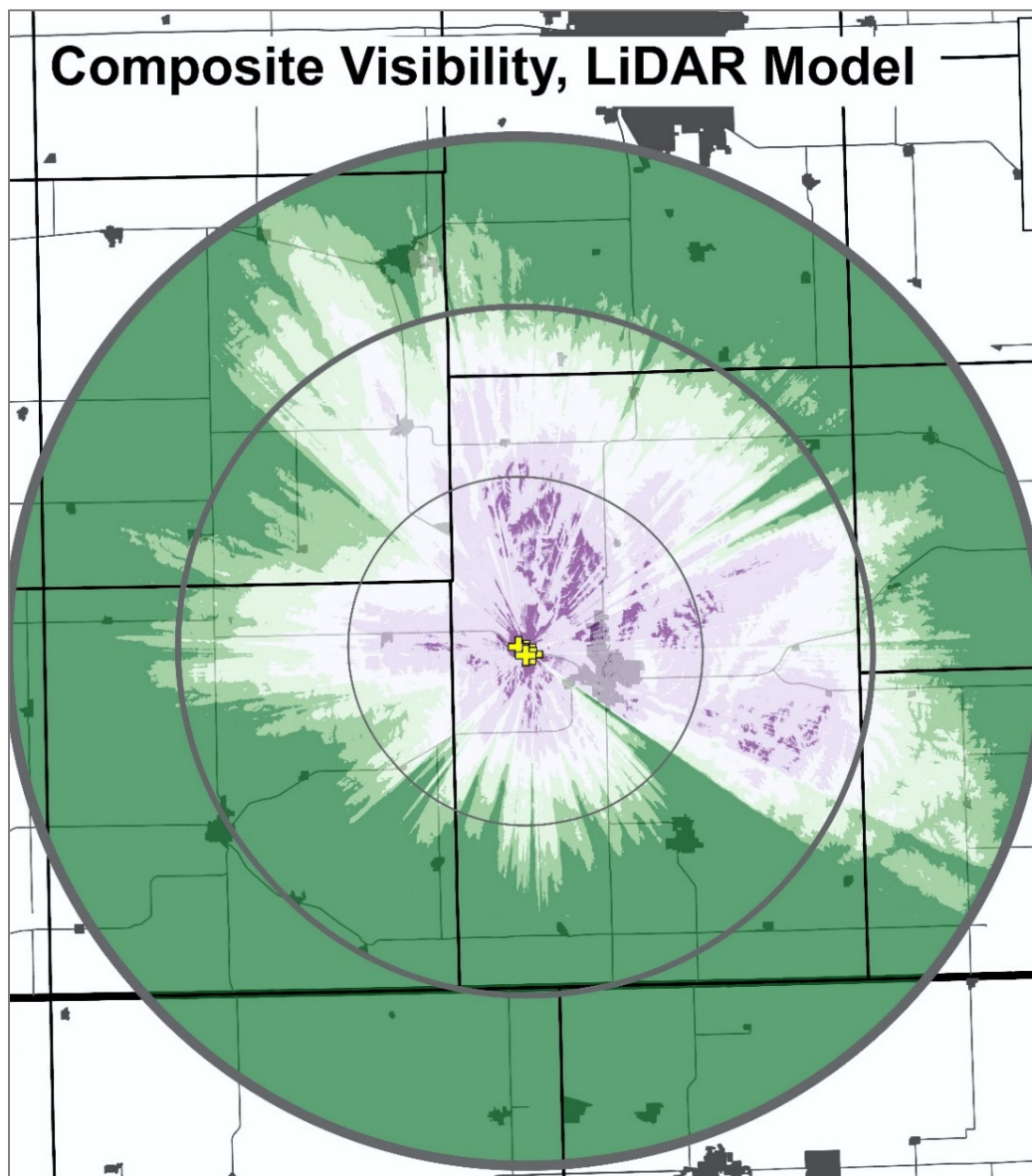




2024 Viewshed Analysis of Homestead National Historical Park

Updated to Include Screening Provided by Trees and Structures



Composite, LiDAR-derived viewshed map for four observation points within park.
UNIVERSITY OF NEBRASKA—LINCOLN / DAN UDEN

