirmed abandonment in that general time period (Figure 86).

Lafayette County

Lexington and St. Louis Railroad

The Lexington and St. Louis Railroad was the first railroad in Lafayette County in 1869, passing through Concordia and on to Aullville (Young, 1910). The railroad passed though Higginsville, created Page City (1871), and continued on to Lexington. The railroad was purchased by Jay Gould's Missouri Pacific Railroad and was renamed the Lexington Branch of the Missouri Pacific Railroad (Masterson, 1988). Rafferty (1981) indicates that the railroad was active in 1970 and but the line has since closed, likely during the late 1970s (Arndt, 2012) (Figure 87).

Lexington, Lake, and Gulf Railroad

Originally known as the Lexington, Chillicothe, and Gulf Railroad (incorporated 1869); the Lexington, Lake, and Gulf Railroad was a proposed railroad partially in Lafayette County (Bryan, 1998b). Often listed as a paper railroad, the Lexington, Lake, and Gulf Railroad was graded in 1870-1871 from Lexington (the northern terminus) to Butler in Bates County, with only one mile at Chapel Hill not graded (Bryan, 1998b). However, before funding ran out, crews managed to lay 200 yards of rail at Lexington but the line was never completed. Part of the planned course appears in the 1877 plat book of Lafayette County, showing the proposed line in three townships, while neglecting the rest of the proposed course. Bryan (1998b) mentions that the Western Coal and Mining Company bought about four miles of the graded bed (then owned by the Chicago, Burlington, and Quincy railroad) and used it for coal transportation.

Rocky Branch Railroad

The Rocky Branch Railroad was a railroad to coal mines in central Lafayette County. It branched off of the main Chicago and Alton Railroad and intersected with the coal company's Belt Line Railroad according to plat maps from 1896, 1914, and 1930. However, a plat map from 1951 lists the railroad as abandoned.

Western Coal Company's Belt Line Railroad

The Western Coal Company's Belt Line Railroad was a railroad to coal mines in central Lafayette County, owned by the Western Coal and Mining Company (Bryan, 1998b). It branched off of the Lexington Branch of the Missouri Pacific Railroad and intersected with the Rocky Branch Railroad according to plat maps from 1896, 1914, and 1930. However, a plat map from 1951 shows the railroad as abandoned.

Saline County

Lexington and St. Louis Railroad

The Lexington and St. Louis Railroad was the first railroad in Saline County in 1869, passing through Sweet Springs in route to Lafayette County (*History of Saline County*, 1881). The railroad was purchased by Jay Gould's Missouri Pacific Railroad and was renamed The Lexington Branch of the Missouri Pacific Railroad (Masterson, 1988). During the 1960s, the railroad was closed east of Sweet Springs, making it a short line railroad (Arndt, 2012). In the late 1970s, the line closed west of Sweet Springs, marking the end of the railroad (Figure 88).

Missouri Pacific Railroad

A trunk line of the Missouri Pacific Railroad was built in 1878 at Marshall (*History of Saline County*, 1881). Approximately two miles long, the line connected the town the main line of the Missouri Pacific Railroad (*History of Saline*, 1976) and later the Union Pacific Railroad. The trunk line remained in operation into the first decade of the 2000s but had ceased operation by 2010 (Figure 89).

Cemeteries

Carroll County

Big Adkins Cemetery

The Big Adkins Cemetery dates from 1831 according to a sign at the cemetery (Figures 90-91). In a rural setting along a gravel road, the Big Adkins Cemetery is nestled in the hills above the floodplain. Still an active cemetery today, there are several hundred stones in the cemetery spanning the period of its existence.

Braden Cemetery

High atop a hill near the ghost town of Coloma, the Braden Cemetery sits on a gravel road (Figures 92-93). The Braden Cemetery dates to circa 1850 (Ellsberry, Spence, & Standley, 1962) and is a medium to small sized cemetery. Still an active cemetery, graves span from the cemetery's founding to a number of recent burials.

DeWitt Evergreen Cemetery

The DeWitt Evergreen Cemetery dates to circa 1880 and serves as the city cemetery for DeWitt (Ellsberry, Spence, & Standley, 1962). Lying just north of DeWitt, the cemetery has a number of old evergreen trees lining a road through the center of the cemetery (Figure 94). As a cemetery for an old, established town, the DeWitt Evergreen Cemetery is large and still active (Figure 95).

Oak Hill Cemetery

The Oak Hill Cemetery is a massive cemetery in the city of Carrollton, county seat of Carroll County (Figures 96-97). An exact date for the founding of the cemetery could not be located, but stones indicate it dates to at least the mid-19th century. The cemetery is still in use today for citizens of the city of Carrollton.

Sacred Heart Cemetery

The Sacred Heart Cemetery is a small Catholic cemetery that dates to 1869 (Unknown, 2003). Located in the Missouri River floodplain and along Moss Creek, the area is prone to severe flooding. A private cemetery, the Sacred Heart Cemetery is still in use today (Figures 98-99).

Chariton County

Elliott Grove Cemetery

Located just north of the town of Brunswick, the Elliott Grove Cemetery serves as the city cemetery for the town. Stones in the cemetery date from the mid 19^{th} century; however, an exact date of founding could not be ascertained. The cemetery is large since it is associated with an old, established town and is used for burials to this day (Figures 100-101).

Mendon Cemetery

Partly lying on the original town site of Mendon, the Mendon Cemetery (also known as the Old Mendon Cemetery) dates from circa 1860 (Gladbach et al., 1990). The cemetery actually predates the town which existed as Salt Creek as early as 1865 and was platted as Mendon in 1871 (Gehrig and Smith, 1923). In 1888, the Atchison, Topeka, and Santa Fe Railroad bypassed the town by a mile and a new town of Mendon was platted on the railroad. As time passed, the Mendon cemetery expanded and began to cover part of the old town site. Today, the cemetery sits on a quiet county road, a rural cemetery still in use (Figure 102).

Newcomer Cemetery

The Newcomer Cemetery dates to circa 1861 (Ellsberry, n.d.). Located near a rural settlement, the cemetery and post office shared the same name that came from a local family

(Moser, 1981). The settlement of Newcomer was also the birthplace of the Missouri Farmers Association (MFA), as indicated by signs at the old Newcomer School. Existing on a gravel road, the Newcomer Cemetery is a small rural cemetery that is still in use today (Figure 103).

St. Mary's Cemetery

The St. Mary's Cemetery dates to 1899 and was the cemetery for the town of Wien (Unknown, 2004). However, the current cemetery is not the original one, with bodies moved from the first one to the new (and current) cemetery south of town. Wien was a small German Catholic town and the cemetery is the resting place primarily of German immigrants and their progeny. The cemetery remains in use today, still serving the local community (Figures 104-105).

Salisbury Cemetery

The Salisbury Cemetery dates to 1851 (Ellsberry, n.d.), predating the town of Salisbury by 16 years (Moser, 1981). Salisbury was an early rail center in Chariton County, and the town grew rapidly in the latter half of the 19th century. The cemetery grew along with the town and is a large city cemetery lying about a mile outside of Salisbury today (Figure 106).

Lafayette County

Confederate Memorial State Historic Site Cemetery

The Confederate Memorial State Historic Site Cemetery dates to the 1890s as a part of the Confederate Soldiers Home of Missouri (Missouri State Parks, 2011). From 1891 to 1950, the facilities provided housing, medical care, and camaraderie to former Confederate soldiers and their families. After the last soldier's burial in 1950, the site was turned over to the Missouri

Parks Board. Today, the cemetery remains as a memorial with over 800 graves (Figures 107-108).

Greenton Baptist Church Cemetery

The Greenton Baptist Church Cemetery was originally two cemeteries with the older one dating to circa 1849 (Brunetti, 1976). On top of one of the highest points in Lafayette County, the cemetery is at the site of Greenton, a ghost town. Today, the Greenton Baptist Cemetery consists of two large, noncontiguous parts with several hundred graves with the western portion of the cemetery still in use today (Figures 109-110).

Mt. Hope Presbyterian Church Cemetery

The Mt. Hope Presbyterian Church Cemetery dates to circa 1840 and is near the Santa Fe Trail where the town of Mt. Hope (Middleton Township) once was (Brunetti, 1974). Construction of US 24 led to the removal of a number of graves, shrinking the size of the cemetery. Today, the Mt. Hope Presbyterian Cemetery is a small, rural cemetery sitting on a hill just south of US 24 (Figures 111-112).

Odessa Cemetery

The Odessa Cemetery dates to circa 1881 (Brunetti, 1978). However, there are several stones in the cemetery that predate the cemetery and were likely moved from a cemetery at Mt. Hope (Sni-a-Bar Township), as much of the town had been moved to Odessa (*History of Lafayette County*, 1881). Today, the large cemetery continues to serve as the city cemetery of Odessa (Figures 113-114).

Shore Cemetery

The Shore Cemetery dates to 1843, as indicated by a marker at the cemetery entrance (Figure 115). A number of early settlers are buried in the cemetery along with Civil War veterans. As a small, rural cemetery the Shore Cemetery still has occasional burials to this day (Figure 116).

Saline County

Cambridge Cemetery

The Cambridge Cemetery dates from circa 1842 and is just southwest of the former town site (Haynes & Campbell, n.d.). Consisting of both a Caucasian and an African American cemetery (independent historically), the cemetery sits on a high point overlooking a large area. A small cemetery, with parts in fair shape, while other parts are overgrown and in poor condition (Figures 117-118).

Fairview Cemetery

The Fairview Cemetery dates to 1883 and functions as a city cemetery for Sweet Springs (*History of Saline*, 1967). Consisting of six acres, the cemetery is rather large and sits on the north side of Sweet Springs. A number of bodies were moved from the former city cemetery (the Brownsville Cemetery) to the new Fairview Cemetery shortly after its founding. The Fairview Cemetery remains in use to this day, still serving as a final resting spot for citizens of the town (Figures 119-120).

Harmony Cemetery

The Harmony Cemetery dates to 1876 and was later deeded to the Harmony Cumberland Presbyterian Church (*History of Saline*, 1967). By 1967, the church was abandoned and the cemetery was in poor condition. However, the cemetery is now well maintained but there is no trace of the former church. The site covers approximately one acre along a quiet, rural road (Figures 121-122).

Mount Nebo Cemetery

The Mount Nebo Cemetery dates to 1918 with the first interment taking place on September 30, 1921 (*History of Saline*, 1967). Reverend C. Gabler gave the cemetery its name, from a Biblical passage, on the day of the first burial. Serving Evangelical settlers of the town of Grand Pass, it was originally one acre and sits about half a mile west of the town. In 1940, St. Luke's Evangelical church decided to make the cemetery public, with certain sections reserved for church members. In 1967 the cemetery had 146 grave sites and it has continued slow growth since (Figures 123-124).

Ridge Park Cemetery

The Ridge Park Cemetery was incorporated in 1885 by three leading citizen of Marshall, the county seat of Saline County (*History of Saline*, 1967). William H. Letcher suggested the name for the 40 acre cemetery as it sits on a small ridge overlooking the surrounding countryside. An additional 10 acres were added to the cemetery in 1901, along with two additional acres soon after. During the Great Depression of the 1930s, an additional 100 acres were acquired for future use, but the land would serve as a golf course until needed. Today, the expansive Ridge Park Cemetery continues to be a place of interment for citizens of Marshall (Figures 125-126).

Chapter 4: Methods

By combining historical data, remotely sensed data, and GIS data, a geographer can create a modern GIS representation of the location and distribution of historical cultural features. With some historical maps decaying and not being preserved, this is an important technique for preserving data about the location of historic towns, settlements, cemeteries, and railroads. The technology of geographic information science makes preservation easier and more accurate than ever before.

Schuppert and Dix (2009) suggested using GIS to recreate historic cultural landscapes. They found GIS to be the only convenient way for dealing with historical maps. Coverage of digital content of historical maps, beyond simple scanning, is only possible via GIS (Plöger, 2003). However, this method has been relatively rare in academic research. Egli et al. (2005) were early pioneers and focused on historic traffic in Switzerland. Schuppert and Dix (2009) pointed out that researchers must not only scan but process, georeference, and digitize historical maps to reveal useful information. Georeferencing of historical maps requires that the original maps were created with consistent, modern surveying methods and that there are suitable points for georeferencing (e.g., crossroads). Gregory and Ell (2007) stated that accuracy depends on a number of factors including: accuracy of the historic survey, degradation of the map (geometric distortion in the paper source maps), distortions resulting from microfilm transfer, and scanning inaccuracies. Schuppert and Dix (2009) suggested overlaying historical maps onto modern imagery and DEMs. In addition, “historical sources could mostly be georeferenced in the GIS by using the field names in the historical text or existing mining tracks that can be found on digital topographic maps, digital aerial photographs, or digital surface models (LIDAR-data)” (p. 430).

Data

The use of historical maps is paramount for precise placement of historical town boundaries and railroad locations. Schuppert and Dix (2009) used georeferenced cadastral maps to identify settlement structures from the early Celtic settlements in Southern Germany. Maps consistent with modern surveying techniques are reliable sources of data and the authors used significant, surviving cultural features for control points. Plat maps are preferable for georeferencing as they offer precise locations due to having townships divided into fractions of townships (Rosenzweig and Bodenhamer, 2006), often into units as small as sections (one by one mile units). Natural and human-created features both appear on plat maps, allowing for cross-referencing with modern maps and remote sensing data.

Sanborn Fire Insurance Maps were also investigated as a potential source of data regarding ghost towns within the study area. The Library of Congress gave duplicate copies of Sanborn Fire Insurance Maps to the University of Missouri who in turn scanned them and made the maps available in digital format (University of Missouri, 2011). However, there were no Sanborn Fire Insurance Maps for the ghost towns within the study area.

From the 1870s to the 1910s, production of county plat books was approximately every twenty years. For this research, these maps will serve as the information source for ghost towns, cemeteries, and abandoned railroads. Towns and railroads represent substantial investments in human time and technology, but as they fall into disrepair, even they will eventually disappear from the landscape. Cemeteries represent an important cultural symbol of remembrance. However, cemeteries frequently are abandoned and the loss of records with successive generations is a concern. Source data for cemeteries comes from both the historic plat books and the GNIS database.

GIS Data

Having GIS data for a study area is important for precise location and creating data products that are user friendly. Data layers required include county boundaries, the public land survey system (PLSS), and GNIS (Table 1). PLSS is available for locations west of the Mississippi River (except Texas) and some states east of the Mississippi River (Florida, Ohio, Mississippi, Alabama, Indiana, Illinois, Michigan, and Wisconsin) (Nationalatlas.gov, 2009). An accurate PLSS data layer allows for locating historical features within at least one mile and provides an easy framework for georeferencing using only four precise control points (Chang, 2006). GNIS data are useful as they show locations and names of both cultural and physical features.

The following layers were used for this dissertation: stream network; lakes and ponds; all Missouri highways; PLSS; and railroads. Waterways were common reference points on historical maps and are more static than most cultural features. However, the courses of many waterways change over time due to natural processes (erosion, flooding, etc.) and human intervention (canals, channeling, etc.) preventing exclusive reliance on time snapshots of waterway data. It is useful to put all of the data into a GIS personal geodatabase for ease of editing and organization.

Remote Sensing Data

Remotely sensed data is of particular importance for detecting and identifying relict features. As we are looking specifically at visible ground features, spatial resolution is of paramount importance. The need for high spatial resolution imagery eliminates mid and wide-field scanners (e.g., Advanced Very High Resolution Radiometer [AVHRR], Indian Remote Sensing [IRS], Moderate-resolution Imaging Spectroradiometer [MODIS], or even Landsat

Thematic Mapper, etc.) in this study. NAIP digital aerial photography is ideal for identifying relict features since the spatial resolution is one meter (United States Department of Agriculture, 2008) and free of charge. Typically, NAIP imagery is georeferenced, allowing for its immediate integration into GIS. Georeferenced NAIP imagery for Missouri is available for download from the Missouri Spatial Data Information Service (MSDIS). However, the NAIP program began in 2003 so there is not an extensive historical catalogue of imagery. NAIP imagery for this dissertation was from 2009 and was natural color digital aerial photography.

It is rare to find large areas of land within the United States for which LiDAR data are available. However, four counties in West-Central Missouri (Lafayette, Saline, Chariton, and Carroll) are available (Figure 1). Processed LiDAR (a hillshade DTM) data is available through the University of Missouri, Columbia (Figure 127). All LiDAR data, including raw .las files were acquired and stored on a 1.5 terabyte portable hard drive for easy transportation.

Design and Procedure

This study spans the timeframe from Missouri Statehood (1821) to the present day, viewing what relict features remain from the period in question. The design of the study is to overlay historical maps on modern GIS data and remotely sensed data to determine what remains of known or predicted relict features and to identify previously unidentified features within ghost towns, abandoned railroads, and cemeteries. Historical data regarding railroads and ghost towns came from plat books of the four counties produced in the 1870s, 1890s, and 1910s. I only selected ghost towns that were actually platted and whose exact borders appear in the plat books (Figure 7). Twenty total ghost towns were selected with five in Carroll County (Coloma, Miami Station, Miles Point, Plymouth, and Wakenda), five in Chariton County (Cunningham, Mendon, Shannondale, Triplett, and Wien), four in Lafayette County (Chapel Hill, Berlin, Hodge, and Mount Hope), and six in Saline County (Cambridge, Elmwood, Laynesville, New Frankfort, Salina, and Saline City). The initial goal was for five platted ghost towns per county; however, an error in the LiDAR data made the fifth available site in Lafayette County (Page City) not viable. In addition, the selection of ghost towns also attempted to include sites both in predominantly grassland/crop fields and sites with large areas under tree canopies. There are 12 ghost towns in predominantly grassland/crop fields (Table 1) and eight ghost towns with large areas under tree canopies (Table 2). Railroad inclusion is dependent on status of the line; if the line is abandoned, the line was included. In the study area, there are eight abandoned lines (Table 2). Selection of cemeteries came from the GNIS database and the historical plat books. I attempted to select cemeteries of various sizes (from very small to large city cemeteries) and cemeteries in both urban and rural settings. A comparison of cemeteries appearing in the plat books and modern data (GNIS, NAIP) was also performed to ensure visibility on NAIP and without extensive tree cover, with five cemeteries per county for a total of 20 cemeteries (Table 3).

The first step was to collect all of the historical data. I photocopied Chariton and Lafayette Counties directly from the original plat books, while I digitally photographed the plat books of Carroll and Saline Counties. The use of two different forms of data collection is to determine whether direct photocopies or digital photographs would provide a statistically significant difference in rectification error as reflected by root mean square (RMS) error. A pilot study indicated that positional accuracy RMS may vary depending on the data source (digital photograph versus scanned images) (Figures 128 and 129), so this suggested further testing to determine which is the superior data source. Digital photography was via high definition Kodak

EasyShare Z812 IS camera with images shot at 8.1 megapixels and photocopies were copied on photocopies in the respective county recorder's office. Photocopied images were then scanned as tagged image file format (TIFF) files at 600 dots per inch (DPI) with a CannonScan LiDE60 scanner.

In the next step, I imported the downloaded GIS data into ArcGIS. As mentioned earlier, the most critical GIS data layers are the boundary lines of the study areas (state, county, township, etc.), a PLSS data layer, GNIS for cemeteries, and waterways information.

Importing raster images of the historical data was the third step. When using historical data or maps that are not georeferenced, they must be georeferenced to a map coordinate system before proceeding. Of primary concern is precise placement of a minimum of three (typically four or more) control points with low RMS error values while still accurately fitting the PLSS data. In this study, I used a minimum of four control points and for areas of higher errors I added additional control points and eliminated those causing the highest RMS error. The basis for control points was section corners from the PLSS system (Figures 128 and 129). After adding the control points, I georectified the images.

Fourth, I imported the remotely sensed imagery (NAIP and LiDAR) and placed the remotely sensed imagery under the existing raster data (historical maps) and GIS data (Figure 130). I overlaid NAIP on the LiDAR hillshade DTM and adjusted the transparency to 70 percent to allow visual examination of LiDAR features underneath the NAIP imagery (Figure 131). At this point, I digitized the relict features of interest for comparison against NAIP and LiDAR. Following the completion of digitization, I exported each of the individual feature classes into the GIS personal geodatabase as individual shape files (.shp). I added additional information, such as period of existence, construction and decommissioning dates, alternate names, and other information of interest as attributes to the shapefiles. Finally, I converted the .shp files to .kmz format to permit viewing in Google Earth. By converting the finds of this dissertation to .kml format, this allows for the democratizing of the data. The data is easily shared and contributed to databases such as AbandonedRails.com that encourage a high level of public input and contribution. By crowdsourcing, this allows for the empowerment of nonacademic individuals and encourages participation from a far wider array of individuals than is typically utilized. This form of grassroots, citizen mapping leads to empowerment of individuals participating as it is low tech enough to attract individuals who might not otherwise consider themselves geographers or lack the access to academic training in GIS and mapping.

I interpreted the results through a historical-geographical context to recreate the historical landscape. Visual interpretation (Stone, 1964) of NAIP imagery utilized size, shape, texture, pattern, and tone/color as image diagnostic tools. Visual interpretation of LiDAR utilized size, shape, texture, and pattern as image diagnostic tools (Campbell, 2008). All features in the three classes of relict features were compared to the historic plat books to determine if traces of the relict features still exist and if they do, whether those features match those found in the historical record. Historical town maps from the plat books were overlaid onto the LiDAR and NAIP imagery to give exact borders of historical towns. LiDAR data were examined for any historical roads (roads that are no longer in use and now are typically overgrown) and any depressions (building foundations) in the lots depicted on the historic plat books. Any surrounding historic roads or house-like depressions were also documented. Railroad data from the historical plat books were overlaid onto the LiDAR to give the approximate location of the rail lines. The LiDAR data were examined for elongated elevated features in the surrounding area, indicating the beds of the historical lines. Examination of NAIP imagery focused on visible traces (existing rails, surface scars, tree lines unrelated to surrounding landscape, etc.) that remain on the landscape. Cemetery data from the historical plat books and the GNIS database were overlaid onto both the LiDAR and the NAIP imagery. Examination of LiDAR data focused on detecting small, high frequency elevation changes that represent grave markers or shallow depressions that represent burial sites. The NAIP imagery was examined for spatial patterns of cemeteries.

Visual interpretation offers several important advantages of automated means such as artificial neural networks (ANN). For ghost towns, visual interpretations of LiDAR and NAIP imagery allows for detailed searchers for depressions, historic road beds, and tree lines. An ANN would identify all depresses in the entire study are whether related to a ghost town or not and the same is true for any road bed within the study area. Modern and abandoned railroads might also be confused by an ANN; in addition, automated means might not detect small, trace remains of an abandoned railroad that could be seen by visual interpretation. Cemeteries are also important to examine through visual interpretation as opposed to ANN. Due to the small size of cemetery stones, their appearance on NAIP imagery is often blurry, indicating mixed pixels (i.e. mixels) which could make ANN algorithms less effective. In addition, it is possible that groups of bee hives, rock out croppings, etc. could also be misinterpreted by an ANN, leading to potentially useless information. ANN may work better for large areas where visual interpretation is not practical or would be too consuming. However, using ANN might miss faint traces of relict features that are detectable through visual interpretation or small fragments of relict features that do not well match the established ANN.

Quantitative results came from three different parts of the study. I conducted an independent samples t-test for statistical significance to compare RMS errors between georectified digital photographs and scans from historical plat books. For research Question B, which sensor or sensors will reveal which categories of relict features of ghost towns more readily, I performed a dependent samples *t*-test for statistical significance to determine if one form of imagery reveals more historical roads than the other. I performed a Pearson R Correlation between approximate death date of a town and remaining historical roads to answer Question C, does age of a relict feature affect sensor detection of the feature. The remaining portion of the study was primarily a visual, qualitative examination of imagery to determine which relict features remained. Reporting of remaining relict features took the form of descriptions, counts of features, and images showing the remains (Figure 132). As this is an empirical study, there were no ethical concerns regarding human subjects, as human subjects were not involved and all data were publically available.

Chapter 5: Results and Discussion

This chapter covers a discussion of research findings and results and their broader implications in responding to the research questions outlined in the Introduction. The initial section focuses on RMS errors, their potential causes, effects, and potential ways to limit such errors in future research. The second section, *What can remote sensing help us to learn about the historical cultural landscape of the area*, includes results and discussion of ghost towns, abandoned railroads, and cemeteries in two subsections: (1) *Will LiDAR and NAIP help to confirm what was depicted on plat books and GNIS* and (2) *Will LiDAR and NAIP reveal features not appearing on historic plat books and GNIS*. Section three, *If relict features are visible on the ground, which ones are detectable via various remote sensing means*, focuses on results and discussion of ghost towns, abandoned railroads, and cemeteries in two subsections: (1) *Which sensor or sensors (LiDAR or NAIP) will reveal which categories of relict features (ghost towns, cemeteries, railroads, and their components) more readily* and (2) *Will overlaying imagery (NAIP overlaid onto LiDAR) increase the ease of relict feature detection*. The fourth section, *Will LiDAR's vertical accuracy be sufficient to detect relict features not revealed by NAIP imagery*, deals with results and discussion of ghost towns, abandoned railroads, and cemeteries in two subsections: (1) *Will detection of relict features lying in open areas such as grasslands or crop fields differ from those under tree canopies* and (2) *Does age of a relict feature affect sensor detection of the feature*.

RMS Rectification Errors

RMS errors represent a numerical estimate of the goodness of fit of a georeferenced dataset and highlight location errors when georectifying imagery (Chang, 2006). Typically, the lower the RMS error when georectifying an image, the better the fit of the imagery source data to the GIS reference data. Comparing RMS errors between georectified digital photographs of plats and georectified map scans from historical plat books helps determine which method (photography or scanning) is more accurate and leads to the least distortion. The mean RMS error for the scanned historical plat books was 5.25 (SD = 2.17), while the mean RMS error for the digital photographs was 9.19 (SD = 5.90). An independent samples t-test indicated that this difference was significant, t (83) = 4.42, p < .000. However, Levene's Test for homogeneity of variance was significant, f = 34.79, p <.000, indicating that the variance of the two populations should not be assumed to be equal. An independent samples t-test, with equal variance not assumed, still indicated that this difference was significant, t (83) = 3.58, p = .001. The independent samples t-test therefore indicated statistically significant lower RMS errors for scanned map images as opposed to digital photographs of plat maps indicating that scanned map images are preferable for this research.

Georectified map scans from historical plat books were created by laying the historical plat maps flat onto a photocopier. Digital photography, on the other hand, might add distortion as maps may not lie perfectly flat or the camera might not be positioned at a perfect 90 degree angle to the map. A way to help mitigate this concern would be the use of a camera stand to ensure a 90 degree angle for shots of maps laid flat (as individual pages maybe laid on the bottom portion of a stand) for less distortion. However, some map depositories may not allow the use of such stands. Even with a camera stand, when a map is in a book it may still be difficult to get the map perfectly flat to avoid distortions.

The physical properties of a camera lens may also account for a large part of the error experienced in the study. Geometric distortion was a concern, as wide angle lenses on digital cameras may introduce distortion of objects having vertical or horizontal edges (Luff, 2010). Luff states that the further away from the center of an image, the greater the amount of distortion in the image when enlarging the image on a flat surface. Two common forms of geometric distortion are barrel distortion and pincushion distortion (Barrel Distortion, 2011). Barrel distortion is when magnification decreases with increasing distance from the optical axis while pincushion distortion is when magnification increases with increasing distance from the optical axis (Barrel Distortion, 2011). The name barrel distortion comes from the image appearing to be mapped around a sphere or barrel, bowing outward. Pincushion distortion occurs when magnification increased with distance from the optical axis, with the visible effect of a pincushion (bowing inward of an image). I noticed several instances of barrel distortion when georectifying digital photographs, which may account for much of the higher RMS error experienced with the digitally photographed historical plat books as opposed to the photocopied historical plat books (Figure 133). However, it is possible that a high-resolution DSLR camera with a macro lens designed for copying could have lessened the distortions.

An additional concern is in cases when a map is too large to be photographed or reproduced with a photocopier. The best option for larger maps would be the use of a large format scanner (such as a plat scanner) for scanning imagery. Large format scanners are expensive and, of the counties in this study, only Lafayette County had one readily available for use by the recorder's office staff for map reproduction. Another alternative would be to join two images via a digital mosaic; however, mosaicing is not perfect and with multiple scans the likelihood of error increases. In this study, there was no attempt to mosaic imagery together. Despite the increased RMS error with digital photographs, the rectifications were sufficiently accurate for this study area, especially for maps produced in the late 19th and early 20th century.

Research Question 1: What can remote sensing help us to learn about the historical cultural landscape of the area?

This research has reaffirmed that remote sensing can help one learn a great deal about historical features in the landscape in this region. Both LiDAR and NAIP imagery proved to be useful for detecting ghost towns, abandoned railroads, and cemeteries. However, each form of imagery provides unique advantages and challenges in the search for relict features.

Research Question 1A: Will LiDAR and NAIP help to confirm what was depicted on plat books and GNIS?

Both LiDAR and NAIP proved to be useful in confirming what was depicted in plat books and the GNIS database. For ghost towns, LiDAR imagery was of particular use in the detection of historic roads (roads depicted on a historic plat but no longer in use). Often, however, NAIP imagery was less useful in the detection of historic roads, as LiDAR can detect faint remains or road beds covered by vegetation. For abandoned railroads, NAIP imagery was most useful for revealing ground patterns of tree lined remnants. LiDAR imagery offers a distinct advantage for showing elevation changes consistent with abandoned railroads, especially in forested areas. NAIP imagery was particularly powerful and superior in the detection of cemeteries and the detailed features within them. LiDAR imagery was only useful in detecting larger monuments, a few cemetery stones, and groups of stones lying close together.

Ghost Towns

LiDAR imagery, and to a lesser extent NAIP imagery, are important in the detection and confirmation of items depicted in plat books and in the GNIS database. For ghost towns, LiDAR imagery revealed a number of relict features including: two depressions (indicating possible house foundations or the remnants of other built features) and four historical roads at Cambridge, Saline County (Figure 134); four depressions and three historical roads Chapel Hill, Lafayette County (Figure 135); seven historical roads at Coloma, Carroll County (Figure 136); 19 historical roads and two unique ponds at Cunningham, Chariton County (Figure 137); one depression at Elmwood, Saline County (Figure 138); three depressions at Hodge, Lafayette County (Figure 139); two historical roads at Miles Point, Carroll County (Figure 140); four depressions and 56 historical roads at New Frankfort, Saline County (Figure 141); one depression at Plymouth, Carroll County (Figure 142); two depression and 19 historical roads at Saline City, Saline County (Figure 143); three historical roads at Shannondale, Chariton County (Figure 144); 21 historical roads at Triplett, Chariton County (Figure 145); 15 historical roads at Wakenda, Carroll County (Figure 146); and one historical road at Wien, Chariton County (Figure 147).

However, NAIP imagery revealed fewer relict features in the ghost towns than did LiDAR imagery: three historical roads at Cunningham, Chariton County (Figure 148); some of the historical borders visible today at Elmwood, Saline County (Figure 149); five historical roads at Saline City, Saline County (Figure 150); four historical roads at Triplett, Chariton County (Figure 151); and 14 historical roads at Wakenda, Carroll (Figure 152).

LiDAR imagery offered a distinct advantage over NAIP imagery in the detection of the number of historic roads. Ghost towns where LiDAR imagery revealed more historic roads include: Cambridge, Saline County (Figure 153; Tables 4-6); Chapel Hill, Lafayette County (Figure 154; Tables 7-9); Coloma, Carroll County (Figure 155; Tables 10-12); Cunningham, Chariton County (Figure 156; Tables 13-15); Miles Point, Carroll County (Figure 157; Tables

10-12); New Frankfort, Saline County (Figure 158; Tables 4-6); Saline City, Saline County (Figure 159; Tables 4-6); Shannondale, Chariton County (Figure 160; Tables 13-15); Triplett, Chariton County (Figure 161; Tables 13-15); and Wien, Chariton County (Figure 162; Tables 13-15).

Wakenda, Carroll County did not exhibit the same pattern of LiDAR imagery revealing more historic roads than NAIP. The town's plats from 1876 and 1896 depict 84 platted roads (Figure 24 shows the 1914 plat). Of the 84 platted roads, 40 remain as modern roads on the NAIP imagery (Figure 152), while 38 show up as modern roads on the LiDAR imagery (Figure 146); 14 historic roads appear on the NAIP imagery (three of these roads also appear on the LiDAR imagery), and 15 historic roads appear on the LiDAR imagery (Figure 163; Tables 10-11). LiDAR imagery revealed 63.1% of combined modern and historic roads while NAIP imagery revealed 64.3% of combined modern and historic roads (Table 6). In the case of Wakenda, NAIP imagery revealed 12 historic roads not revealed by LiDAR, along with two that appear on both forms of imagery, while LiDAR showed 13 historic roads not revealed by NAIP along with two that appear on both forms of imagery. This unique result may be the result of errors in the LiDAR data, as the LiDAR imagery shows a grainy pattern that was not necessarily related to items seen on the NAIP imagery (Figure 164).

Nine ghost towns had no historic roads that appeared either on LiDAR or NAIP imagery: Berlin, Lafayette, County (Figure 165, Tables 7-9); Elmwood, Saline County (Figure 166; Tables 4-6); Hodge, Lafayette County (Figure 167; Tables 7-9); Laynesville, Saline County (Figure 168; 4-6); Miami Station, Carroll County (Figure 169; Tables 10-12); Mt. Hope, Lafayette County (Figure 170; Tables 7-9); Old Mendon, Chariton County (Figure 171; Tables 13-15); Plymouth, Carroll County (Figure 172; Tables 10-12); and Salina, Saline County (Figure 173; Tables 4-6).

LiDAR and NAIP imagery both were useful in the detection of historic roads in ghost towns. However, as demonstrated in all cases, aside from Wakenda, LiDAR imagery revealed a larger number of roads when compared to the NAIP imagery. As LiDAR data detects subtle changes in elevation, it was not surprising that LiDAR imagery more readily reveals historic road beds. NAIP imagery proves useful when there are remaining surface traces but LiDAR imagery offered the same information as well as the ability to see through vegetation and to the abandoned road beds.

As the GNIS database offers only point data for ghost towns, it was impossible to match specific, historical features aside from the ghost town's location. All ghost towns included in the GNIS database match the data gleaned from the respective counties' historical plat books except for Miles Point. Miles Point, Carroll County was depicted as further east in the GNIS database than the historical plats indicate (Figure 174).

Abandoned Railroads

LiDAR and NAIP imagery are useful for the identification and documentation of abandoned railroads depicted in historical plat books. As the GNIS database does not contain information regarding railroads, there was no way to cross check the data. NAIP imagery tends to show ground patterns of tree-lined abandoned railroad beds (Figures 175-176) and exposed areas of remaining beds (Figures 177-178). The patterns are on display along the abandoned Brunswick, Chillicothe, and Omaha Railroad, Chariton County; the abandoned Chicago, Burlington, and Quincy Railroad, Carroll County; the Lexington and St. Louis Railroad, Lafayette and Saline Counties; and the abandoned Missouri Pacific Railroad, Saline County.

However, with NAIP imagery it was often not possible to actually see the abandoned railroad beds due to trees and/or physical degradation of exposed railroad beds.

LiDAR imagery is most effective for showing elevation differences, especially for forested areas along abandoned railways (Figures 179-180). However, areas where the railroad beds had heavily weathered or had been cropped do not appear well on LiDAR imagery (Figures 181-182). All abandoned railroads, aside from the Western Coal Company's Belt Line Railroad, showed some relict features on LiDAR imagery. The Lexington, Lake, and Gulf Railroad, Lafayette County (Figure 183) and the Rocky Branch Railroad, Lafayette County (Figure 184) only showed trace remains on LiDAR imagery as opposed to no visible relict features on NAIP imagery. The Western Coal Company's Belt Line Railroad has no discernible traces remaining on either the LiDAR or the NAIP imagery.

Comparison of the length of abandoned railroads remaining on the landscape to historical plat books provides a more accurate measure of historical abandoned railroad length. The Brunswick, Chillicothe, and Omaha Railroad (in Chariton County) showed a total length of 19.8 miles in the 1876 county plat book. LiDAR imagery showed the full length of the railroad, while NAIP imagery slightly less: 19.3 miles of the abandoned railroad (Table 16). An 1896 plat book of Carroll County depicted the Chicago, Burlington, and Quincy Railroad as having a length of 12.3 miles. LiDAR imagery revealed a total of 11.6 still visible while NAIP imagery revealed 8.5 miles of visible railroad (Table 16). Much of the discrepancy was near the southern terminus of the railroad (in an urban area) on both LiDAR and NAIP imagery, with heavily wooded areas throughout the course of the railroad particularly affecting the NAIP imagery.

The 1876 plat book of Chariton County depicts the Keokuk and Kansas City Railroad as running 12.7 miles. Weaver (2010) states that the line was abandoned in 1942, and there are few visible remains. LiDAR imagery revealed only 3.4 miles while NAIP imagery revealed even less, 1.8 miles (Table 16) - both forms of imagery indicated no visible traces south of Shannondale (Figure 3). The Lexington and St. Louis Railroad spanned portions of both Lafayette County (the 1914 plat book) and Saline County (the 1878 plat book), with a total length of 38.4 miles. LiDAR imagery revealed 29.7 miles of the railroad (Table 16), with large sections not appearing on the imagery directly west of Concordia, Lafayette and to points east, past Sweet Springs in Saline County (Figures 4-5). Much of the area not appearing on LiDAR imagery has been heavily farmed, destroying the historical rail bed. NAIP imagery only revealed 20.6 miles of abandoned tracks (Table 16) with areas of heavy woodlands and areas subjected to repeated cropping no longer showing the historical rail bed.

The Lexington, Lake and Gulf Railroad only appeared in the 1877 plat book of Lafayette County and only 11 miles of the graded, but never completed, railroad appeared in the plat book. LiDAR imagery showed .6 miles of abandoned rail bed northeast of Chapel Hill, Lafayette County (Figure 4), while NAIP imagery revealed no visible remains (Table 16). The Rocky Branch Railroad appeared in the 1914 Lafayette County plat book and covered a distance of 2.2 miles south of Higginsville (Figure 4). LiDAR imagery revealed only .1 miles of the abandoned railroad at the site where it joined the Chicago and Alton Railroad (now Kansas City Southern Railways), while NAIP imagery did not reveal any visible traces (Table 16). A branch line of the Missouri Pacific Railroad appeared in the 1878 plat book of Saline County, covering 2.4 miles in and near Marshall (Figure 5). LiDAR imagery revealed only .9 miles, as there is a gap in the LiDAR data that covers the remaining 1.5 mile section of the abandoned line (Table 16). NAIP imagery revealed 2.4 miles of abandoned tracks, coinciding with the same length depicted in the 1878 Saline County plat book (Table 16). The Western Coal Company's Belt Line appeared in the 1914 Lafayette County plat book and was depicted as running 2.6 miles near Higginsville (Figure 4). Neither LiDAR nor NAIP imagery revealed any visible remains of the abandoned railroad (Table 16).

Comparing the length of abandoned railroads represented in plat books to remaining relict features reinforces the power of remotely sensed imagery in uncovering the past, with LiDAR generally superior to high-resolution aerial photography in revealing former rail lines.

Overall, abandoned railroads were clearly more visible on LiDAR imagery as opposed to NAIP imagery. NAIP imagery was most useful for tree-lined abandoned railroad beds and exposed areas of remaining beds. However, LiDAR imagery was superior overall since it detects slight elevation changes and relict features no longer visible on the NAIP imagery.

Cemeteries

Both LiDAR and NAIP imagery were also important in confirming the location of cemeteries depicted in both historical plat books and the GNIS database. All of the cemeteries appear on the historical plat books for each county. The GNIS database lists all of the cemeteries in the study except for the Confederate Memorial State Historic Site Cemetery, Lafayette County; the Greenton Baptist Church Cemetery, Lafayette County; the Harmony Cemetery, Saline County; and the Mt. Hope Presbyterian Church Cemetery, Lafayette County. The Confederate Memorial State Historic Site Cemetery is a part of a state historical site that is documented in the GNIS database. Both the ghost town of Greenton and the Greenton Baptist Church appear in the GNIS database in lieu of the Greenton Baptist Church Cemetery. The Mt. Hope Presbyterian Church Cemetery does not appear in any form in the GNIS database. Finally, while the Harmony Cemetery does not appear in the GNIS database, the site of the Harmony Church was in the database.

NAIP imagery is excellent for depicting cemeteries mentioned in historical sources and NAIP imagery's spatial resolution is fine enough to show rows of stones and occasionally individual stones (Figure 185). However, the LiDAR imagery used in this study proved to be not as useful, as it is was rarely able to reveal details regarding cemeteries. This is because the LiDAR-derived DTM has a horizontal spatial resolution of two meters, meaning that cemetery stones are often below the threshold of spatial resolution.

NAIP imagery revealed a spatial pattern of cemetery stones at all 20 of the cemeteries (Figures 185-204). However, LiDAR provided sporadic information regarding cemetery monuments and individual and groups of cemetery stones. LiDAR imagery showed several larger monuments; with examples of this are visible at: Confederate Memorial State Historic Site Cemetery (Figure 205), Ridge Park Cemetery (three monuments) (Figure 206), and Sacred Heart Cemetery (two monuments) (Figure 207). In addition, LiDAR imagery detected large individual cemetery stones at: DeWitt Evergreen Cemetery (one stone) (Figure 208), Fairview Cemetery (two stones) (Figure 209), Greenton Baptist Church Cemetery (one stone) (Figure 210), Mount Nebo Cemetery (one stone) (Figure 211), Oak Hill cemetery (five stones) (Figure 212), and Ridge Park Cemetery (four stones) (Figure 206). LiDAR imagery also can detect groups of cemetery stones in close proximity; examples are present at: Fairview Cemetery (six groups) (Figure 209), Mendon Cemetery (two groups) (Figure 213), Mount Nebo Cemetery (one group) (Figure 211), Odessa Cemetery (one group) (Figure 214), Ridge Park Cemetery (three groups) (Figure 206), St. Mary's Cemetery (three groups) (Figure 215), Salisbury Cemetery (two groups) (Figure 216), and Shore Cemetery (two groups) (Figure 217). Overall, NAIP imagery proved to be more useful than LiDAR imagery for the location of cemeteries and the depiction of individual features within the cemeteries.

Historical plat books and the GNIS database both offer little more than locational information about cemeteries. This makes it impossible to glean historical data, aside from location, from the two resources. Neither source offers information about number of graves, date of founding, etc. NAIP imagery was more useful in this scenario as it depicts the spatial pattern of cemetery stones (Figure 185). LiDAR imagery was only useful when larger stones, groups of stones in close proximity, or large monuments are present in a cemetery (Figures 205-217).

Research Question 1B: Will LiDAR and NAIP reveal features not appearing on historic plat books and GNIS?

In the previous question, I discussed how both LiDAR and NAIP imagery were useful in confirming what was depicted in plat books and the GNIS database. However, LiDAR and NAIP imagery also offer the potential for detecting features not appearing in historic plat books and the GNIS database. LiDAR imagery proved to be of particular value when searching for relict features that do not appear in historical plat books or in the GNIS database.

Ghost Towns

LiDAR imagery indicated the existence of roads not shown in plat books while NAIP imagery did not. Examples of non-platted roads were found at New Frankfort, Saline County (Figure 218). New Frankfort features three roads that were not on the historical plats of the town (Figure 72). Another example was a road not seen on historical plats at Saline City, Saline County (Figure 159). A final example of a non-platted road was found at Triplett, Chariton

County (Figure 161). Roads added after platting of a town are not a surprising phenomenon. Often, items not included on original town plats are poorly documented historically, as demonstrated at these three ghost towns. LiDAR imagery can help boost historical knowledge and documentation.

Abandoned Railroads

LiDAR was important in detecting abandoned railroads that are not well documented in historic plat books and the GNIS database. As the GNIS database does not list any railroads, the database was not a consideration in this case. The Lexington, Lake, and Gulf Railroad appears in the 1877 plat book of Lafayette County (Figure 219) as a proposed railroad; however, its exact path was never documented on maps, and few rails were ever laid (Bryan, 1998b). Figure 220 shows LiDAR imagery of the exact path of a small portion of the railroad, something not documented on any map. Nearly 140 years later, a small portion of the rail bed appears on the LiDAR imagery, showing the exact location of the railroad that apparently never appeared on any map. NAIP imagery, however, did not reveal any additional information regarding this abandoned railroad. For railroads not well documented in historical sources, LiDAR imagery appears to offer significant advantages over NAIP due to its ability to detect small differences in elevation and its ability to see though vegetation.

Cemeteries

As all cemeteries in this study were listed in either historical county plat books or in the GNIS database with no accompanying data (aside from a name), LiDAR and NAIP imagery were not useful in detecting additional information. County plat books and the GNIS database revealed site location with no accompanying information regarding cemetery size, number of burials, or founding data.

Research Question 2: If relict features are visible on the ground, which ones are detectable via various remote sensing means?

Often, there are visible remains of relict features still detectable on the ground. Researchers need to determine which form of remotely sensed imagery can provide the best data regarding relict features. It is important to determine which sensor (in this case LiDAR or NAIP) will be most helpful in revealing the relict features of ghost towns, railroads, and cemeteries most readily.

Research Question 2A: Which sensor or sensors (LiDAR or NAIP) will reveal which categories of relict features (ghost towns, cemeteries, railroads, and their components) more readily?

Imagery from both LiDAR and NAIP sensors were useful in revealing different categories of relict features. Each sensor offers different strengths and weaknesses depending on the relict feature of interest. In general, LiDAR imagery was better for detecting features tied to small elevation changes (the notable exceptions are cemeteries) while NAIP imagery was better for detecting spatial patterns of a landscape.

<u>Ghost Towns</u>

For historic roads (roads depicted on a town plat but no longer in use) in ghost towns, LiDAR is of particular value. The mean number of historic roads in ghost towns appearing on

NAIP imagery was 1.30 (*SD* = 3.58), while the mean number of historic roads appearing on LiDAR imagery was 8.43 (*SD* = 14.7). A dependent samples *t*-test indicated that there was a significant difference between the imagery types, t (29) = 2.71, p = .011, indicating that LiDAR imagery revealed significantly more historical roads than NAIP imagery. Examples of this included roads in: Cambridge, Saline County (Figure 153); Chapel Hill, Lafayette County (Figure 154); Coloma, Carroll County (Figure 155); Cunningham, Chariton County (Figure 156); Miles Point, Carroll County (Figure 157); New Frankfort, Saline Country (Figure 158); Saline City, Saline County (Figure 159); Shannondale, Chariton County (Figure 160); Triplett, Chariton County (Figure 161); and Wien, Chariton County (Figure 162). In some ghost towns both LiDAR and NAIP revealed the same historical roads, including: three roads in Cunningham, Chariton County (Figure 156); five roads in Saline City, Saline County (Figure 159); four roads in Triplett, Chariton County (Figure 161); and three roads in Wakenda, Carroll County (Figure 163). One notable exception is the town of Wakenda in Carroll County, which showed 11 roads appearing on the NAIP imagery that do not appear on the LiDAR imagery (Figure 163).

Wakenda, Carroll County shows 15 historic roads that appear on the LiDAR imagery, 14 historic roads that appear on the NAIP imagery, and three historic roads that appear on both the LiDAR and NAIP imagery (Figure 163). An anomaly, Wakenda goes against the pattern seen in other ghost towns as NAIP imagery reveals different historic roads than does LiDAR imagery. In the southern half of the ghost town the pattern of historic roads appearing on NAIP as opposed to LiDAR was dominant (Figure 164). The LiDAR imagery appears grainy, almost a mesh pattern, in most of the southern part of the ghost town and that may account for the reason that several streets do not appear on the LiDAR imagery (Figure 164). This may argue that the lack of historic road appearances on the LiDAR imagery could potentially be due to corruption in the

LiDAR imagery rather than the roads actually not appearing on the imagery. However, directly north of the grainy portion of the LiDAR imagery lies Second Street, and two of the three segments of the street do not appear on the LiDAR (Figure 164). This would argue against there being a problem with the LiDAR imagery, as the area directly south appears grainy as opposed to the area of Second Street. In addition, as noted in the Study Area section on Wakenda, the town was destroyed in 1993 by floodwaters, likely altering the topography of the town (Forte, 2011). Wakenda provides a powerful reminder of the need for multiple sources of data to ensure correct conclusions from imagery.

LiDAR also proved superior in the detection of depressions (suggesting former building foundations) and other relict ground features of ghost towns. NAIP revealed no information regarding depressions in ghost towns that are visible on LiDAR imagery. LiDAR revealed a number of ground depressions at Cambridge, Saline County (Figure 134); Chapel Hill, Lafayette County (Figure 135); Elmwood, Saline County (Figure 138); Hodge, Lafayette County (Figure 139); New Frankfort, Saline County (Figure 141); Plymouth, Carroll County (Figure 142); and Saline City, Saline County (Figure 143).

Cambridge, Saline County revealed two depressions on the LiDAR imagery (Figure 134) along with a tree line on the NAIP imagery, approximating much of the northern border of the ghost town (Figure 221). The depression in the southwest corner of the map appears to be much larger than even a modern house (possibly a business or large civic building) and the same was true of the depression in the east-central part of the map (Figure 222). Below the depression in the east-central portion of the map was another depression but it appears to be a pond that was either intermittent or now dry (Figure 222).

Chapel Hill, Lafayette County shows four depressions on the LiDAR imagery (Figure 135) along with a tree line (at the same location as the three historic roads) on the NAIP imagery approximating the western border of the ghost town (Figure 223). The furthest south depression appears to be too large to be a home and may have been a civic building (Figure 224). However, the two central depressions appear to be approximately the size of a home and were possibly foundations (Figure 224). The depression furthest north was circular and appears to be some type of pit as opposed to a house foundation (Figure 225). NAIP imagery of Chapel Hill reveals a tree line that correlates to the historic roads that made the western town boundary (Figure 223).

Coloma, Carroll County shows a tree line on the NAIP imagery approximating the western boundary of the ghost town (Figure 226). Of interest was the southern border of the ghost town and the digitized historical plats. As seen on the LiDAR imagery (Figure 136), the two southeastern historical blocks are still visible but do not match well (off approximately 62 feet) with the georeferenced data from the county plat books. In addition, the NAIP imagery (Figure 226) shows a tree line that lined up with an historic road appearing on the LiDAR imagery (Figure 136). It seems likely that slight cartographic errors in the creation of the historical plat maps or rectification errors account for this seeming lack of matching. However, the rectification RMS error was lower than it was for other ghost towns in Carroll County (Appendix A) that do not show as great a physical displacement. I believe this to be a slight flaw in the historical cartography of the three plat books as suggested by Gregory and Ell (2007) and Schuppert and Dix (2009).

Cunningham, Chariton County shows a retention pond (not of particular historical significance) and an additional pond that appear on both NAIP and LiDAR imagery and a tree line that may relate to the historic eastern border (Figure 156). The retention pond appears most clearly on LiDAR imagery and to a lesser extent on the NAIP imagery (Figure 156). In addition, there was a definite tree line on the eastern border of the ghost town that does not line up perfectly with digitized historical city boundaries (Figure 148). Georeferencing of Cunningham's historical plat produced the highest RMS error of any ghost town in Chariton County (Appendix C), so this may play a part in the lack of overlap between the digitized historical borders and the eastern tree line. However, since the rest of the borders match reasonably well and there are remaining blocks for comparison, I believe it was likely that the historical plat maps had some error in the cartography extending the town border too far east.

Elmwood, Saline County shows one depression on the LiDAR imagery (Figure 138) and the 1896 and 1916 northern border of the town appears on the LiDAR imagery (Figure 138) and the NAIP imagery (Figure 149). The lone depression appears to be slightly larger than the foundations of current homes in the area so it is possible it was once a very large home or some other form of building. On the northern border of the ghost town, LiDAR imagery and to a lesser extent NAIP imagery, shows a topographic rise along the 1896 and 1916 town boundary (Figures 227-228). Seemingly, south of the boundary were homes with yards and to the north of the boundary may have been fields for cropping. It is possible this topographic rise could be accounted for as it likely marks a transition area between residential and cropped areas.

Hodge, Lafayette County shows three depressions on the LiDAR imagery (Figure 139). To the west, the largest depression appears to be too large to be a house foundation. The remaining two depressions are in the eastern part of the ghost town and appear close together. As both depressions are approximately the size of a home, it is likely both represent the foundations of homes now gone.

New Frankfort, Saline County shows four depressions on the LiDAR imagery (Figure 141). The northern two depressions are very large, larger than a typical home but show a square to rectangular pattern (Figure 229). Near the center of New Frankfort, the smallest depression appears to be a flat area that was likely the foundation of a home and rotated at approximately a 45 degree angle, likely to face the crossroads (Figure 230). The depression furthest south appears to be a house foundation due to relative size and rectangular shape (Figure 230).

Plymouth, Carroll County shows one depression on the LiDAR imagery (Figure 142). The depression appears to share a similar size and shape of footprint as a barn directly west of the depression.

Saline City, Saline County shows two depressions on the LiDAR imagery (Figure 143). The depression that was furthest north is approximately the size of a modern home and is of a rectangular shape so it was likely a house foundation. In the southern half of the map, the southern depression was slightly smaller than a modern house foundation and was rectangular so it was likely a foundation of a home.

However, some ghost towns have no visible traces that remain on either LiDAR or NAIP imagery. Berlin, Lafayette County was burned to the ground in 1855 only to experience more destruction during the Civil War with the town finally dying in the 1870s (Bryan, 1998a). As Berlin was destroyed numerous times and suffered death at such an early date, it is not surprising there are no relict features remaining (Figure 165). Laynesville, Saline County was completely destroyed by the Missouri River shifting south in 1881, placing the site in modern day Carroll County (History of Saline, 1967). As the river shifted its course, covering the town and re-channelizing over the town, it would be surprising to find any remaining relict features (Figure 168). Miami Station, Carroll County was repeatedly flooded in the 1950s and an additional flood in 1967 destroyed the town and it was never rebuilt (Carroll County, 1968). After repeated destruction by flooding, it is again not surprising that there are no remaining relict features there (Figure 169). Mount Hope, Lafayette County was abandoned in 1879 with the founding of Odessa along the Chicago and Alton Railroad just a few miles to the north (Young, 1910). The entire area has been plowed under repeatedly since the town was abandoned around 1880 - even the city cemetery has disappeared (Figure 170). Old Mendon, Chariton County was abandoned around 1888 as the new town was built along the railroad about a mile away (Gehrig and Smith, 1923). There are likely no discernible relict features or remains of Old Mendon due to the fact the former town was split between a cemetery (which has expanded over time) and farm fields or crop fields which have been repeatedly tilled (Figure 171). Salina, Saline County has little written history but appears as late as the 1876 plat book of Saline County. As the town likely suffered an early death, was in a low lying area that was likely flooded relatively often, or possibly was only a paper town (a town platted but never truly built) it is not surprising that no relict features remain (Figure 173).

Abandoned Railroads

For abandoned railroads, both LiDAR and NAIP imagery reveal important information about historical location. However, abandoned railroads are typically more easily detectable via LiDAR imagery than they are via NAIP imagery. The vertical precision of LiDAR is important for seeing remaining railroad relict features (primarily railroad beds) that are not easily detectable via NAIP imagery.

The Brunswick, Chillicothe, and Omaha Railroad, Chariton County (later owned by the Wabash Railroad) is visible on both LiDAR and NAIP imagery today. NAIP imagery reveals a pattern on land that is easily visible through most of Chariton County whether as a tree line (Figure 231) or in areas where the abandoned rail bed itself was exposed (Figure 177). Near the southern end of the railroad line in the county, the railroad is not as easily visible on the LiDAR imagery as it is on the NAIP imagery, as tree lines associated with where the tracks once existed appear more clearly than do any topographic rises (Figure 232). However, on NAIP imagery, the path of the railroad is easily lost in areas of heavy tree canopy. LiDAR imagery offers a clear advantage for areas that have heavy tree canopies and areas where NAIP imagery reveals few visible surface remnants (Figure 180). In addition, LiDAR shows the railroad as a topographically elevated rail bed on the land throughout the county.

The Chicago, Burlington, and Quincy Railroad, Carroll County (later owned by the Burlington Northern Railroad) is easily seen on both LiDAR and NAIP imagery. On the NAIP imagery, the railroad is easily detectable by a tree line that has grown in the railroad right-of-way since abandonment (Figure 175). However, in areas of heavy tree cover (Figure 179), LiDAR imagery offers a clear advantage with its ability to cut through vegetation and detect small changes in vertical elevation.

The Keokuk and Kansas City Railroad, Chariton County (later owned by the Wabash Railroad) appears on both LiDAR and NAIP imagery. Abandoned in 1942 (Weaver, 2010), there are large sections of the railroad that do not appear well on any form of modern imagery (Figure 182). On NAIP imagery, the railroad appears sporadically as tree lines (Figure 233) with few other visible traces. However, the railroad is visible more often on LiDAR imagery than on NAIP imagery, particularly in the town of Salisbury (Figure 234) and through fields on its course to the south (Figure 235). This is also true south of the ghost town of Shannondale where the railroad does not appear at all on NAIP imagery, but does appear as a series of elevated areas near water bodies on the LiDAR imagery (Figure 236).

The Lexington and St. Louis Railroad, Lafayette and Saline Counties (later a part of the Missouri Pacific Railroad) appears on both LiDAR and NAIP imagery. LiDAR imagery was particularly helpful in areas of heavy tree growth where the exact path of the abandoned railroad was obscured on NAIP imagery (Figure 237). Urban areas also demonstrate the advantage of LiDAR imagery over NAIP imagery when locating abandoned railroads (Figure 238). In areas with narrow tree lines paralleling abandoned rail lines, NAIP imagery can be revealing as to the location of an abandoned railroad (Figure 176) as well as areas where the abandoned bed was exposed (Figure 178). However, in areas where the land has been heavily farmed or cropped, neither LiDAR imagery nor NAIP imagery readily reveals abandoned railroads (Figure 181).

The Lexington, Lake, and Gulf Railroad, Lafayette County (originally the Lexington, Chillicothe, and Gulf Railroad) only appears on LiDAR imagery as one, small section (Figure 220). NAIP imagery does not reveal any visible remains of the abandoned railroad bed at the site (Figure 239). It is surprising that any trace remains of this abandoned railroad, as the railroad was graded in the 1870s but never functioned as an active line.

The Rocky Branch Railroad and the Western Coal Company's Belt Line Railroad were railroads in Lafayette County that formed a short network leading to coal mines. LiDAR imagery reveals only one trace of the Rocky Branch Railroad, its divergence from the Chicago and Alton Railroad (now the Kansas City Southern Railroad) (Figure 184). However, this spilt was not visible on NAIP imagery (Figure 184). Nothing remains of the Western Coal Company's Belt Line Railroad.

The Missouri Pacific Railroad, Saline County (later owned by the Union Pacific Railroad) is easily visible on both LiDAR and NAIP imagery. Passing through a primarily urban area, the line was abandoned during the first decade of the 2000s, so it is visible on both forms of imagery (Figure 240). LiDAR imagery shows elevation change from surrounding topography, while both LiDAR and NAIP imagery shows the actual path of the abandoned rail line (Figure 240). This abandoned railroad is important as it provides an example of a recently abandoned line (within the last decade) to compare with other railroads that have been abandoned for longer periods. In the case of a recently abandoned railroad, NAIP imagery was far more useful than it was for railroads abandoned further in the past.

When searching for abandoned railroads, both LiDAR and NAIP imagery have their uses. NAIP imagery was best for areas where railroads have been abandoned recently and areas where there are narrow tree lines that follow the abandoned lines. However, in areas with heavier tree cover it may not be possible to determine the tree line associated with the abandoned railroad from the surrounding trees. LiDAR was most useful in areas where there was heavy tree cover and areas where there are few surface artifacts (rails, tree lines, bridges, etc.) remaining. The superior vertical accuracy of LiDAR offers the unique advantage of differentiating terrain changes, often associated with railroad beds, from the surrounding topography. However, in areas that have been heavily farmed or cropped over the former rail beds, it was often difficult to see remains of abandoned railroads on either LiDAR or NAIP imagery.

Cemeteries

As demonstrated with ghost towns and railroads, LiDAR imagery offers many advantages when searching for relict features; however, NAIP imagery is extremely useful in the search for cemeteries and features within cemeteries. For cemeteries, LiDAR imagery was best for revealing general location while NAIP imagery was better at showing the location of individual cemetery stones. In all cases, NAIP imagery reveals a patterning of cemetery stones.

Of the 20 cemeteries in the study, only 13 cemeteries showed any noticeable features on LiDAR. Cemeteries showing features on LiDAR are as follows: Confederate Memorial State Historic Cemetery, a large monument (Figure 241); DeWitt Evergreen Cemetery, a cemetery building and a stone (Figure 242); Fairview Cemetery, six groups of stones and two individual stones (Figure 243); Greenton Baptist Church Cemetery, one individual stone (Figure 244); Mendon Cemetery, two groups of stones (Figure 245); Mount Nebo Cemetery, two groups of stones (Figure 246); Oak Hill Cemetery, patterning of graves and five individual stones (Figure 247); Odessa Cemetery, a row of stones and patterning on the ground that may not be related to the cemetery (Figure 248); Ridge Park Cemetery, three larger monuments, four individual stones, and a three groups of stones (Figure 249); Sacred Heart Cemetery, two large monuments (Figure 250); Salisbury Cemetery, a great deal of patterning on the ground and two groups of stones (Figure 251); Shore Cemetery, two groups of stones (Figure 252); and St. Mary's Cemetery, three groups of stones (Figure 253). However, all 20 of the cemeteries appear on the NAIP imagery showing the full extent of the cemeteries, indicating NAIP imagery is likely to be superior when searching for and classifying cemeteries (Figures 185-204).

In regard to cemeteries, NAIP imagery proved to be more useful as it reveals clear spatial patterns of cemetery stones in a cemetery. However, tree cover sometimes can prevent NAIP imagery from accurately representing the size and extent of a cemetery. LiDAR imagery may be problematic, however, as its horizontal resolution was generally not sufficient to detect many individual stones as shown in this study. Results from this study do show that often large monuments or on occasion, groups of cemetery stones situated close together, may appear on LiDAR imagery. LiDAR imagery does show ground patterning that might reveal graves in three cemeteries. In the Oak Hill Cemetery, the elevation rises are larger than individual stones, likely indicating LiDAR was actually revealing the sites of individual burials (Figure 212). The Odessa Cemetery, Lafayette County reveals a pattern that may or may not be related to the cemetery as the patterning extends beyond the confines of the cemetery (Figure 214). In addition, the Salisbury Cemetery, Chariton County shows a number of elevations in the cemetery that are likely associated with graves or groups of graves (Figure 216).

Research Question 2B: Will overlaying imagery (NAIP overlaid onto LiDAR) increase the ease of relict feature detection?

Overlaying NAIP imagery onto LiDAR imagery can prove useful for increasing the ease of detection of relict features. The technique was designed to allow topographic features to be more easily detectable with NAIP imagery. A NAIP imagery transparency of 70% was selected after hours of experimentation with transparency settings.

Ghost Towns

In ghost towns, overlaying NAIP imagery onto LiDAR imagery can make historical roads which still appear on LiDAR imagery visible on the NAIP imagery. For ghost towns, overlaying LiDAR imagery onto NAIP imagery at a 70% transparency level also has the potential to increase the ease of relict feature detectability for other features.

The technique highlighted the beds of historic roads in Cambridge, Saline County (Figure 254); Chapel Hill, Lafayette County (Figure 255); Cunningham, Chariton County (Figure 256);

Miles Point, Carroll (Figure 257); New Frankfort, Saline County (Figure 258); Saline City, Saline County (Figure 259); Shannondale, Chariton County (Figure 260); Triplett, Chariton County (Figure 261); Wakenda, Carroll County (Figure 262); and Wien, Chariton County (Figure 263). Only Coloma, Carroll County (Figure 264) did not show an increase in ease of detection of historic roads. This was likely because many of the abandoned roads are faint on the LiDAR imagery or are covered by trees on the NAIP imagery. The remaining towns: Berlin, Lafayette County (Figure 265); Elmwood, Saline County (Figure 266); Hodge, Lafayette County (Figure 267); Laynesville, Saline County (Figure 268); Miami Station, Carroll County (Figure 269); Mt. Hope, Lafayette County (Figure 270); Old Mendon, Chariton County (Figure 271); Plymouth, Carroll County (Figure 272); and Salina, Saline County (Figure 273) do not have any detectable historic roads remaining.

Overlaying LiDAR imagery onto NAIP imagery at a 70% transparency was often useful in the detection of depressions and foundations. Ghost towns where the technique proved to be useful were: the farthest west depression at Cambridge, Saline County (Figure 254); the farthest north depression (Figure 255) and the farthest east depression (Figure 255) at Chapel Hill, Lafayette County; a retention pond at Cunningham, Chariton County (Figure 256); the lone depression at Elmwood, Saline County (Figure 266); all three depressions at Hodge, Lafayette County (Figures 267); three of the four depressions at New Frankfort, Saline County (Figures 274-275); the depression in northeast Plymouth, Carroll County (Figure 272); and the two depressions at Saline City, Saline County (Figure 276).

However, in some cases the overlay did not improve detectability. There were four cases where a 70% transparency of NAIP imagery overlaid on LiDAR imagery was not helpful. At Cambridge, Saline County (Figure 254) the farthest east depression was difficult to detect as it was completely tree covered on the NAIP imagery, increasing viewing difficulty when overlaid onto LiDAR imagery. The two depressions in the southwestern part of Chapel Hill, Lafayette County (Figure 255) were hard to detect as the overlaid NAIP imagery was forested, increasing difficulty in their detection on the LiDAR imagery. Finally, the depression lying at a rotation of approximately 45 degrees in New Frankfort, Saline County (Figure 275) was difficult to detect despite being in a grassy area. A possible reason for the difficulty in detection was that the depression was very faint on the LiDAR imagery and despite the carefully balanced overlay transparency of NAIP imagery, the depression was hidden by the overlay. Essentially, for depressions that are faint on LiDAR imagery, they become difficult to detect when the NAIP imagery is forested.

To summarize, of the 11 ghost towns with remaining traces of abandoned roads, 91% (10 towns) of the abandoned roads were clearly visible on the combined imagery with only one town not having undetectable roads. Depressions were visible in 78% (14 depressions) of the cases when overlaying LiDAR imagery with NAIP imagery at a transparency of 70%. Only 22% (four depressions) of depressions were more difficult or impossible to detect when utilizing the overlaying technique. However, no previously undocumented depressions or historic roads in ghost towns were revealed by this technique.

Abandoned Railroads

Abandoned railroads also appear well when overlaying NAIP imagery at a 70% transparency onto LiDAR imagery. The technique has the potential to increase the ease of detection of abandoned railroads. As elevation differences are often steep on either side of the abandoned rail bed, the overlaying process was useful for railroads. Due to the vertical nature of railroad beds, it should not be surprising that overlaying NAIP imagery onto the high vertical resolution of LiDAR imagery creates a dataset that lends itself to more effective visual interpretations. Overlays highlight minor surface features detectable on NAIP imagery while the vertical data from LiDAR imagery emphasizes any surfaces trace of an abandoned railroad.

The Brunswick, Chillicothe, and Omaha Railroad, Chariton County (later owned by the Wabash Railroad) highlights the overlaying process in areas where the track was above the surrounding terrain, specifically at creeks (Figure 277) and under tree cover (Figure 278). The Chicago, Burlington, and Quincy Railroad, Carroll County (later owned by the Burlington Northern Railroad) also appears clearly on the combined imagery at depressions and elevations that vary from the surrounding terrain, and at water bodies (Figure 279). In Chariton County, the Keokuk and Kansas City Railroad (later owned by the Wabash Railroad) likewise appears above the surrounding terrain (Figure 280). The Lexington and St. Louis Railroad, Lafayette and Saline Counties (later a part of the Missouri Pacific Railroad) was also highlighted where the track was above the surrounding terrain (Figure 281), specifically at creeks and under tree cover. In Lafayette County, the Lexington, Lake, and Gulf Railroad (originally the Lexington, Chillicothe, and Gulf Railroad) appears as a small segment of a rise from the surrounding topography and was enhanced by overlaying NAIP at a 70% transparency onto LiDAR imagery (Figure 220). The Rocky Branch Railroad in Lafayette County has one remaining trace and the trace appears vividly with the imagery overlay technique (Figure 282). In Saline County, the former Missouri Pacific Railroad (later a part of the Union Pacific Railroad) illustrates that overlaying NAIP imagery at a 70% transparency onto LiDAR imagery was effective for showing where a rail bed was either above or below the level of surrounding terrain (Figure 283). In Lafayette County, the Western Coal Company’s Belt Line Railroad shows no remaining traces.

Overlaying NAIP imagery with a transparency of 70% onto LiDAR imagery often enhances detectability of abandoned railroads. The effect was most apparent where the elevation of the rail bed varies from surrounding topography. However, in areas where the abandoned rail bed varies little from surrounding terrain, the overlaying technique was less useful. In such cases, it is possible that NAIP imagery alone may suffice if a tree line or other such feature follows the course of the abandoned railroad.

Cemeteries

Cemeteries benefit the least of the three discussed relict features from a NAIP and LiDAR imagery overlay. NAIP imagery is excellent for depicting cemeteries mentioned in historical sources and NAIP imagery's spatial resolution is fine enough to show rows of stones and occasionally individual stones (Figure 185). However, the LiDAR imagery used in this study proved to be not as useful, as it is was rarely able to reveal details regarding cemeteries. This is because the LiDAR derived DTM has a horizontal spatial resolution of two meters, meaning that that cemetery stones are often below the threshold of spatial resolution. As LiDAR rarely reveals information regarding cemetery stones, overlaying NAIP imagery is not particularly helpful.

Research Question 3: Will LiDAR's vertical accuracy be sufficient to detect relict features not revealed by NAIP imagery?

LiDAR imagery offers highly accurate elevation data that may reveal relict features not readily visable on NAIP imagery. Having a vertical accuracy of between .5 and 15 centimeters (Corns and Shaw, 2009), LiDAR is useful for detecting small, subtle changes on the surface of the earth. NAIP offers a consistent spatial resolution of one meter horizontal; however, it contains no vertical data (United States Department of Agriculture, 2008). Both forms of imagery have the potential to reveal different information in the search for relict features.

Research Question 3A: Will detection of relict features lying in open areas such as grasslands or crop fields differ from those under tree canopies?

Both LiDAR and NAIP imagery highlight differences between relict features lying in open areas such as grasslands or crop fields and those under tree canopies. The nature of the sensor dictates what is shown on the imagery. In grasslands or crop fields, NAIP offers the advantage of showing true color images of what remains on the earth's surface while LiDAR imagery only offers information about elevation changes. NAIP imagery also shows spatial patterns that still appear on the earth's surface but does not penetrate tree canopies. LiDAR imagery works well for penetration of tree canopies, revealing subtle elevation changes of features lying underneath. However, LiDAR imagery is not true color and may present an unfamiliar view of the landscape to the untrained eye.

Ghost Towns

Detection of relict features via remote sensing differed greatly between the open areas of grasslands or crop fields and areas under tree canopies. There are 12 ghost towns in predominantly grassland or crop fields areas (Table 1) (Figures 148-149, 152, 226, 304-311) and eight ghost towns with large areas under tree canopies (Table 2) (Figures 150, 221, 223, 312-316). Four ghost towns show visible remains of historic roads on NAIP imagery: Cunningham, Chariton County (Figure 148); Saline City, Saline County (Figure 150); Triplett, Chariton County (Figure 151); and Wakenda, Carroll County (Figure 152). Of the four ghost towns, only

Saline City was primarily under tree canopy. However, the five historic roads that appear on the NAIP imagery are in areas where there is little tree cover (Figure 150). Also, the three towns that are not under heavy tree canopy were the last ghost towns to be abandoned, meaning the roads were in later use and erosion may have not had as much time to destroy their remnants.

Half of the remaining ghost towns predominantly situated in grasslands and crop fields did not have any historic roads remaining: Elmwood, Saline County (Figure 166); Laynesville, Saline County (Figure 168); Miami Station, Carroll County (Figure 169); Mount Hope, Lafayette County (Figure 170); Old Mendon, Chariton County (Figure 171); and Plymouth, Carroll County (Figure 172). However, six ghost towns in predominantly grassland and crop fields did have historic roads remaining that were visible on LiDAR imagery: Coloma, Carroll County (Figure 136); Cunningham, Chariton County (Figure 137); Miles Point, Carroll County (Figure 140); Shannondale, Chariton County (Figure 144); Triplett, Chariton County (Figure 145); and Wakenda, Carroll County (Figure 146). Of those six ghost towns, three appeared on both LiDAR and NAIP imagery: Cunningham, Chariton County (Figure 148); Triplett, Chariton County (Figure 151); and Wakenda, Carroll County (Figure 152).

Of the eight ghost towns predominantly under tree canopies (Table 1), seven of the ghost towns showed no trace of historic roads on NAIP imagery (Tables 4, 7, 10, and 13). The towns with no trace of historic roads on NAIP imagery were: Berlin, Lafayette County (Figure 312); Cambridge, Saline County (Figure 221); Chapel Hill, Lafayette County (Figure 223); Hodge, Lafayette County (Figure 313); New Frankfort, Saline County (Figure 314); Salina, Saline County (Figure 315); and Wien, Chariton County (Figure 316). However, LiDAR imagery detected historic roads undetected by NAIP imagery (Tables 5, 8, 11, and 14), through the tree canopies, at four of those ghost towns: Cambridge, Saline County (Figure 153); Chapel Hill, Lafayette County (Figure 154); New Frankfort, Saline County (Figure 158); and Wien, Chariton County (Figure 162). The only case in which NAIP imagery revealed any historic roads in an area heavily covered by tree canopies was at Saline City, Saline County (LiDAR imagery also revealed the same roads). However, the five historic roads that appear on the NAIP imagery of Saline City are in areas where there is little tree cover (Figure 150) and are still used by a local farmer.

Detection of relict features via remote sensing differed greatly between the open areas of grasslands or crop fields and areas under tree canopies. Recently abandoned ghost towns such as Wakenda, Carroll County (Figure 152) tend to reveal historical roads on NAIP more readily than do ghost towns abandoned longer ago (such as Berlin, Lafayette County [Figure 312]) and those that are heavily farmed such as Mount Hope, Lafayette County (Figure 307). However, LiDAR imagery showed all of the same historical roads revealed by NAIP (aside from some roads at Wakenda, Saline County) plus additional roads (Tables 4-16).

Abandoned Railroads

Abandoned railroads also differ in terms of detectability between grasslands or crop fields and in areas under tree canopies. Typically, both LiDAR and NAIP imagery revealed abandoned railroads in grassland areas where there has not been extensive cropping (Figures 317-318). NAIP imagery was most useful in areas where the rail beds are exposed. Examples of exposed rail beds on NAIP imagery are easily found in multiple locations, including the Brunswick, Chillicothe, and Omaha Railroad north of Sumner in Chariton County (Figure 177) and the Lexington and St. Louis Railroad west of Page City (Figure 178). NAIP imagery was also useful in grassland or croplands where the former rail bed was lined by trees and there are few other trees in the surrounding area. Examples of rail beds lined with trees on NAIP imagery are easily found in multiple locations, including along the Chicago, Burlington, and Kansas City Railroad south of Bogard in Carroll County (Figure 175) and the Lexington and St. Louis Railroad near Aullville in Lafayette County (Figure 176). LiDAR imagery also reveals the same abandoned railroads in same locations.

LiDAR imagery's greatest strength is in areas where abandoned railroad beds lie under tree canopies. As LiDAR provides extremely accurate elevation data and penetrates vegetation, it was ideal for seeing rail beds that are obscured by tree canopies on photographic imagery. Examples of rail beds obscured by tree canopies on NAIP imagery but appearing on LiDAR imagery are numerous and include the Chicago, Burlington, and Kansas City Railroad north of Carrollton in Carroll County (Figure 179) and the Brunswick, Chillicothe, and Omaha Railroad southwest of Mendon (Figure 180).

However, neither form of imagery reveals details when an abandoned railroad bed has been heavily cropped and tilled. Numerous examples exist on many of the railroads in the study area. The Lexington and St. Louis Railroad east of Concordia in Lafayette County (Figure 181) provides an example of where contour farming has reduced the visible trace of the railroad bed to virtually nothing on both NAIP and LiDAR imagery. An additional example was along the Keokuk and Kansas City Railroad north of Shannondale in Chariton County (Figure 182) where contour farming has destroyed traces of the railroad.

Cemeteries

Cemeteries chosen for this part of the study were in areas that lack heavy tree canopies and tend to either be in grasslands or areas with relatively few trees planted for landscaping.

Cemeteries are typically maintained so that they are not under extensive tree canopies, although some trees are often present. As none of the cemeteries in this study were predominantly under tree canopies, it might pose the question of how do cemeteries in grasslands versus those under tree canopies differ. As discussed with both ghost towns and abandoned railroads, NAIP imagery does not easily reveal data regarding relict features when there is an extensive overlaying tree canopy. In addition, as noted elsewhere LiDAR imagery may be problematic for cemeteries as its horizontal resolution is often not sufficient to detect individual stones as per results of this study. Results indicate that large monuments or on occasion, groups of cemetery stones situated close together, may appear on LiDAR imagery.

Research Question 3B: Does age of a relict feature affect sensor detection of the feature?

The age of a relict feature seems to affect a sensor's ability to detect a feature, no doubt because of erosion and other physical decay. This particularly true of historic roads in ghost towns where more recently abandoned ghost towns have more historic roads remaining on imagery. In addition, the same hold true for abandoned railroads.

<u>Ghost Towns</u>

The age of a relict feature affects a sensor's ability to detect features. As expected, the date of abandonment of towns was statistically linked to the likelihood of historic roads remaining. The correlation between approximate death date of a town and remaining historic roads was statistically significant, r (18) = -.43, p = .027. This indicates that the earlier in time a town became a ghost town, the less likely historic roads will remain visible on either NAIP or LiDAR imagery. NAIP imagery reveals only four towns still having historic roads: Cunningham, Chariton County (Figure 148); Saline City, Saline County (Figure 150); Triplett, Chariton County (Figure 311); and Wakenda, Carroll County (Figure 152). Of the towns in this study, Cunningham (1980), Wakenda (1995), and Triplett (2001) were the last three towns to be abandoned. The exception, Saline City, was abandoned in 1960, yet several abandoned homes remain and the area of the former main street is relatively free from tree canopies as opposed to the rest of the ghost town. Three towns abandoned between the time Saline City and Cunningham were abandoned all have different stories that may explain why no historic roads remain on the NAIP imagery. Hodge (abandoned about 1963) and New Frankfort (abandoned about 1970) both are predominantly under tree canopies so it isn't surprising that neither show historic roads on NAIP imagery. In addition, LiDAR imagery shows numerous historic roads at New Frankfort (Figure 141). Miami Station (abandoned about 1967) was flooded repeatedly, particularly during the 1950s, and little remained when it was again flooded in the 1960s. It was likely that flooding destroyed many of the traces of Miami Station, as it has flooded several times since the 1960s, in particular in 1993.

Abandoned Railroads

The date when a railroad was abandoned also seems linked to a sensor's ability to detect remnants of the abandoned railroads. All but four of the railroads (the Keokuk and Kansas City Railroad; the Lexington, Lake and Gulf Railroad; the Rocky Branch Railroad, and the Western Coal Company's Belt Line Railroad) were abandoned post 1970 (Rafferty, 1982). Visibility of the railroads abandoned after 1970 tends to be more related to tree canopy cover and the extent to which the area has been cropped. NAIP imagery reveals no data about the Lexington, Lake and Gulf Railroad; Rocky Branch Railroad; and the Coal Company's Belt Line Railroad.

However, NAIP imagery does reveal several parts of the rail bed of the abandoned Keokuk and Kansas City Railroad (Figures 233 and 234). This may be due to the fact that the rail line was abandoned in 1942, presumably later than the other three lines discussed. LiDAR imagery does reveal some vertical features of the Keokuk and Kansas City Railroad (Figures 235 and 280); the Lexington, Lake, and Gulf Railroad (Figure 220); as well as the Rocky Branch Railroad (Figure 238). However, the information gleaned from the LiDAR imagery was minimal as only small sections, well less than a mile each, are visible.

Cemeteries

A sensor's ability to detect cemeteries was not as hampered by age as with ghost towns and abandoned railroads. In general, as long as markers remain, cemeteries do not show degradation with age on NAIP imagery. The concept of cemeteries is to act as lasting monuments to life and as such, are designed to maintain a long term presence – headstones themselves may be regarded as relict features as they are designed to be permanent. Age may degrade stones; however, care is often taken to preserve them. As noted earlier, NAIP imagery shows a cemetery's spatial pattern as long as stones are visible above the surface of the surrounding terrain, while LiDAR imagery is often only appropriate for large monuments or occasional groups of cemetery stones situated close together.

Chapter 6: Conclusions

Both LiDAR and NAIP imagery are useful in the detection of relict features. Each sensor offers unique advantages and disadvantages due to the design and construction of the sensor. LiDAR can strip away vegetation to present a bare earth model (a DTM) of terrain, useful in the detection of features revealed by subtle elevation and terrain changes. Specifically, LiDAR was useful in this dissertation for revealing historic roads and depressions in ghost towns, exposing abandoned railroad beds under tree canopies, and for the detection of monuments and other larger features in cemeteries. In addition, LiDAR also proves useful for uncovering previously undocumented roads and offers precise locations of railroad beds that were previously uncertain. NAIP presents a researcher with a color (either natural color or near-infrared) birds-eye view of the earth with vegetation intact, revealing spatial patterns on the surface of the earth, often through differentiation of vegetation patterns. For ghost towns in this dissertation, NAIP imagery was most useful for the detection of historic roads in ghost towns that were recently abandoned. NAIP imagery was also useful for the detection of abandoned railroads where the bed is exposed or when there is a single tree line in the bed and for visualizing the spatial patterning of cemeteries.

In this dissertation, visual interpretation of LiDAR imagery is useful for the detection of abandoned roads in ghost towns, detecting depressions in the terrain within ghost towns, detecting abandoned railroad beds that either rise above or fall below the surrounding topography, and detecting monuments and other large markers in cemeteries. Specifically, these results confirm what the research literature states about LiDAR's ability to detect even subtle changes in elevation. Hyyppa et al. (2000) found DTMs derived from laser scanning to be extremely accurate. Ackerman (1999) documented airborne laser scanning for the creation of digital terrain models (DTMs) and surface models dating back to NASA concepts in the 1970s and 1980s in the United States and Canada. In addition, many early LiDAR researchers realized LiDAR's value to measure the elevation of terrain (Wehr and Lohr, 1999; Jensen, 2000; Holden et al., 2002; Bewley et al., 2005; Crutchley, 2006; Gallagher, 2007). Devereux et al's (2005) research indicated that LiDAR is indeed very accurate at detecting subtle changes in elevation, especially linear features. As the body of literature regarding LiDAR is small but expanding, this dissertation is timely in applying LiDAR imagery to relict features, a previously underexplored field.

In this dissertation, visual interpretation of NAIP imagery is useful in the detection of abandoned roads in ghost towns that have been recently abandoned, detecting exposed railroad beds (i.e., those not under tree cover), tree lines associated with abandoned rail lines, and detecting spatial patterns within cemeteries. Results gleaned from NAIP imagery confirm what is known about high resolution imagery and expands that to include more cultural relict features. Previous research has demonstrated that high resolution imagery is important for seeing fine resolution on the earth's surface. Hawbaker et al. (2006) utilized aerial photography to map road changes for five different dates from 1937 to 1999 to measure change in habitat patch size. Kavzoglu et al. (2009) found that IKONOS imagery is useful to determine the need for road repairs where vehicles reduce or increase speed rapidly, or where vehicles have stopped. Hakeem and Raju (2009) found that by using high spatial resolution imagery (IKONOS), it is possible to create an accurate inventory of water storage, demonstrating that even small features are detectable with high-resolution imagery. This dissertation demonstrates the continued viability and importance of high resolution imagery, especially when applied to the previously under-explored area of detecting and mapping relict features.

Limitations

For all of the information gained for this study, there were some minor limitations. When obtaining information from historical plat books, it is preferable to photocopy data as opposed to taking digital pictures. Potential error introduced from geometric distortion, specifically: barrel distortion and pincushion distortion are reduced when using photocopies as opposed to digital photographs. However, if different equipment such as a high resolution digital single-lens reflex (DSLR) camera with a macro lens specifically designed for copying were employed, this likely would have lessened the optical distortions. Using photocopies, as opposed to digital photographs, of historical plat books probably would lead to a reduction in rectification RMS error. As RMS error was statistically significant between scans and photographs, geometric distortion in the photographs would seem to be the likely source of error. Gregory and Ell (2007) and Schuppert and Dix (2009) discuss a number of potential errors inherent in historical maps that may inflate RMS errors that are difficult or impossible to correct for. However, if digital photography is required for any reason, images should always be taken in lossless compression format (such as TIFF) as opposed to a lossy compression (such as .jpg). Due to file size and data storage concerns, the digital photographs I took of historical plat books were lossy (.jpg) and if tasked with photographing such data again, I would use a lossless compression format.

Another limitation in this study is the size and location of the geographic area. The study area consists of approximately 2,873 square miles (Earngey, 1995) with topography representative of much of the central United States. It certainly is possible that an investigation of ghost towns, abandoned railroads, and cemeteries in different areas of the world could yield different results. Studying additional relict features on the landscape with this methodology would prove useful and could potentially offer more understanding regarding the usage of LiDAR and NAIP imagery for this purpose.

A final consideration is the historical accuracy of the plat books and their maps. As towns are typically platted before they are built, it is possible some roads were never actually built and the borders of a town may not have reached the extent of the platted area. In addition, more precise dates of railroad abandonment would have been helpful. Although this study included eight abandoned railroads, the identification of additional railroads would have been helpful, specifically if located in different climatic regions that could lead to different weathering patterns.

Significance for Other Research Areas

The implications of this research can reach far beyond geography. Aside from the geographic search for relict features, this methodology is applicable to a number of other disciplines. This study adds to the existing literature of applying remote sensing, particularly high resolution digital aerial photography and LiDAR, to the detection and mapping of cultural features and landscapes. Currently, many relict features suffer from poor documentation and are becoming physically degraded. The GNIS database provides some basic information but is incomplete, contains numerous errors, and does little to document anything not well represented by point data. Several cemeteries in this study were not listed in the GNIS database; rather, adjacent features such as churches or historic sites are included in the database. Documentation of abandoned railroads or any railroads are nonexistent in the GNIS database as the database is not designed to handle anything aside from point data.

This study also directly benefits the field of HGIS. A 1999 meeting of the SSHA, began to standardize practical, theoretical and substantive issues of HGIS. Knowles (2000) suggested in a special issue of Social Science History, the beginning of a movement toward HGIS as a mainstream research area. The issue was to convey the varied nature of HGIS, the potential of HGIS to expand the scope of social science history, its utility to find new answers to historical questions, and difficulties researchers face when applying GIS to their own studies. Ell and Gregory (2001) identified HGIS as a rapidly developing area of research with GIS making use of all three common components of a data set: thematic information of the object itself, spatial information on an object's location, and information on time elements. HGIS offers a wealth of possibilities for adding to the current literature of historical and cultural geographies and this study adds to the current discussion and methodologies.

Historians and archivists will directly benefit from this study, as the methodology offers precise locations of historic features for documentation. Sites of ghost towns and railroad sidings often suffer from poor documentation and the methodology presented in this study makes the data available for historians as well as other interested parties. In addition, historians can now document the remains of ghost towns, railroads, and cemeteries as the sites are precisely located.

The three categories of relict features in this study each generally lack adequate data in accessible format to researchers and the general public. Ghost towns suffer from a general lack of documentation and historical maps of them are not always preserved. Gregory and Ell (2007) discussed how the deterioration of maps introduces geometric distortion from the paper source maps and distortions resulting from microfilm transfer, further complicating precise data acquisition. As records of many short-lived or "paper" towns are rare and often in deteriorating condition, it is important to put them in a digital format before the historical maps degrade to a point that such an effort is moot.

At present, there is no database for all railroads. After a peak of approximately 254,000 miles of railroads in 1916, active track mileage fell to between 70,000 and 75,000 miles by 1995 (Hiss, 1997). Hiss stated there were nearly 179,000 miles of abandoned railroads in the United States in 1997. GIS data exist for some railroads that survived until the latter 20th century; however, data are often inaccurate or incomplete. The rise of the rails-to-trails movement makes documentation of historical rail lines more important now than ever.

Baker (1991) and Fitzgerald (1994) both noted that one of the most frequent remnants of a ghost town is a cemetery. Cemeteries are in great danger of being forgotten and going undocumented. Smaller cemeteries and those in now sparsely populated areas may fall into disrepair and digital documentation is rare if not currently included in the GNIS database. Often private citizens document overgrown and forgotten cemeteries for genealogical purposes but do not always translate their documentation into digital data. Cemetery books are not always accessible to the public and are often available only regionally. Digitization and mapping of these relict features can help ensure a surviving record to provide information for the public.

Genealogists will benefit from this type of data as it provides locations of where ancestors lived and their place of interment. The popularity of websites including Ancestry.com, findagrave.com, etc. indicates a growing interest in genealogy, including its locational aspects. Creation of a file of relict features compatible with Google Earth will ensure the digital availability to those without commercial software such as ArcGIS from ESRI (Environmental Systems Research Institute) or similar GIS software.

Archeologists, geoarcheologists, and anthropologists are leaders in the application of remote sensing to the cultural landscape. Wilson (2000) suggested that rapid advancements in remote sensing technology have altered the way people view the earth, while St. Joseph (1996) discussed nearly 100 years of aerial reconnaissance and photography as data for archeologists. In 2005, Bewley et al. discussed the history of remote sensing for archeological research and the movement toward the usage of LiDAR, while Crutchley (2006) suggested that LiDAR would have application in aerial archaeology research. Many early LiDAR researchers realized LiDAR's value to measure the elevation of terrain (Wehr and Lohr, 1999; Jensen, 2000; Holden et al., 2002; Bewley et al., 2005; Crutchley, 2006; Gallagher, 2007). In addition, Holden et al. (2002) believed that developments in airborne digital surveying for environmental mapping would begin a new era for discovering and recording archaeological sites via multispectral sensors and LiDAR. Lucas et al. (2005) noted that traditionally, there are three major factors for identifying archeological sites: they must be small enough for visualization and interpretation from visible remains; they must be visible and recognizable despite subsequent human activities; and despite weathering and erosion, the sites should be recognizable. Remote sensing offers a way to overcome these limitations. However, research primarily focuses on locations outside of the United States. This study demonstrates that these same tools and methodologies so often applied outside of the United States can effectively reveal domestic relict features.

Geologists will also benefit from this research, as the same principles shown here apply to pits, mines, quarries, and surficial geology. No database of pits, mines, and quarries exists for Missouri or Kansas, creating problems in mapping the features. DTMs derived from LiDAR offer greater accuracy for determining historical flood patterns and prediction of future flooding.

In addition, high spatial resolution imagery could help to correct fieldwork errors in surficial geologic mapping.

This study offers further justification for the use of advanced remotely sensed imagery to identify relict features of the central United States. Documentation of "lost" relict features is important, as no comprehensive database currently exists. The current GNIS database is poorly populated with data and often incorrect. In addition, the methodology allows for easy documentation of what remains of relict features. The methodology offers the advantage of conserving both time and money (Gallagher & Josephs, 2008). Remote sensing will never completely replace fieldwork. However, remote sensing is a valuable tool for discovering cultural remains and planning further fieldwork.

Future Research Directions

There are a number of directions that can be taken in following up on this research in the future. One research topic would be to compare the usefulness of a standard 10 meter DEM with a LiDAR derived DTM. Kvamme (2005) discussed the use of SAR X-band imagery [from Shuttle Imaging Radar-C (SIR-C)] of Angkor Wat, Cambodia, to reveal new structures, temples, mounds, roads, and additional features. As SRTM data is the most common elevation dataset, it would be important to study the benefits of that imagery versus LiDAR imagery. SRTM was launched on February 11th, 2000 and landed on February 22nd, 2000 and during its 11 day mission, imaged approximately 80% of the earth's surface (between 60^{0}N and 56^{0}S) (Campbell, 2008). Interferomic data from the STRM mission was used in the production of DEMs of the earth's surface with 30 meter spatial resolution for the United States and 90 meter spatial resolution internationally currently available. As LiDAR imagery is much less common, there are a number of areas of the world where SRTM data may be the only elevation imagery available to study relict features.

Another form of imagery to consider for future research is ground penetrating radar (GPR). Reeder et al. (2004) utilized GPR to detect 122 previously undiscovered additional suspected gravesites that offered no surface expression. As demonstrated, GPR offers the ability to see relict features that are not visible or detectable at the surface. GPR can image below the surface of the earth, offering a unique advantage for producing imagery. Detection of foundations, additional road beds, artifacts related to abandoned railroads, and potentially greater information about cemeteries are all possibilities with the utilization of GPR. However, GPR is expensive and data gathering would have to be site specific due to locate relict features.

An additional form of imagery to consider using is color infrared photography (CIR). While CIR might not seem an intuitive choice, its unique properties might make the imagery a valuable research tool. As CIR responds strongly to actively growing vegetation, it is possible that CIR could reveal features not visible on standard color imagery due to differences in vegetation vigor. If searching for any water features, CIR is a superior choice as water appears black on the imagery, thereby creating a strong visual contrast with surrounding land features. CIR photography does exist for the area and would be relatively easy to acquire.

Another direction to take this research would be to focus on additional categories of relict features for investigation. Using LiDAR imagery to study abandoned forts and historic trails in the Trans-Mississippi west could offer additional areas of study. Another feature common in the same region are human built-canals. Often found in drier climates, human built canals are often poorly documented and were abandoned with population movement or a loss of water supply. All of these human-created features play an important part in the American cultural landscape and are often forgotten. LiDAR and other forms of remote sensing offer one the ability to record information before all traces of such historical records are wiped from the earth's surface permanently.

Chapter 7: Epilogue

A pattern of frequent river flooding, including destructive floods in 1844 (a great flood), 1881, 1927, 1947, 1950, 1951 (a great flood), and 1967 has, in many ways, defined much of the study area (History of Saline, 1967). However, the Great US Flood of 1993 set a new precedent of river crest at Kansas City and points eastward toward St. Louis during July of 1993 (Larson, 1996). At this time, Landsat 5 was in orbit (Campbell, 2008), which provided imagery of the flood. Landsat 5 imagery from August 17, the closest image in the time to the date of the flooding peak, shows damage and continued flooding after the peak of the flood in mid-July. Brown areas on the imagery, near the flood waters, show areas that had been earlier covered by water. Ghost towns in the study area inundated during the flood of 1993 included Hodge (Figure 319), Laynesville (Figure 329), Miami Station (Figure 321), Miles Point (Figure 322), and Wakenda (Figure 323). In addition, the Sacred Heart Cemetery was flooded and destroyed (Figure 324).

In the process of writing this dissertation, massive flooding along the Missouri River in 2011 again brought the urgency of documenting relict features to light. Exceptionally heavy winter precipitation and record release of water from reservoirs in the Dakotas led to massive flooding once again. As I conducted my fieldwork at sites in flood-prone areas early in the spring, I watched daily flood reports roll in as the spring progressed into summer. The gravity of documenting relict features was highlighted daily as I made a few last minute trips for photographs and GPS readings before sites potentially were under flood waters. However, such is life along a river and in a floodplain. As levees began to fail along the Missouri River and natural floodplain began to fill with water, I watched flood waters lap once more at many of the sites destroyed in 1993. By the summer of 2011 the ghost towns of Hodge (Figure 325), Laynesville (Figure 326), Miami Station (Figure 327), Miles Point (Figure 328), and Wakenda (Figure 329) succumbed either partially or completely to the murky flood waters of the Missouri River (imagery from Landsat 7 on July 26).

As the waters began to recede, I revisited several of my study sites that had experienced severe flooding earlier in the summer. On August 28, 2011, I watched the river waters lapping at the Union Pacific railroad tracks that define the north side of Hodge (Figure 330). This was something I had thought about while standing at the same spot with my camera on a chilly March day. That same day, I also visited Miami Station once again. I was shocked by the stark contrast in appearance between my visits, separated by approximately five months. My visit in the spring revealed an area of farm fields, creeks, and a few remaining homes along a paved state supplemental route (Figure 13). Upon my return in late August, I found a very different place than the one I encountered in the spring. While one home remained, much of the area was still under water and there was no way, short of a boat, to return to the site where I took a picture in the spring. Rather, I was forced to photograph the area looking south this time as opposed to the north as I did in the spring. One of the most striking changes was state supplemental route V, now reduced to a gravel bed with not a trace of asphalt remaining and littered with debris (Figure 331). While a child's swing set remained, all of the surrounding plants and grass were dead. This was a powerful reminder of the power of water and the hand of time, erasing traces of what once was in a place.

As summer began to wane and fall began wax, I decided to visit Miles Point in Carroll County once more. I assumed that by the beginning of October, much of the flood waters would have receded and I could survey damage at the site. However, to my surprise, the murky floodwaters of the Missouri River still lapped up against on the southeast side of the ghost town

(Figure 332). As I stood there with a camera, the sound of water lapping at the field was nearly deafening, while accompanied by the surrounding silence coupled with the stench of mud and a view of the slowly receding waters. This served as a powerful reminder that even when the media forgets about a natural disaster, the effects remain for those who live there and must live with them.

Documenting relict features is important, as every day each feature fades a little bit more from the landscape. Floods may bring massive destruction in a short amount of time but natural weathering will just as surely eventually erase the traces of our shared past. Nothing can hold back time, so it is imperative we preserve a record before all traces of relict features are gone and there is no way to preserve any information from them or about them. In the end, I am reminded of a quote from one of my favorite authors and I believe it is a fitting way to close this dissertation: "The past is never dead. It's not even past." - William Faulkner in *Requiem for a Nun*

Chapter 8: References

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Chapter 7: Tables

Table 1

Ghost towns in predominantly grassland/crop fields.

Ghost Town Name	County
Coloma	Carroll County
Cunningham	Chariton County
Elmwood	Saline County
Laynesville	Saline County
Miami Station	Saline County
Miles Point	Carroll County
Mount Hope	Lafayette County
Old Mendon	Chariton County
Plymouth	Carroll County
Shannondale	Chariton County
Triplett	Chariton County
Wakenda	Carroll County

Table 2

Ghost towns predominantly covered by tree canopies.

Ghost Town Name	County
Berlin	Lafayette County
Cambridge	Saline County
Chapel Hill	Lafayette County
Hodge	Lafayette County
New Frankfort	Saline County
Salina	Saline County
Saline City	Saline County
Wien	Chariton County

Table 3

Abandoned railroads.

Railroad Name	County
Brunswick, Chillicothe, and Omaha Railroad	Chariton County
Chicago and Alton Railroad	Saline County
Chicago, Burlington, and Quincy Railroad	Carroll County
Keokuk and Kansas City Railroad	Chariton County
Lexington and St. Louis Railroad	Lafayette and Saline Counties
Lexington, Lake, and Gulf Railroad	Lafayette County
Rocky Branch Railroad	Lafayette County
Western Coal Company's Belt Line Railroad	Lafayette County

Table 4

Roads appearing on NAIP imagery of ghost towns in Saline County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Cambridge	1876	56	9	0
	1896	47	9	0
Elmwood	1876	3	3	0
	1896	4	4	0
Laynesville*	1876	9	0	0
New Frankfort**	1876	686	37	0
	1896	641	37	0
Salina	1876	44	0	0
Saline City***	1876	88	5	5****
	1896	88	5	5****

* = The site is now on the north side of the Missouri River in Carroll County
** = Platted as Frankfurt
*** = Also known as Little Rock Post Office
**** = All roads appear on both LiDAR and NAIP

Table 5

Roads appearing on LiDAR imagery of ghost towns in Saline County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Cambridge	1876	56	9	4
	1896	47	9	4
Elmwood	1876	3	3	0
	1896	4	4	0
Laynesville*	1876	9	0	0
New Frankfort**	1876	686	37	56
	1896	641	37	56
Salina	1877	44	0	0
Saline City***	1876	88	5	19****
	1896	88	5	19****

* = The site is now on the north side of the Missouri River in Carroll County
** = Platted as Frankfurt
*** = Also known as Little Rock Post Office
**** = Five roads appear on both LiDAR and NAIP

Table 6

Percentage of roads appearing on modern LiDAR and NAIP in Saline County, Missouri.

		Total Roads		Historic Roads	
Town	Year	LiDAR	NAIP	LiDAR	NAIP
Cambridge	1876	16.1%	16.1%	23.2%	16.1%
	1896	19.2%	19.2%	27.7%	19.2%
Elmwood	1876	100%	100%	100%	100%
	1896	100%	100%	100%	100%
Laynesville*	1876	0%	0%	0%	0%
New Frankfort**	1876	5.4%	5.4%	13.6%	5.4%
	1896	5.8%	5.8%	14.5%	5.8%
Salina	1876	0%	0%	0%	0%
Saline City***	1876	5.7%	5.7%	27.3%	11.4%
	1896	5.7%	5.7%	27.3%	11.4%

* = The site is now on the north side of the Missouri River in Carroll County
** = Platted as Frankfurt
*** = Also known as Little Rock Post Office

Table 7

Roads appearing on NAIP imagery of ghost towns in Lafayette County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Berlin	1877	142	0	0
	1897	142	0	0
Chapel Hill*	1877	50	8	0
	1897	46	8	0
Hodge**	1897	16	6	0
Mt. Hope	1877	60	12	0

* = Originally Cool Spring and then Harrisburg, platted as Chapel Hill
** = Also known as Edward's Station and Hodge Post Office, platted as Edward's Station

Table 8

Roads appearing on LiDAR imagery of ghost towns in Lafayette County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Berlin	1877	142	0	0
	1897	142	0	0
Chapel Hill*	1877	50	8	0
	1897	46	8	3
Hodge**	1897	16	6	0
Mt. Hope	1877	60	12	0

* = Originally Cool Spring and then Harrisburg, platted as Chapel Hill
** = Also known as Edward’s Station and Hodge Post Office, platted as Edward’s Station

Table 9

Percentage of roads appearing on modern LiDAR and NAIP in Lafayette County, Missouri.

		Total Roads		Historic Roads	
Town	Year	LiDAR	NAIP	LiDAR	NAIP
Berlin	1877	0%	0%	0%	0%
	1897	0%	0%	0%	0%
Chapel Hill*	1877	16%	16%	16%	16%
	1897	17.4%	17.4%	23.9%	17.4%
Hodge**	1897	40%	40%	40%	40%
Mt. Hope	1877	20%	20%	20%	20%

* = Originally Cool Spring and then Harrisburg, platted as Chapel Hill
** = Also known as Edward’s Station and Hodge Post Office, platted as Edward’s Station

Table 10

Roads appearing on NAIP imagery of ghost towns in Carroll County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Coloma	1876	49	4	0
	1896	55	10	0
Miami Station	1876	115	14	0
	1896	115	14	0
Miles Point*	1876	66	9	0
	1896	68	9	0
Plymouth	1876	4	3	0
Wakenda**	1876	84	40	14***
	1896	84	40	14***

* = Also known as Shanghai
** = Platted as Eugene City
*** = Three of the roads appear on both LiDAR and NAIP

Table 11

Roads appearing on LiDAR imagery of ghost towns in Carroll County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Coloma	1876	49	4	7
	1896	55	10	7
Miami Station	1876	115	14	0
	1896	115	14	0
Miles Point*	1876	66	9	2
	1896	68	9	2
Plymouth	1876	4	3	0
Wakenda**	1876	84	38	15***
	1896	84	38	15***

* = Also known as Shanghai
** = Platted as Eugene City
*** = Three of the roads appear on both LiDAR and NAIP

Table 12

Percentage of roads appearing on modern LiDAR and NAIP in Carroll County, Missouri.

		Total Roads		Historic Roads	
Town	Year	LiDAR	NAIP	LiDAR	NAIP
Coloma	1876	8.2%	8.2%	22.5%	8.2%
	1896	18.2%	18.2%	30.9%	18.2%
Miami Station	1876	12.2%	12.2%	12.2%	12.2%
	1896	12.2%	12.2%	12.2%	12.2%
Miles Point*	1876	13.6%	13.6%	16.7%	13.6%
	1896	13.2%	13.2%	16.2%	13.2%
Plymouth	1876	75%	75%	75%	75%
Wakenda**	1876	47.6%	45.2%	63.1%	64.3%
	1896	47.6%	45.2%	63.1%	64.3%

* = Also known as Shanghai
** = Platted as Eugene City
*** = Three of the roads appear on both LiDAR and NAIP

Table 13

Roads appearing on NAIP imagery of ghost towns in Chariton County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Cunningham	1897	126	41	3*
Old Mendon	1897	5	1	0
Shannondale	1897	27	9	0
Triplett	1897	95	53	4*
Wien***	1897	21	9	0

* = All roads appear on both LiDAR and NAIP
** = Originally Mendon
** *= Originally Mt. St. Mary's

Table 14

Roads appearing on LiDAR imagery of ghost towns in Chariton County, Missouri.

Town	Map Year	Platted Roads	Modern Roads	Historical Roads
Cunningham	1897	126	41	19*
Old Mendon**	1897	5	1	0
Shannondale	1897	27	9	3
Triplett	1897	95	53	21***
Wien****	1897	21	9	1

* = Three roads appear on both LiDAR and NAIP
** = Originally Mendon
*** = Four roads appear on both LiDAR and NAIP
****= Originally Mt. St. Mary's

Table 15

Percentage of roads appearing on modern LiDAR and NAIP in Chariton County, Missouri.

		Total Roads		Historic Roads	
Town	Year	LiDAR	NAIP	LiDAR	NAIP
Cunningham	1897	32.5%	32.5%	47.6%	34.9%
Old Mendon*	1897	20%	20%	20%	20%
Shannondale	1897	33.3%	33.3%	44.4%	33.3%
Triplett	1897	55.8%	55.8%	77.9%	60%
Wien**	1897	42.9%	42.9%	47.6%	42.9%

* = Originally Mendon
**= Originally Mt. St. Mary's

Table 16

Length in miles of historical railroads in plat books, on LiDAR imagery, and on NAIP imagery.

Railroad Name	Plat Book	LiDAR	NAIP
Brunswick, Chillicothe, and Omaha	19.8	19.8	19.3
Chicago, Burlington, and Quincy	12.3	11.6	8.5
Keokuk and Kansas City	12.7	3.4	1.8
Lexington and St. Louis Railroad	38.4	29.7	20.6
Lexington, Lake and Gulf Railroad	11.0	0.6	0.0
Rocky Branch Railroad	2.2	0.1	0.0
Missouri Pacific Railroad	2.4	0.9*	2.4
Western Coal Company's Belt Line	2.6	0.0	0.0

* = An error in the LiDAR data cut off the railroad after 0.9 miles

Table 18

Cemeteries with features appearing on LiDAR.

Cemetery	County	Individual Stones	Group of Stones	Other
Confederate Memorial SHS	Lafayette	0	0	1
DeWitt Evergreen	Carroll	1	0	1
Fairview Cemetery	Saline	2	6	0
Greenton Baptist Church	Lafayette	1	0	0
Mendon	Chariton	0	2	0
Mount Nebo	Saline	0	2	0
Oak Hill	Carroll	5	0	0
Odessa	Lafayette	1	0	0
Ridge Park	Saline	3	4	3
Sacred Heart	Carroll	0	0	2
Salisbury	Chariton	0	2	0
Shore	Lafayette	0	2	0
St. Mary's	Chariton	0	3	0

Table 19

Cemeteries without features appearing on LiDAR.