2024 viewshed analysis of Homestead National Historical Park: Updated to include screening provided by trees and structures

Science Report NPS/SR—2025/311

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Abstract

Homestead National Historical Park (HOME), southeast Nebraska, commemorates the 1862 Homestead Act with series of exhibits, including outdoor ecosystems that represent how the landscape may have appeared historically. The historical, scenic views of HOME have high aesthetic value but are threatened by land use changes, especially construction of tall structures visible over long distances. The impacts of development on scenic views depends on the location and height of constructed objects, topographical variability of the landscape, and the degree of visual obstruction from existing aboveground objects, such as buildings and trees. Viewshed analysis was used to estimate the impacts of development and other forms of landscape change on historic, scenic views within HOME. Two 1-meter [3.28-foot (ft)] landscape elevation datasets, a bare earth digital elevation model (DEM) and a light detection and ranging (LiDAR) digital surface model (DSM), were used to model the minimum height for aboveground object visibility in the 30-mile (mi) radius of HOME. The LiDAR-derived DSM accounted for the effects of aboveground objects on landscape visibility, while the bare earth DEM did not. Minimum height for aboveground object visibility maps were generated for four HOME observation points, based both on the bare earth DEM and LiDAR-derived DSM. Lastly, composite maps of bare earth and LiDAR-derived visibility that combine minimum height class maps across the four observation points were developed. Visibility varied across the radius, among observation points, and between elevation datasets. Despite landscape visibility generally being greater in the bare earth than LiDAR-derived viewshed maps, there was a notable degree of similarity between the bare earth composite and LiDAR-derived composite maps. Overall, visibility is greatest to the southeast and northwest, lesser to the northeast, and lowest to the southwest of HOME. Both the bare earth and LiDAR-derived composite maps indicate that aboveground objects with heights of at least 20 ft are likely to be visible from at least one of the four observation points if they are within 10 mi of HOME. Between 10 mi and 20 mi from HOME, aboveground objects with heights of at least 20–100 ft are likely to be visible if they are located north, but not south, of HOME. Between 20 mi and 30 mi from HOME, aboveground objects less than 400 ft tall are unlikely to be visible, except for small areas to the southeast and northwest. These findings can help inform future viewshed management within HOME and the surrounding landscape.

List of Terms

Bare earth viewshed model: Viewshed analysis that uses bare earth elevation data as an input, and as such, does not account for the effects of aboveground objects on landscape visibility.

Digital elevation model (DEM): Representation of landscape topography as a continuous data layer composed of elevation estimates, not including the height of aboveground objects.

LiDAR viewshed model: Viewshed analysis that uses LiDAR-derived digital surface model elevation data as an input, and as such, accounts for the effects of aboveground objects on landscape visibility.

Digital surface model (DSM): Representation of landscape topography as a continuous data layer composed of elevation estimates, including the height of aboveground objects.

Geographic Information System (GIS): A system for construction, storage, and analysis of spatial data.

.las file: Decompressed form of LiDAR point cloud data.

.laz file: Compressed form of LiDAR point cloud data.

LiDAR (Light detection and ranging): Remote sensing technique that uses laser light pulse reflections to estimate object distances for three-dimensional representations of landscape topography.

Viewshed: Representation of landscape visibility from a given observation point(s), in the form of portions of the landscape that are visible or the minimum height for aboveground object visibility.

Acknowledgments

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Photograph of the western horizon, taken from the Homestead National Historical Park, Heritage Center Patio observation point.

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Introduction

Homestead National Historical Park (HOME) is a U.S. National Park Service (NPS) property located in Gage County of southeast Nebraska, U.S.A., several miles west of the City of Beatrice. HOME commemorates the 1862 Homestead Act and its contributions to the early American nation. Among the park's prominent features are two outdoor exhibits—a 100-acre restored tallgrass prairie and 60-acre lowland bur oak woodland—which represent how the land may have appeared in 1863 when the first homesteader in the country, Daniel Freeman, filed his Homestead Claim for the land. In the roughly 150 years since, the surrounding landscape has experienced marked changes in land use and landcover, including conversion of a large proportion of its prairies and woodlands to rowcrop production and various forms of development. The Nebraska Natural Legacy Plan, which serves as Nebraska's State Wildlife Action Plan, lists conversion and fragmentation of natural habitats from agriculture and development among the primary threats faced by regional tallgrass prairie and oak woodland ecosystems (Schneider et al. 2011). In addition to the direct impacts of land use conversion on ecosystems, it impacts cultural ecosystem services provided to people in surrounding areas, such as the aesthetic beauty and appreciation of ecosystems and historic sites (Ridding et al. 2018).

In 2007, the NPS placed a new visitors center to the east of the Freeman claim at HOME, with its design and placement intended to shield visitors from observing new developments to the north and limiting views of an Osage Orange hedgerow originally developed by Daniel Freeman. The scenic inventory value of several of the park's historical sites was rated as high to very high in a 2020 NPS Landscape Inventory. For this reason, the NPS has a vested interest in protecting the park's historic views, also known as viewsheds, from the impacts of changes in the surrounding landscape.

This study builds on previous efforts in developing viewshed maps for ascertaining and visualizing the impacts of regional developments on historic views within HOME. Viewshed maps show which portions of the earth's surface are visible to an observer at a known location(s), or relatedly, how tall aboveground objects must be to be visible from the observation point(s). There are various sources of visual obstruction capable of blocking portions of landscapes from observer views, including topographical variability, aboveground objects like trees or buildings, and the curvature of the earth.

Viewshed integrity can be managed by only siting aboveground objects (e.g., towers) in locations where they do not detract from the value of views at given observation points and/or by strategically placing more desirable aboveground objects (e.g., trees) in locations that shield viewers from the detrimental effects of more distant and less desirable objects.

Viewshed maps can help guide proactive and reactive management aimed at maintaining or enhancing the value of landscape views. Viewshed maps are generated through viewshed analyses within geographic information systems (GIS) and require, at a minimum, two data sources: 1) an observation point location and 2) a continuous representation of the landscape's elevational surface. A prior viewshed analysis for HOME was conducted with a single observation point and a moderate (i.e., 10-meter) resolution bare earth digital elevation model (DEM) as the data inputs. While generally useful for assessing landscape visibility, bare earth DEMs are inherently limited by their

failure to account for visual obstruction due to trees, buildings, and other aboveground objects, which in some instances, can drastically impact visibility. To account for obstruction from aboveground objects, light detection and ranging (LiDAR) point cloud data can be processed to develop digital surface models (DSMs) that account for the presence of aboveground objects, and thereby, provide more realistic and detailed viewshed products for guiding management decisions. In the same way, viewshed analyses based on multiple observation points provide a more comprehensive representation of landscape visibility and the impacts of landscape changes on it. Comparing viewshed maps among multiple observation points and combining them into composite viewshed maps can support more robust assessments of land use change viewshed impacts. Lastly, higher resolution (e.g., < 10-m) data inputs allow for generation of higher resolution viewshed maps, which more accurately represent landscape visibility.

Study Approach

The objective of this study was to develop high-resolution viewshed maps from both bare earth DEM (hereafter referred to as bare earth) and LiDAR-derived DSM (hereafter referred to as LiDAR) data layers for four locations with valuable scenic views within HOME. For each location, high-resolution spatial data layers and maps showing the minimum required heights for aboveground object visibility within the 30-mi radius of HOME were generated, both according to bare earth and LiDAR. Map products categorize all locations within the 30-mi radius of historic observation points according to the following minimum height classes for aboveground object visibility: 0 feet (ft) aboveground, 10 ft aboveground, 20 ft aboveground, 100 ft aboveground, 200 ft aboveground, 300 ft aboveground, and 400 ft aboveground. Finally, composite bare earth and LiDAR viewshed maps were generated, which integrate the respective viewshed layers from the four observation points into single map outputs. Individual and composite bare earth and LiDAR viewshed maps can be used to gauge the potential for changes in surrounding land use, such as the construction of structures of various heights, to impact historic views within HOME. Viewshed maps can also be used to assess the contributions of existing aboveground objects in the vicinity of the observation points, such as individual trees, planted shelterbelts, and buildings like the NHP Heritage Center, in shaping historic views. Finally, viewshed maps can be used to inform the siting of additional trees and buildings for shaping the park's viewsheds.