Cemetery	County
Big Adkins	Carroll
Braden	Carroll
Cambridge	Saline
Elliott Grove	Chariton
Harmony	Saline
Mount Hope Presbyterian Church	Lafayette
Newcomer	Chariton

Chapter 10: Figures

Figure 1.

Map showing the location of the study area within the state of Missouri.

Figure 2.

A generalized map of Carroll County showing towns, cemeteries, railroads, and highways.

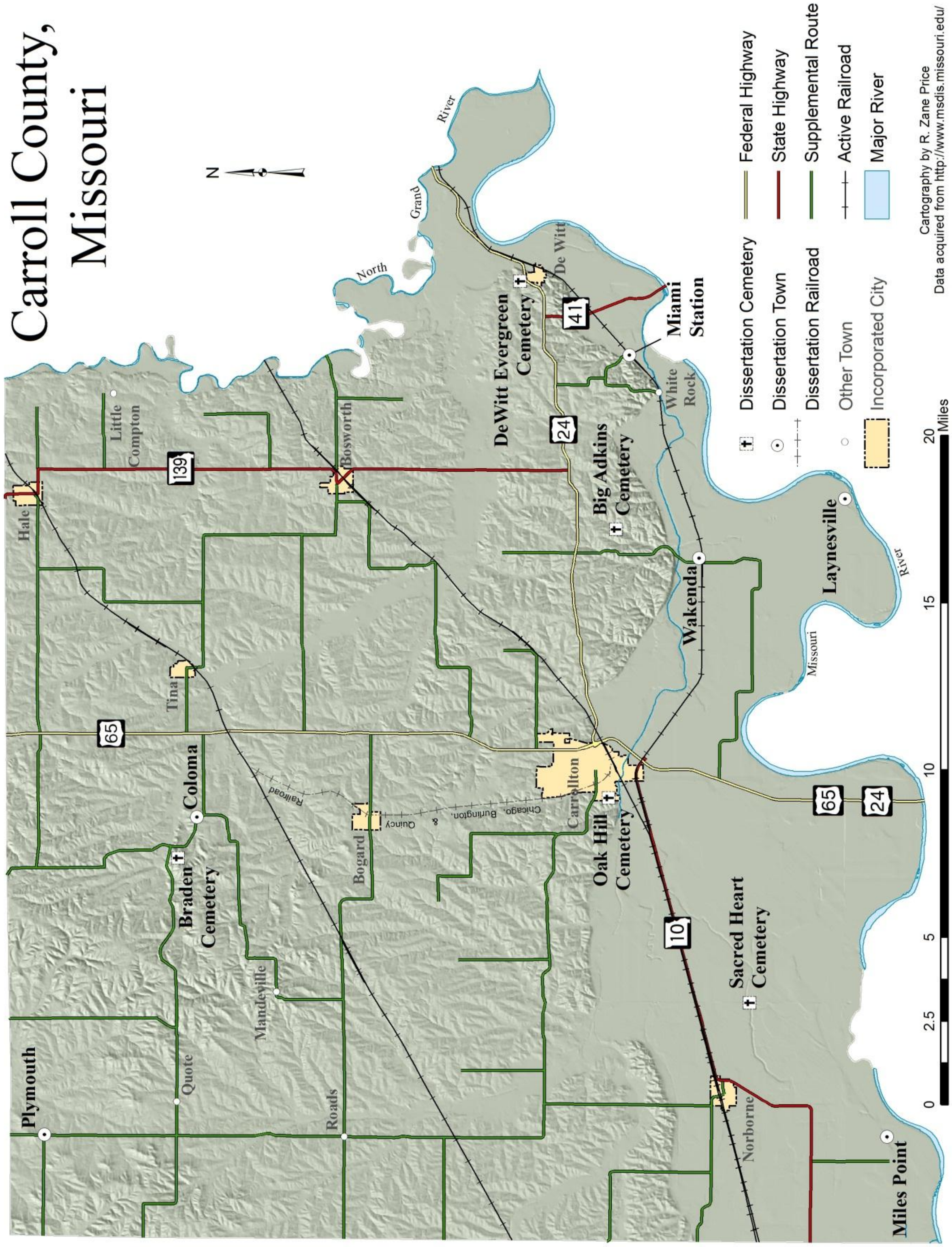


Figure 3.

A generalized map of Chariton County showing towns, cemeteries, railroads, and highways.

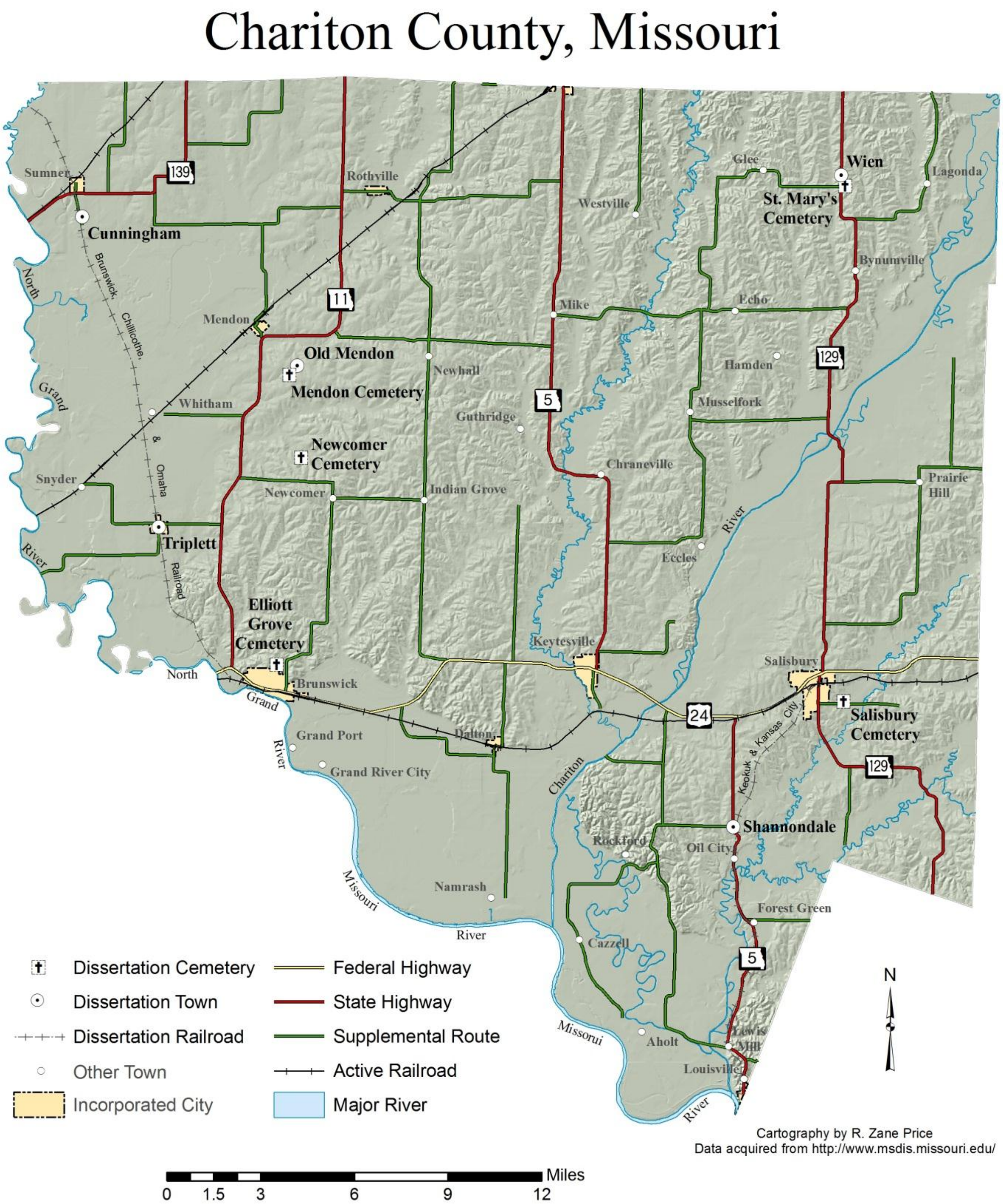


Figure 4.

A generalized map of Lafayette County showing towns, cemeteries, railroads, and highways.

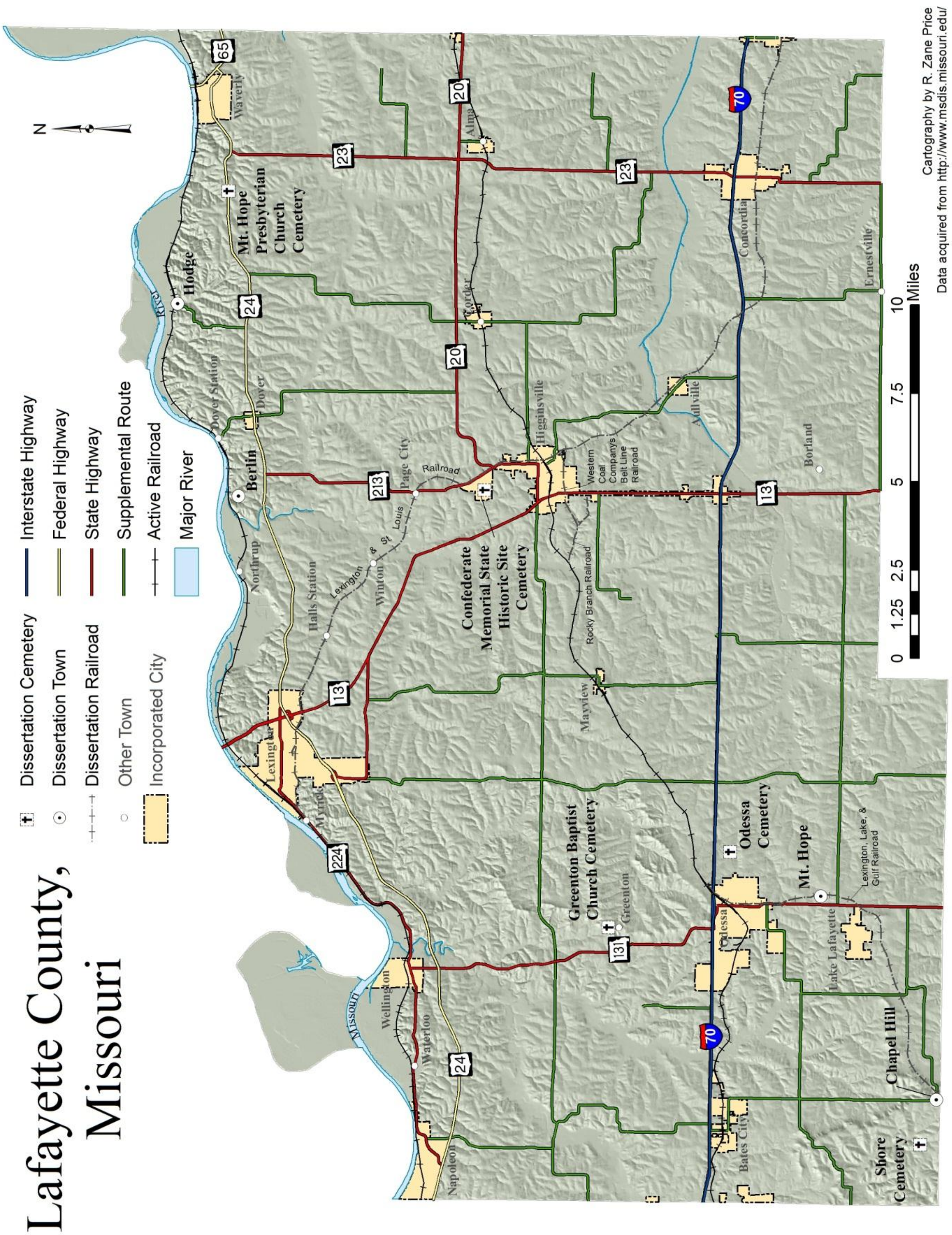


Figure 5.

A generalized map of Saline County showing towns, cemeteries, railroads, and highways.

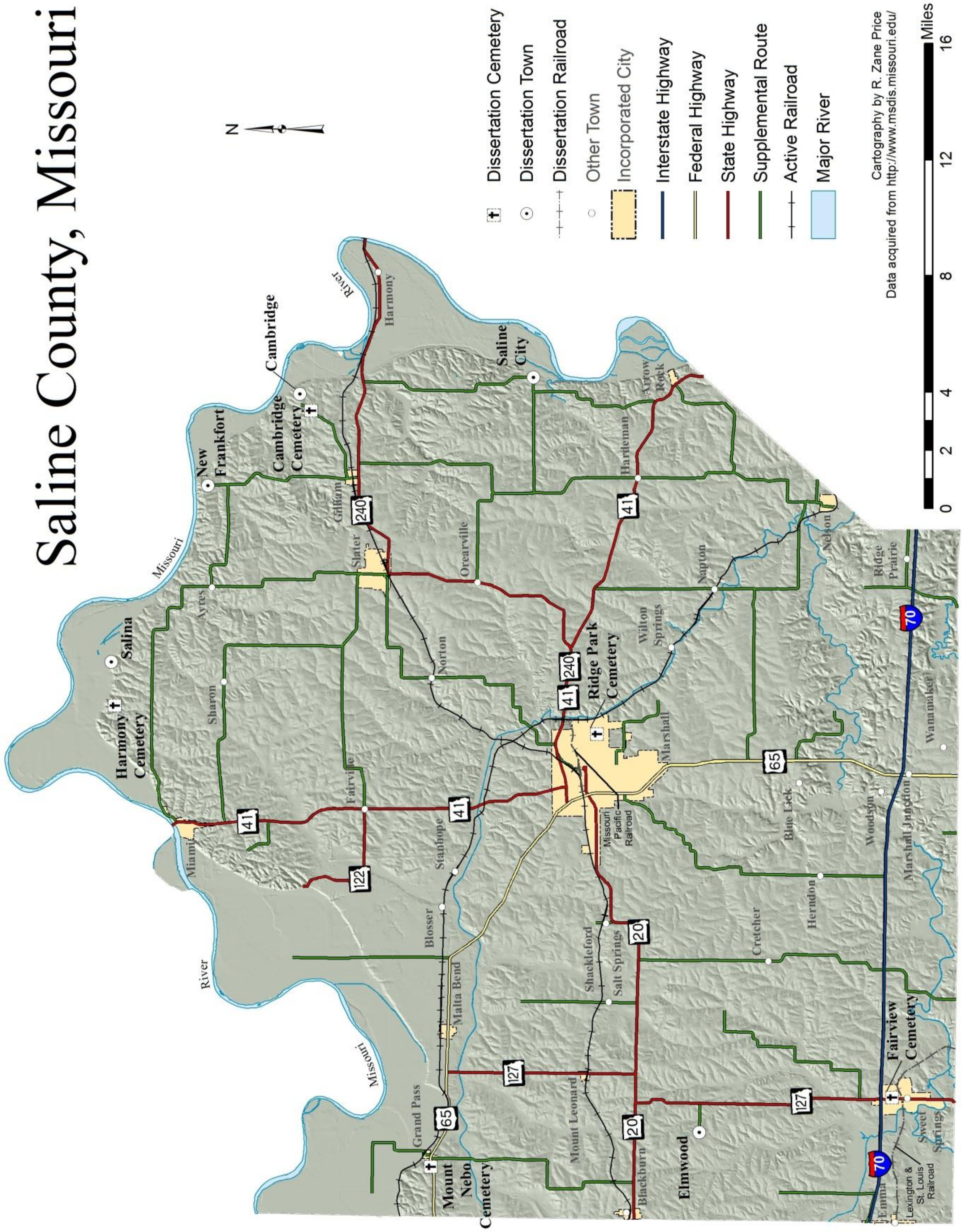


Figure 6.

Map showing available LiDAR date for the central United States in red, from http://lidar.cr.usgs.gov/LIDAR_Viewer/viewer.php. LiDAR for Iowa is available from http://www.geotree.uni.edu/LidarProject.aspx. Additional LiDAR for Kansas is available from http://www.kansasgis.org/catalog/index.cfm.

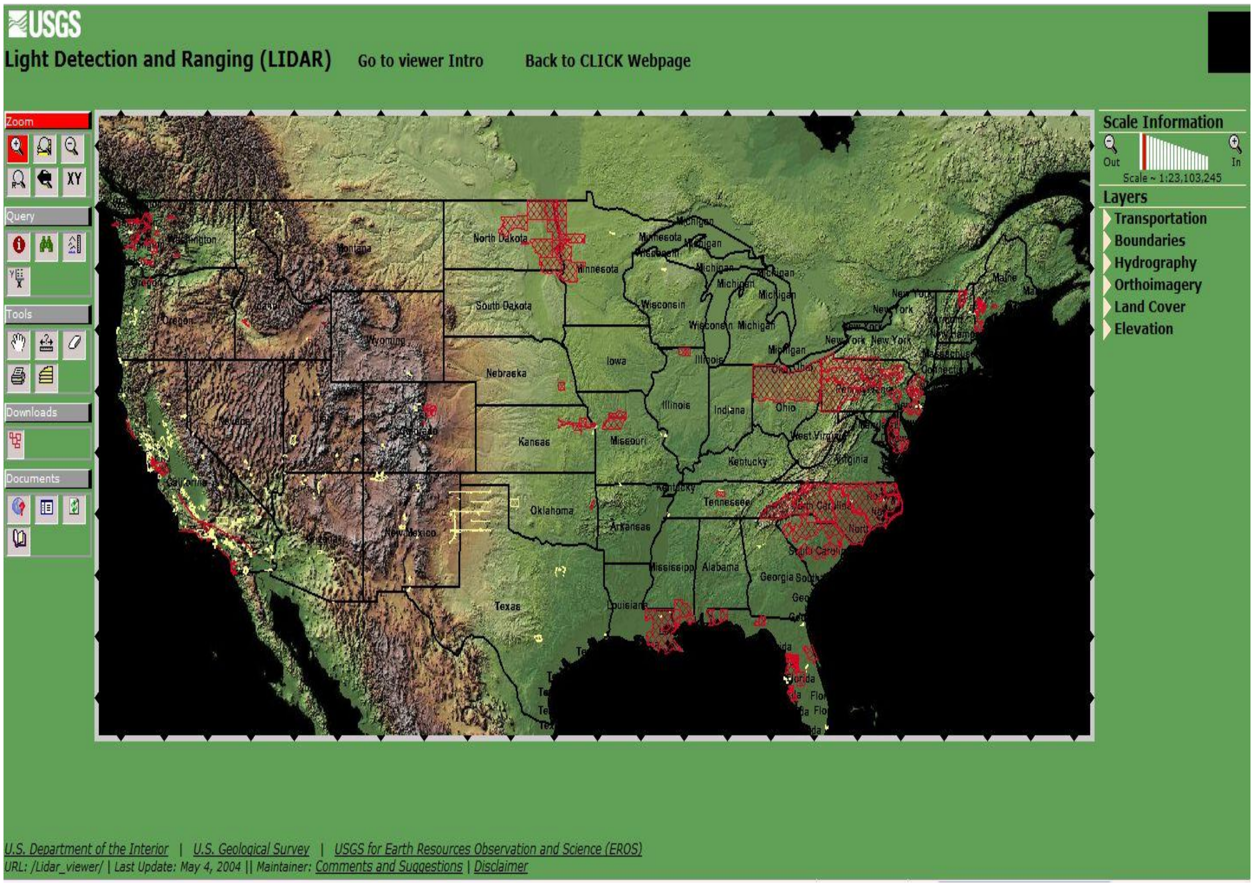


Figure 7.

The location of Coloma from the 1896 Carroll County Plat book.

Figure 8.

A picture of Coloma's 1914 plat.

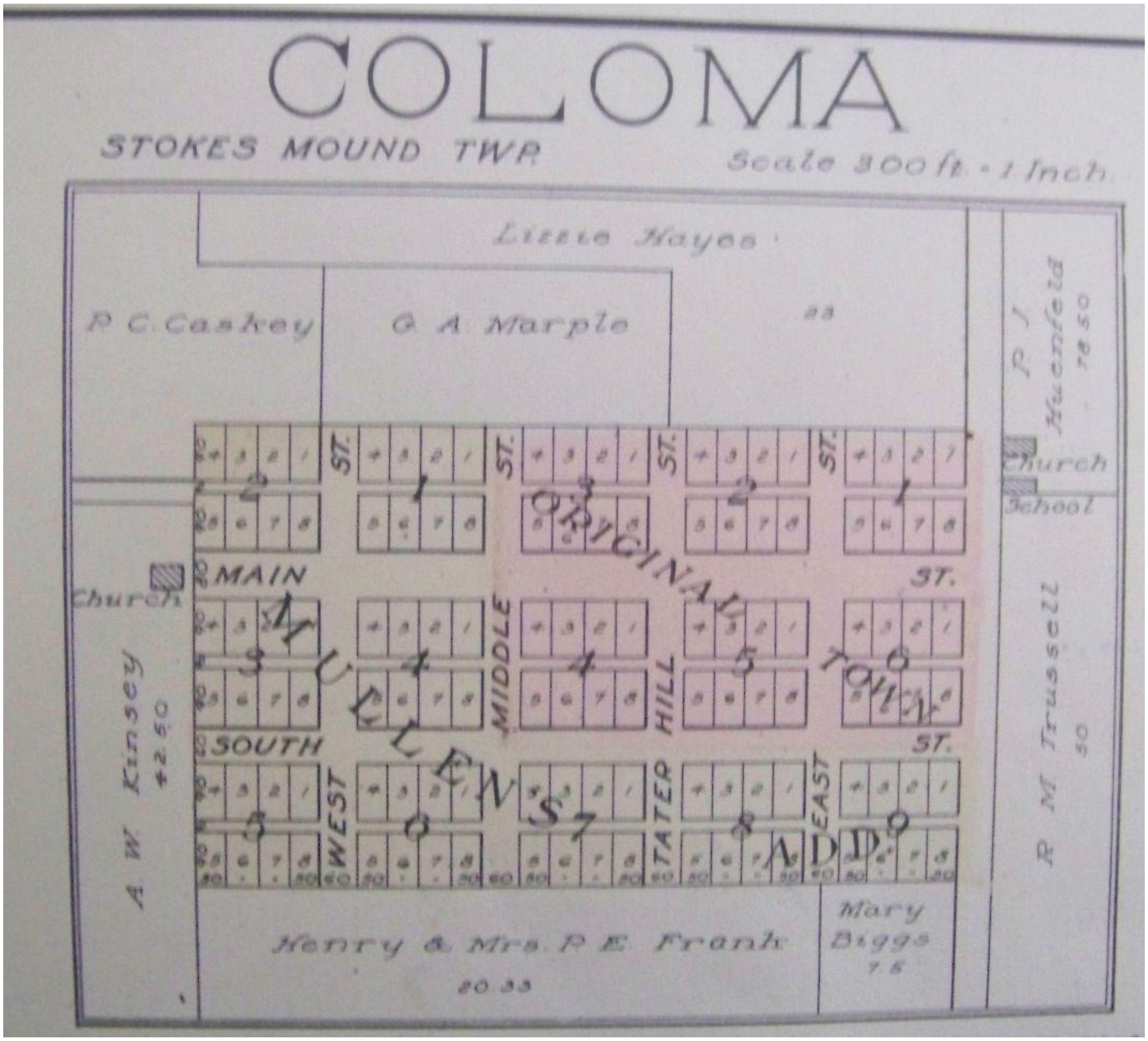


Figure 9.

A picture of the former town of Coloma, looking south.

Figure 10.

A picture of the former town of Coloma, looking south.

Figure 11.

The location of Miami Station from the 1896 Carroll County Plat book.

Figure 12.

A picture of Miami Station's 1896 plat.

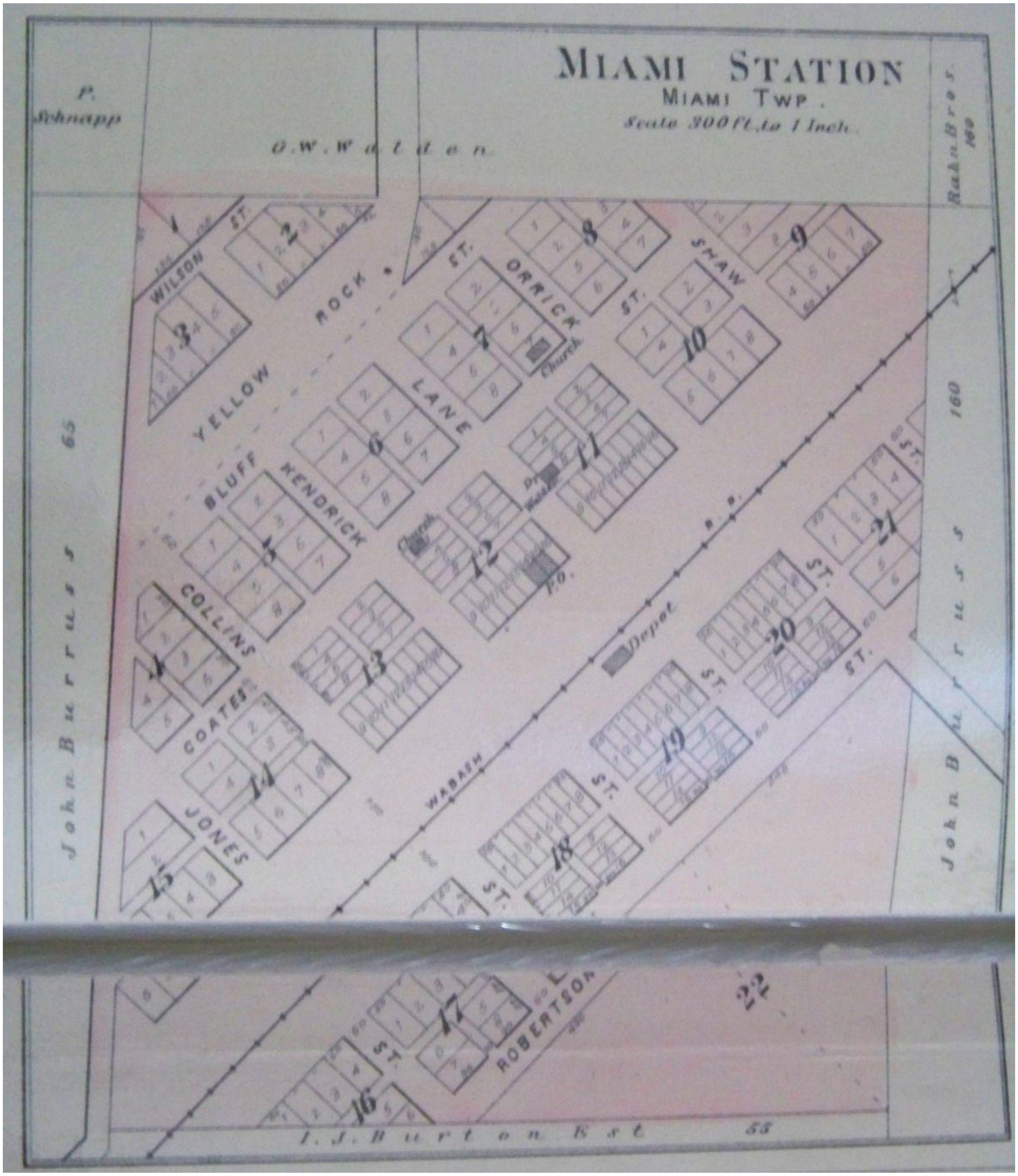


Figure 13.

A picture of the former town of Miami Station, looking northeast.

Figure 14.

A picture of the former town of Miami Station, looking north.

Figure 15.

The location of Miles Point from the 1896 Carroll County Plat book.

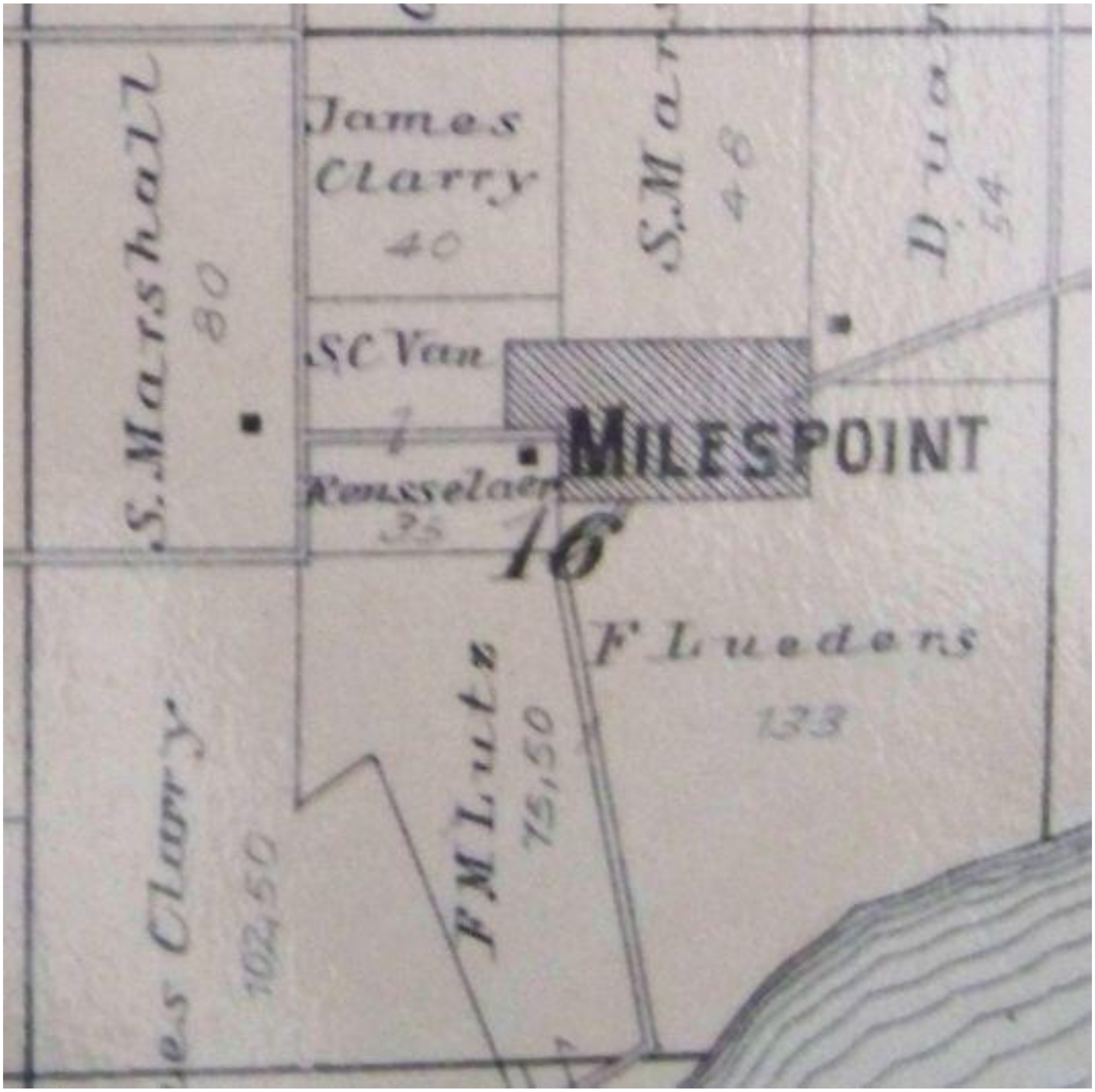


Figure 16.

A picture of Miles Point's 1896 plat.

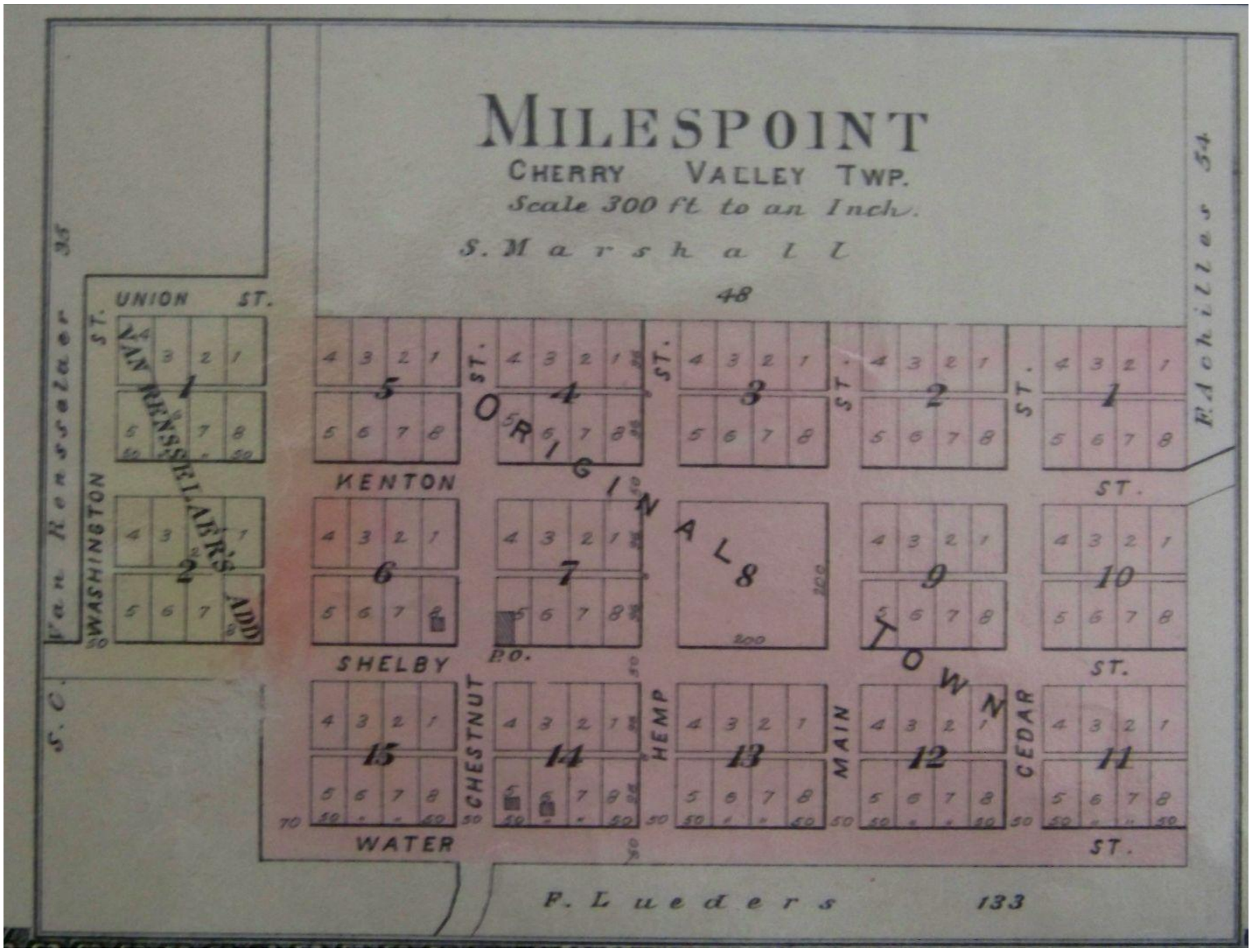


Figure 17.

A picture of the former town of Miles Point, looking south toward the Missouri River.

Figure 18.

A picture of the former town of Miles Point, looking northeast.

Figure 19.

The location of Plymouth from the 1896 Carroll County Plat book.

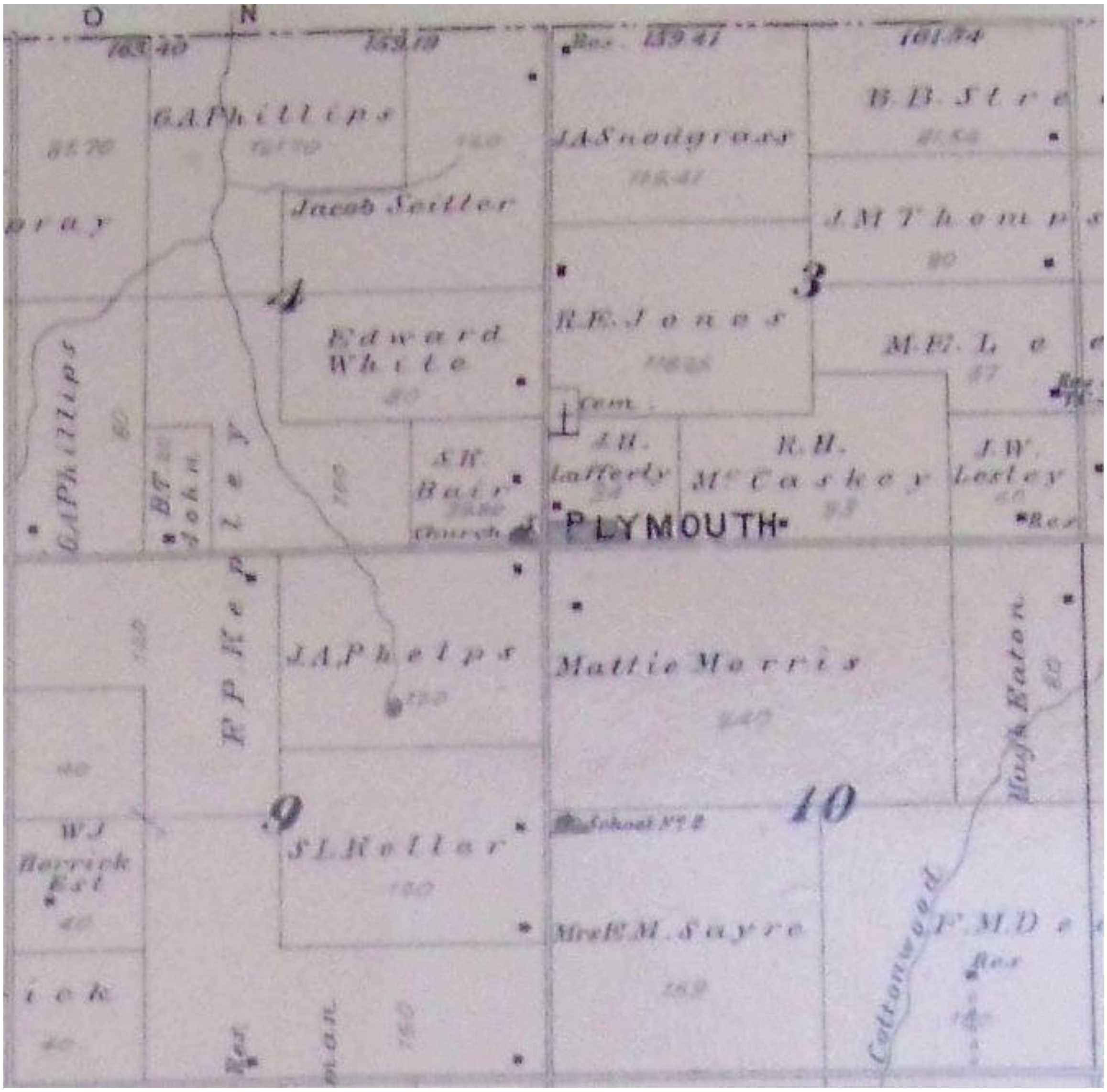


Figure 20.

A picture of Plymouth's 1914 plat.

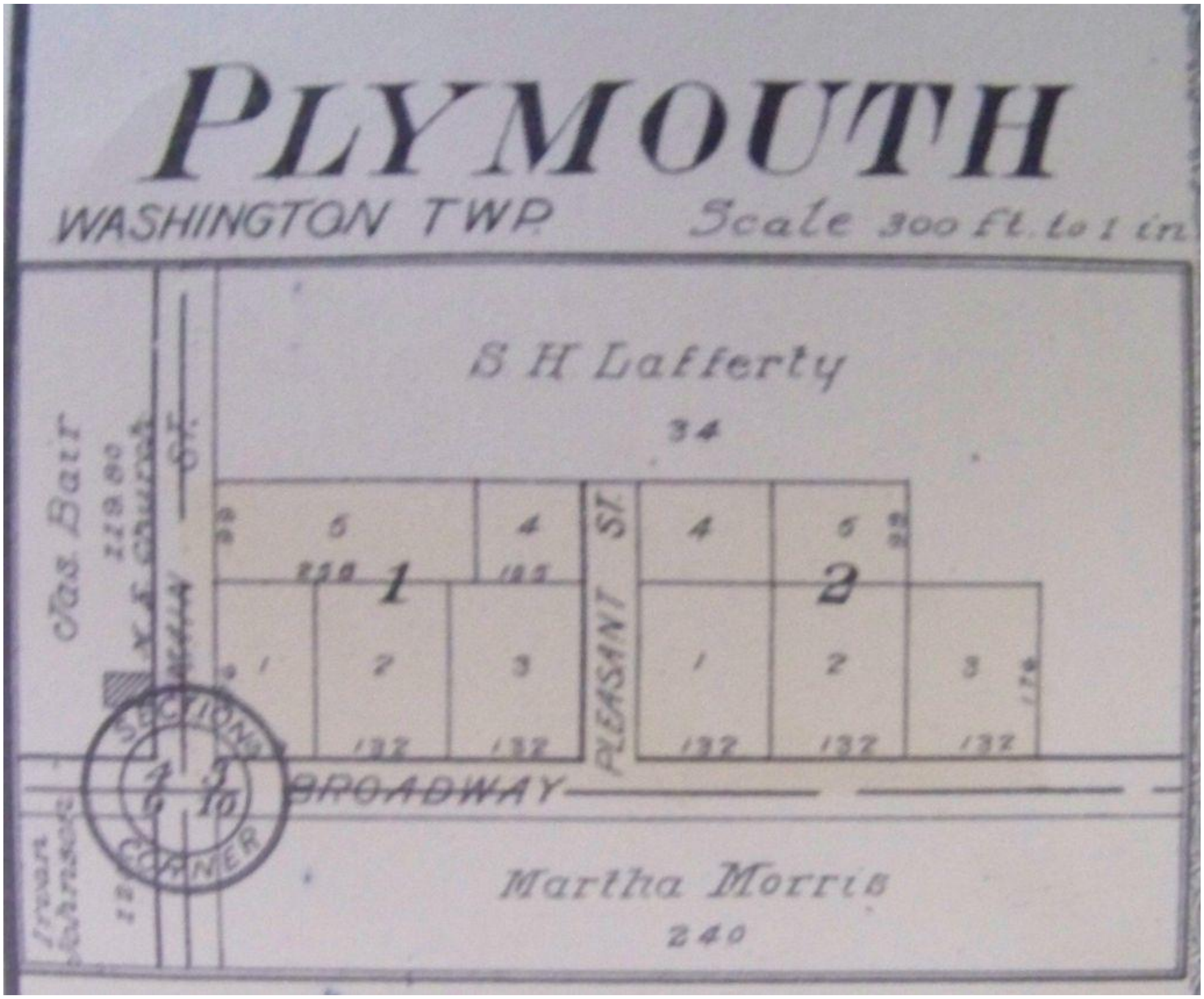


Figure 21.

A picture of the former town of Plymouth, looking east.

Figure 22.

A picture of the former town of Plymouth, looking west.

Figure 23.

The location of Wakenda from the 1896 Carroll County Plat book.

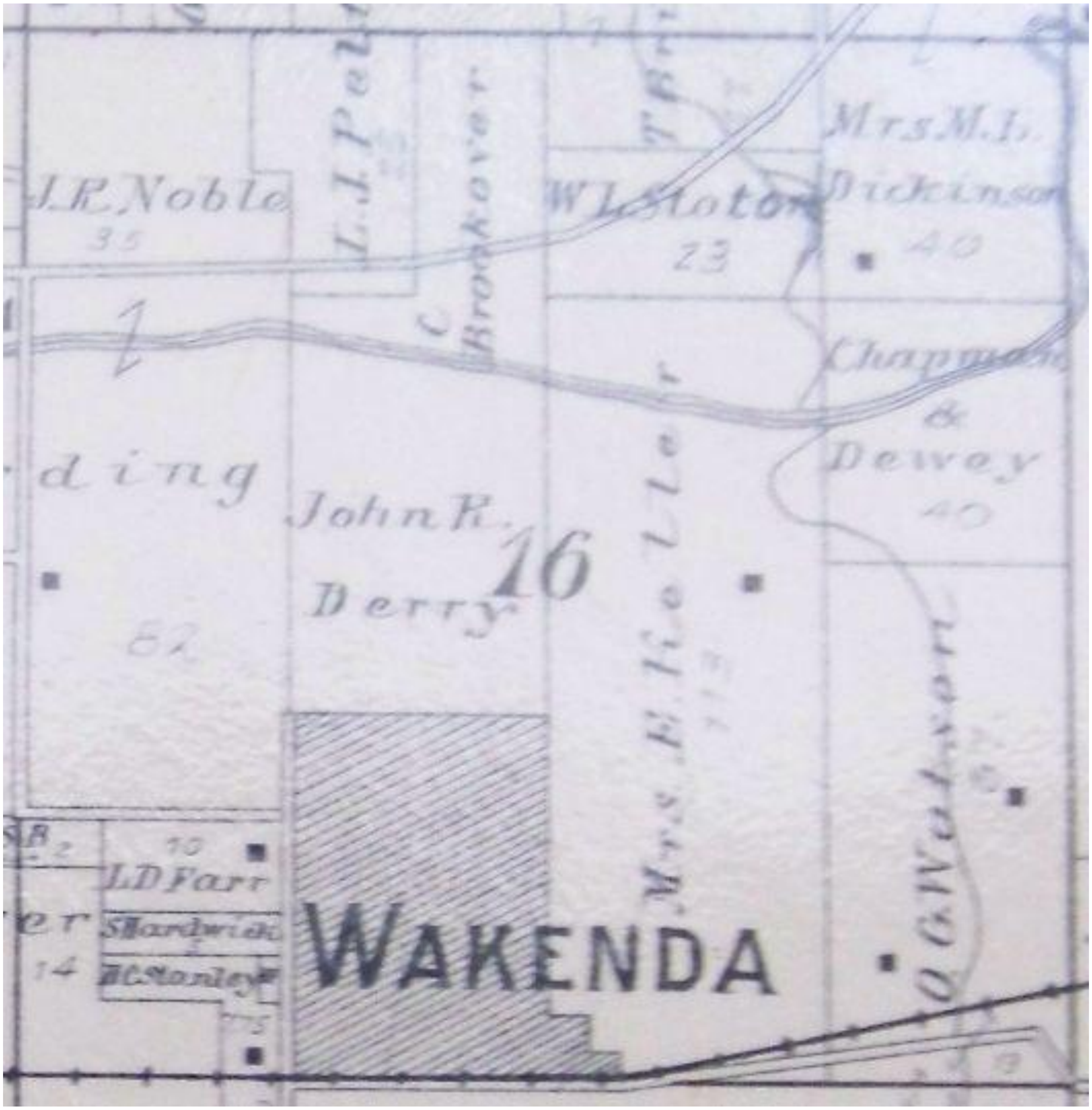


Figure 24.

A picture of Wakenda's 1914 plat.

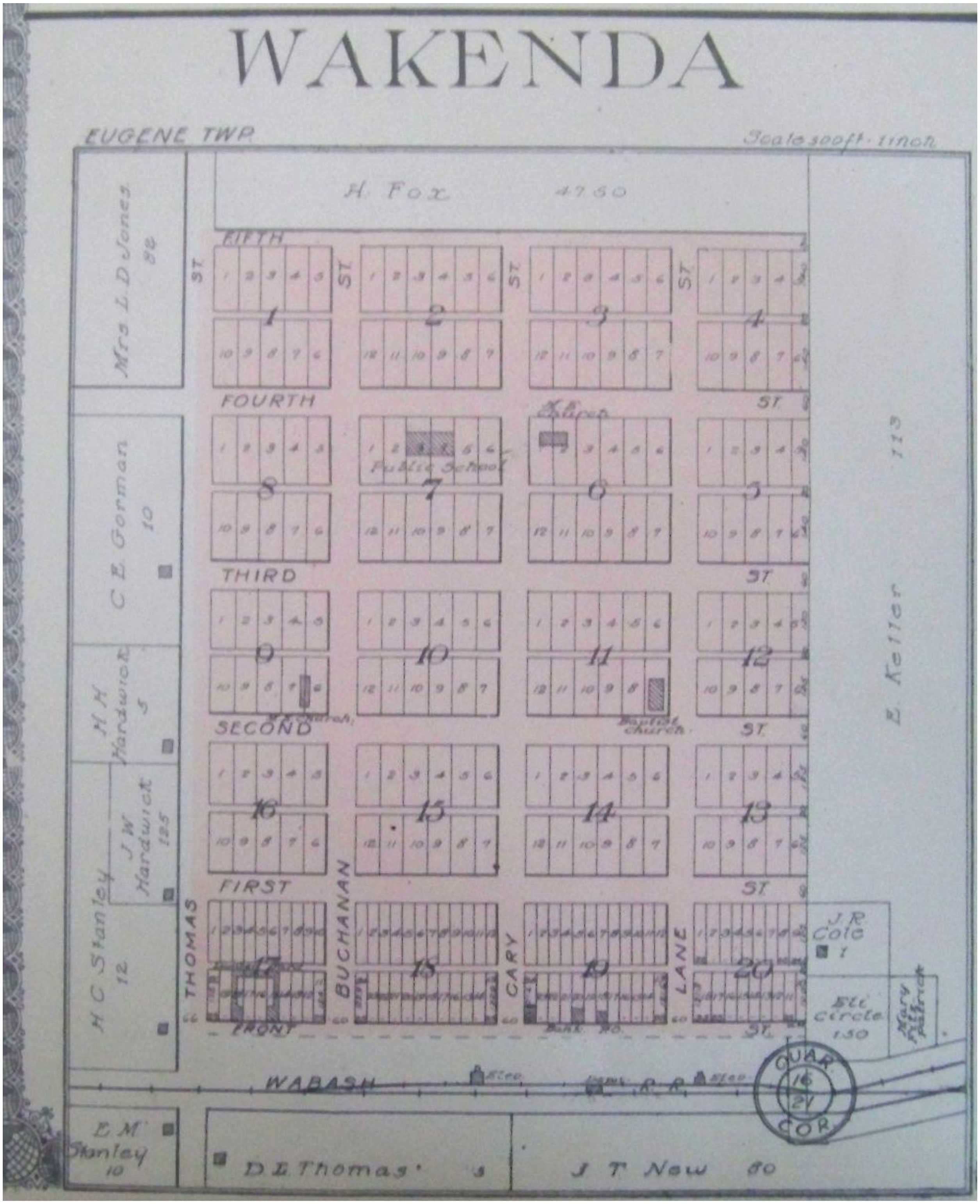


Figure 25.

A picture of a monument in the former town of Wakenda.

Figure 26.

A picture of the former town of Wakenda, looking northwest at abandoned roads.

Figure 27.

A picture of the former town of Wakenda, looking south.

Figure 28.

The location of Cunningham from the 1915 Chariton County Plat book.

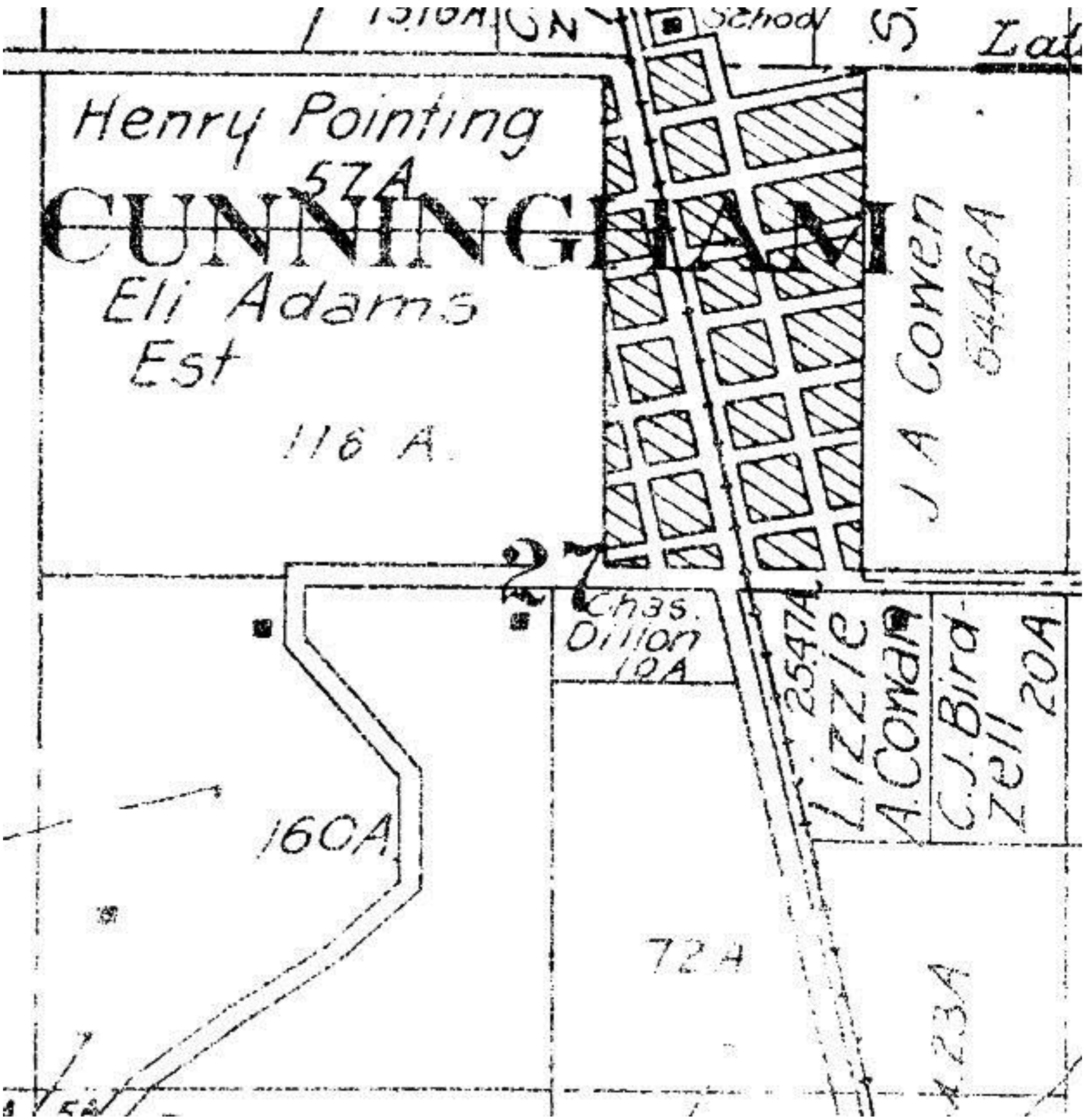


Figure 29.

A picture of Cunningham's 1897 plat.

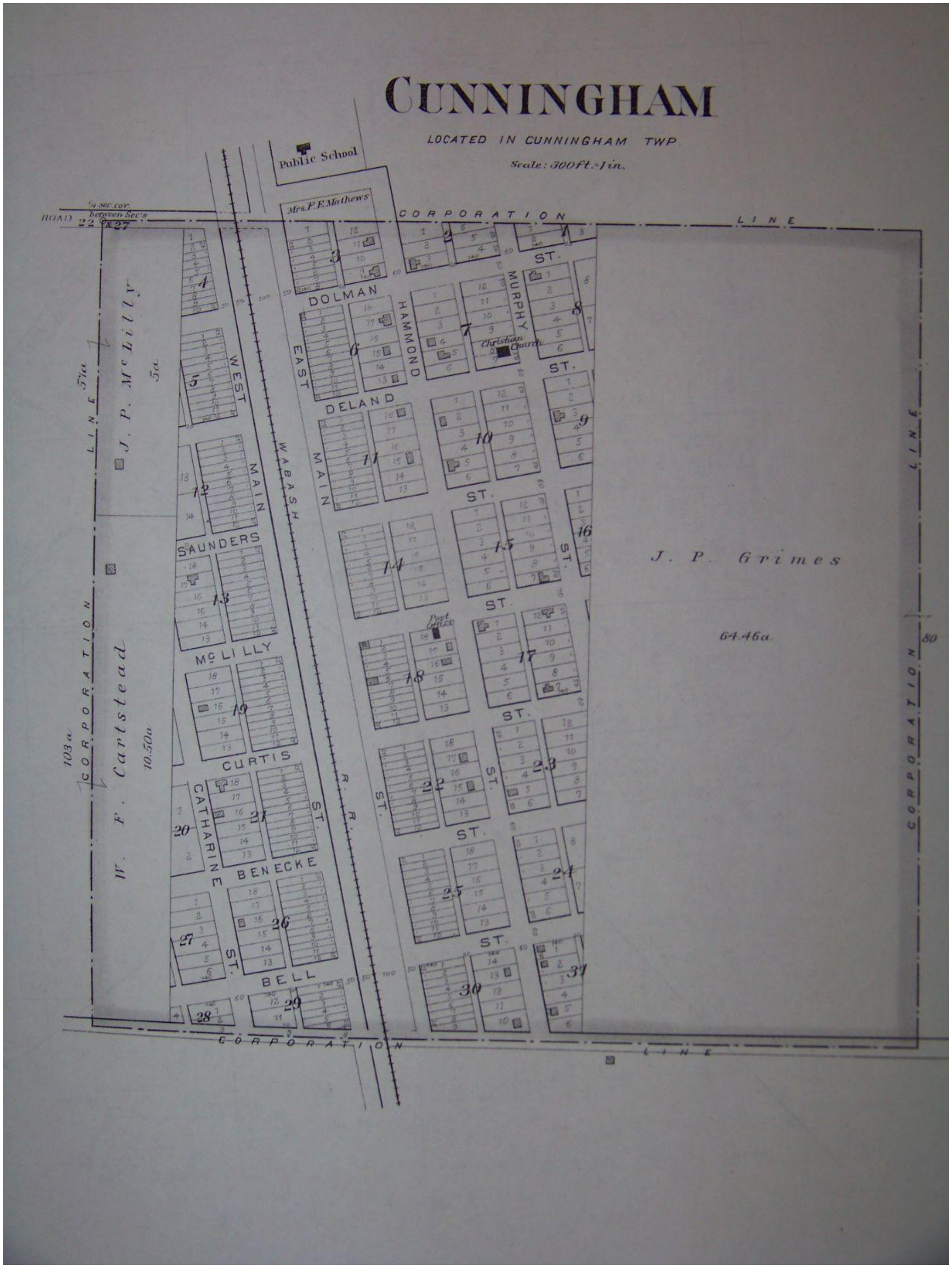


Figure 30.

A picture of the former town of Cunningham, looking north.

Figure 31.

A picture of the former town of Cunningham, looking south.

Figure 32.

The location of Old Mendon from the 1897 Chariton County Plat book.

Figure 33.

A copy of Old Mendon's 1897 plat.

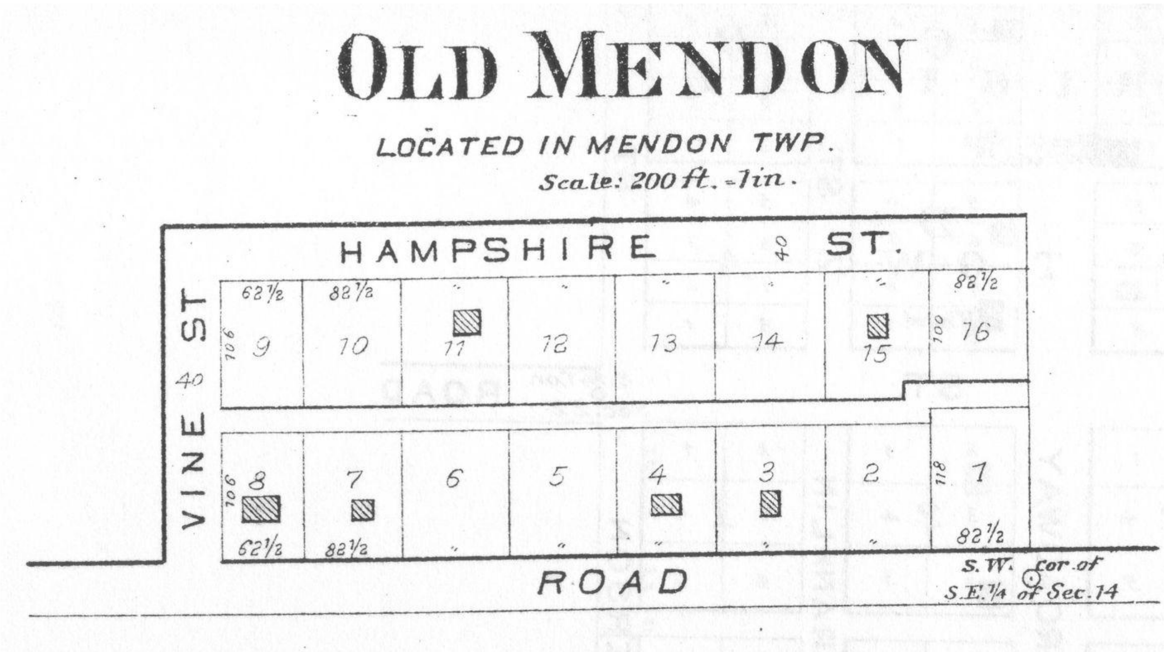


Figure 34.

A picture of the former town of Old Mendon, looking east.

Figure 35.

The location of Shannondale from the 1897 Chariton County Plat book.

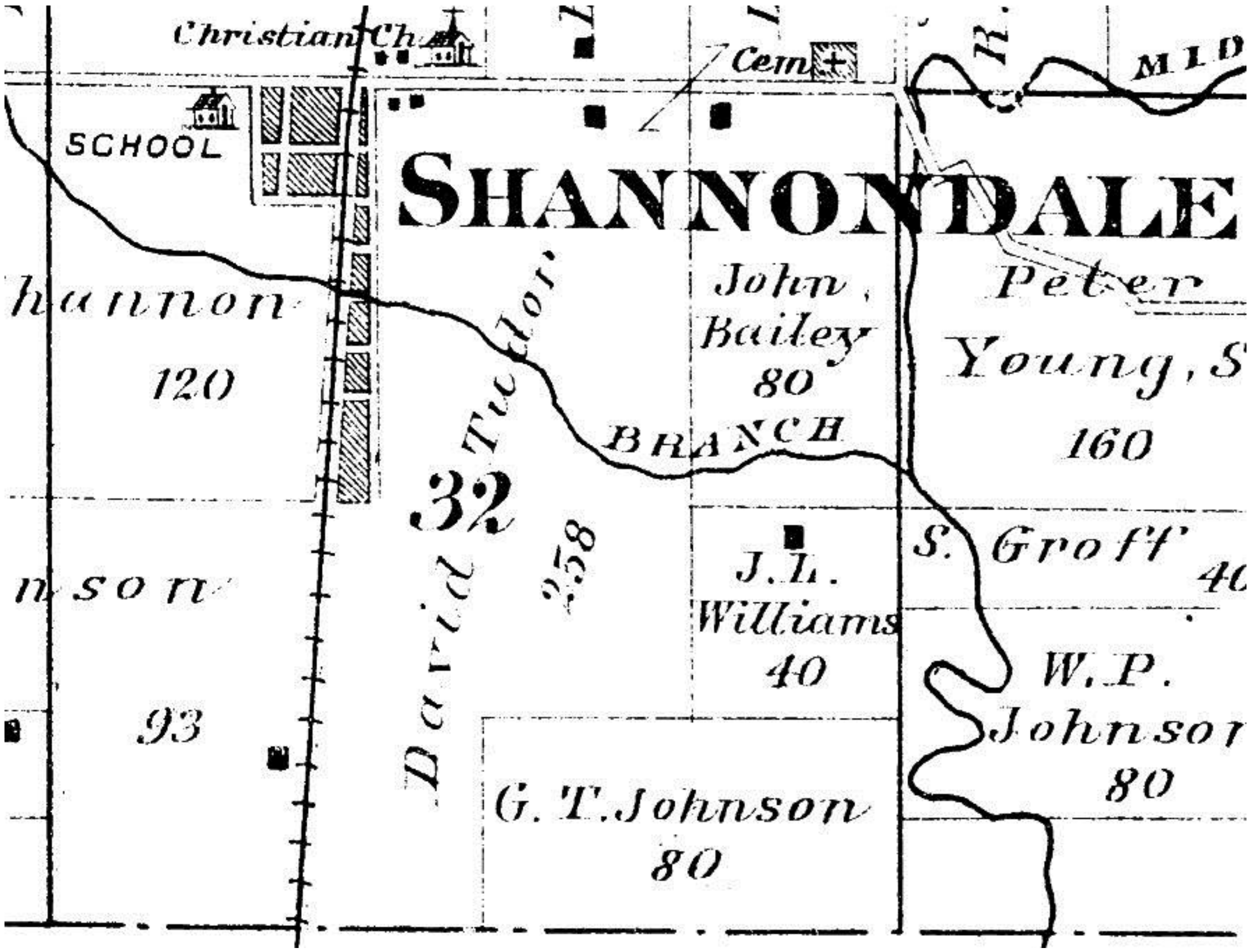


Figure 36.

A picture of Shannondale's 1897 plat.

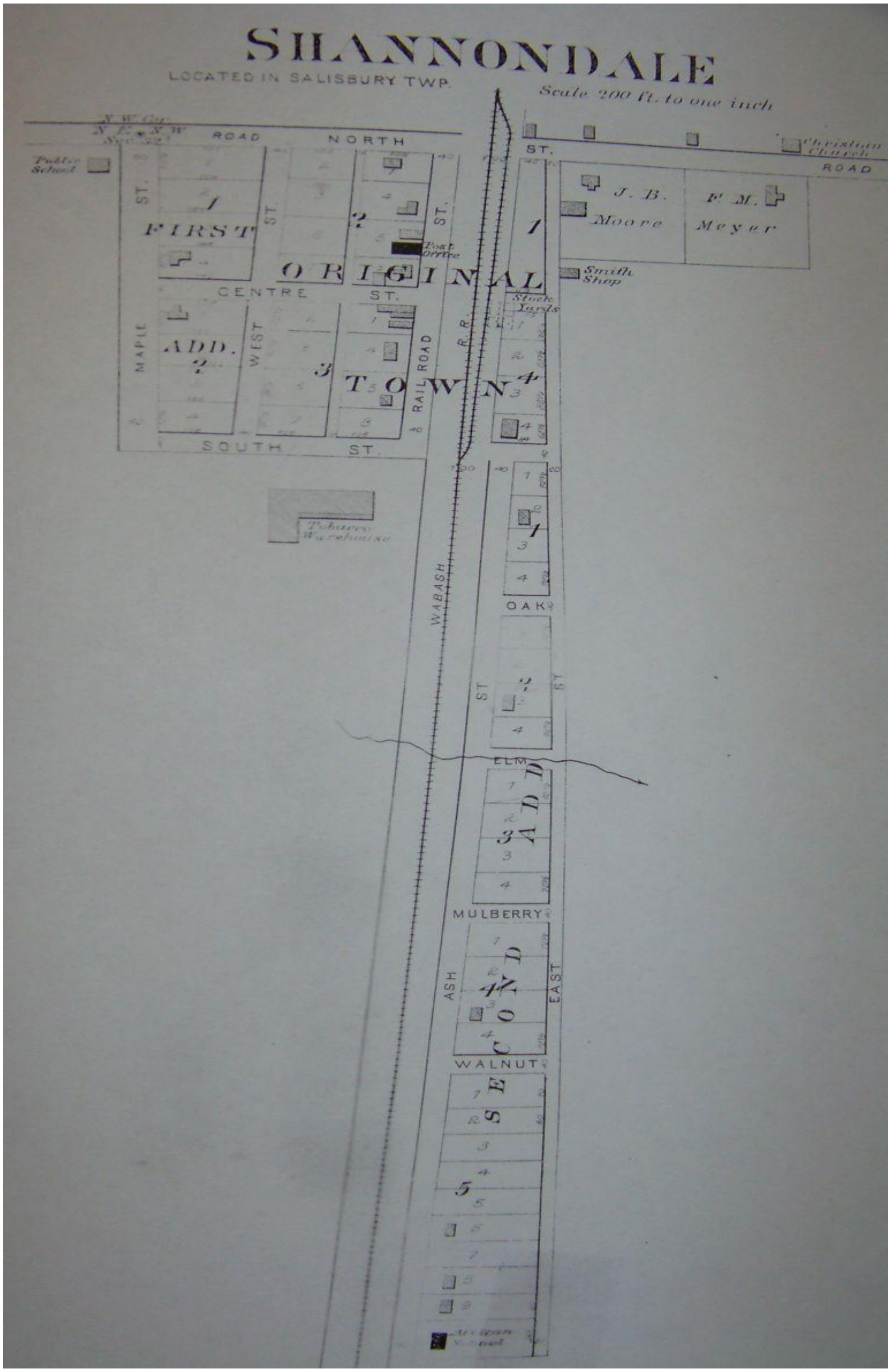


Figure 37.

A picture of a sign in the former town of Shannondale.

Figure 38.

A picture of the former town of Shannondale, looking west.

Figure 39.

A picture of the former town of Shannondale, looking south.

Figure 40.

The location of Triplett from the 1897 Chariton County Plat book.

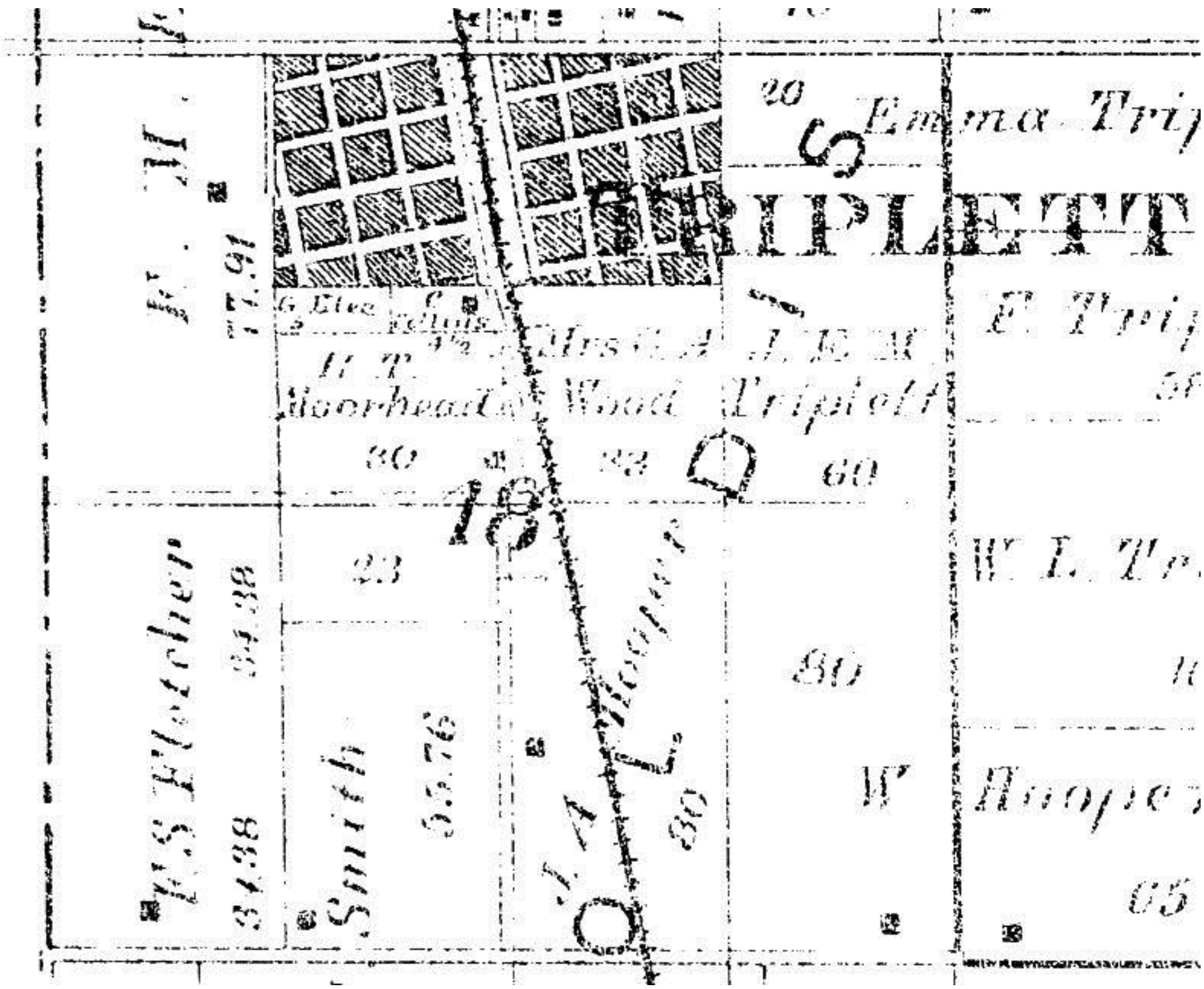


Figure 41.

A picture of Triplett’s 1897 plat.

Figure 42.

A picture of a collapsed house in the former town of Triplett.

Figure 43.

A picture of the former town of Triplett, looking west.

Figure 44.

A picture of the former town of Triplett, looking north.

Figure 45.

A picture of the abandoned Brunswick, Chillicothe, and Omaha Railroad in the former town of Triplett.

Figure 46.

The location of Wien from the 1897 Chariton County Plat book.

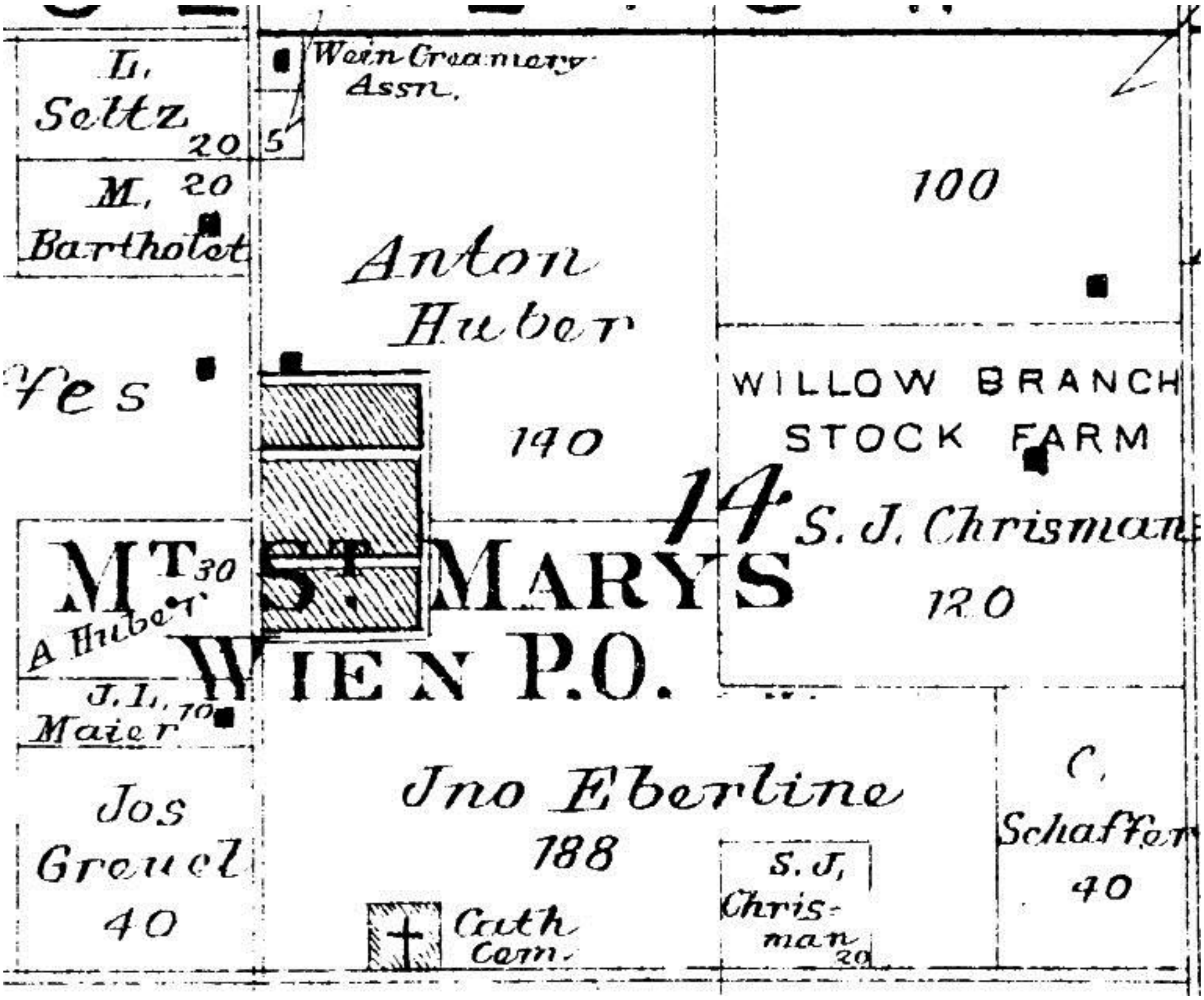


Figure 47.

A copy of Wien's 1897 plat.

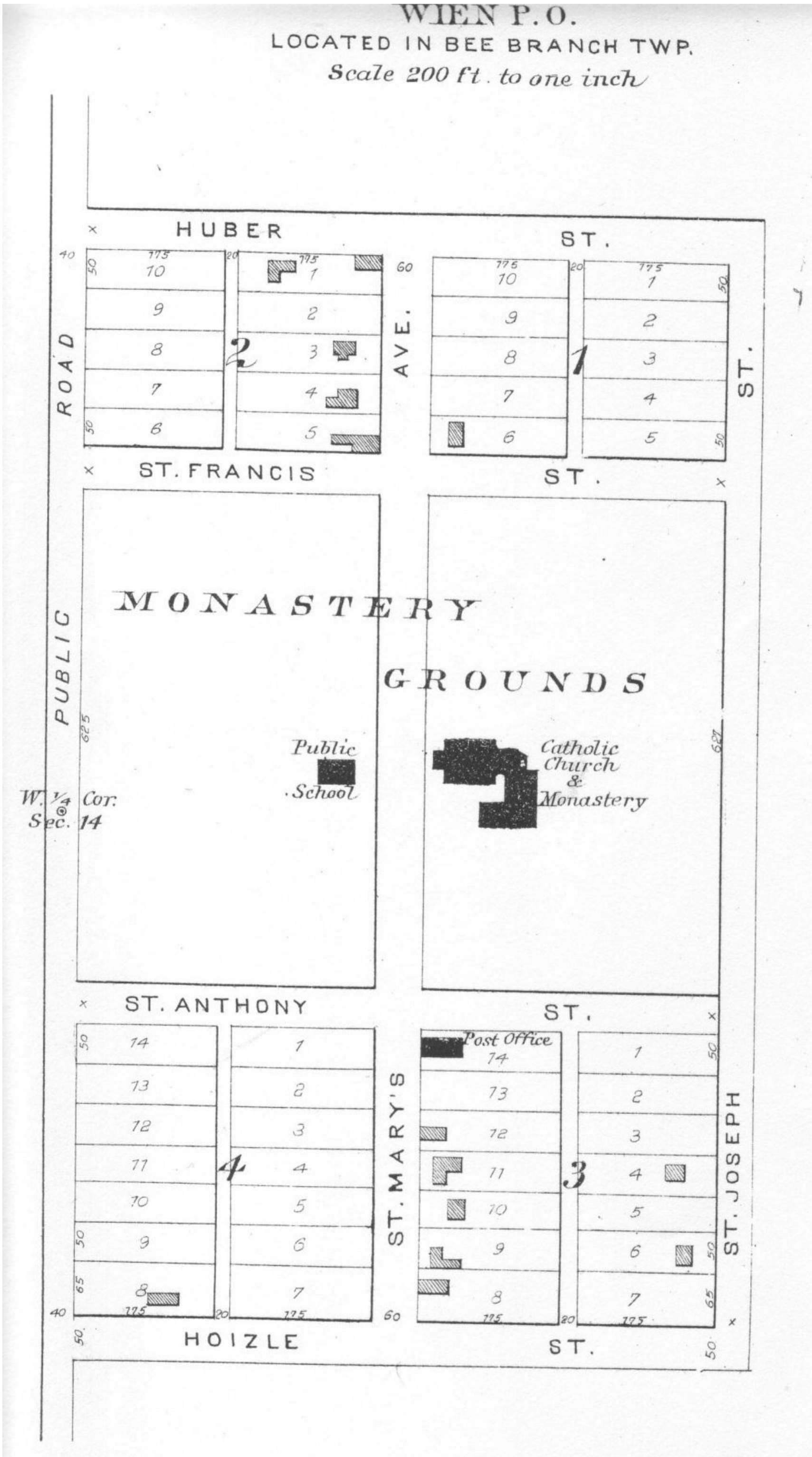


Figure 48.

A picture of the former town of Wien, looking south.

Figure 49.

A picture of the former town of Wien, looking north.

Figure 50.

A picture of the Mount St. Mary's Church in former town of Wien.

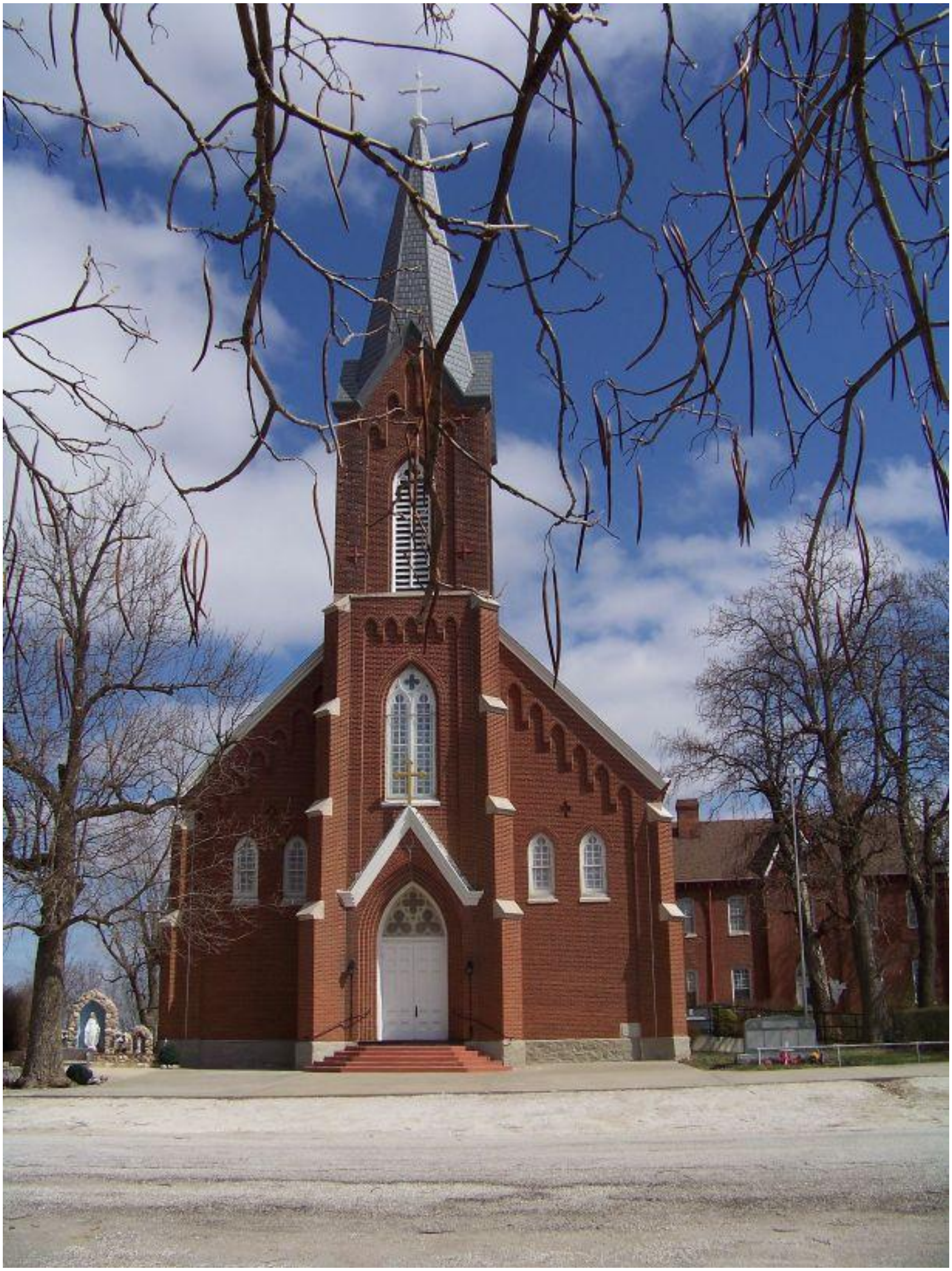


Figure 51.

The location of Berlin from the 1897 Lafayette County Plat book.

Figure 52.

A copy of Berlin's 1877 plat.

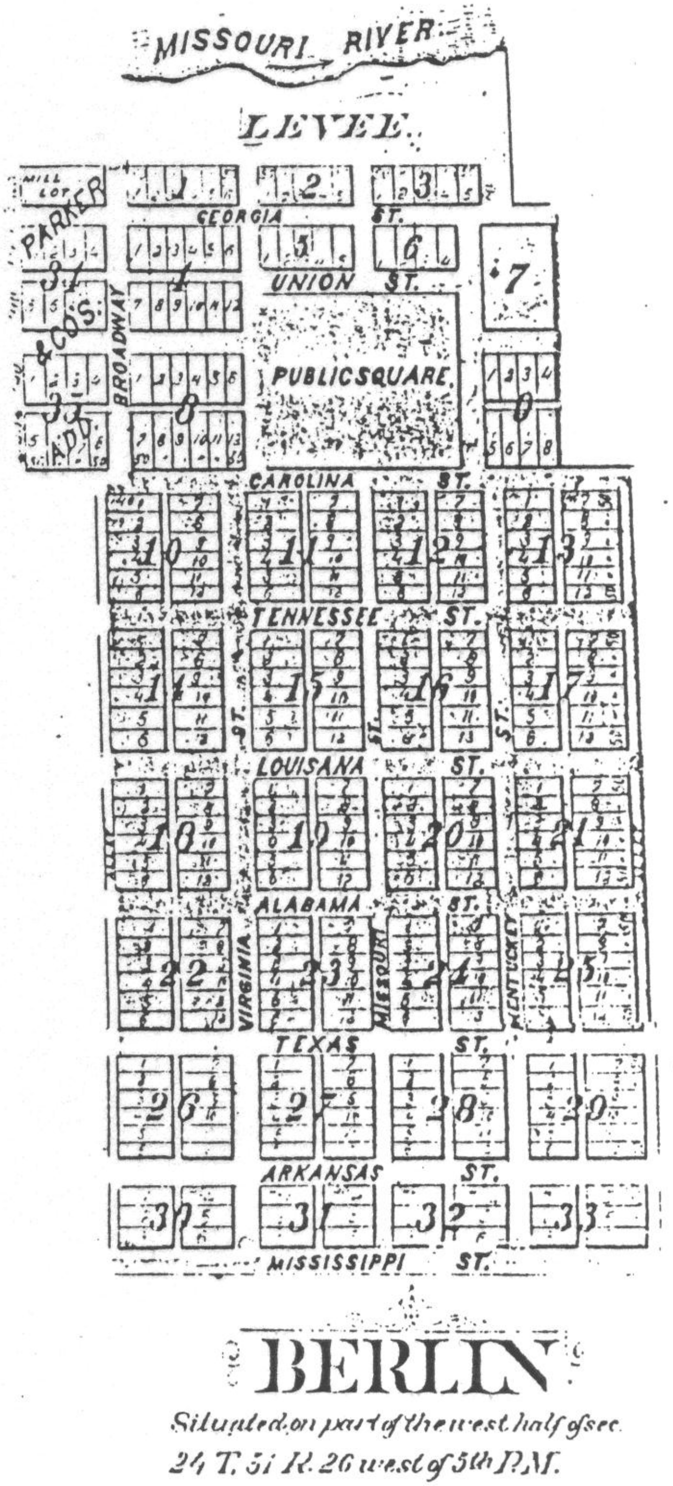


Figure 53.

The location of Chapel Hill from the 1897 Lafayette County Plat book.

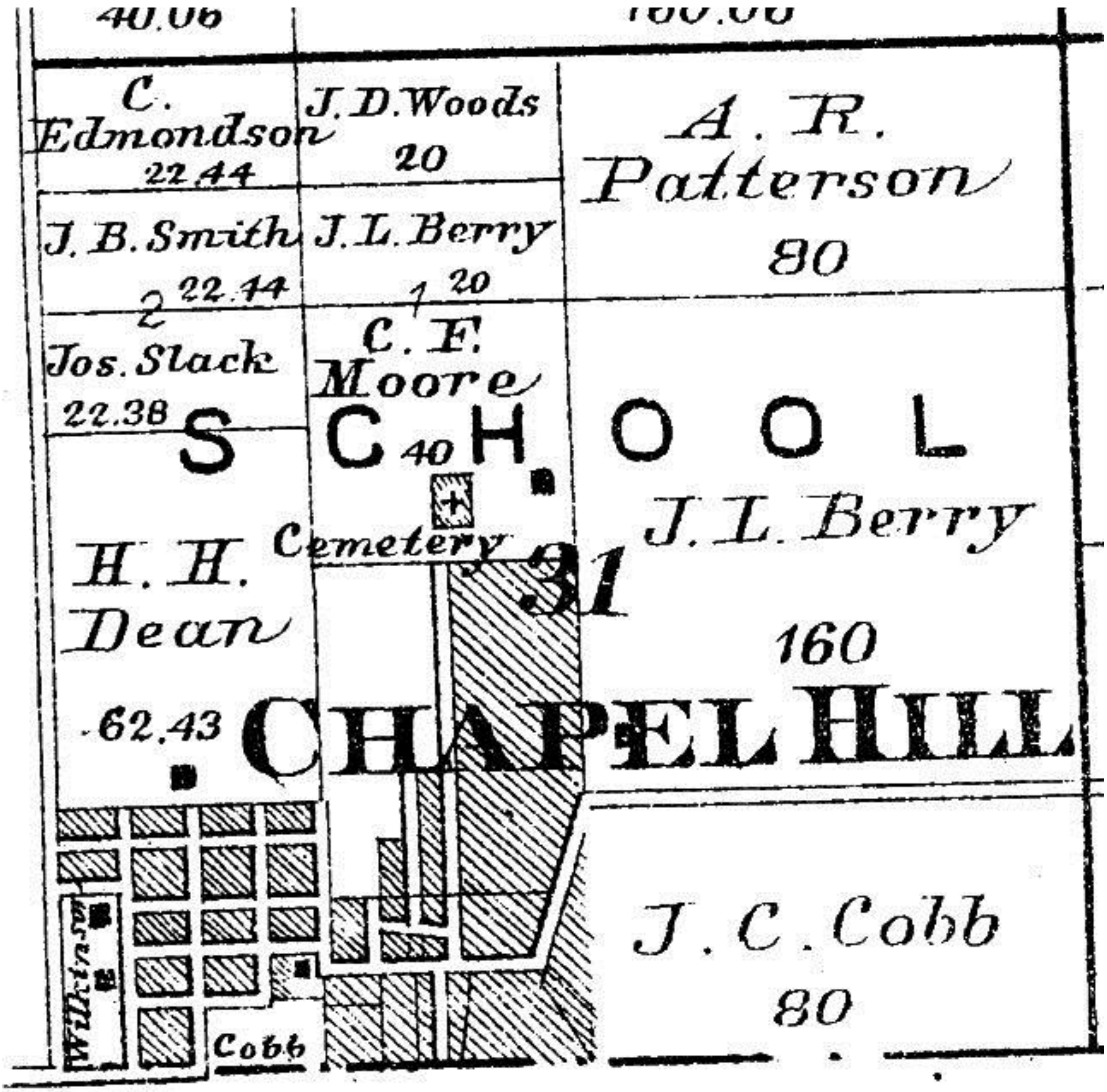


Figure 54.

A copy of Chapel Hill's 1877 plat.

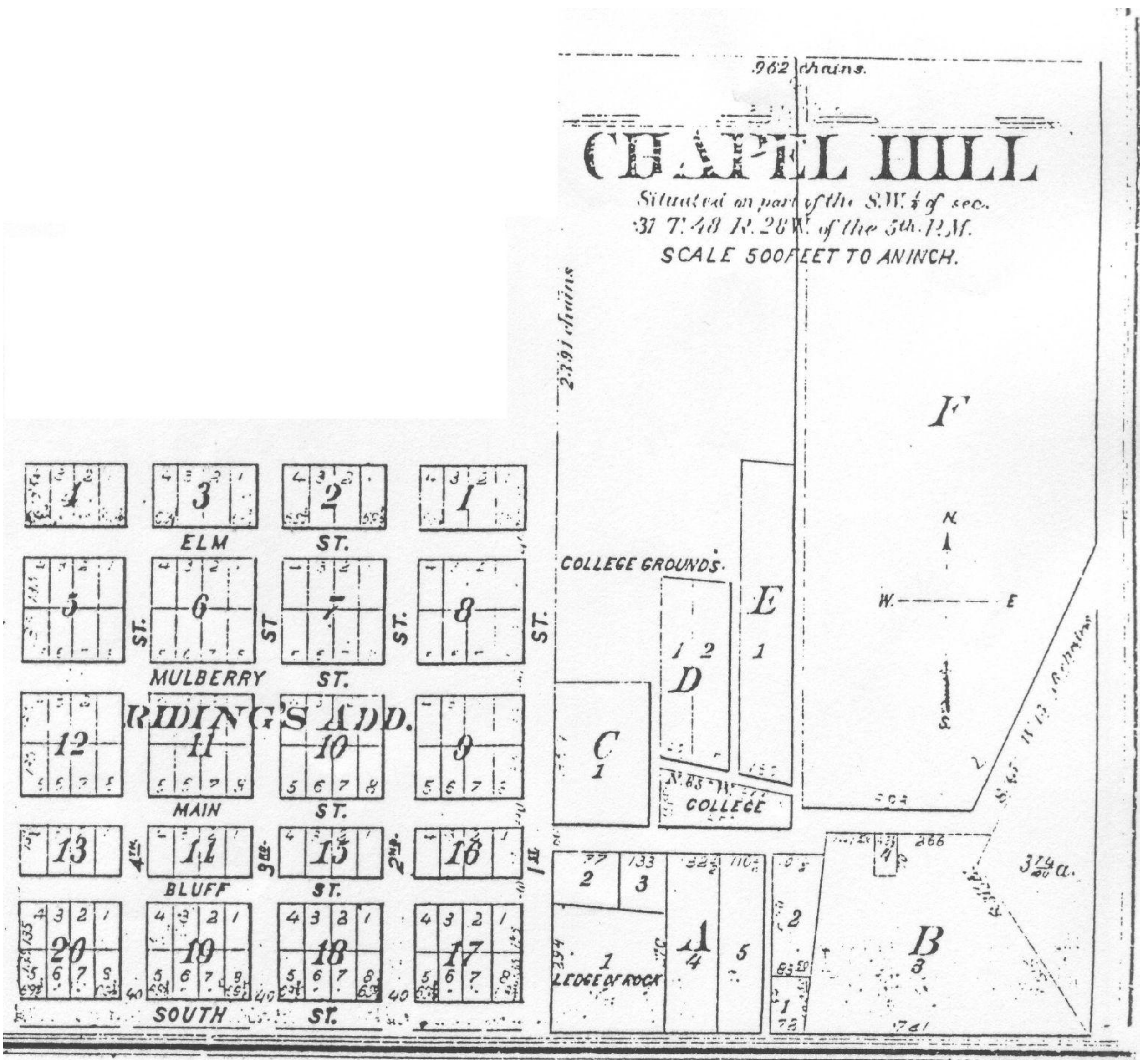


Figure 55.

A picture of the former town of Chapel Hill, looking southwest.

Figure 56.

A picture of the former town of Chapel Hill, looking west.

Figure 57.

The location of Hodge from the 1897 Lafayette County Plat book.

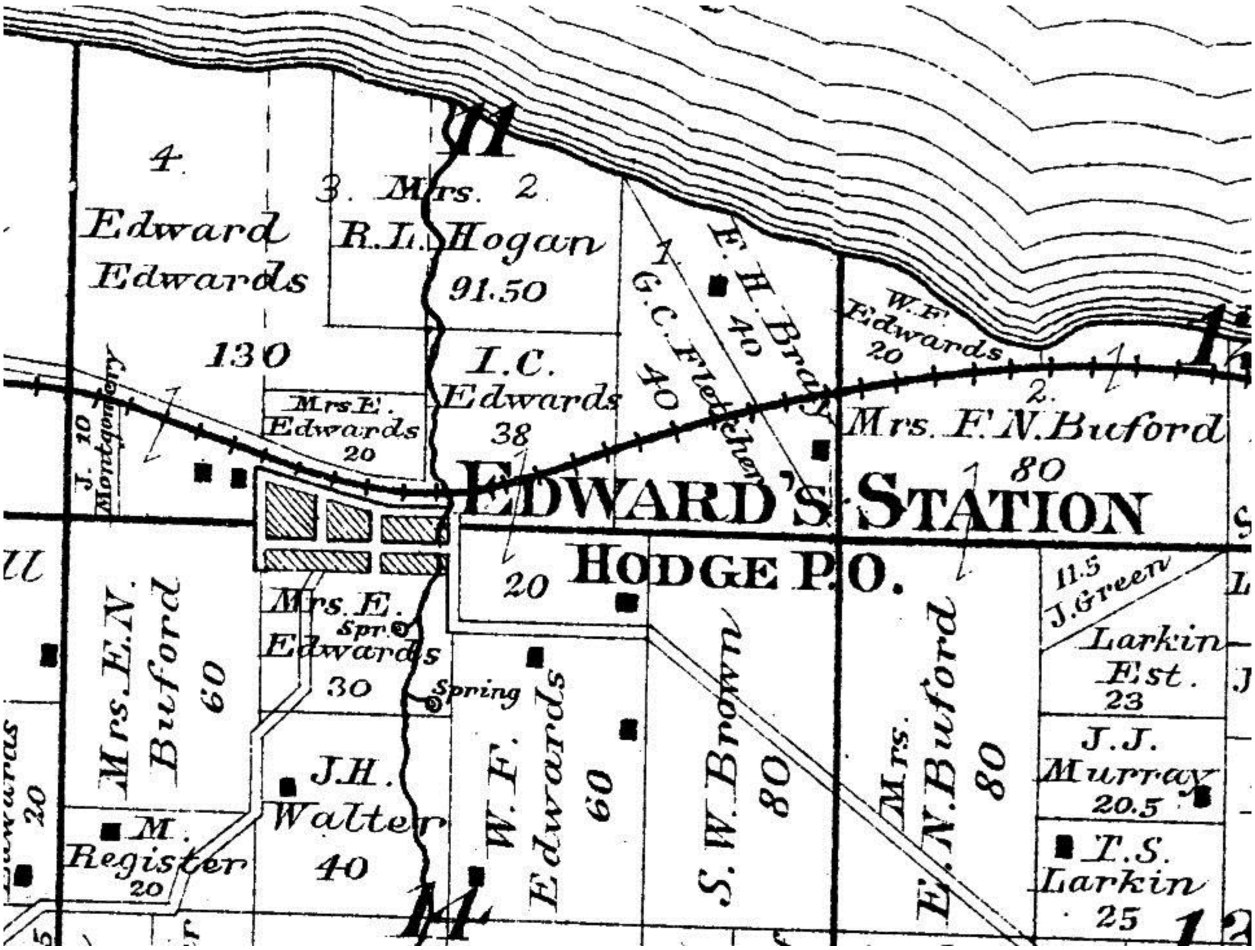


Figure 58.

A copy of Hodge's 1897 plat.

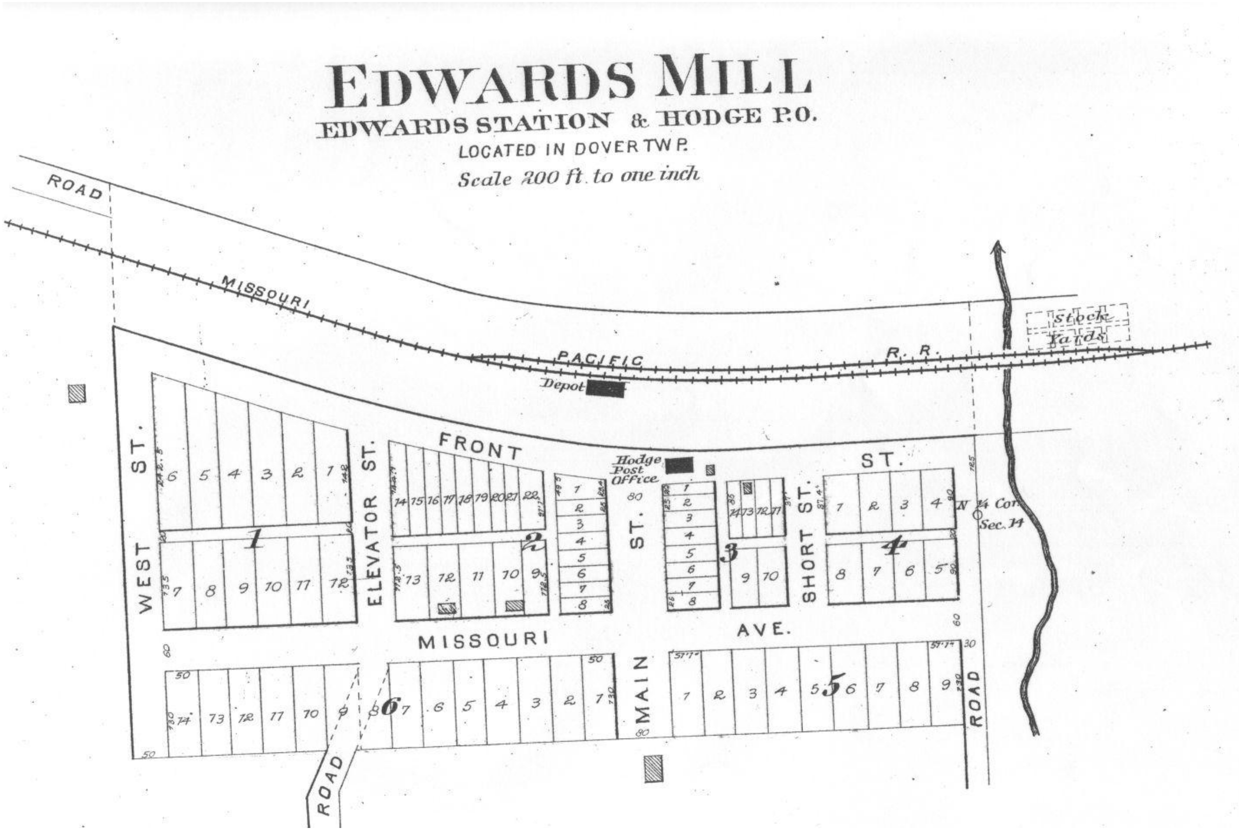


Figure 59.

A picture of the former town of Hodge, looking south.

Figure 60.

The location of Mount Hope from the 1877 Lafayette County Plat book.

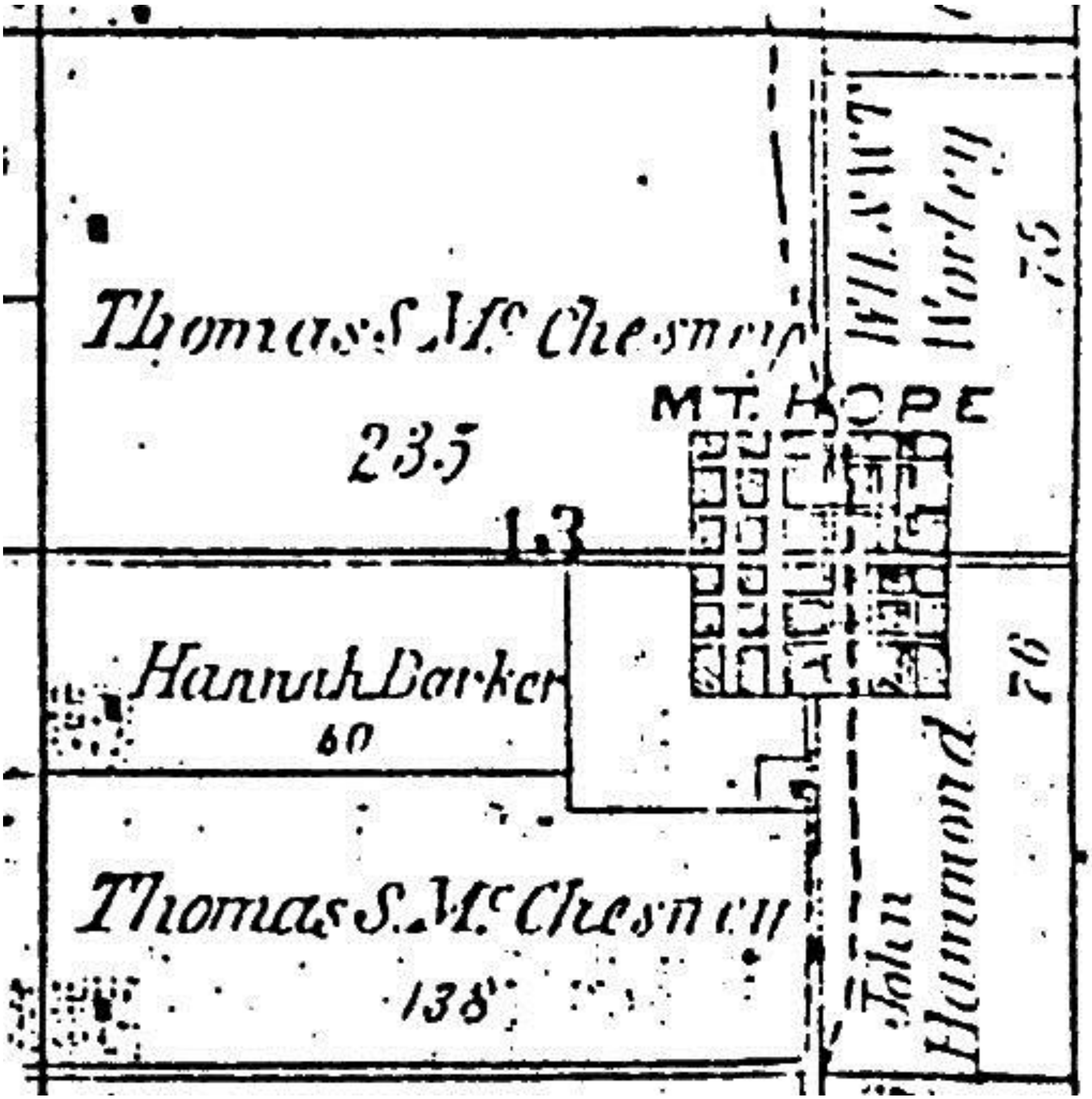


Figure 61.

A copy of Mount Hope's 1897 plat.

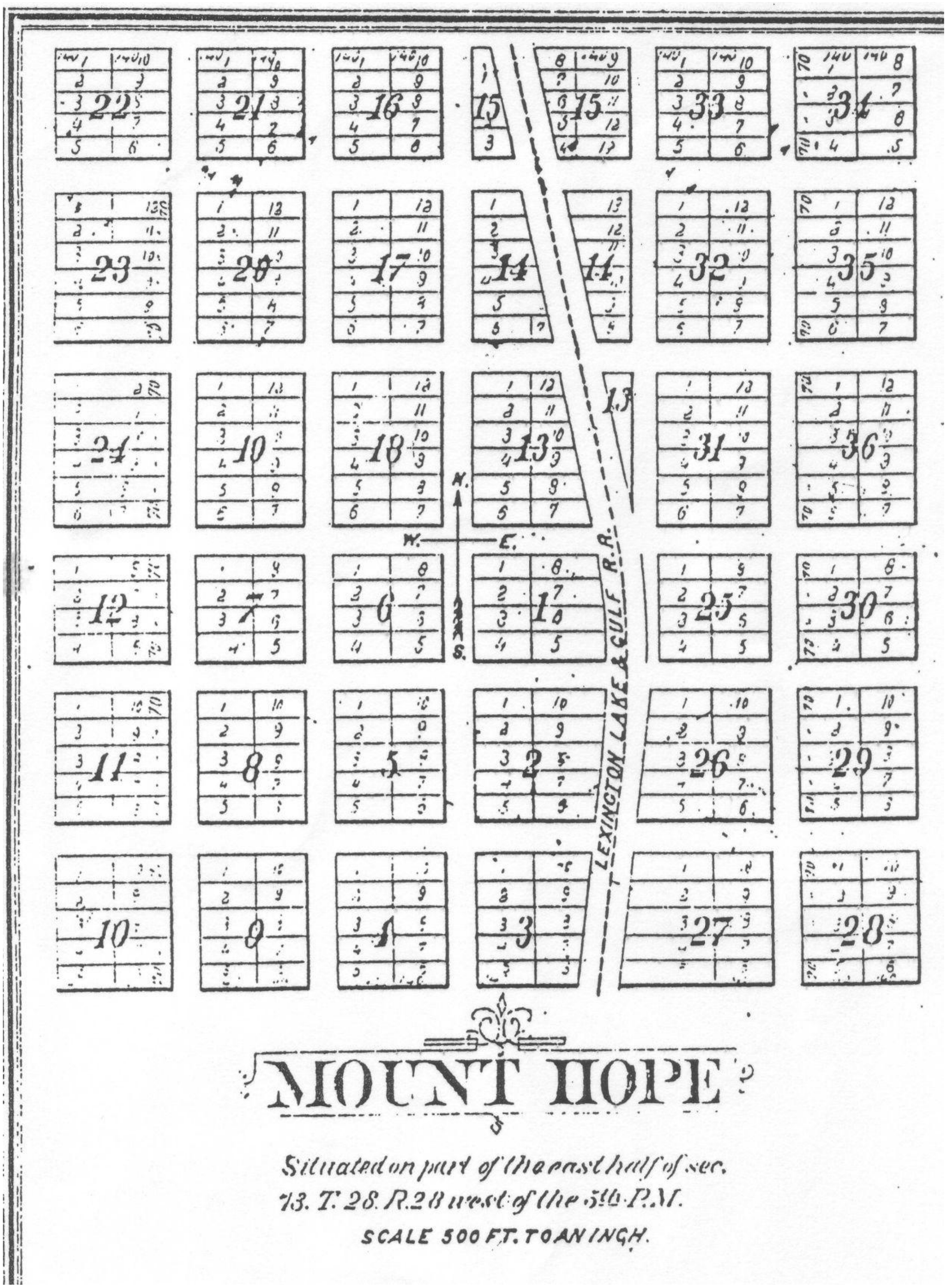


Figure 62.

A picture of the former town of Mount Hope, looking south.

Figure 63.

The location of Cambridge from the 1896 Saline County Plat book.

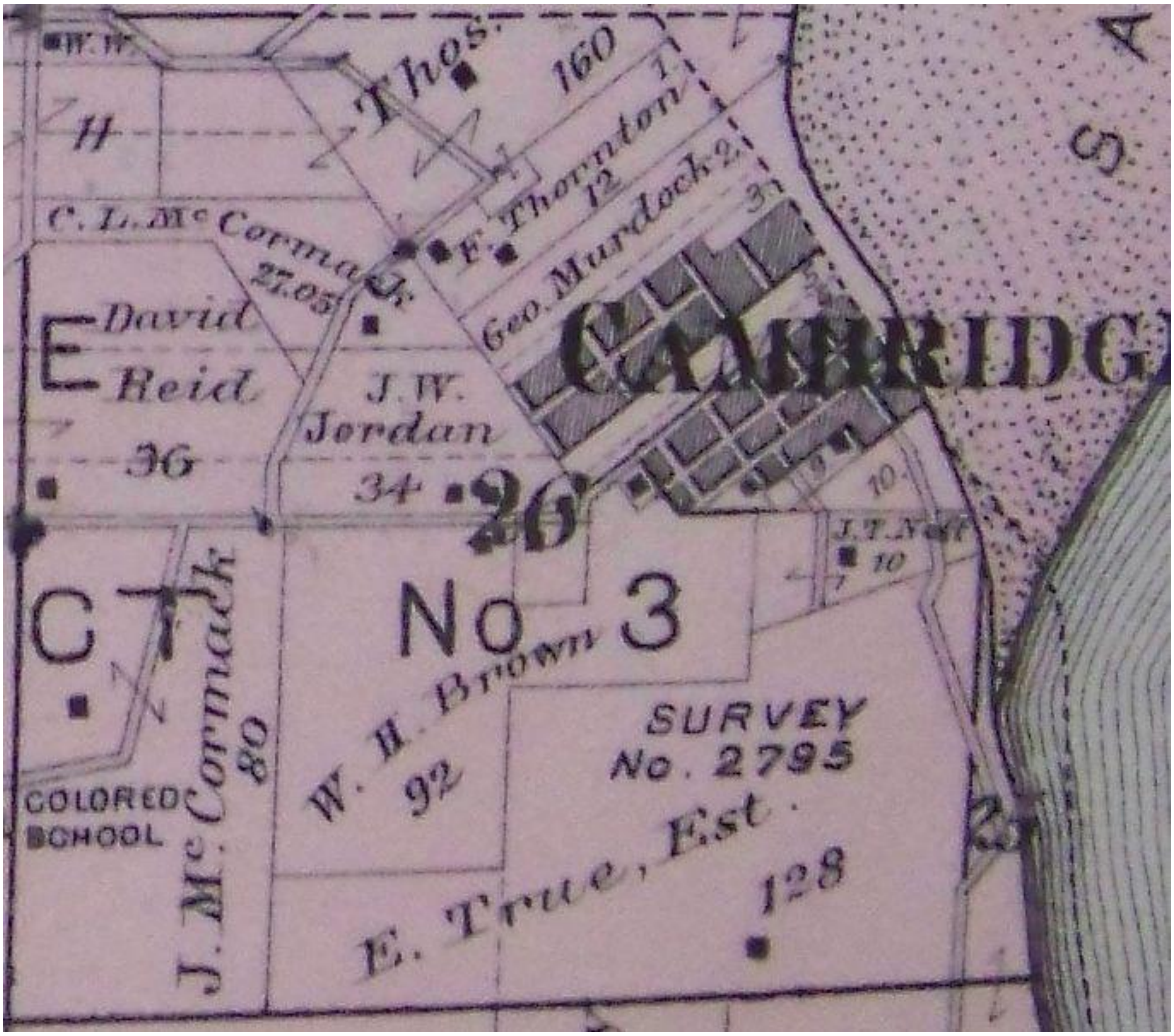


Figure 64.

A copy of Cambridge's 1876 plat.

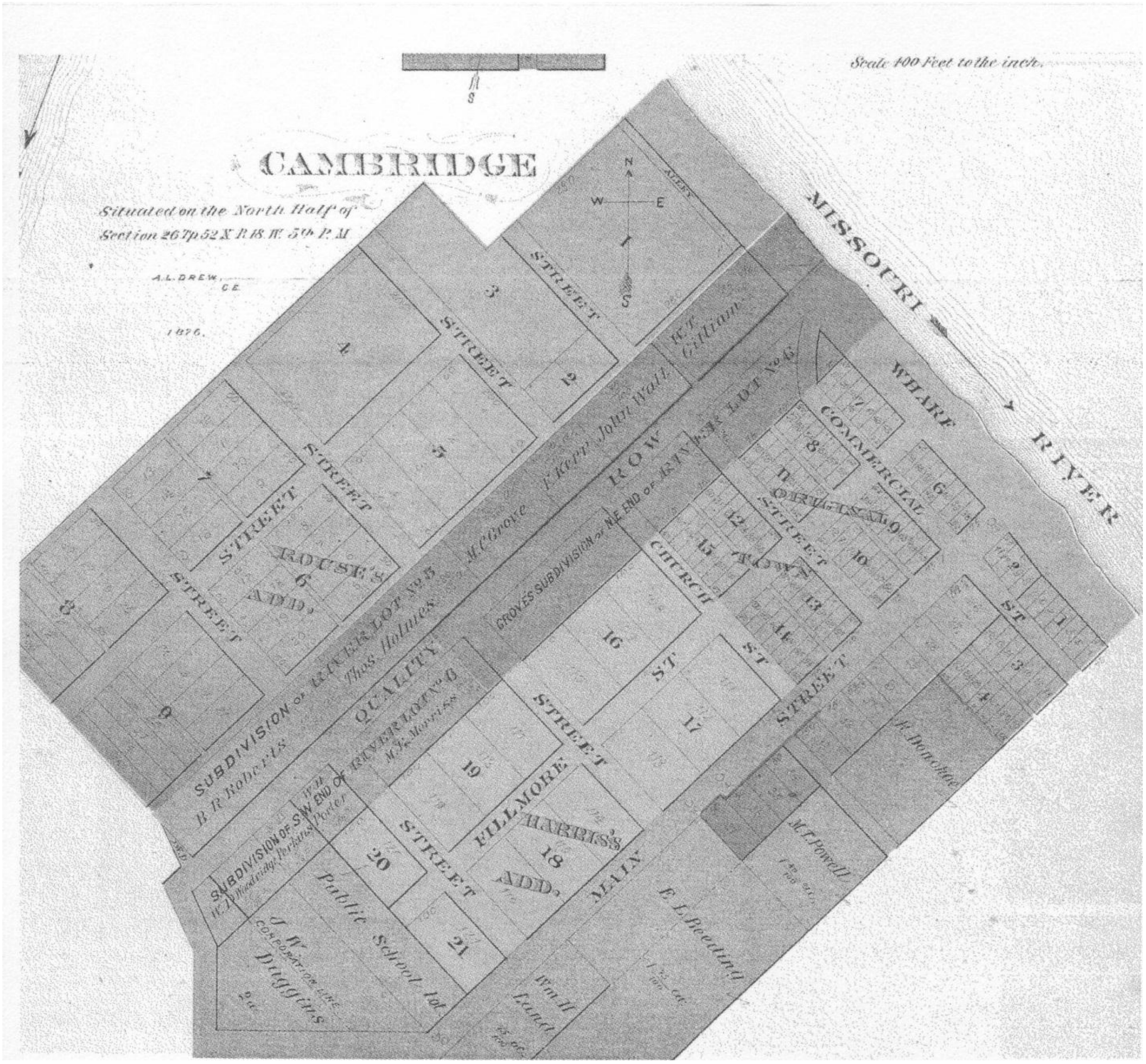


Figure 65.

A picture of the former town of Cambridge, looking east.

Figure 66.

A picture of the former town of Cambridge, looking west.

Figure 67.

The location of Elmwood from the 1876 Saline County Plat book.

Figure 68.

A picture of the former town of Elmwood, looking west.

Figure 69.

The location of Laynesville from the 1876 Saline County Plat book.

Figure 70.

A copy of Laynesville's 1876 plat.

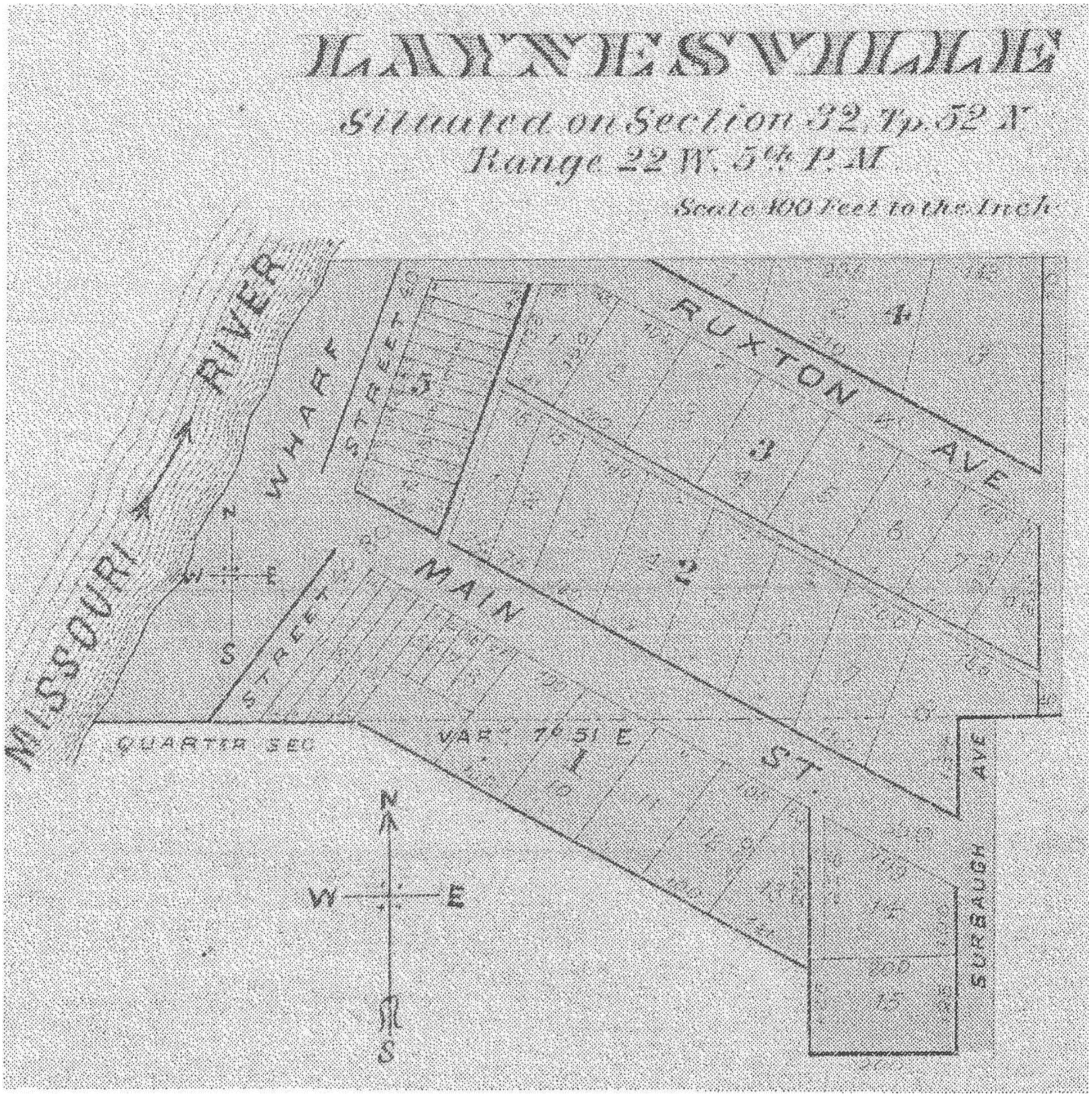


Figure 71.

The location of New Frankfort (Frankfurt) from the 1876 Saline County Plat book.

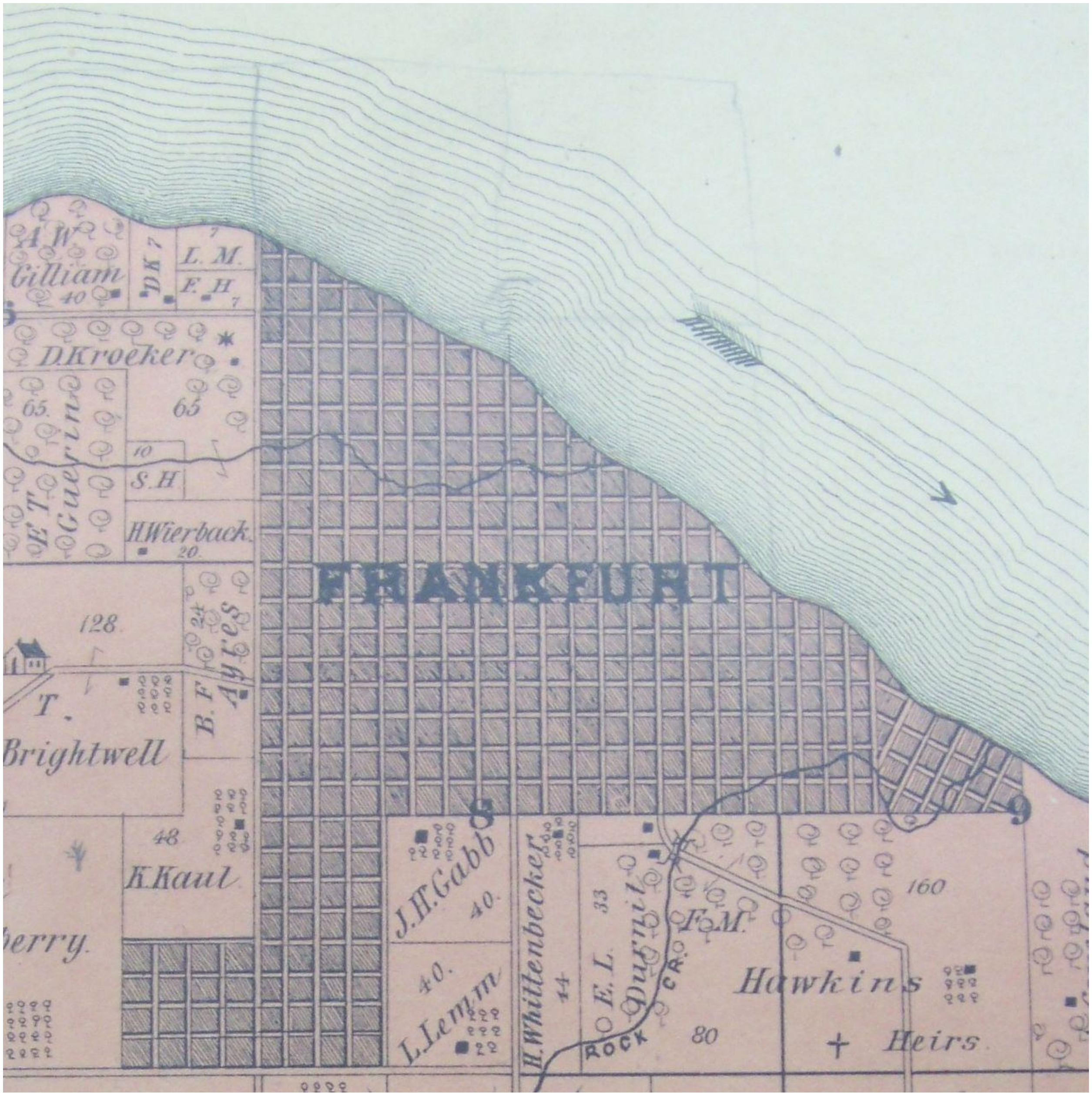


Figure 72.

A copy of New Frankfort's 1896 plat.

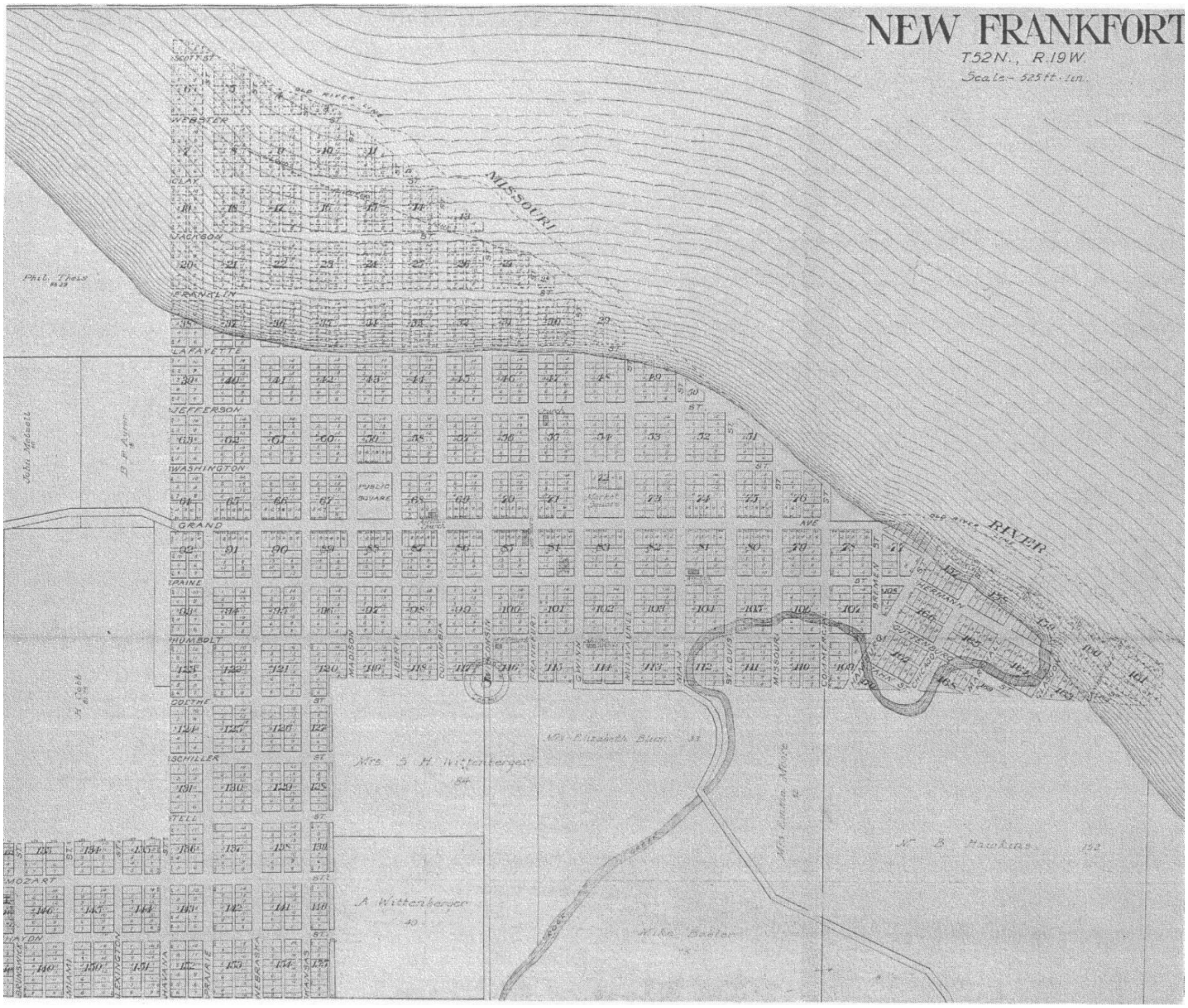


Figure 73.

A picture of the former town of New Frankfort, looking east.

Figure 74.

A picture of the former town of New Frankfort, looking west.

Figure 75.

A picture of the former town of New Frankfort, looking north.

Figure 76.

The location of Salina from the 1876 Saline County Plat book.

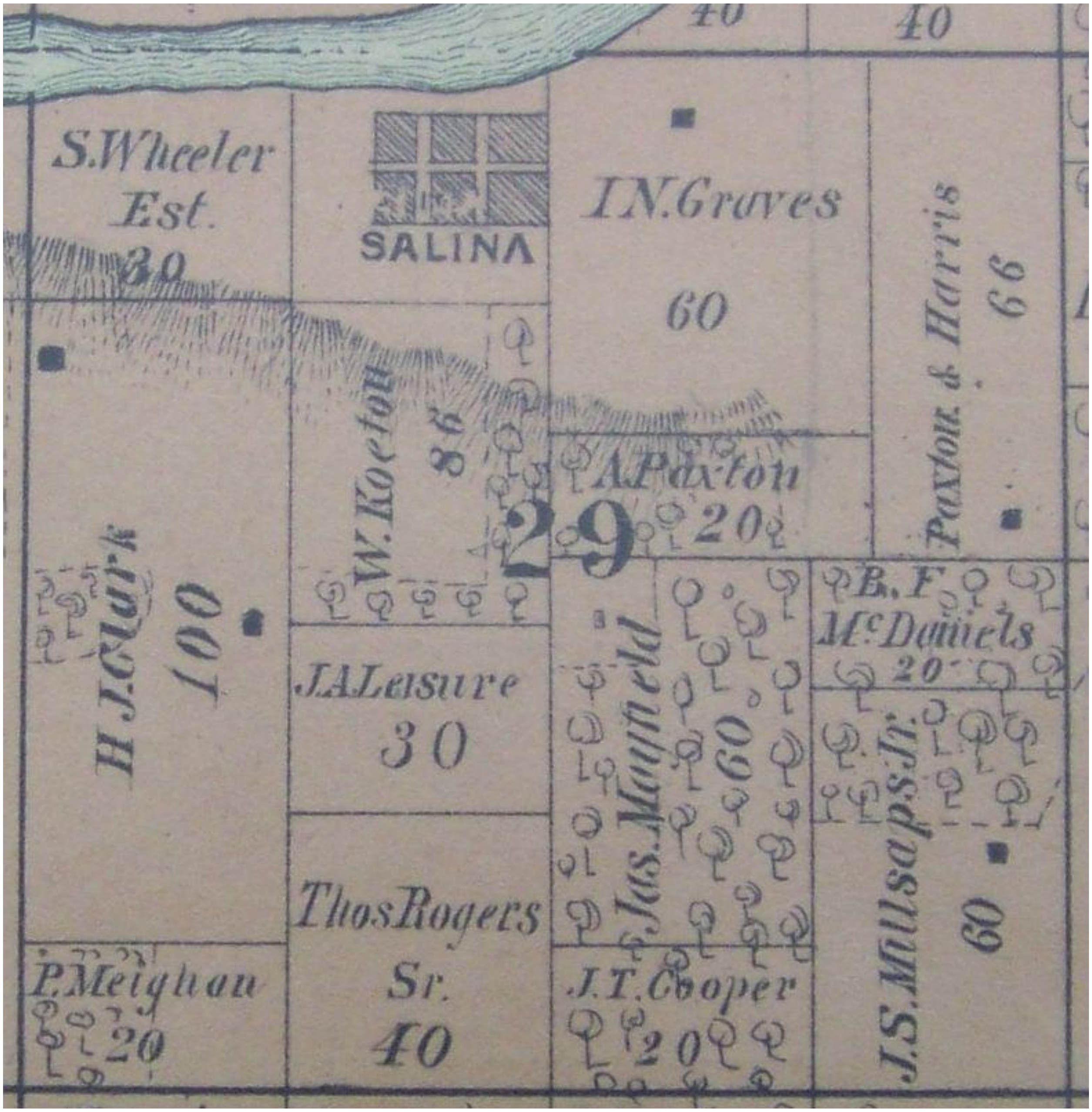


Figure 77.

A copy of Salina's 1876 plat.

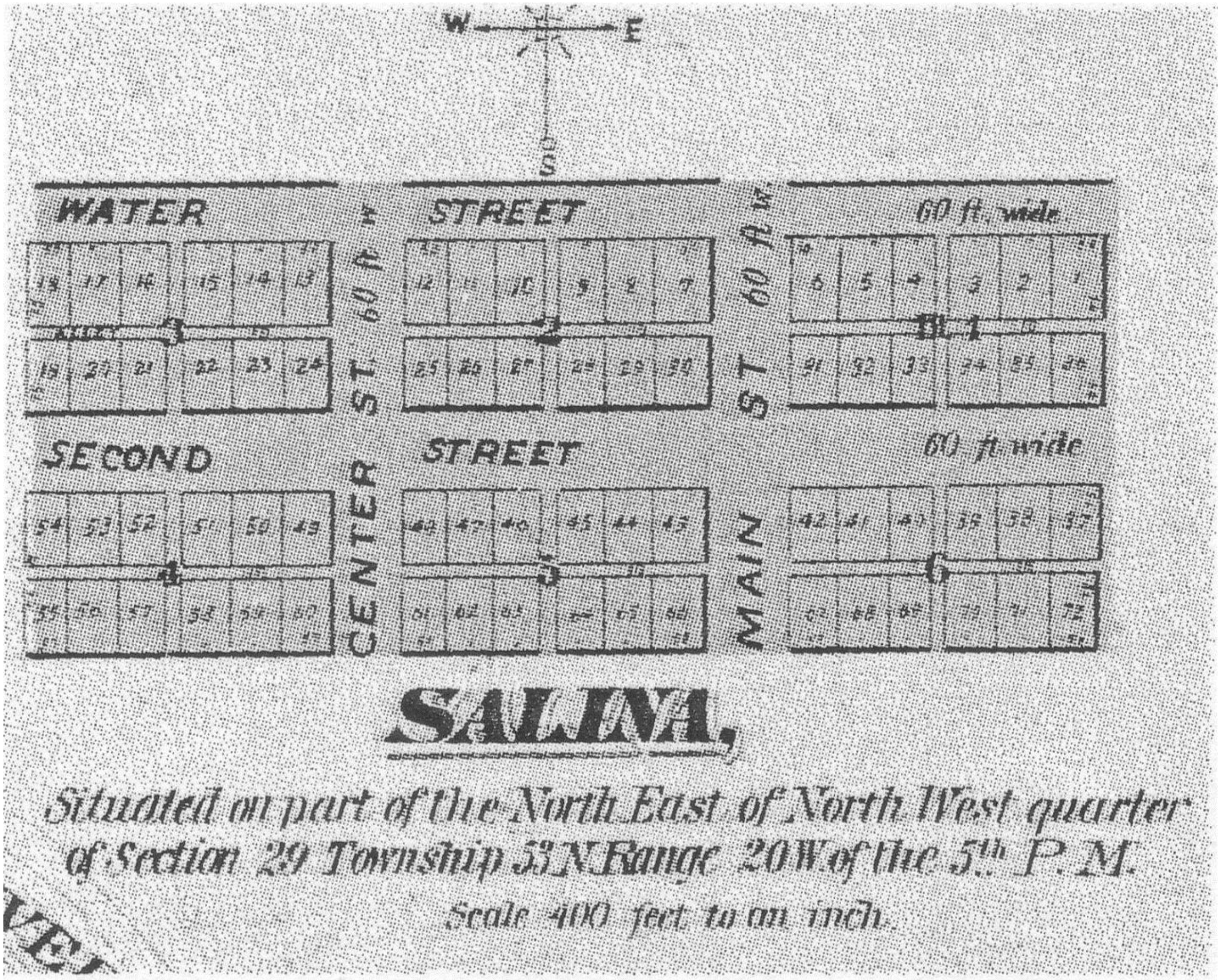


Figure 78.

The location of Saline City from the 1876 Saline County Plat book.

Figure 79.

A picture of Saline City's 1876 plat.

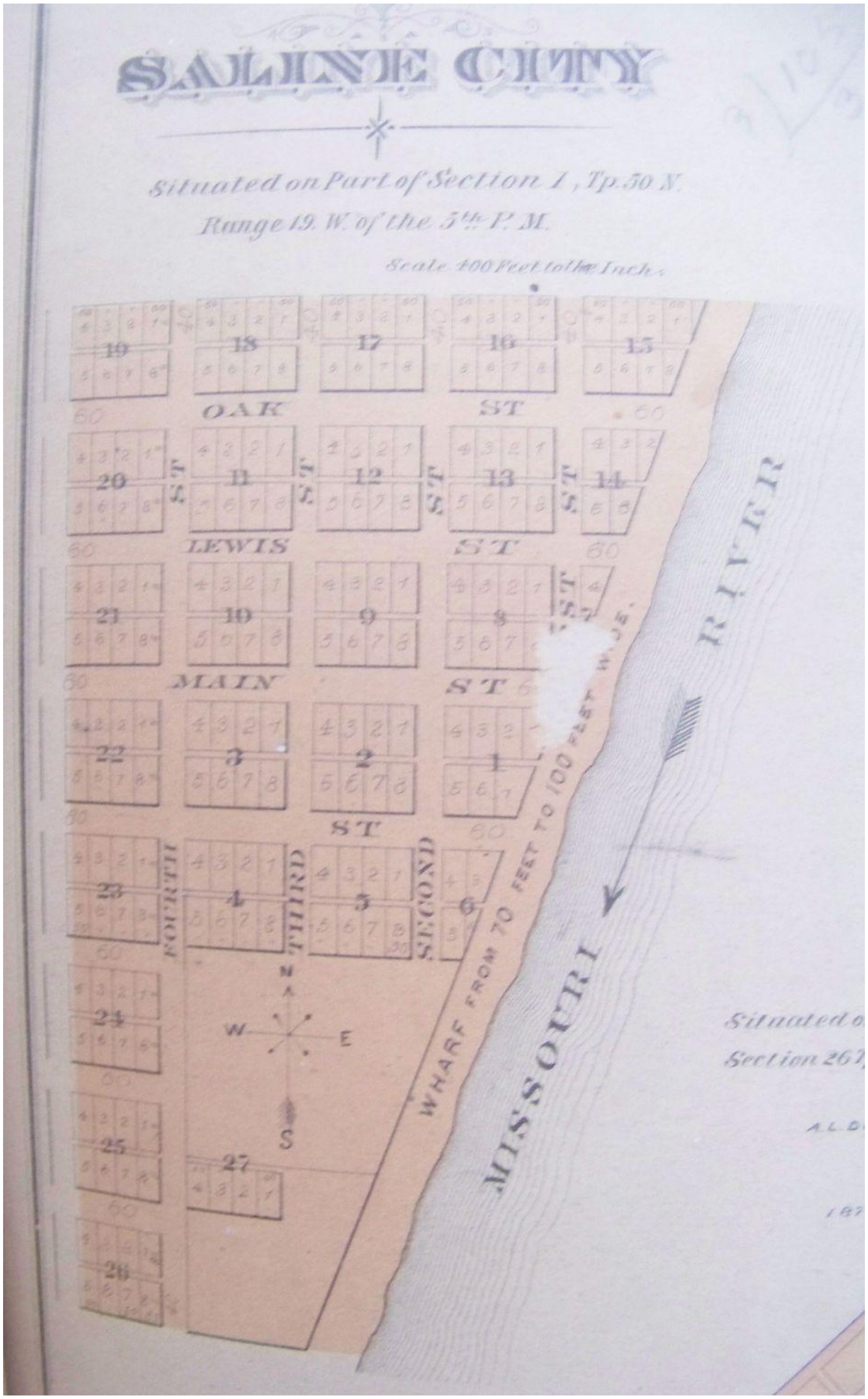


Figure 80.

A picture of the former town of Saline City, looking south.

Figure 81.

A picture of a collapsed house in the former town of Saline City.

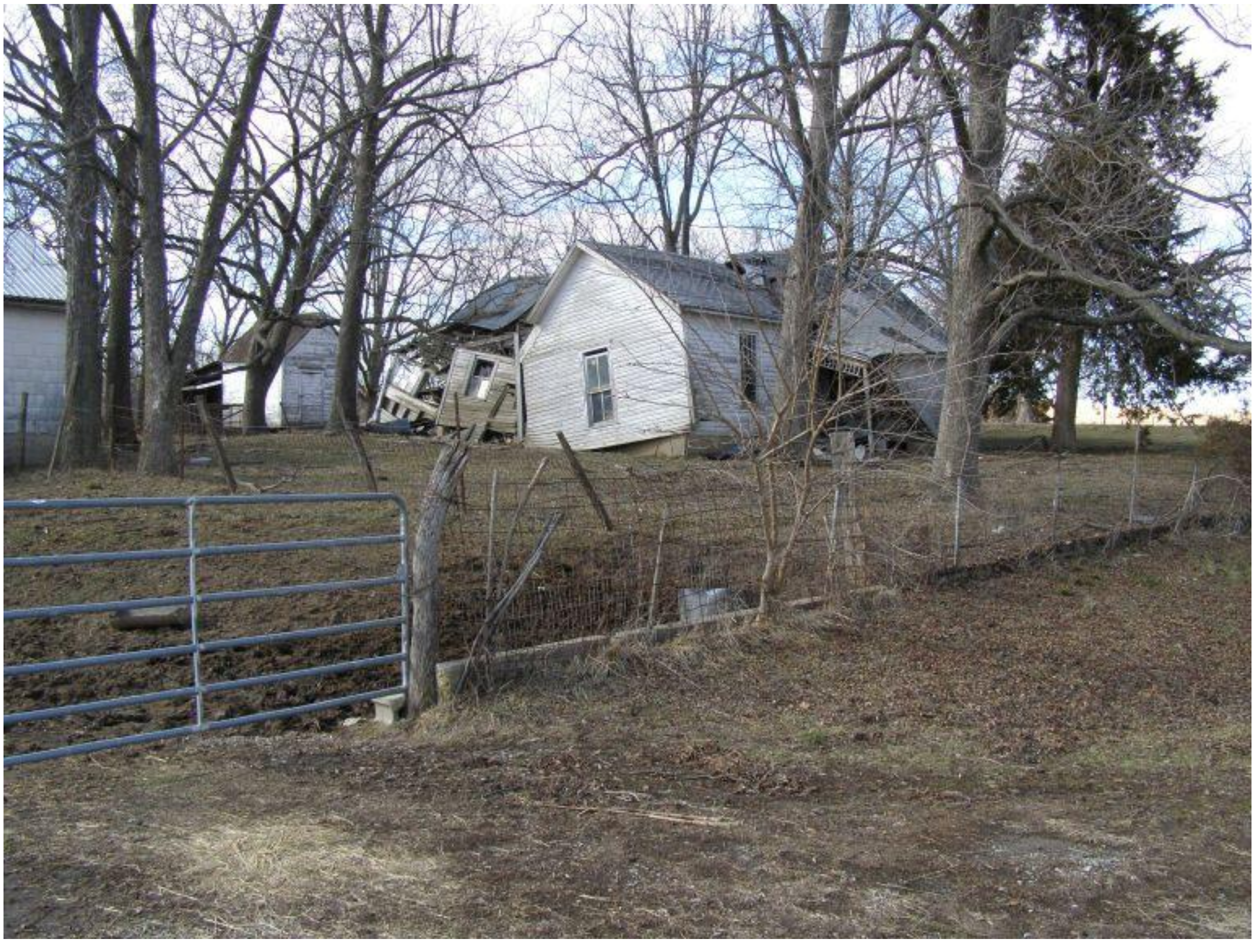


Figure 82.

A picture of an abandoned house in the former town of Saline City.

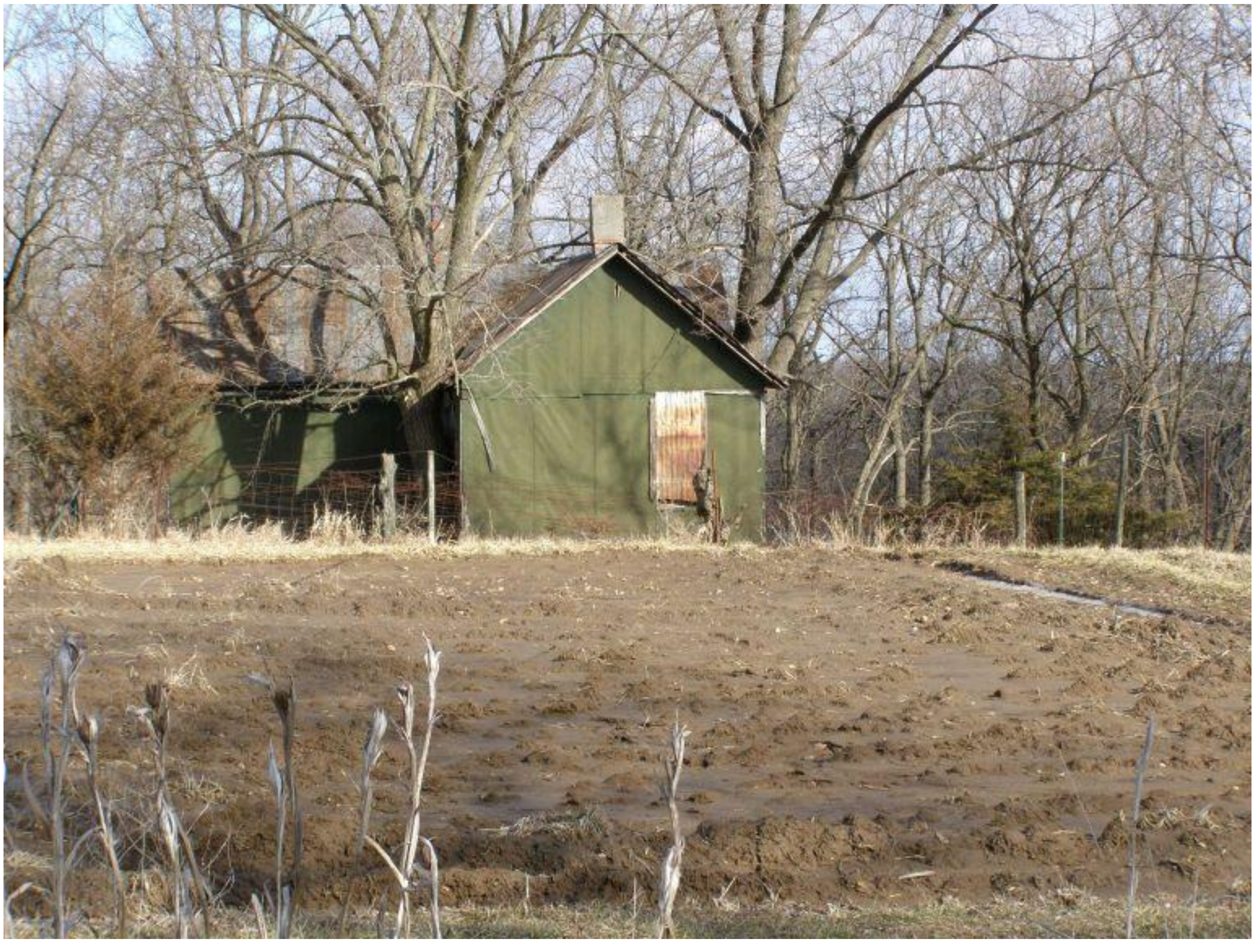


Figure 83.

A picture of an abandoned house in the former town of Saline City.

Figure 84.

A picture of the abandoned Chicago, Burlington, and Quincy Railroad south of Bogard.

Figure 85.

A picture of the abandoned Brunswick, Chillicothe, and Omaha Railroad south of Salisbury.

Figure 86.

A picture of the abandoned Keokuk and Kansas City Railroad near the ghost town of Whitham.

Figure 87.

A picture of the abandoned Lexington and St. Louis Railroad in Higginsville.

Figure 88.

A picture of the abandoned Lexington and St. Louis Railroad in the town of Sweet Springs.

Figure 89.

A picture of the abandoned Missouri Pacific Railroad near Marshall.

Figure 90.

A picture of the Big Adkins Cemetery sign in rural Carroll County.

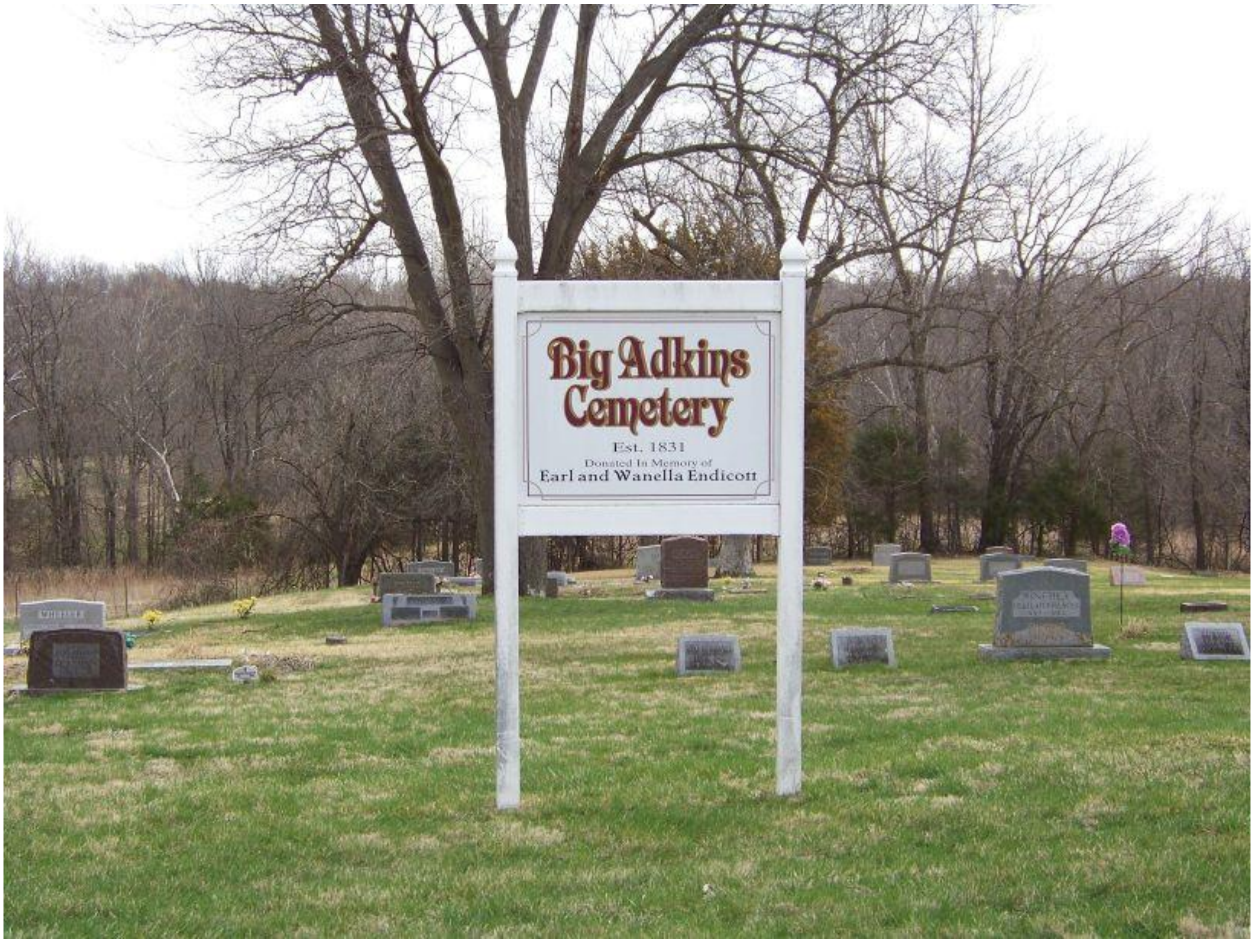


Figure 91.

A picture of the Big Adkins Cemetery in rural Carroll County.

Figure 92.

A picture of the Braden Cemetery sign in rural Carroll County.

Figure 93.

A picture of the Braden Cemetery in rural Carroll County.

Figure 94.

A picture of the entrance of the DeWitt Evergreen Cemetery near DeWitt in Carroll County.

Figure 95.

A picture of the DeWitt Evergreen Cemetery near DeWitt in Carroll County.

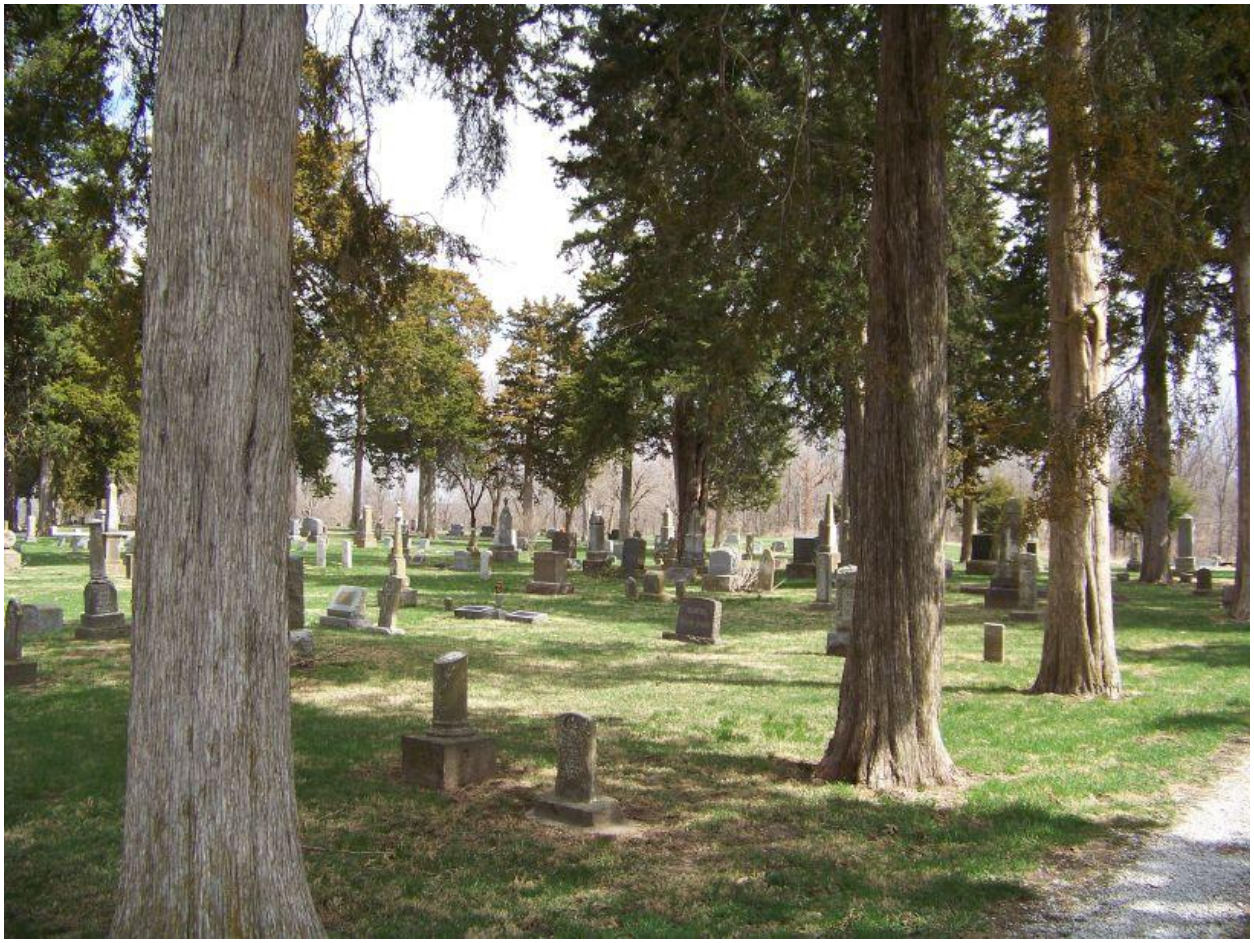


Figure 96.

A picture of the entrance of the Oak Hill Cemetery in Carrollton, Carroll County.

Figure 97.

A picture of the Oak Hill Cemetery in Carrollton, Carroll County.

Figure 98.

A picture of the Sacred Heart Cemetery in rural Carroll County.

Figure 99.

A picture of the Sacred Heart Cemetery in rural Carroll County.

Figure 100.

A picture of the entrance of Elliott Grove Cemetery in Brunswick, Chariton County.

Figure 101.

A picture of the Elliott Grove Cemetery near Brunswick, Chariton County.

Figure 102.

A picture of the Mendon Cemetery in the sight of the ghost town of Old Mendon, Chariton County.

Figure 103.

A picture of the entrance of the Newcomer Cemetery in rural Chariton County.

Figure 104.

A picture of the entrance of the St. Mary's Cemetery near the ghost town of Wien, Chariton County.

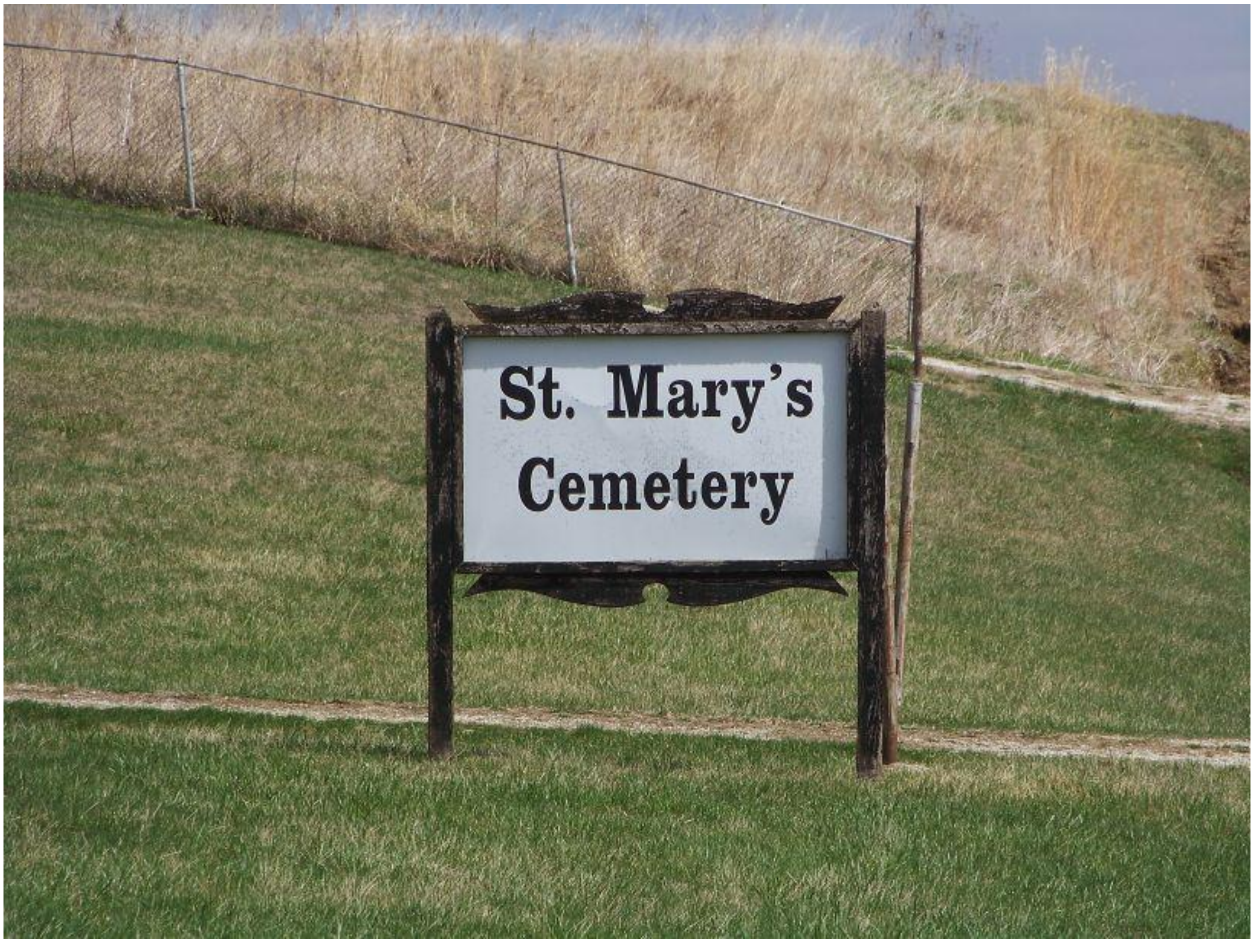


Figure 105.

A picture of the St. Mary’s Cemetery near the ghost town of Wien, Chariton County.

Figure 106.

A picture of the Salisbury Cemetery near Salisbury, Chariton County.

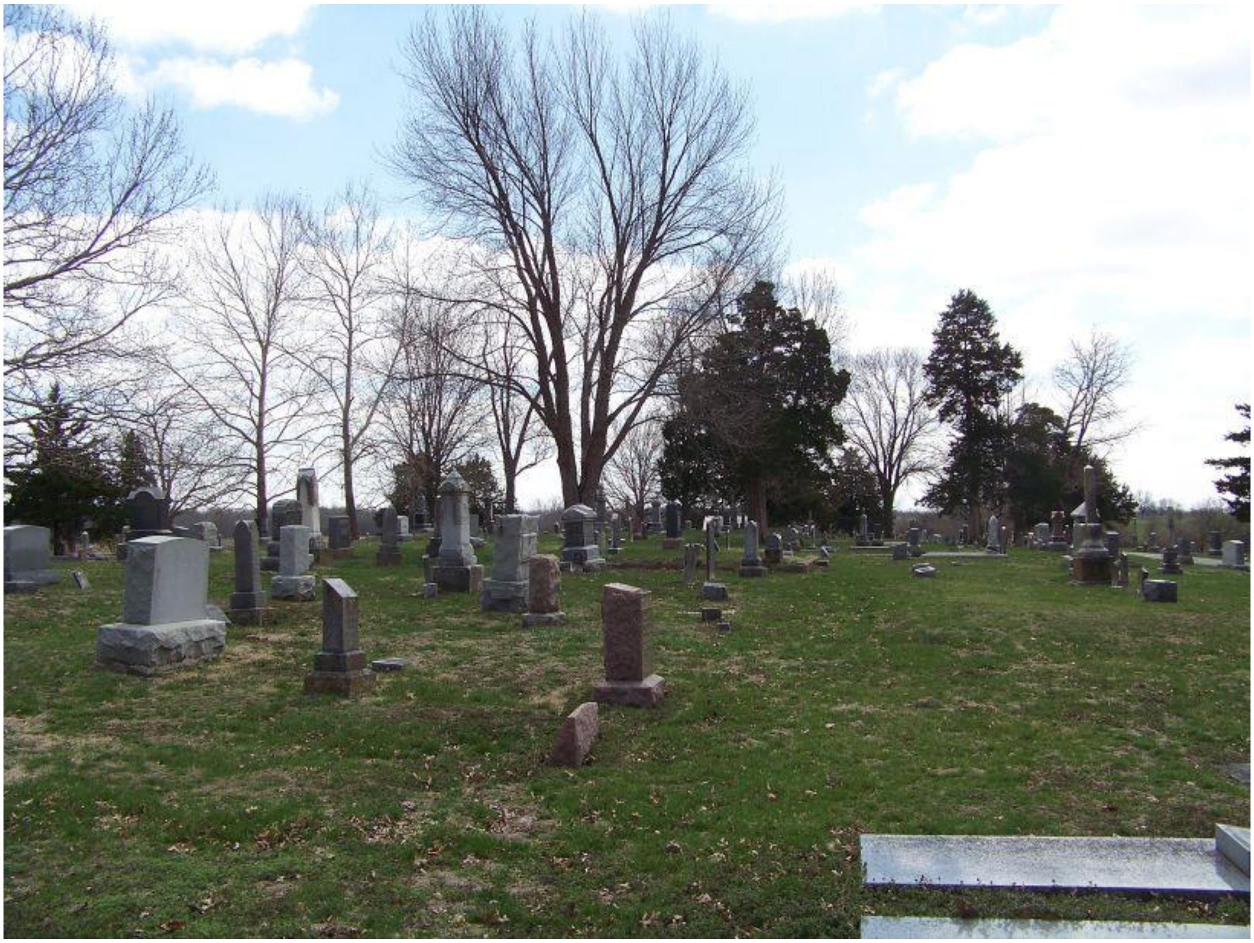


Figure 107.

A picture of the Confederate Memorial State Historic Site Cemetery near Higginsville, Lafayette County.

Figure 108.

A picture of the Confederate Memorial State Historic Site Cemetery near Higginsville, Lafayette County.

Figure 109.

A picture of the Greenton Baptist Church Cemetery near the ghost town of Greenton, Lafayette County.

Figure 110.

A picture of the Greenton Baptist Church Cemetery near the ghost town of Greenton, Lafayette County.

Figure 111.

A picture of the gate of the Mt. Hope Presbyterian Church Cemetery in rural Lafayette County.

Figure 112.

A picture of the Mt. Hope Presbyterian Church Cemetery in rural Lafayette County.

Figure 113.

A picture of the entrance of the Odessa Cemetery near Odessa, Lafayette County.

Figure 114.

A picture of the Odessa Cemetery near Odessa, Lafayette County.

Figure 115.

A picture of the entrance of the Shore Cemetery in rural Lafayette County.

Figure 116.

A picture of the Shore Cemetery in rural Lafayette County.

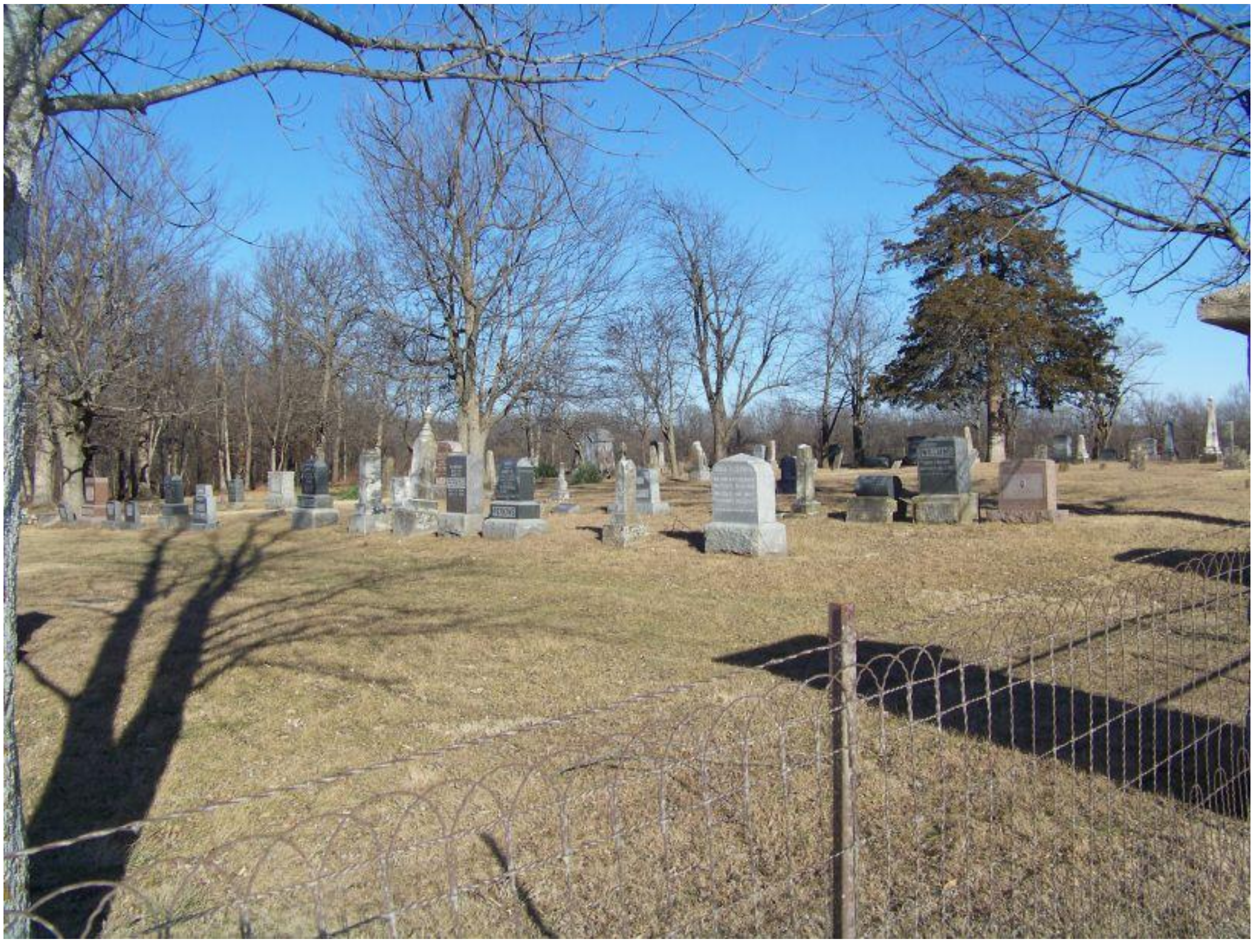


Figure 117.

A picture of the sign for the Cambridge Cemetery near the ghost town of Cambridge, Saline County.

Figure 118.

A picture of the Cambridge Cemetery near the ghost town of Cambridge, Saline County.

Figure 119.

A picture of the entrance of the Fairview Cemetery in Sweet Springs, Saline County.

Figure 120.

A picture of the Fairview Cemetery in Sweet Springs, Saline County.

Figure 121.

A picture of the sign in the Harmony Cemetery in rural Saline County.

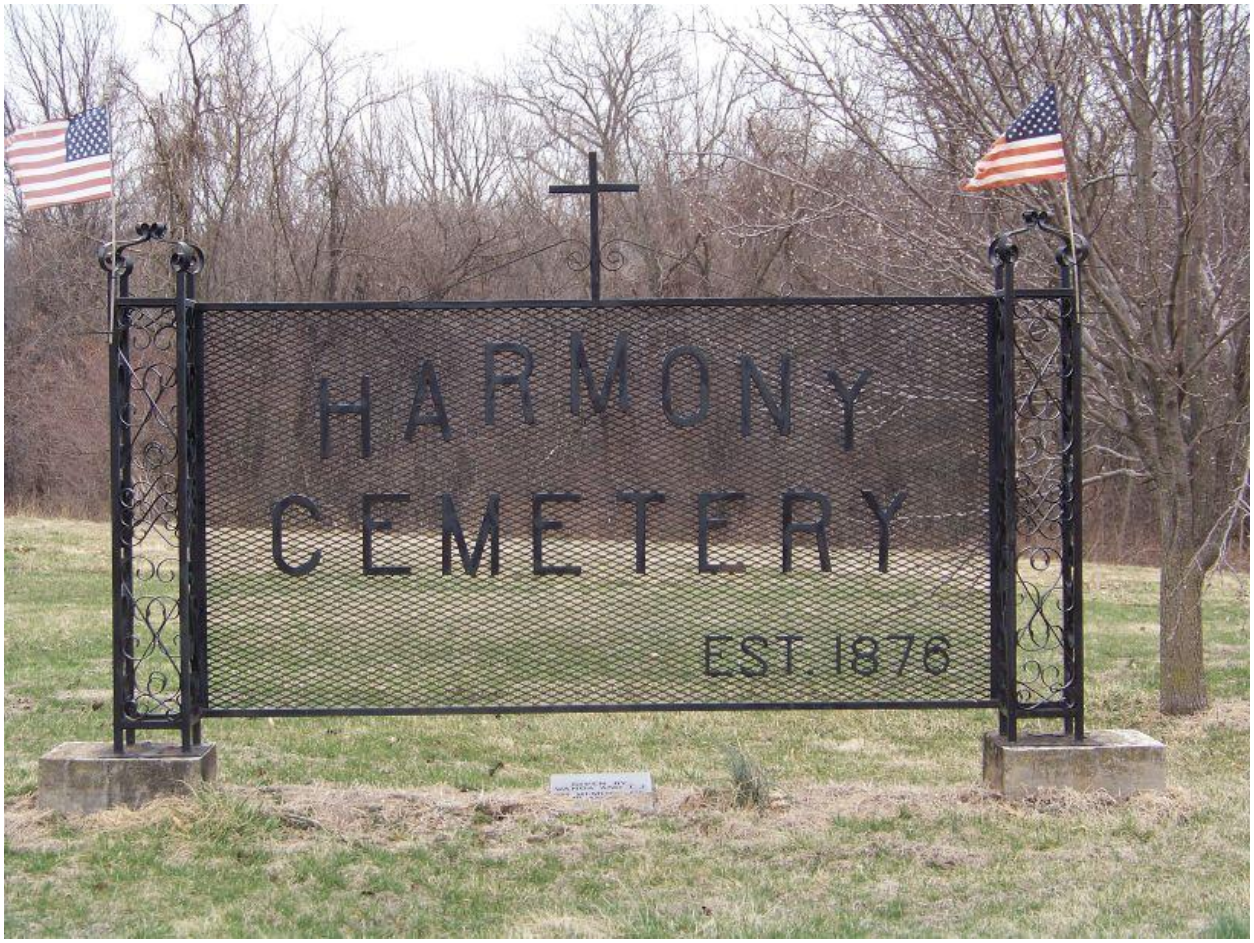


Figure 122.

A picture of the Harmony Cemetery in rural Saline County.

Figure 123.

A picture of the entrance of the Mount Nebo Cemetery near Grand Pass, Saline County.

Figure 124.

A picture of the Mount Nebo Cemetery near Grand Pass, Saline County.

Figure Caption

Figure 125. A picture of the entrance to the Ridge Park Cemetery in Marshall, Saline County.

Figure 126.

A picture of the Ridge Park Cemetery in Marshall, Saline County.

Figure 127.

A map showing the LiDAR hillshade DTM and county boundaries for the study area.

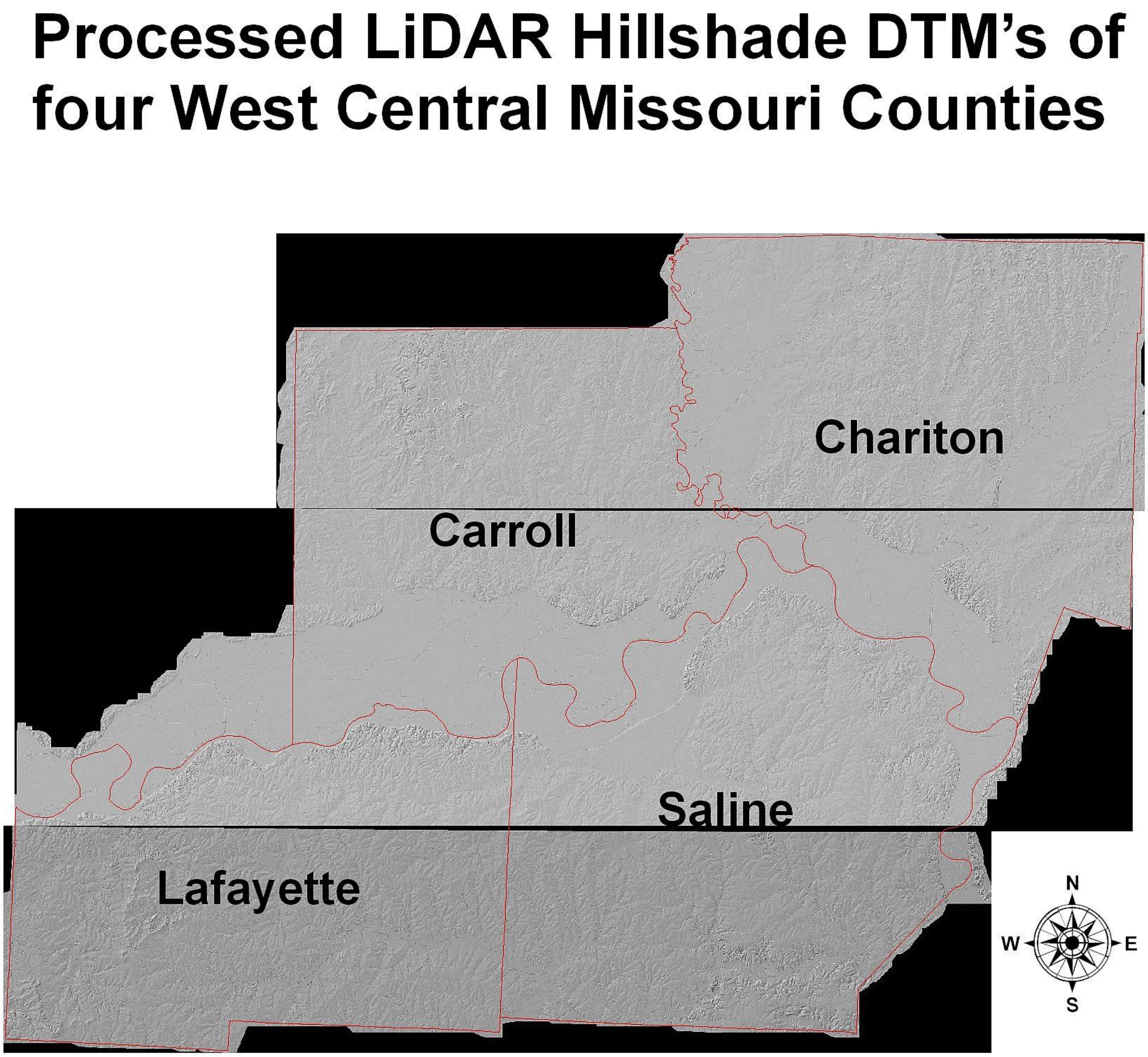
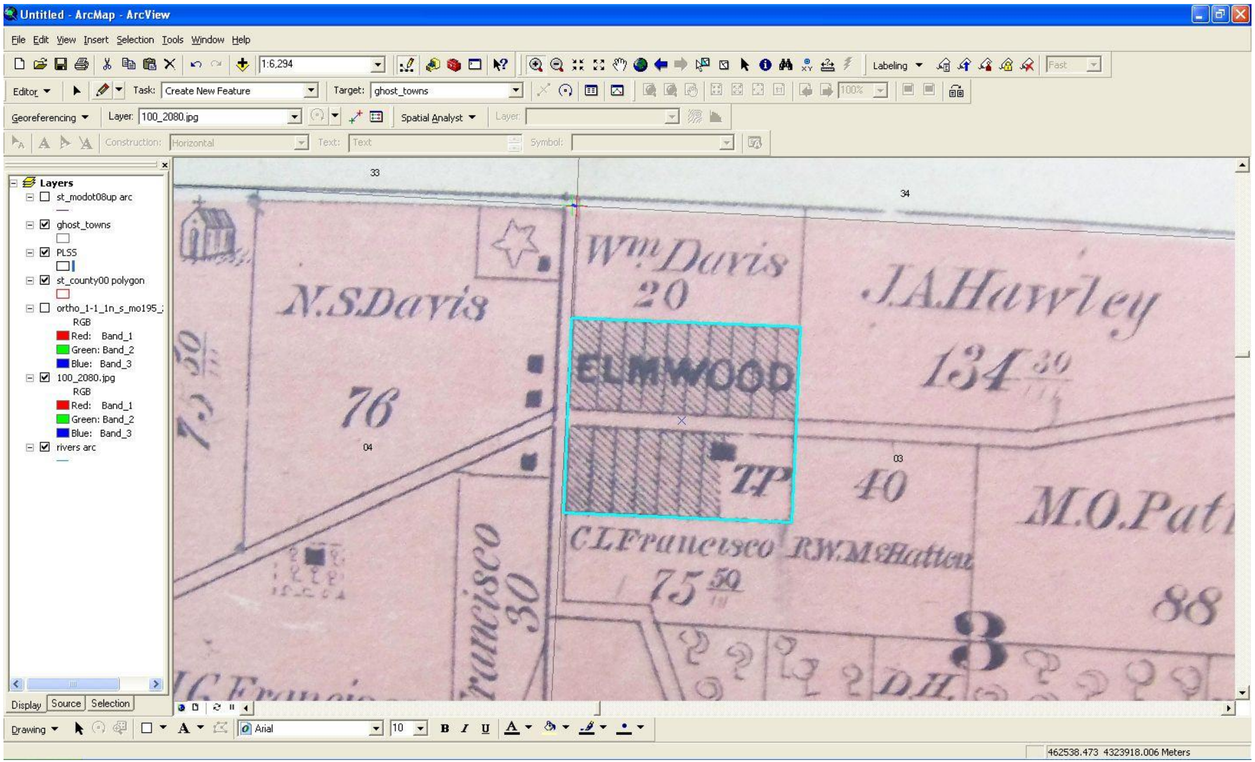
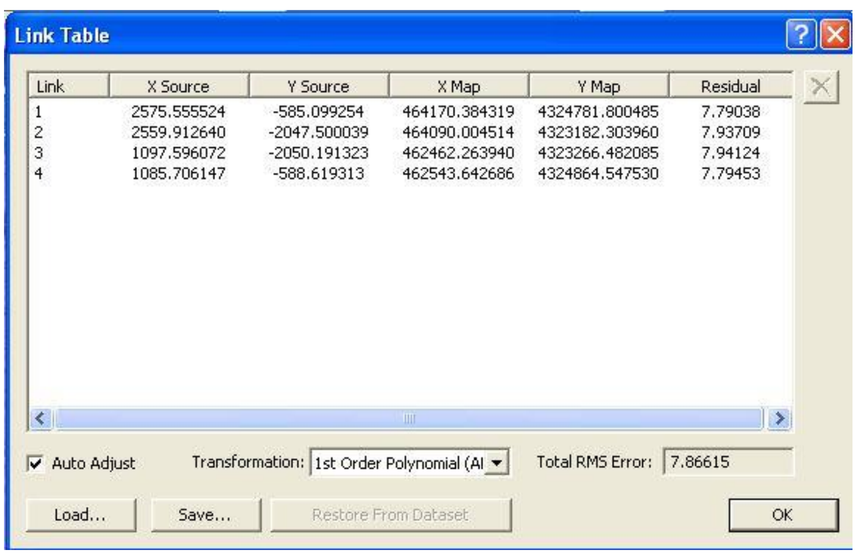


Figure 128.

Georeferenced digital photograph from the 1896 Plat Book of Saline County, Missouri.




Link Table

Link	X Source	Y Source	X Map	Y Map	Residual
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2	2559.912640	-2047.500039	464090.004514	4323182.303960	7.93709
3	1097.596072	-2050.191323	462462.263940	4323266.482085	7.94124
4	1085.706147	-588.619313	462543.642686	4324864.547530	7.79453

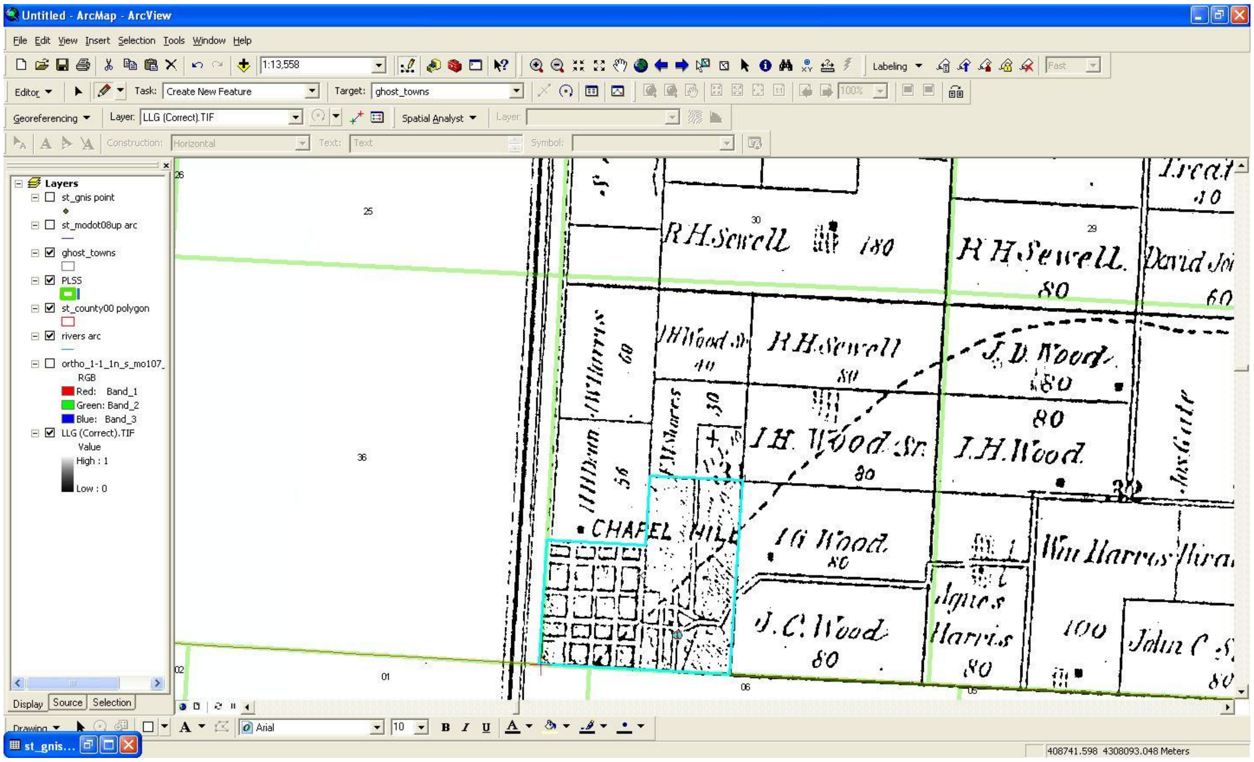
Auto Adjust Transformation: 1st Order Polynomial (Af Total RMS Error: 7.86615

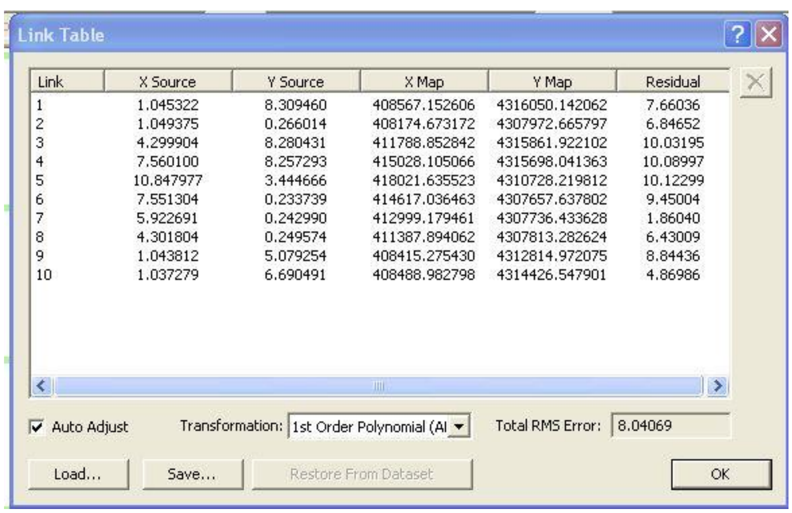
Load... Save... Restore From Dataset OK

Figure 129.

Georeferenced photocopy of the 1877 Plat Book of Lafayette County, Missouri.

Lafayette County, Missouri.





Link Table

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3	4.299904	8.280431	411788.852842	4315861.922102	10.03195
4	7.560100	8.257293	415028.105066	4315698.041363	10.08997
5	10.847977	3.444666	418021.635523	4310728.219812	10.12299
6	7.551304	0.233739	414617.036463	4307657.637802	9.45004
7	5.922691	0.242990	412999.179461	4307736.433628	1.86040
8	4.301804	0.249574	411387.894062	4307813.282624	6.43009
9	1.043812	5.079254	408415.275430	4312814.972075	8.84436
10	1.037279	6.690491	408488.982798	4314426.547901	4.86986

Auto Adjust Transformation: 1st Order Polynomial (Af Total RMS Error: 8.04069

Load... Save... Restore From Dataset OK

Figure 130.

Georeferenced digital photograph of the town plat of Elmwood, from the Saline County, Missouri Plat Book of 1896 overlaid on NAIP imagery. The image is partially transparent to allow one to see the modern day landscape of the NAIP imagery in the background.

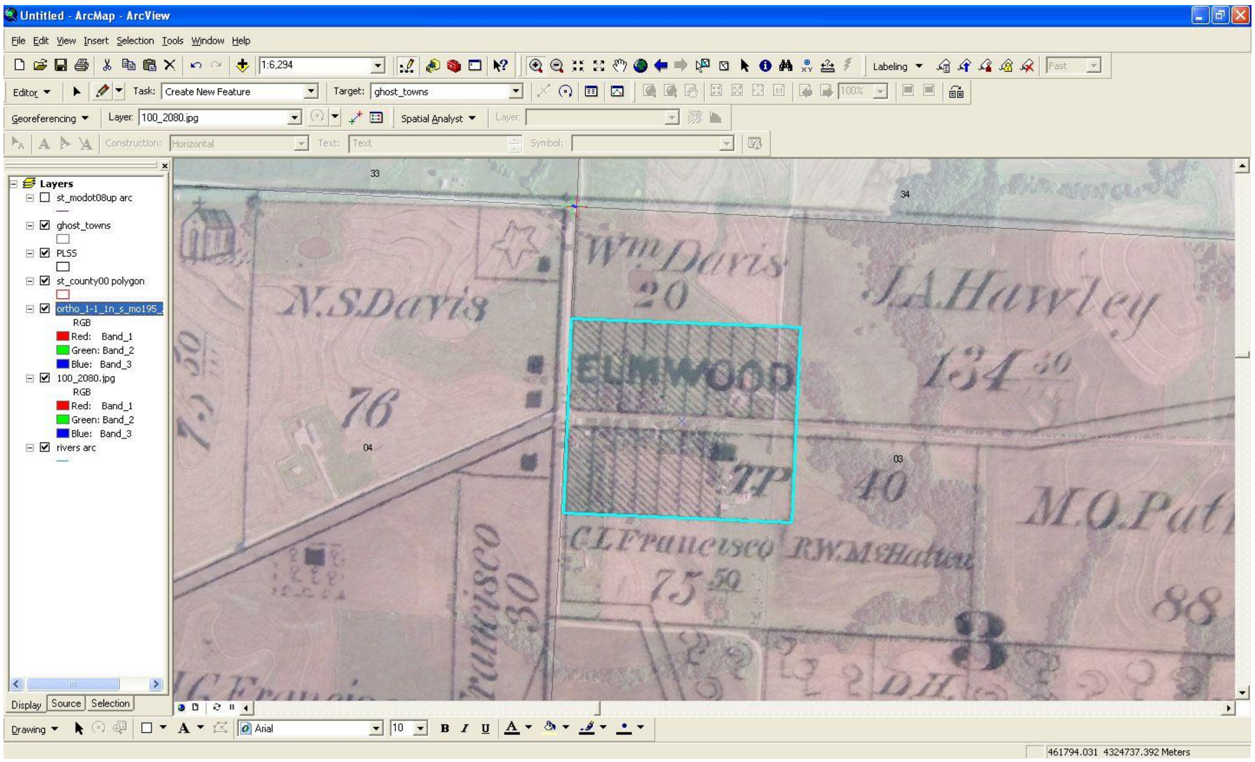


Figure 131.

An overlay of NAIP imagery at 70% transparency on the LiDAR hillshade DTM of the abandoned Lexington Branch of the Missouri Pacific Railroad.

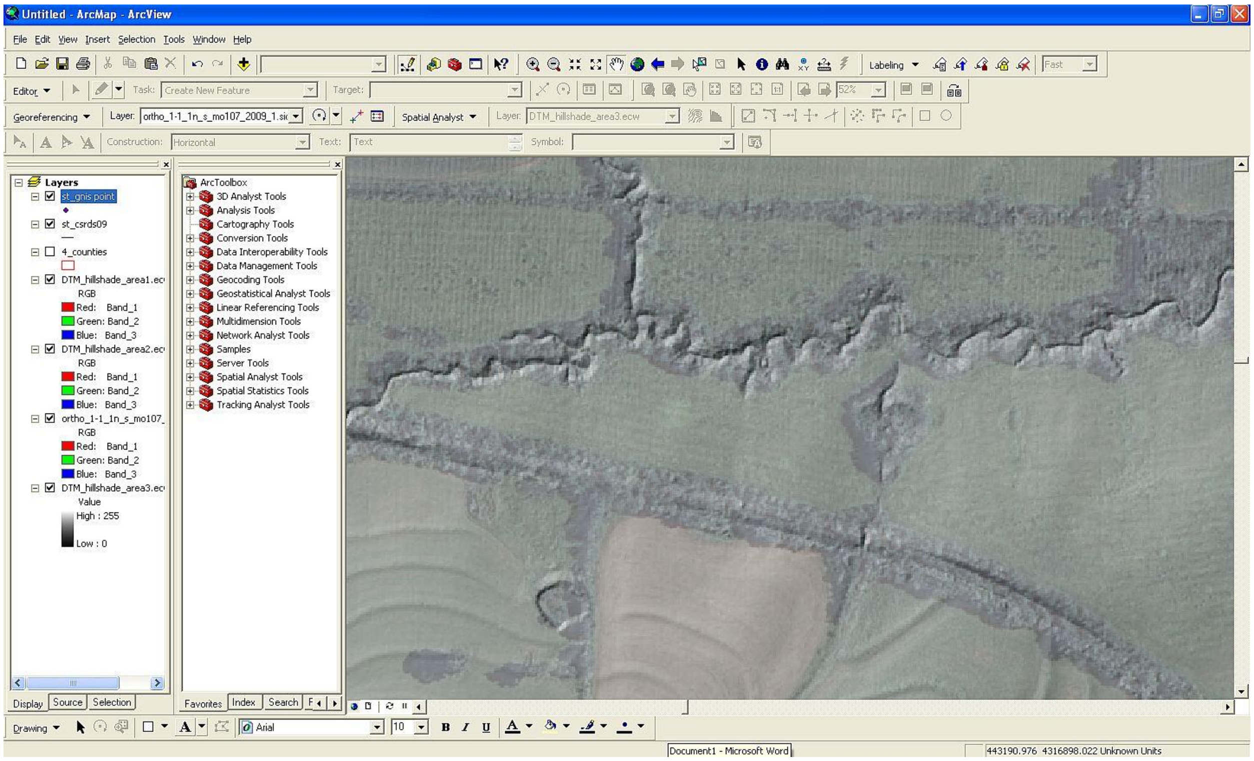
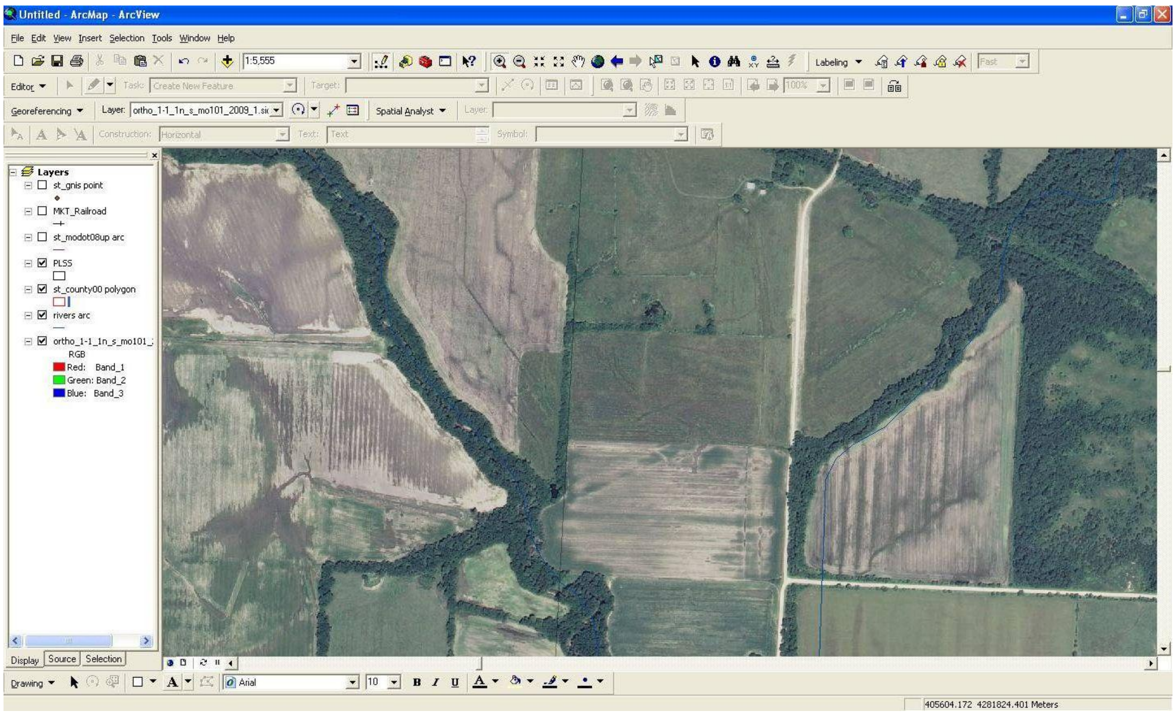


Figure 132.

NAIP 2009 imagery showing relict features along the path of the Holden Division of the Missouri, Kansas, and Texas Railroad (above). A digitized line for the railroad (below).



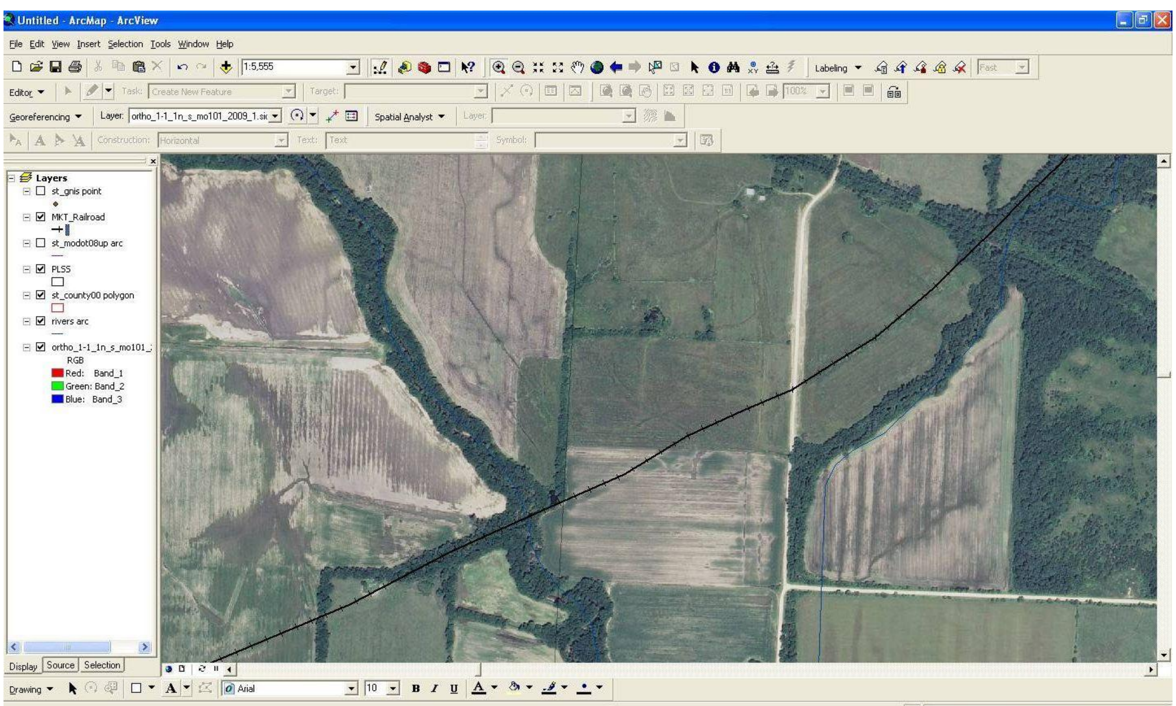


Figure 133.

An example of Barrel Distortion on a digital photograph of the 1876 Saline County Plat Book.

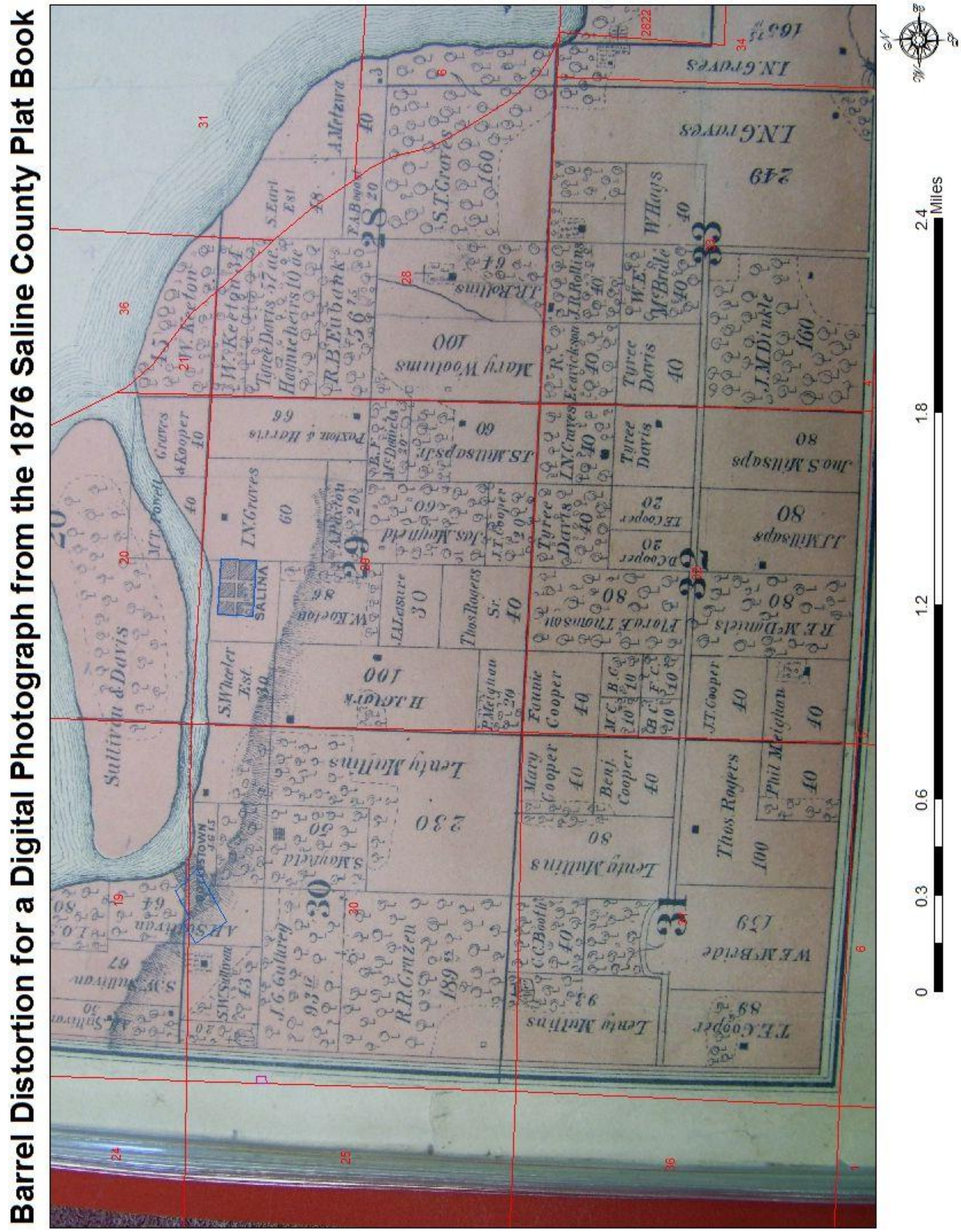


Figure 134.

LiDAR imagery of relict features in Cambridge, Saline County.

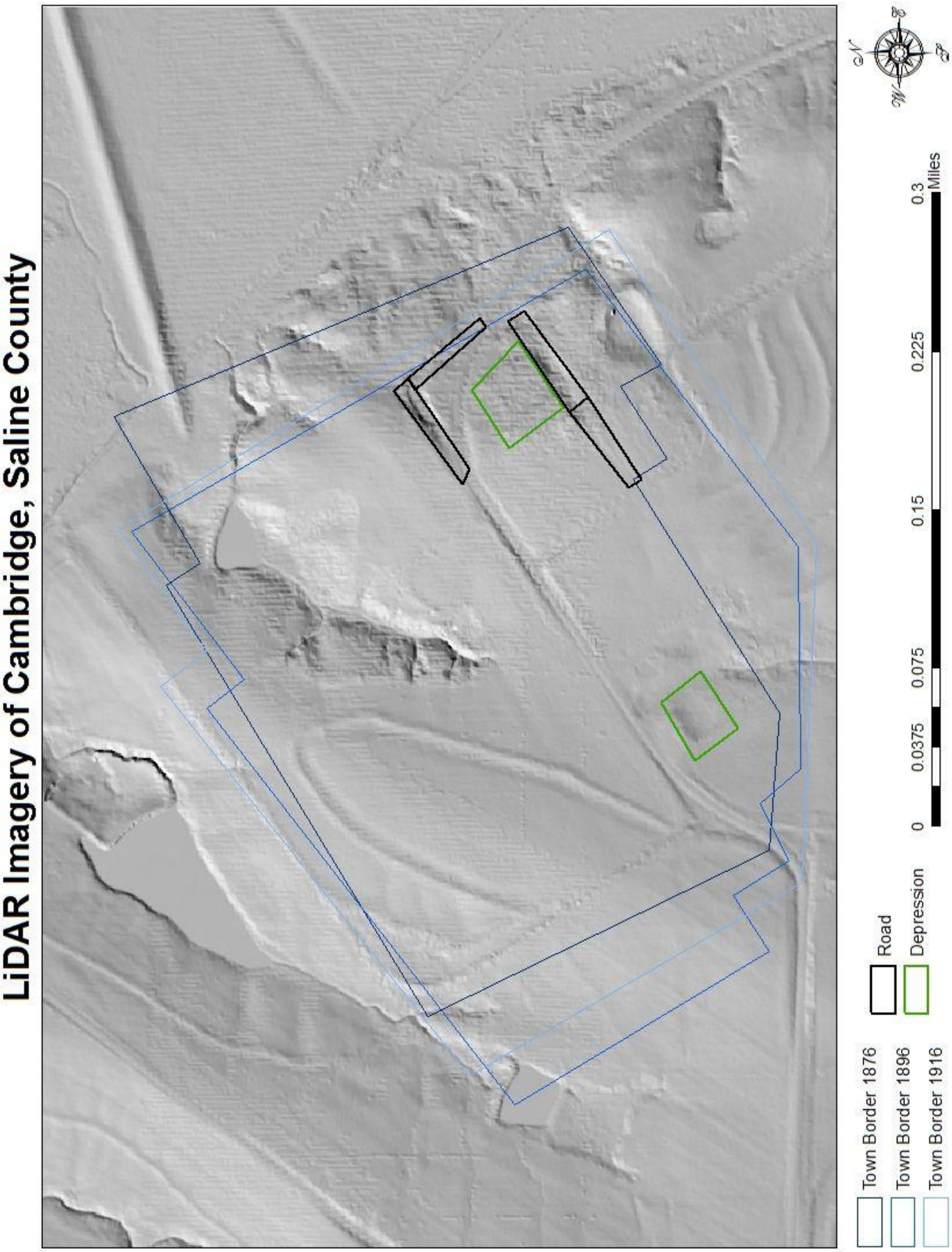


Figure 135.

LiDAR imagery of relict features in Chapel Hill, Lafayette County.

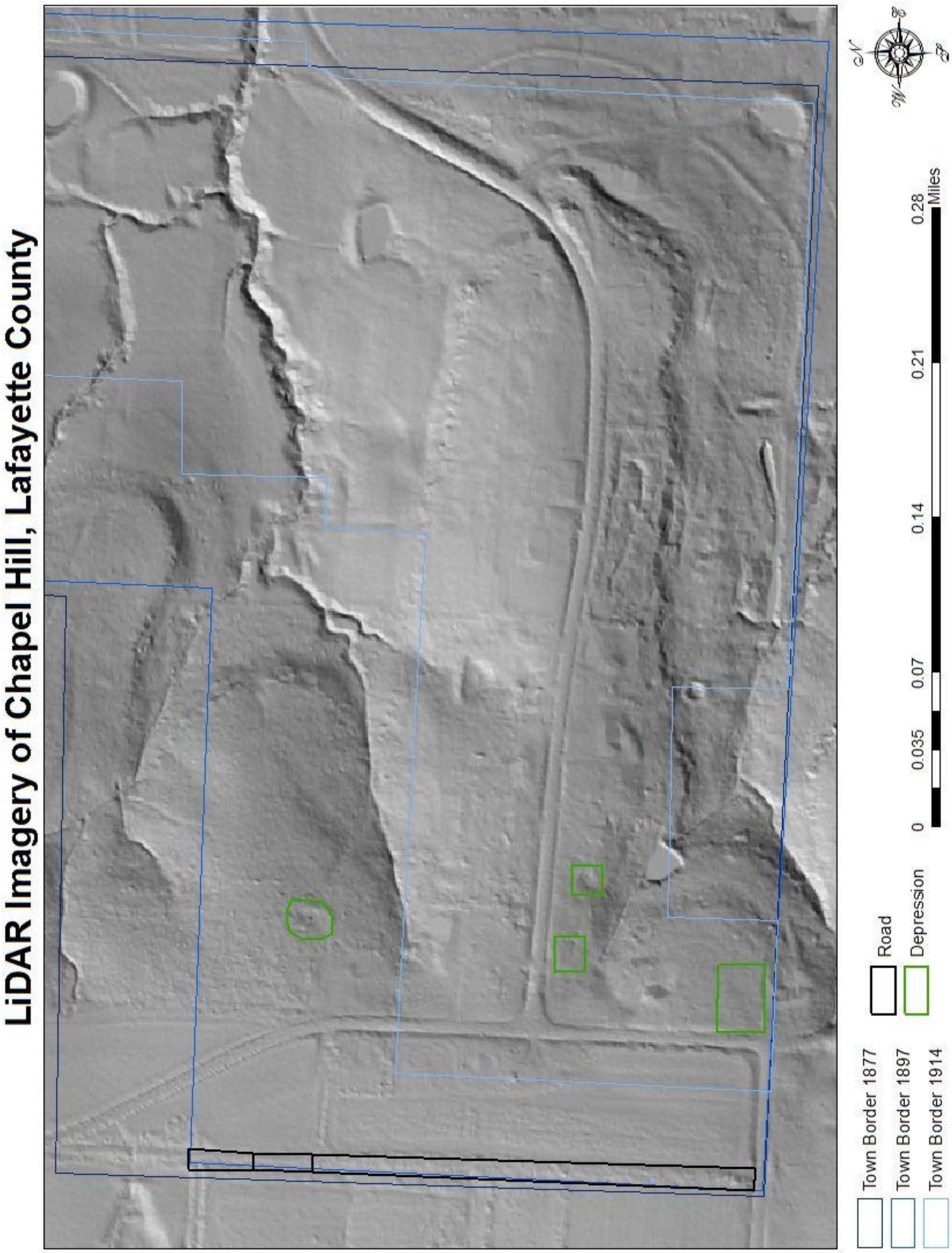


Figure 136.

LiDAR imagery of relict features in Coloma, Carroll County.