Selection of Key Resources, Indicators, and Reference Criteria

This study builds upon a prior HOME viewshed analysis through its: 1) Comparison and integration of multiple observation points, 2) Comparison of maps produced with bare earth and LiDAR elevation data, and 3) High-resolution data inputs and map outputs. The result is a diverse set of viewshed maps that provide robust representations of landscape visibility and potential land use change impacts, both of which can help inform proactive and reactive land management decisions.

Data Sources

Viewshed analyses were performed with two main classes of data input: 1) geographic coordinates of four observation locations within HOME and 2) continuous digital models (i.e., GIS layers) of landscape elevation. Two different landscape elevation models were utilized, with separate viewshed maps generated for each. One of the elevation inputs was a bare earth layer that represents landscape elevation (i.e., height above sea level) with aboveground objects (e.g., trees and buildings) removed. The other elevation input was a LiDAR layer that accounts for the presence of aboveground objects in its representation of landscape elevation. Multiple within-park observation points allow for the generation and comparison of multiple viewshed maps that collectively provide a fuller representation of landscape visibility than a single map generated for one location. In addition to comparing viewsheds among observation points, viewsheds from multiple locations can be combined in a single composite viewshed map that simultaneously shows visibility from the full set of observation points. Similarly, the comparison of viewshed maps generated with bare earth and LiDAR data allows and supports more robust assessments of the degree to which aboveground objects shape landscape visibility than either data source provides alone.

Geographic coordinates of four observation points within HOME were provided by Jesse Bolli, Resource Management Specialist at HOME (Table 1). After entering the observation point coordinates into a Microsoft Excel file, they were converted to point shapefile (.shp) format in ArcPro software. The resulting point shapefile was reprojected to the North American Datum 1983 Universal Transverse Mercator Zone 14 North (NAD 1983 UTM 14 N) coordinate system and the observation points were exported as individual point shapefiles.

Table 1. Observation point names and locations, with latitudinal and longitudinal coordinates in degrees, minutes, and seconds.

Observation point	Latitude	Longitude
Freeman School	40°17'31.35" N	96°50'31.34" W
Heritage Center Patio	40°17'7.65" N	96°49'36.50" W
Prairie Plaza	40°17'19.37" N	96°50'0.19" W
Trail	40°17'4.71" N	96°50'3.07" W

High-resolution bare earth elevation data layers (i.e., DEM GeoTIFFs) were downloaded from the U.S. Geological Survey's (USGS 2023) The National Map website, processed, and used to generate a series of high-resolution viewshed maps that do not take into account visual obstruction from aboveground objects. Similarly, LiDAR point cloud data was downloaded from The National Map website and processed to create a regional DSM—and corresponding viewshed maps—that account for visual obstruction from aboveground objects. Detailed descriptions of both elevational datasets, processing steps, and viewshed outputs can be found in this report's Methodology/Analysis section.

Finally, the full set of TIGER spatial data layers from the U.S. Census Bureau (2023) were downloaded for the States of Nebraska and Kansas. From these datasets, the following layers were used in development of viewshed maps: counties, municipalities, designated places, and roads.

Methodology/Analysis

The geographic extent of the viewshed analyses was the collective (i.e., combined) 30-mi radii around the four observation points. To produce this extent layer, a 30-mi radius was generated around each of the observation points, using the Buffer tool in ArcPro. The four individual 30-mi radius polygons were then merged (i.e., combined) into a single 30-mi radius polygon that captures their collective extents. Collective 40-mi, 20-mi, and 10-mi radii shapefiles were also generated with the same set of steps. The 40-mi shapefile was used to download elevation data and to help manage the large number of elevational files requested/downloaded at once. The 40-mi radius was subdivided into four quadrants (northeast, southeast, southwest, and northwest) (Figure 1), each of which was exported as a new shapefile.