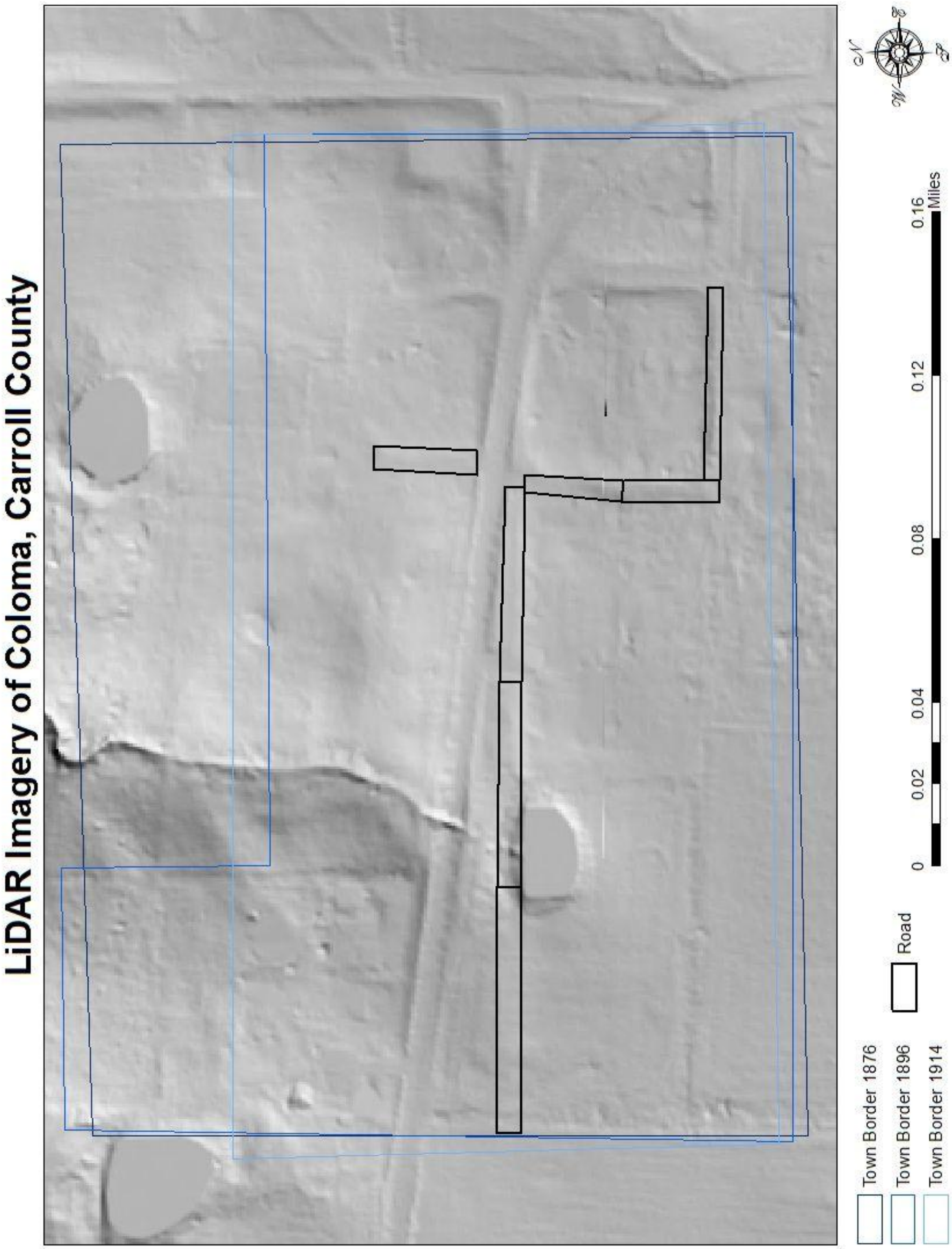


Figure 137.

LiDAR imagery of relict features in Cunningham, Chariton County.

Figure 138.

LiDAR imagery of relict features in Elmwood, Saline County.

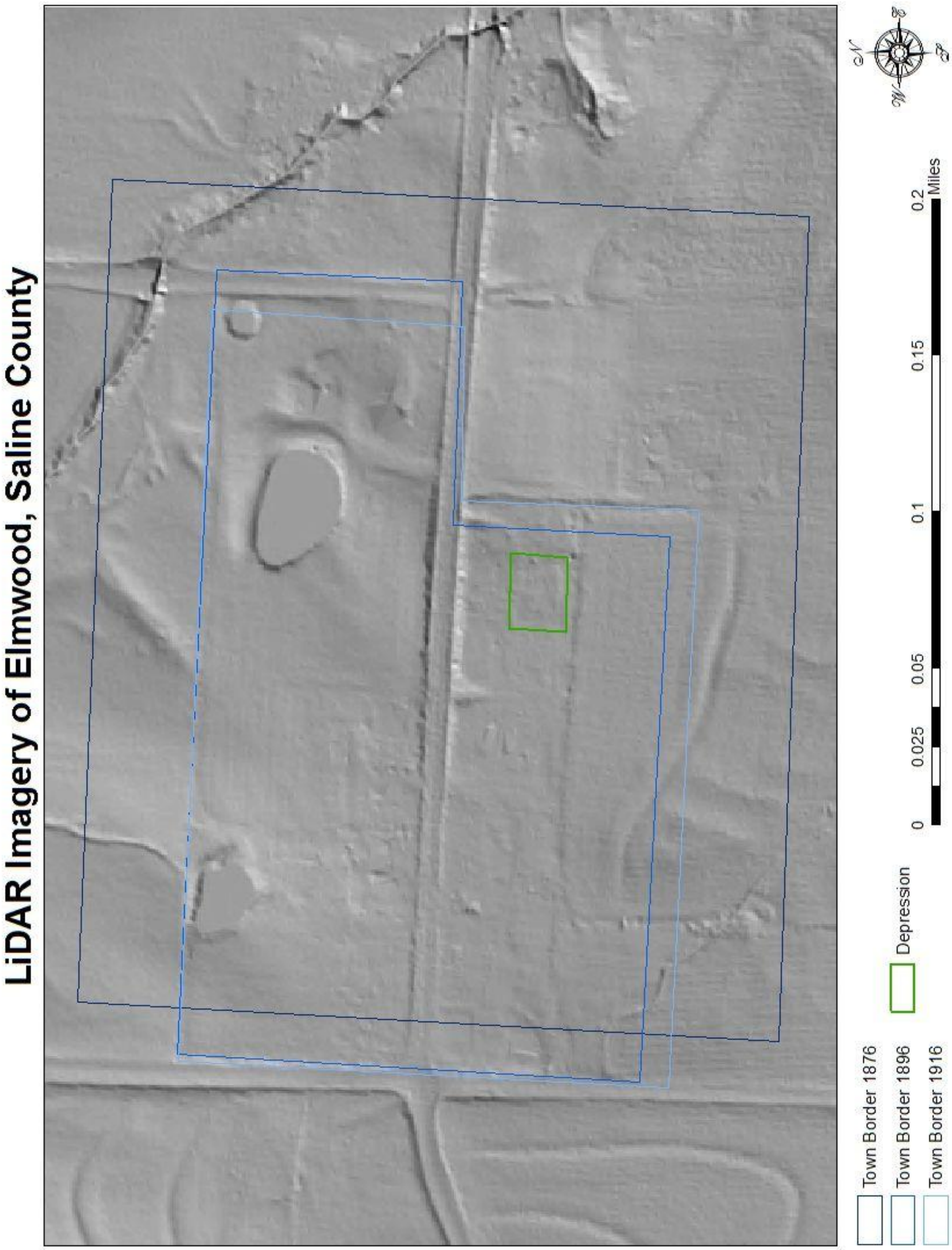


Figure 139.

LiDAR imagery of relict features in Hodge, Lafayette County.

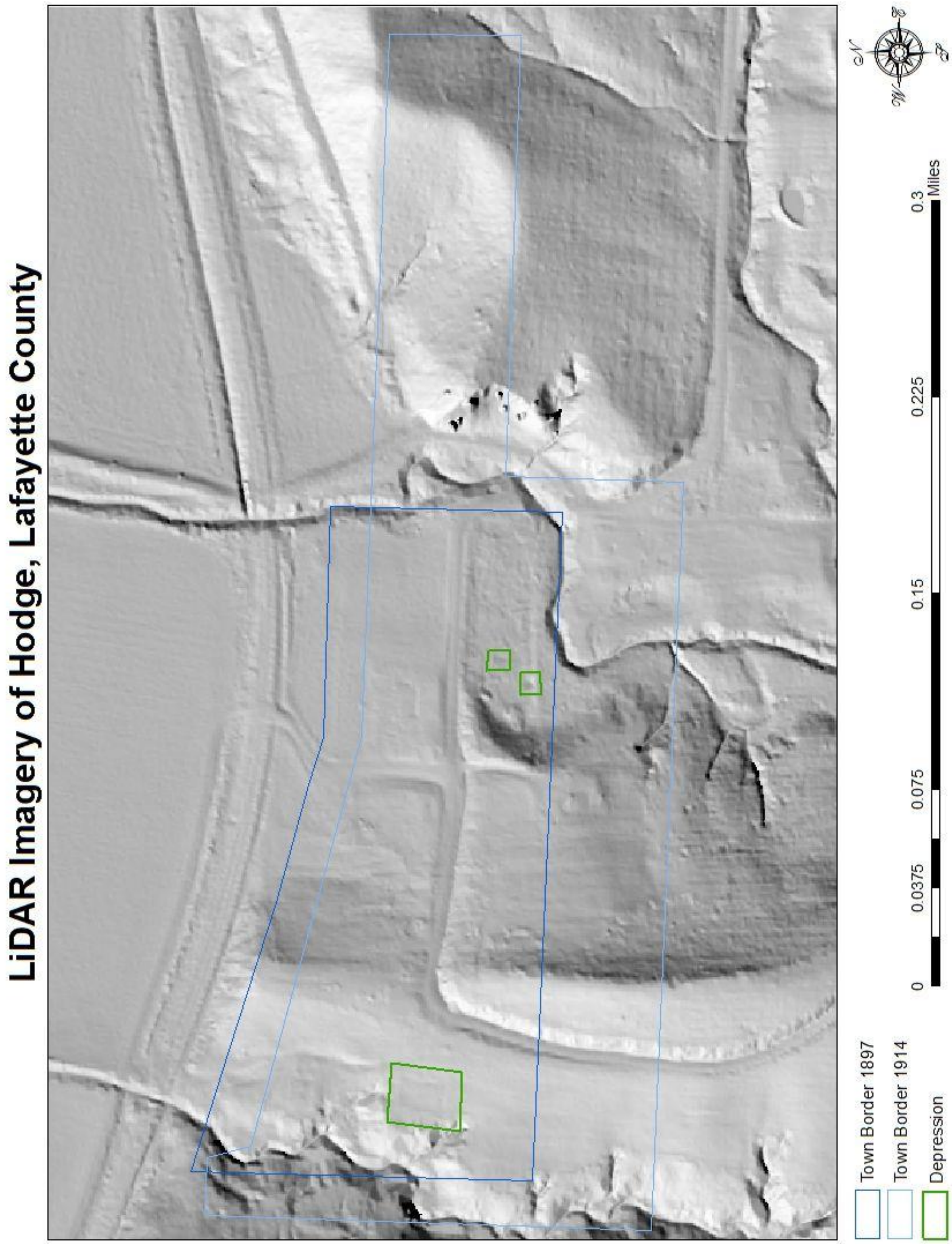


Figure 140.

LiDAR imagery of relict features in Miles Point, Carroll County.

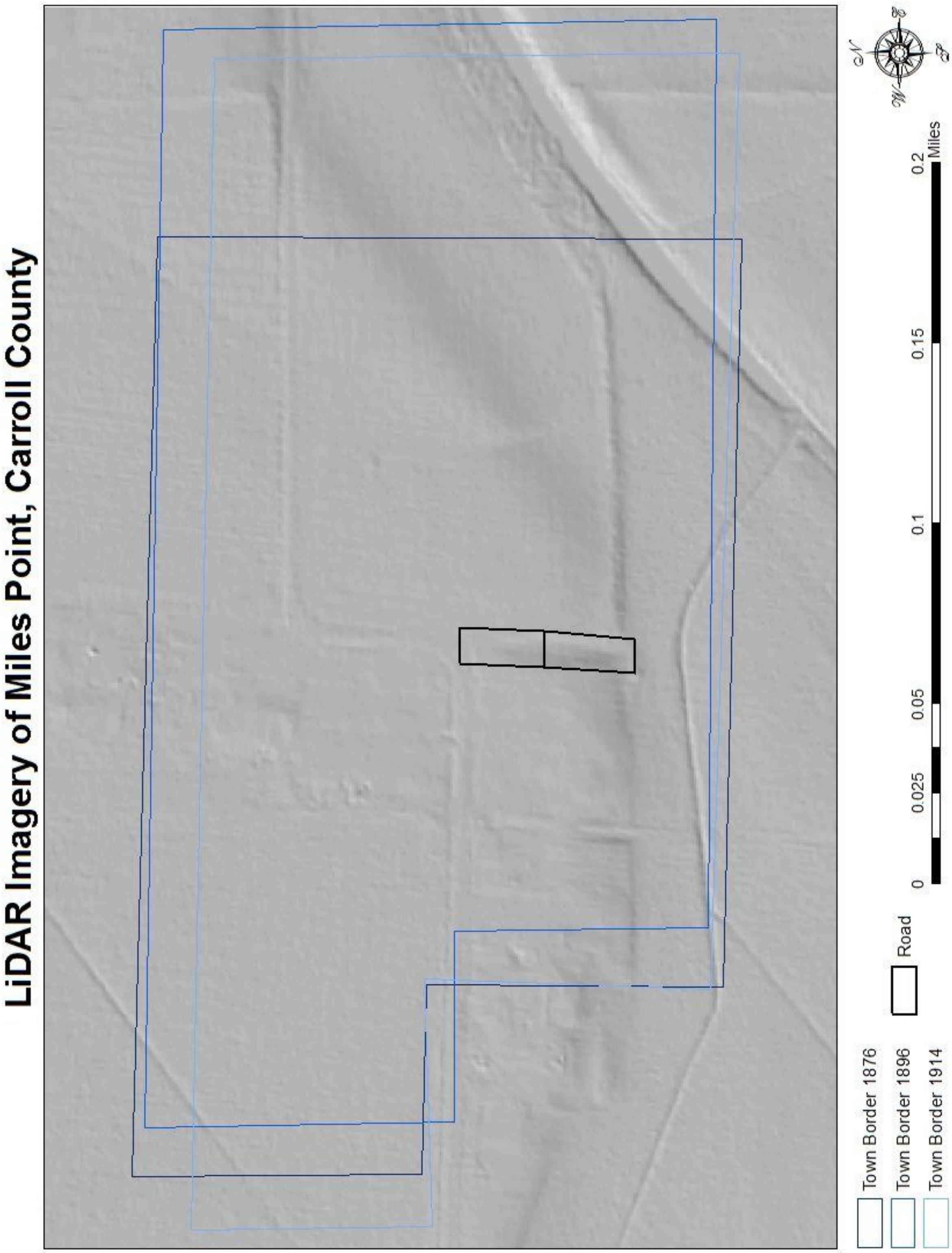


Figure 141.

LiDAR imagery of relict features in New Frankfort, Saline County.

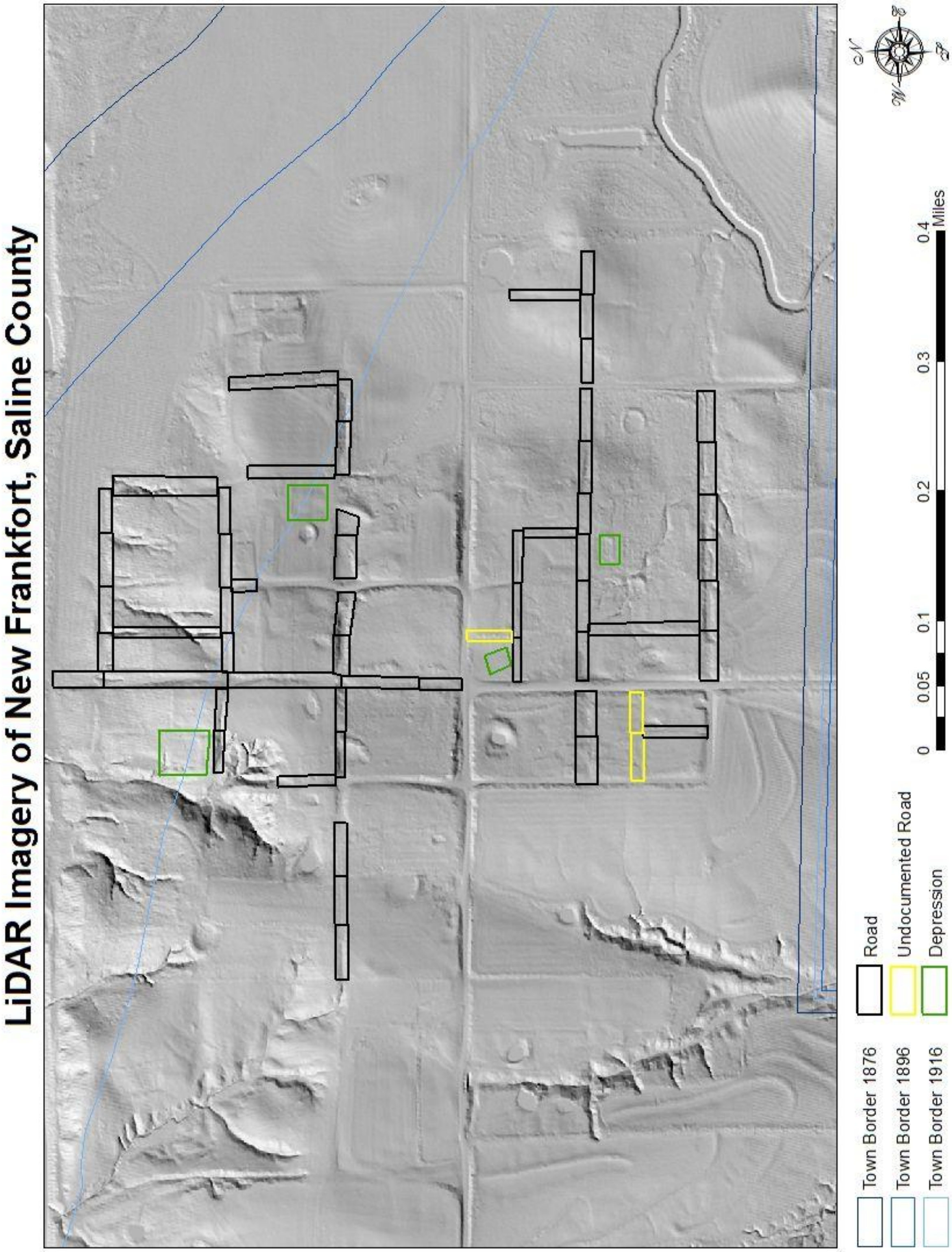


Figure 142.

LiDAR imagery of relict features in Plymouth, Carroll County.

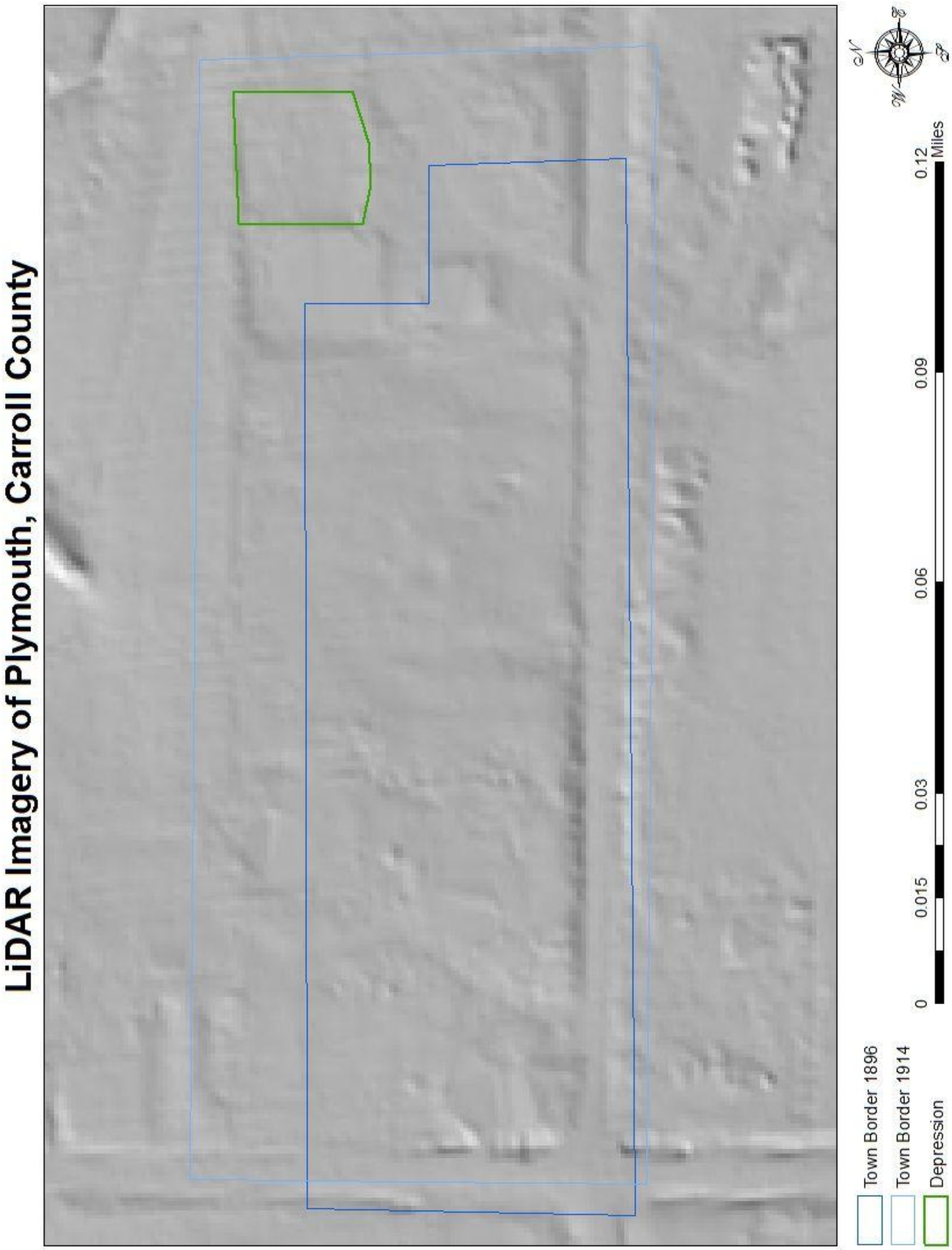


Figure 143.

LiDAR imagery of relict features in Saline City, Saline County.

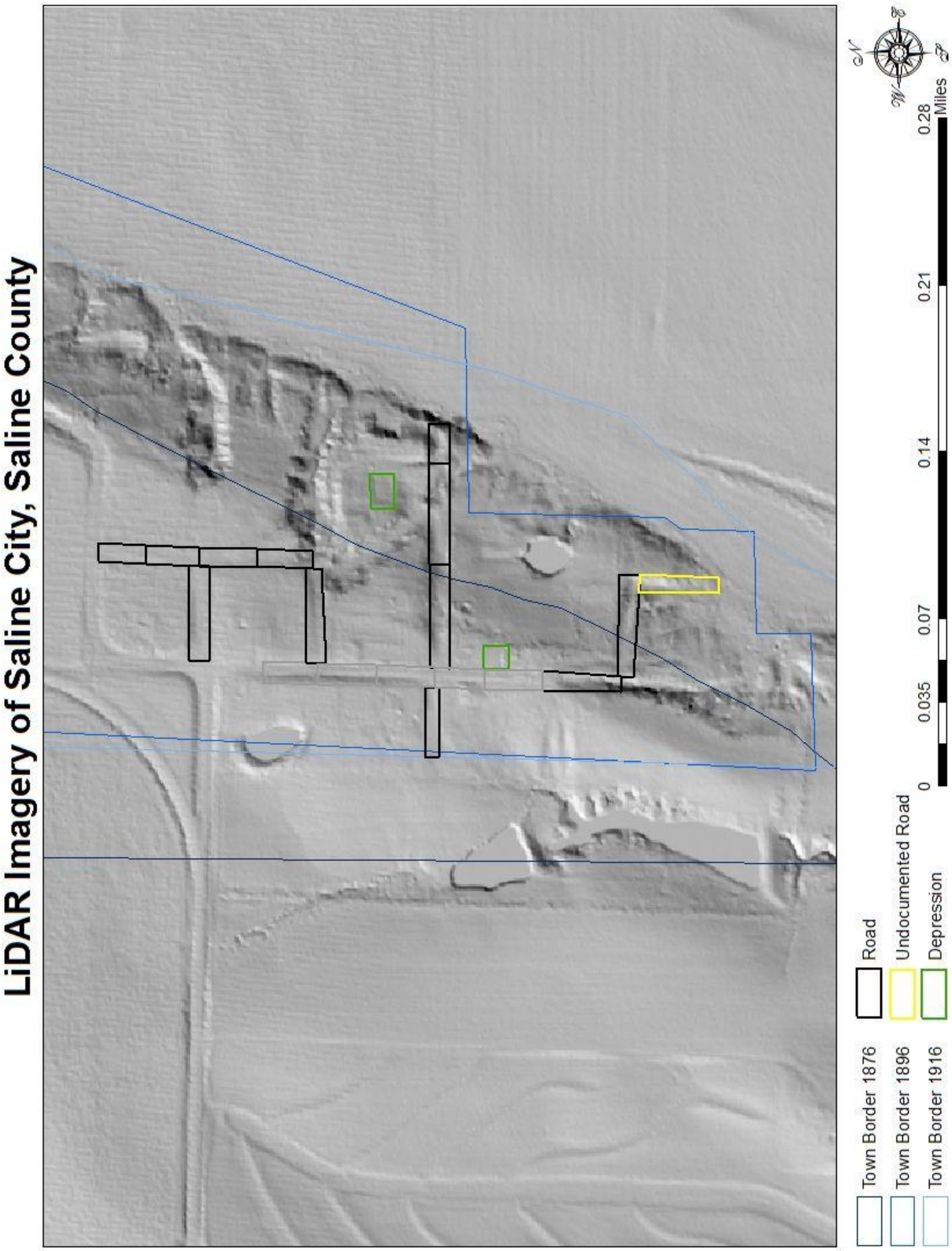


Figure 144.

LiDAR imagery of relict features in Shannondale, Chariton County.

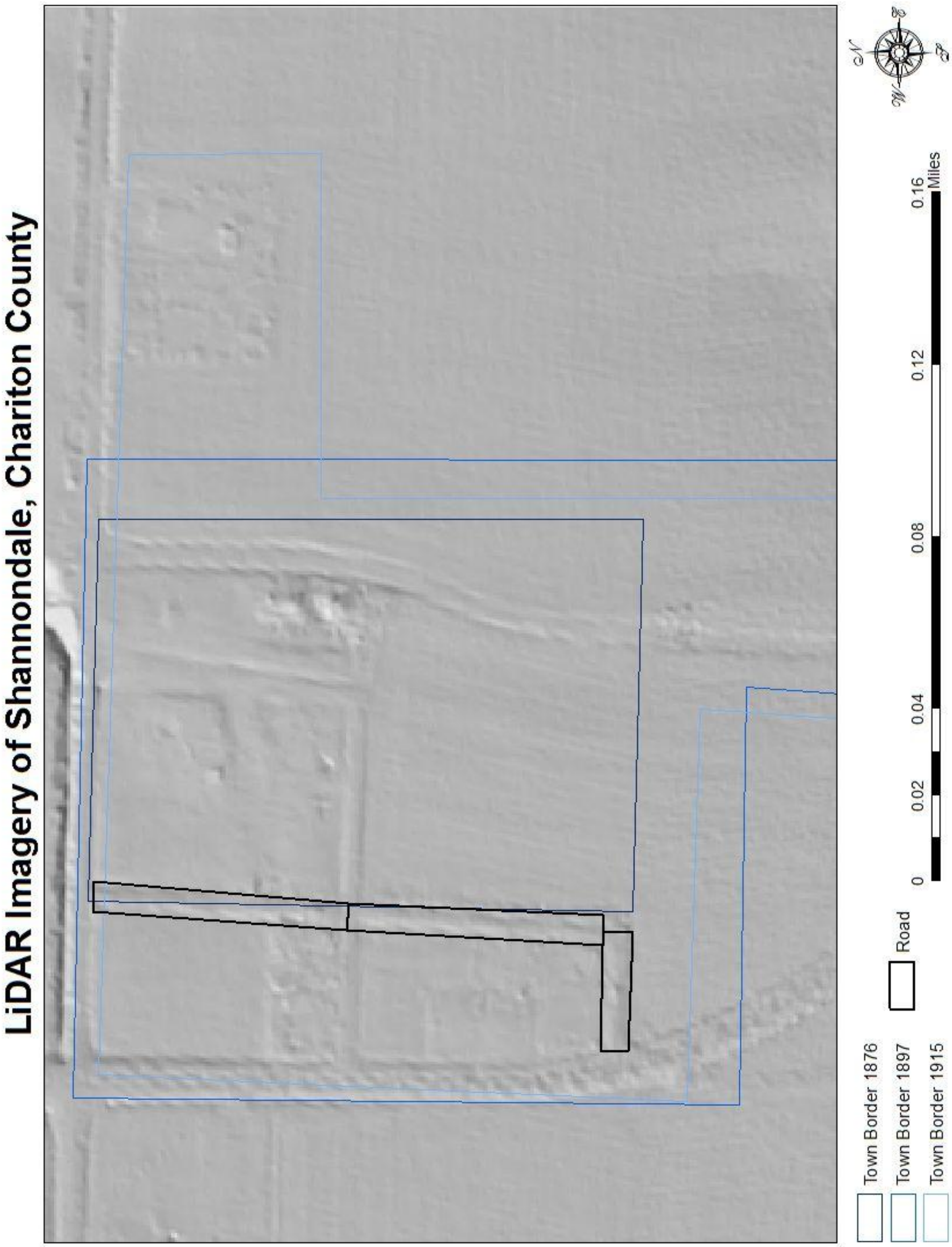


Figure 145.

LiDAR imagery of relict features in Triplett, Chariton County.

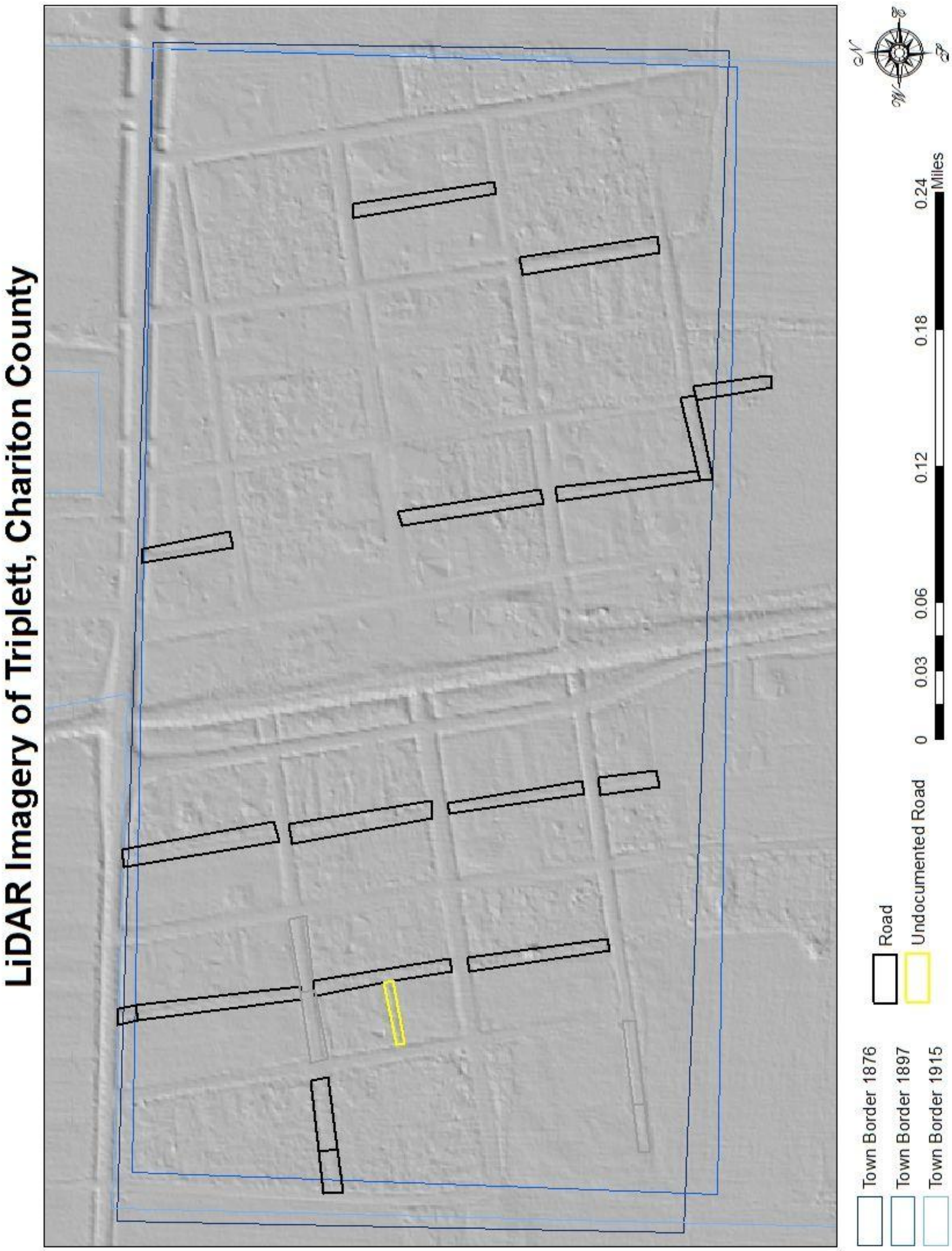


Figure 146.

LiDAR imagery of relict features in Wakenda, Carroll County.

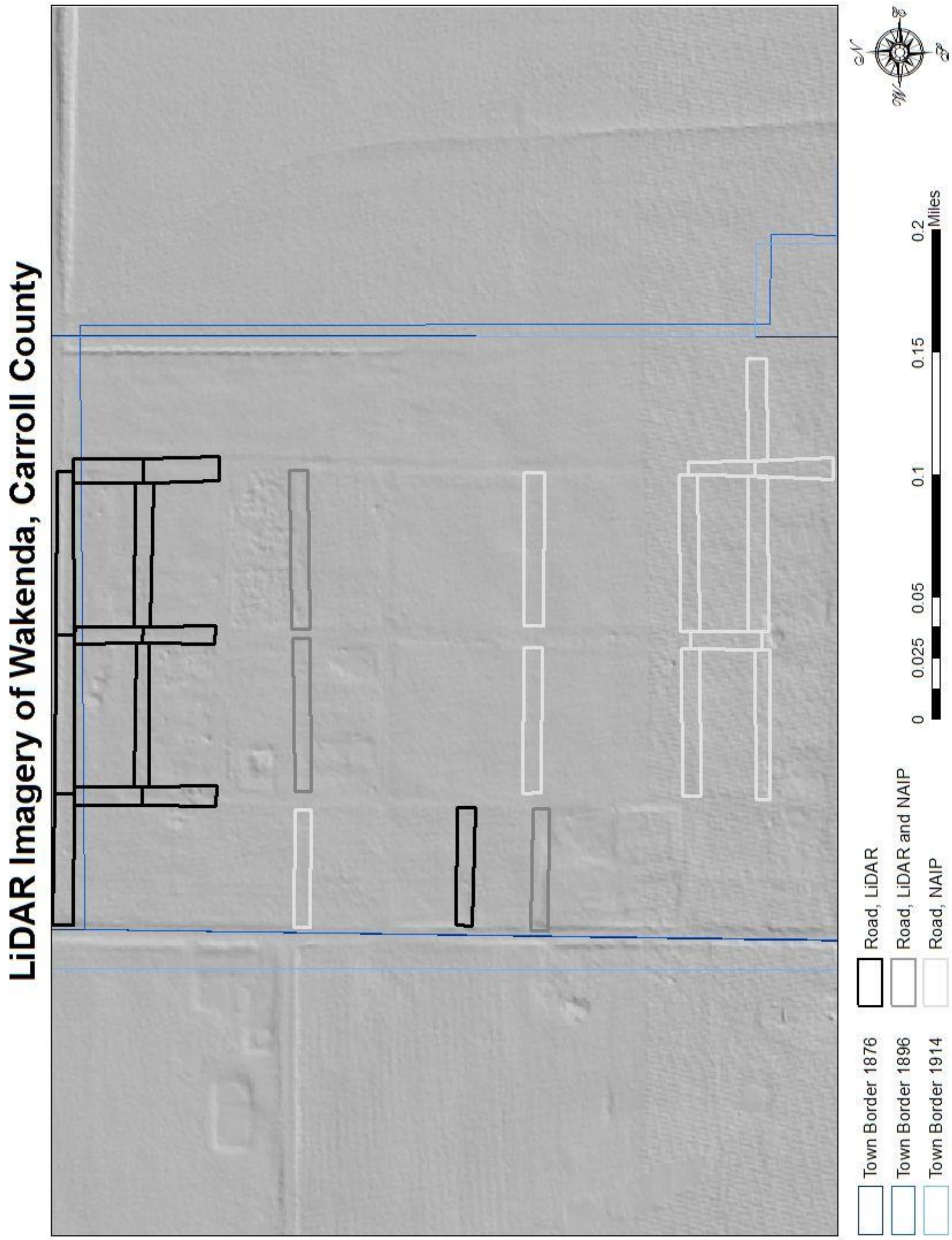


Figure 147.

LiDAR imagery of relict features in Wien, Chariton County.

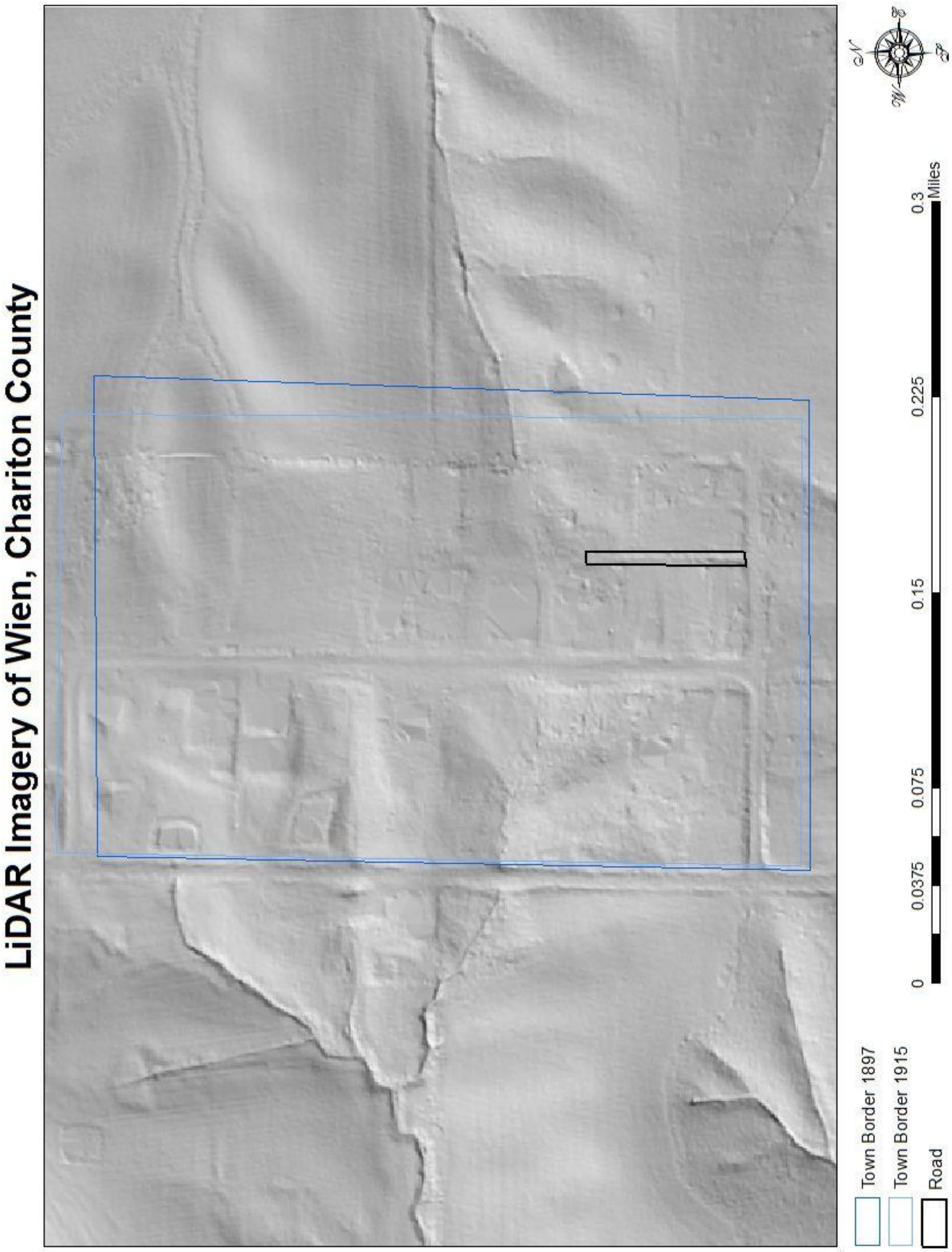


Figure 148.

NAIP imagery of relict features in Cunningham, Chariton County.

Figure 149.

NAIP imagery of relict features in Elmwood, Saline County.

Figure 150.

NAIP imagery of relict features in Saline City, Saline County.

Figure 151.

NAIP imagery of relict features in Triplett, Chariton County.

Figure 152.

NAIP imagery of relict features in Wakenda, Carroll County.

Figure 153.

LiDAR and NAIP imagery Cambridge, Saline County.

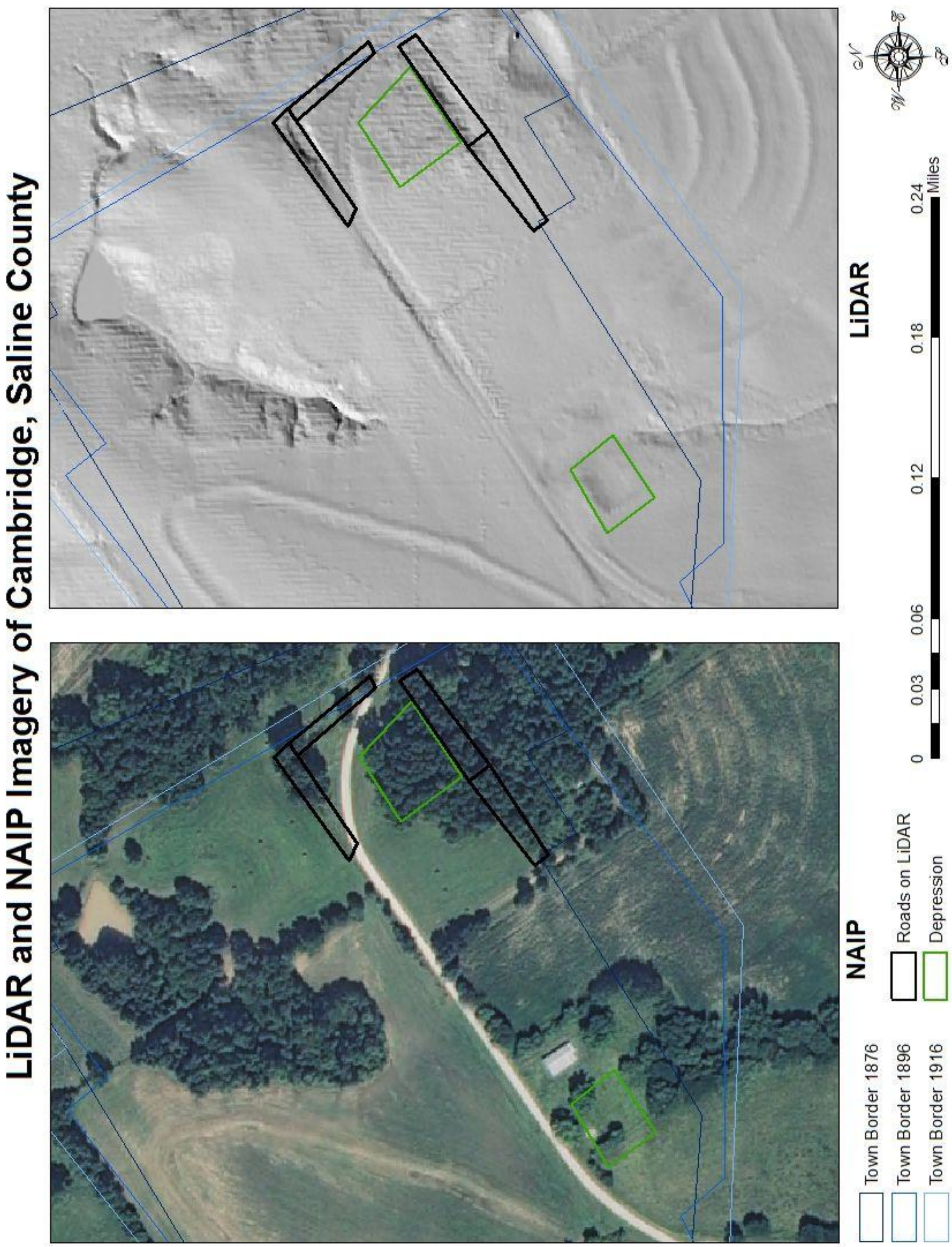


Figure 154.

LiDAR and NAIP imagery of Chapel Hill, Lafayette County.

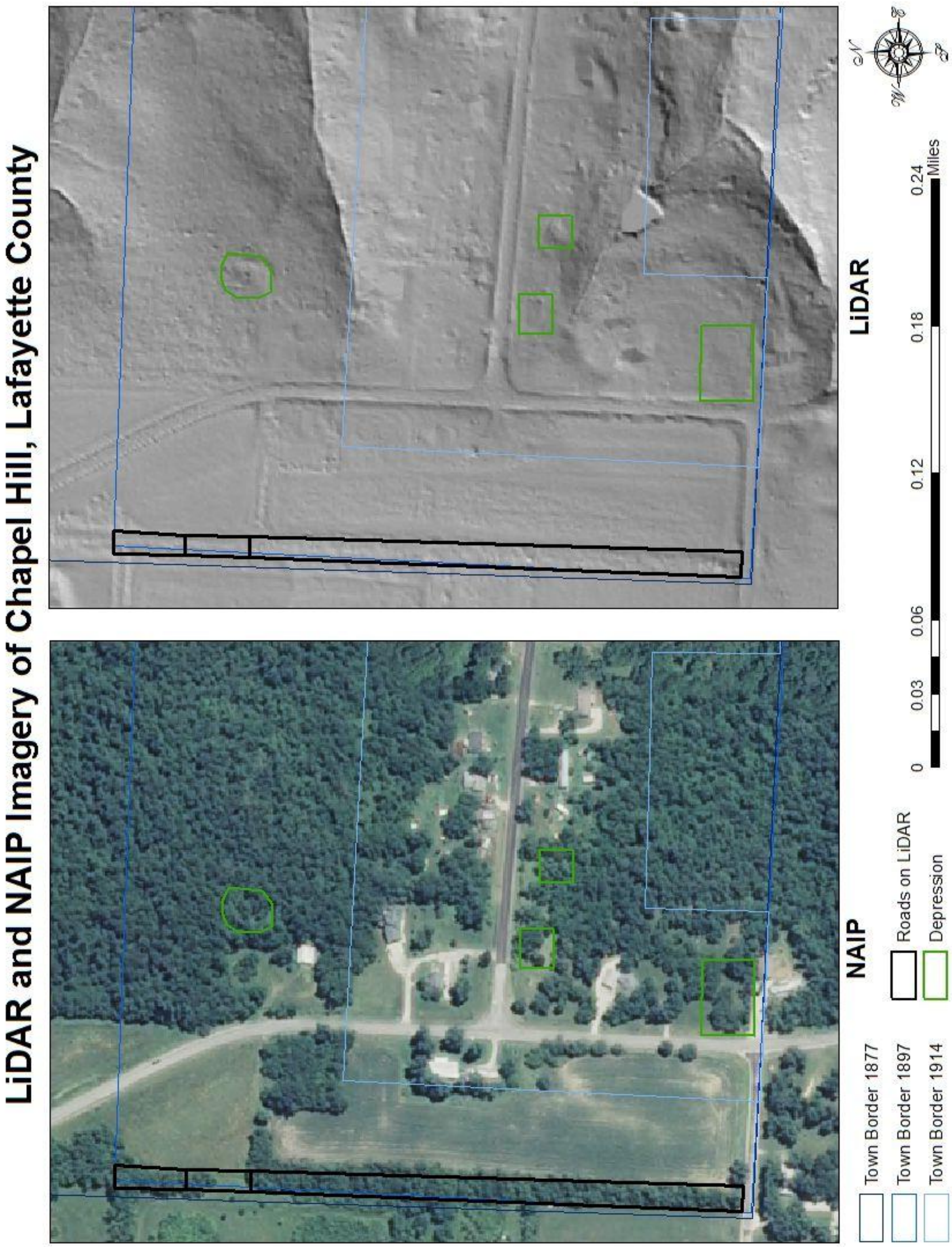


Figure 155.

LiDAR and NAIP imagery of Coloma, Carroll County.

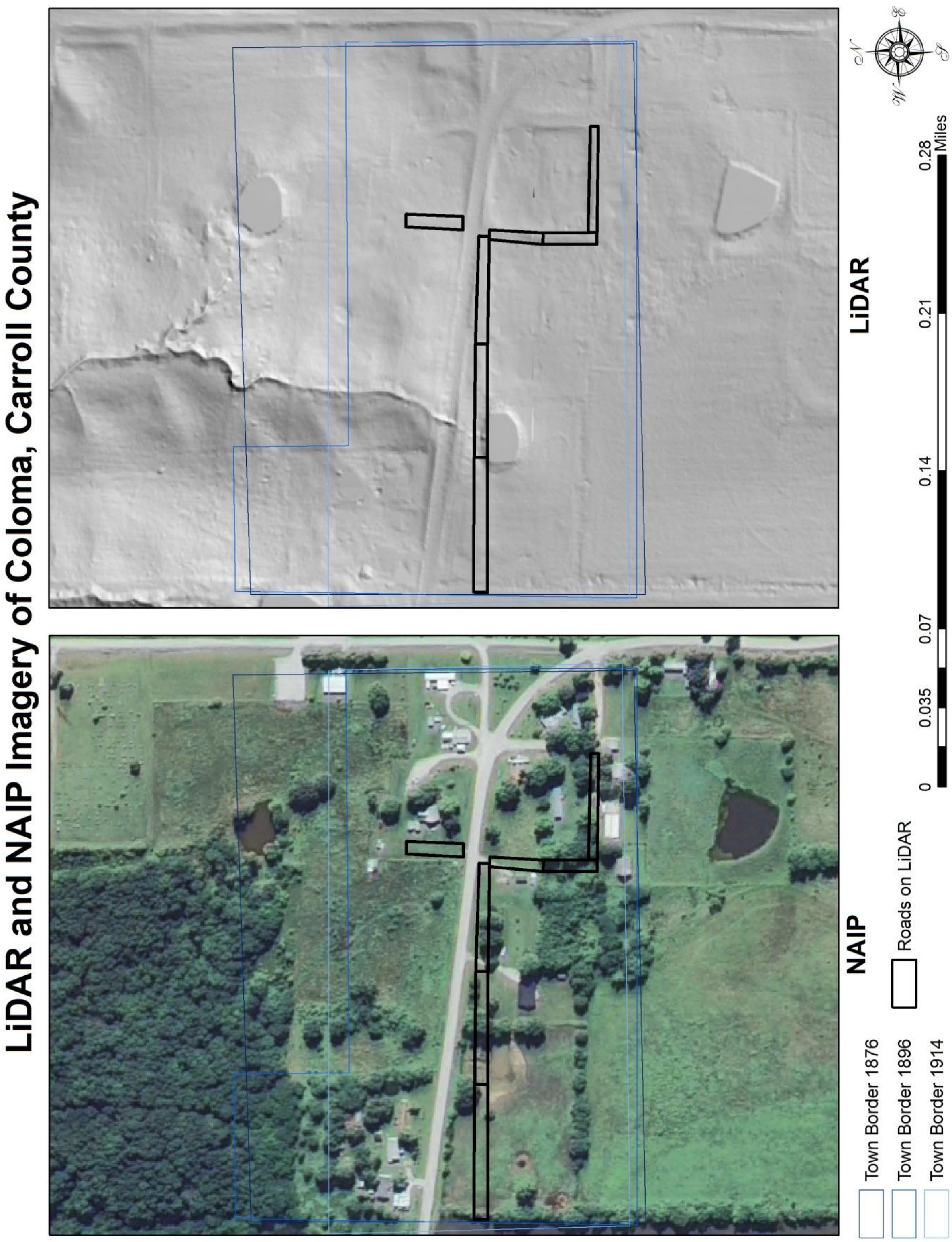


Figure 156.

LiDAR and NAIP imagery of Cunningham, Chariton County.

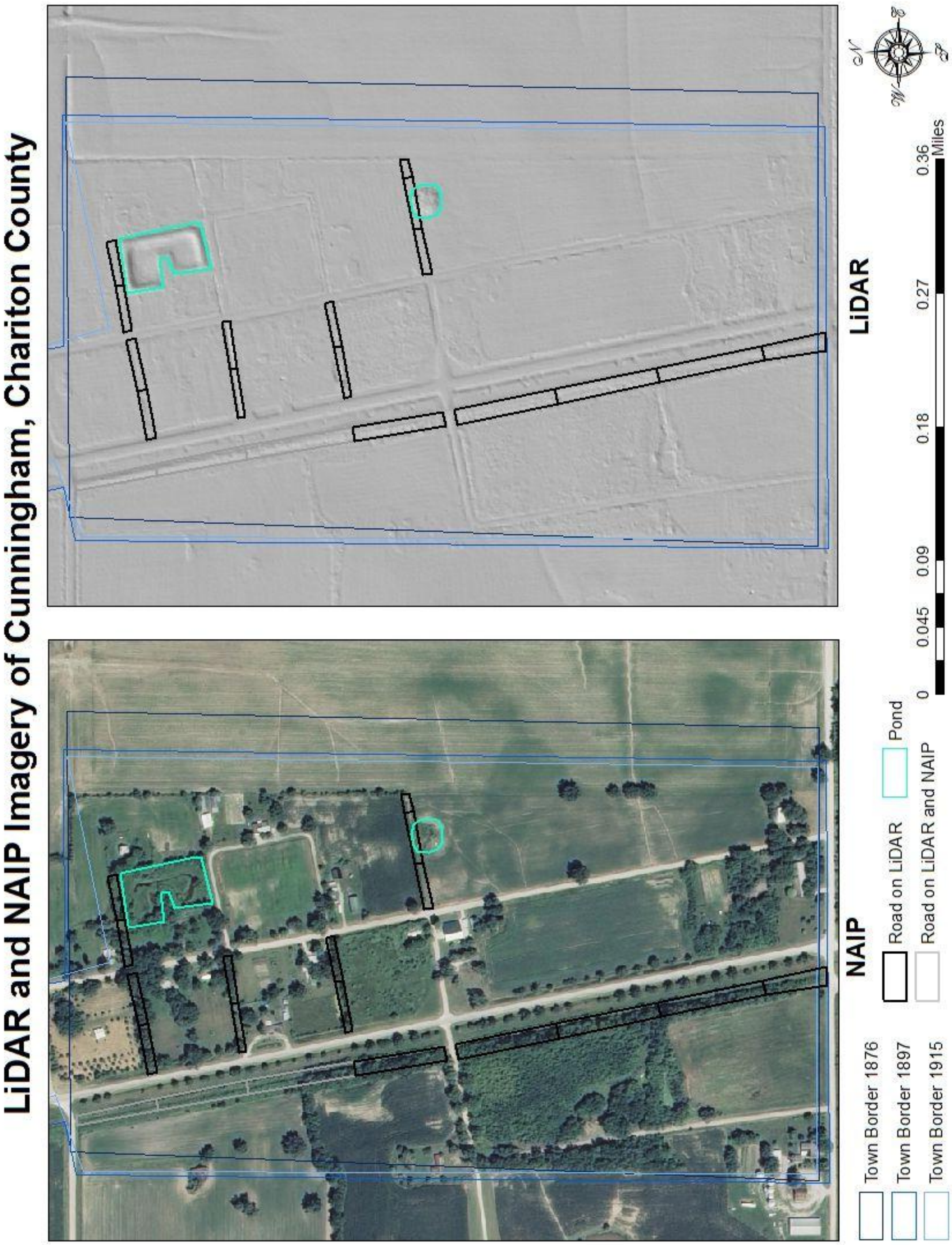


Figure 157.

LiDAR and NAIP imagery of Miles Point, Carroll County.

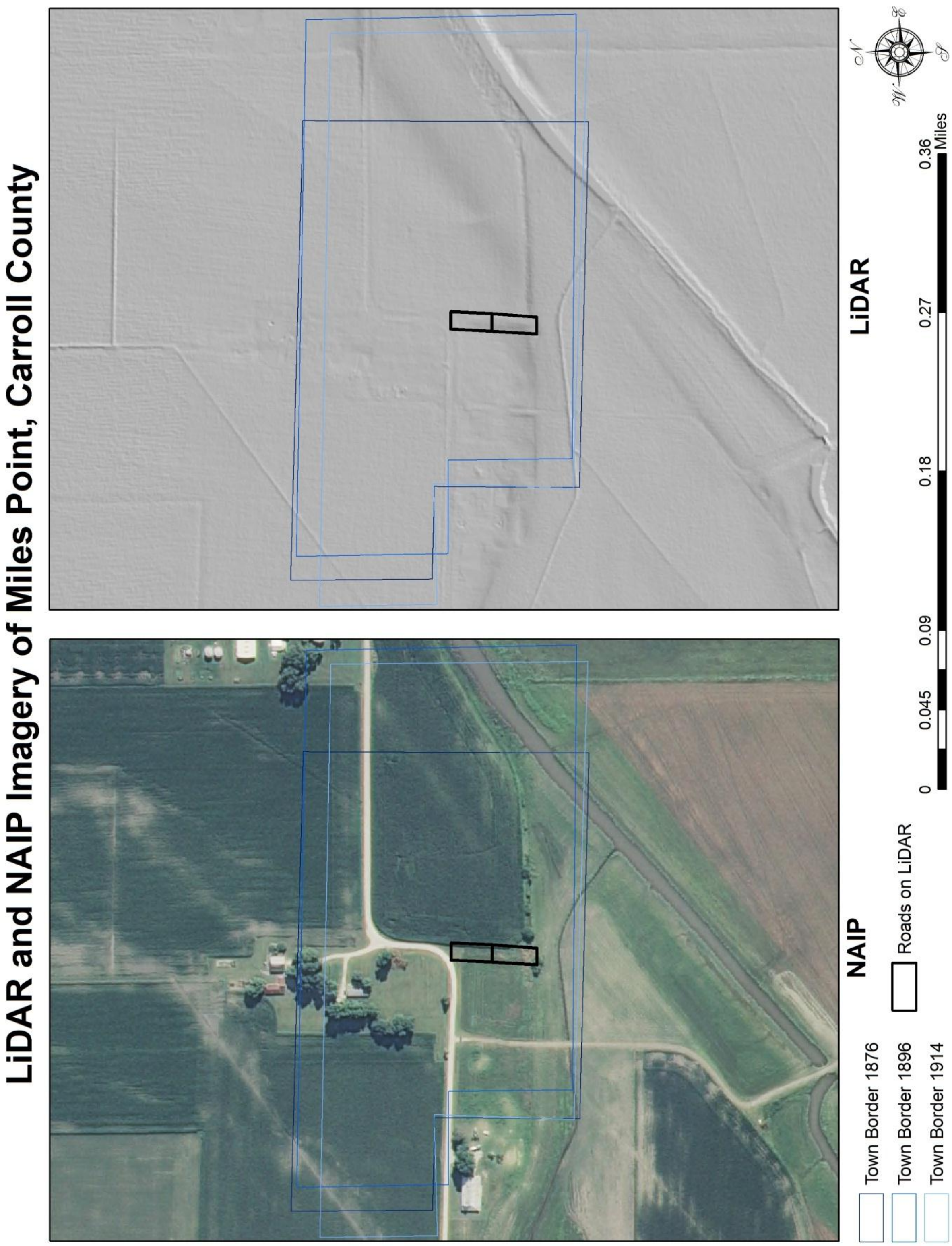


Figure 158.

LiDAR and NAIP imagery of New Frankfort, Saline County.

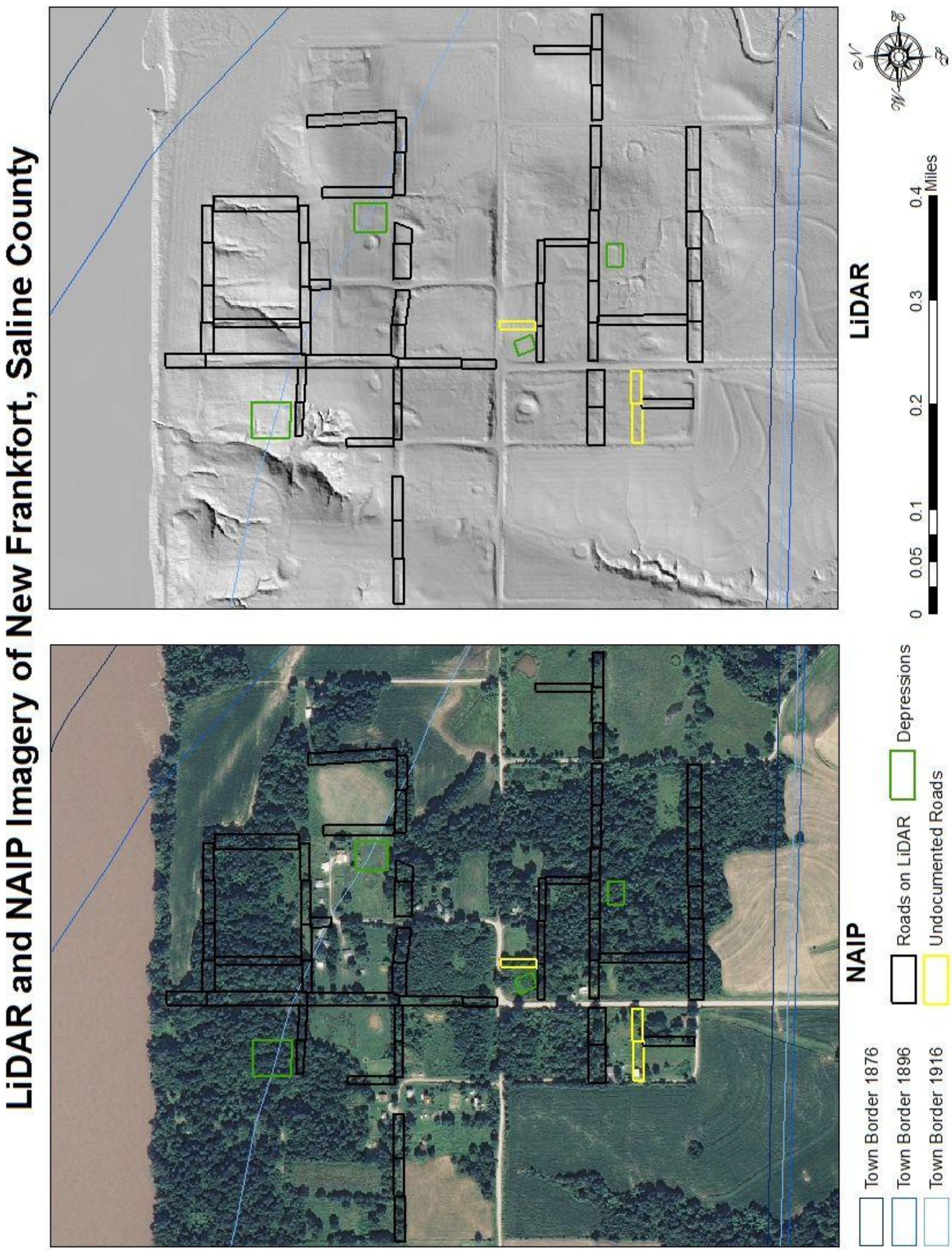


Figure 159.

LiDAR and NAIP imagery of Saline City, Saline County.

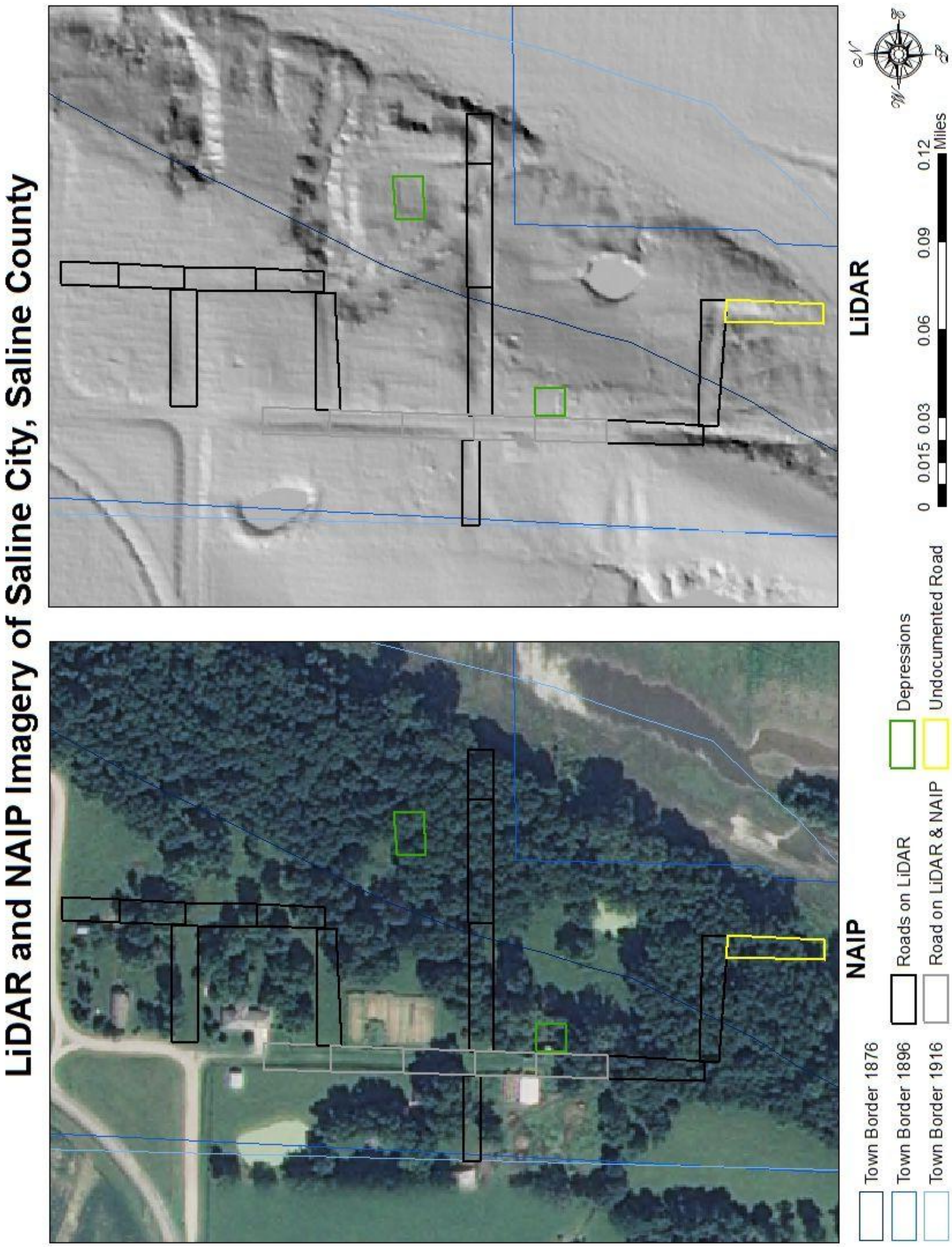


Figure 160.

LiDAR and NAIP imagery of Shannondale, Chariton County.

Figure 161.

LiDAR and NAIP imagery of Triplett, Chariton County.

Figure 162.

LiDAR and NAIP imagery of Wien, Chariton County.

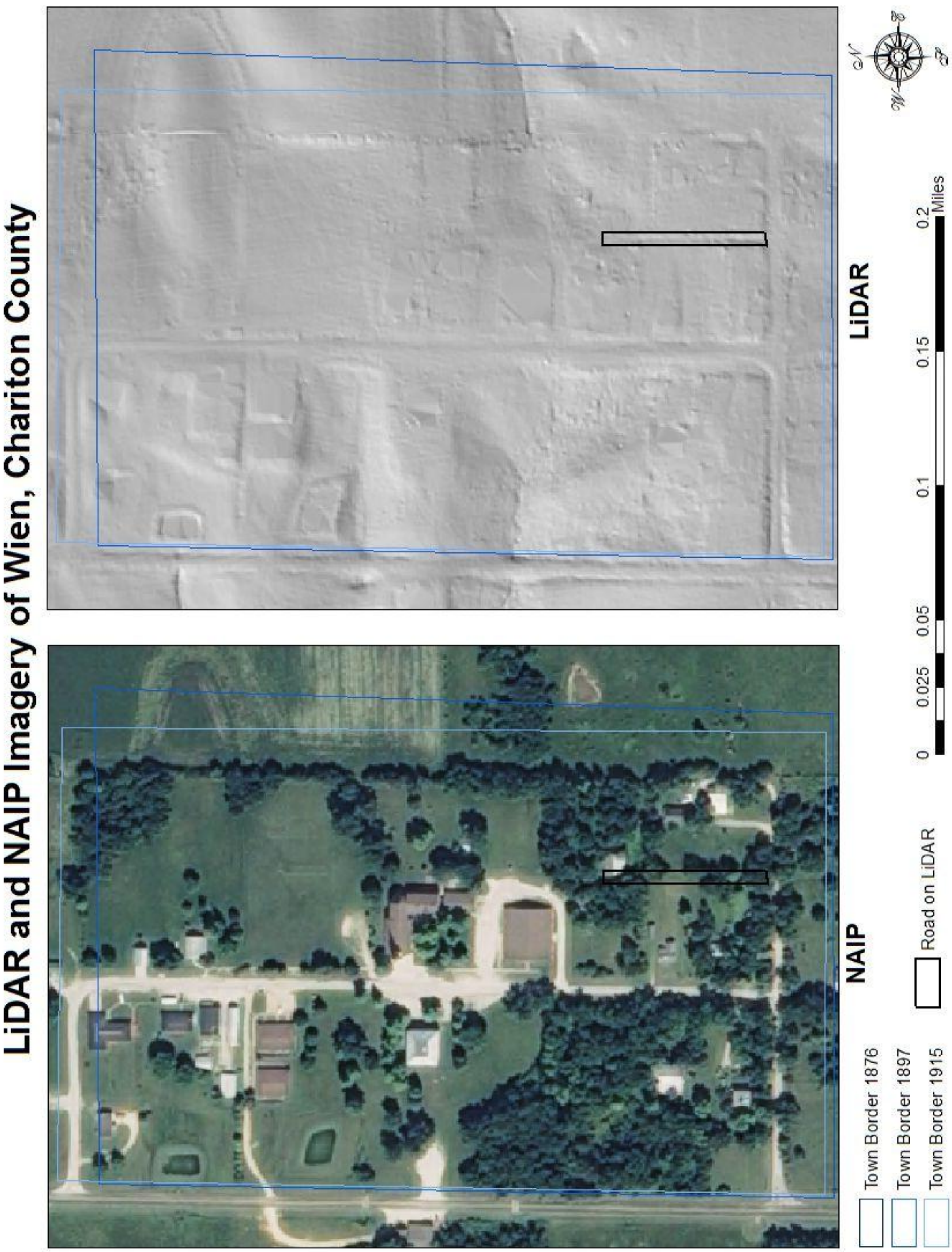


Figure 163.

LiDAR and NAIP imagery of Wakenda, Chariton County.

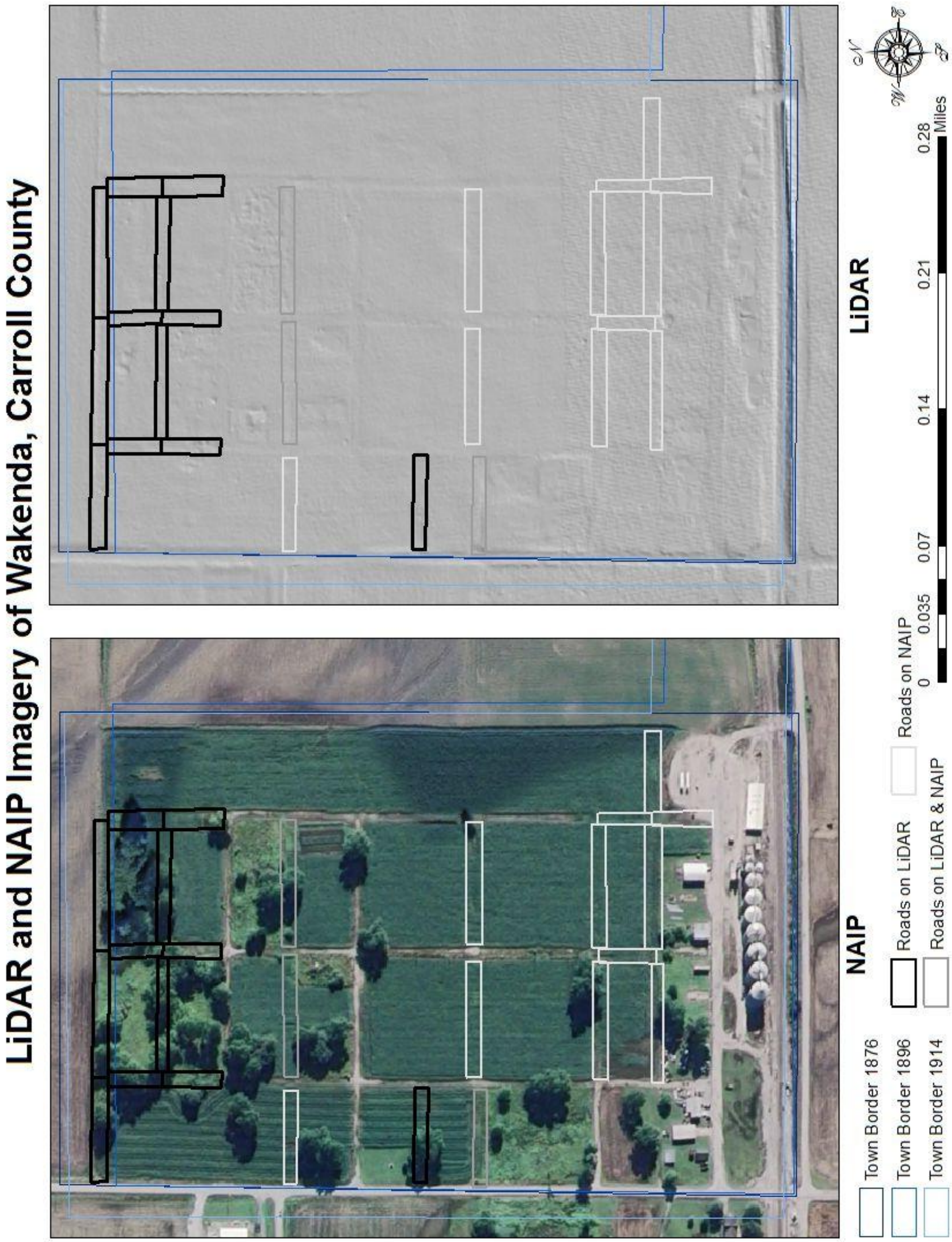


Figure 164.

Potential errors in the southern half of the LiDAR imagery of Wakenda, Carroll County.

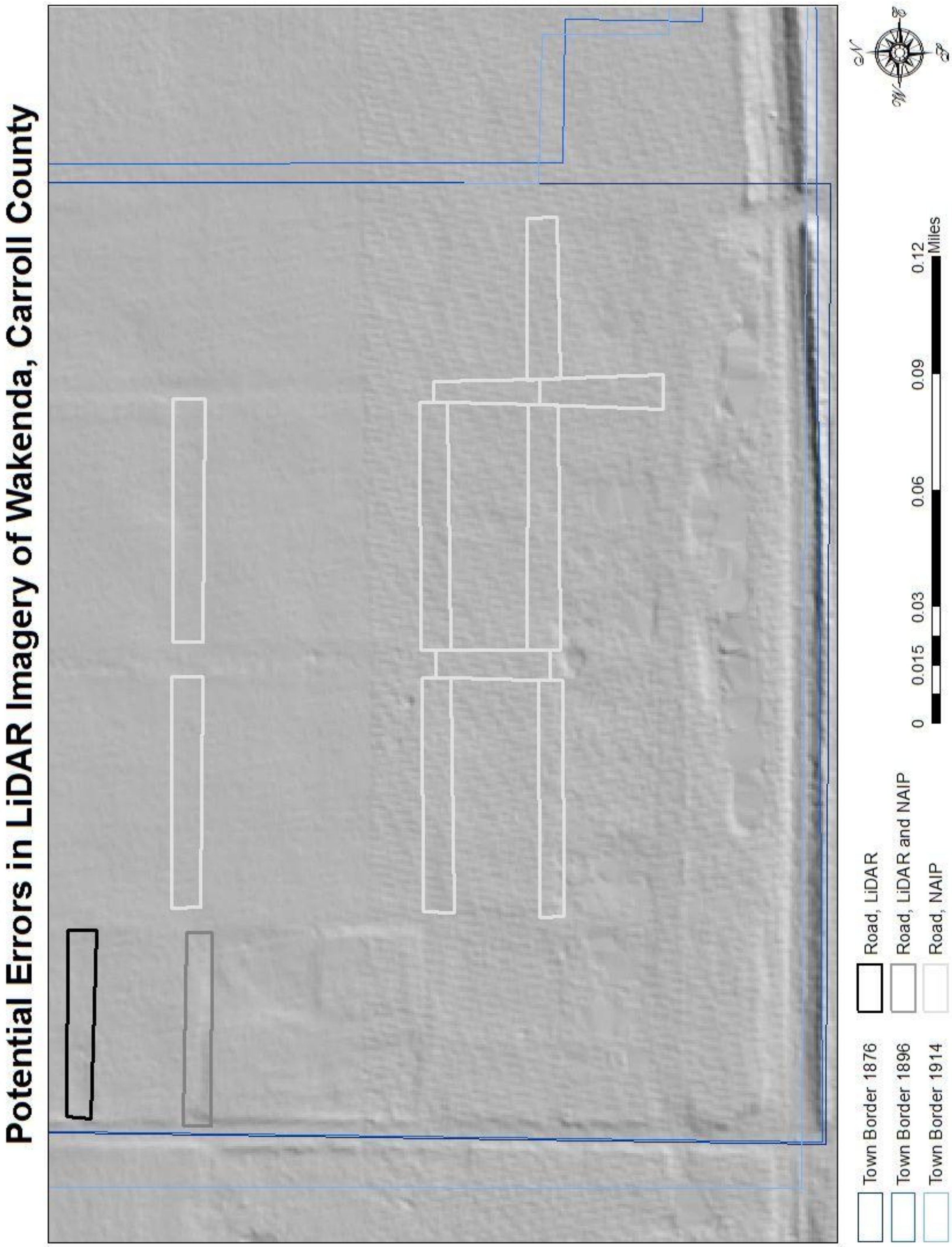


Figure 165.

LiDAR and NAIP imagery of Berlin, Lafayette County.

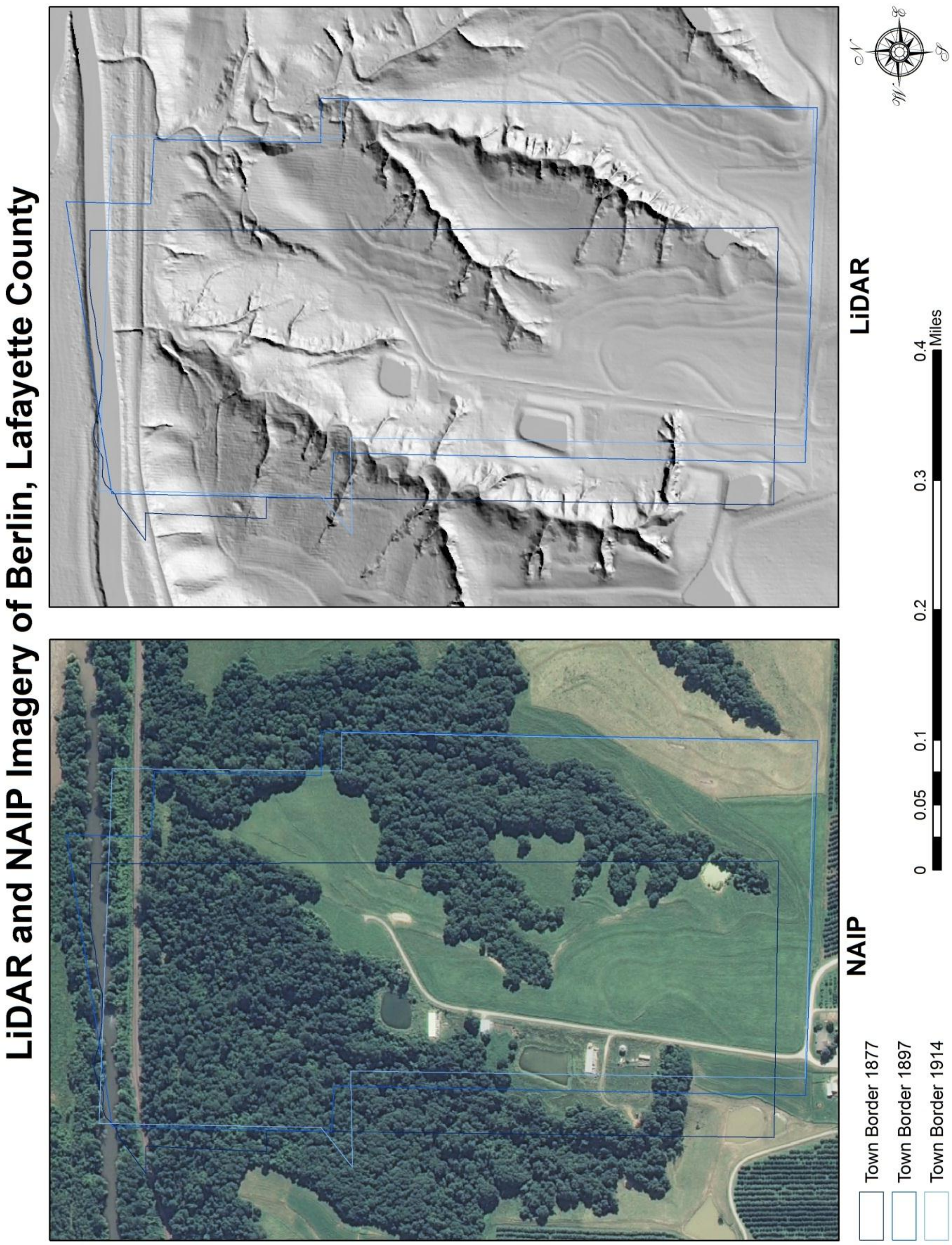


Figure 166.

LiDAR and NAIP imagery of Elmwood, Saline County.

Figure 167

LiDAR and NAIP imagery of Hodge, Lafayette County.

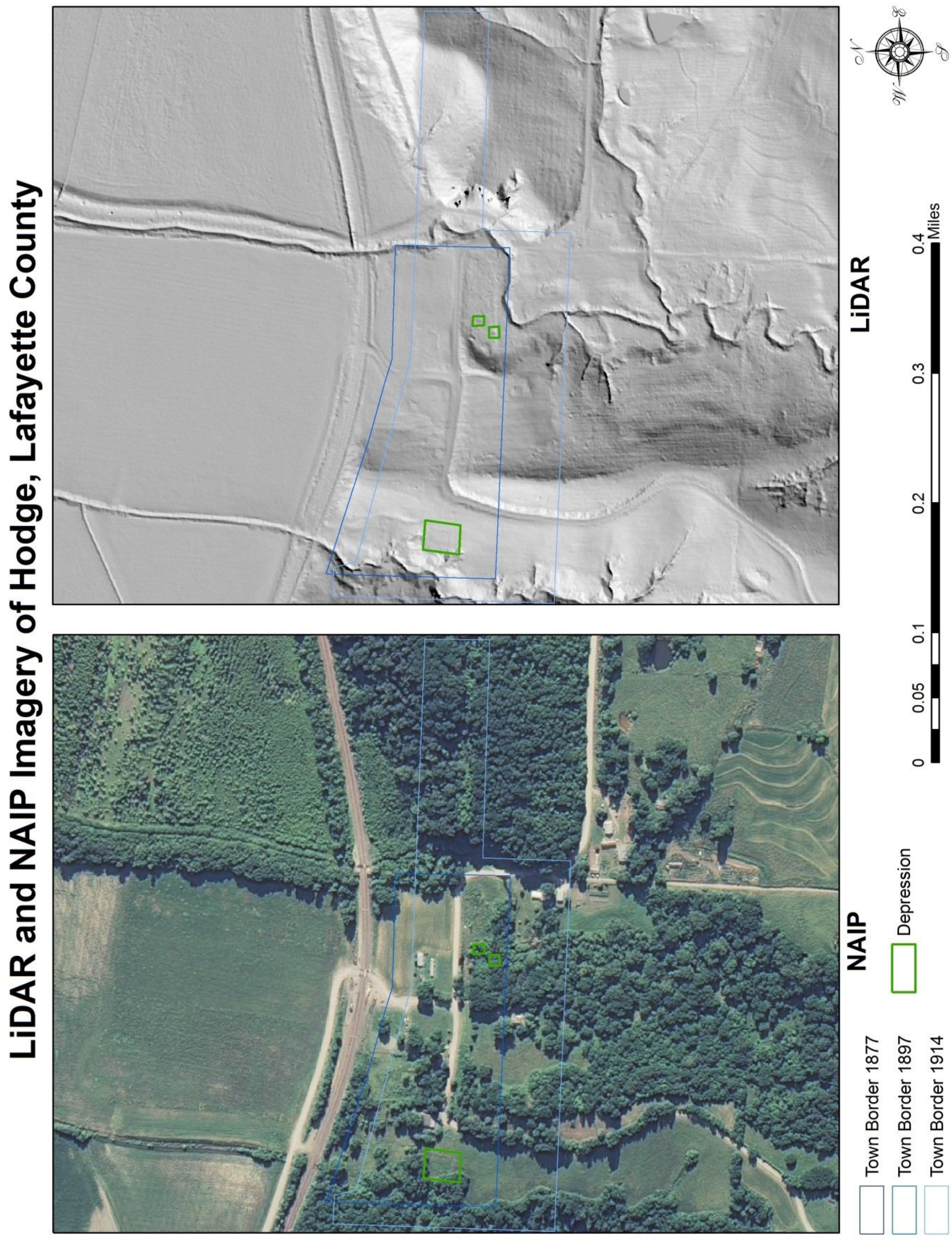


Figure 168.

LiDAR and NAIP imagery of Laynesville, Saline County.

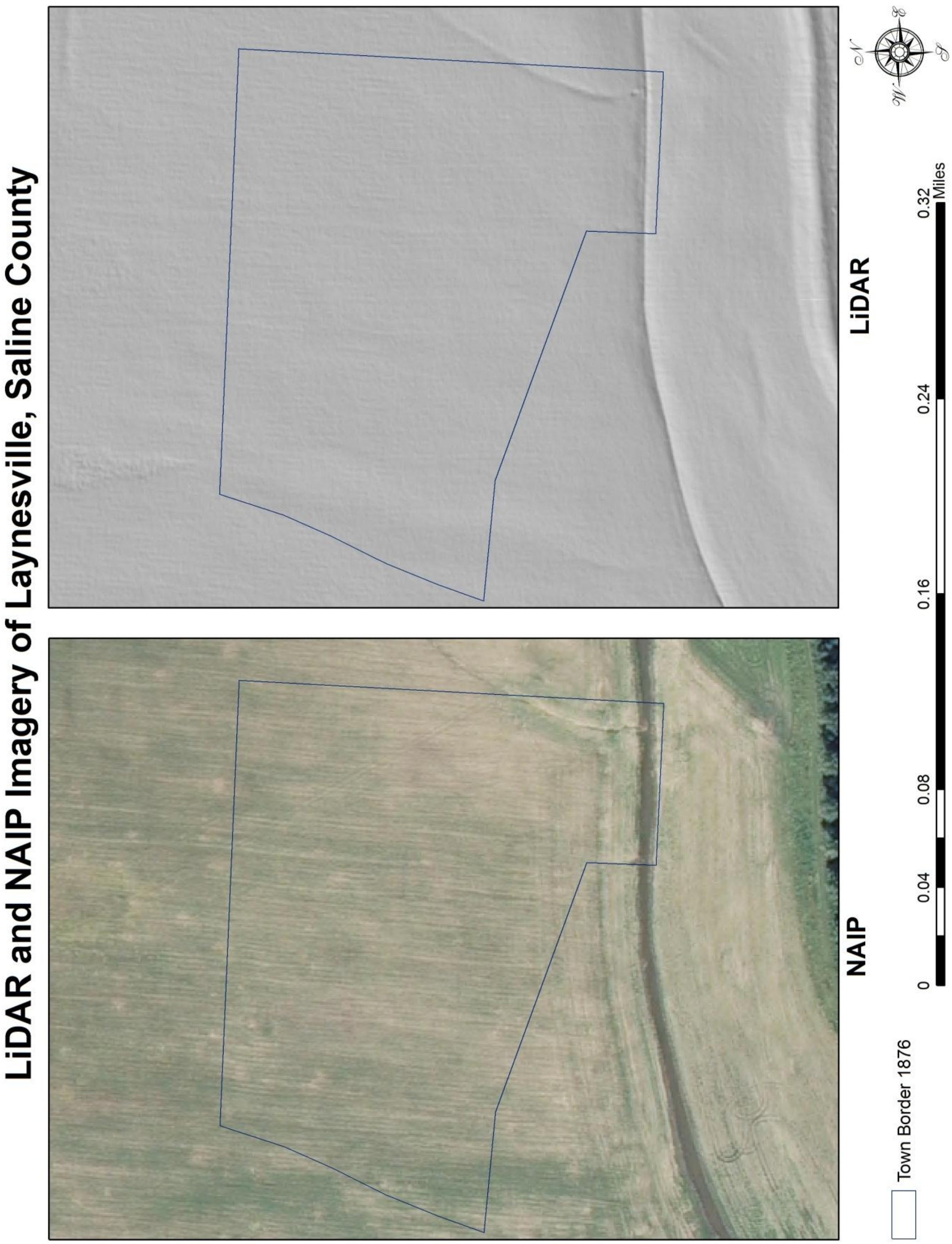


Figure 169.

LiDAR and NAIP imagery of Miami Station, Carroll County.

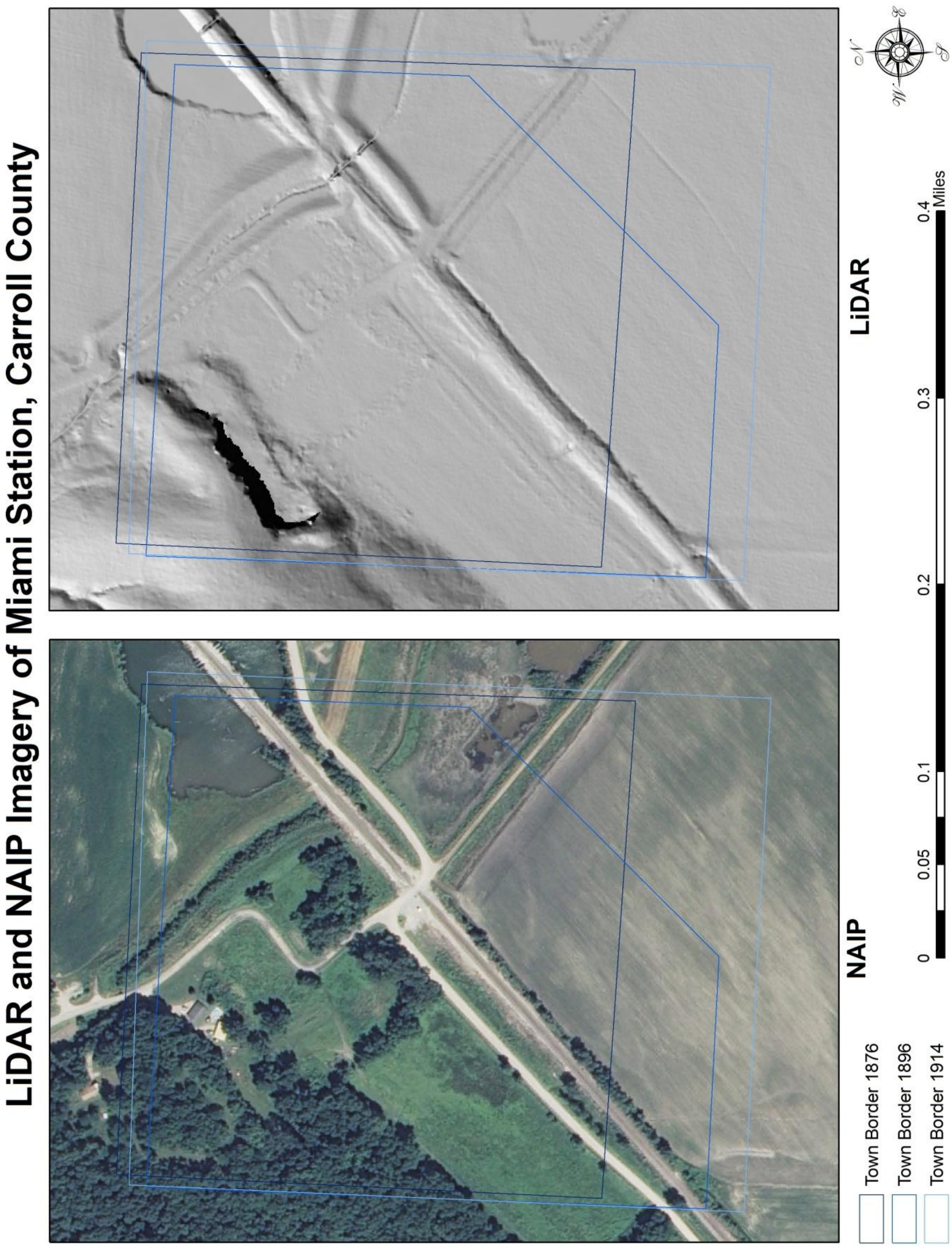


Figure 170.

LiDAR and NAIP imagery of Mt. Hope, Lafayette County.

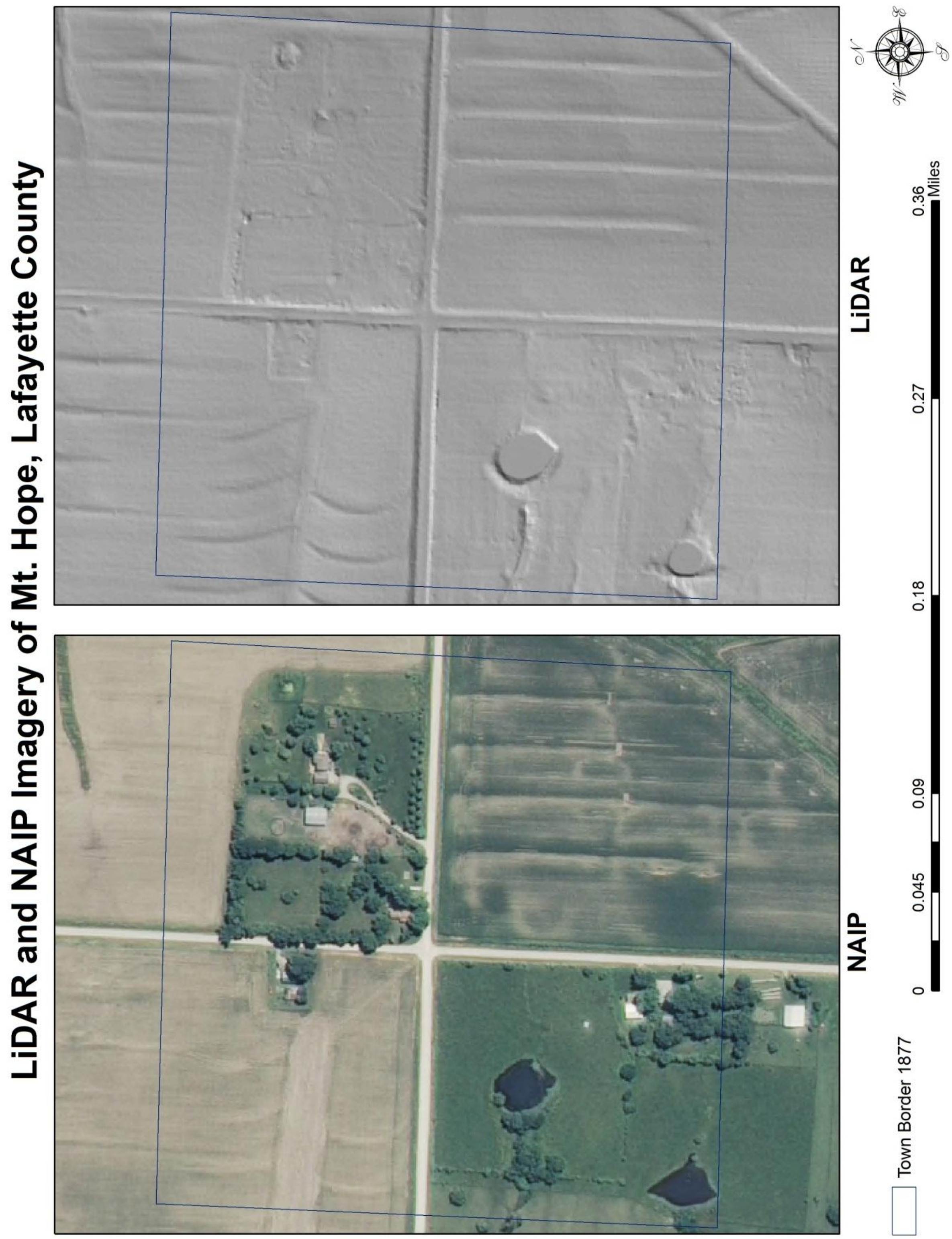


Figure 171.

LiDAR and NAIP imagery of Old Mendon, Chariton County.

Figure 172.

LiDAR and NAIP imagery of Plymouth, Carroll County.

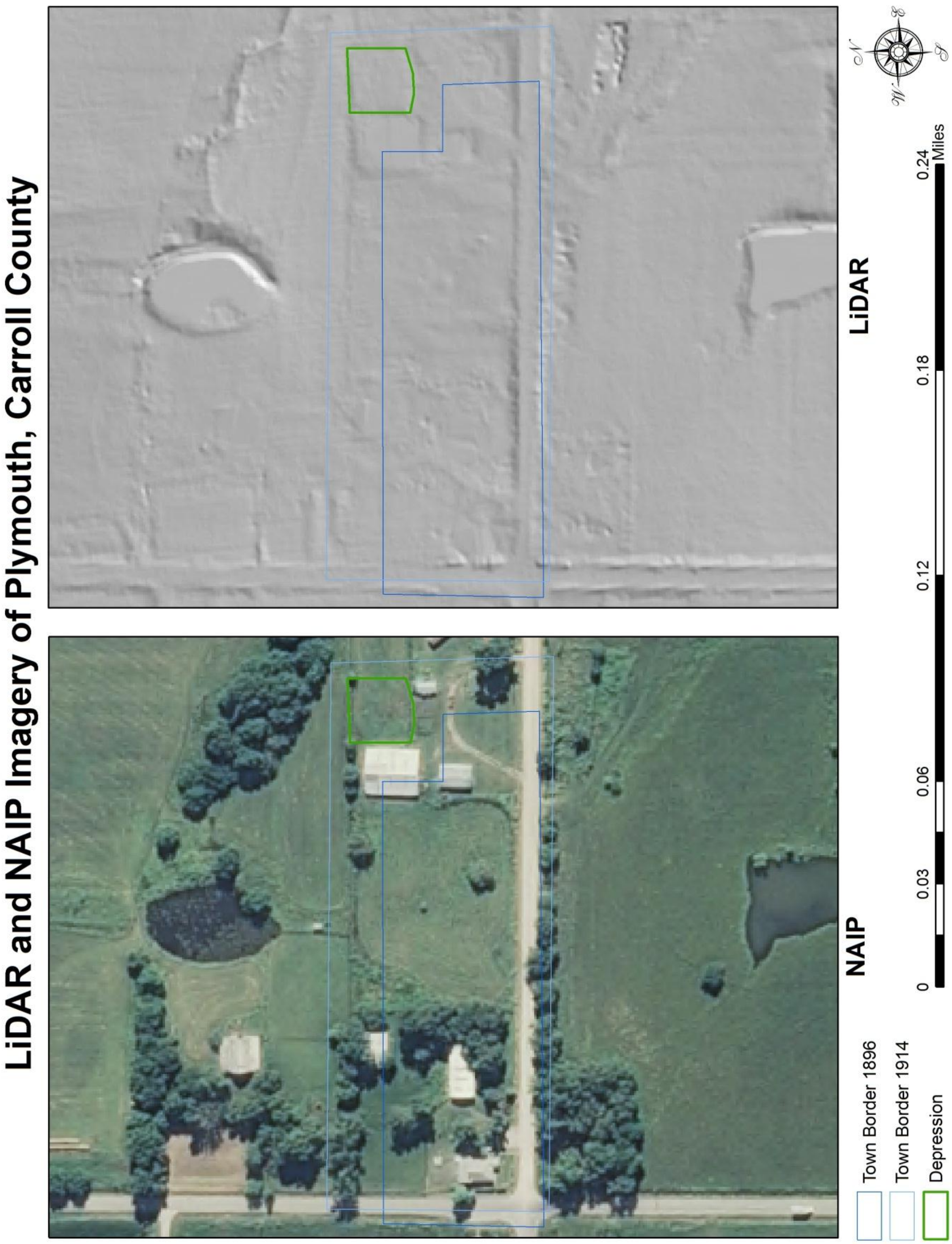


Figure 173.

LiDAR and NAIP imagery of Salina, Saline County.

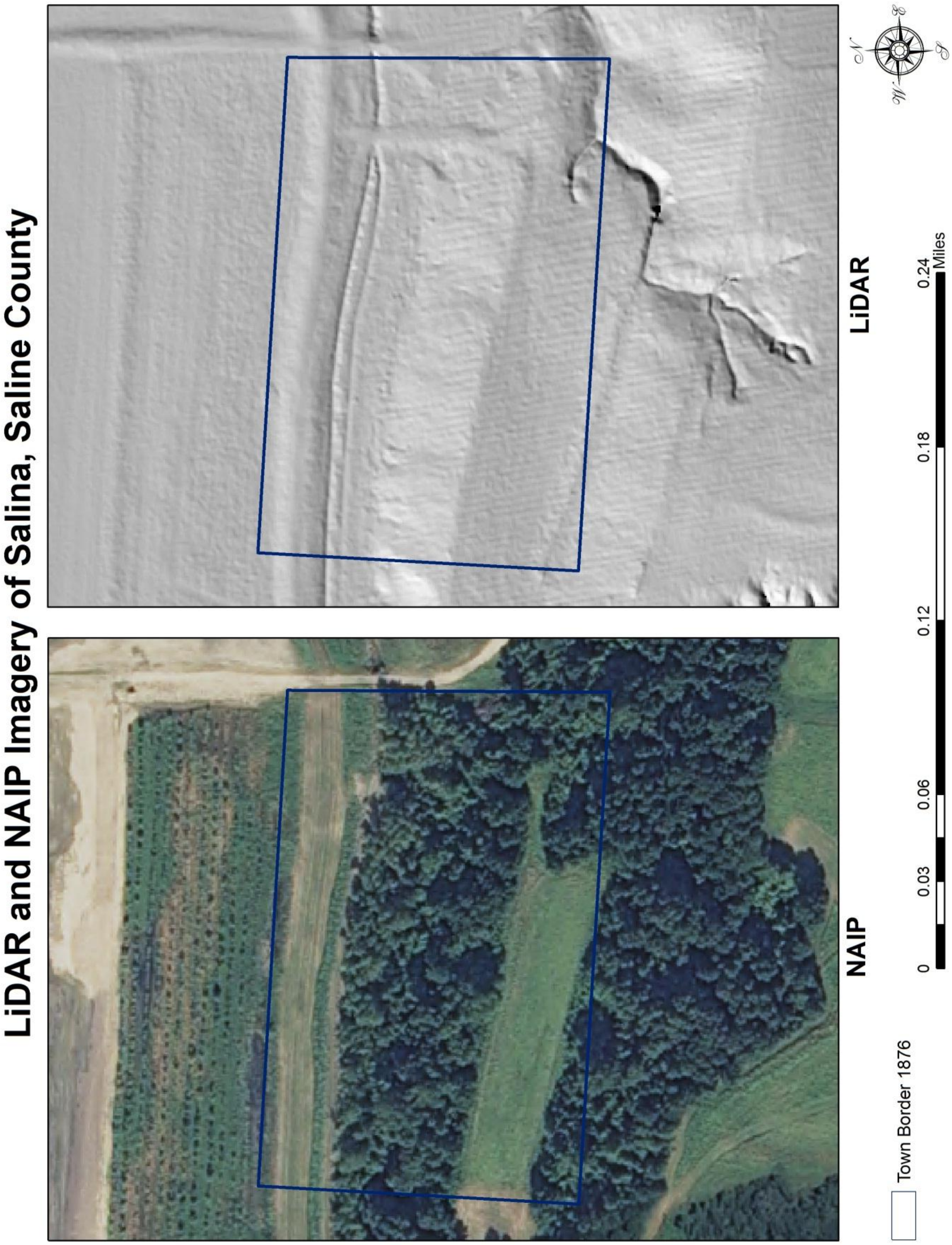


Figure 174.

Plat Book and GNIS locations of Miles Point, Carroll County.

Figure 175.

NAIP imagery of the tree lined abandoned Chicago, Burlington, and Kansas City Railroad, south of Bogard, Carroll County.

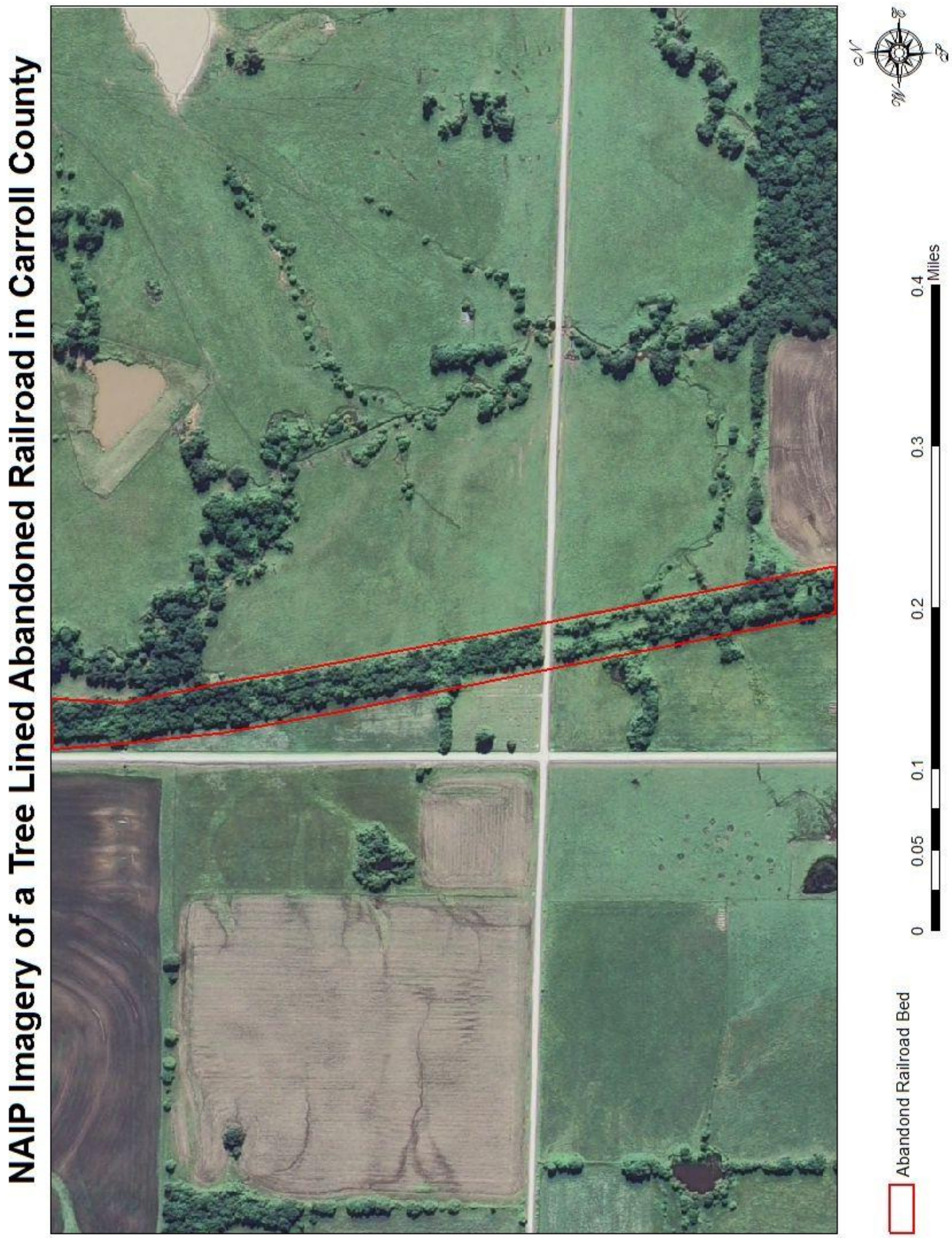


Figure 176.

NAIP imagery of the tree lined abandoned Lexington and St. Louis Railroad near Aullville, Lafayette County.

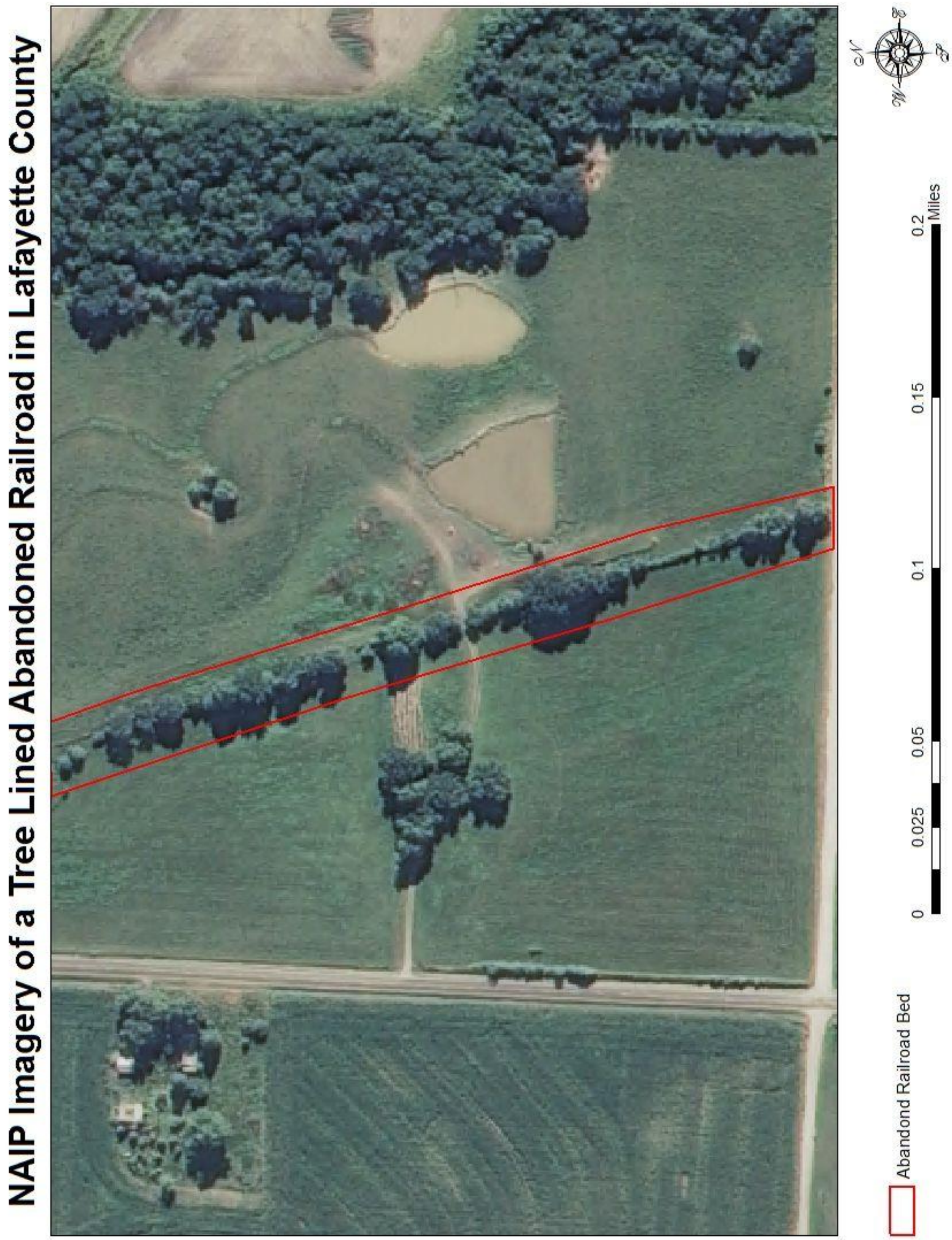


Figure 177.

NAIP imagery of the abandoned and exposed Brunswick, Chillicothe, and Omaha Railroad bed, north of Sumner, Chariton County.

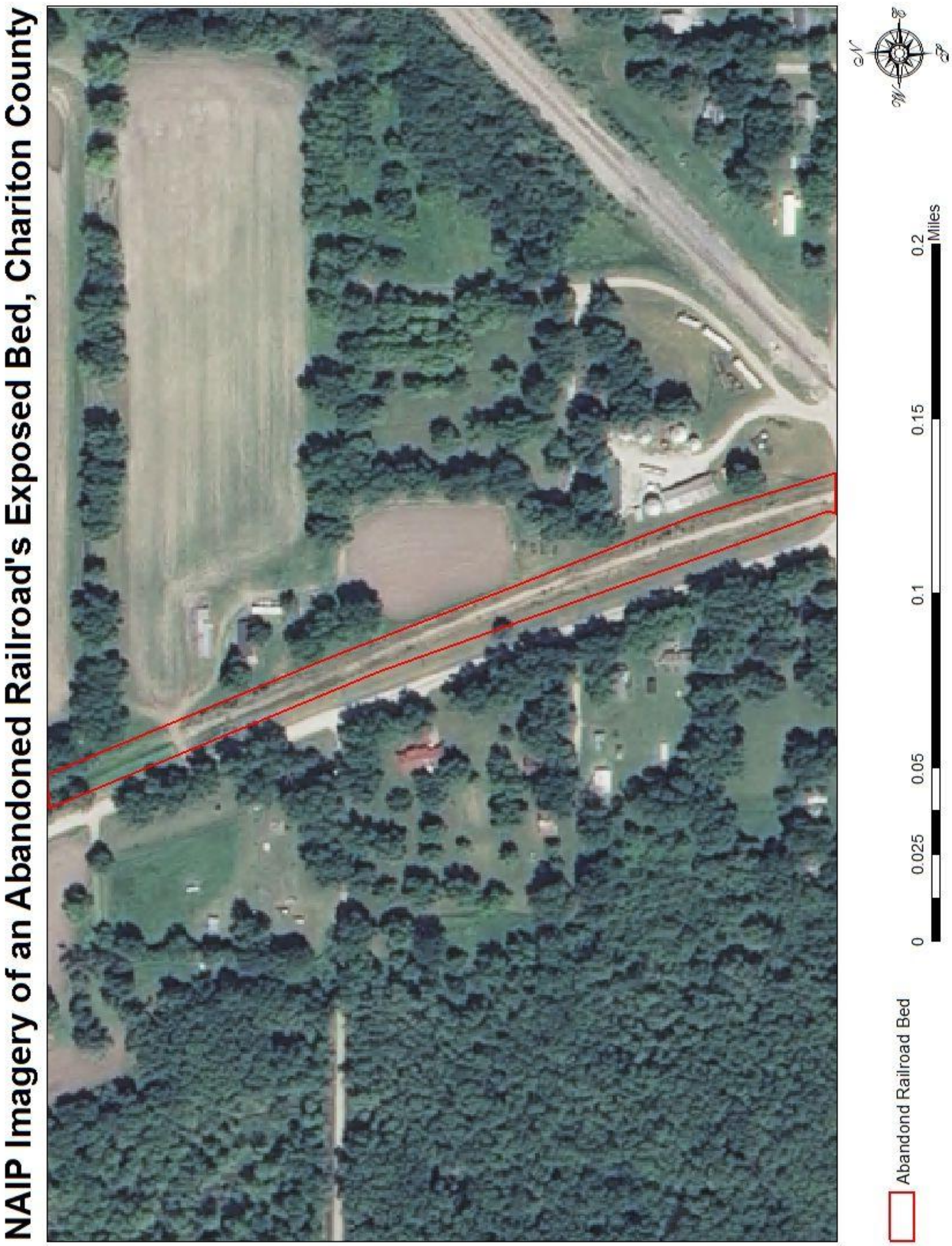


Figure 178.

NAIP imagery of the abandoned and exposed Lexington and St. Louis Railroad bed, west of Page City, Lafayette County.

Figure 179.

NAIP and LiDAR imagery of the abandoned and exposed Chicago, Burlington, and Kansas City Railroad north of Carrollton, Carroll County, obscured by tree canopies.

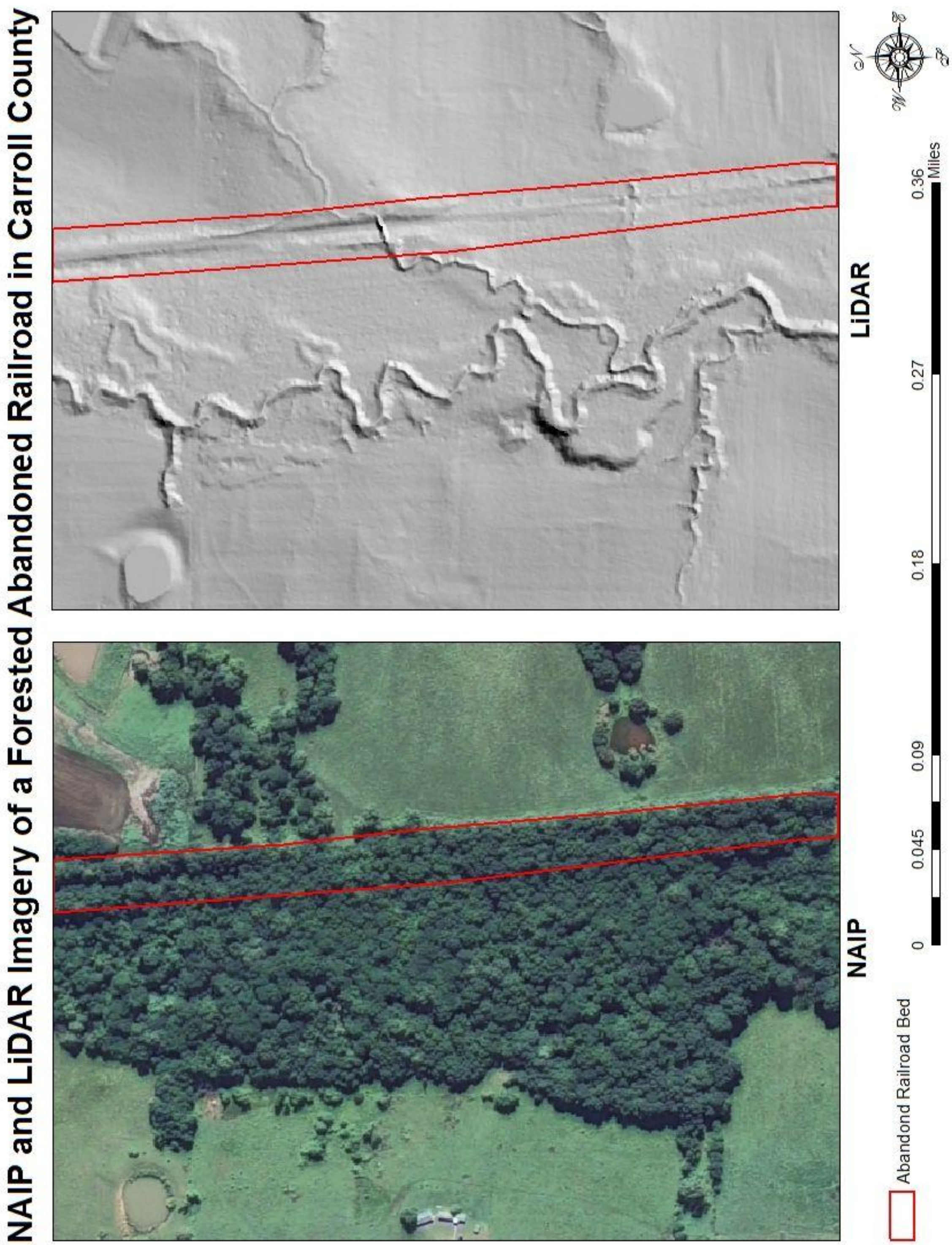


Figure 180.

NAIP and LiDAR imagery of the abandoned and exposed Brunswick, Chillicothe, and Omaha Railroad southwest of Mendon, Chariton County, obscured by tree canopies.

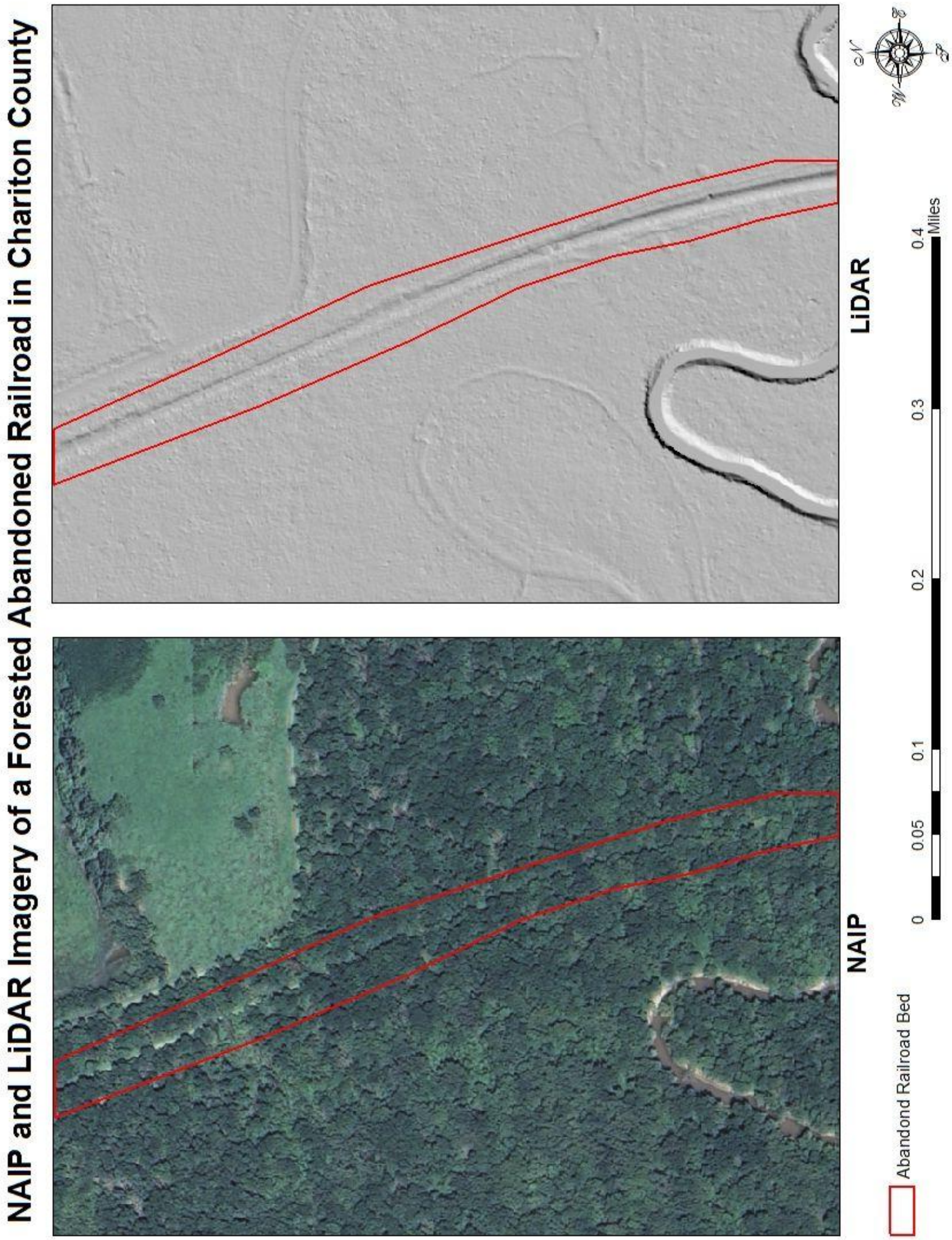


Figure 181.

NAIP and LiDAR imagery of the heavy cropped Lexington and St. Louis Railroad, east of Concordia, Lafayette County.

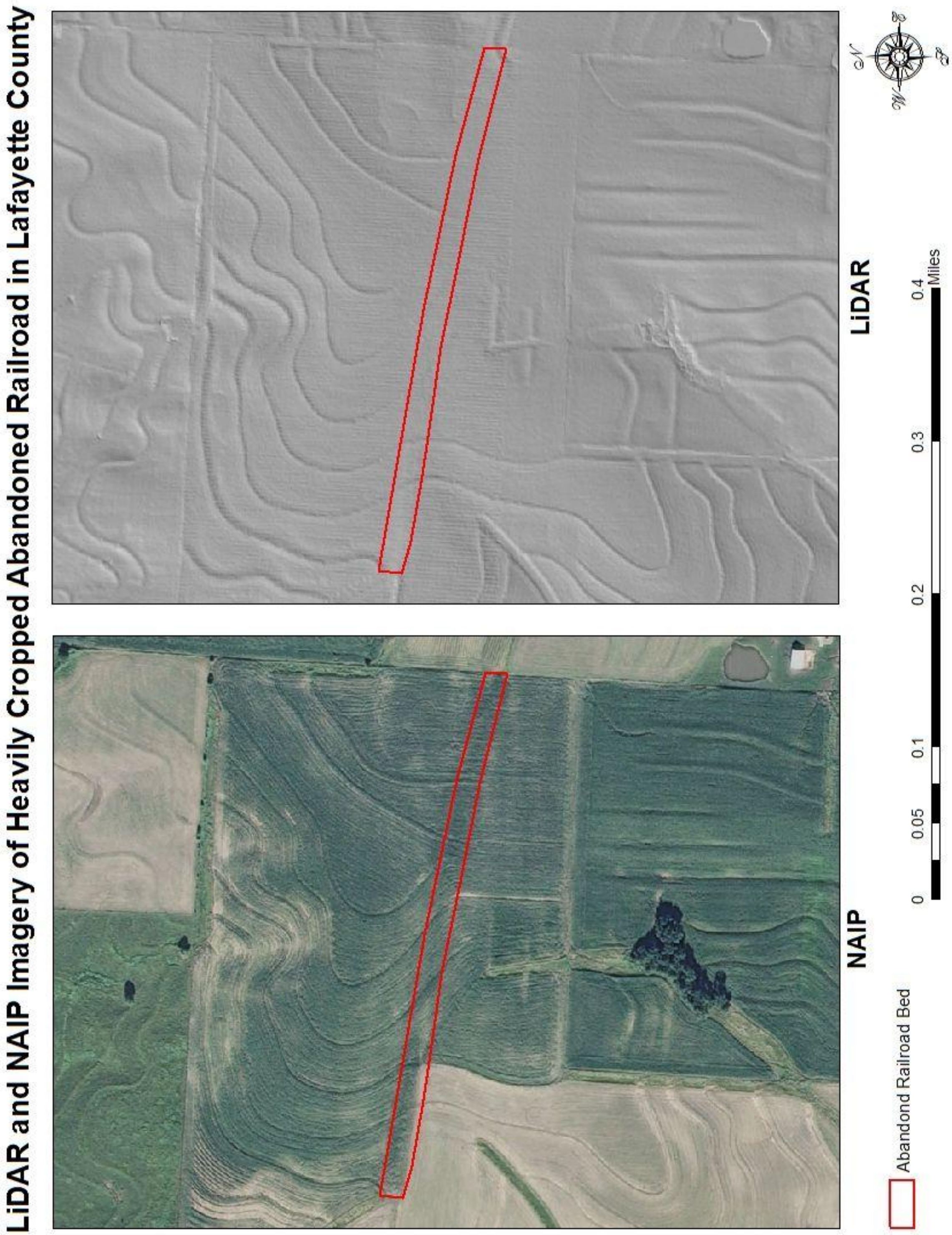


Figure 182.

NAIP and LiDAR imagery of the heavy cropped Keokuk and Kansas City Railroad, north of Shannondale, Chariton County.

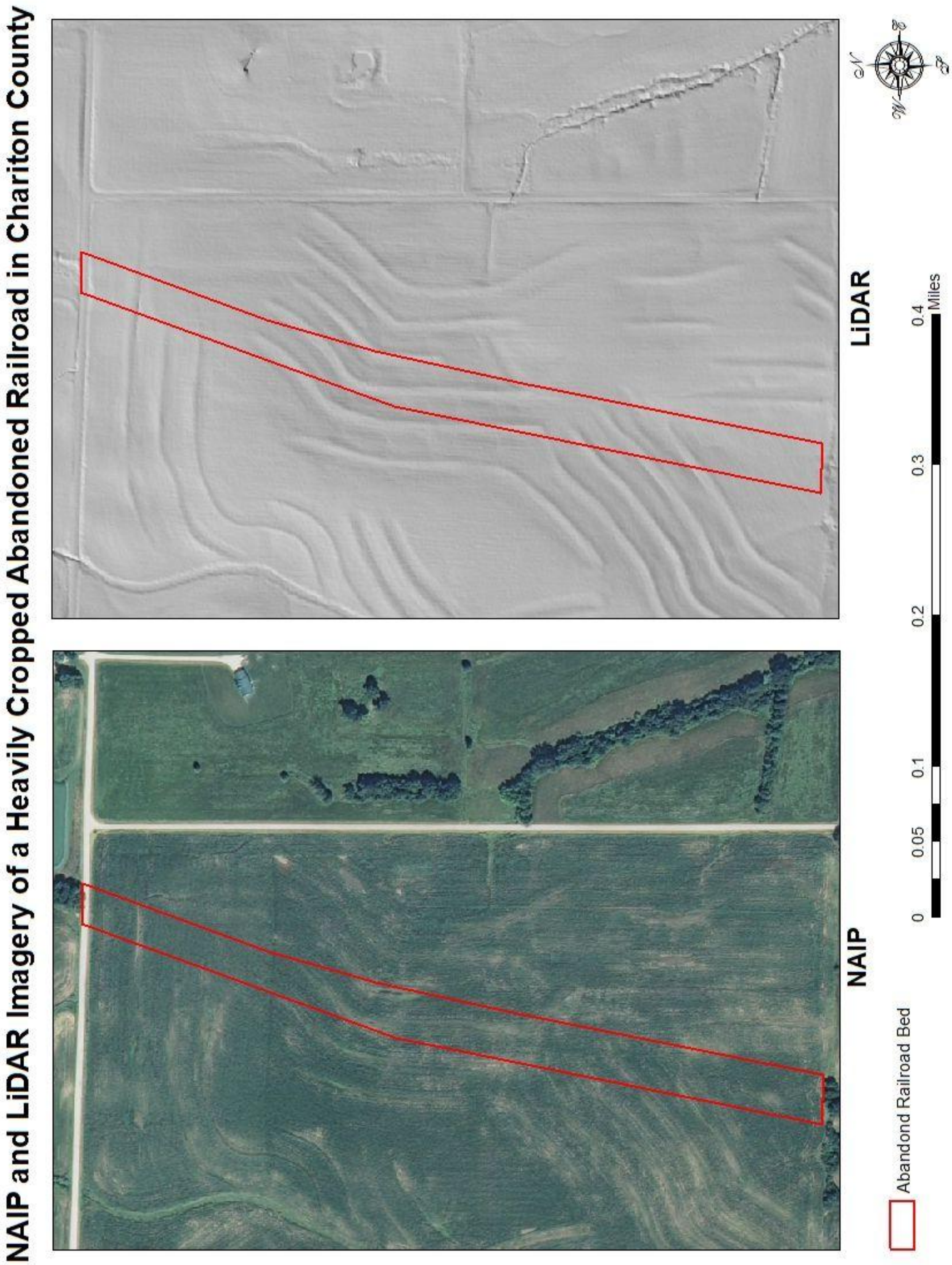


Figure 183.

NAIP and LiDAR imagery of the Lexington, Lake, and Gulf Railroad, Lafayette County.

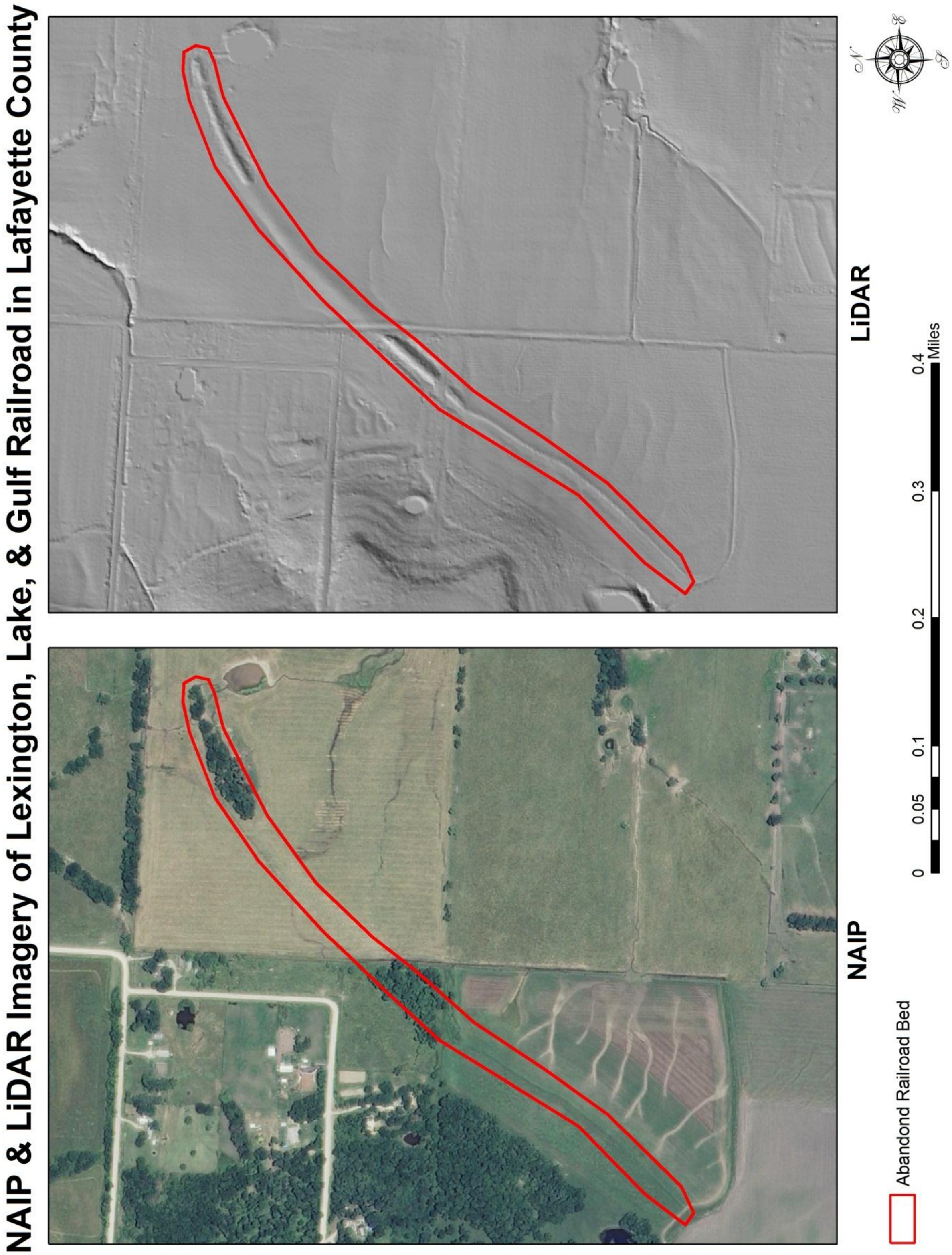


Figure 184.

NAIP and LiDAR imagery of the Rocky Branch, Lafayette County.

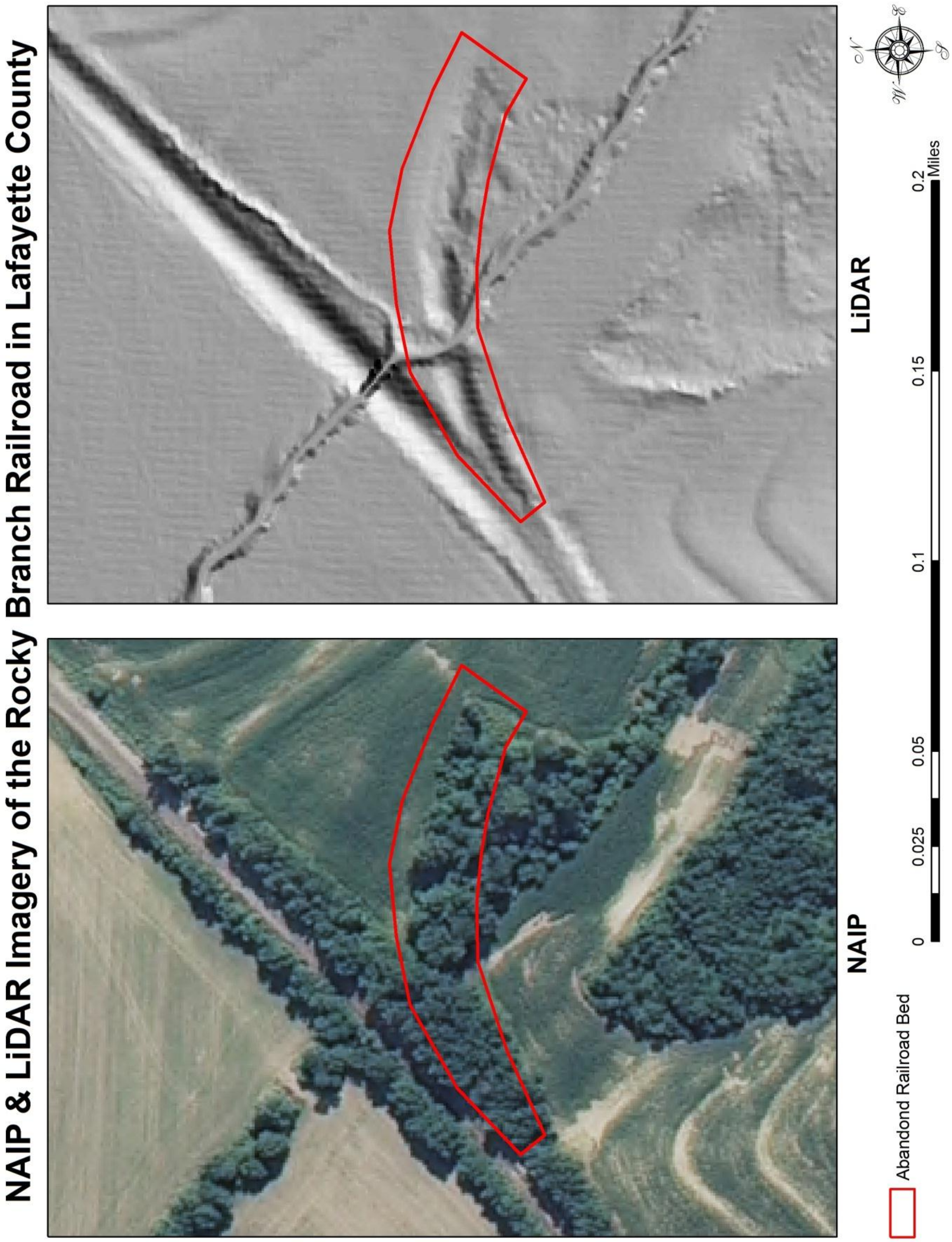


Figure 185.

NAIP imagery of the DeWitt Evergreen Cemetery near DeWitt, Carroll County.

Figure 186.

NAIP imagery of the Big Adkins Cemetery north of Wakenda, Carroll County.

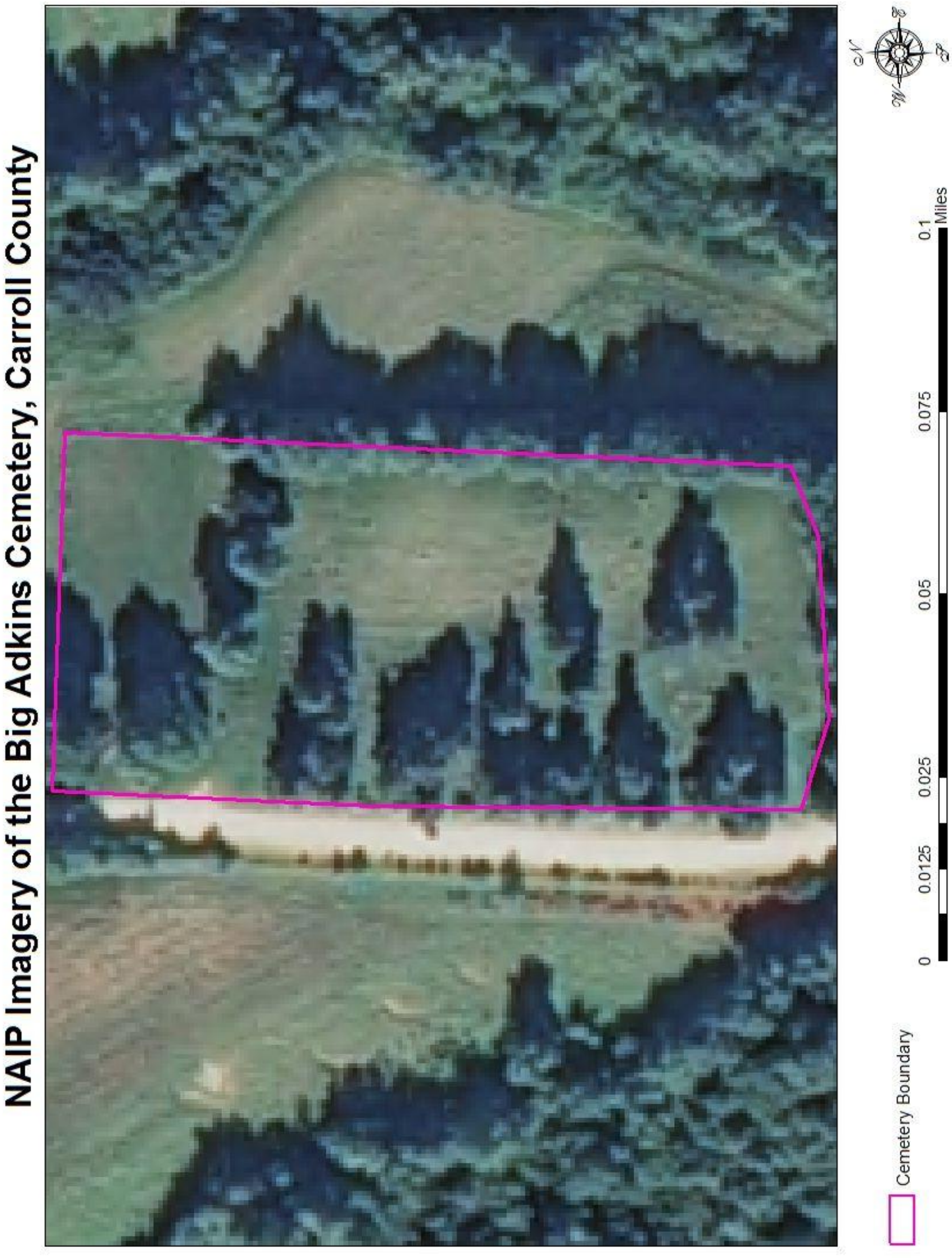


Figure 187.

NAIP imagery of the Braden Cemetery west of Coloma, Carroll County.

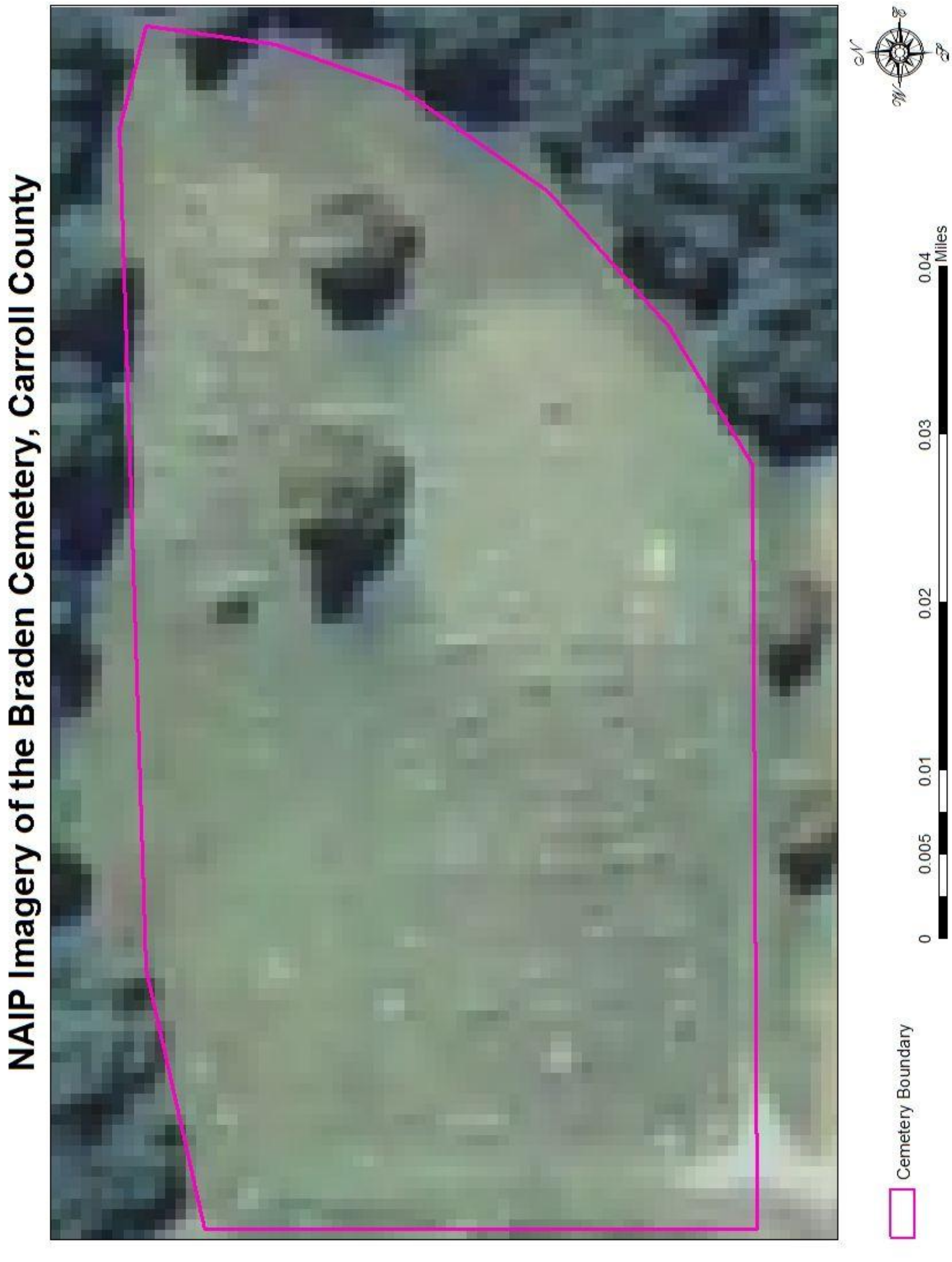


Figure 188.

NAIP imagery of the Cambridge Cemetery near Cambridge, Saline County.

Figure 189.

NAIP imagery of the Confederate Memorial State Historic Site Cemetery near Higginsville, Lafayette County.

Figure 190.

NAIP imagery of the Elliott Grove Cemetery near Brunswick, Chariton County.

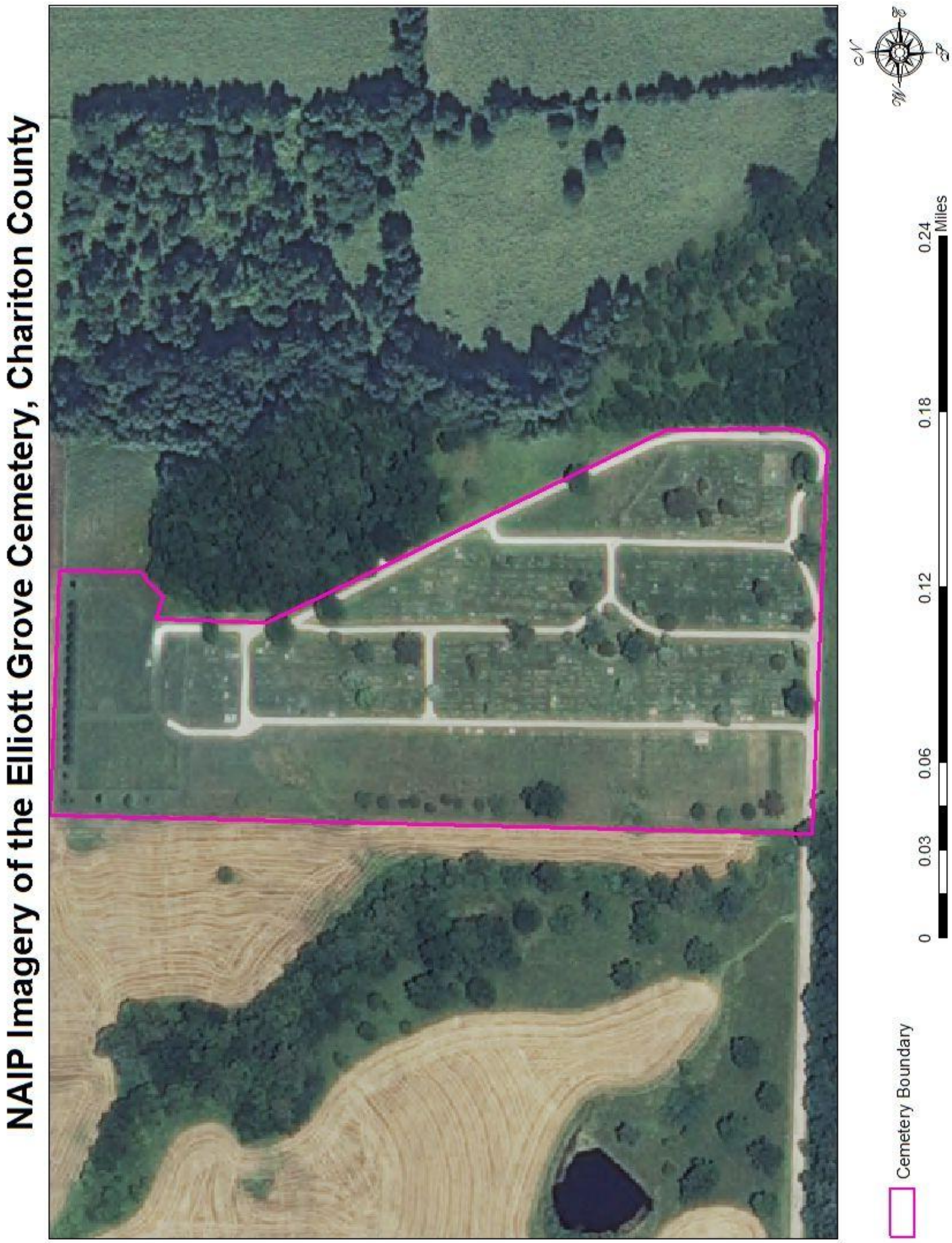


Figure 191.

NAIP imagery of the Fairview Cemetery in Sweet Springs, Saline County.

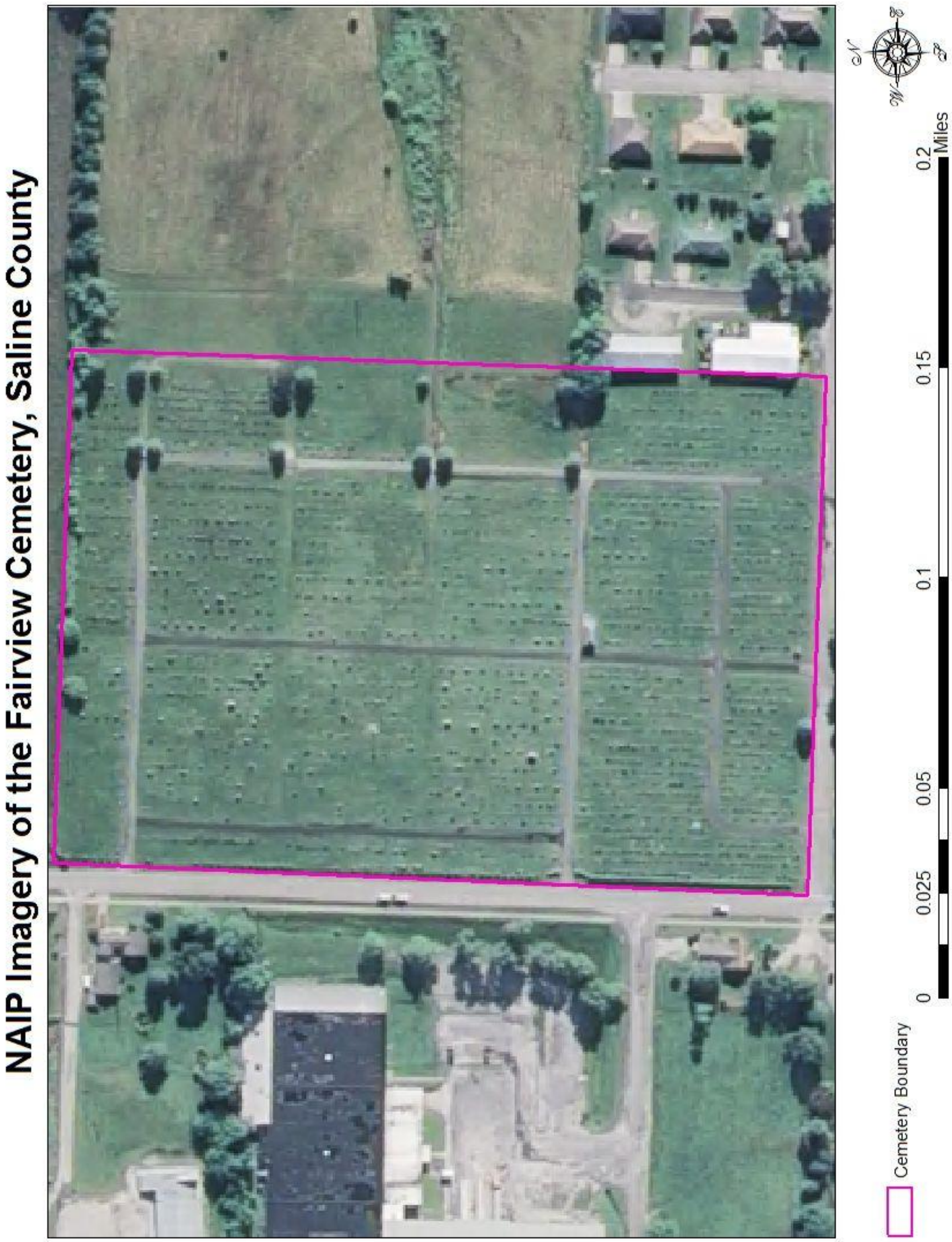


Figure 192.

NAIP imagery of the Greenton Baptist Church Cemetery in Greenton, Lafayette County.

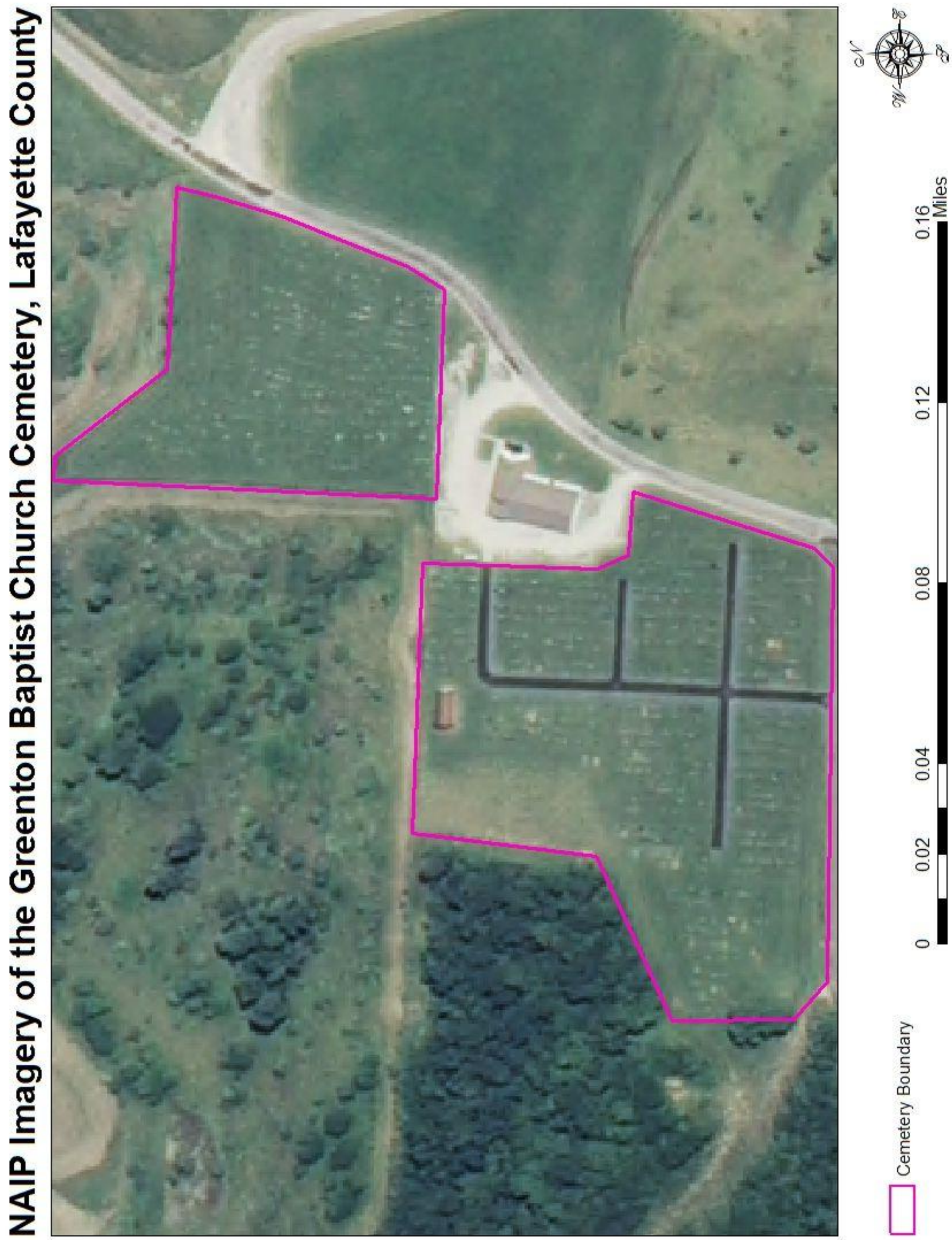


Figure 193.

NAIP imagery of Harmony Cemetery in rural Saline County.

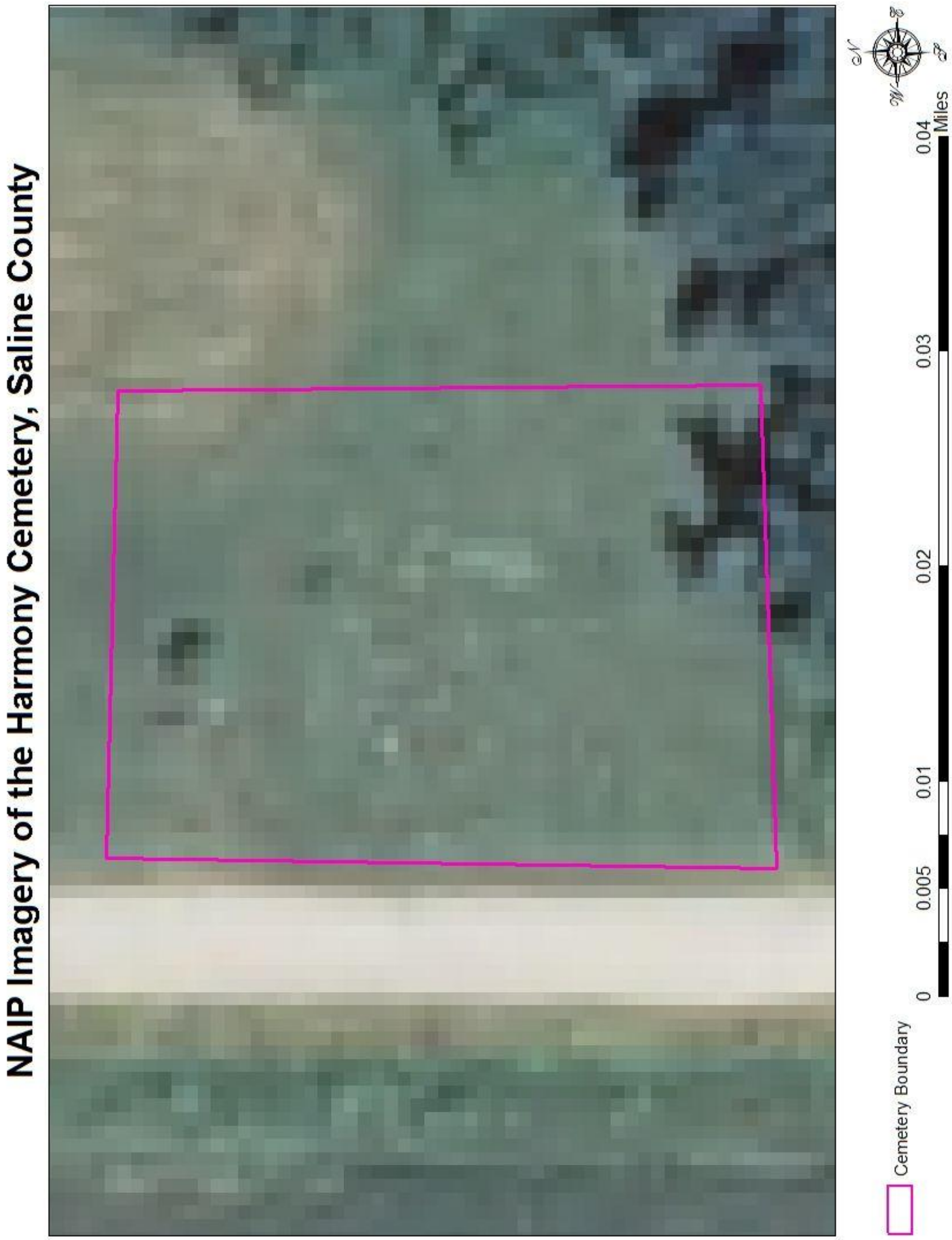


Figure 194.

NAIP imagery of Mendon Cemetery southeast of Mendon, Chariton County.

Figure 195.

NAIP imagery of the Mount Nebo Cemetery west of Grand Pass, Saline County.

Figure 196.

NAIP imagery of the Mt. Hope Presbyterian Church Cemetery in rural Lafayette County.

Figure 197.

NAIP imagery of the Newcomer Cemetery north of Newcomer, Chariton County.

Figure 198.

NAIP imagery of the Oak Hill Cemetery in Carrollton, Carroll County.

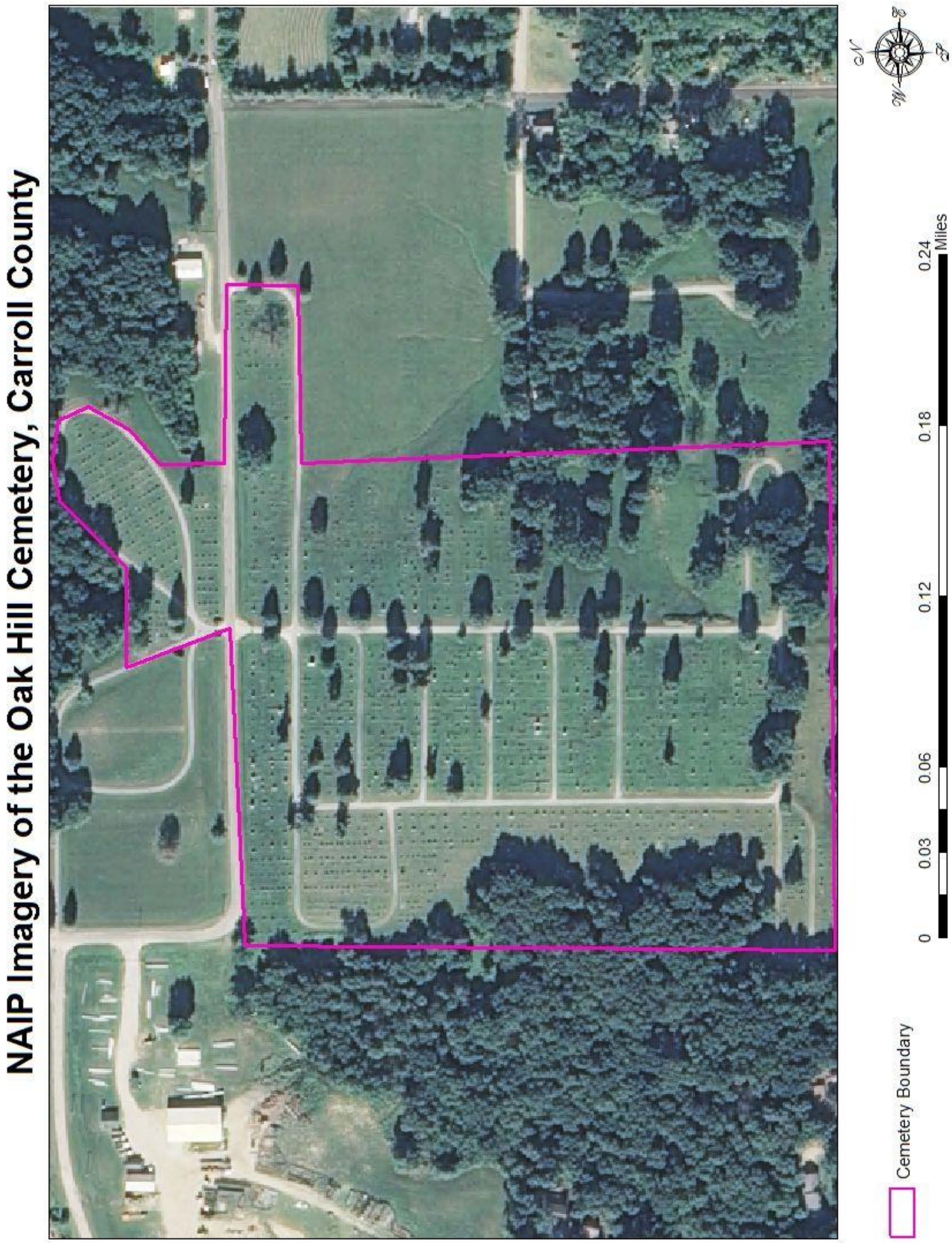


Figure 199.

NAIP imagery of the Odessa Cemetery east of Odessa, Lafayette County.

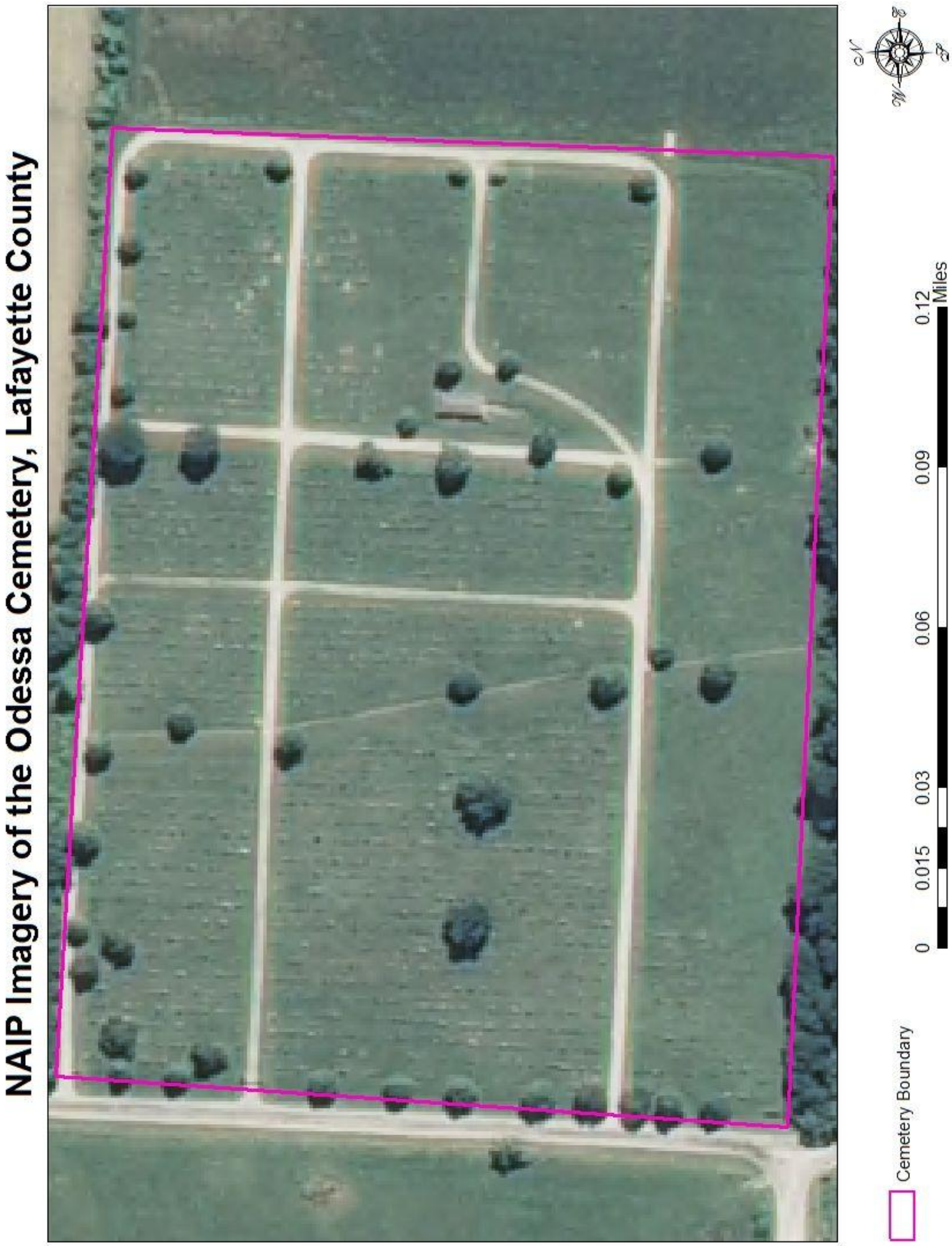


Figure 200.

NAIP imagery of the Ridge Park Cemetery in Marshall, Saline County.

Figure 201.

NAIP imagery of the Sacred Heart Cemetery in rural Carroll County.

Figure 202.

NAIP imagery of the Salisbury Cemetery near Salisbury, Chariton County.

Figure 203.

NAIP imagery of the Shore Cemetery west of Chapel Hill, Lafayette County.

Figure 204.

NAIP imagery of the St. Mary's Cemetery near Wien, Chariton County.

Figure 205.

LiDAR imagery of the Confederate Memorial State Historic Site Cemetery near Higginsville, Lafayette County.

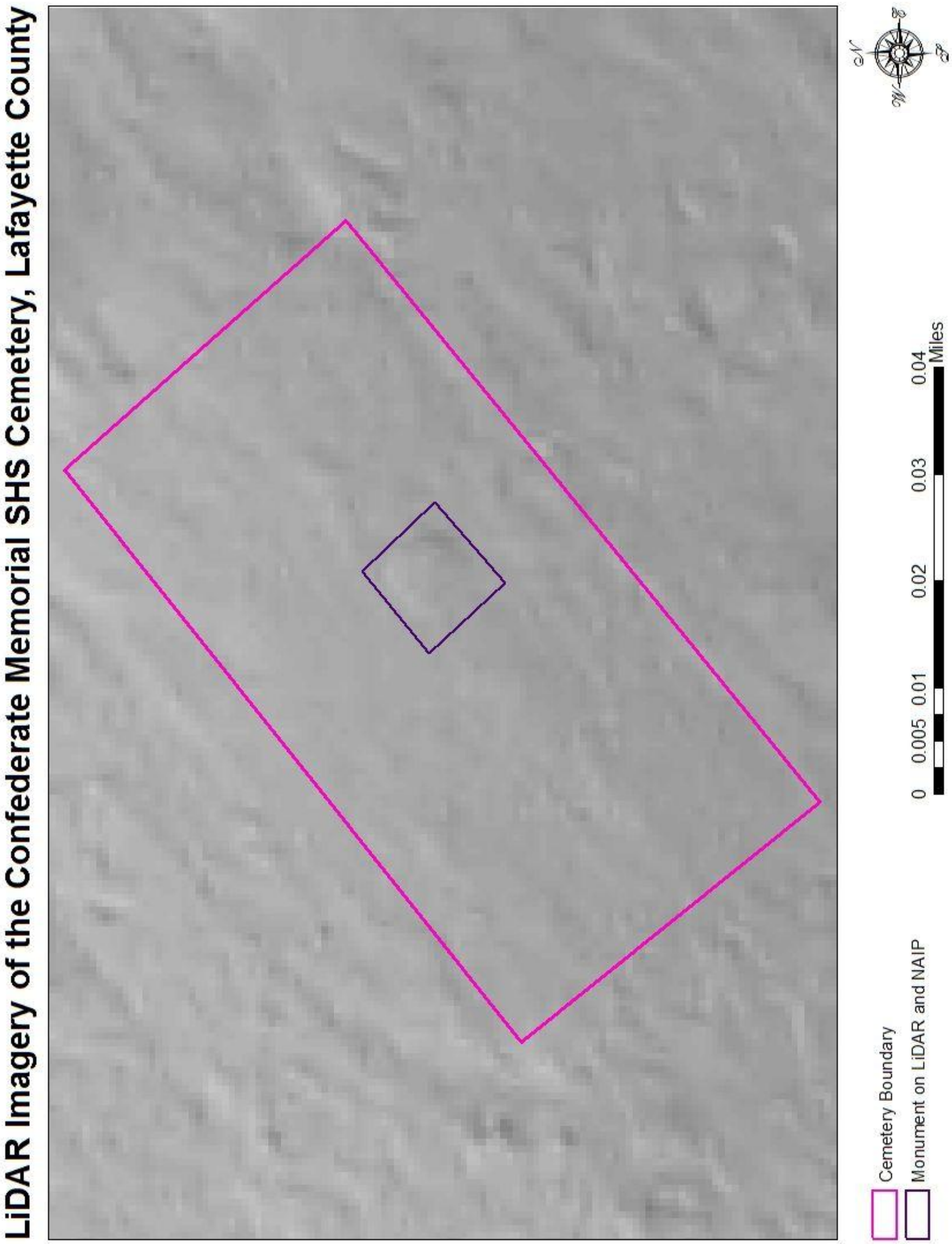


Figure 206.

LiDAR imagery of the Ridge Park Cemetery in Marshall, Saline County.

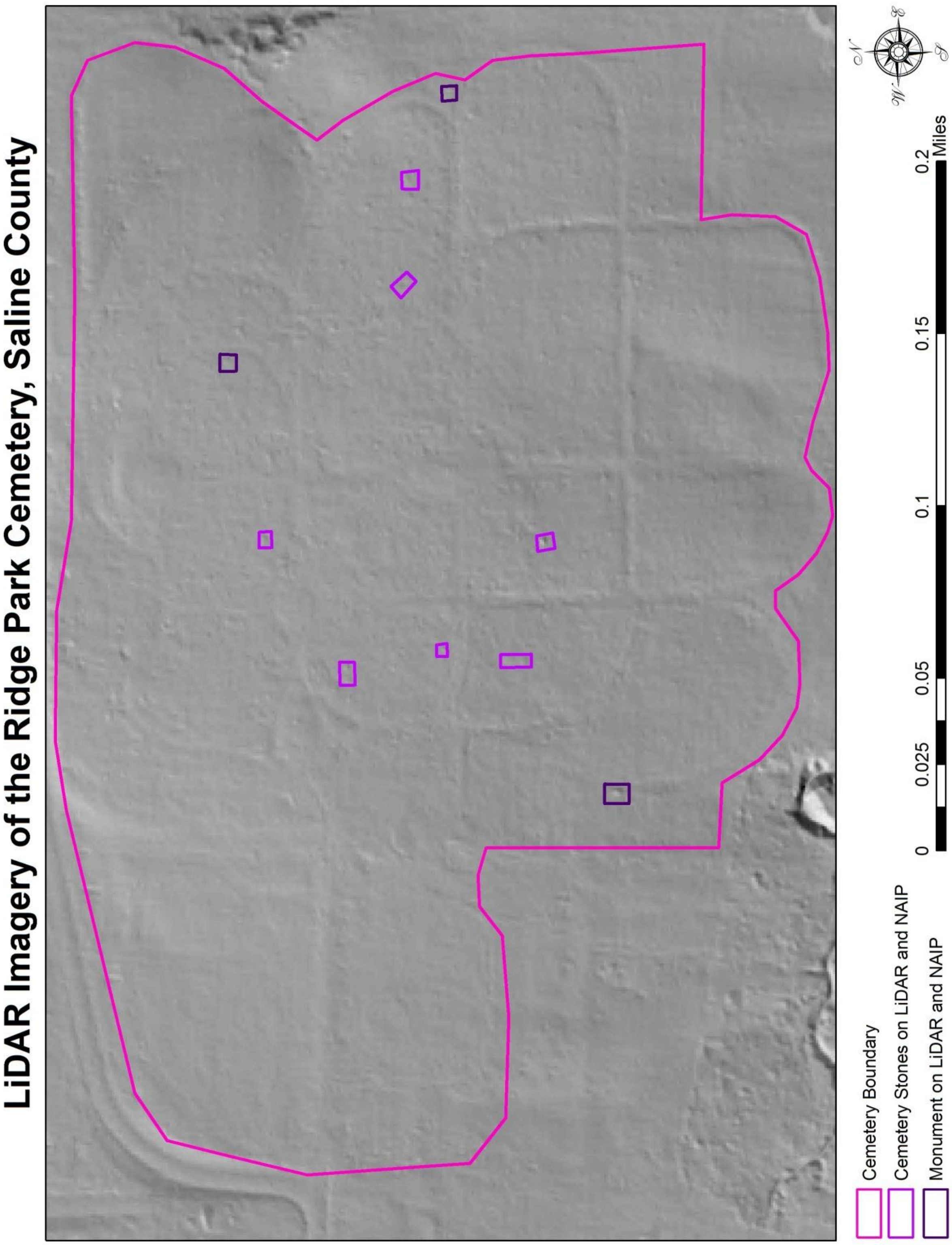


Figure 207.

LiDAR imagery of the Sacred Heart Cemetery in rural Carroll County.

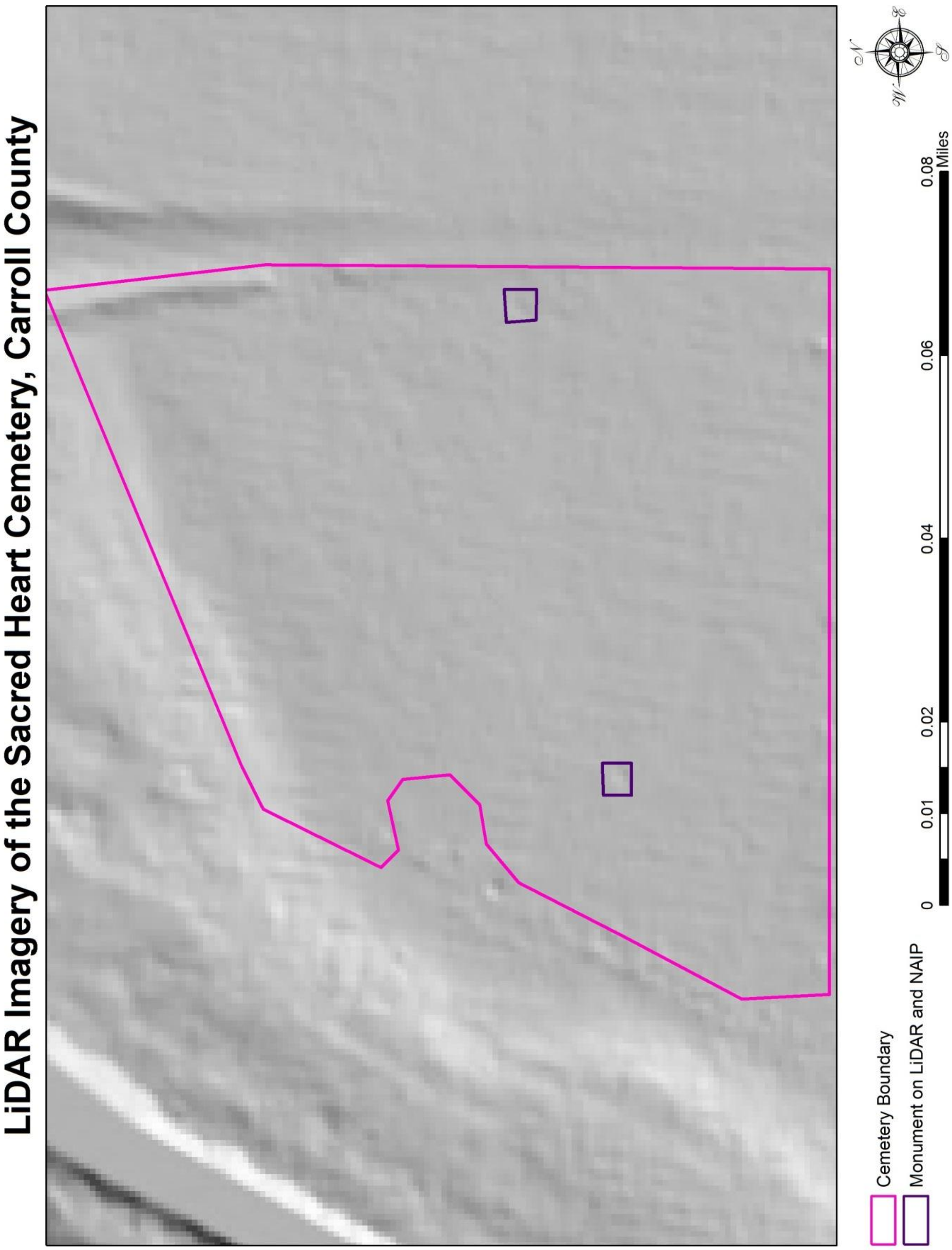


Figure 208.

LiDAR imagery of the DeWitt Evergreen Cemetery near DeWitt, Carroll County.

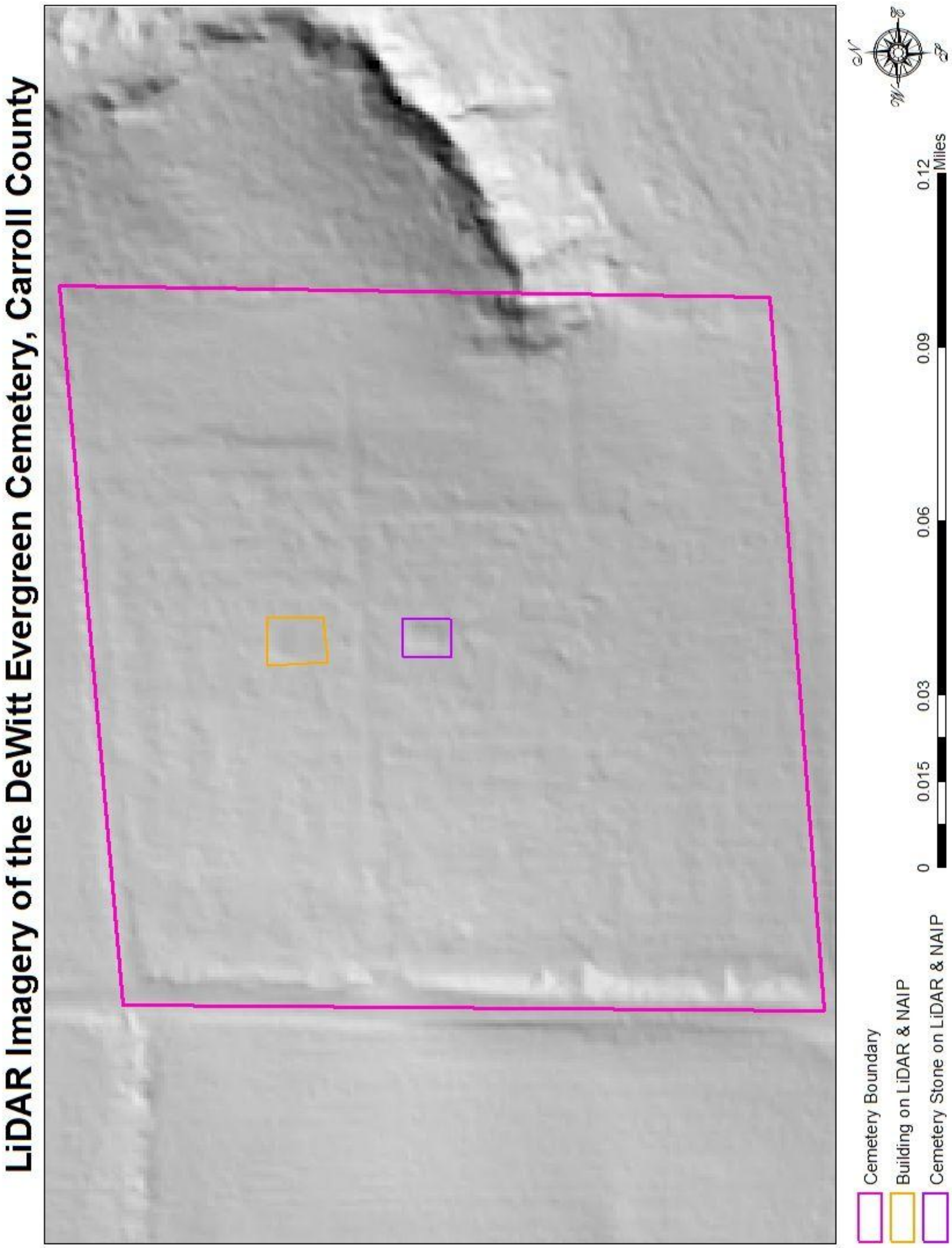


Figure 209.

LiDAR imagery of the Fairview Cemetery, Saline County.

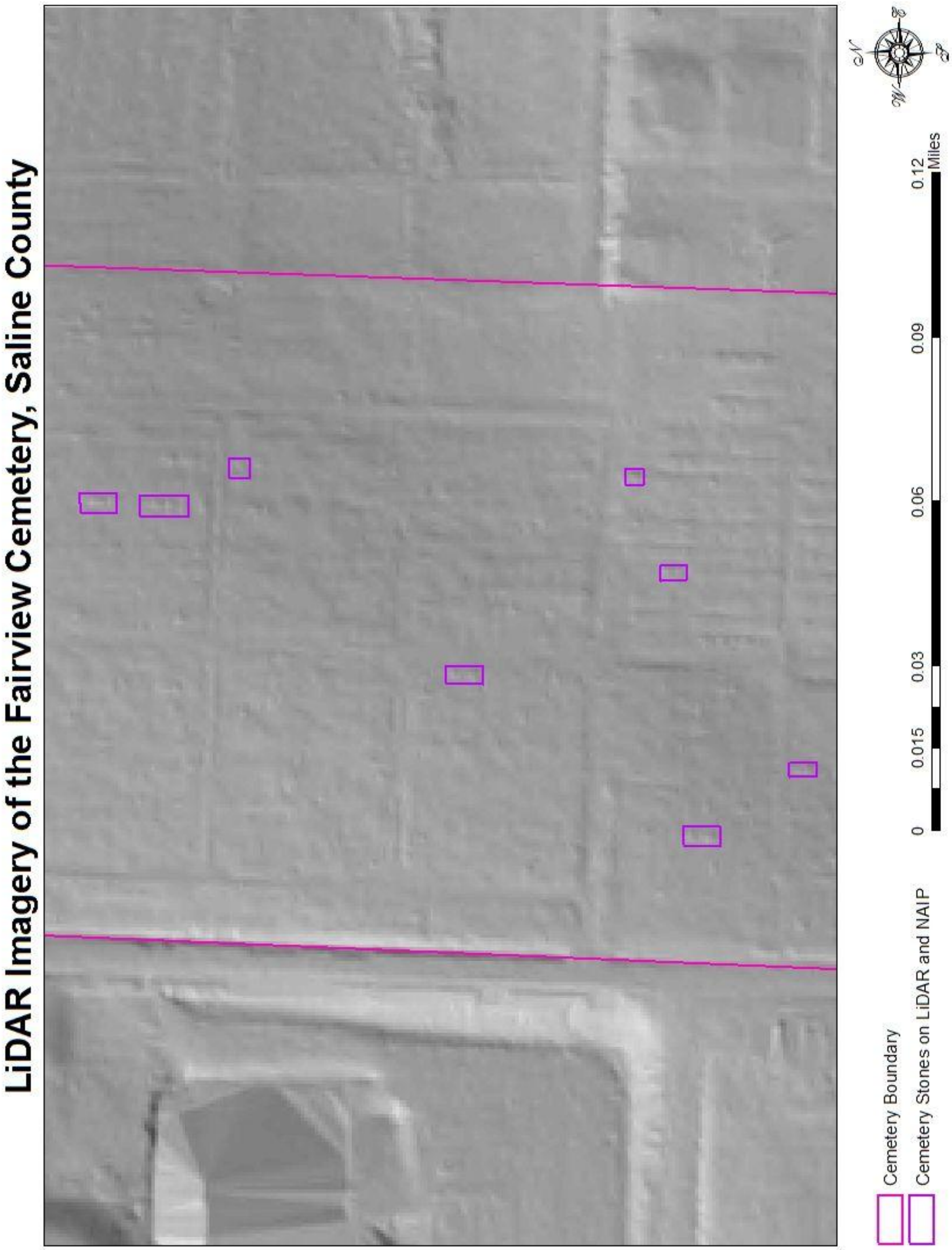


Figure 210.

LiDAR imagery of the Greenton Baptist Church Cemetery near Odessa, Lafayette County.

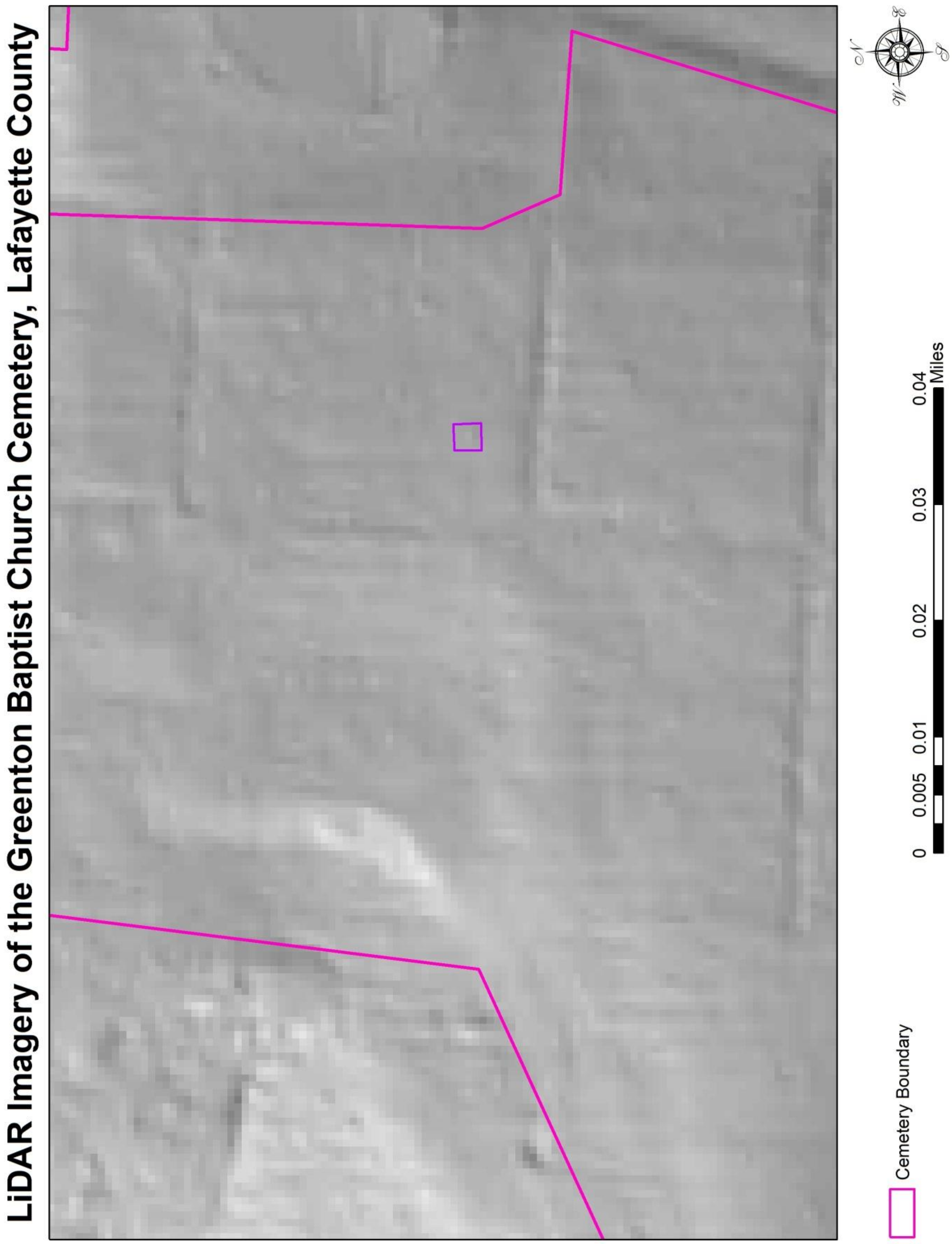


Figure 211.

LiDAR imagery of the Mount Nebo Cemetery west of Grand Pass, Saline County.

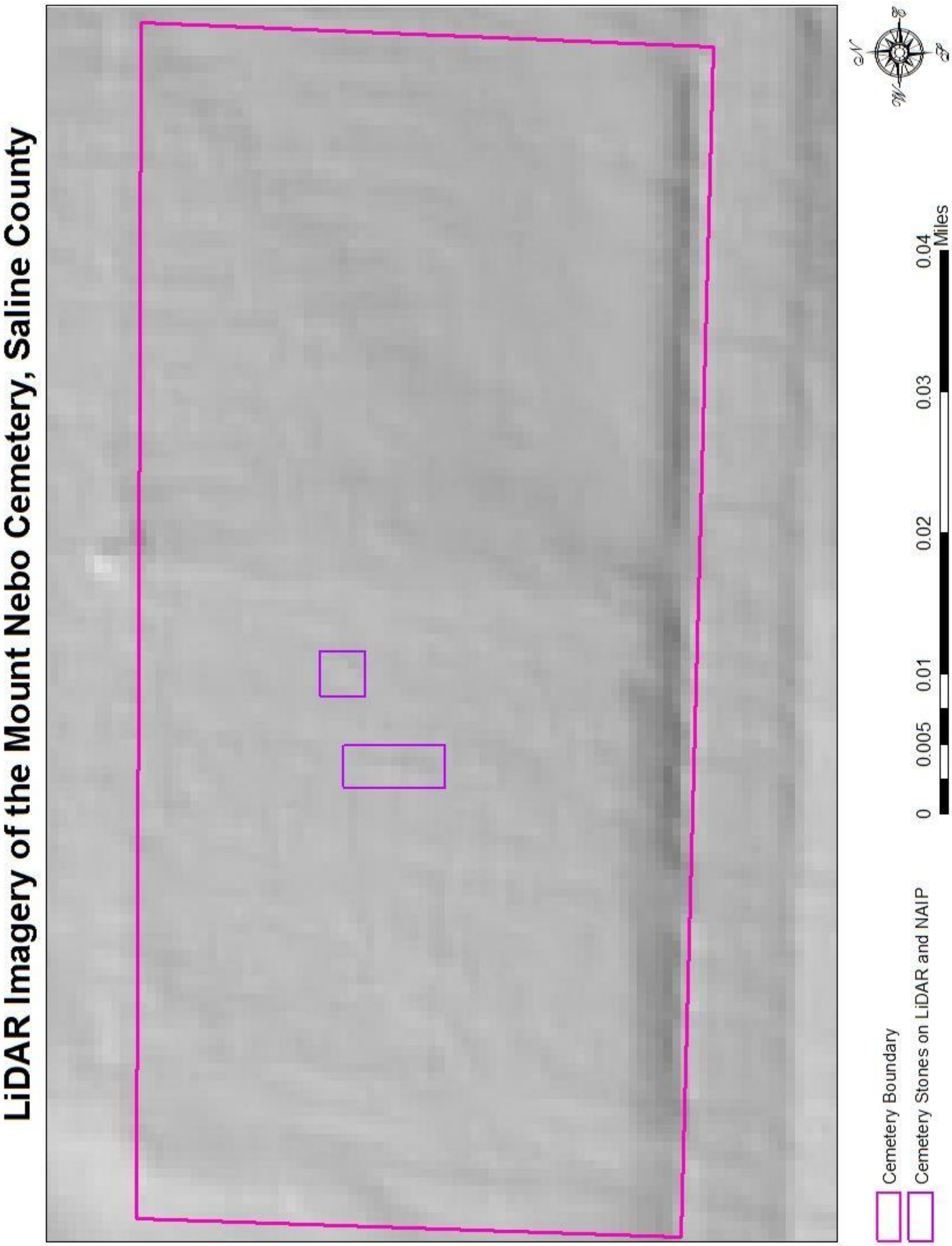


Figure 212.

LiDAR imagery of the Oak Hill Cemetery in Carrollton, Carroll County.

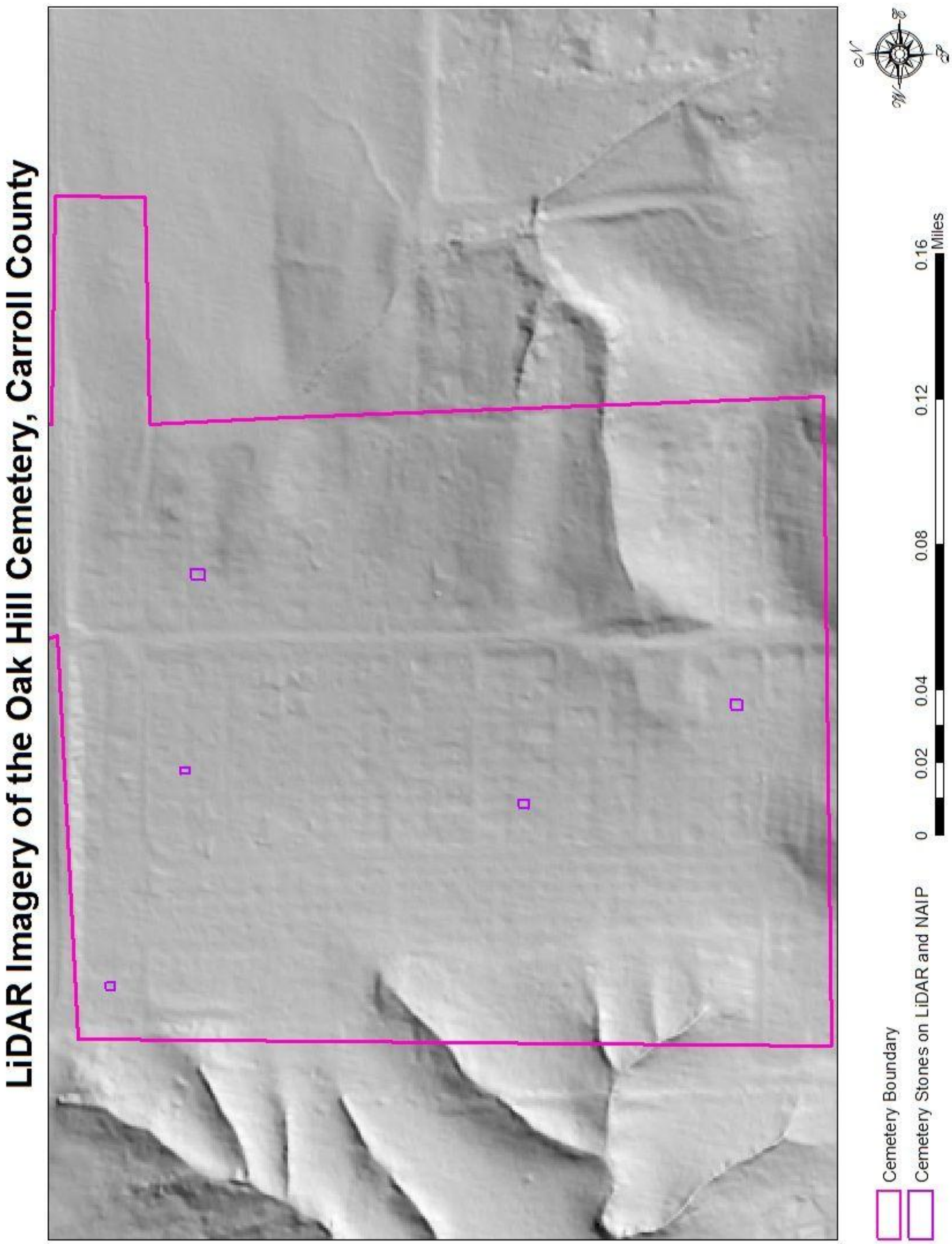


Figure 213.

LiDAR imagery of Mendon Cemetery southeast of Mendon, Chariton County.

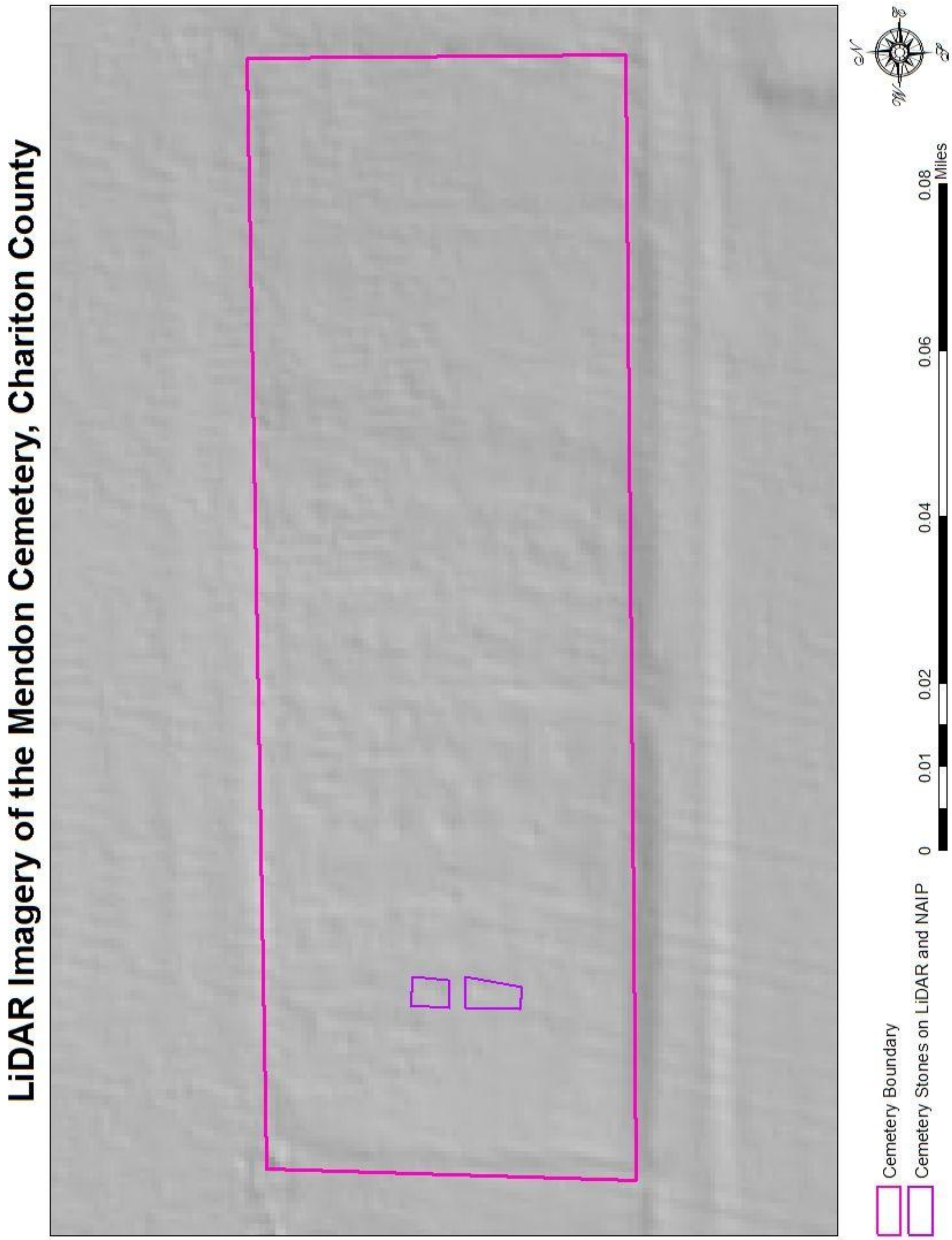


Figure 214.

LiDAR imagery of the Odessa Cemetery east of Odessa, Lafayette County.

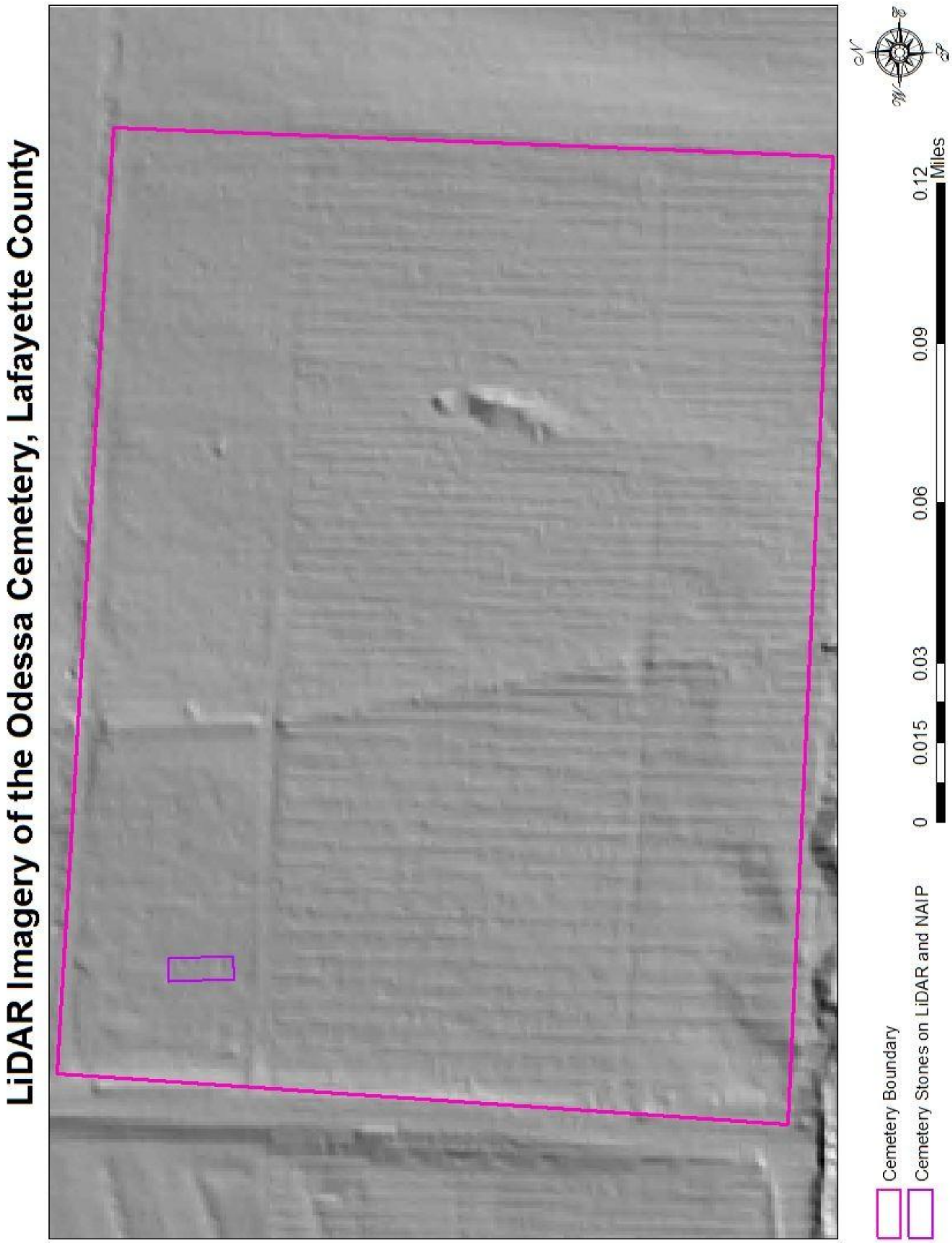


Figure 215.

LiDAR imagery of the St. Mary’s Cemetery south of Wien, Chariton County.

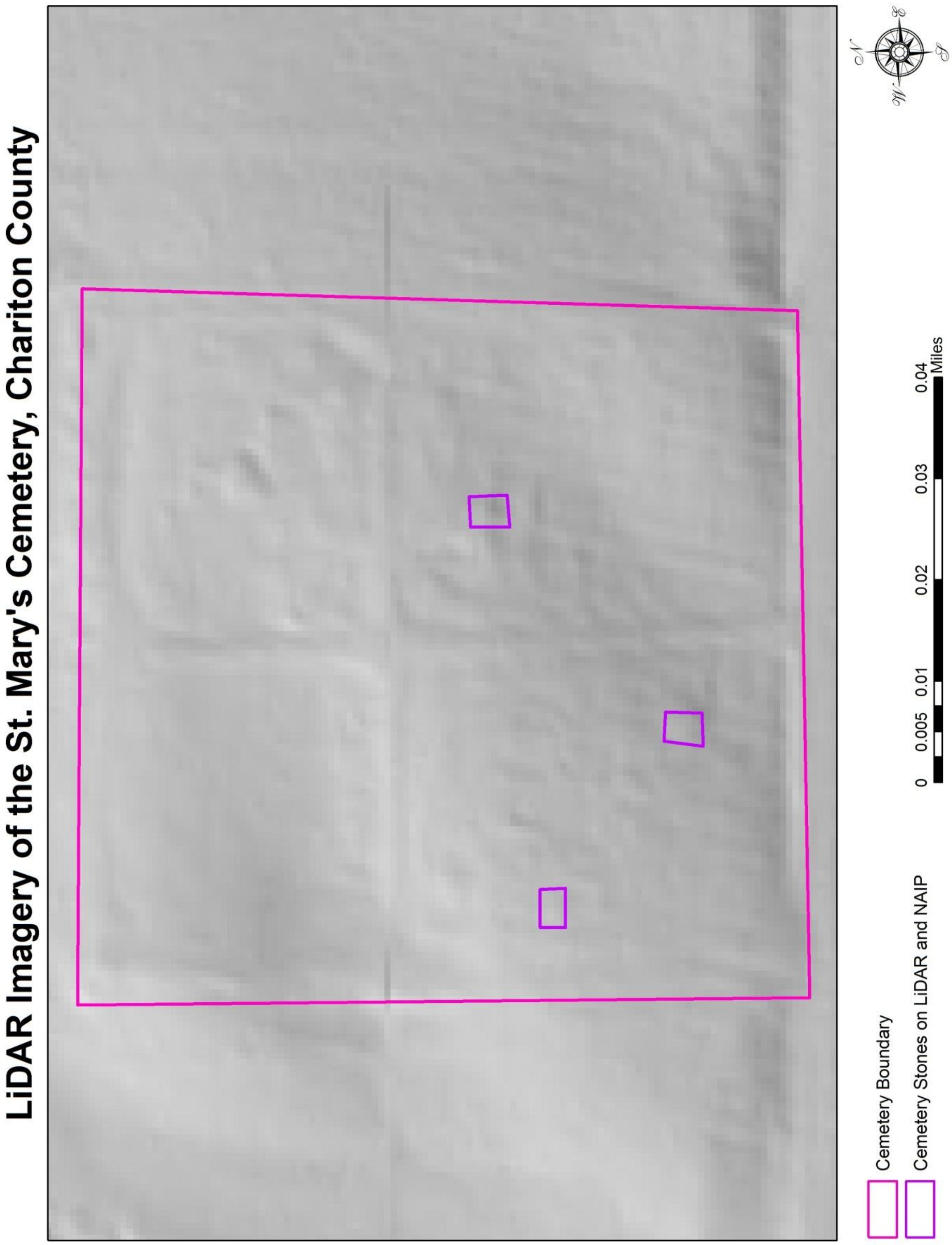


Figure 216.

LiDAR imagery of the Salisbury Cemetery near Salisbury, Chariton County.

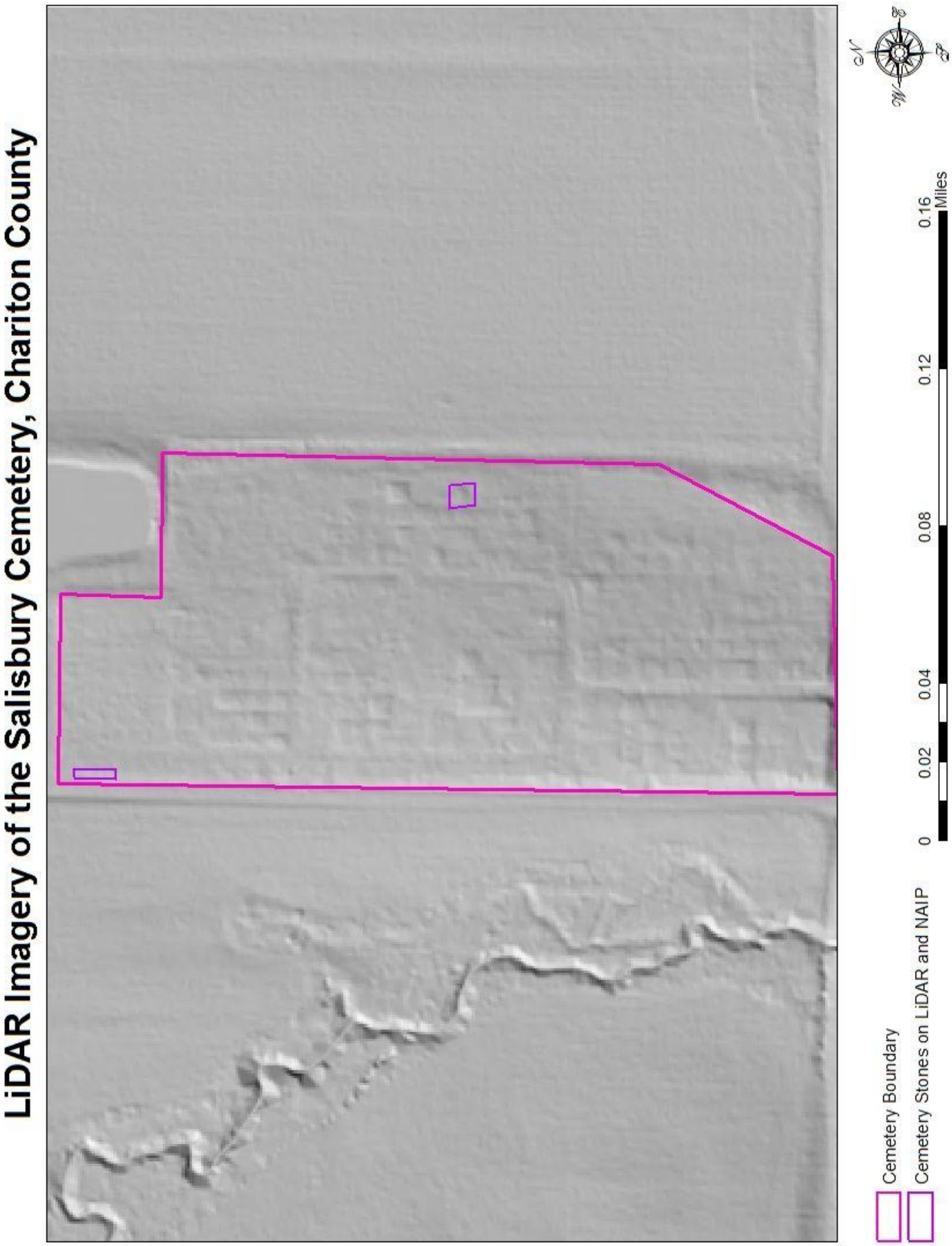


Figure 217.

LiDAR imagery of the Shore Cemetery west of Chapel Hill, Lafayette County.

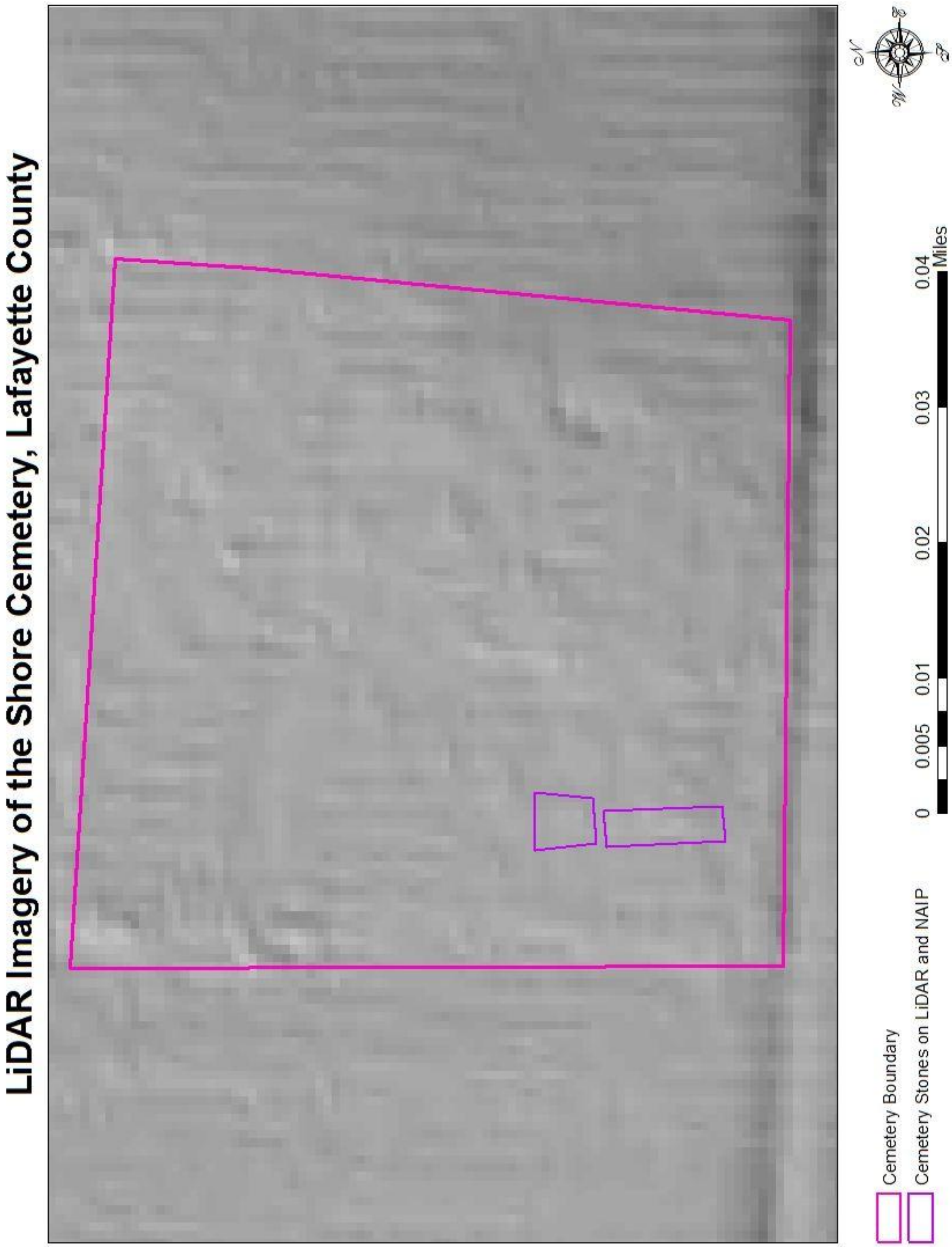


Figure 218.

LiDAR imagery of a previously undocumented road in New Frankfort, Saline County.

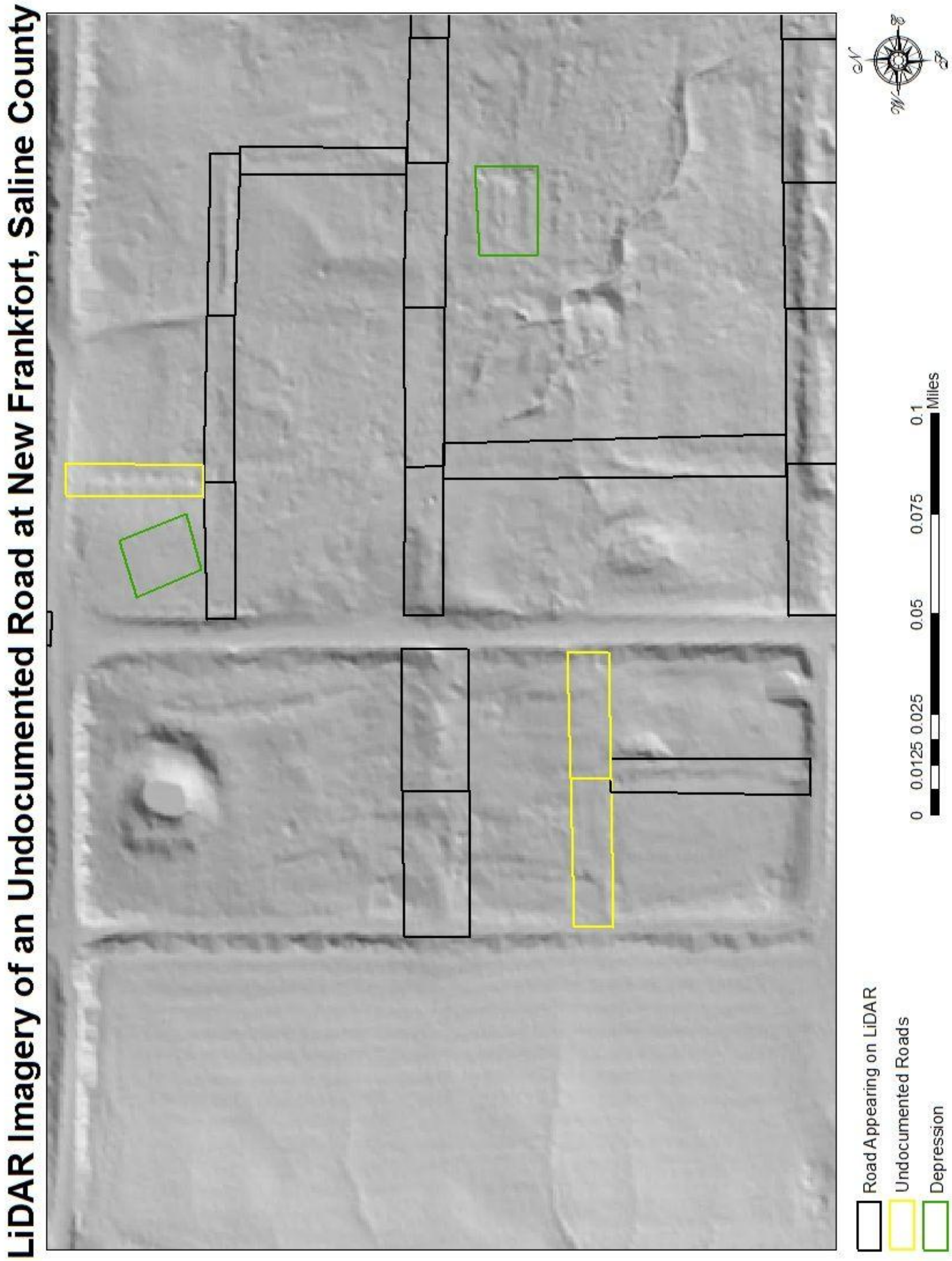


Figure 219.

The proposed path of the Lexington, Lake, and Gulf Railroad.

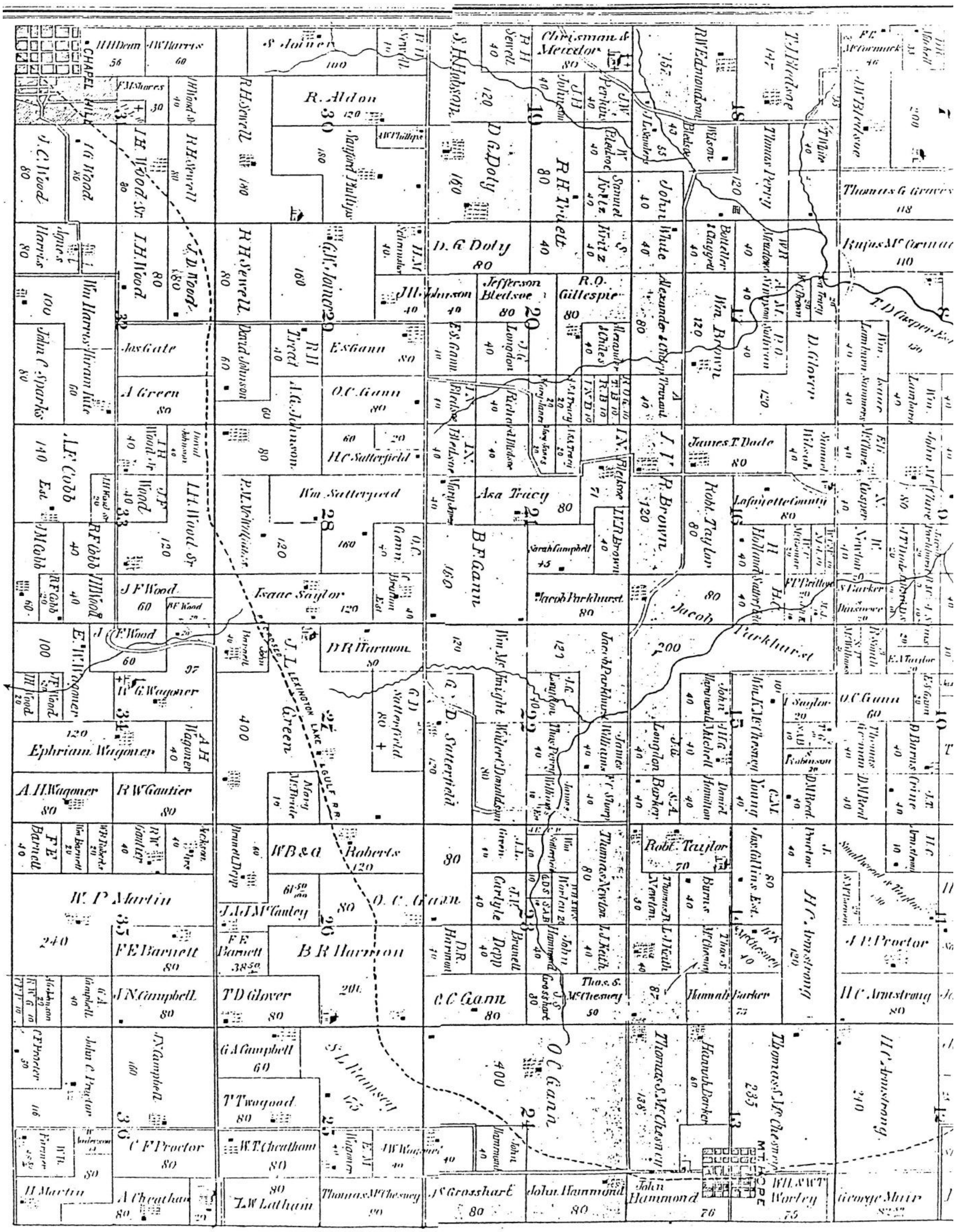


Figure 220.

LiDAR imagery of the Lexington, Lake, and Gulf Railroad, Lafayette County.

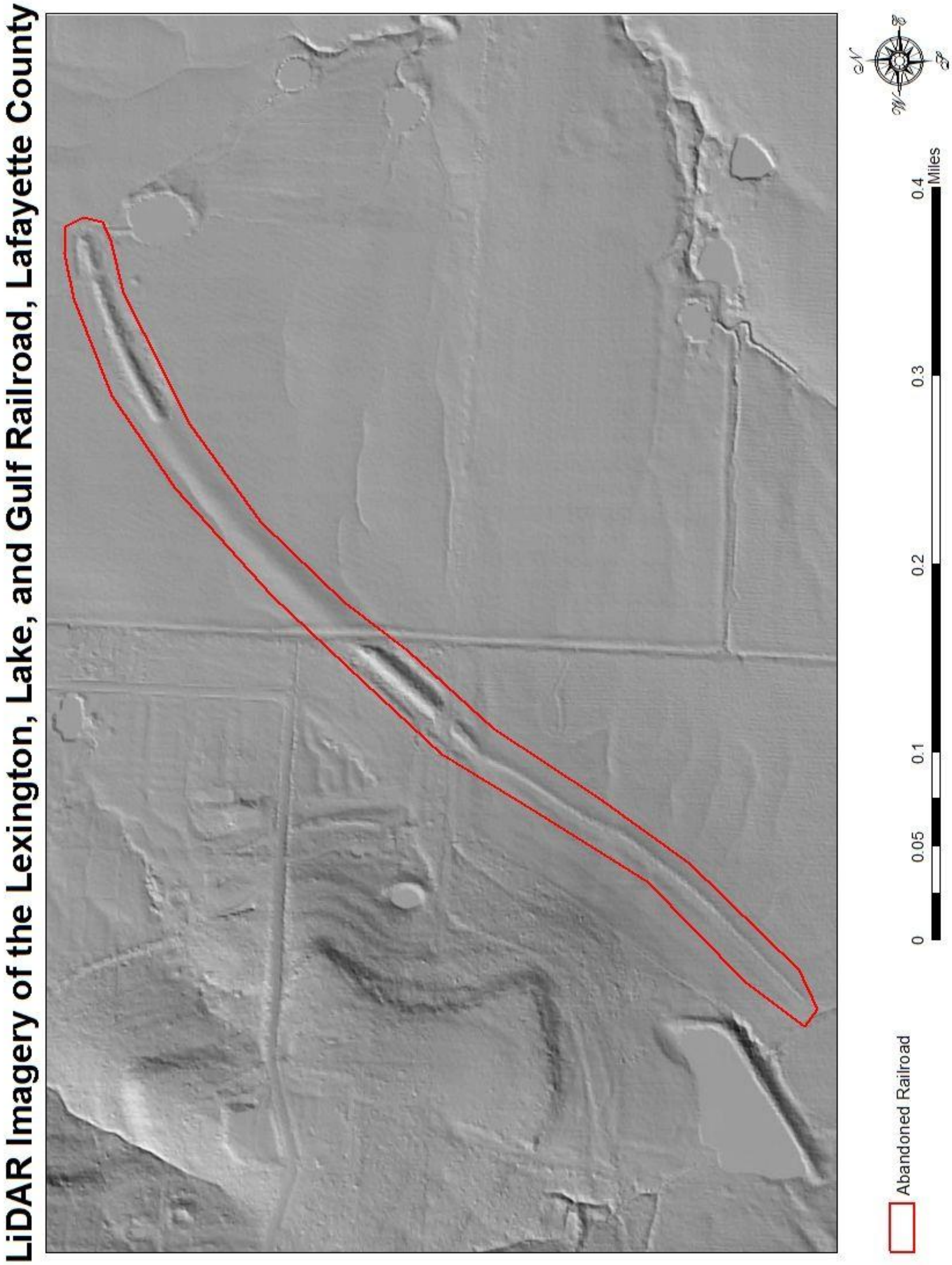


Figure 221.

NAIP imagery of relict features in Cambridge, Saline County.

Figure 222.

NAIP imagery depicting depressions in Cambridge, Saline County.

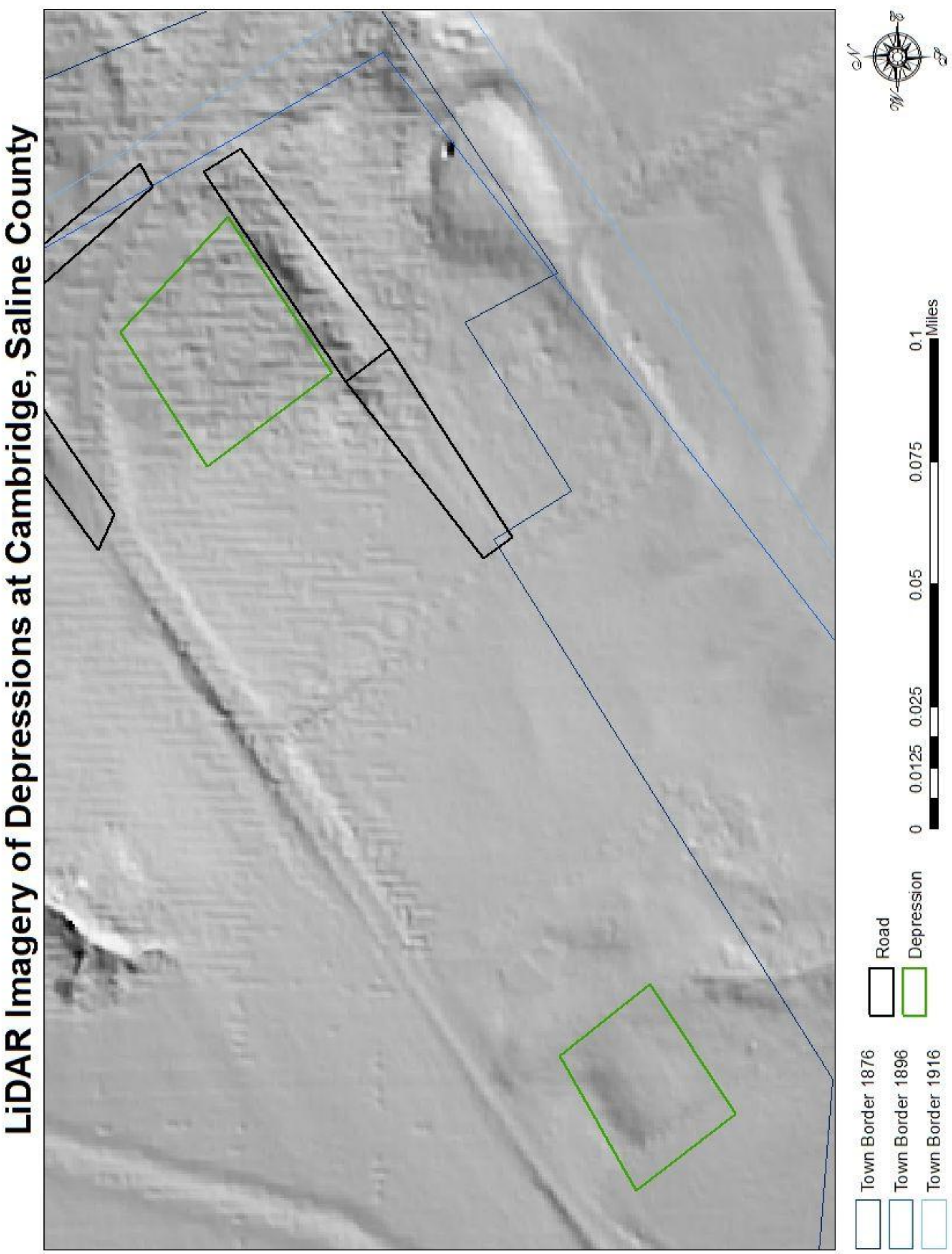


Figure 223.

NAIP imagery of relict features in Chapel Hill, Lafayette County.

Figure 224.

NAIP imagery depicting the southern depressions in Chapel Hill, Lafayette County.

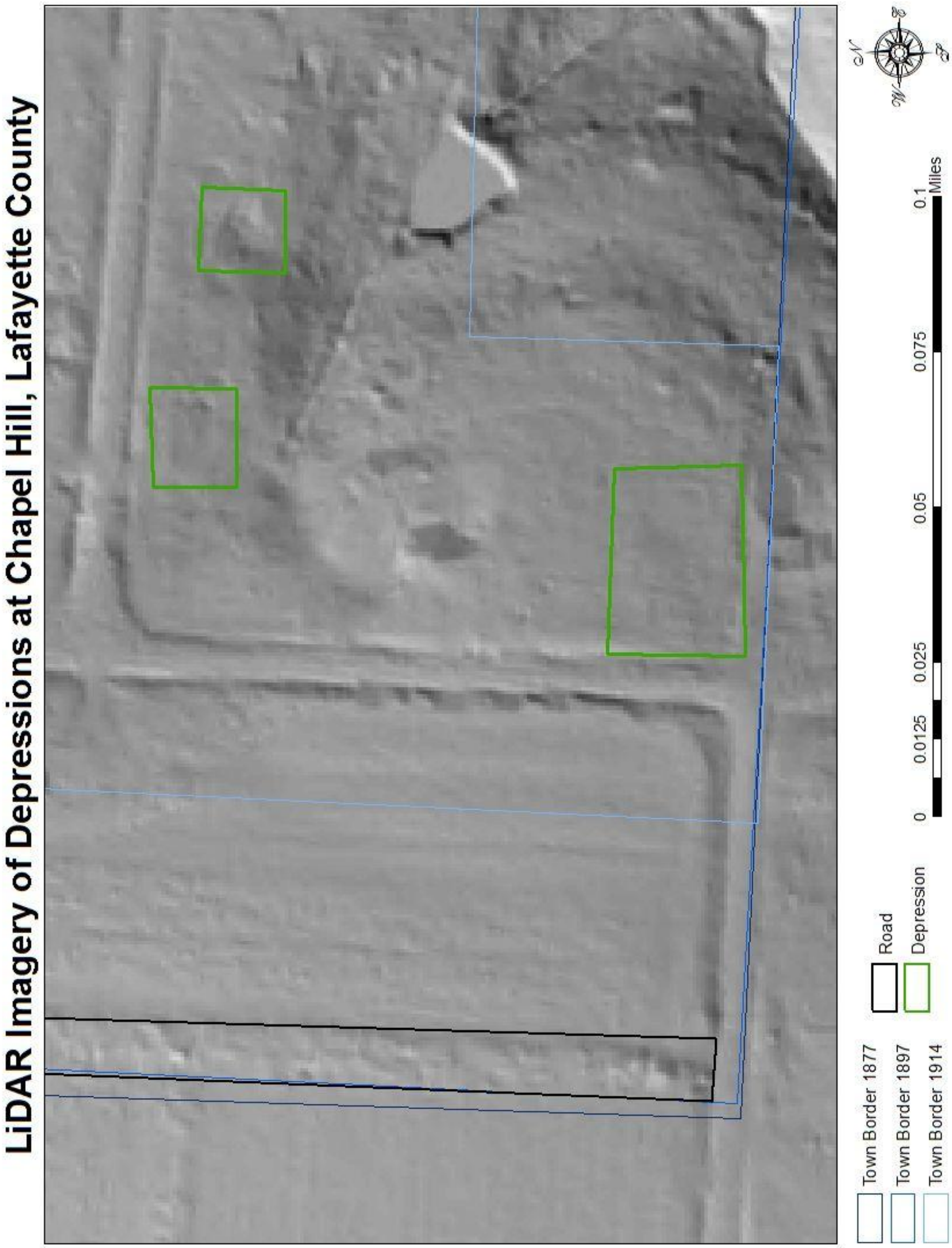


Figure 225.

NAIP imagery depicting the northern depression in Chapel Hill, Lafayette County.

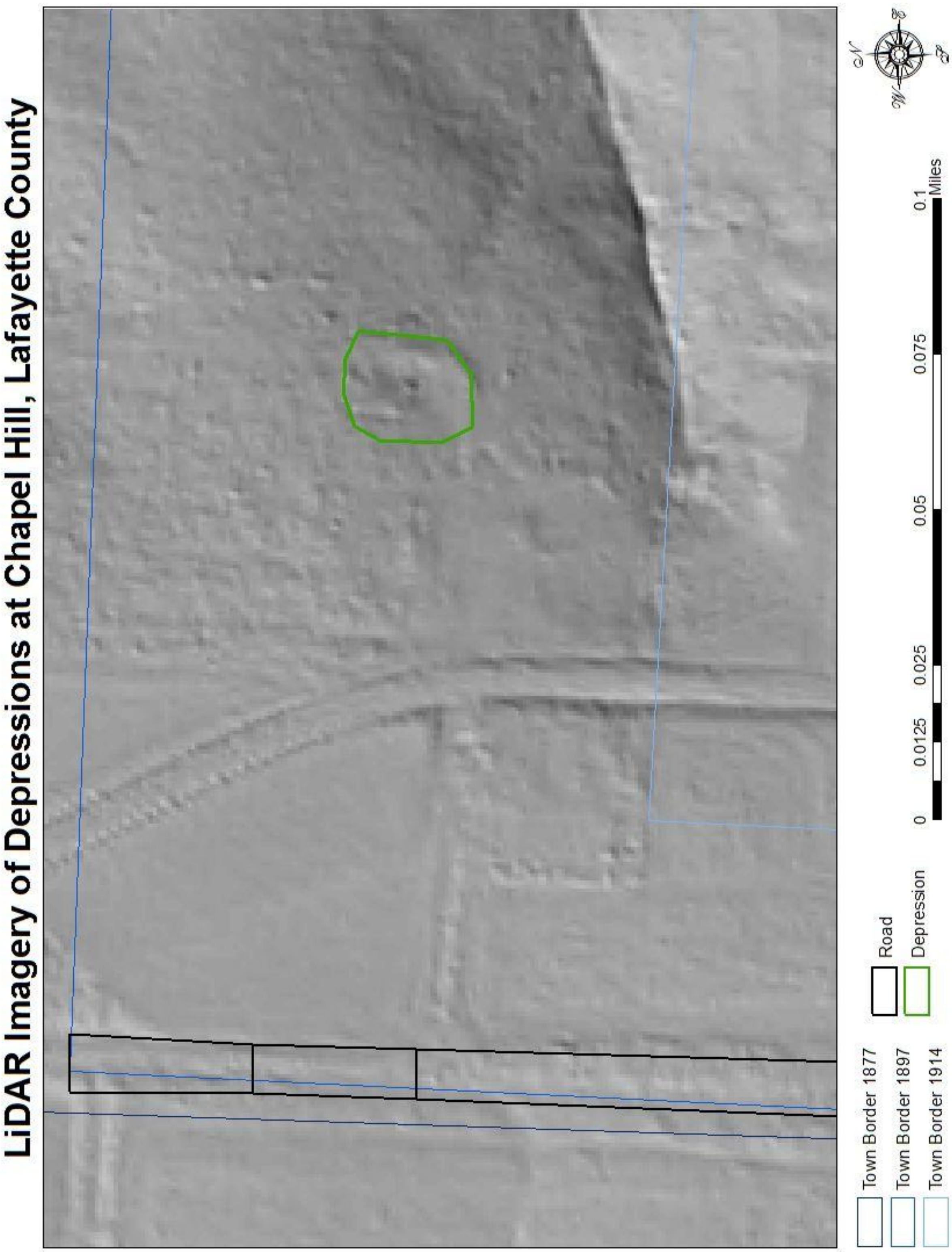


Figure 226.

NAIP imagery of relict features in Coloma, Carroll County.

Figure 227.

LiDAR imagery of the north border of Elmwood, Saline County.

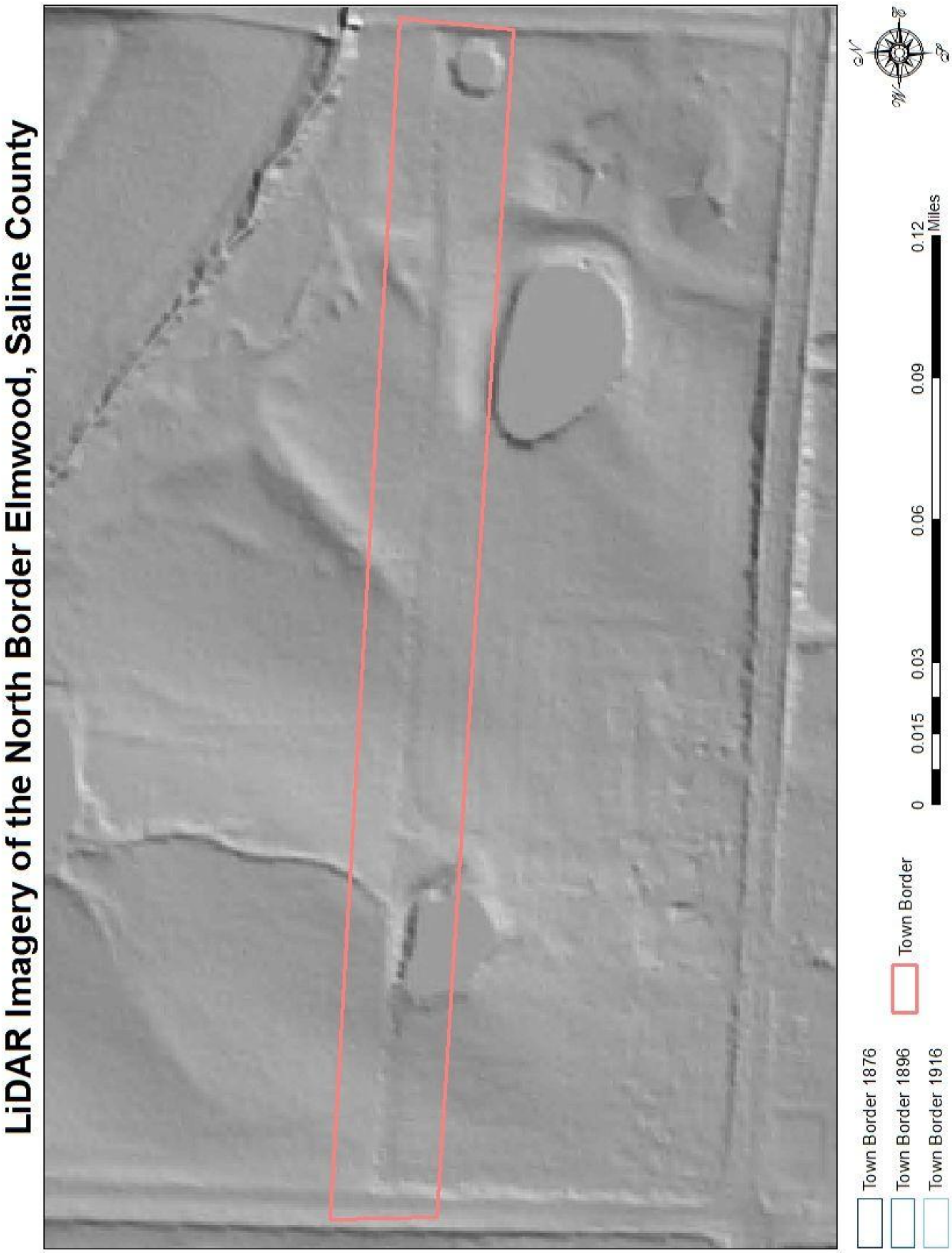


Figure 228.

NAIP imagery of the north border of Elmwood, Saline County.

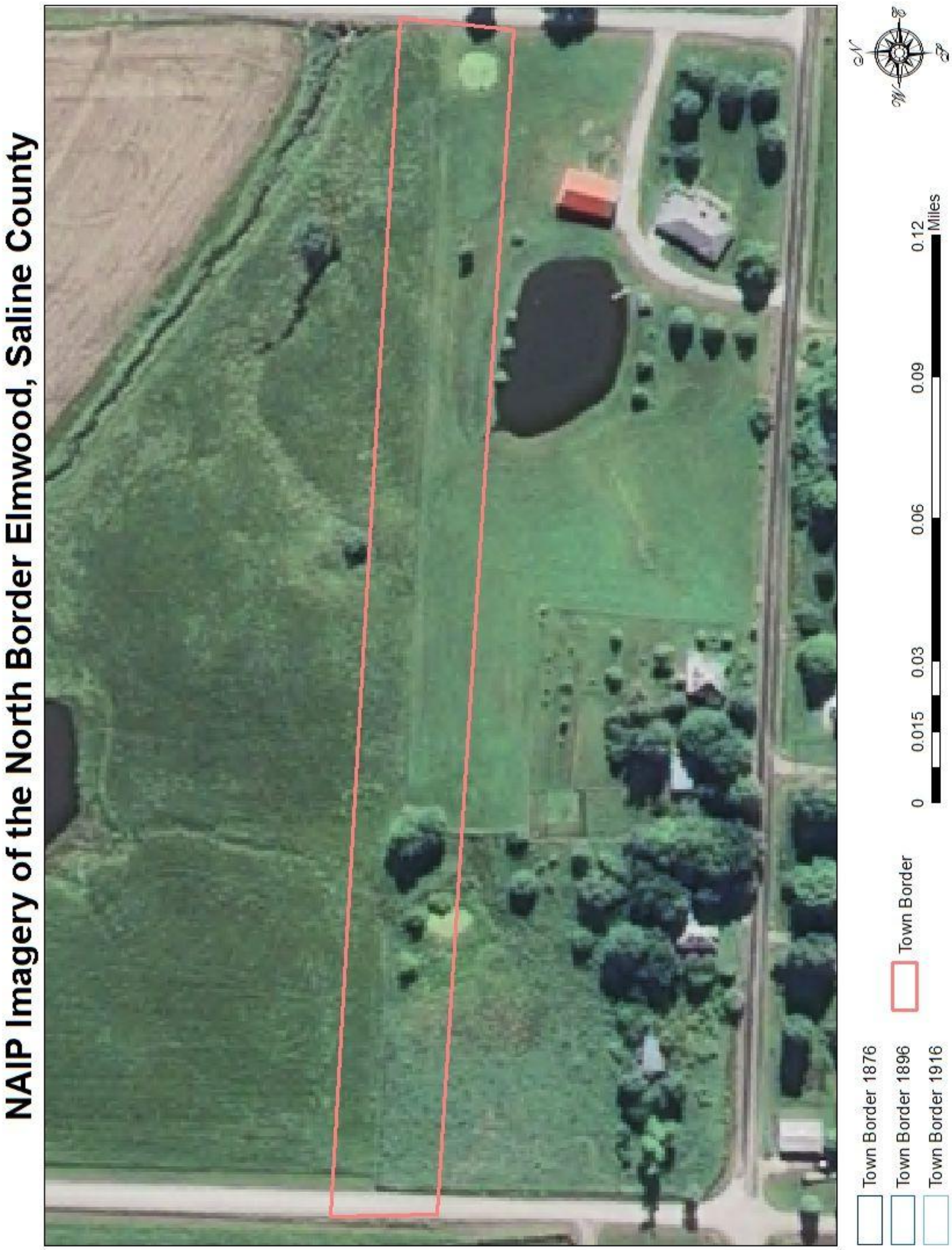


Figure 229.

NAIP imagery depicting two northern depressions in New Frankfort, Saline County.

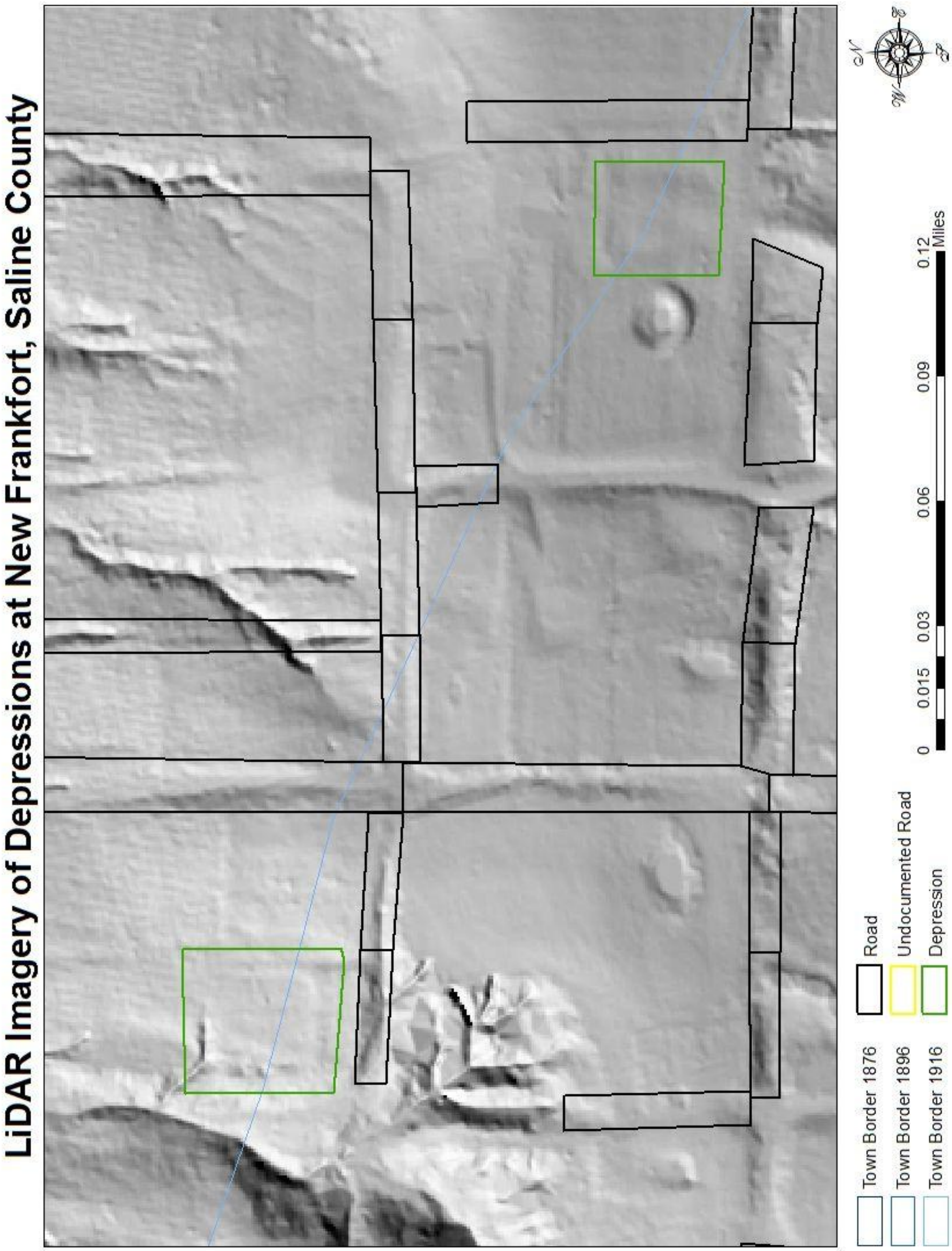


Figure 230.

NAIP imagery depicting two southern depressions in New Frankfort, Saline County.

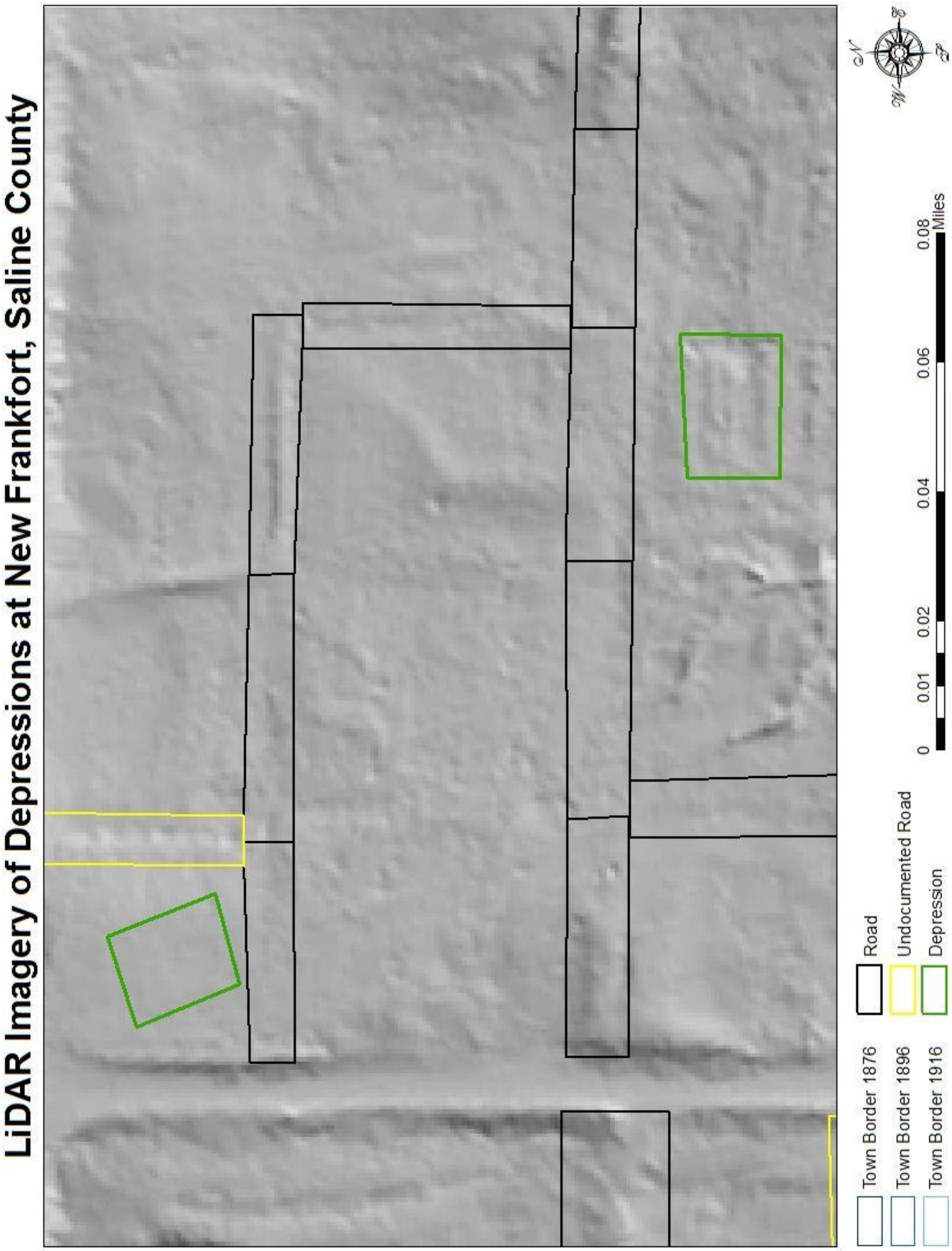


Figure 231.

LiDAR imagery of the abandoned Brunswick, Chillicothe, and Omaha Railroad, in the ghost town of Whitham, Chariton County.

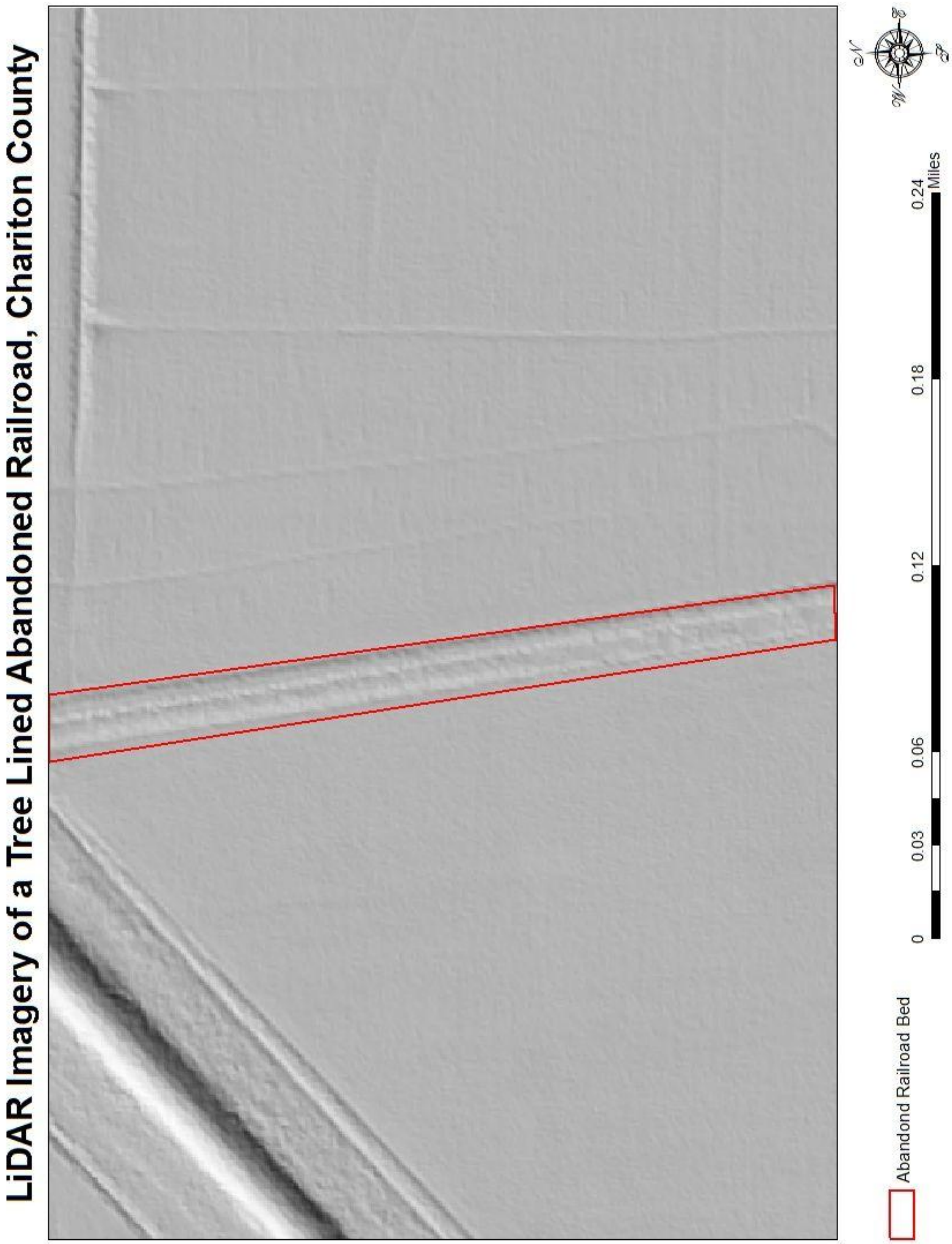


Figure 232.

LiDAR and NAIP imagery of the abandoned Brunswick, Chillicothe, and Omaha Railroad near Brunswick, Chariton County.

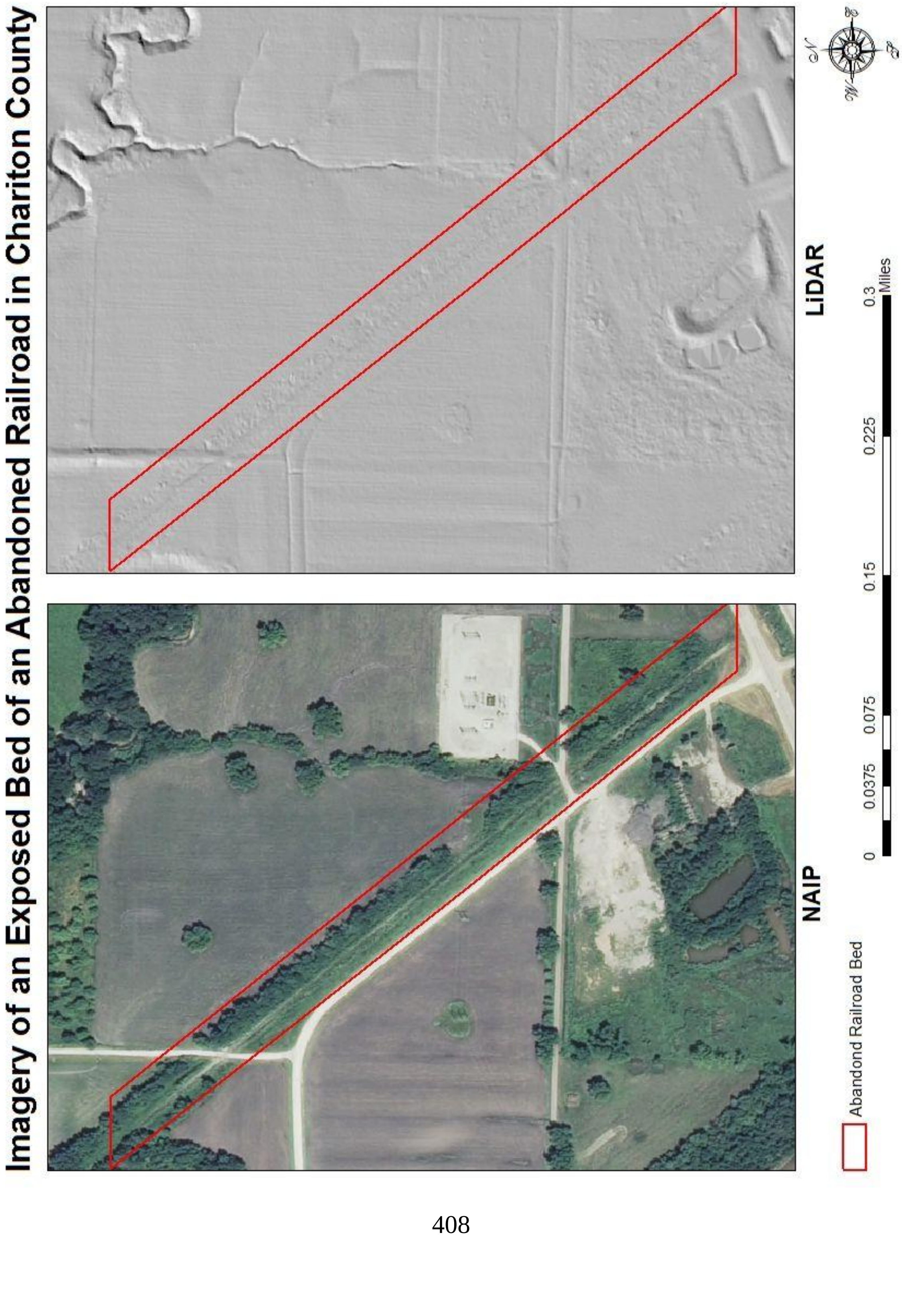


Figure 233.

LiDAR and NAIP imagery of the tree lined, abandoned Keokuk and Kansas City Railroad in rural Chariton County.

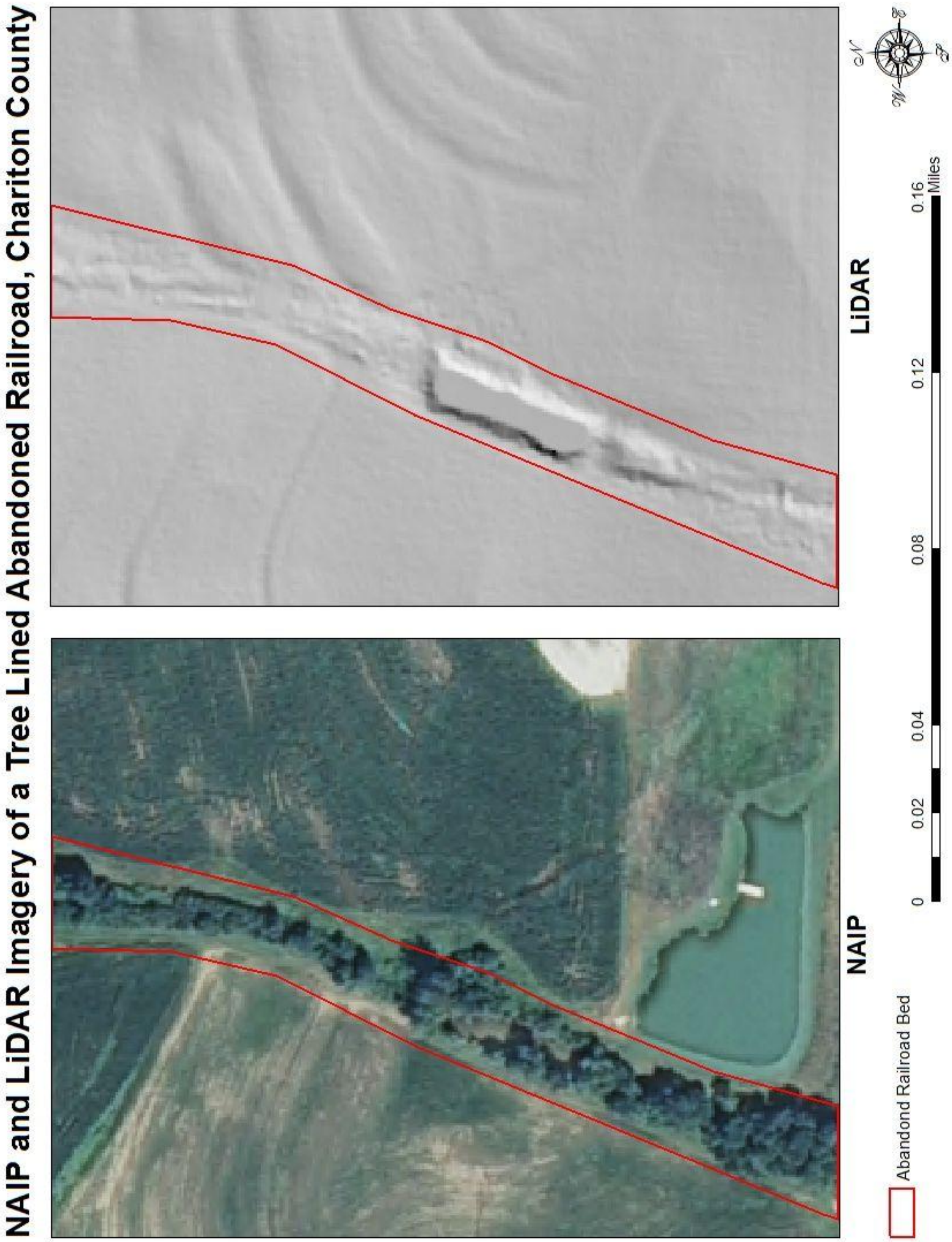


Figure 234.

LiDAR and NAIP imagery of the abandoned Keokuk and Kansas City Railroad in Salisbury, Chariton County.

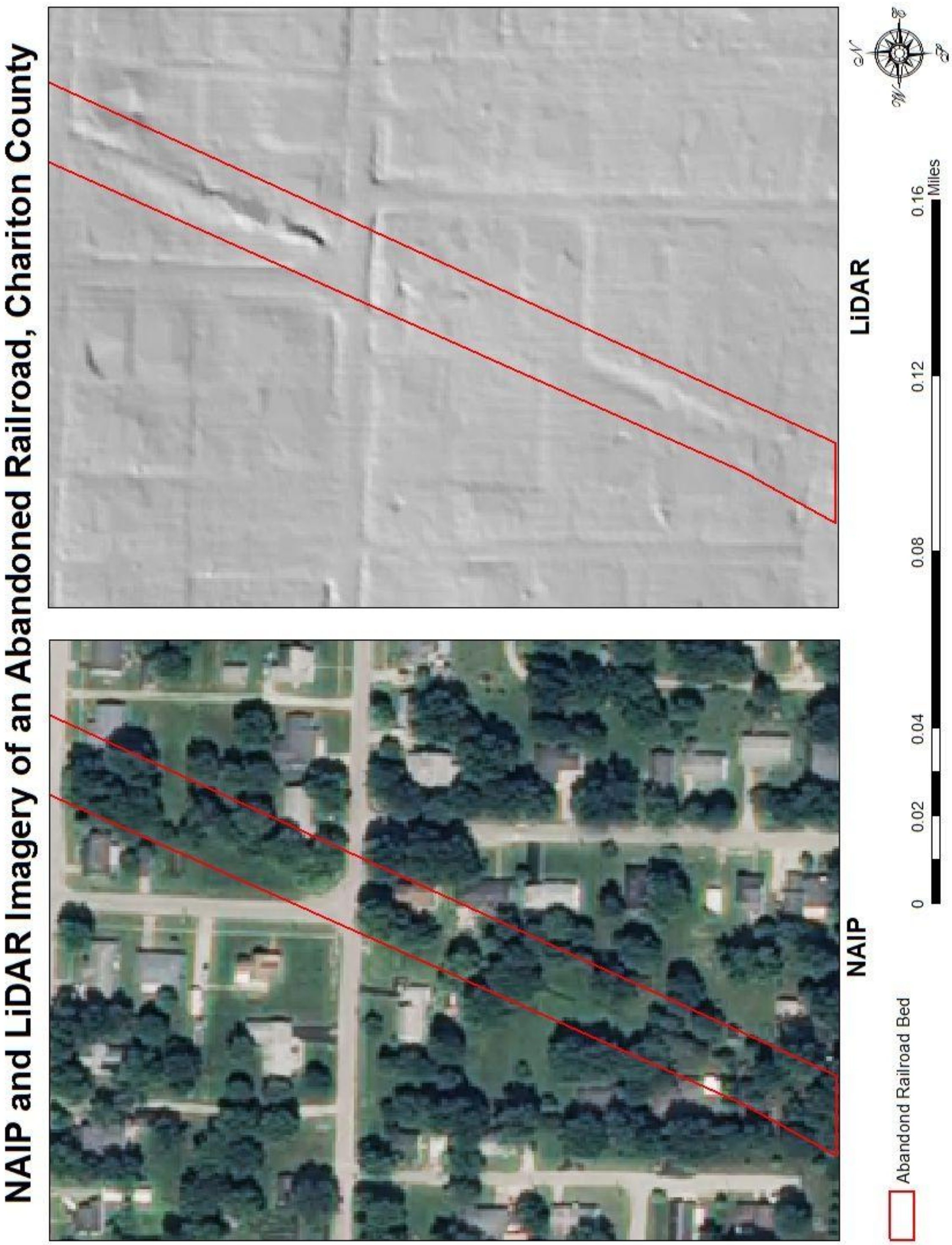


Figure 235.

Imagery of the heavy cropped Keokuk and Kansas City Railroad; where the rail bed is visible on the LiDAR imagery but not the NAIP imagery; south of Salisbury, Chariton County.

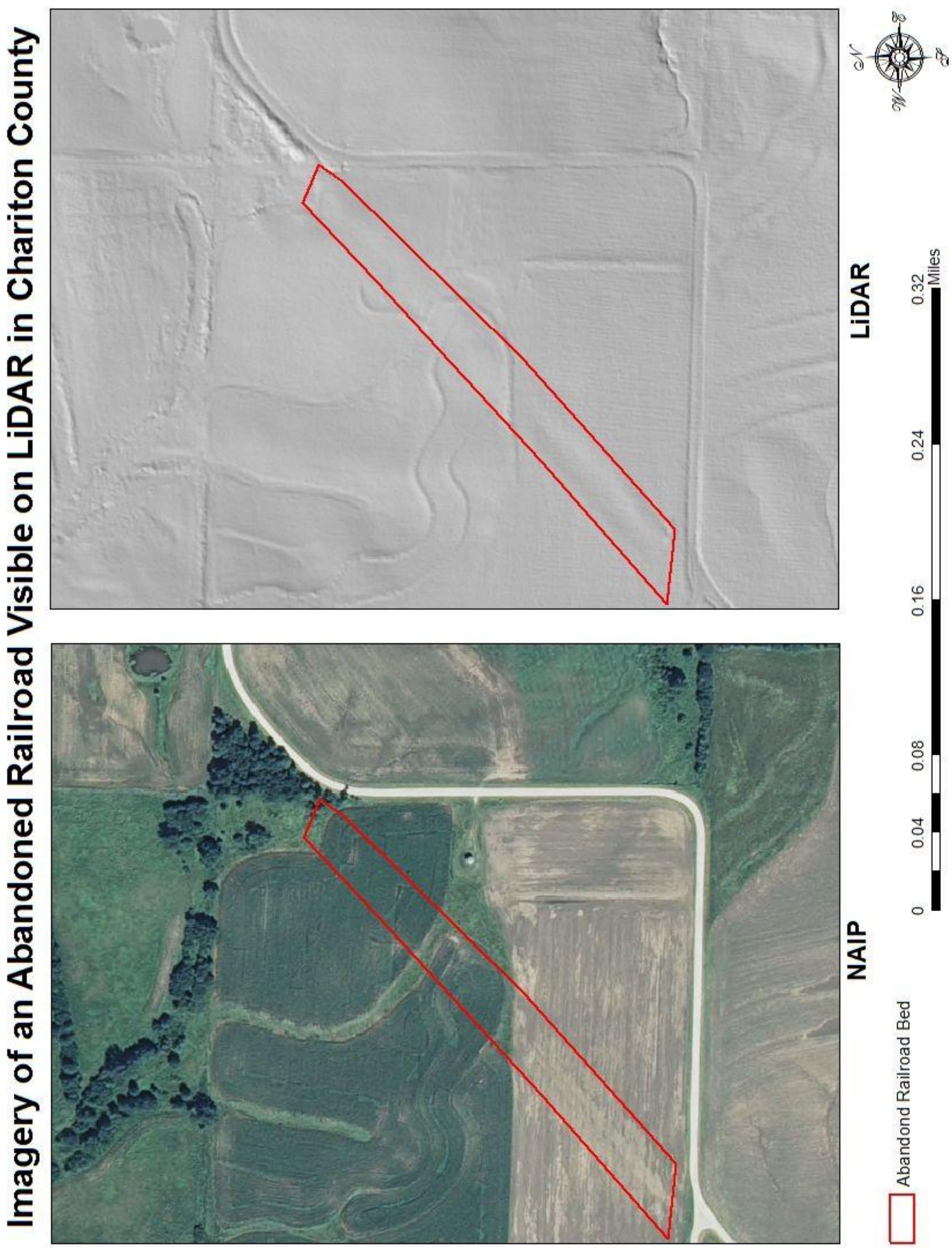


Figure 236.

LiDAR and NAIP imagery of the abandoned Keokuk and Kansas City Railroad south of Forest Green, Chariton County.

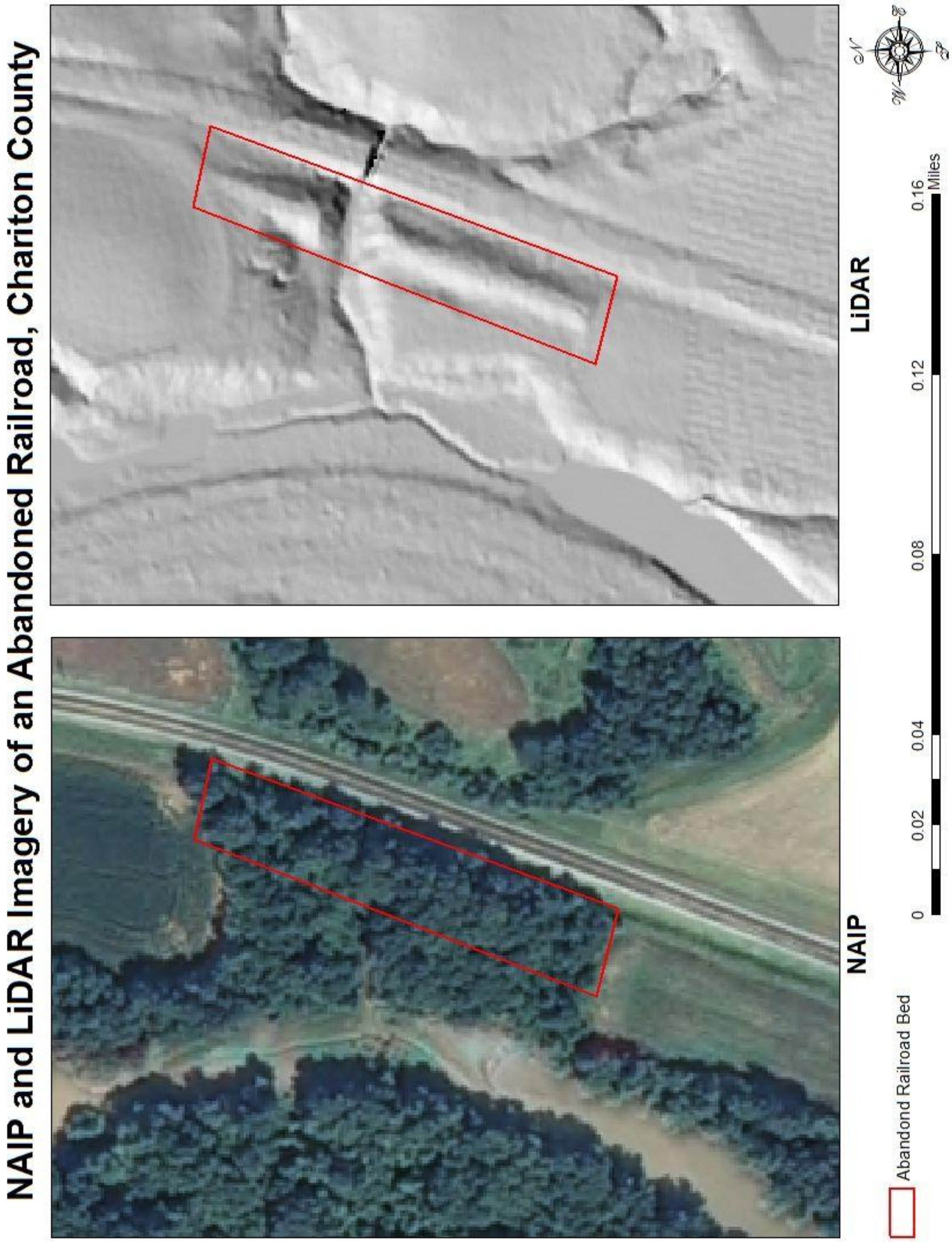


Figure 237.

NAIP and LiDAR imagery of the abandoned and exposed Lexington and St. Louis Railroad in Rural Lafayette County, obscured by tree canopies.

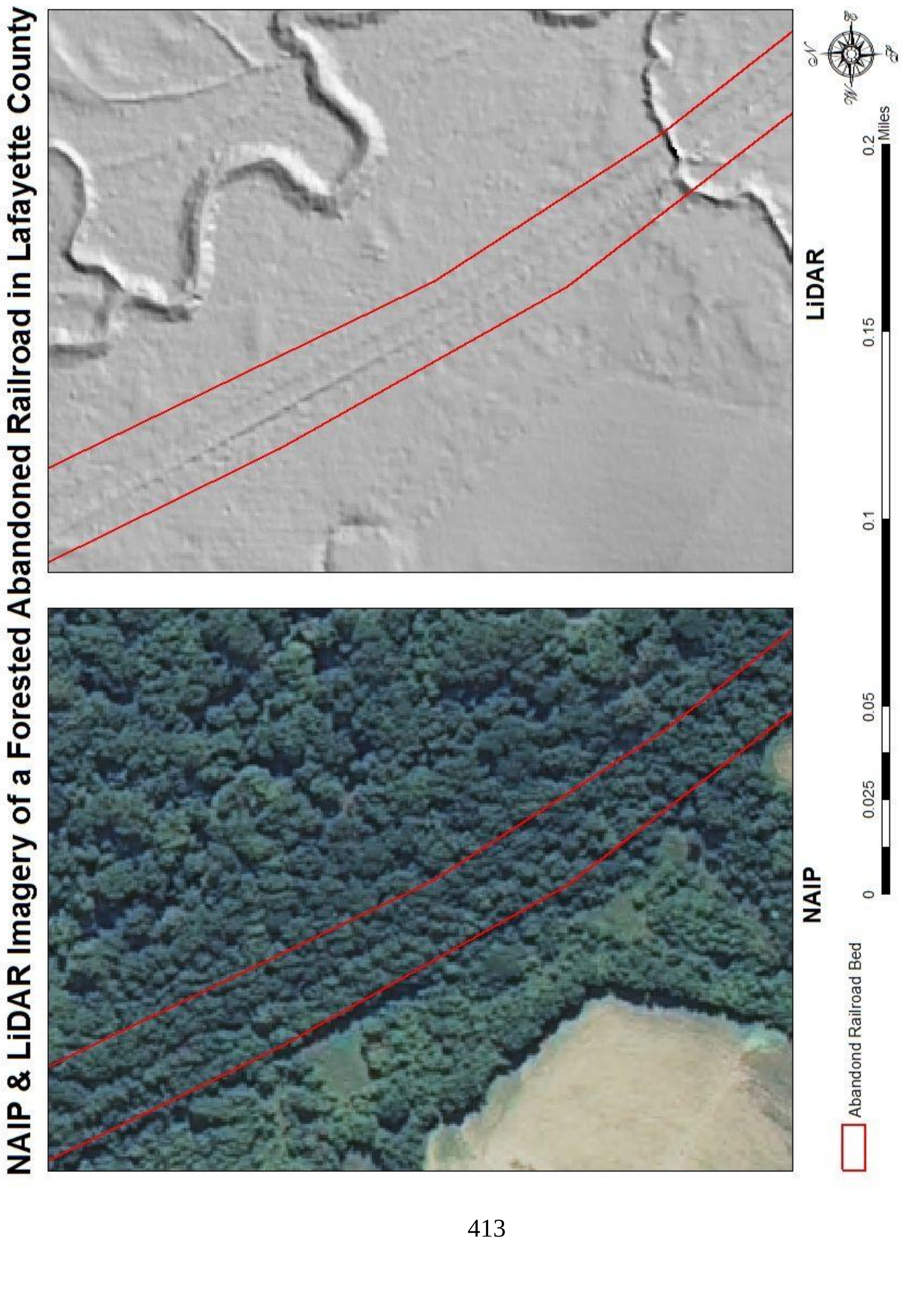


Figure 238.

LiDAR and NAIP imagery of the abandoned Lexington and St. Louis Railroad in Higginsville, Lafayette County.

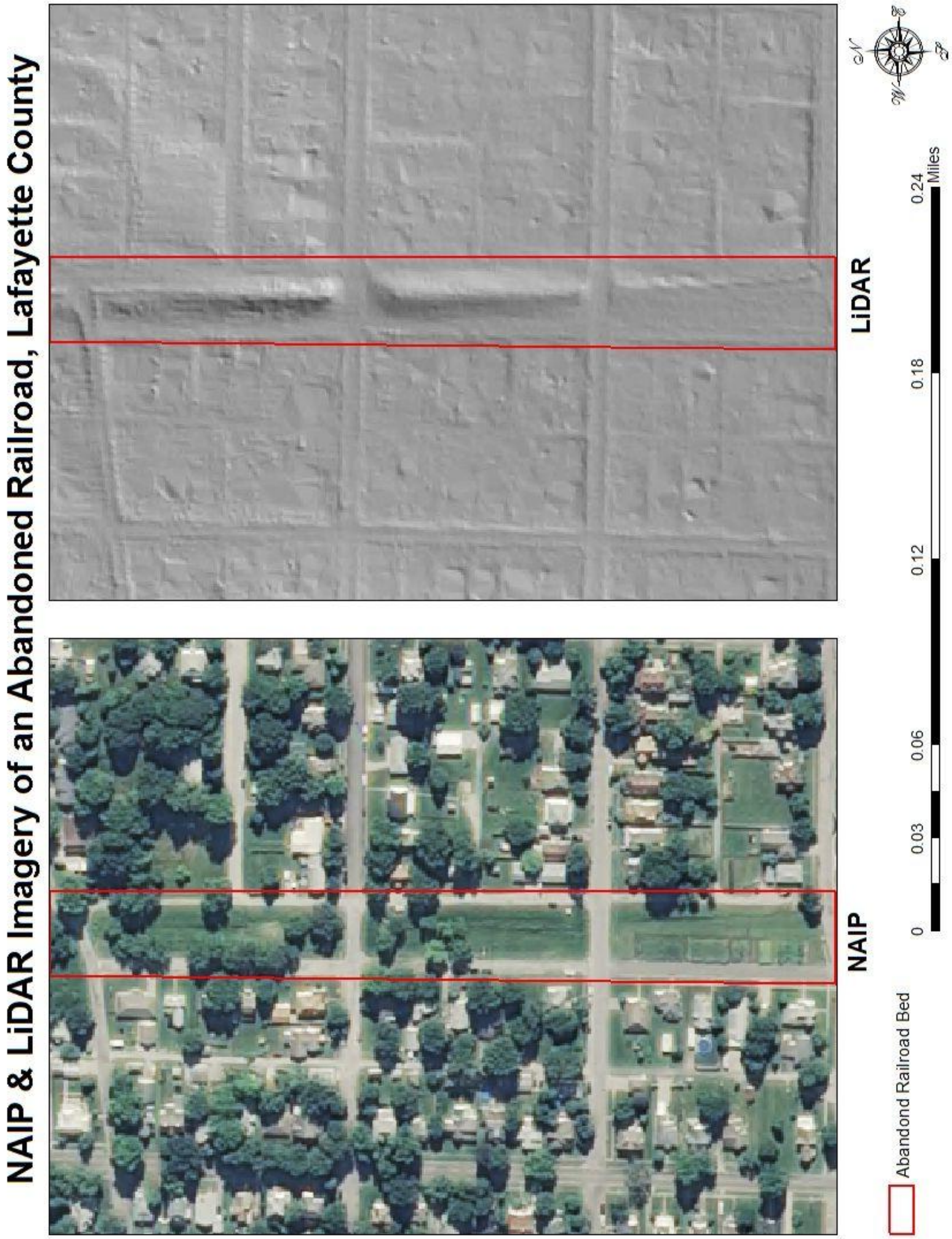


Figure 239.

NAIP imagery of the Lexington, Lake, and Gulf Railroad, Lafayette County.

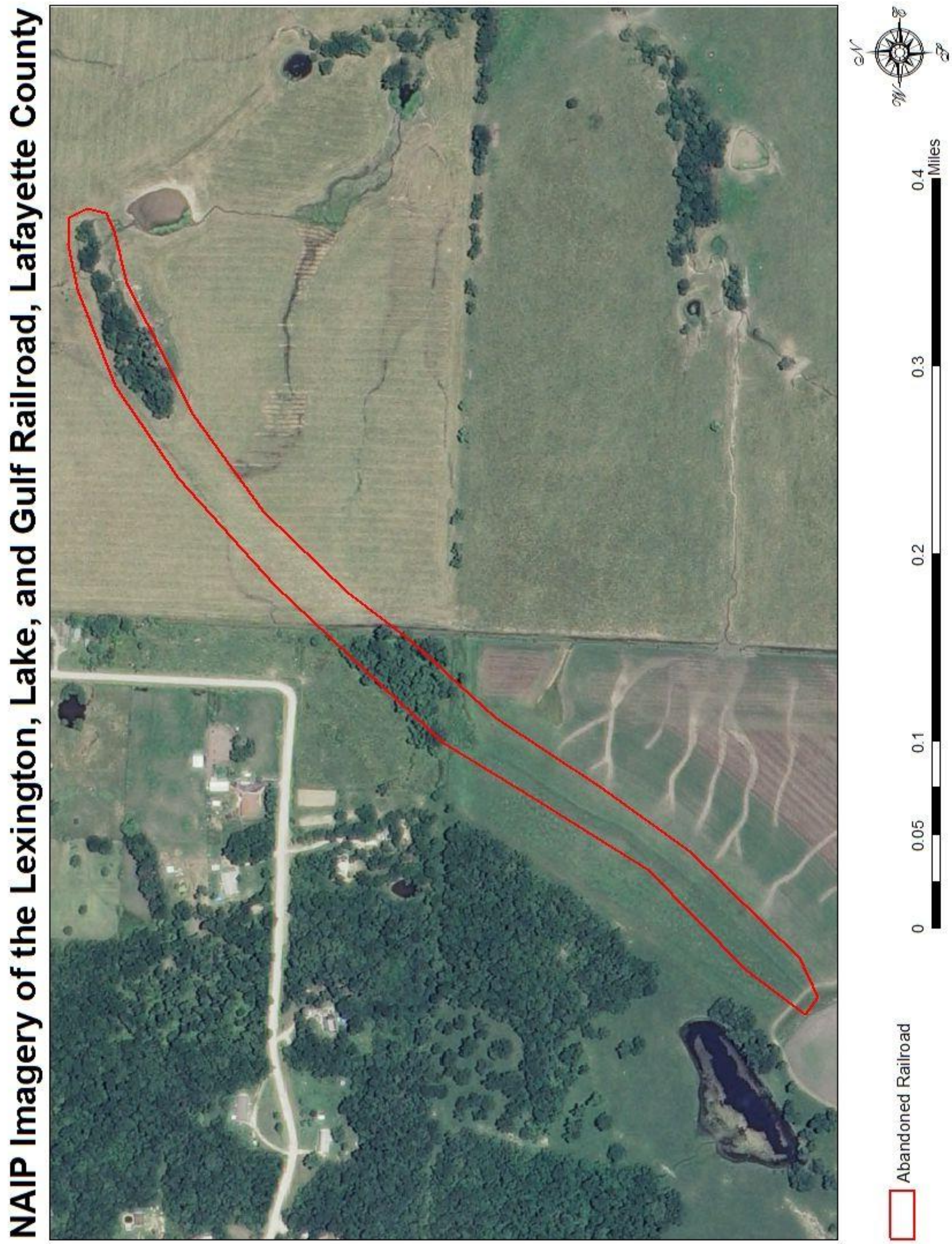


Figure 240.

NAIP and LiDAR imagery of the abandoned rail bed of the Missouri Pacific Railroad in Marshall, Saline County.

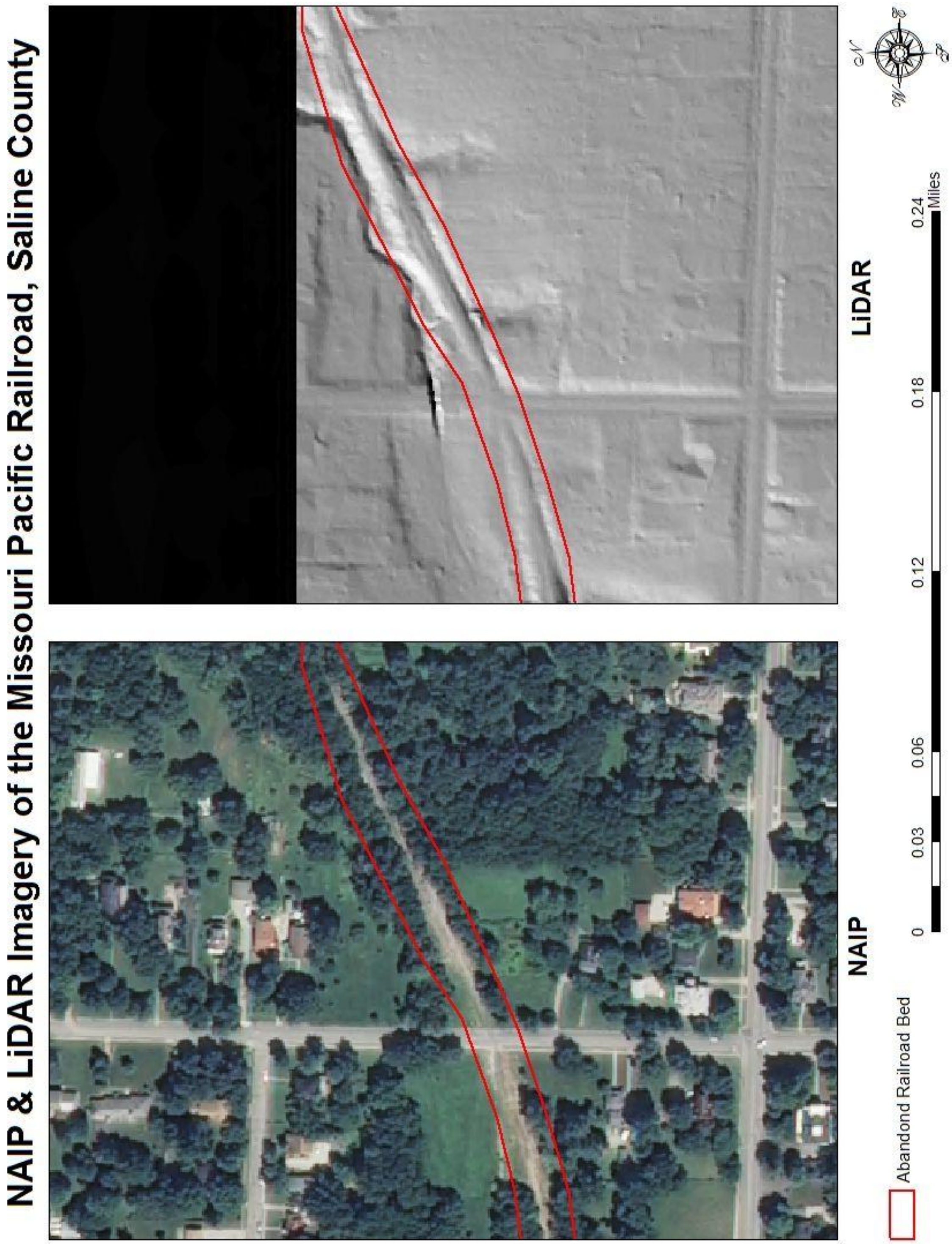


Figure 241.

Imagery of the Confederate Memorial State Historic Site Cemetery, Lafayette County.

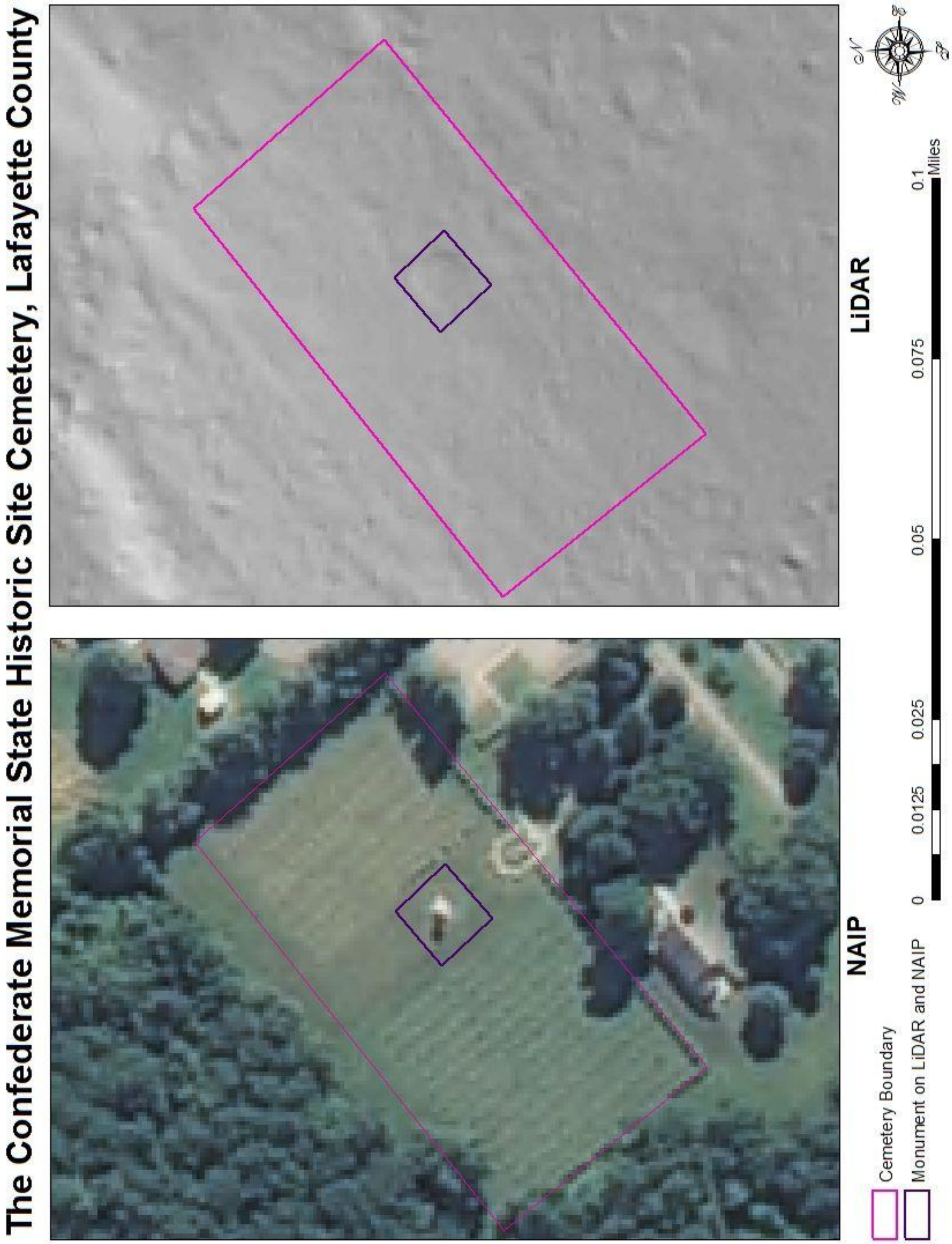


Figure 242.

Imagery of the DeWitt Evergreen Cemetery, Carroll County.

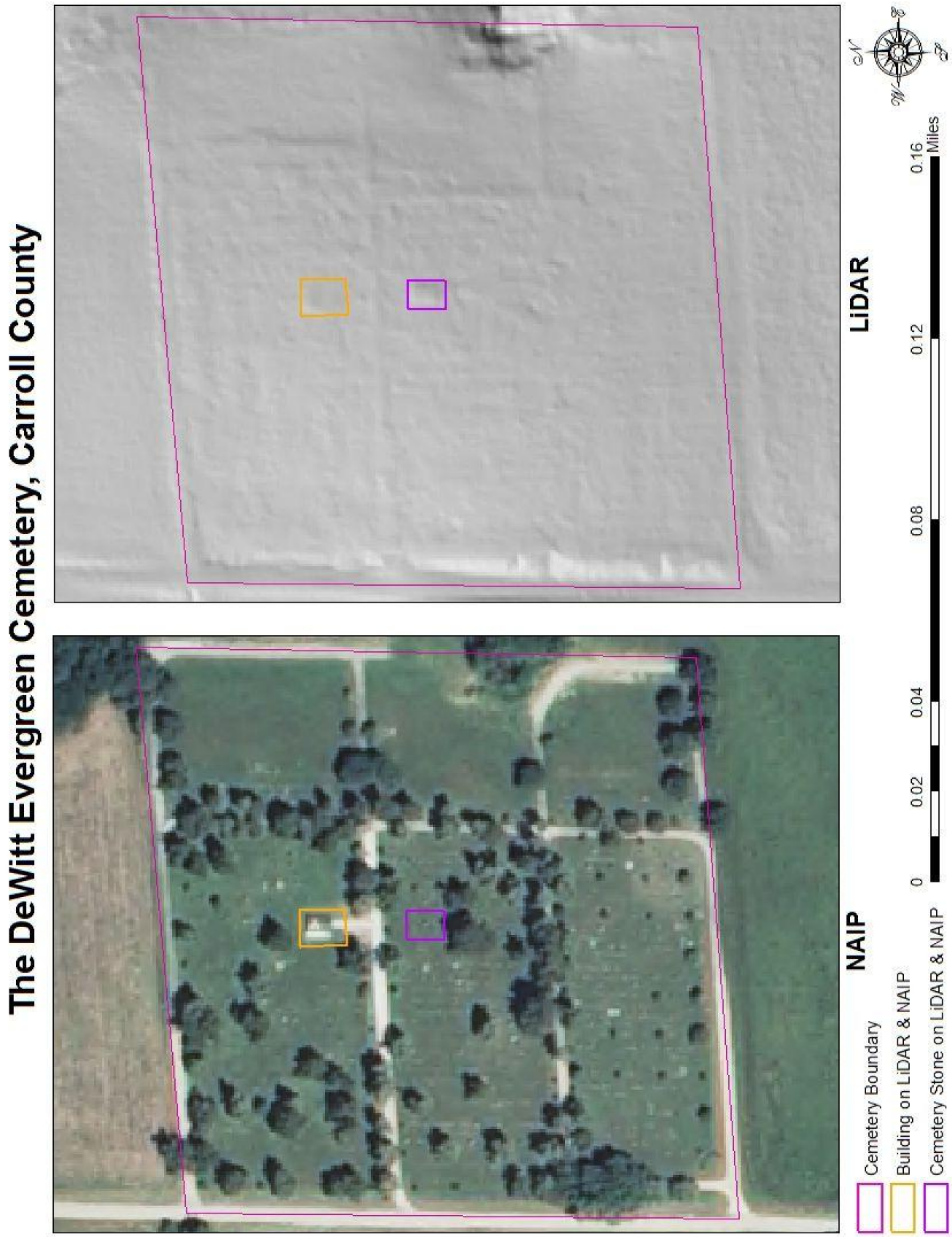


Figure 243.

Imagery of the Fairview Cemetery, Saline County.

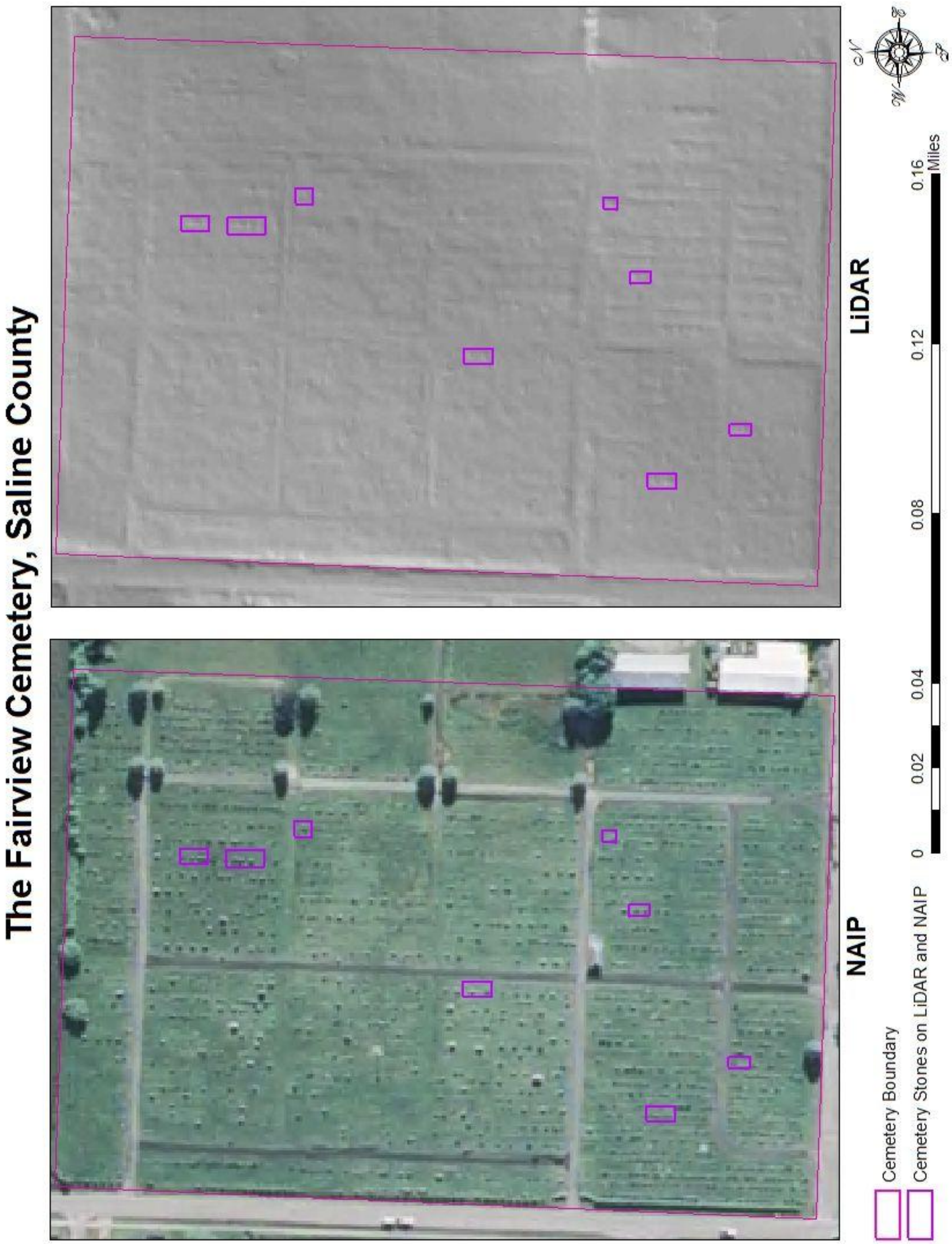


Figure 244.

Imagery of the Greenton Baptist Cemetery, Lafayette County.

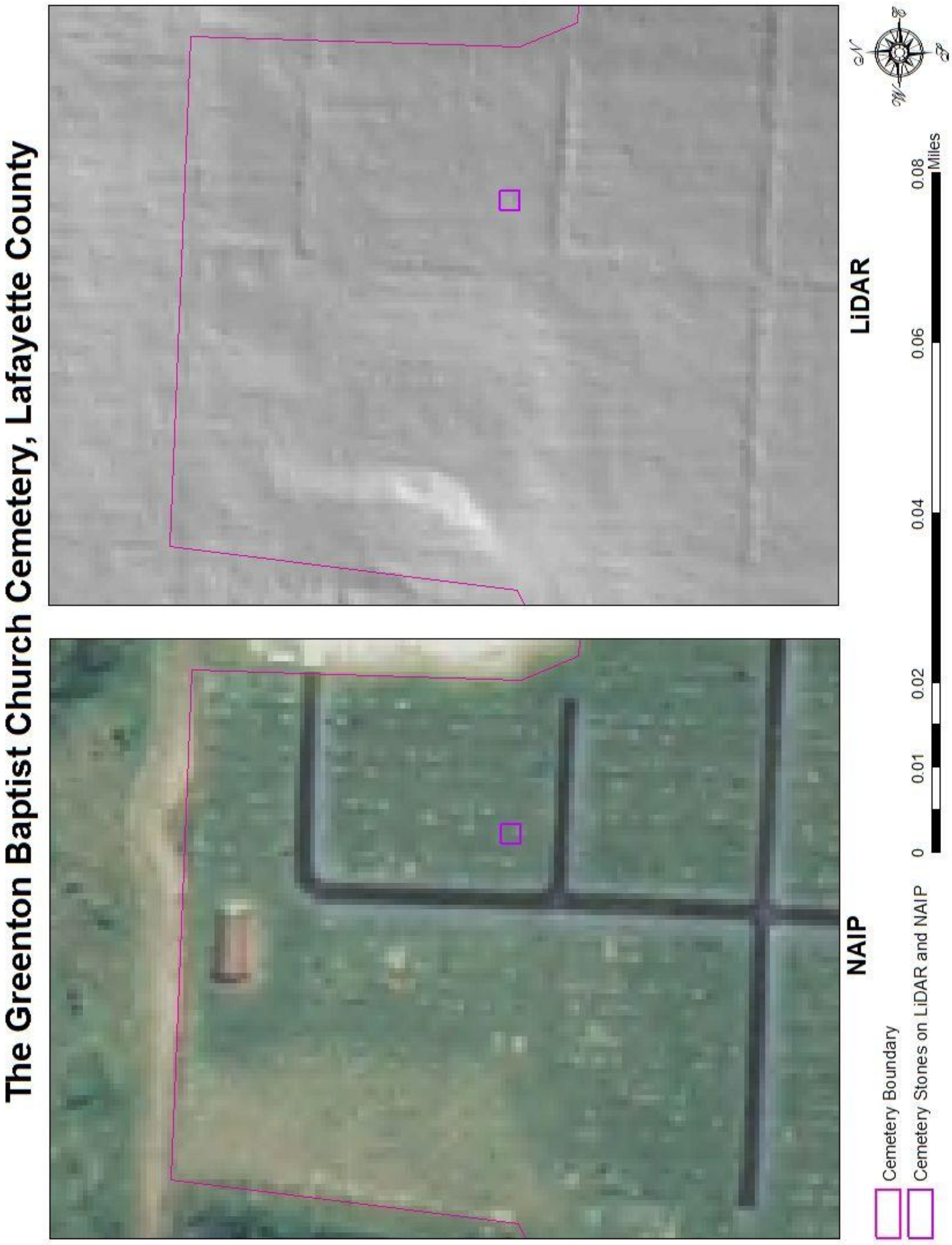


Figure 245.

Imagery of the Mendon Cemetery, Chariton County.

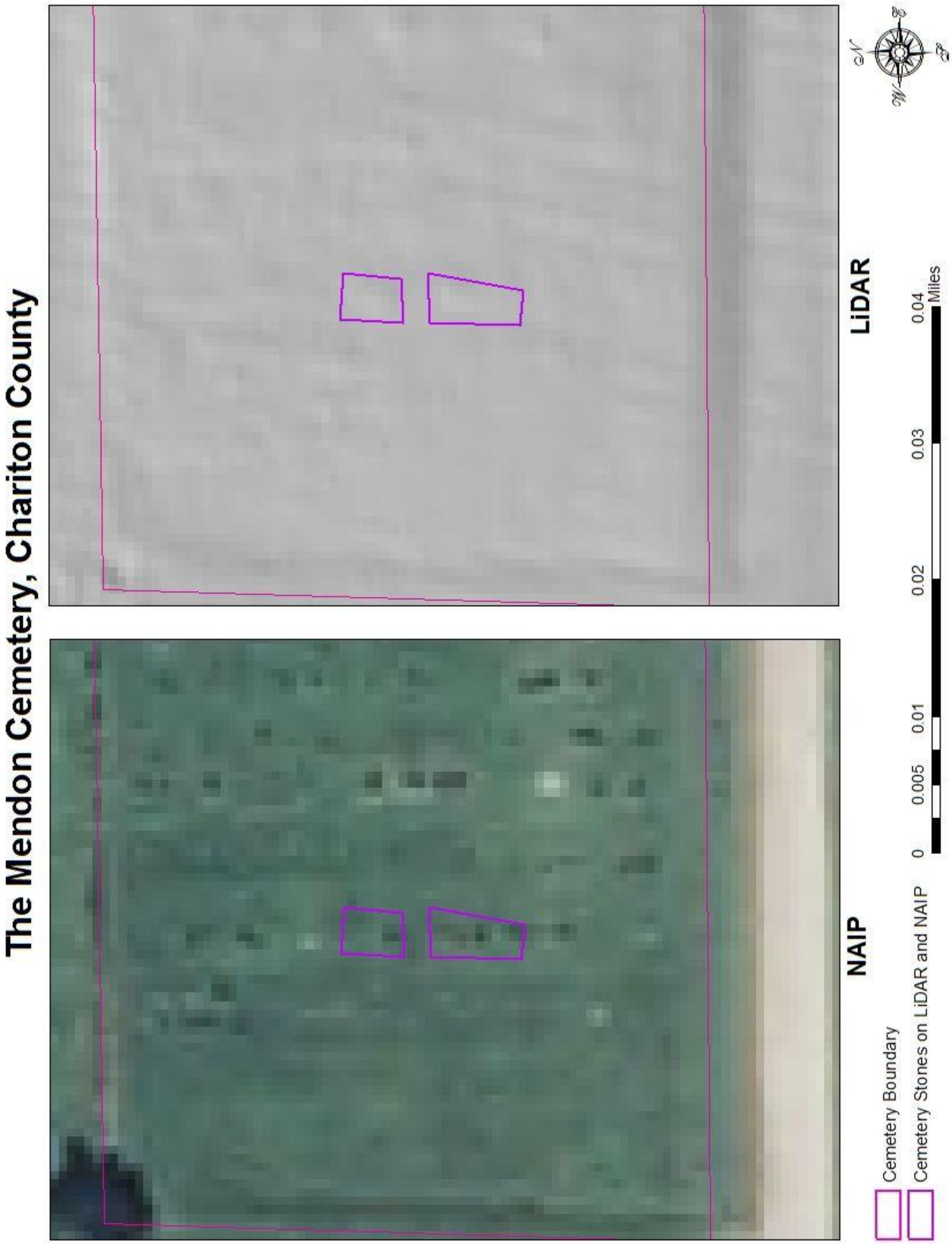


Figure 246.

Imagery of the Mount Nebo Cemetery, Saline County.

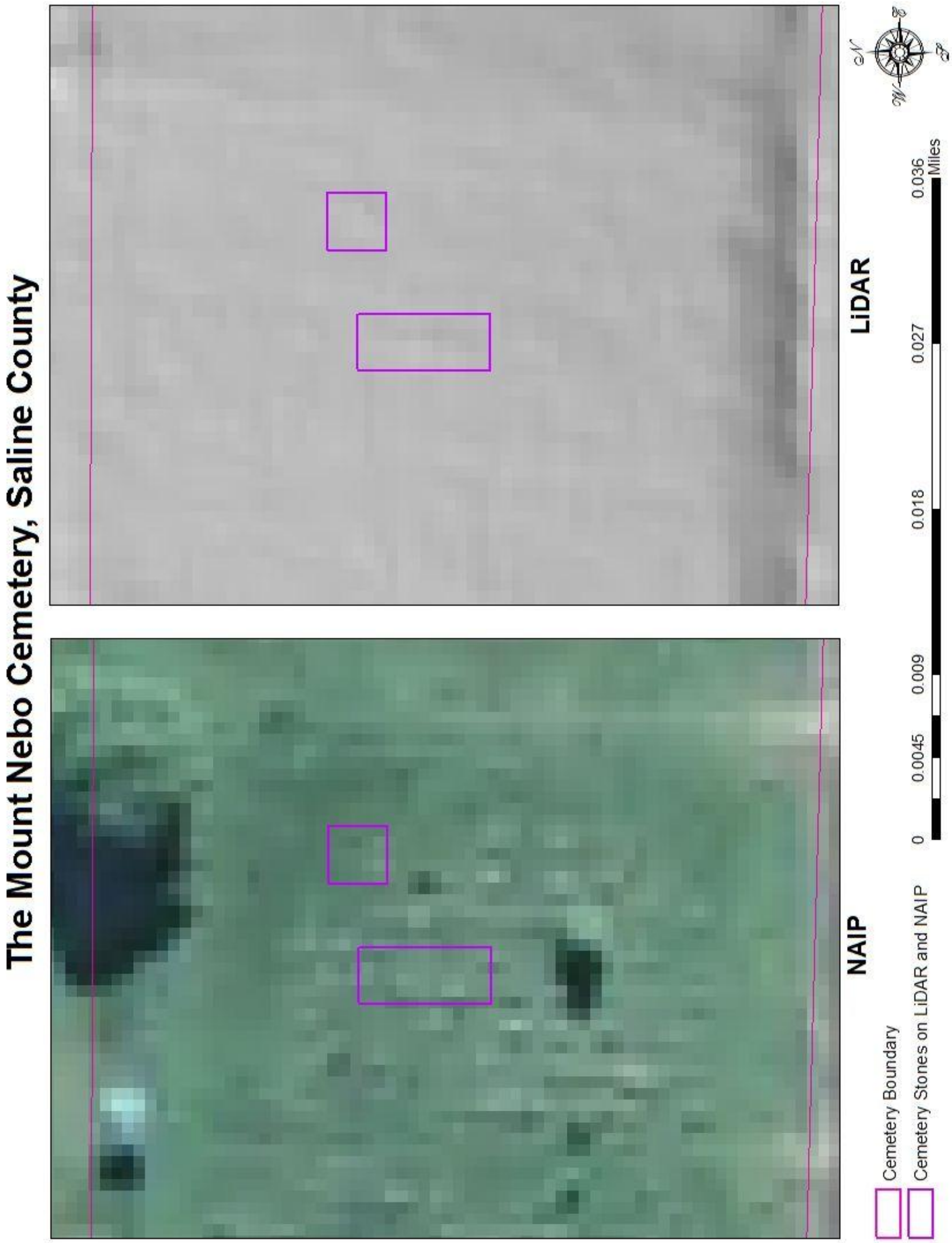


Figure 247.

Imagery of the Oak Hill Cemetery, Carroll County.

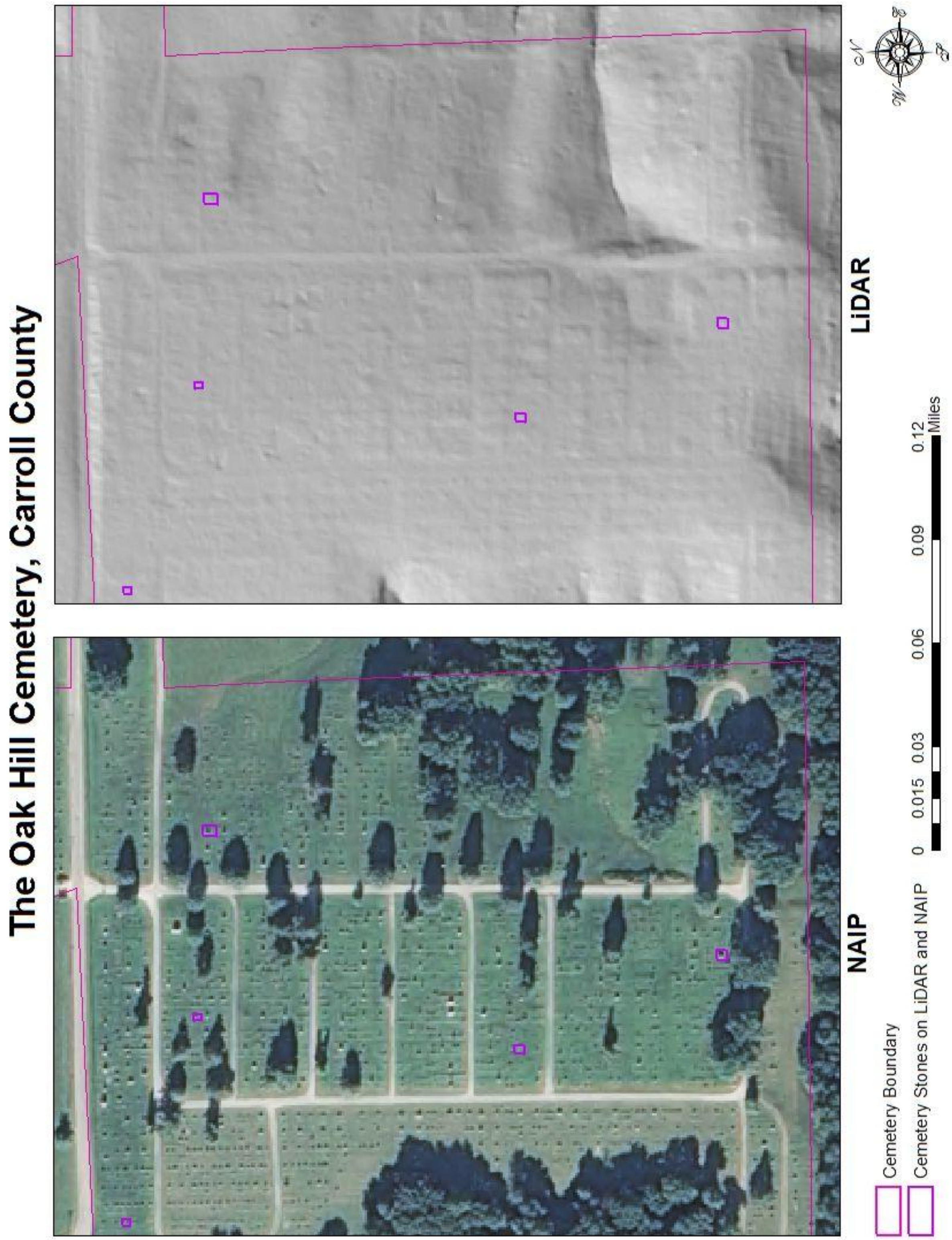


Figure 248.

Imagery of the Odessa Cemetery, Lafayette County.

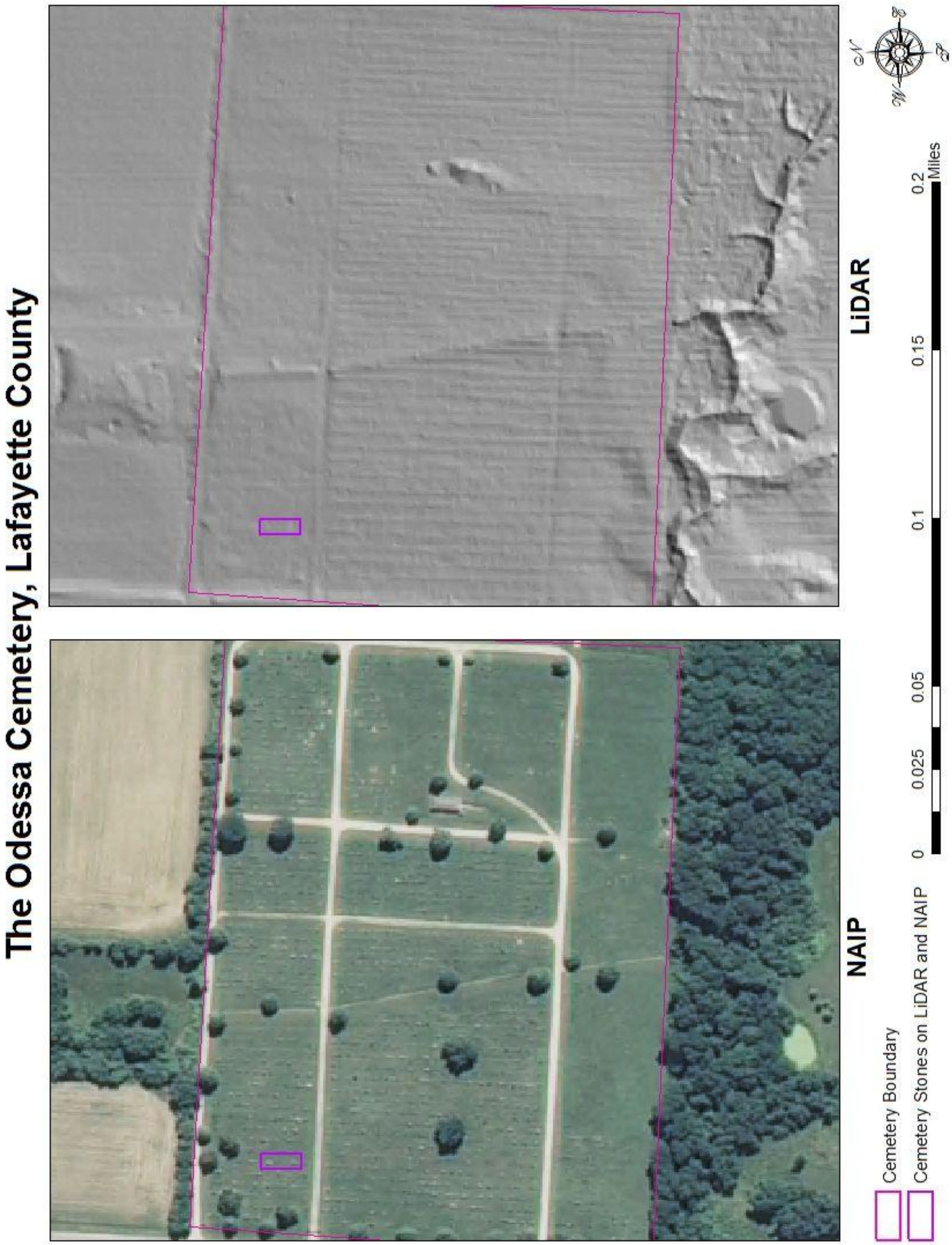


Figure 249.

Imagery of the Ridge Park Cemetery, Saline County.

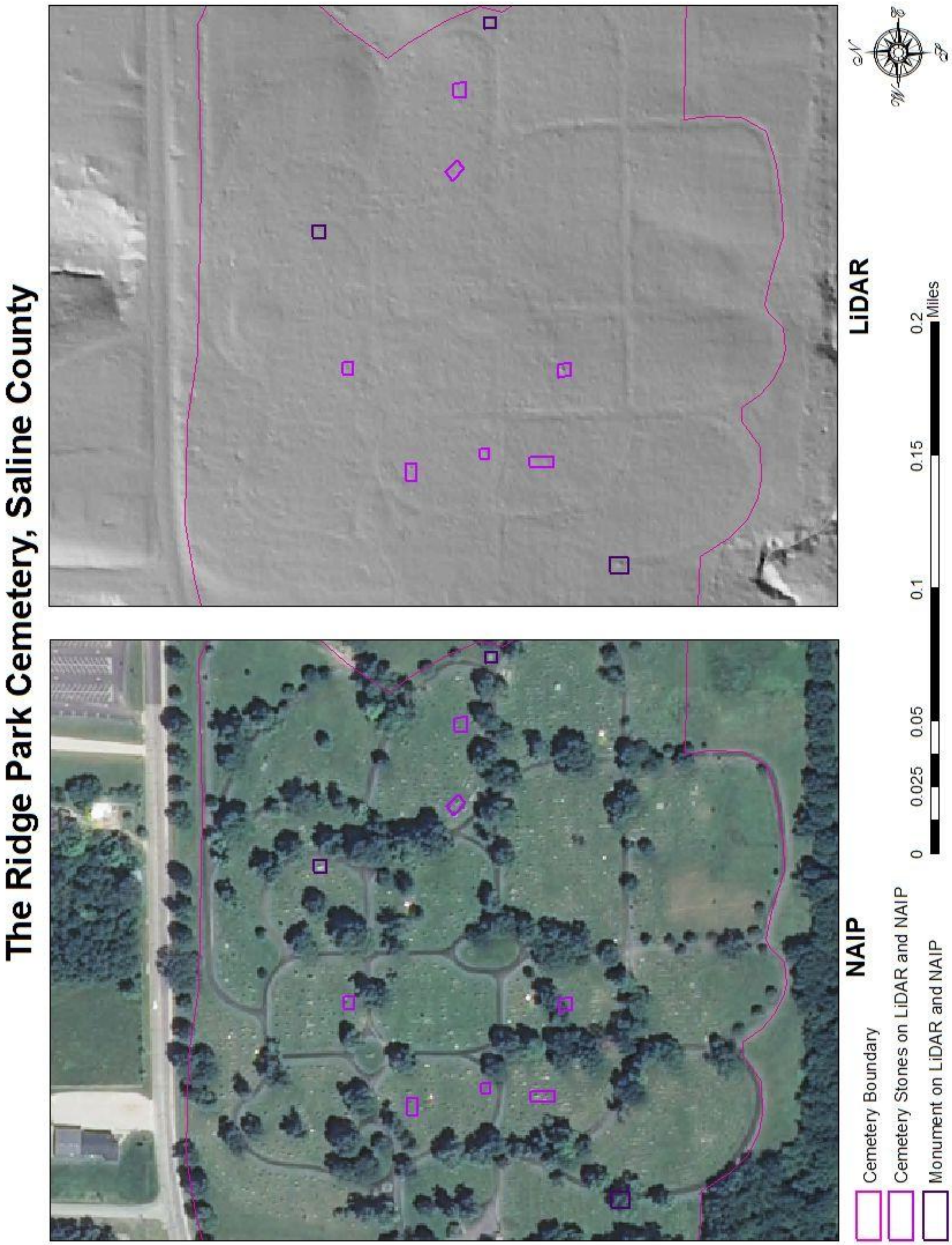


Figure 250.

Imagery of the Sacred Heart Cemetery, Carroll County.

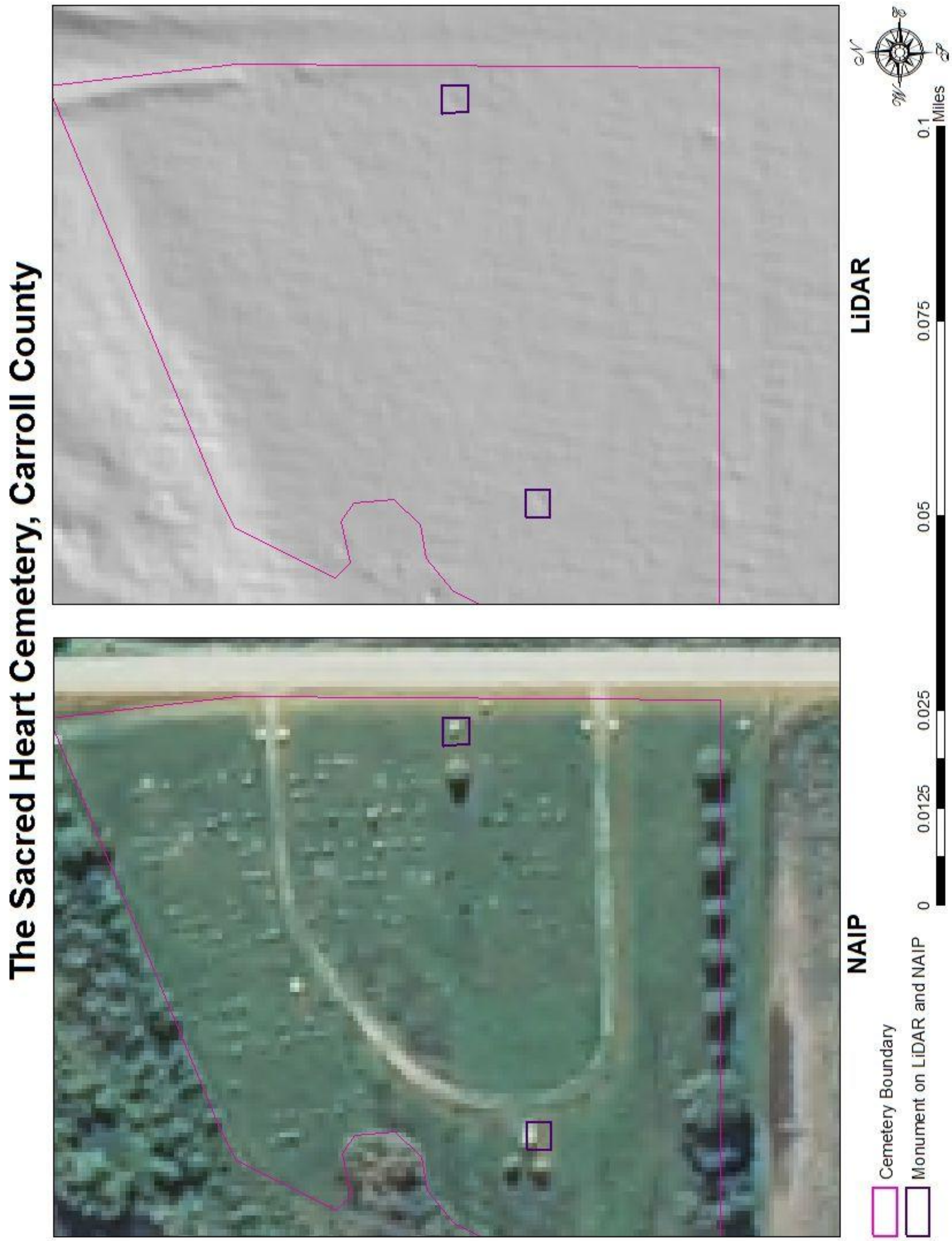


Figure 251.

Imagery of the Salisbury Cemetery, Chariton County.

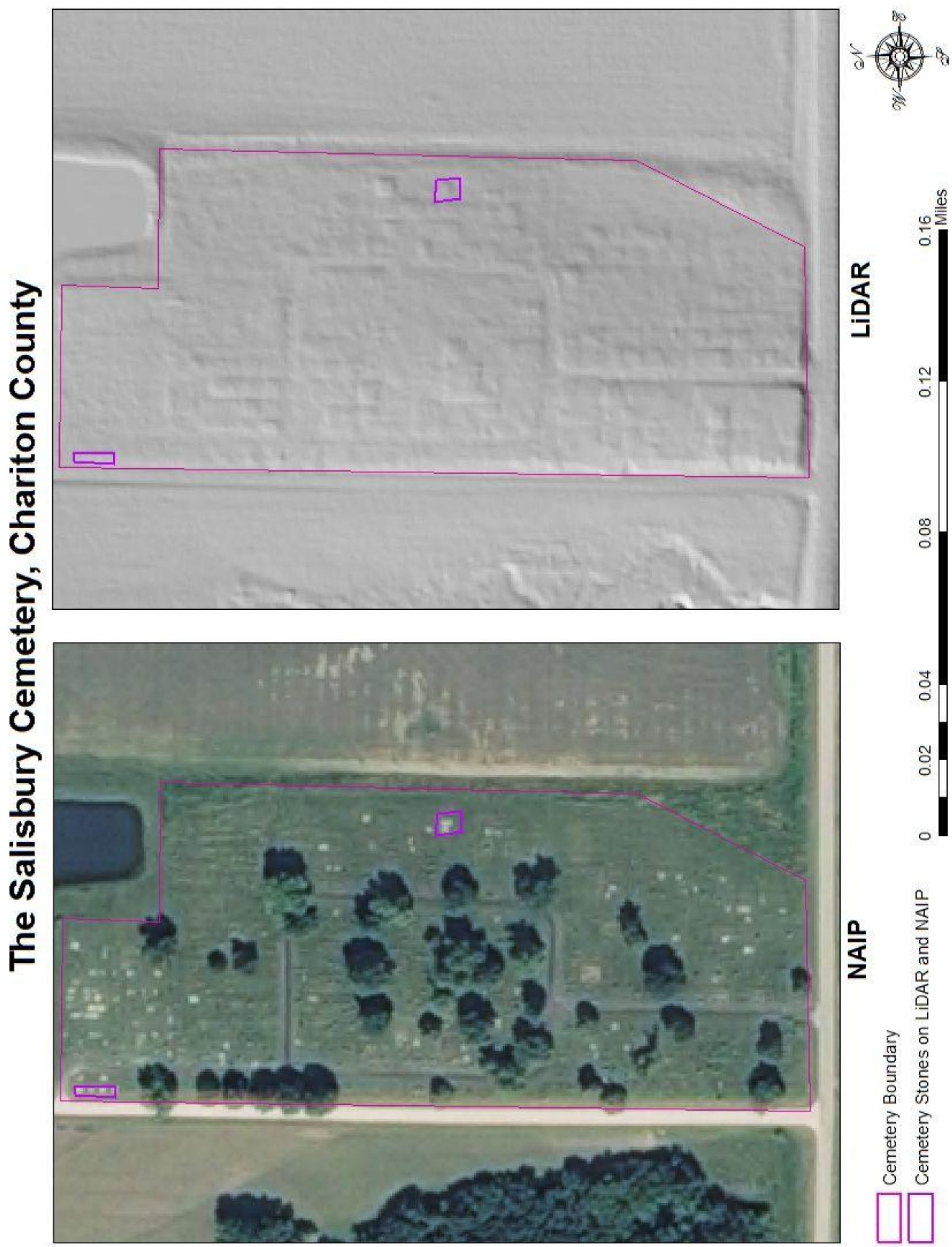


Figure 252.

Imagery of the Shore Cemetery, Lafayette County.

Figure 253.

Imagery of the St. Mary's Cemetery, Chariton County.

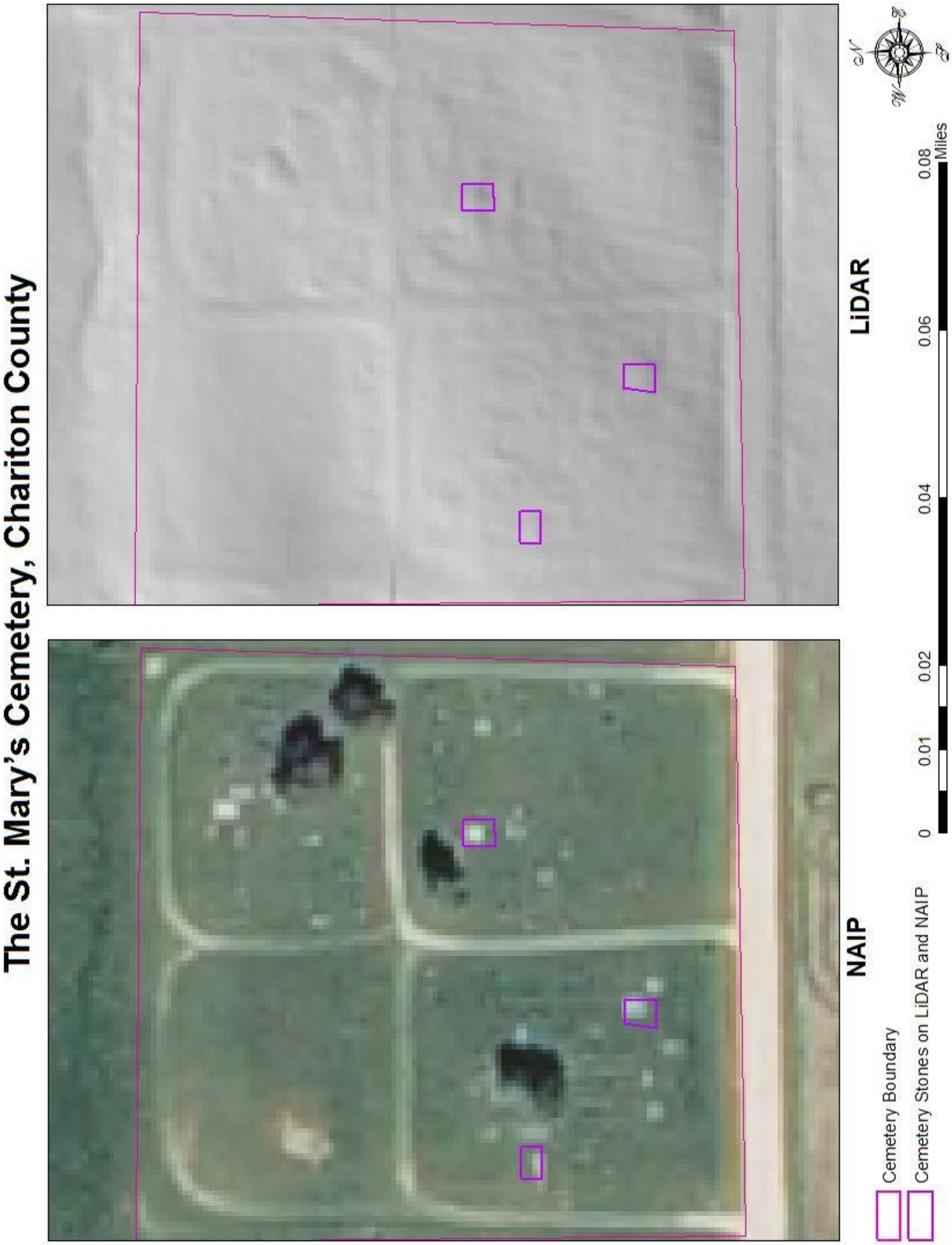


Figure 254.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Cambridge, Saline County.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Chapel Hill, Lafayette County.

Figure 256.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Cunningham, Chariton County.

Figure 257.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Miles Point, Carroll County.

Figure 258.

NAIP imagery at a 70% transparency overlying LiDAR imagery of New Frankfort, Saline County.

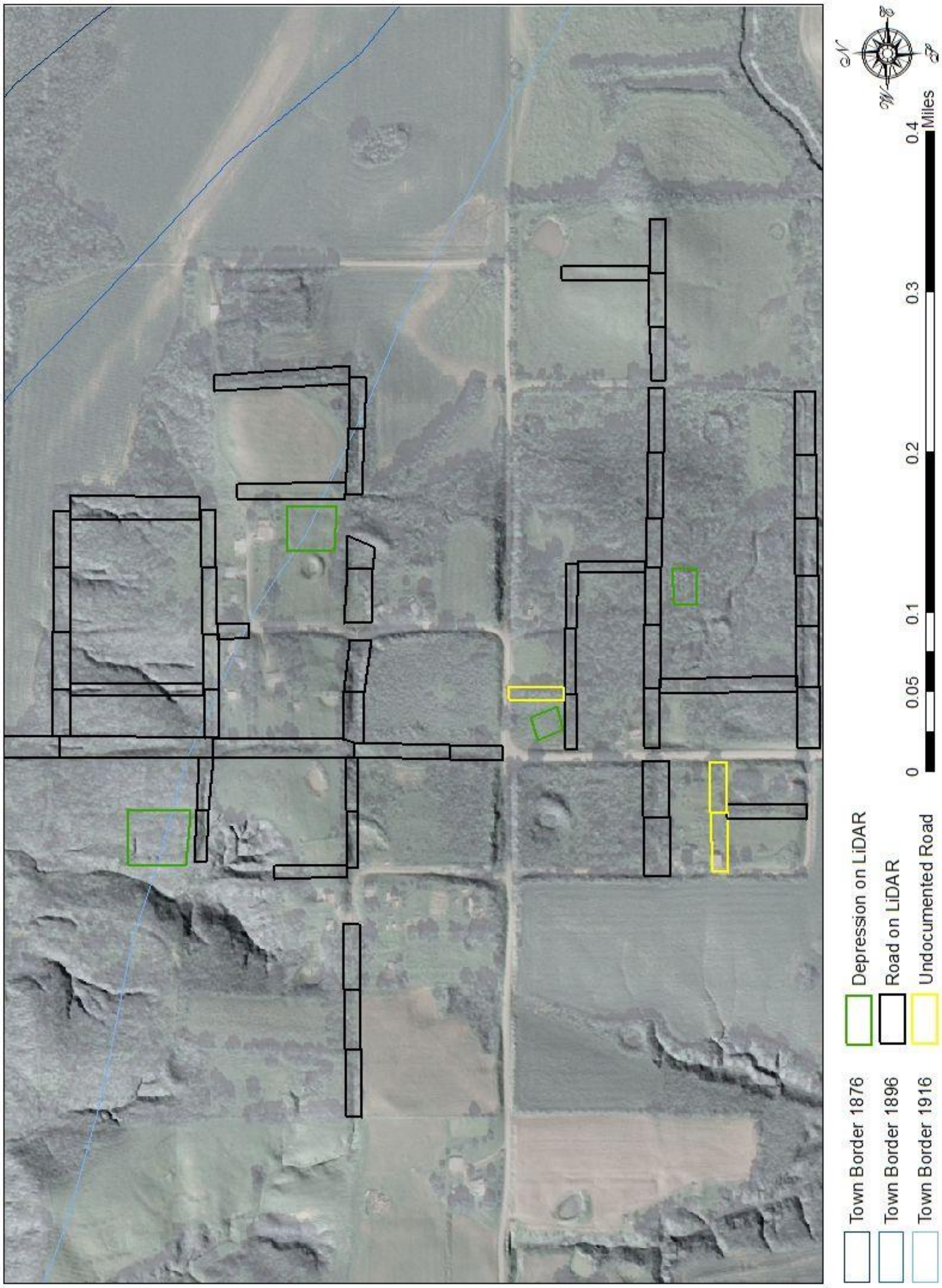


Figure 259.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Saline City, Saline County.

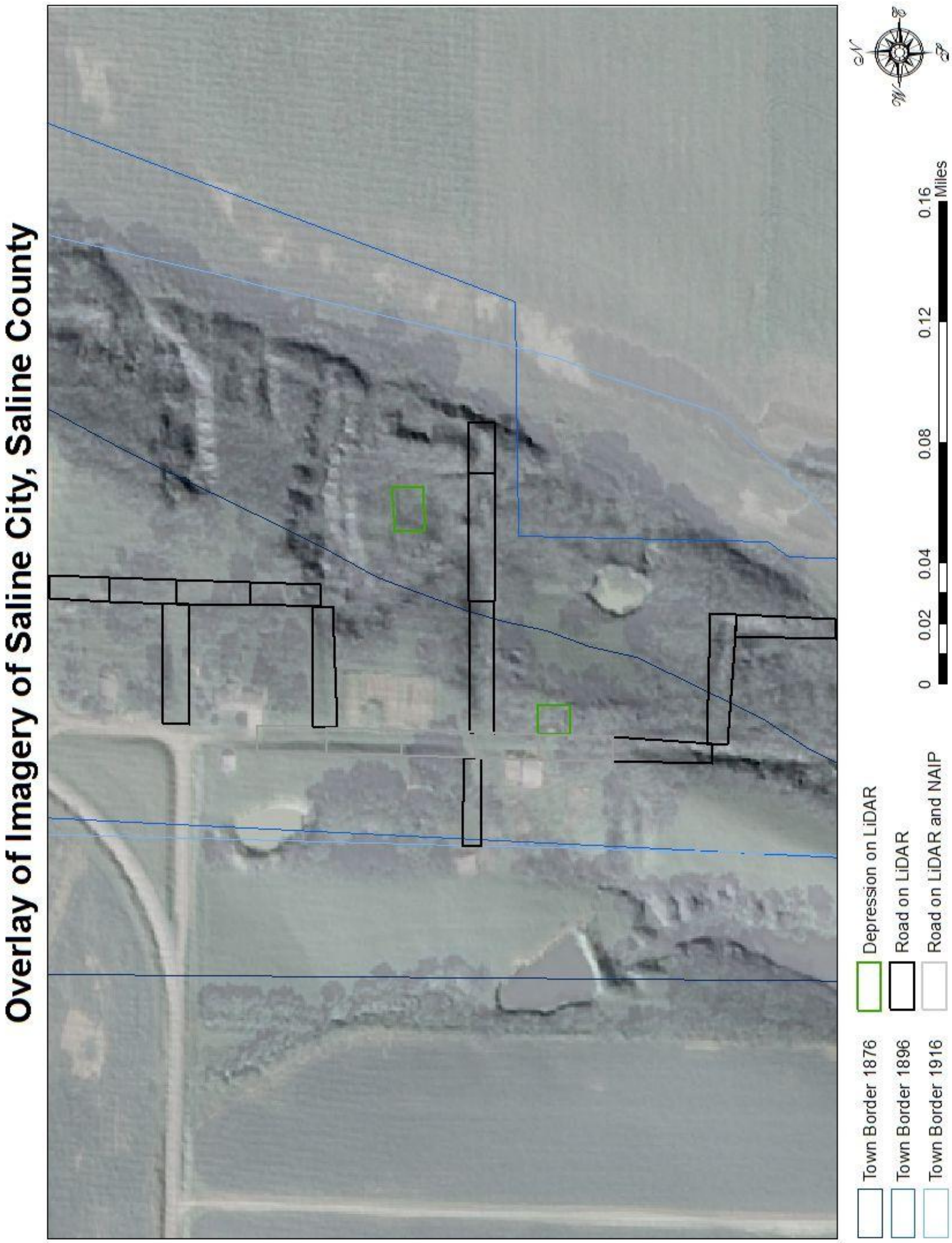


Figure 260.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Shannondale, Chariton County.

Figure 261.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Triplett, Chariton County.

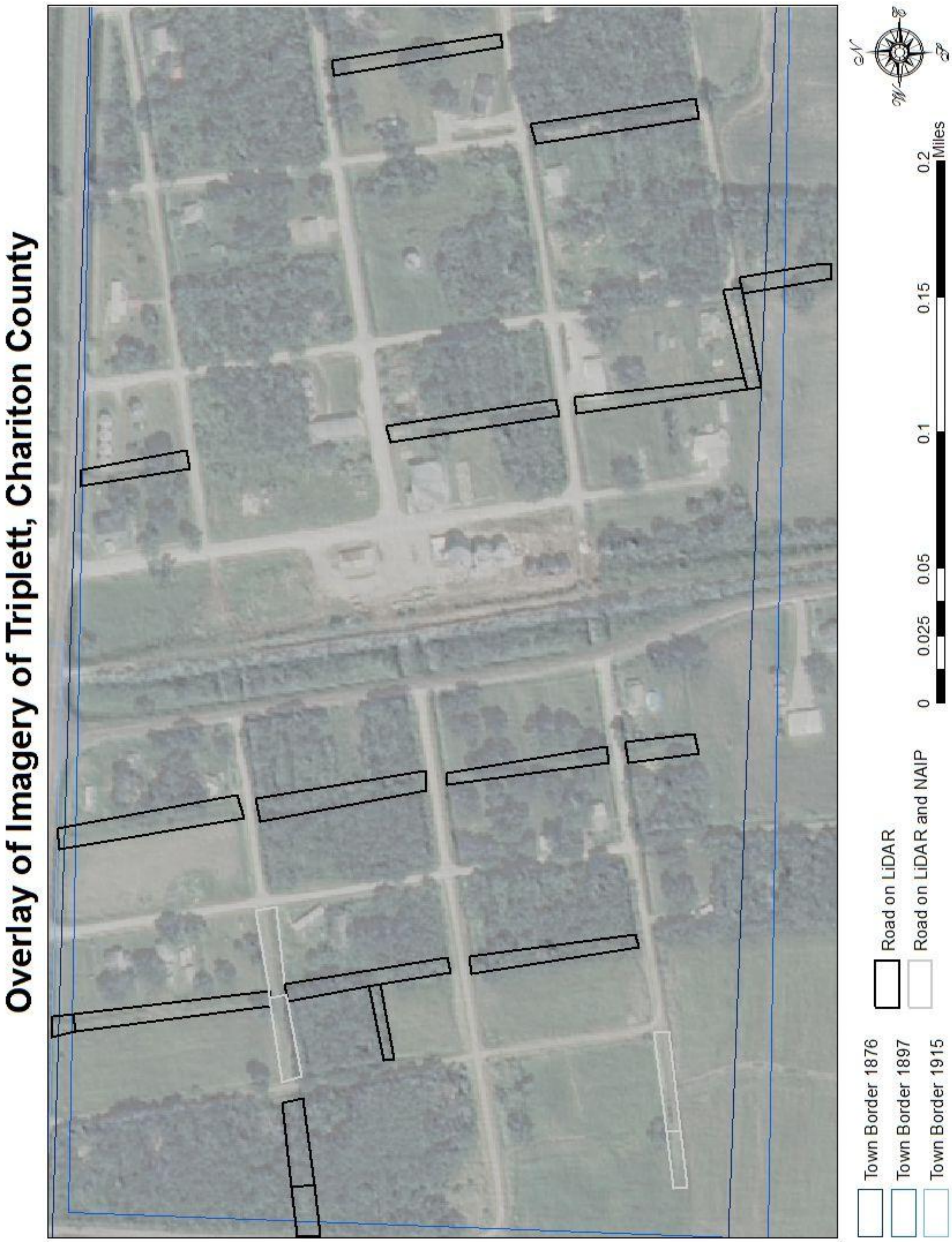


Figure 262.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Wakenda, Carroll County.

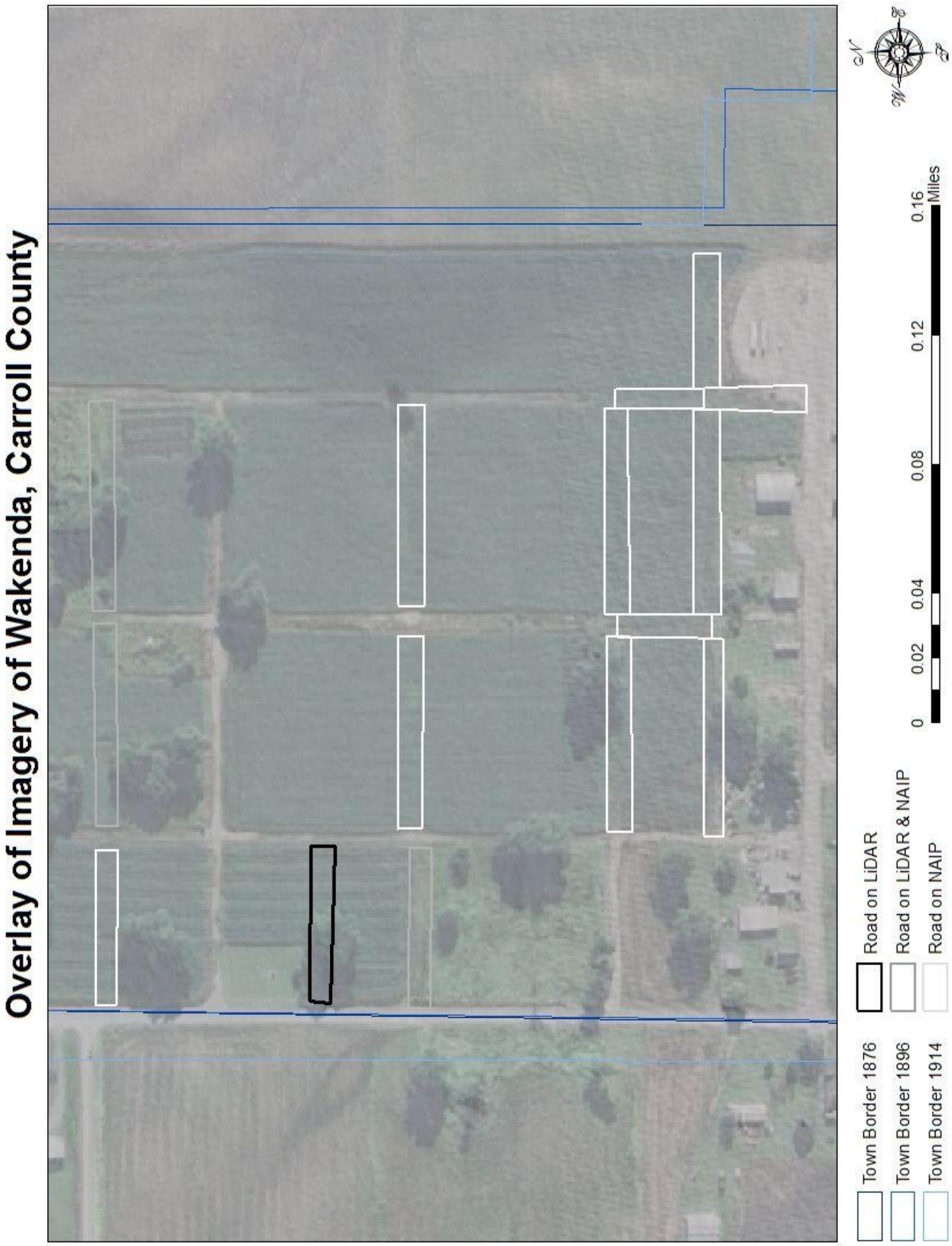


Figure 263.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Wien, Chariton County.

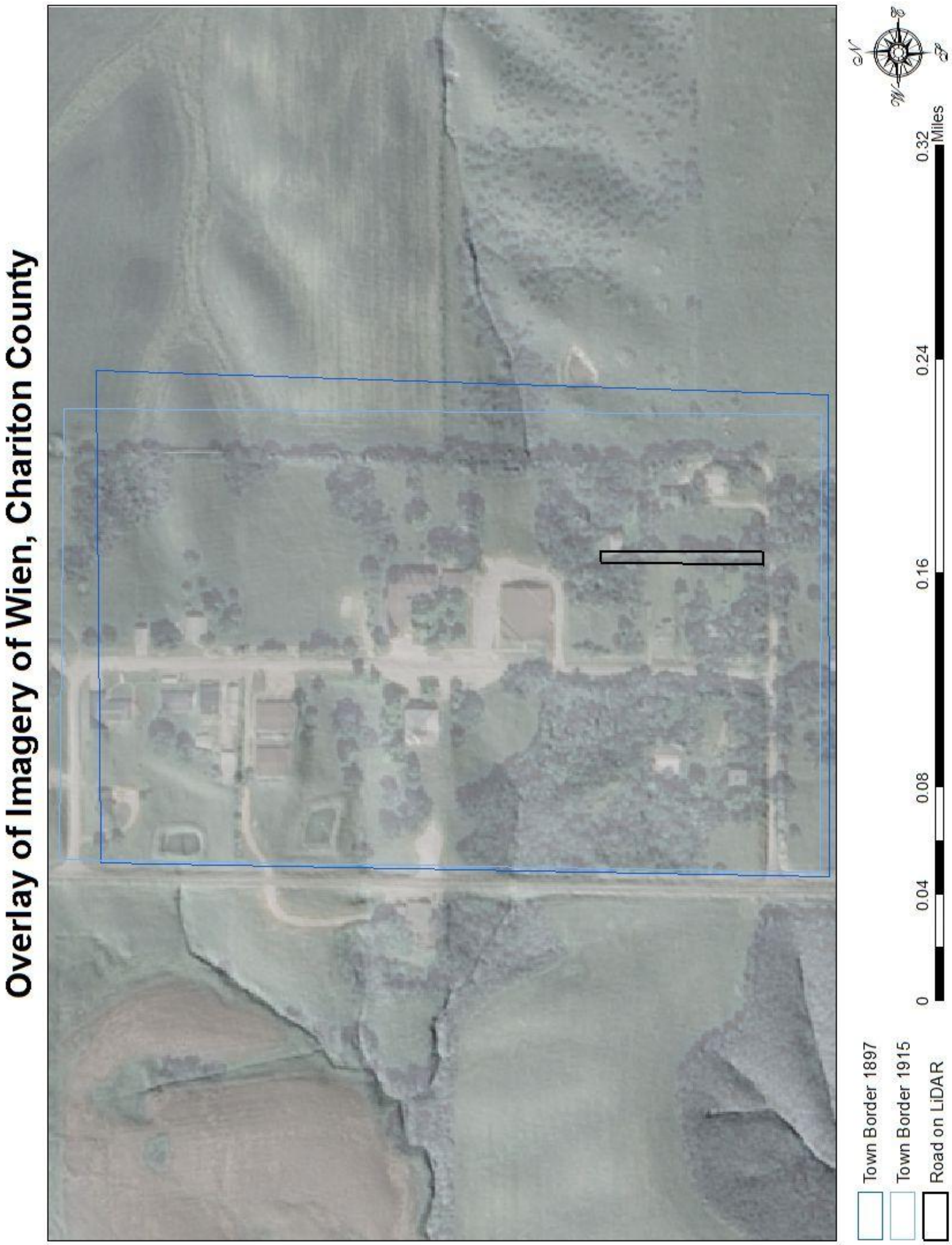


Figure 264.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Coloma, Carroll County.

Figure 265.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Berlin, Lafayette County.

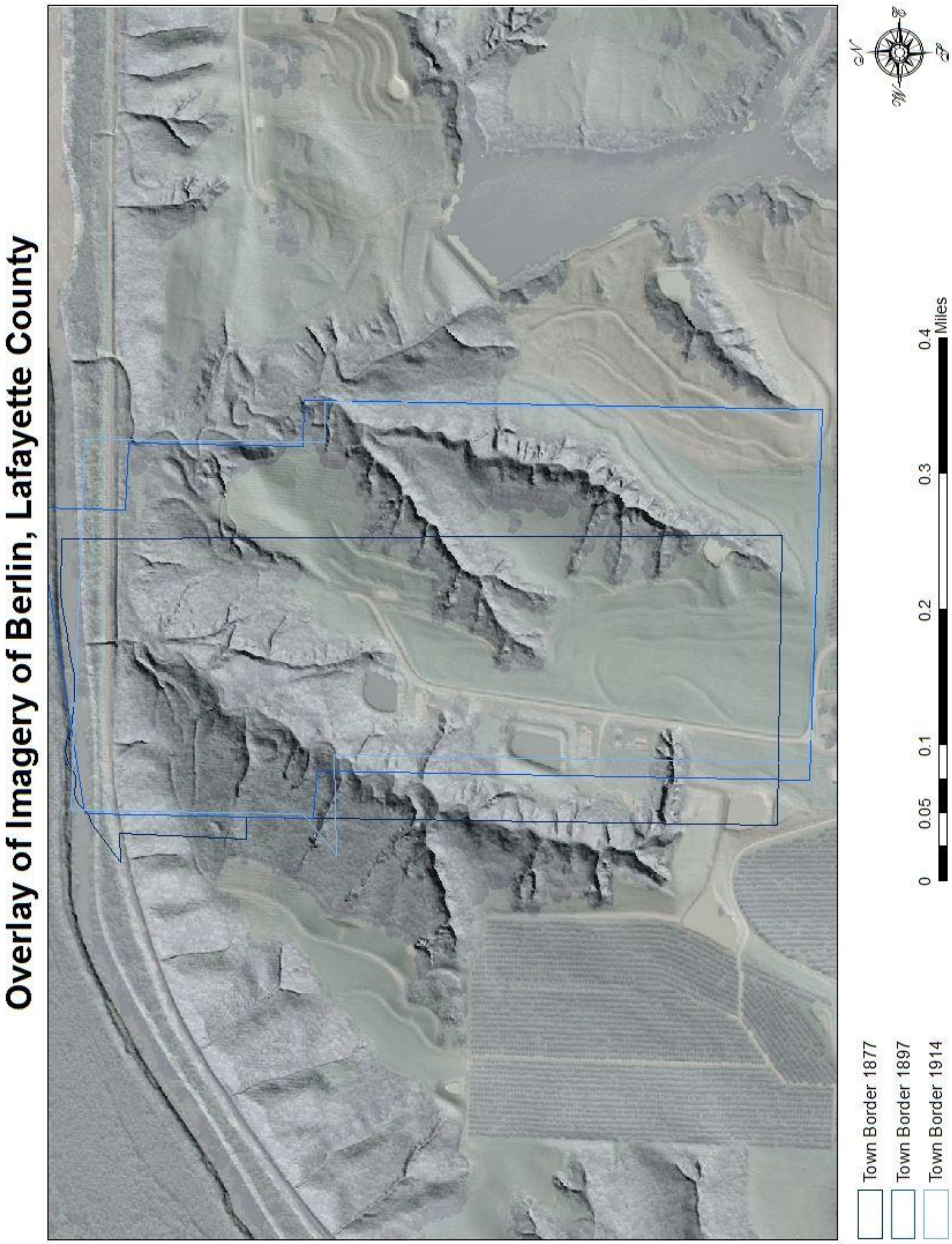


Figure 266.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Elmwood, Saline County.

Figure 267.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Hodge, Lafayette County.

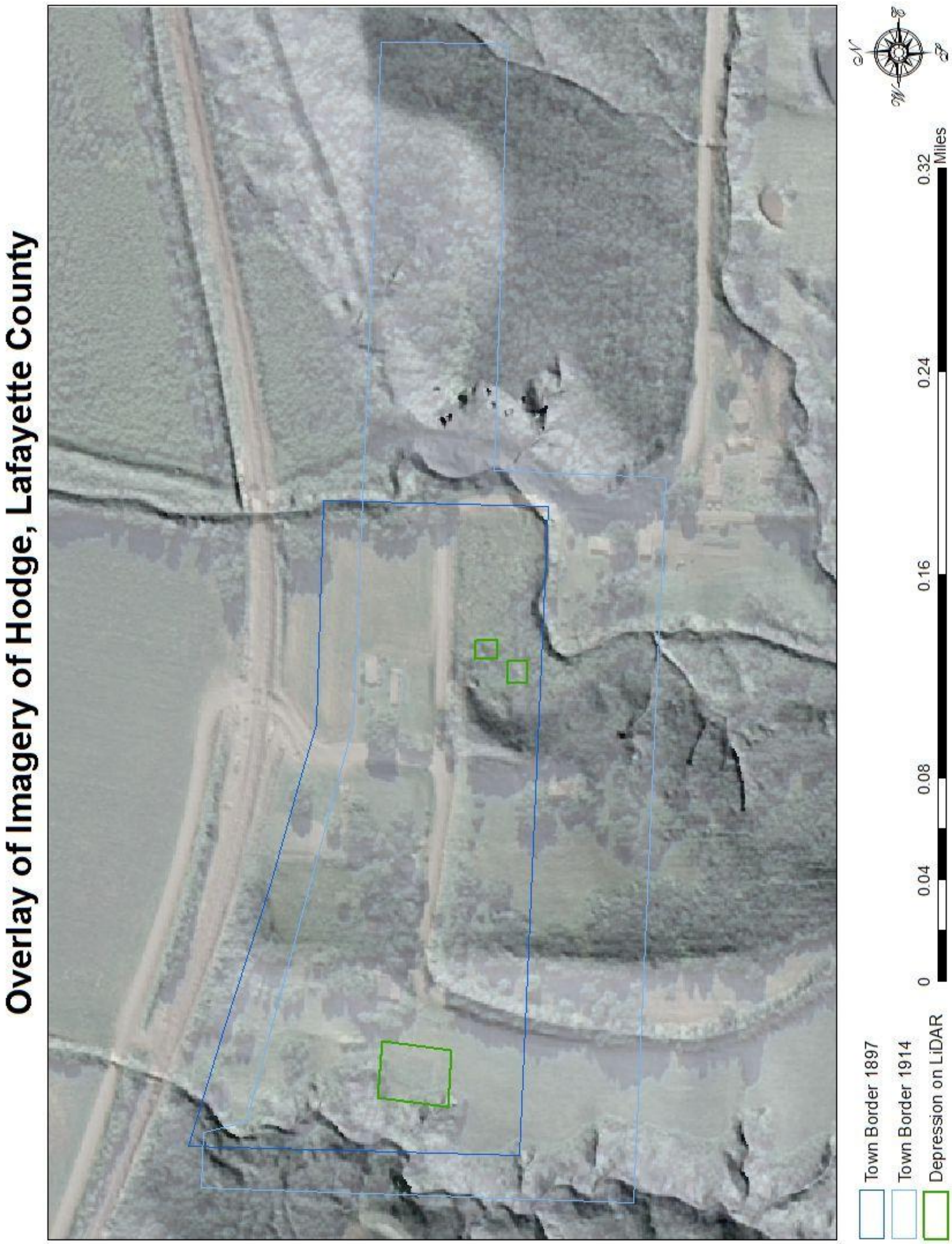


Figure 268.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Laynesville, Saline County.

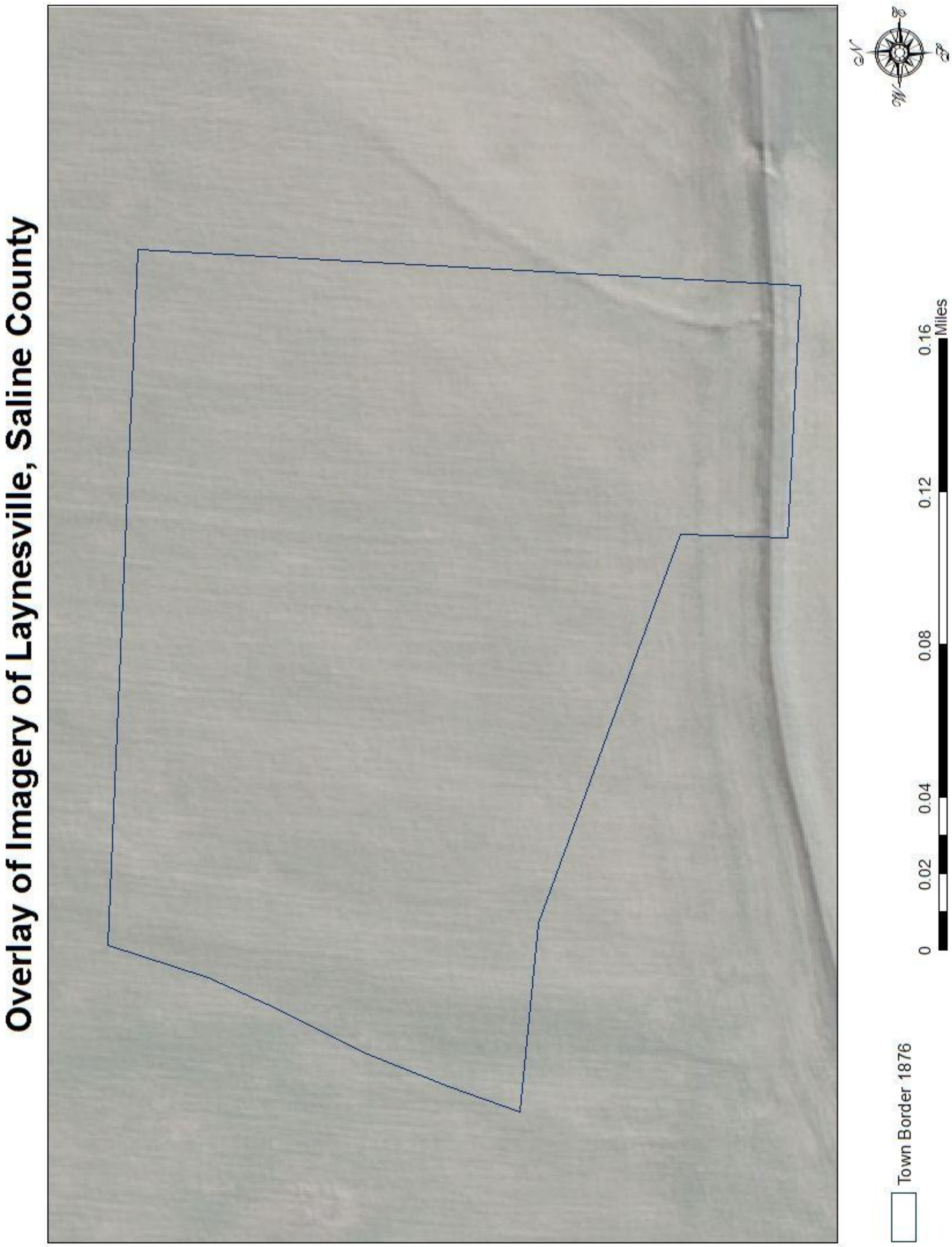


Figure 269.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Miami Station, Carroll County.

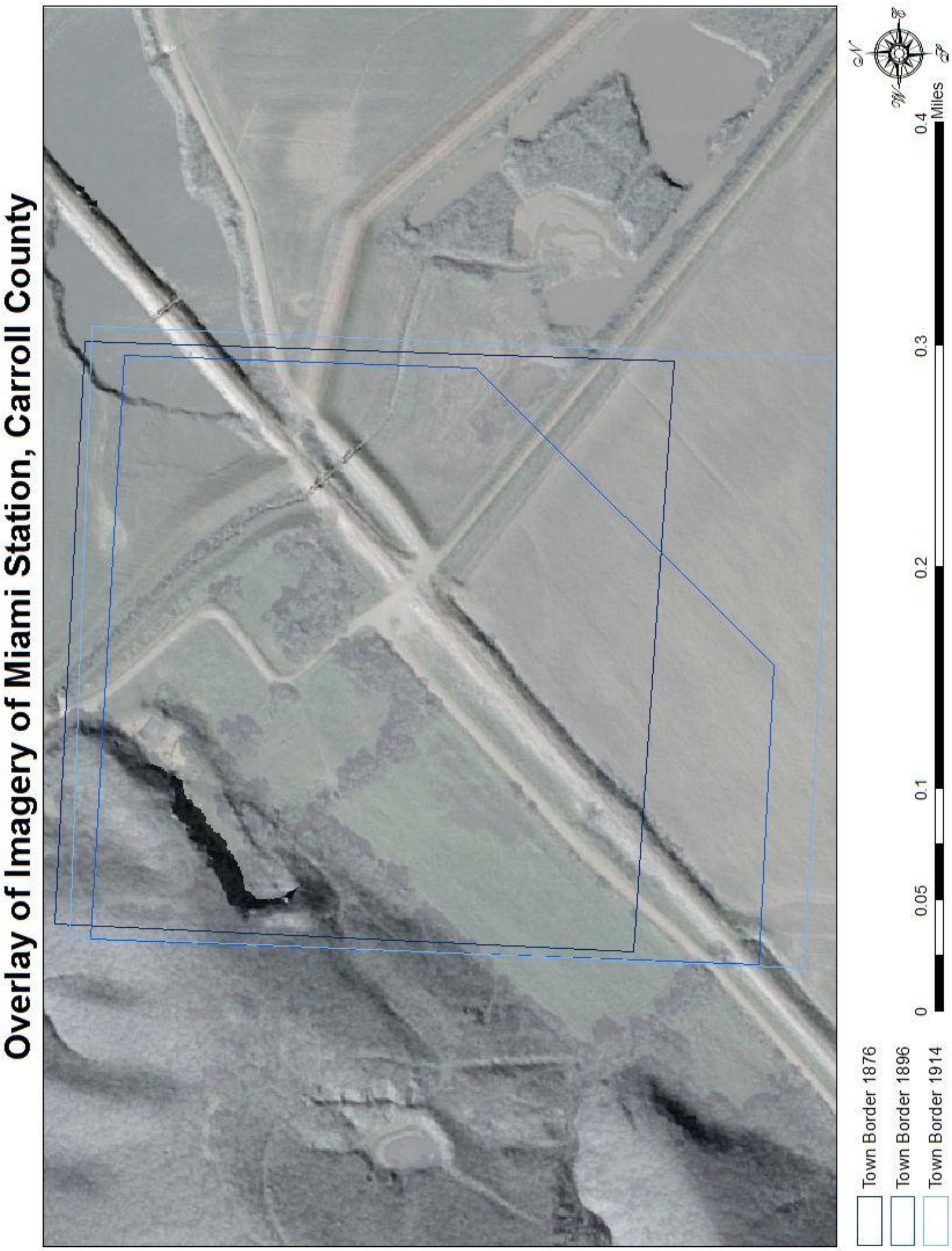


Figure 270.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Mt. Hope, Lafayette County.

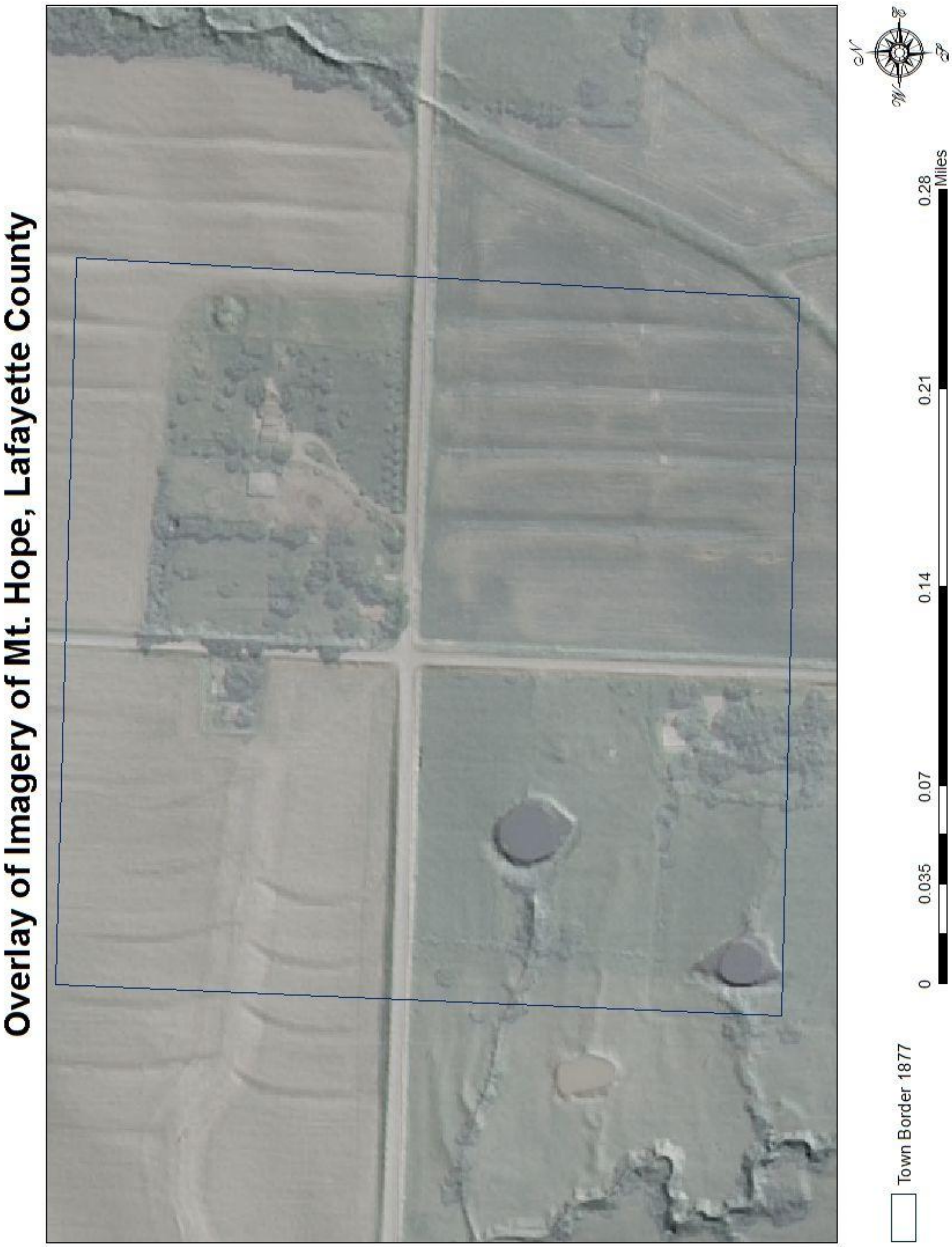


Figure 271.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Old Mendon, Chariton County.

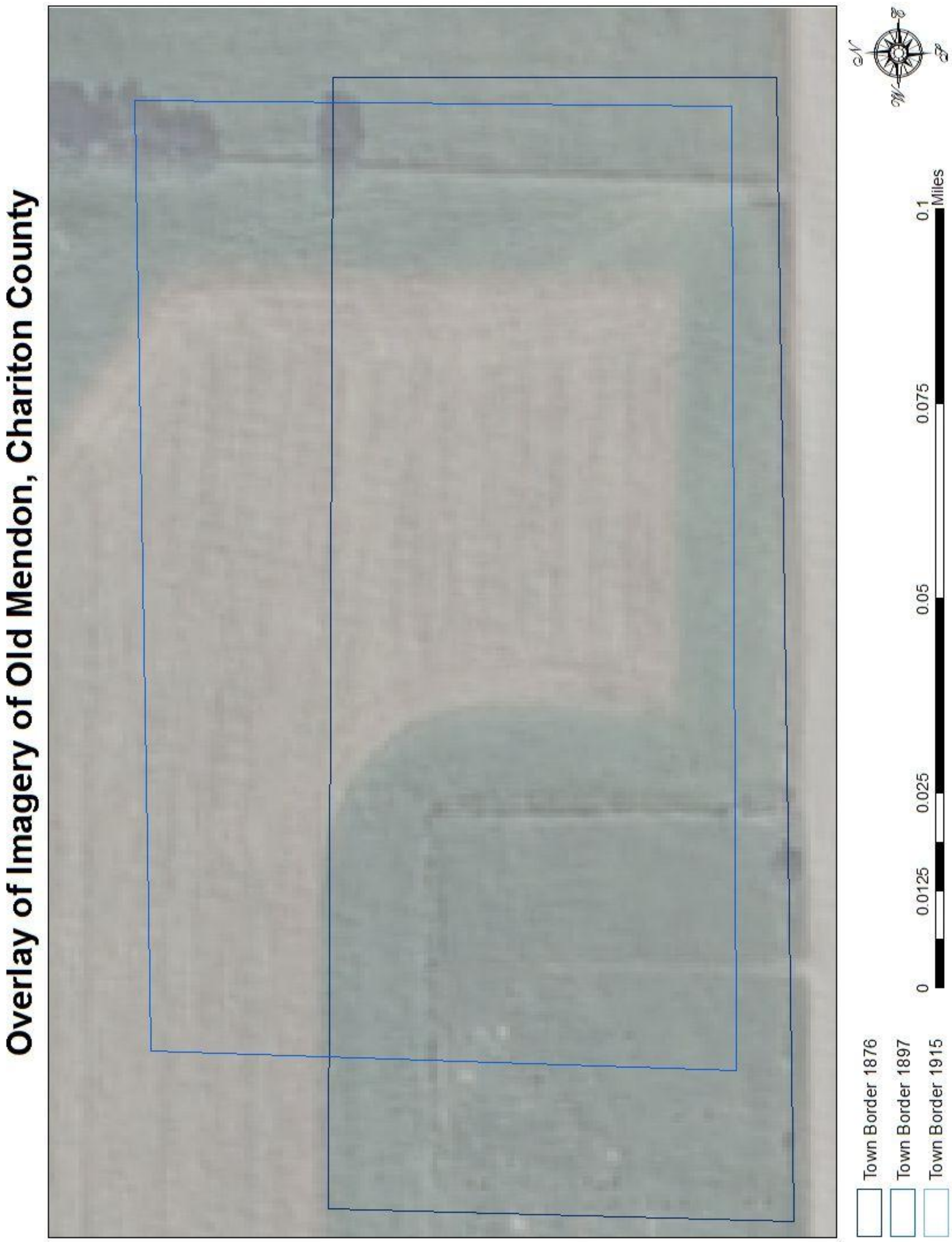


Figure 272.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Plymouth, Carroll County.

Figure 273.

NAIP imagery at a 70% transparency overlying LiDAR imagery of Salina, Saline County.

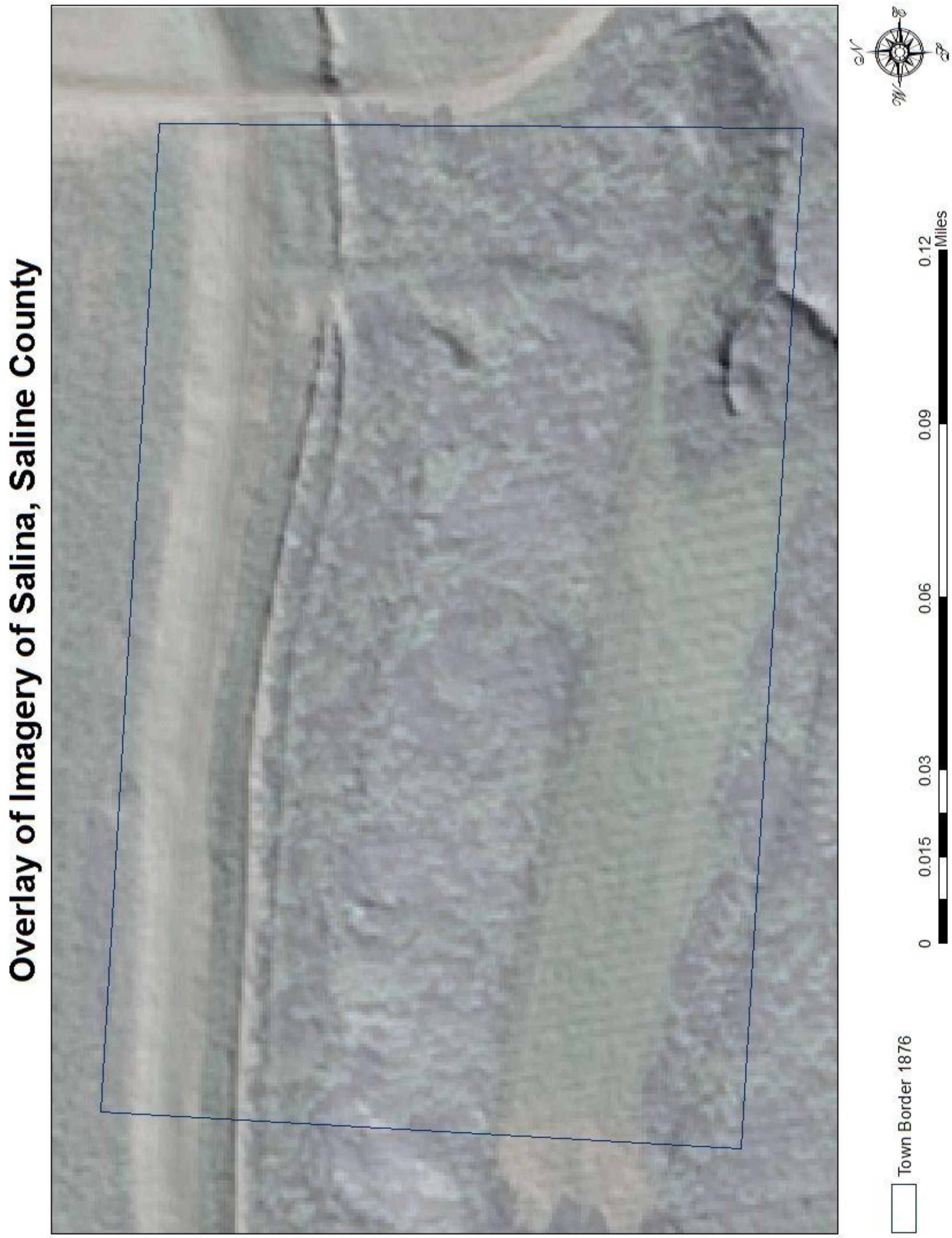


Figure 274.

NAIP imagery at a 70% transparency overlying LiDAR imagery showing the northern depressions in New Frankfort, Saline County.

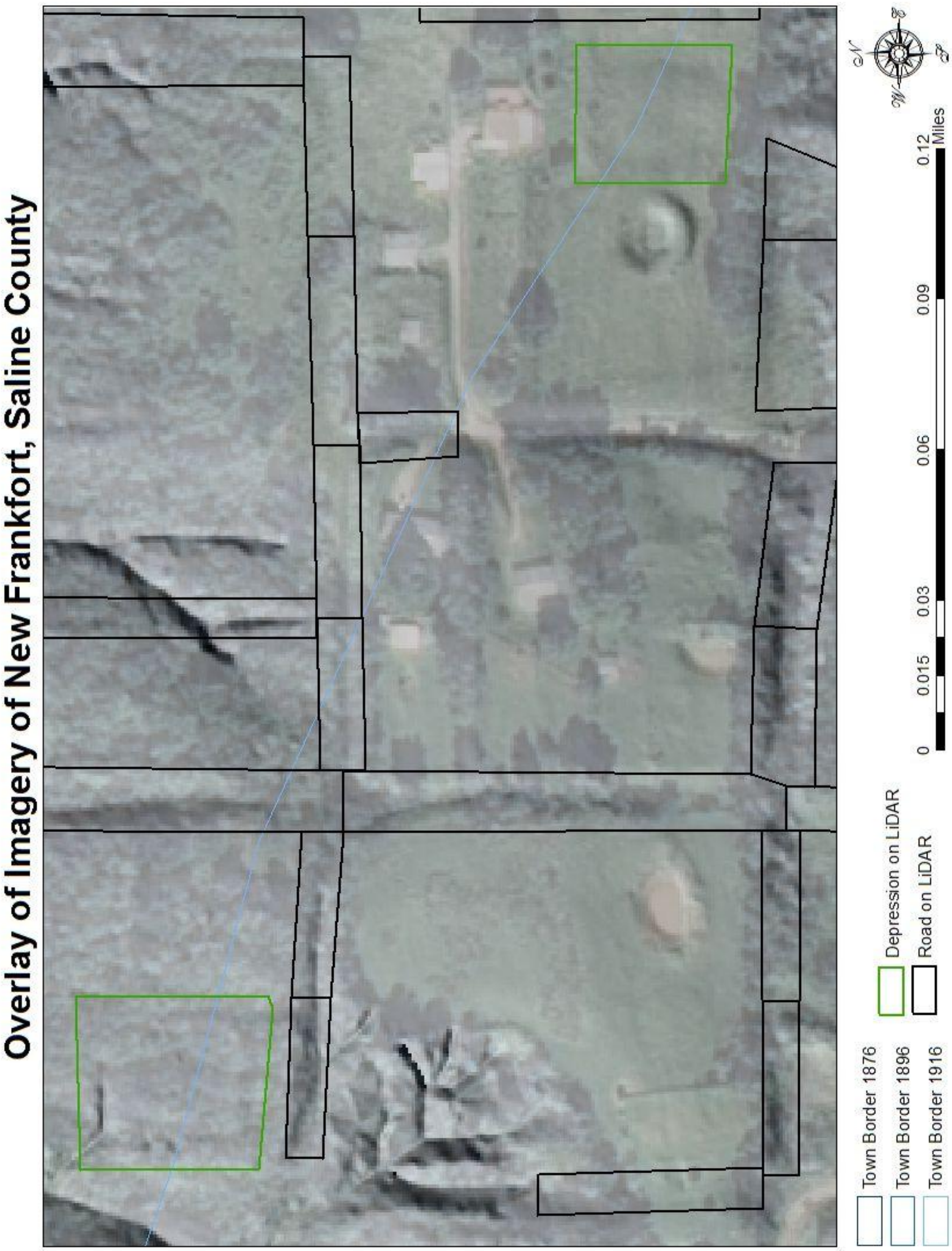


Figure 275.

NAIP imagery at a 70% transparency overlying LiDAR imagery showing the southern depressions in New Frankfort, Saline County.

Figure 276.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the depressions in Saline City, Saline County.

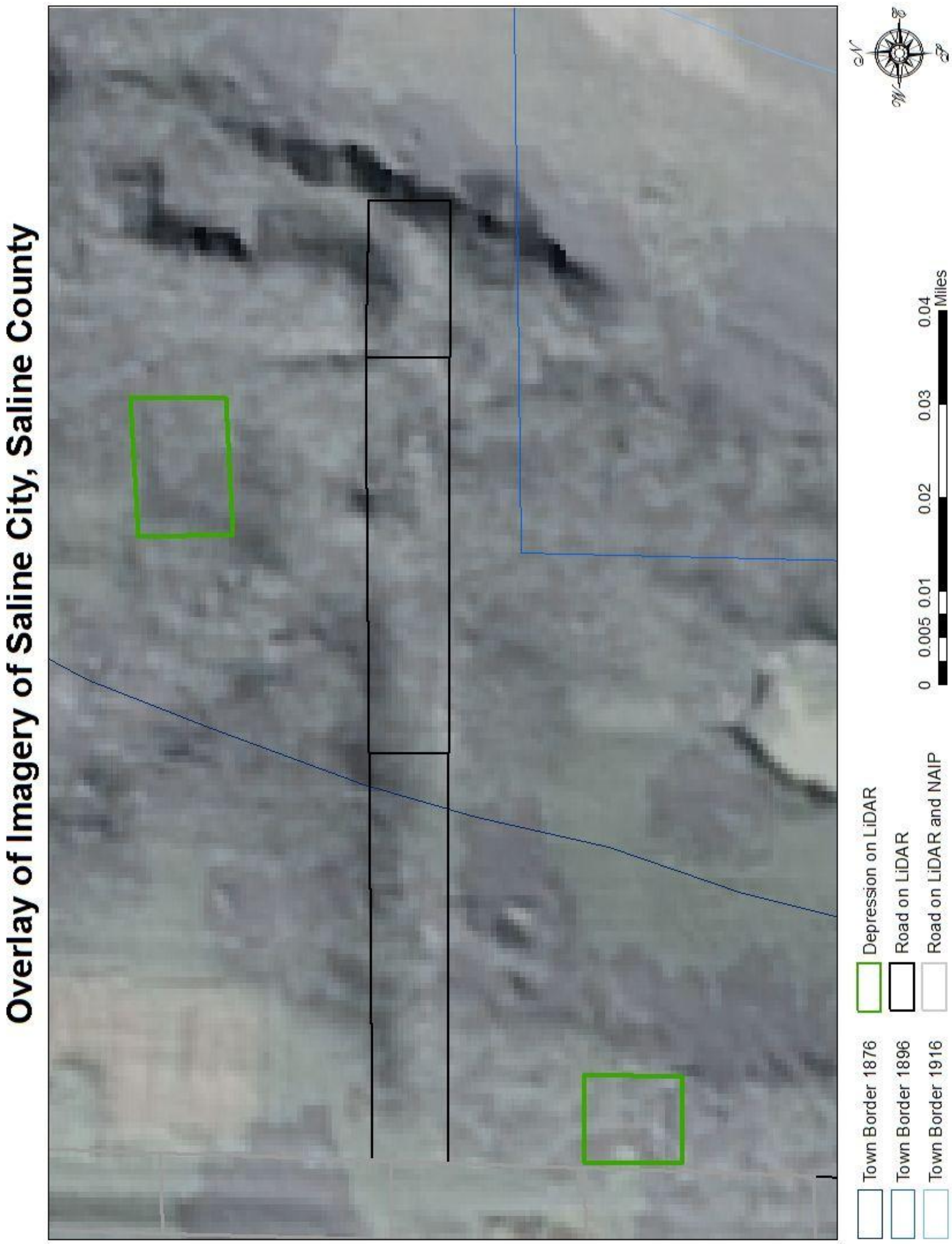


Figure 277.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the rail bed of the Brunswick, Chillicothe, and Omaha Railroad.

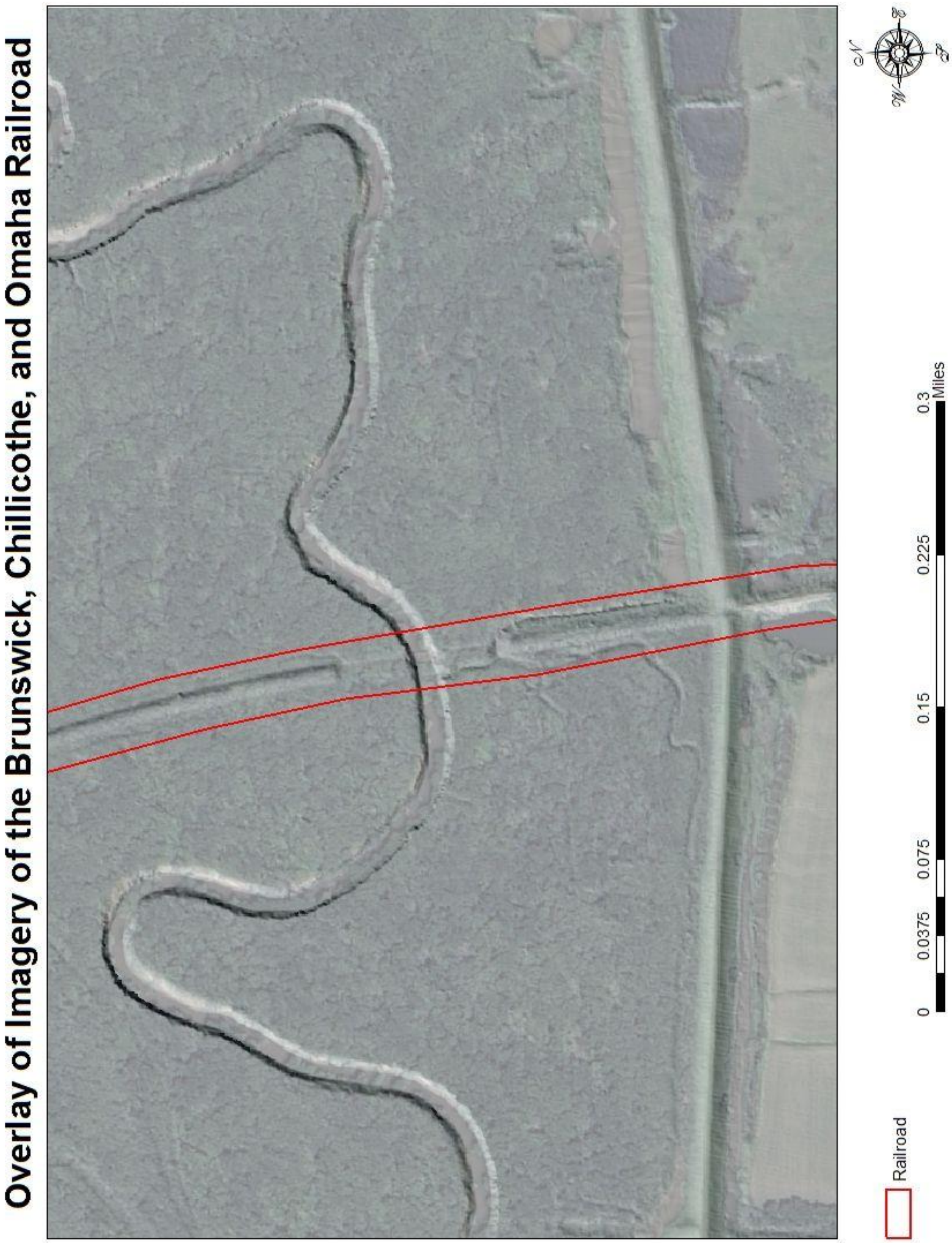


Figure 278.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the tree covered rail bed of the Brunswick, Chillicothe, and Omaha Railroad.

Figure 279.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the abandoned rail bed of the Chicago, Burlington, and Quincy Railroad.

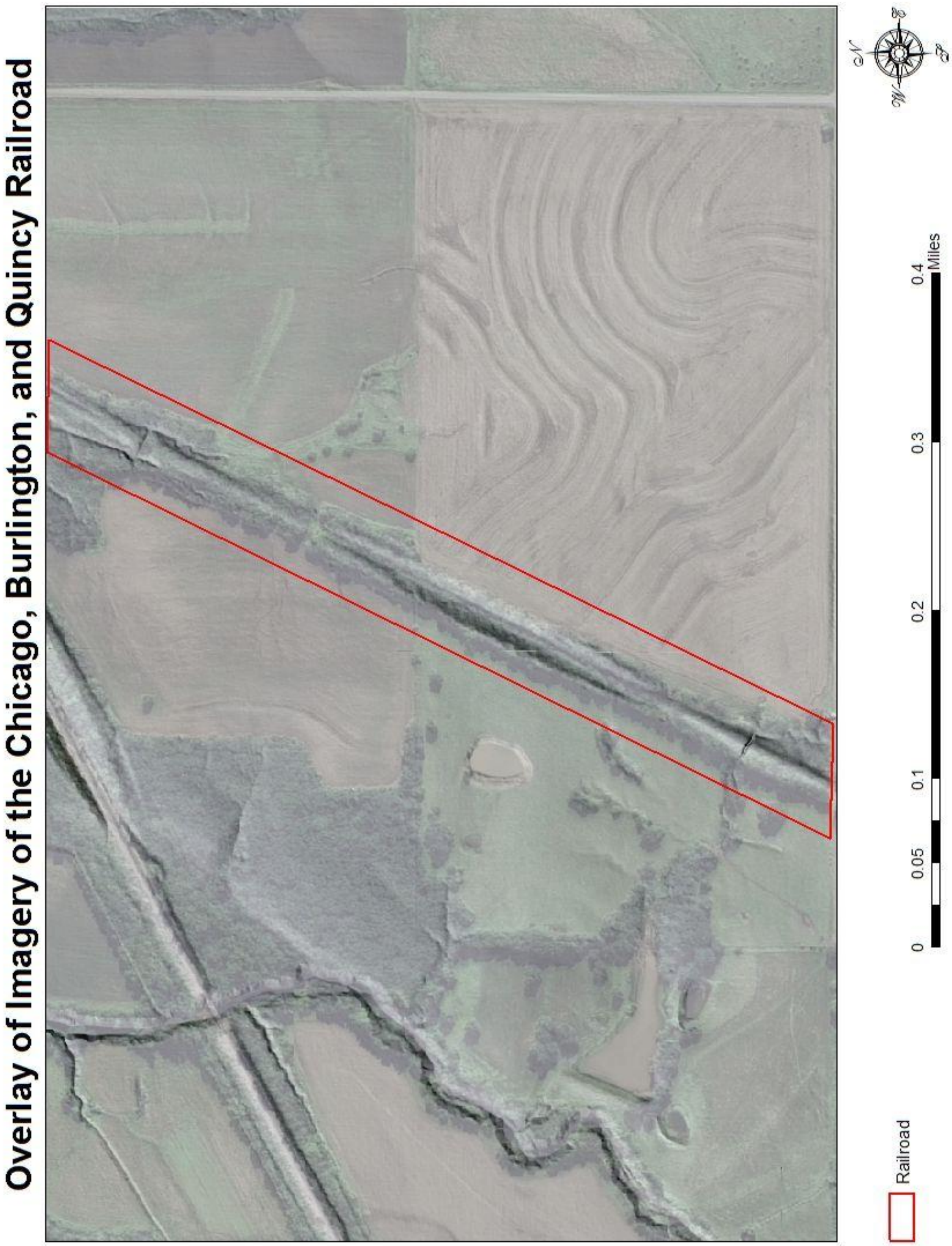


Figure 280.

NAIP imagery at a 70% transparency overlying LiDAR imagery of a rise in the rail bed of the Keokuk and Kansas City Railroad.

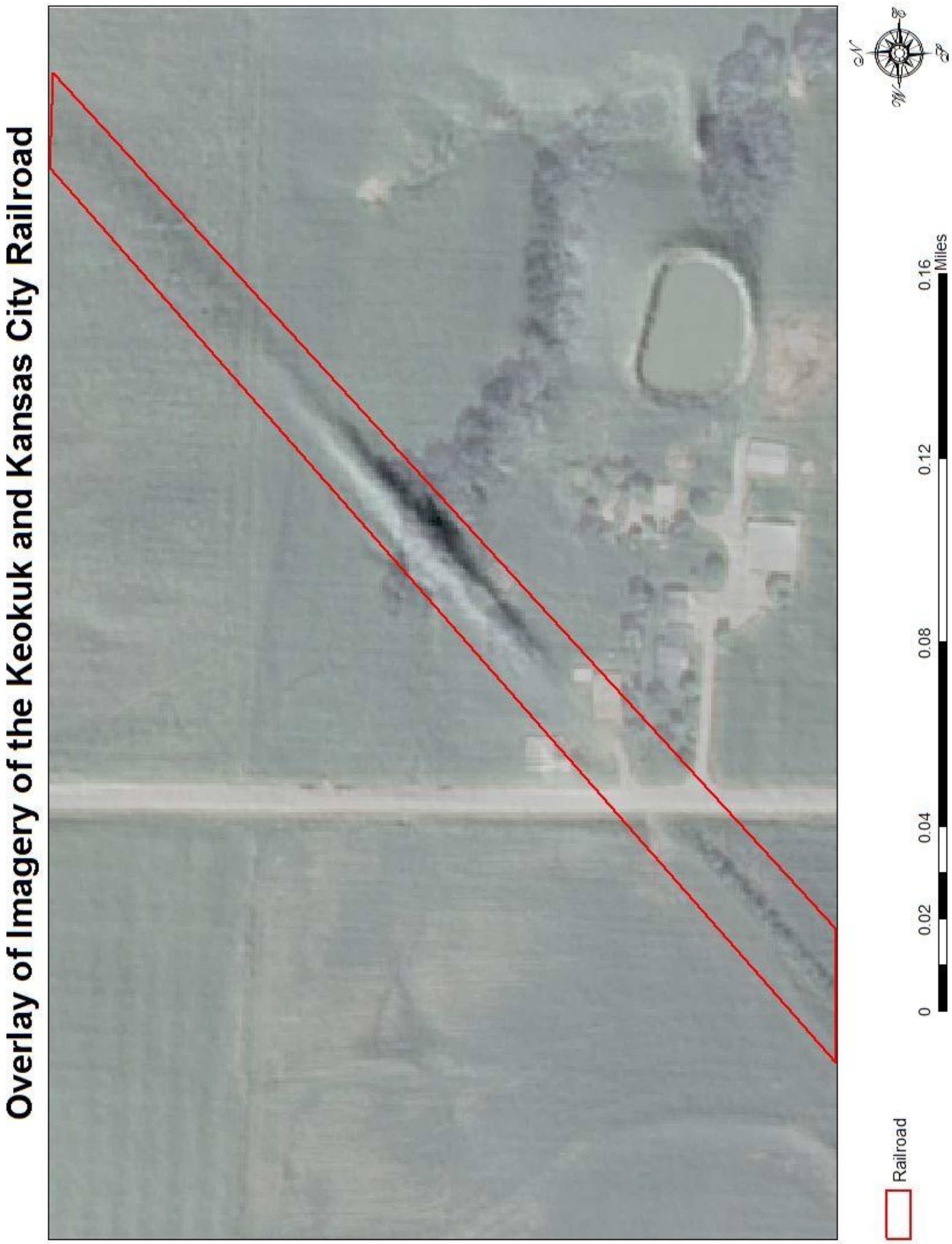


Figure 281.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the abandoned rail bed of the Lexington and St. Louis Railroad.

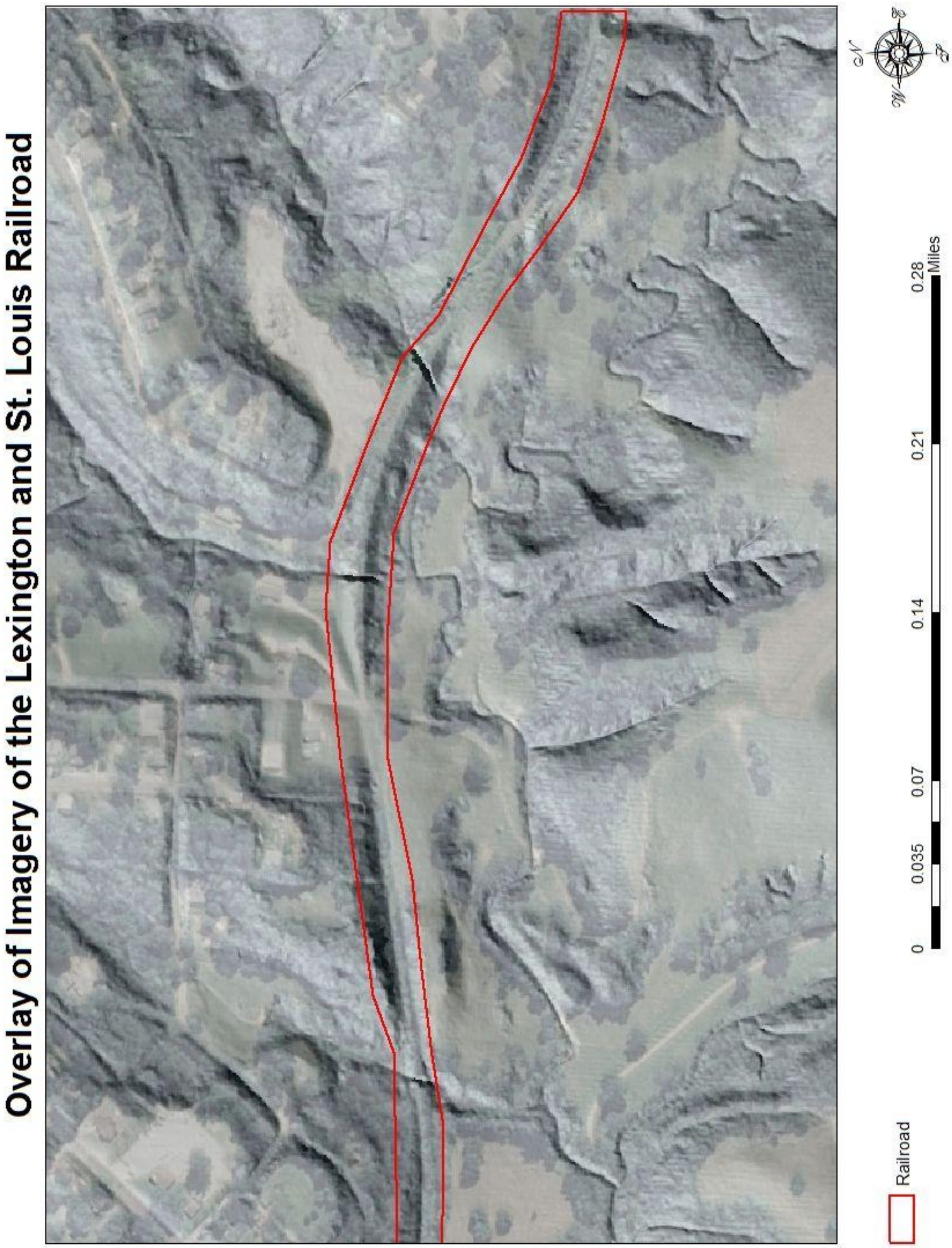


Figure 282.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the abandoned rail bed of the Rocky Branch Railroad.

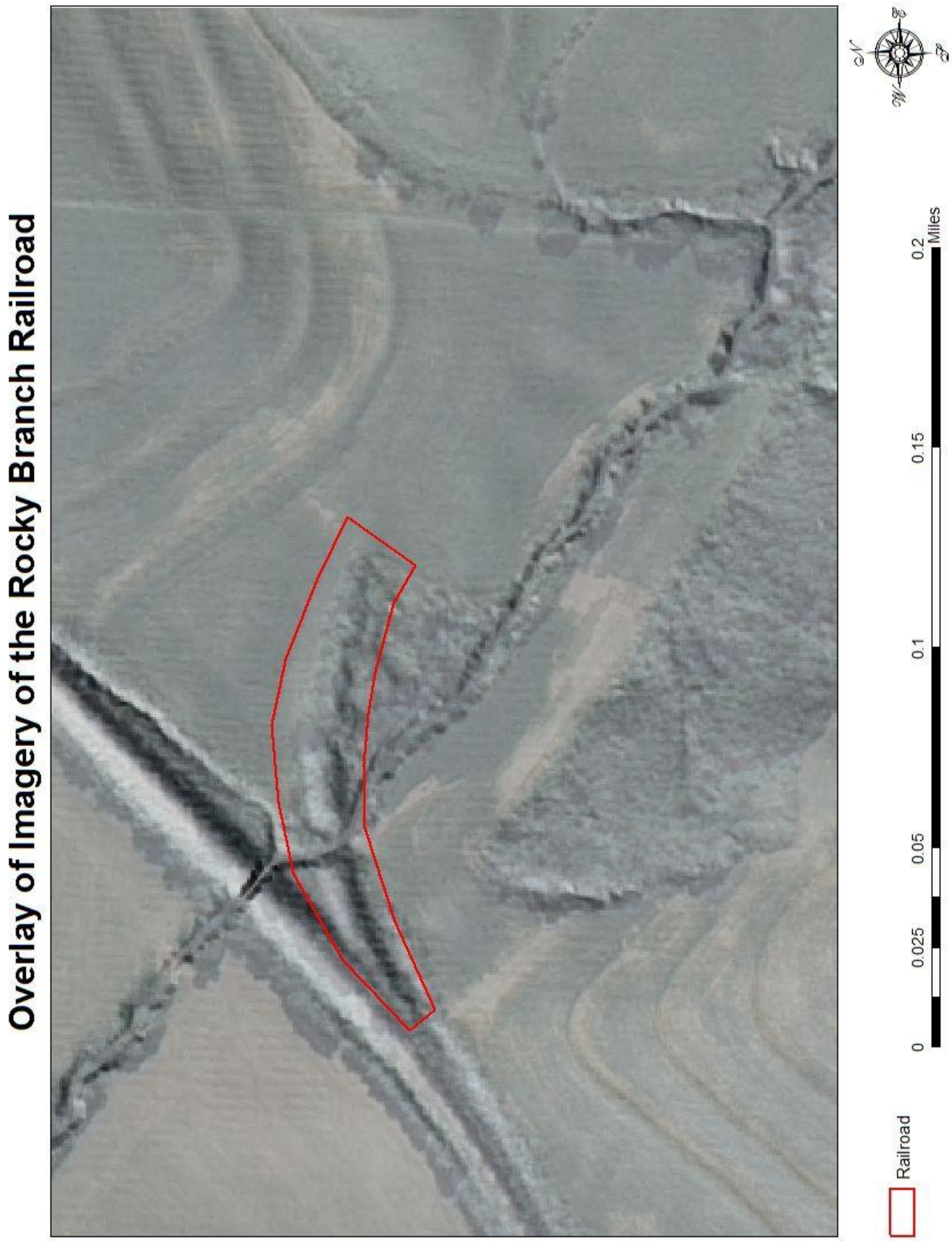


Figure 283.

NAIP imagery at a 70% transparency overlying LiDAR imagery of the abandoned rail bed of the Missouri Pacific Railroad.

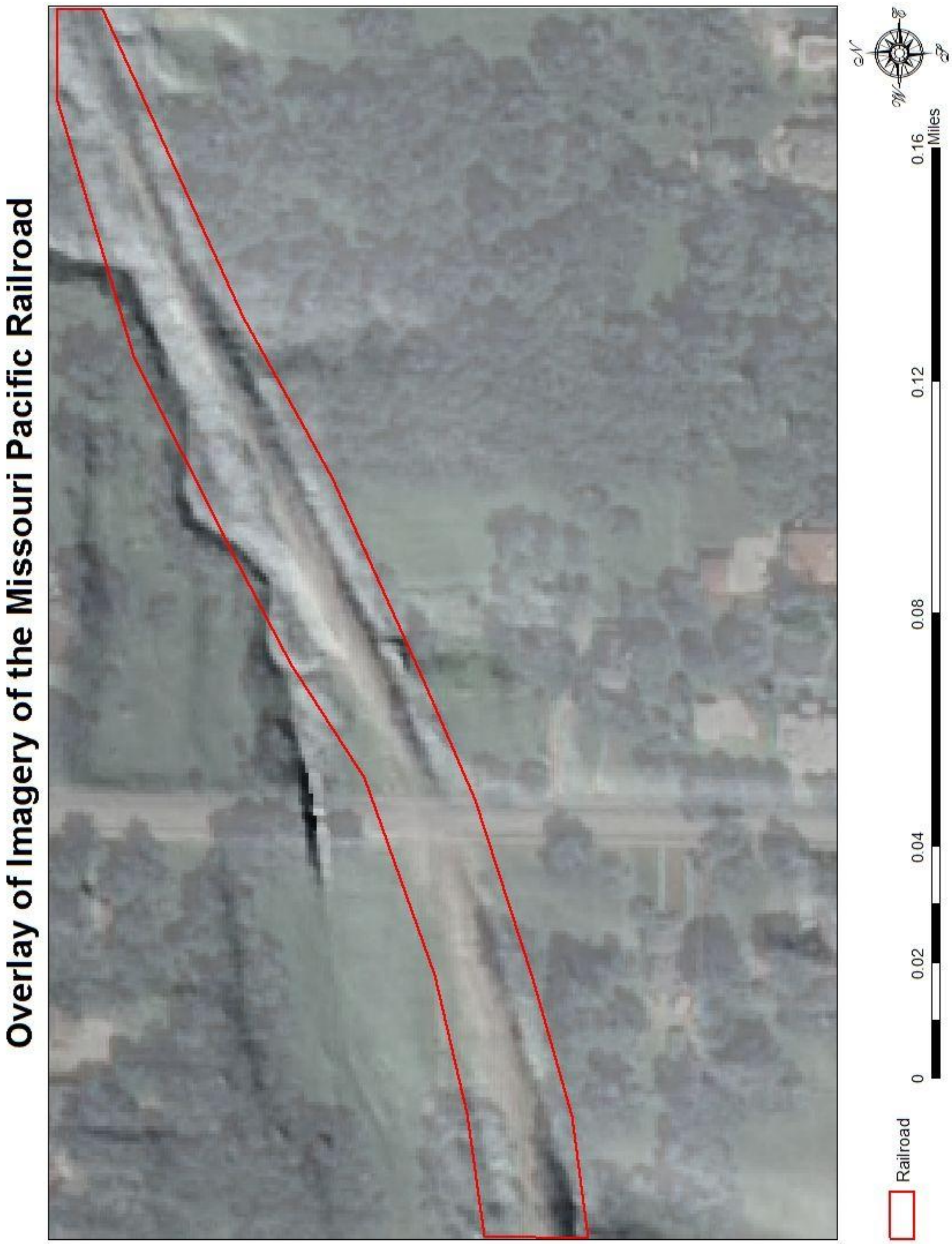


Figure 284.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Big Adkins Cemetery, Carroll County.

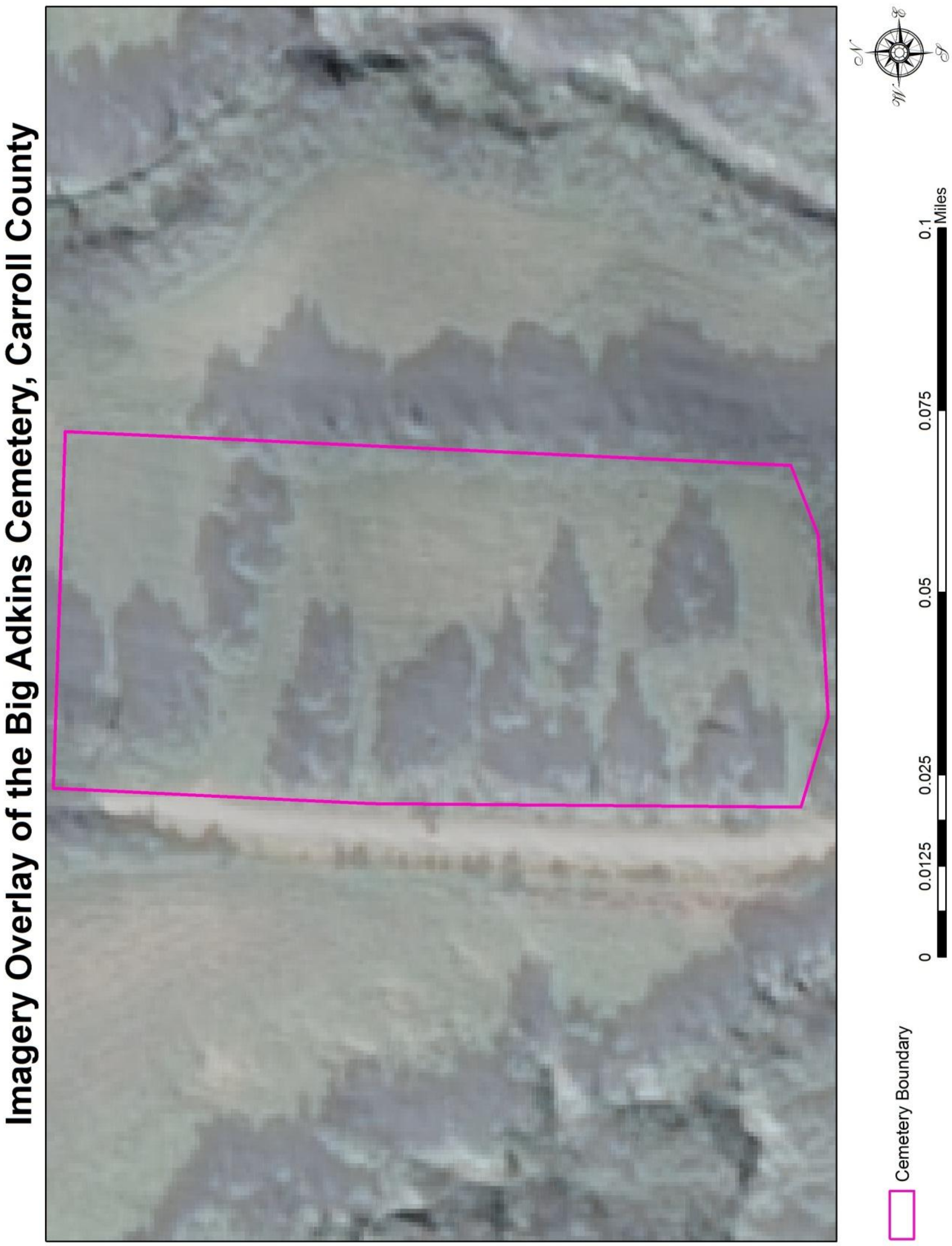


Figure 285.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Braden Cemetery, Carroll County.

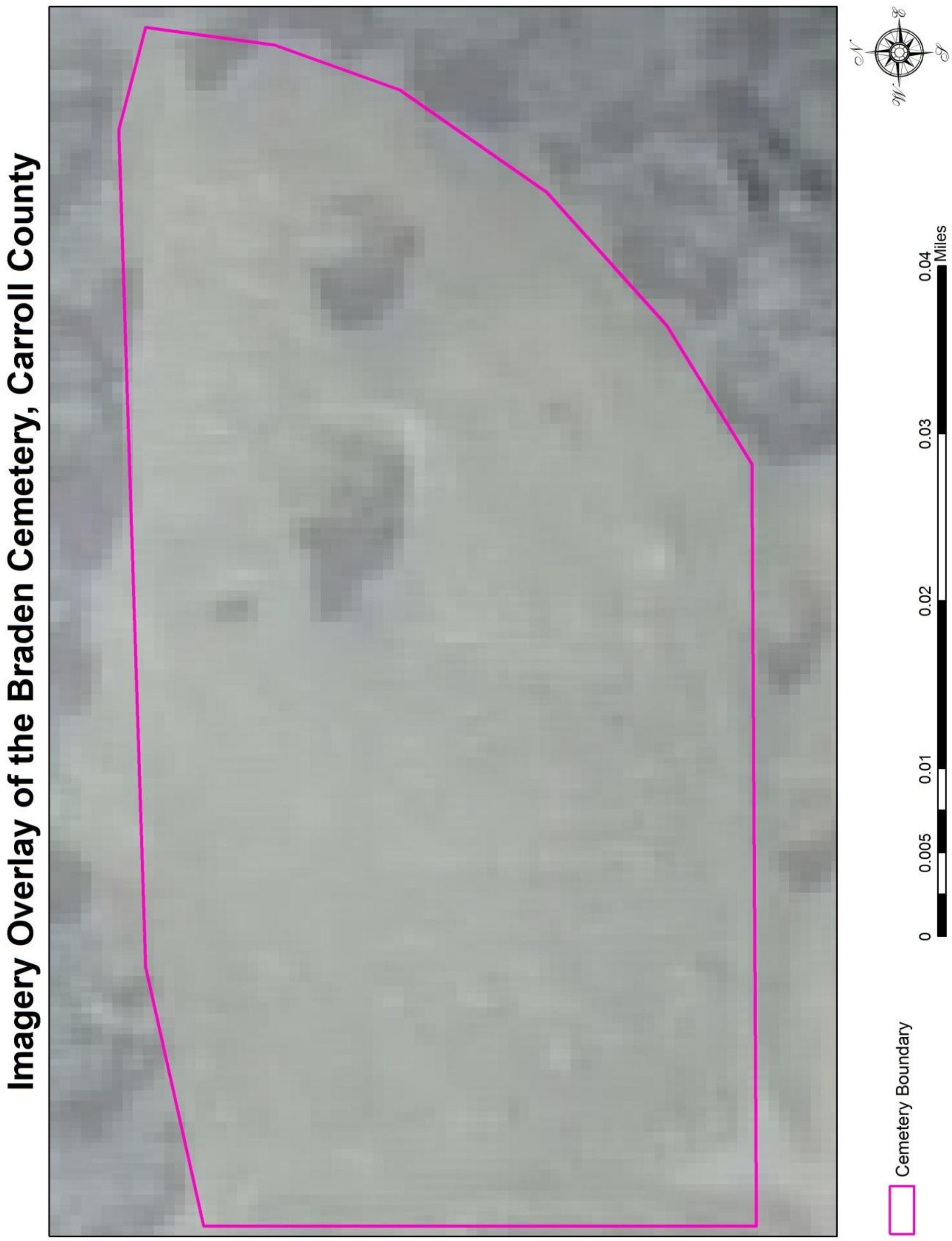


Figure 286.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Cambridge Cemetery, Saline County.

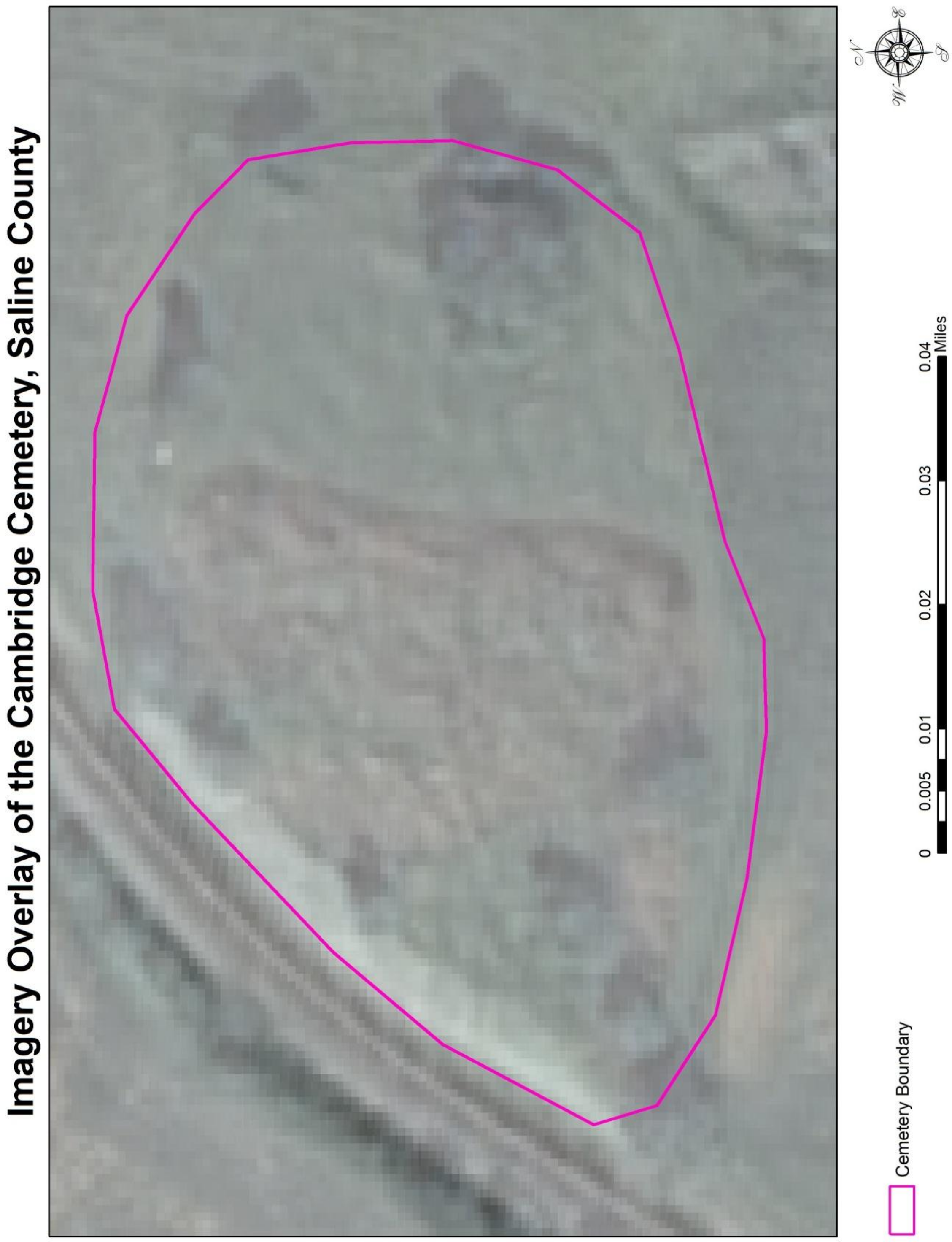


Figure 287.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Confederate Memorial State Historic Site Cemetery, Lafayette County.

Figure 288.

NAIP imagery at a 70% transparency overlying LiDAR imagery, DeWitt Evergreen Cemetery, Carroll County.

Figure 289.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Elliott Cemetery, Carroll County.

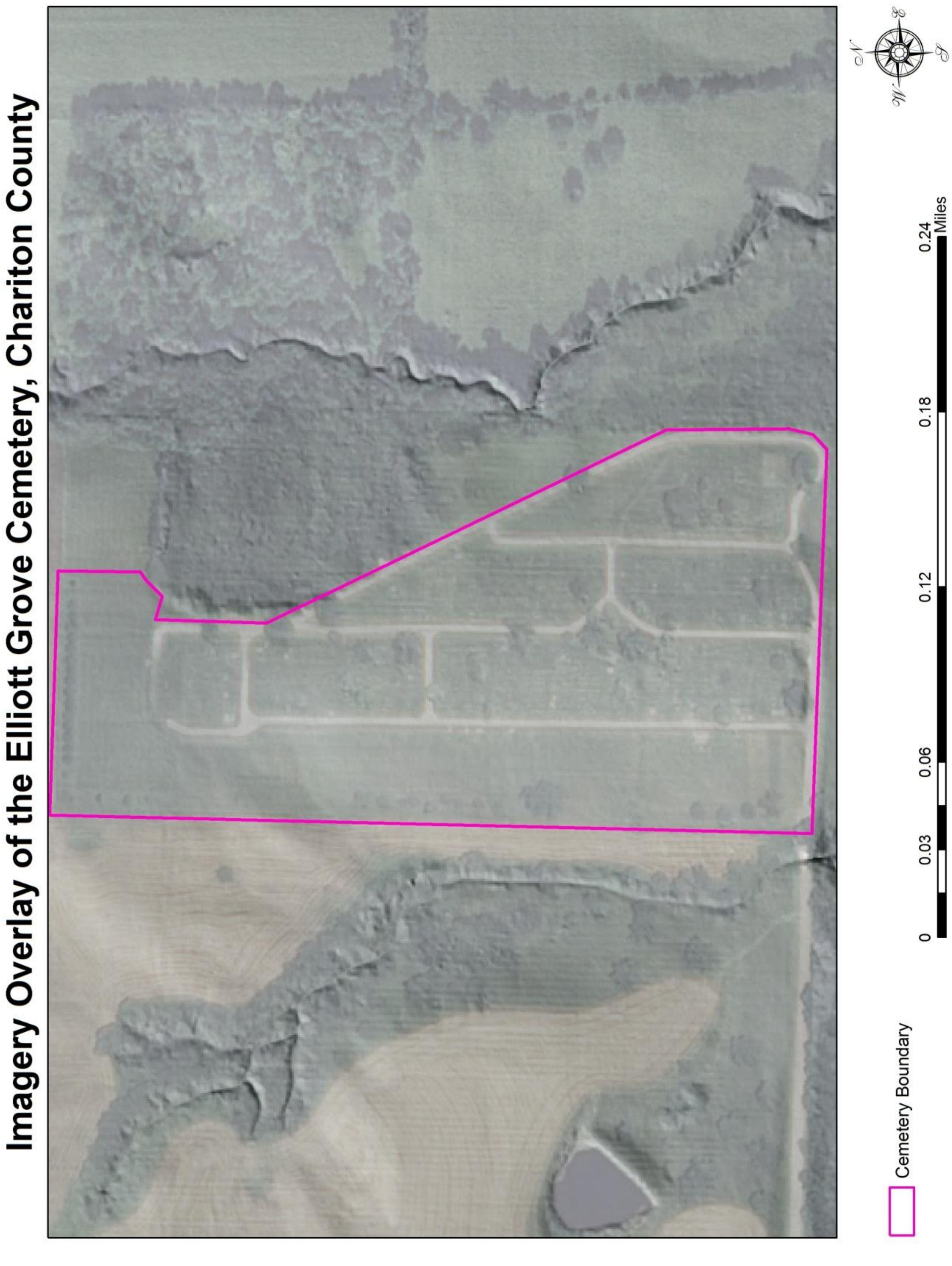


Figure 290.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Fairview Cemetery, Saline County.

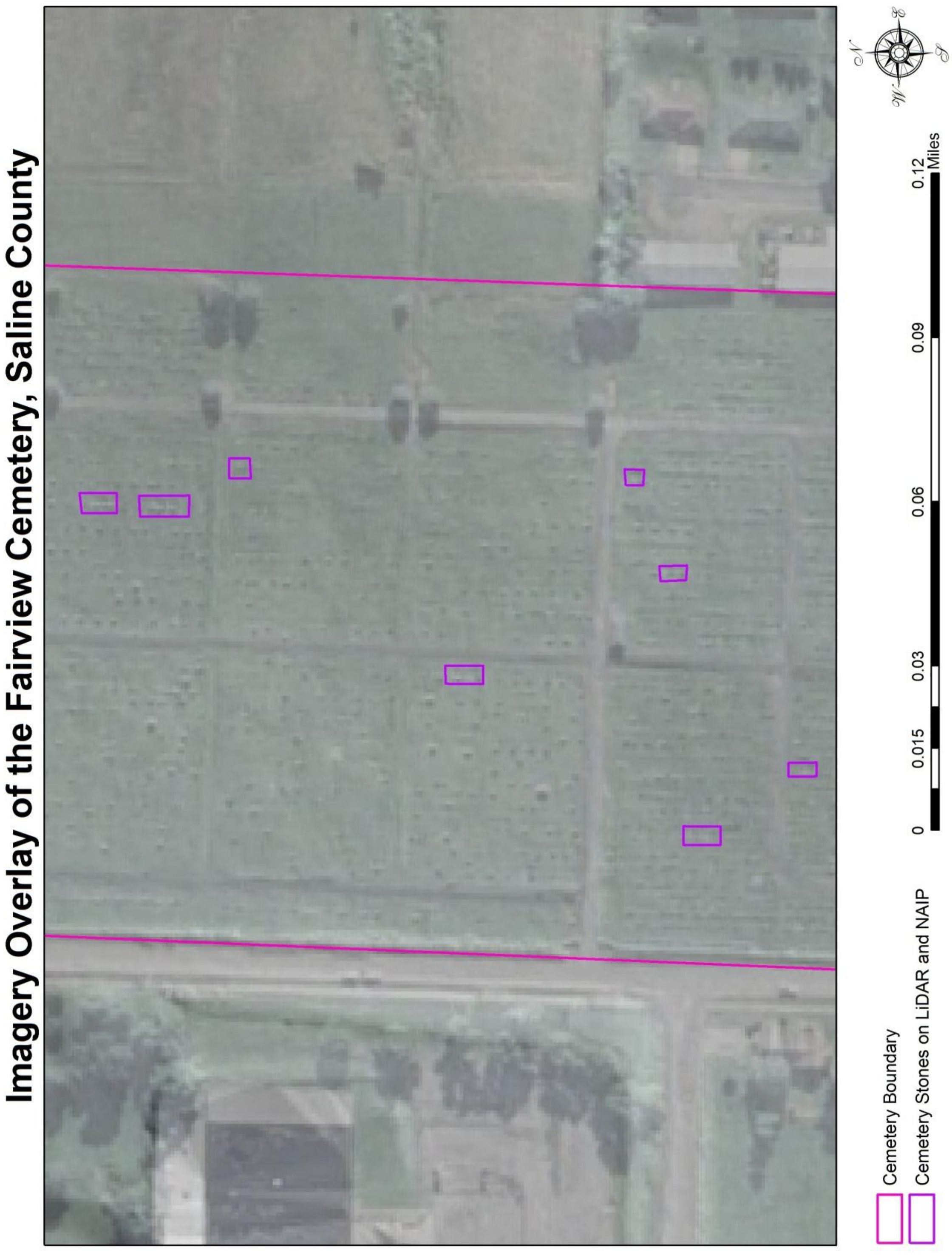


Figure 291.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Greenton Baptist Church Cemetery, Lafayette County.

Figure 292.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Harmony Church Cemetery, Saline County.

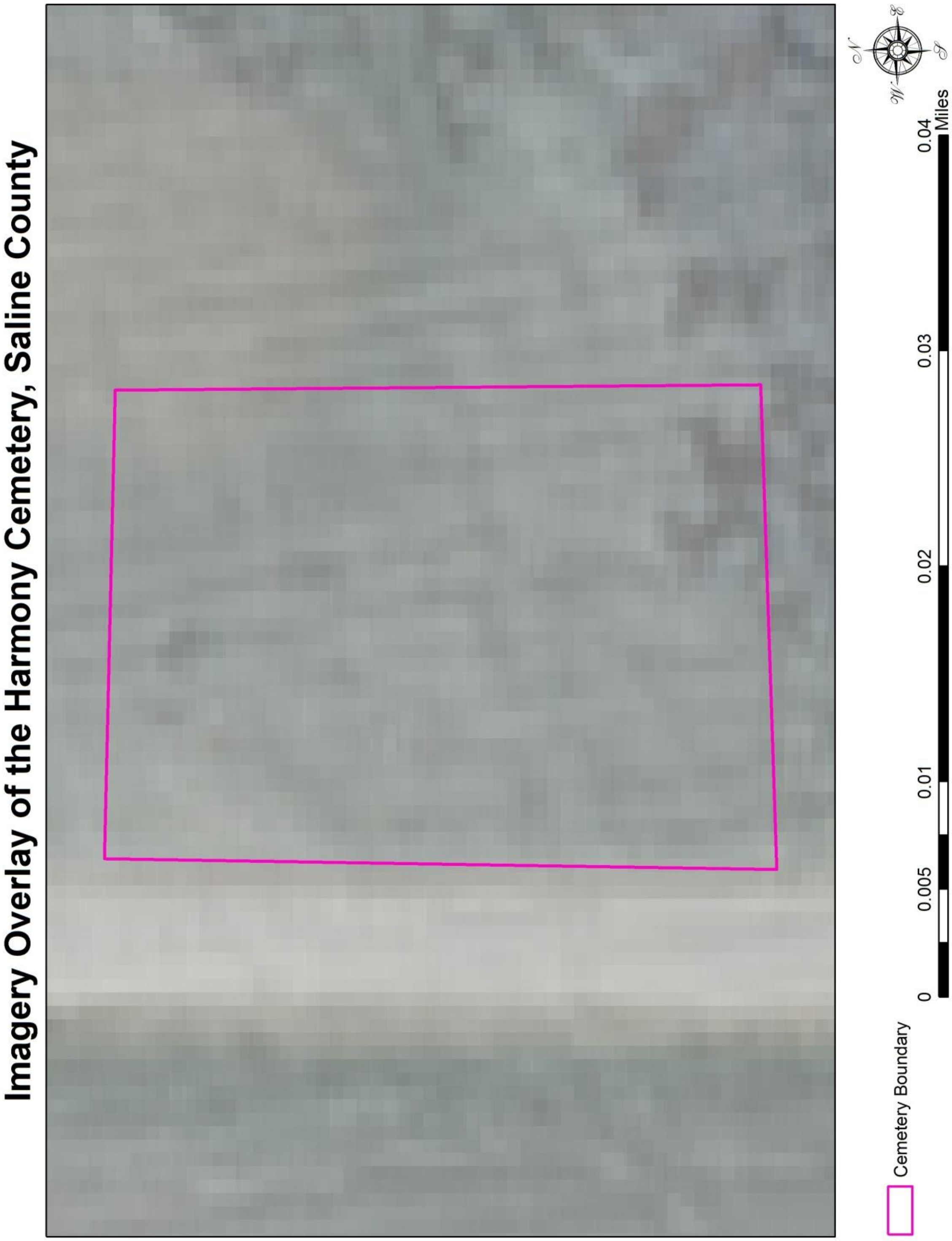


Figure 293.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Mendon Cemetery, Chariton County.

Figure 294.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Mt. Hope Presbyterian Church Cemetery, Lafayette County.

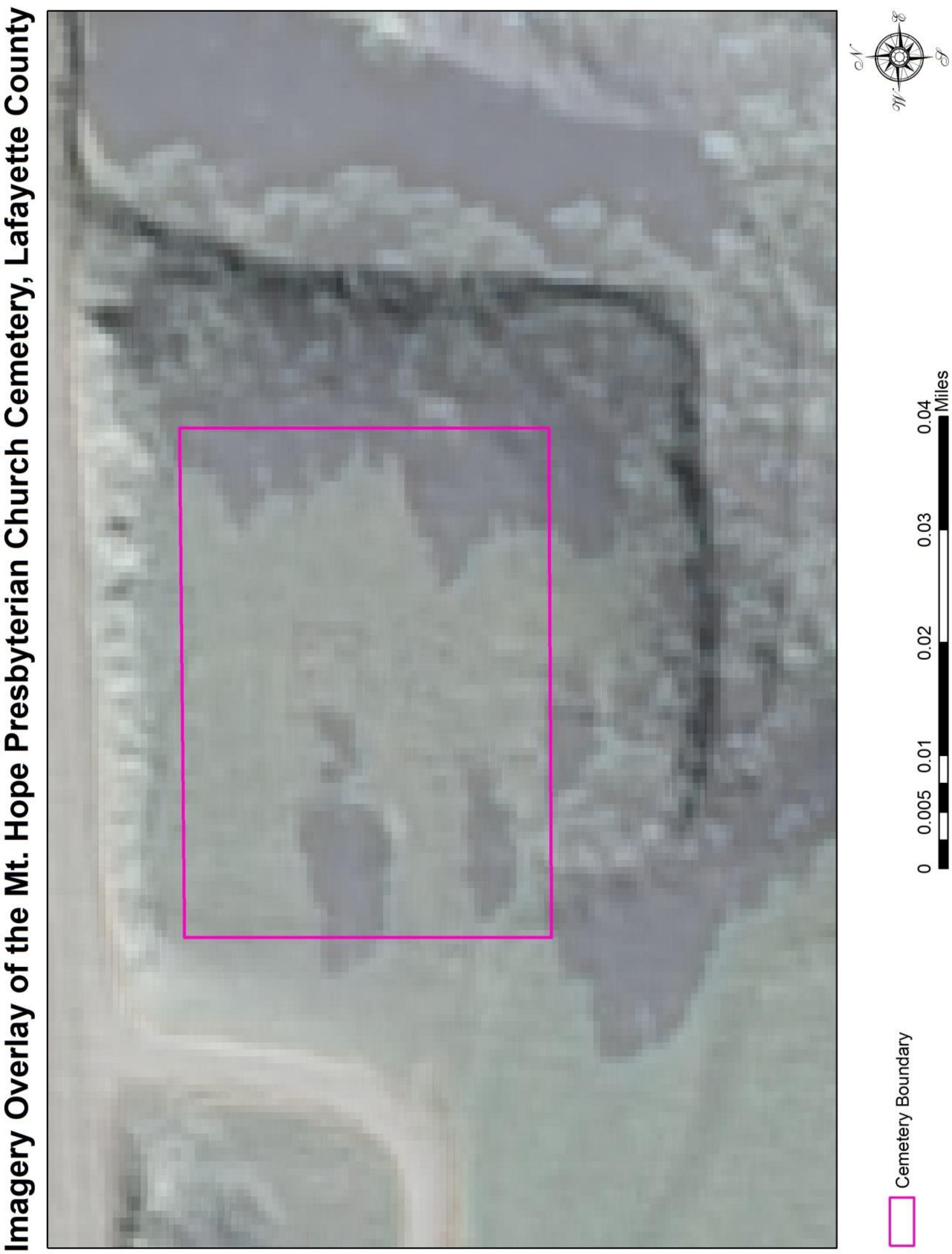


Figure 295.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Mt. Nebo Cemetery, Saline County.

Figure 296.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Newcomer Cemetery, Chariton County.

Figure 297.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Oak Hill Cemetery, Carroll County.

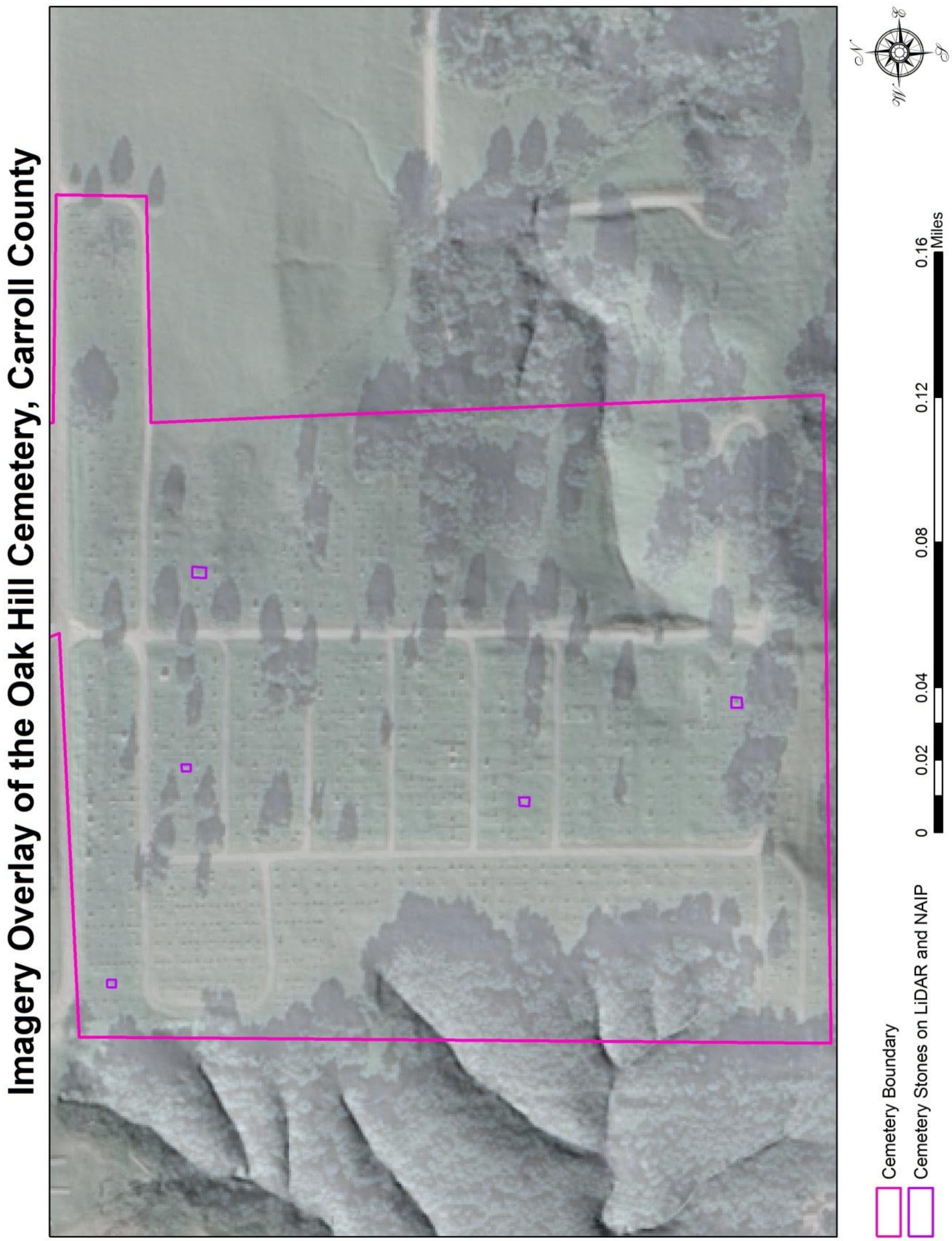


Figure 298.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Odessa Cemetery, Lafayette County.

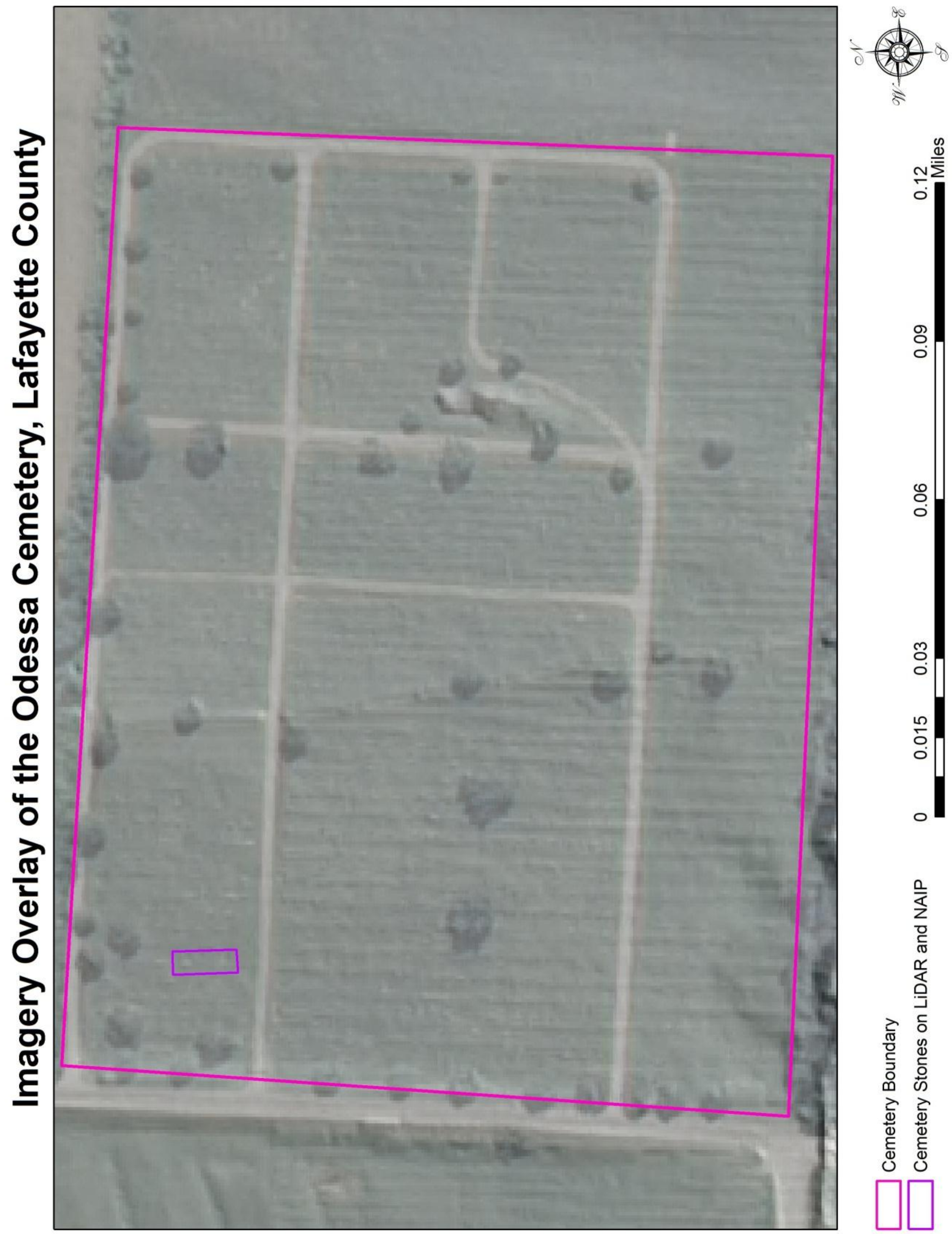


Figure 299.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Ridge Park Cemetery, Saline County.

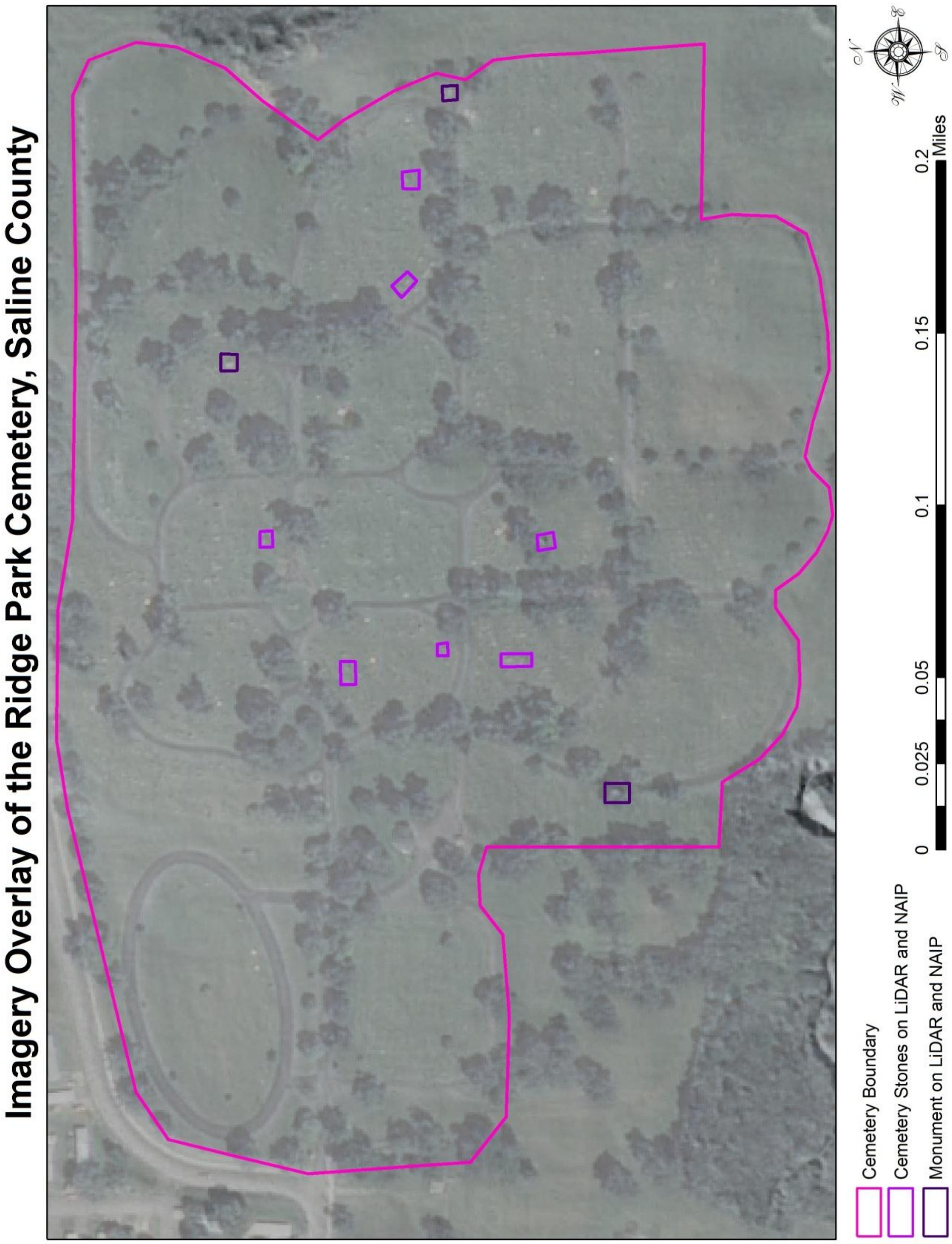


Figure 300.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Sacred Heart Cemetery, Carroll County.

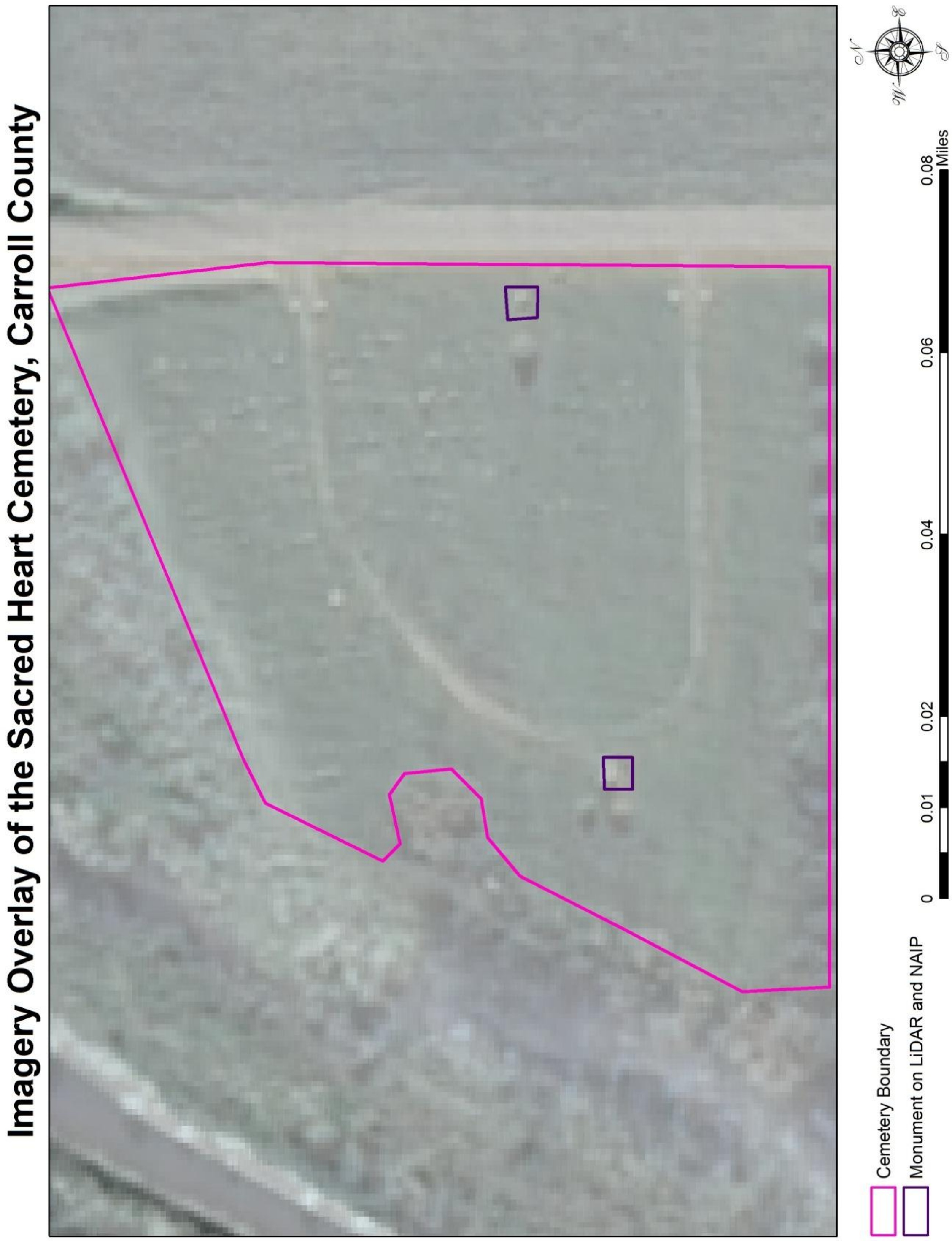


Figure 301.

NAIP imagery at a 70% transparency overlying LiDAR imagery, St. Mary's Cemetery, Chariton County.

Figure 302.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Salisbury Cemetery, Chariton County.

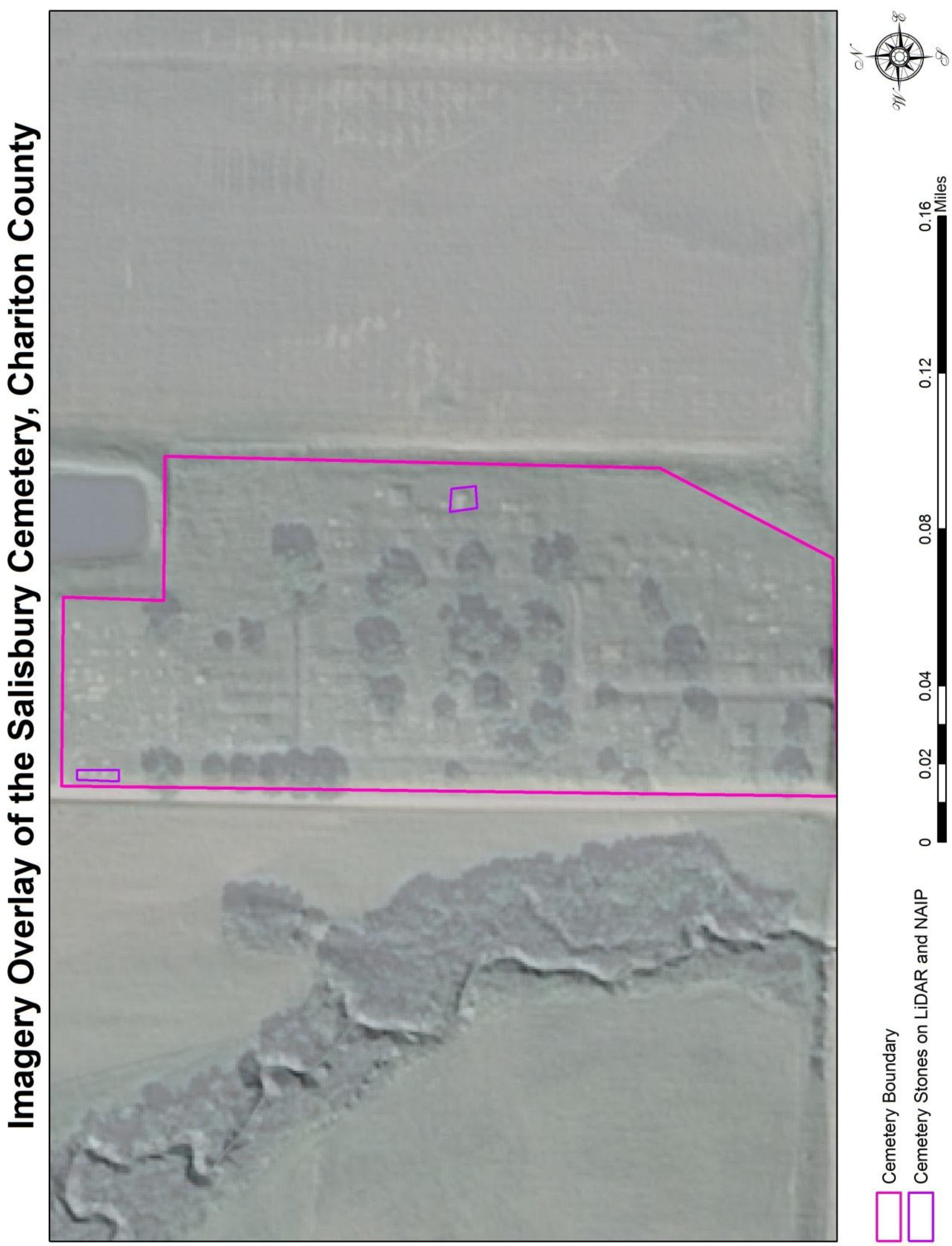


Figure 303.

NAIP imagery at a 70% transparency overlying LiDAR imagery, Shore Cemetery, Lafayette County.

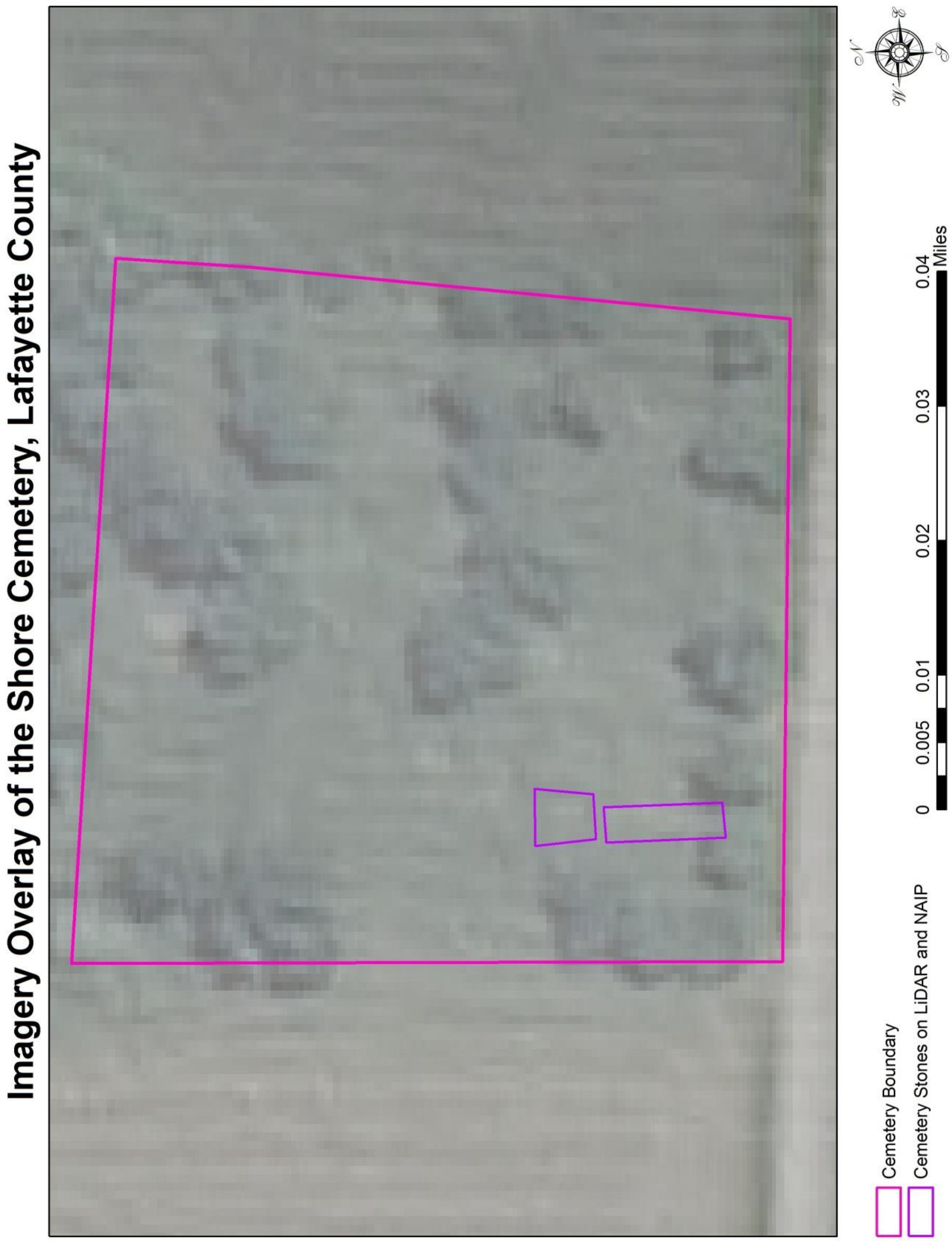


Figure 304.

NAIP imagery of relict features in Laynesville, Saline County.

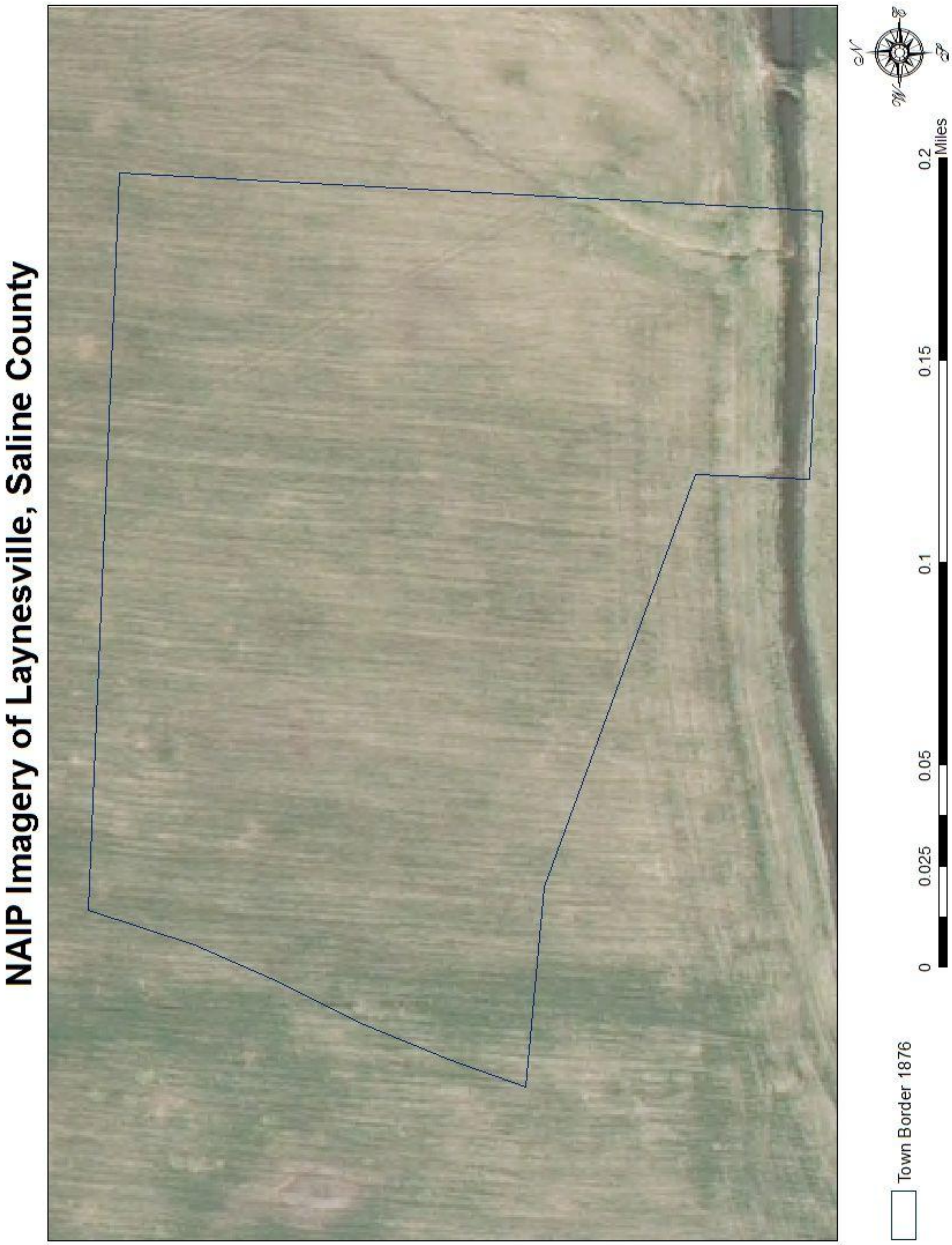


Figure 305.

NAIP imagery of relict features in Miami Station, Carroll County.

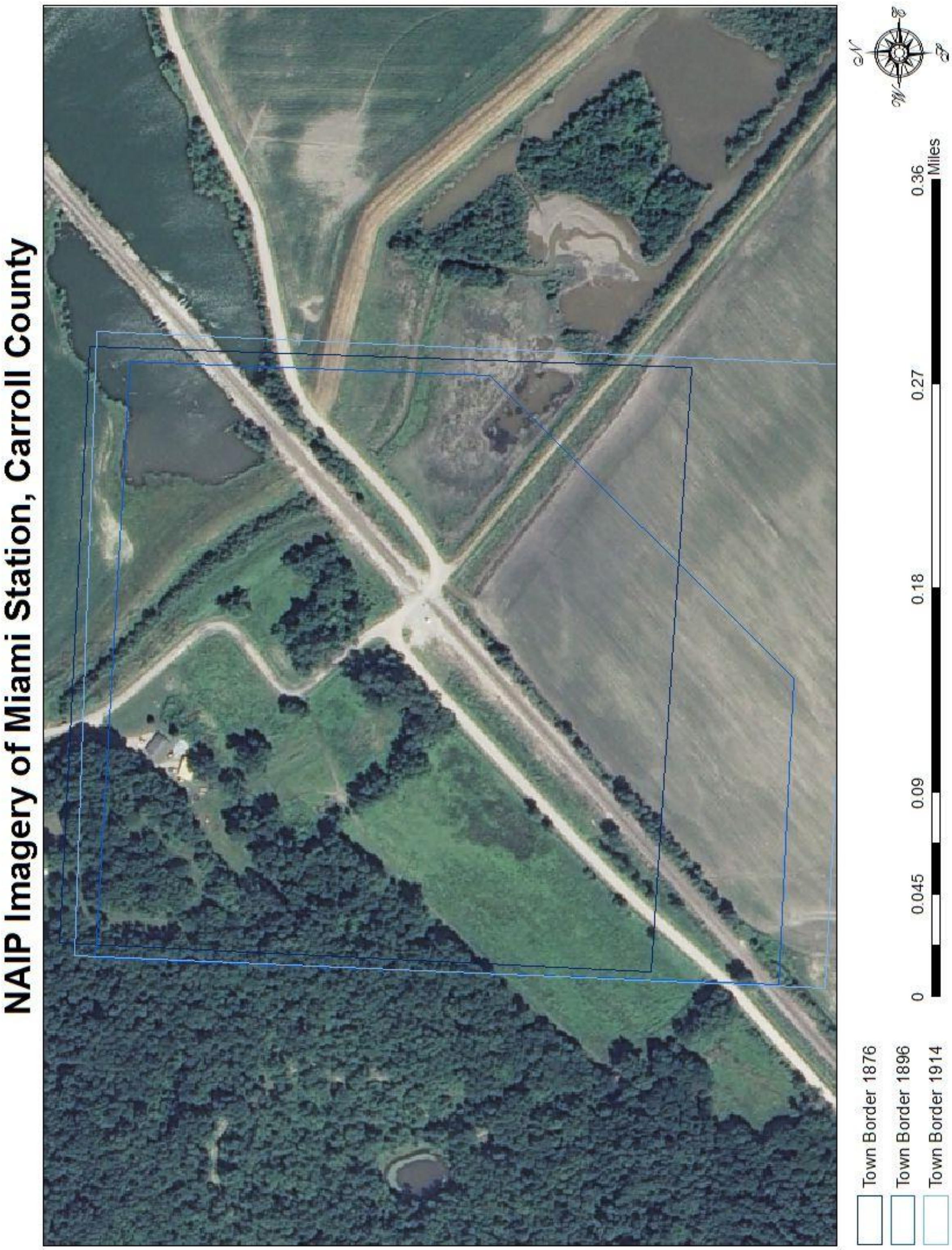


Figure 306.

NAIP imagery of relict features in Miles Point, Carroll County.

Figure 307.

NAIP imagery of relict features in Mount Hope, Lafayette County.

Figure 308.

NAIP imagery of relict features in Old Mendon, Chariton County.

Figure 309.

NAIP imagery of relict features in Plymouth, Carroll County.

Figure 310.

NAIP imagery of relict features in Shannondale, Chariton County.

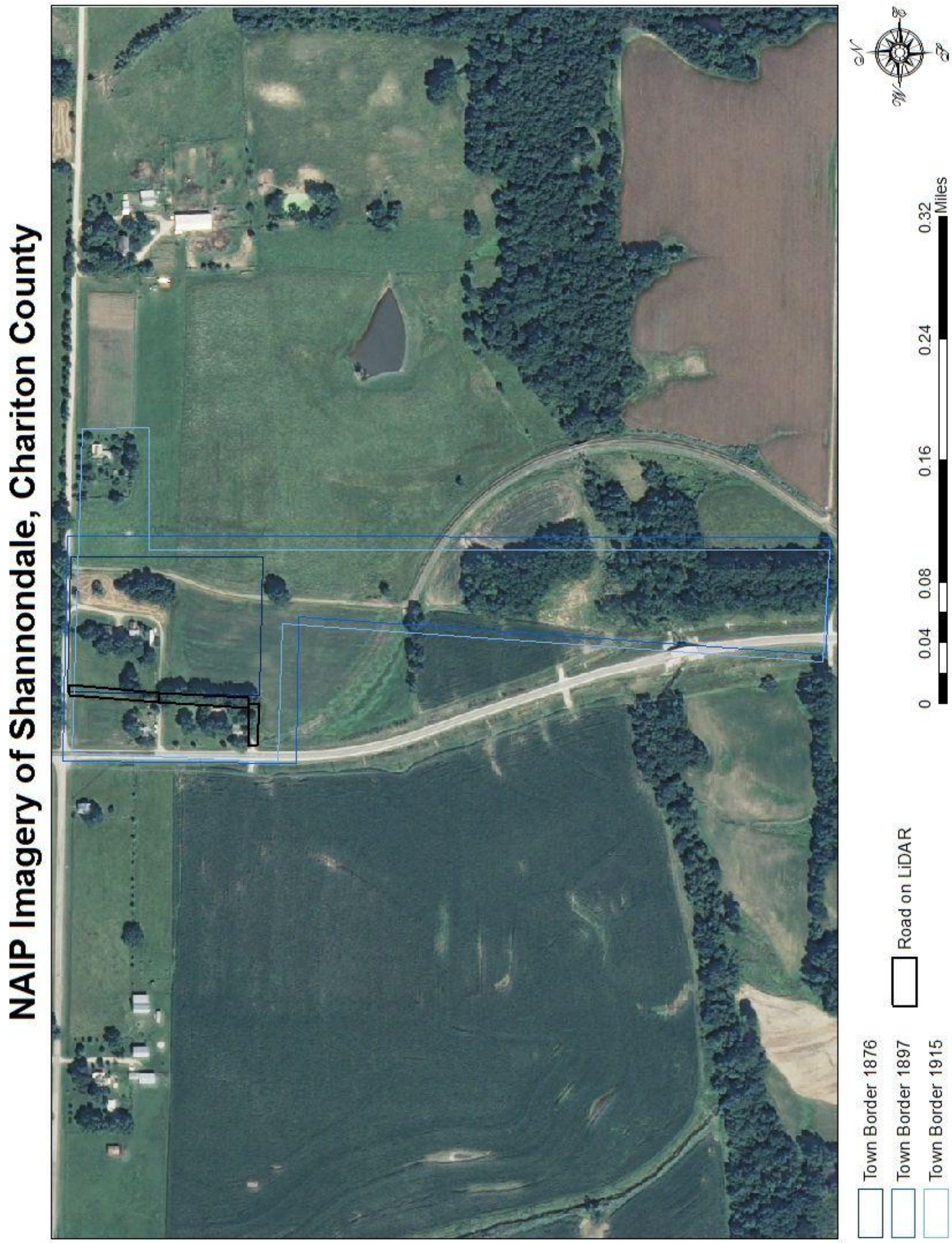


Figure 311.

NAIP imagery of relict features in Triplett, Chariton County.

Figure 312.

NAIP imagery of relict features in Berlin, Lafayette County.

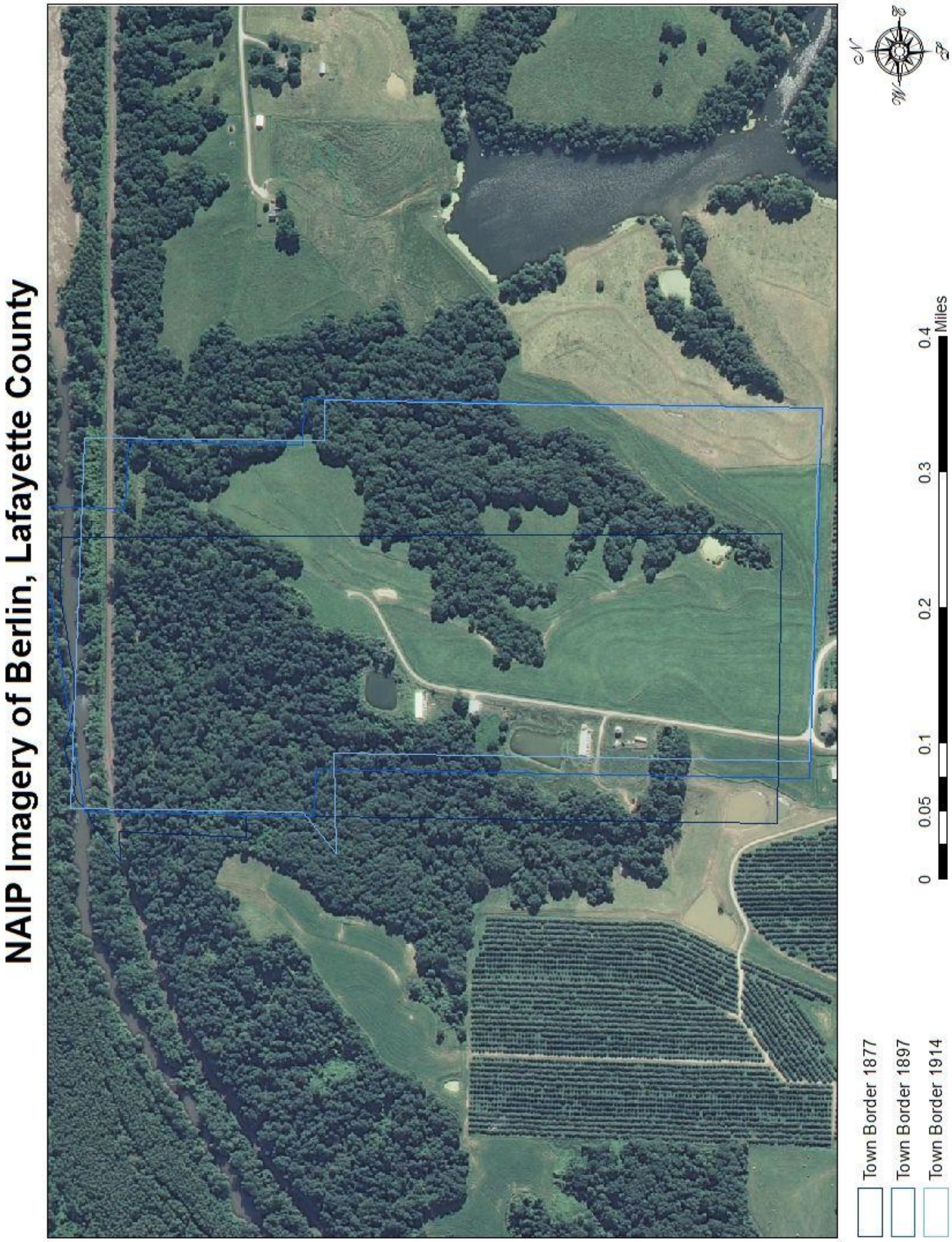


Figure 313.

NAIP imagery of relict features in Hodge, Lafayette County.

Figure 314.

NAIP imagery of relict features in New Frankfort, Saline County.

Figure 315.

NAIP imagery of relict features in Salina, Saline County.

Figure 316.

NAIP imagery of relict features in Wien, Chariton County.

Figure 317.

NAIP and LiDAR imagery of the abandoned and exposed Brunswick, Chillicothe, and Omaha Railroad bed, north of Sumner, Chariton County.

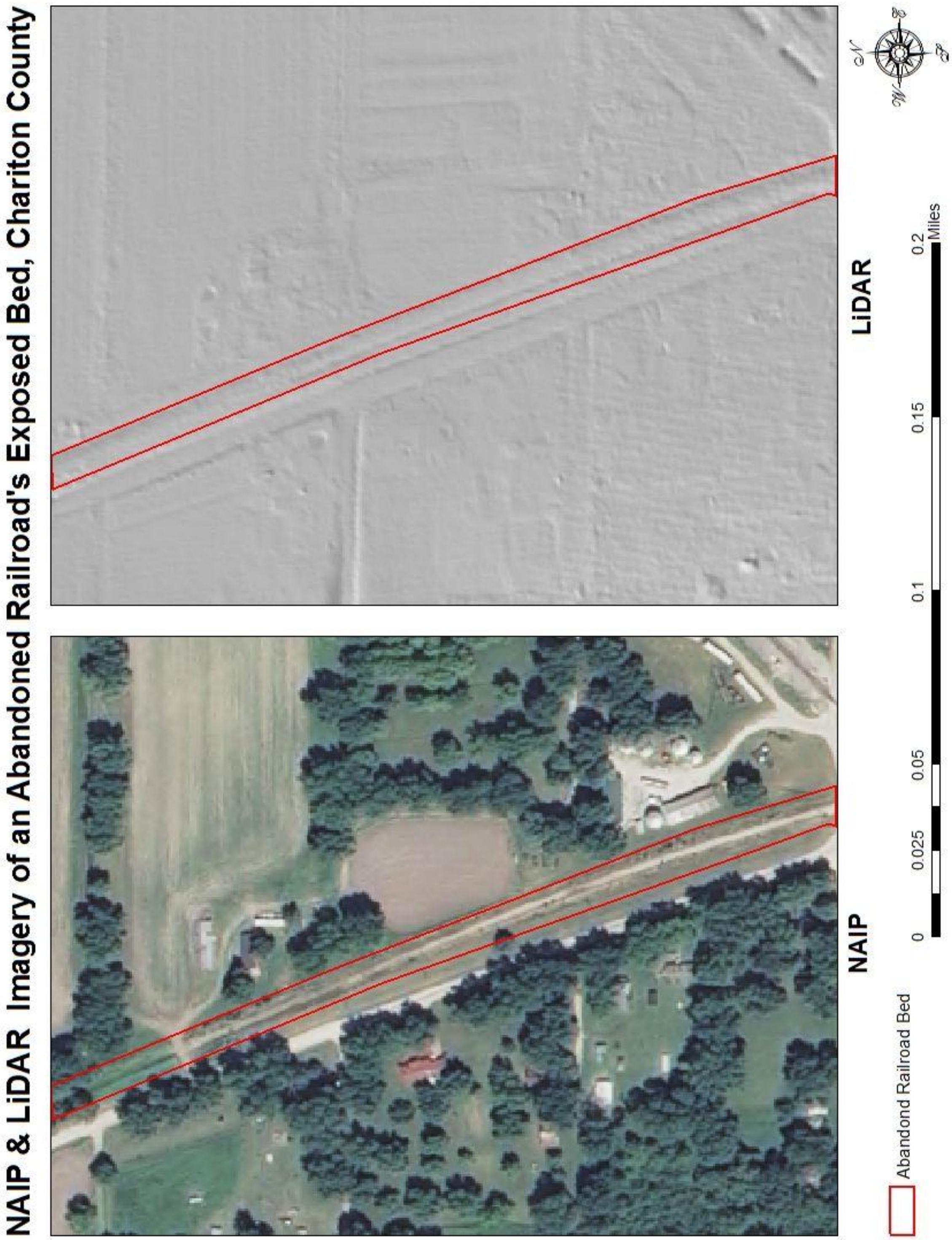


Figure 318.

NAIP and LiDAR imagery of the abandoned and exposed Lexington and St. Louis Railroad bed, west of Page City, Lafayette County.

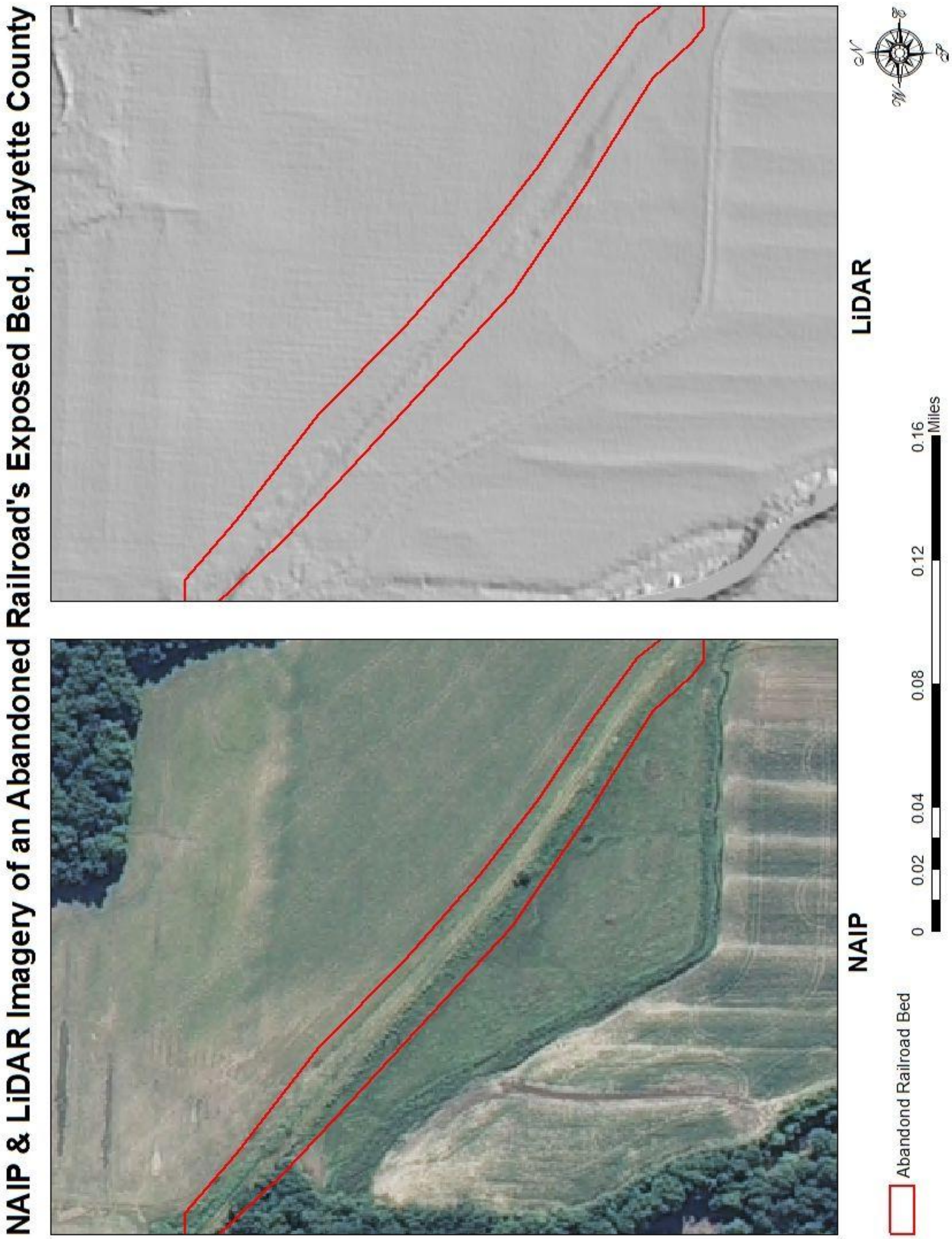


Figure 319.

Landsat imagery from August 17th of the Great US Flood of 1993, Hodge, Lafayette County.

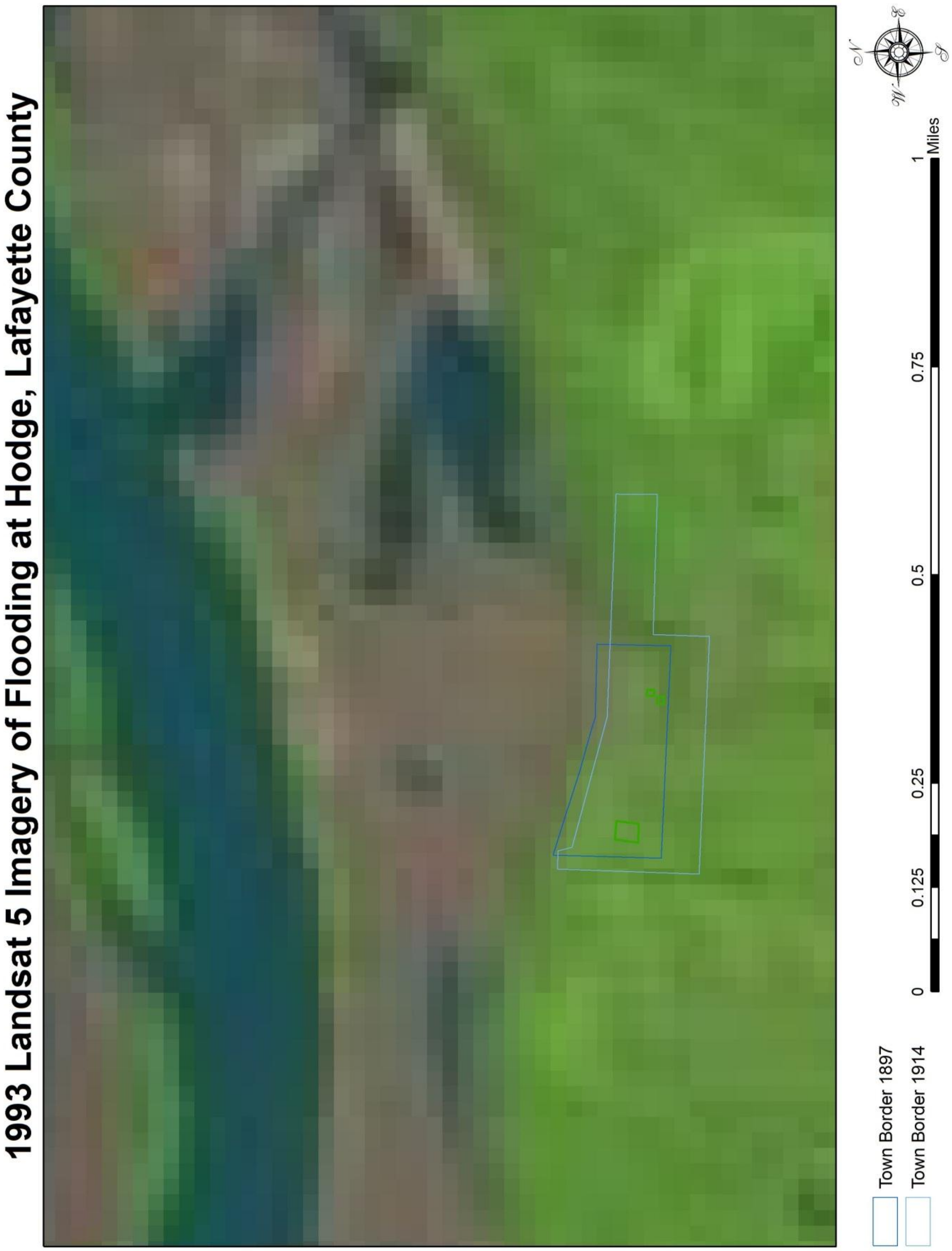


Figure 320.

Landsat imagery from August 17th of the Great US Flood of 1993, Laynesville, Saline County.

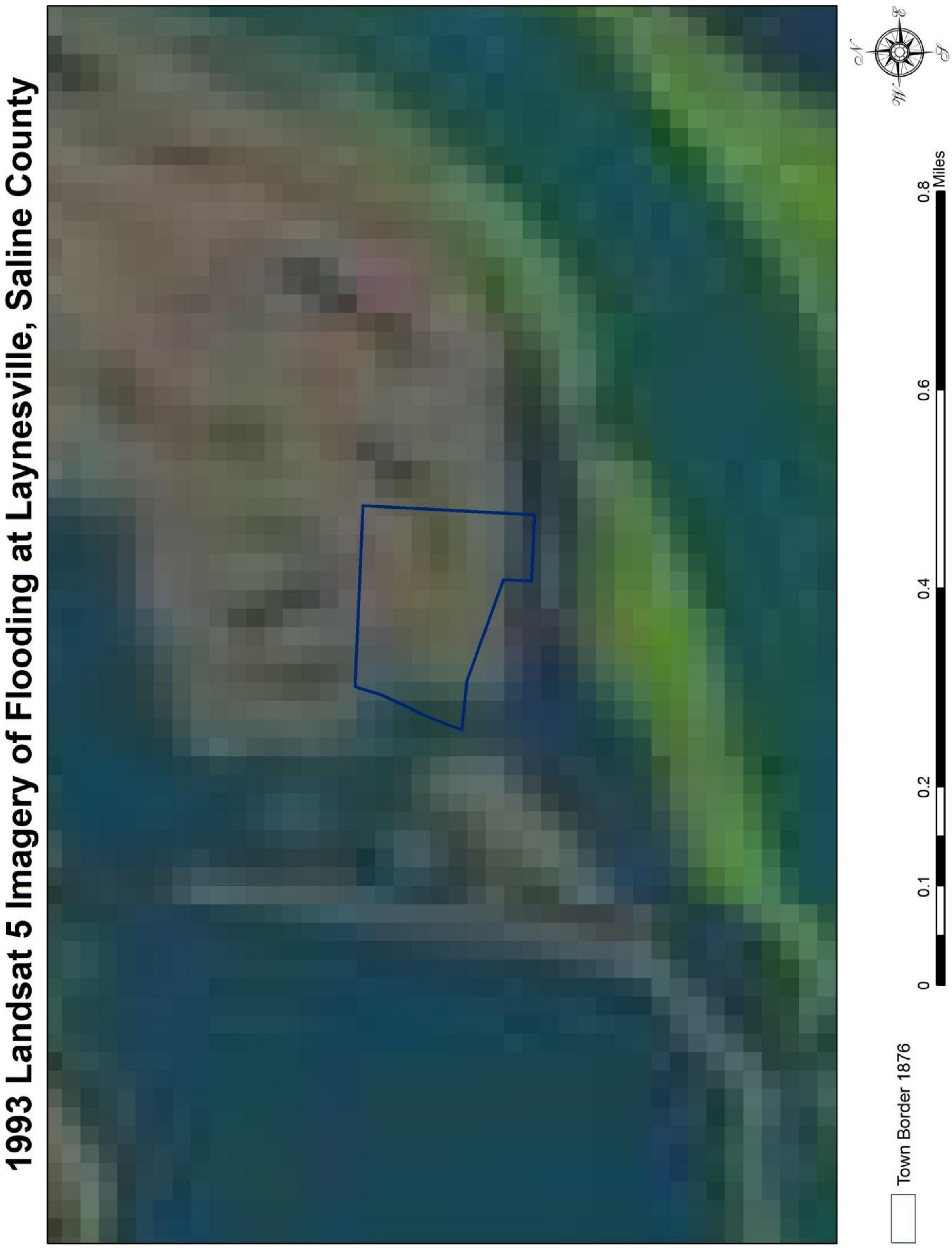


Figure 321.

Landsat imagery from August 17th of the Great US Flood of 1993, Miami Station, Carroll County.

Figure 322.

Landsat imagery from August 17th of the Great US Flood of 1993, Miles Point, Carroll County.

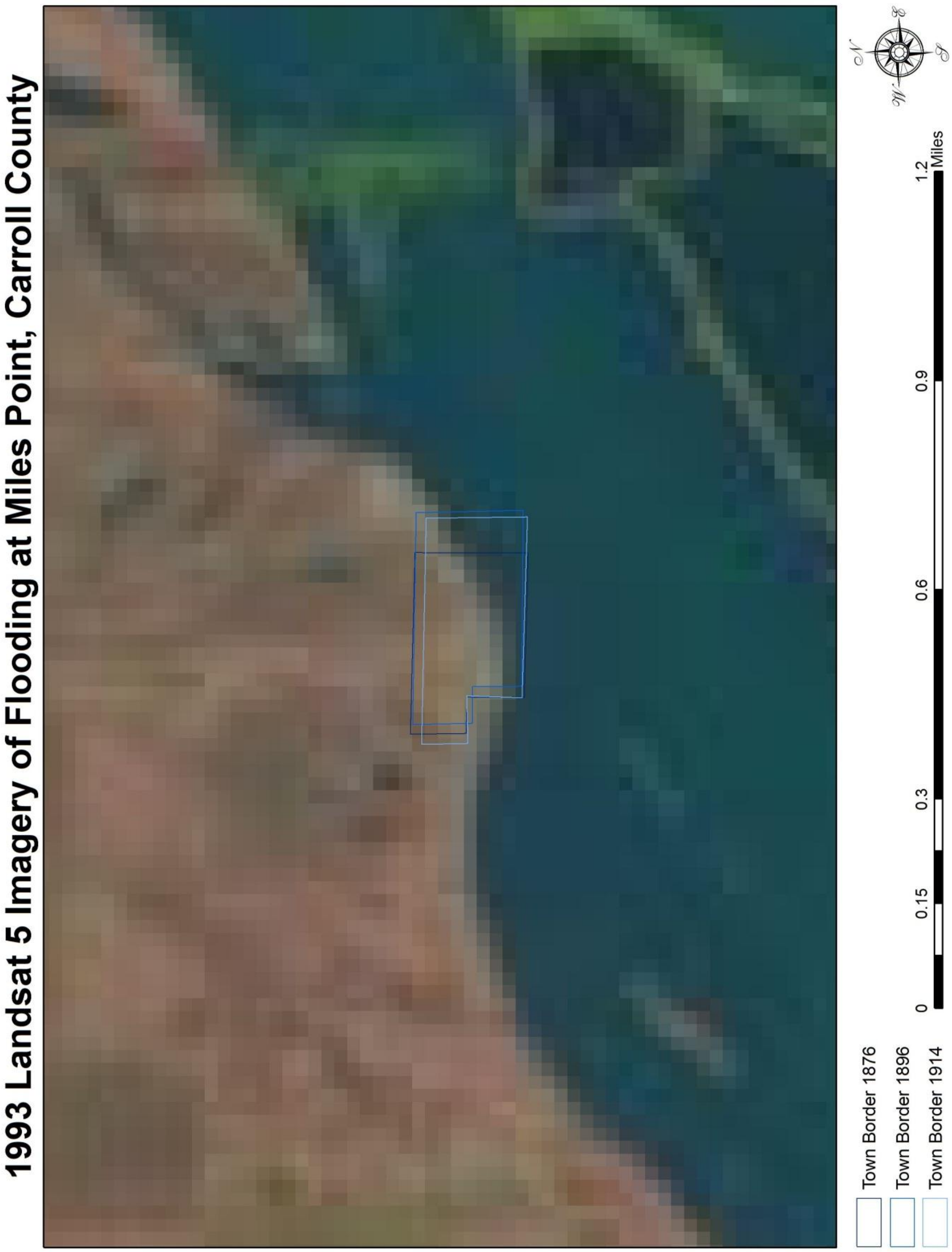


Figure 323.

Landsat imagery from August 17th of the Great US Flood of 1993, Wakenda, Carroll County.

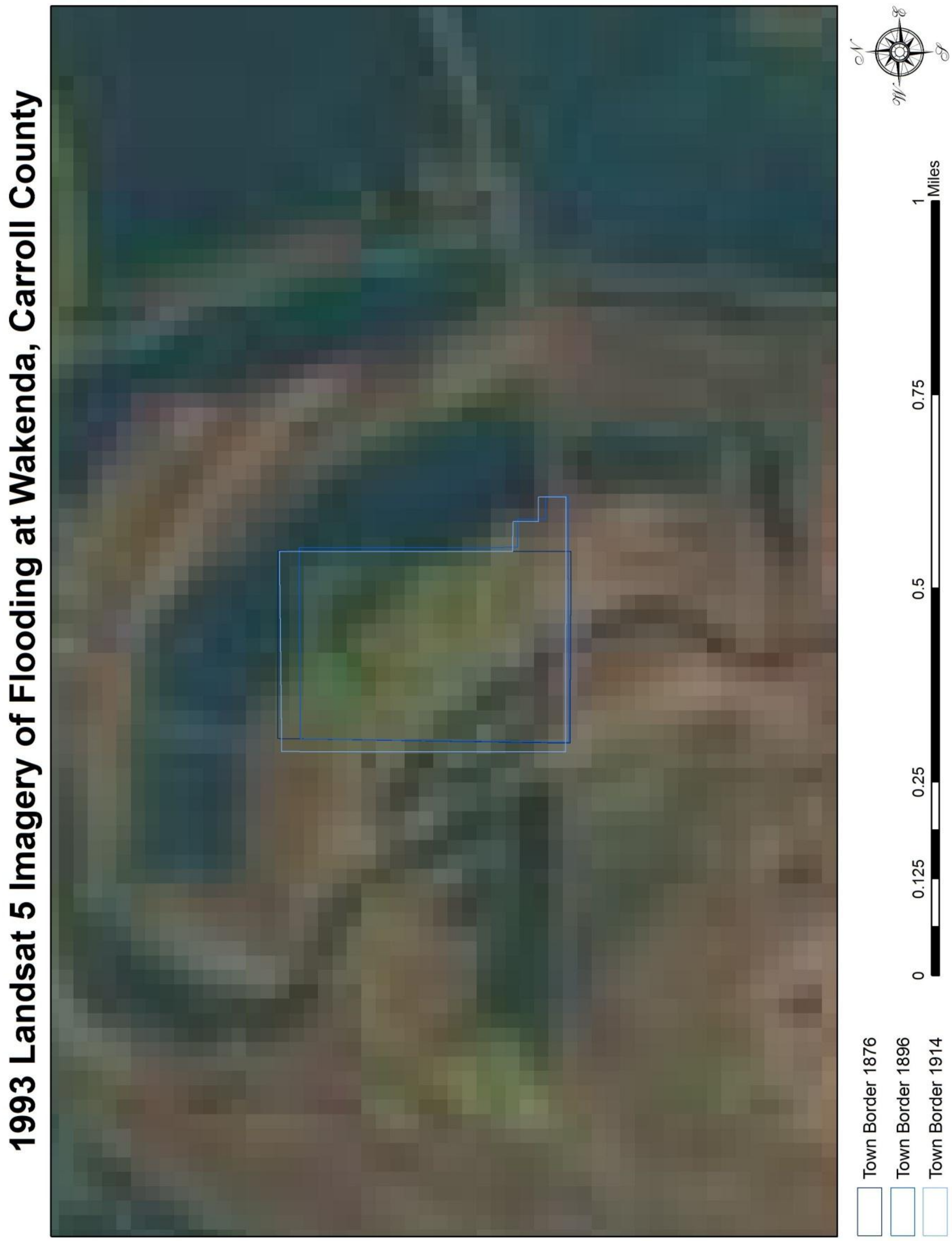


Figure 324.

Landsat imagery from August 17th of the Great US Flood of 1993, Sacred Heart Cemetery, Carroll County.

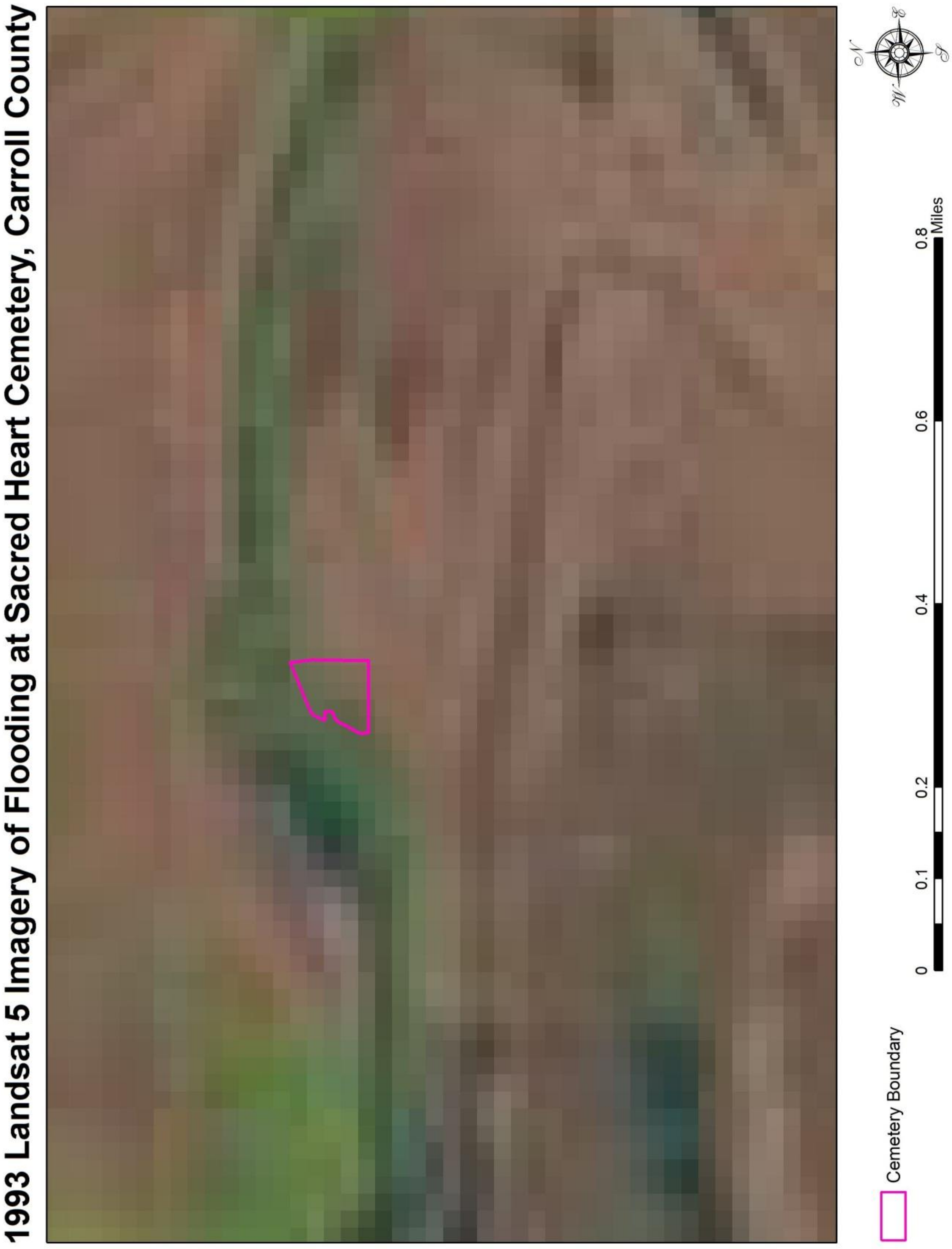


Figure 325.

Landsat imagery (SLC off) from July 26th, 2011, Missouri River Flood, Hodge, Lafayette County.

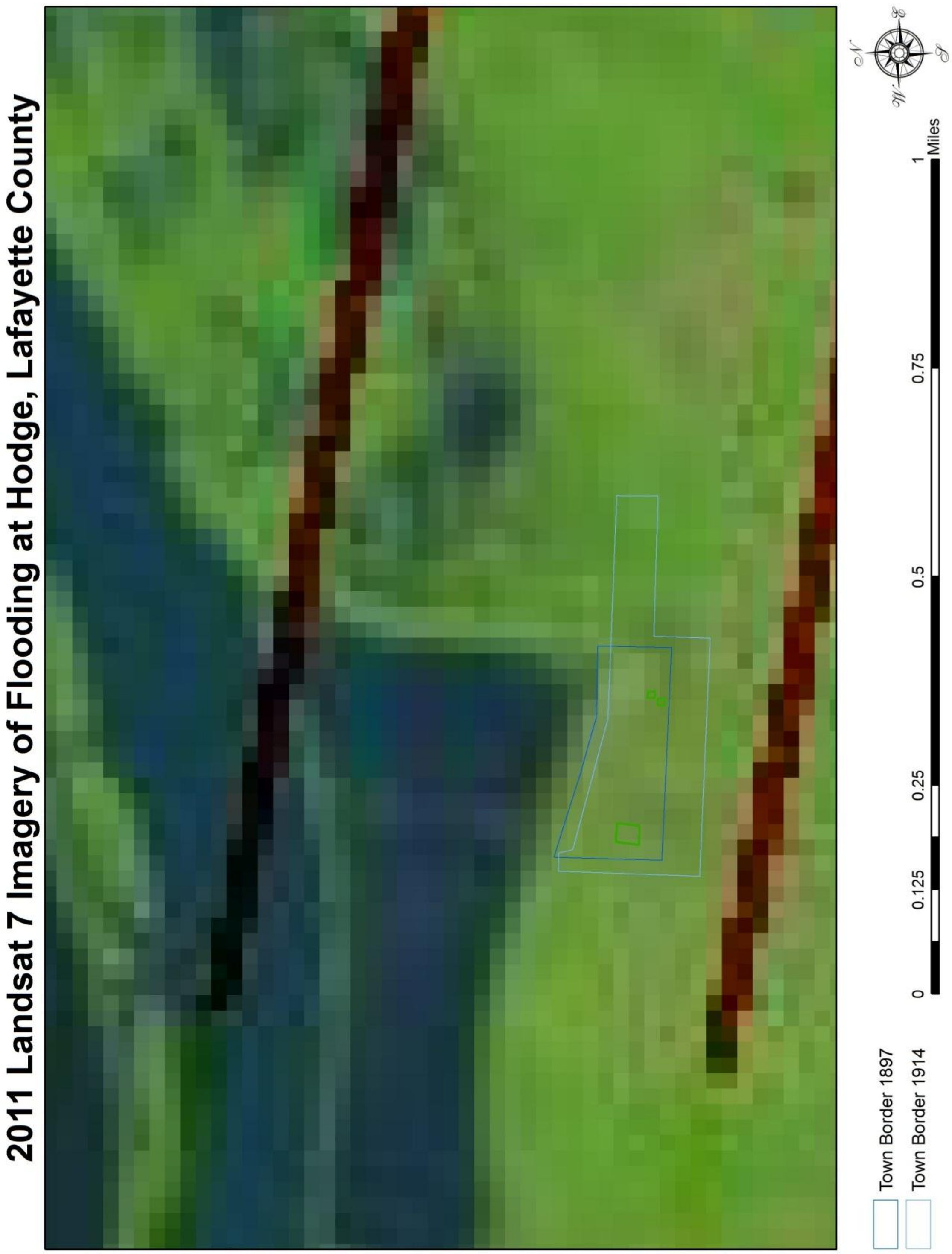


Figure 326.

Landsat imagery (SLC off) from July 26th, 2011, Missouri River Flood, Laynesville, Saline County.

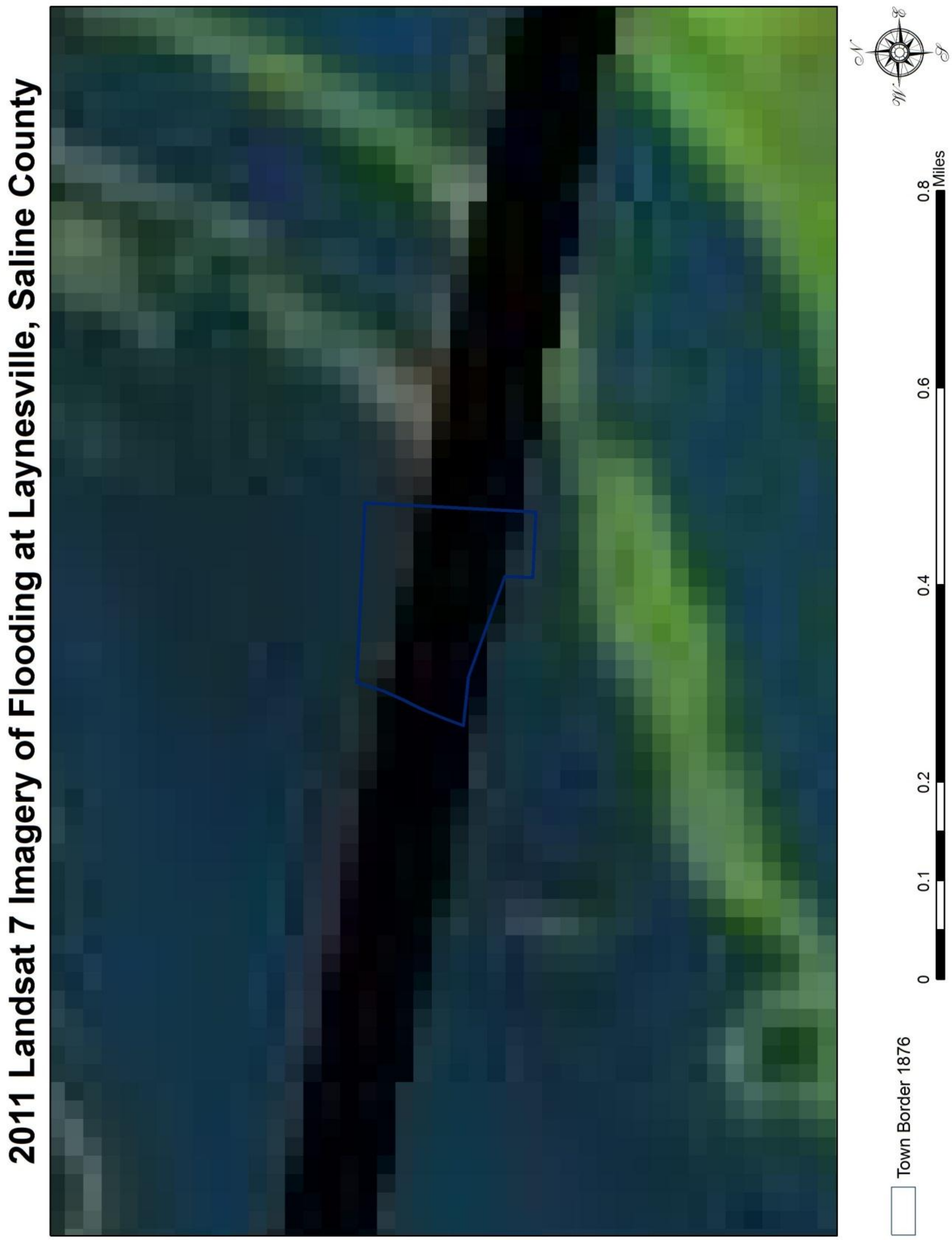


Figure 327.

Landsat imagery (SLC off) from July 26th, 2011, Missouri River Flood, Miami Station, Saline County.

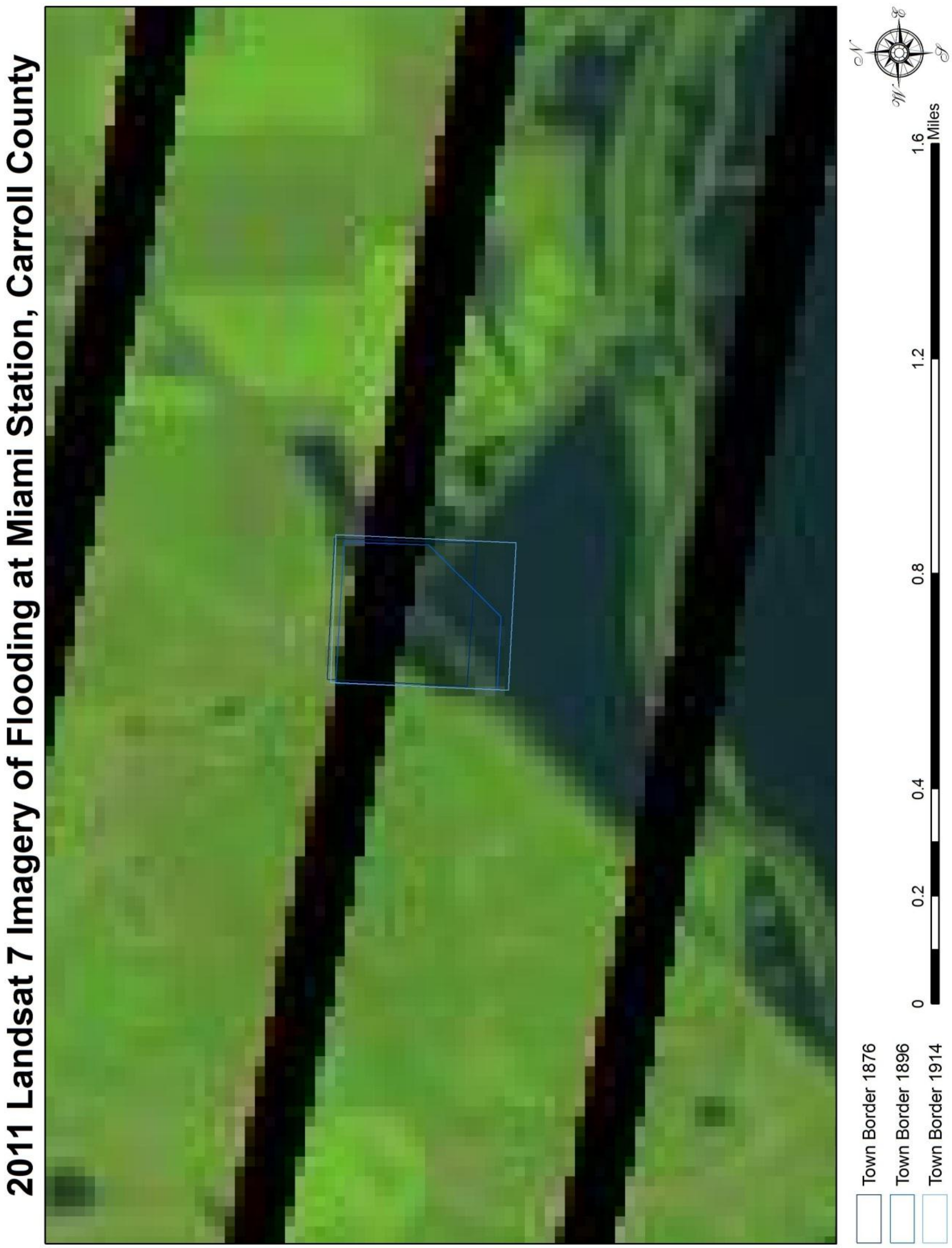


Figure 328.

Landsat imagery from July 26th of the 2011 Missouri River Flood, Miles Point, Saline County.

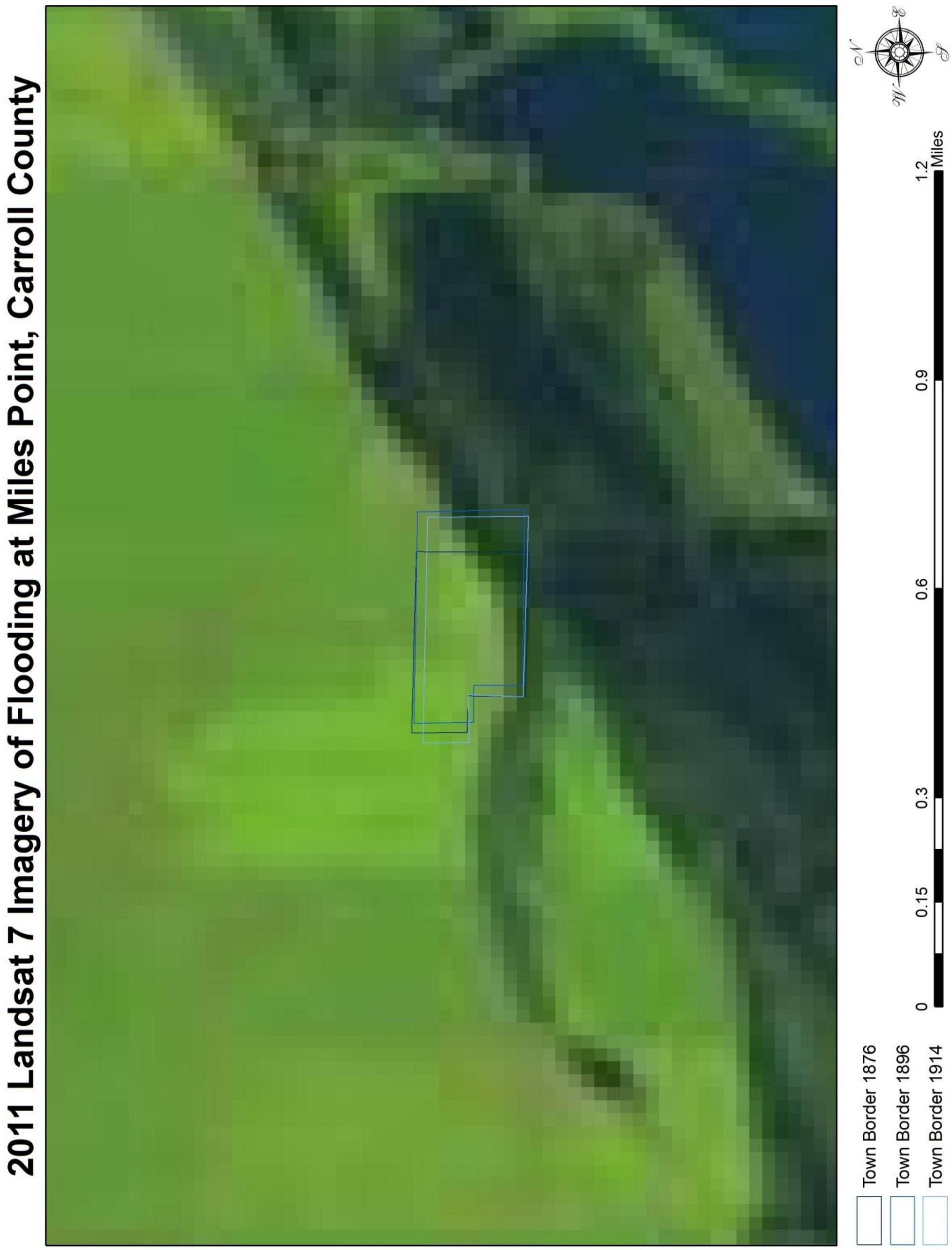


Figure 329.

Landsat imagery (SLC off) from July 26th, 2011, Missouri River Flood, Wakenda, Saline County.

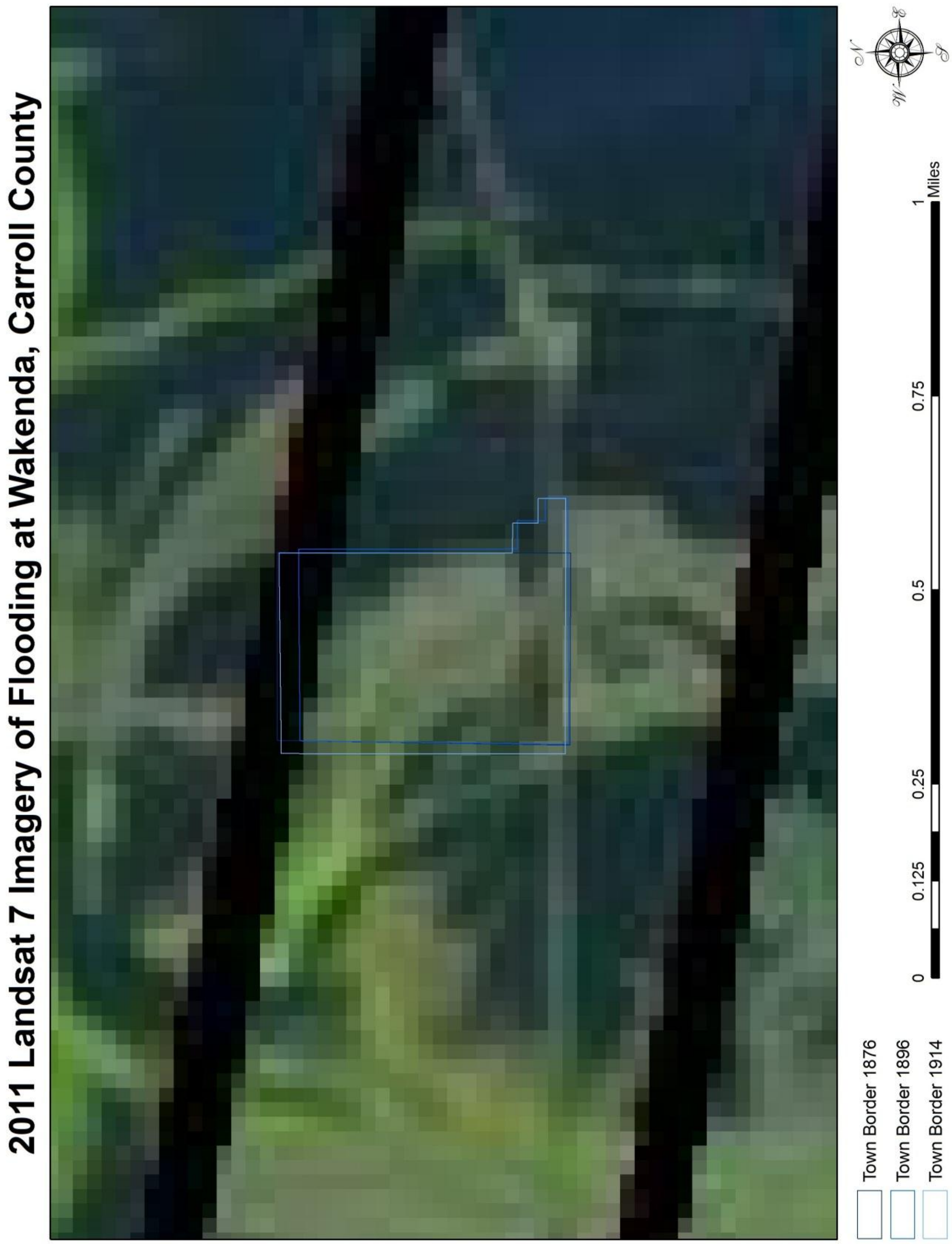


Figure 330.

A photograph of the flooding devastation at Hodge, Lafayette County, from August 26th.

Figure 331.

A photograph of the flooding devastation in Miami Station, Carroll County, from August 26th,

after the water began to recede.

Figure 332.

A photograph of the flooding devastation in Miles Point, Carroll County, from October 8th, after the water began to recede.

Appendix A

RMS error and control points for towns in Carroll County, Missouri.

Format	Town	Year	Control Points	RMS
Photocopy	Coloma	1876	4	5.36934
Digital Photo	Coloma	1896	4	4.05569
Digital Photo	Coloma	1914	4	7.09471
Photocopy	Miami Station	1876	4	4.28986
Digital Photo	Miami Station	1896	4	5.96884
Digital Photo	Miami Station	1914	4	10.1368
Photocopy	Miles Point*	1876	4	3.57210
Digital Photo	Miles Point*	1896	4	9.51044
Digital Photo	Miles Point	1914	4	8.92772
Digital Photo	Plymouth	1896	4	10.6506
Digital Photo	Plymouth	1914	4	19.3891
Photocopy	Wakenda**	1876	4	7.75954
Digital Photo	Wakenda**	1896	4	6.89486
Digital Photo	Wakenda**	1914	4	9.70281

* = Also known as Shanghai
** = Platted as Eugene City

Appendix B

RMS error and control points for railroads in Carroll County, Missouri.

Format	Township/Range	Year	Control Points	RMS
Photocopy	T 54N - R 23W (Middle)	1896	4	7.66642
Photocopy	T 54N - R 23W (South)	1896	4	7.44306
Photocopy	T 53N - R 23W (North)	1896	4	6.36363
Photocopy	T 53N - R 23W (South)	1896	4	6.59339

Note: The railroad was originally the Chicago, Burlington, and Quincy Railroad.

Appendix C

RMS error and control points for towns in Chariton County, Missouri.

Format	Town	Year	Control Points	RMS
Photocopy	Cunningham	1876	4	7.72964
Photocopy	Cunningham	1897	4	6.53091
Photocopy	Cunningham	1915	4	7.05721
Photocopy	Old Mendon*	1876	4	2.66029
Photocopy	Old Mendon*	1897	4	3.02891
Photocopy	Triplett	1876	4	2.17437
Photocopy	Triplett	1897	4	5.38578
Photocopy	Triplett	1915	4	5.42421
Photocopy	Wein**	1876	4	1.87906
Photocopy	Wein**	1897	4	2.45278

* = Originally Mendon
** = Originally Mt. St. Mary's

Appendix D

RMS error and control points for railroads in Chariton County, Missouri.

Format	Township/Range	Year	Control Points	RMS
Photocopy	T 56N - R 21W*	1876	4	5.79738
Photocopy	T 55N - R 21W (North)*	1876	4	1.39179
Photocopy	T 55N - R 21W (Middle)*	1876	4	7.13738
Photocopy	T 55N - R 21W (South)*	1876	4	7.30919
Photocopy	T 55N - R 20W*	1876	4	2.16634
Photocopy	T 54N - R 20W*	1876	4	5.54695
Photocopy	T 53N - R 20W*	1876	4	4.42655
Photocopy	T 53N - R 17W**	1876	7	7.37430
Photocopy	T 52N - R 17W**	1876	7	7.10211

* = The railroad was originally the Brunswick, Chillicothe, & Omaha Railroad
** = The railroad was originally the Keokuk & Kansas City Railroad

Appendix E

RMS error and control points for towns in Lafayette County, Missouri.

Format	Town	Year	Control Points	RMS
Photocopy	Berlin	1877	4	5.38475
Photocopy	Berlin	1897	4	3.44088
Photocopy	Berlin	1914	4	3.67545
Photocopy	Chapel Hill*	1877	4	4.63182
Photocopy	Chapel Hill*	1897	4	2.86079
Photocopy	Chapel Hill*	1914	4	3.90981
Photocopy	Hodge**	1897	4	3.45668
Photocopy	Hodge**	1914	4	5.48586
Photocopy	Mt. Hope	1877	4	4.69282

* = Originally Cool Spring and then Harrisburg, platted as Chapel Hill
** = Also known as Edward's Station and Hodge Post Office, platted as Edward's Station

Appendix F

RMS error and control points for railroads in Lafayette County, Missouri.

Format	Township/Range	Year	Control Points	RMS
Photocopy	T 49N - R 26W*	1897	4	4.03267
Photocopy	T 49N - R 26W*	1914	4	7.18139
Photocopy	T 51N - R 27W**	1914	4	5.01121
Photocopy	T 50N - R 26W (North)**	1914	7	4.37395
Photocopy	T 50N - R 26W (Middle)**	1914	4	1.65949
Photocopy	T 50N - R 26W (South)**	1914	4	4.67355
Photocopy	T 49N - R 25W (North)**	1914	4	4.54577
Photocopy	T 49N - R 25W (Middle)**	1914	4	7.36163
Photocopy	T 49N - R 25W (South)**	1914	4	7.64180
Photocopy	T 48N - R 25W**	1914	4	6.43557
Photocopy	T 48N - R 24W**	1914	4	3.01226
Photocopy	T 49N - R 28W***	1877	4	1.59988
Photocopy	T 49N - R 28W (North)***	1877	4	7.49939
Photocopy	T 49N - R 28W (Middle)***	1877	4	4.79794
Photocopy	T 49N - R 28W (South)***	1877	4	6.80252

* = This area included both the Rocky Branch and the Coal Co's Belt Line Railroad
** = Originally the Lexington & St. Louis Railroad, later the Missouri Pacific Railroad
*** = This was a paper railroad known as the Lexington, Lake, and Gulf Railroad

Appendix G

RMS error and control points for towns in Saline County, Missouri.

Format	Town	Year	Control Points	RMS
Digital Photo	Cambridge	1870	6	19.9626
Digital Photo	Cambridge	1896	6	7.82191
Digital Photo	Cambridge	1916	6	5.67262
Digital Photo	Elmwood	1870	4	7.23577
Digital Photo	Elmwood	1896	4	3.96845
Digital Photo	Elmwood	1916	4	4.45438
Digital Photo	Laynesville*	1870	5	5.26318
Digital Photo	New Frankfort**	1870	5	6.08628
Digital Photo	New Frankfort**	1896	5	0.93182
Digital Photo	New Frankfort**	1916	5	0.56511
Digital Photo	Salina	1870	4	10.0304
Digital Photo	Saline City***	1870	4	5.59702
Digital Photo	Saline City***	1896	4	0.85729
Digital Photo	Saline City***	1916	4	2.92501

* = The site is now on the north side of the Missouri River in Carroll County
** = Platted as Frankfurt
*** = Also known as Little Rock Post Office

Appendix H

RMS error and control points for railroads in Saline County, Missouri.

Format	Township/Range	Year	Control Points	RMS
Digital Photo	T 48N - R 23W (West)*	1870	4	18.8113
Digital Photo	T 48N - R 23W (West-Ct)*	1870	4	19.5532
Digital Photo	T 48N - R 23W (East-Ct)*	1870	4	15.6038
Digital Photo	T 48N - R 23W (East)*	1870	4	16.6257
Digital Photo	T 48N - R 22W*	1870	4	14.7387
Digital Photo	T 50N - R 21W**	1896	4	18.5027

* = Originally the Lexington & St. Louis Railroad, later the Missouri Pacific Railroad
** = Originally the Missouri Pacific Railroad

Appendix I

A list of acronyms used in the proposal and their full names.

Acronym	Full name
3D	Three-Dimensional
ANN	Artificial Neural Networks
AVHRR	Advanced Very High Resolution Radiometer
CIR	Color Inferred Photography
DEM	Digital Elevation Model
DPI	Dots Per Inch
DSLR	Digital Single-Lens Reflex
DTM	Digital Terrain Model
ERS-1	Earth Resources Satellite 1
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
GNIS	Geographic Names Information System
GPR	Ground Penetrating Radar
LiDAR	Light Detection And Ranging
IRS	Indian Remote Sensing
ISAR	Interferometric Synthetic Aperture RADAR
MIVIS	Multispectral Infrared and Visible Imaging Spectrometer
MODIS	Moderate-resolution Imaging Spectroradiometer
MSDIS	Missouri Spatial Data Information Service
NAIP	National Agriculture Imagery Program
NATO	North Atlantic Treaty Organization
NIR	Near Infrared
NMP	English Heritage's National Mapping Programme
PCA	Principal Components Analysis
PLSS	Public Land Survey System
RMS	Root Mean Square
SAR	Synthetic Aperture Radar

SIR-C	Shuttle Imaging Radar-C
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
SSHA	Social Science History Association
TIF	Tagged Image File Format
UNESCO	United Nations Educational, Scientific and Cultural Organization