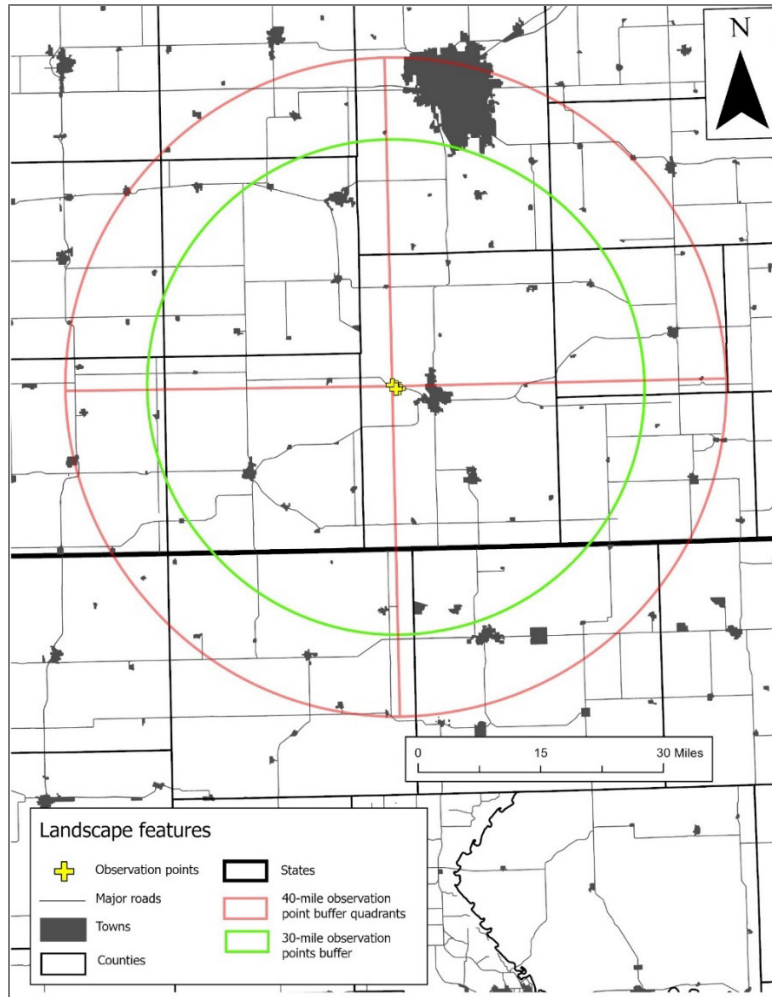


Figure 1. Map of 30-mile and 40-mile radii around Homestead National Historical Park, with the 40-mile radius polygon separated into four quadrants.

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For each of the four quadrants of the 40-mi radius, high-resolution (1-meter) bare earth data layers were downloaded from the U.S. Geological Survey’s (2023) The National Map website (Figure 2). To access a list of available 1-m GeoTIFF files within each of the four quadrants, zipped shapefiles of the quadrants were uploaded and a list of available images in each geography were downloaded as .txt files, which were then manually filtered to include only data collected in years 2016, 2017, and 2018, as they represented the most recently available data with complete coverage of the study area. Because each of the four quadrants contained many bare earth DEM GeoTIFFs—each covering different portions of the quadrant—the uGet download manager (<https://ugetdm.com/>) was used for mass downloading of files listed in the edited .txt file. All bare earth data layers within each of the four quadrants in each year were combined using the “Mosaic to New Layer” tool in ArcPro. The resulting four bare earth layers were similarly mosaicked into a single bare earth layer with an extent that covered the full 40-mi radius. Finally, the “Extract by Mask” tool in ArcPro was used to trim the extent of the bare earth layer to the combined 30-mi radius of the four observation points. All files

were securely stored on an external hard drive and backed up on the University of Nebraska-Lincoln Holland Computing Center's Attic system (<https://hcc.unl.edu/attic>).

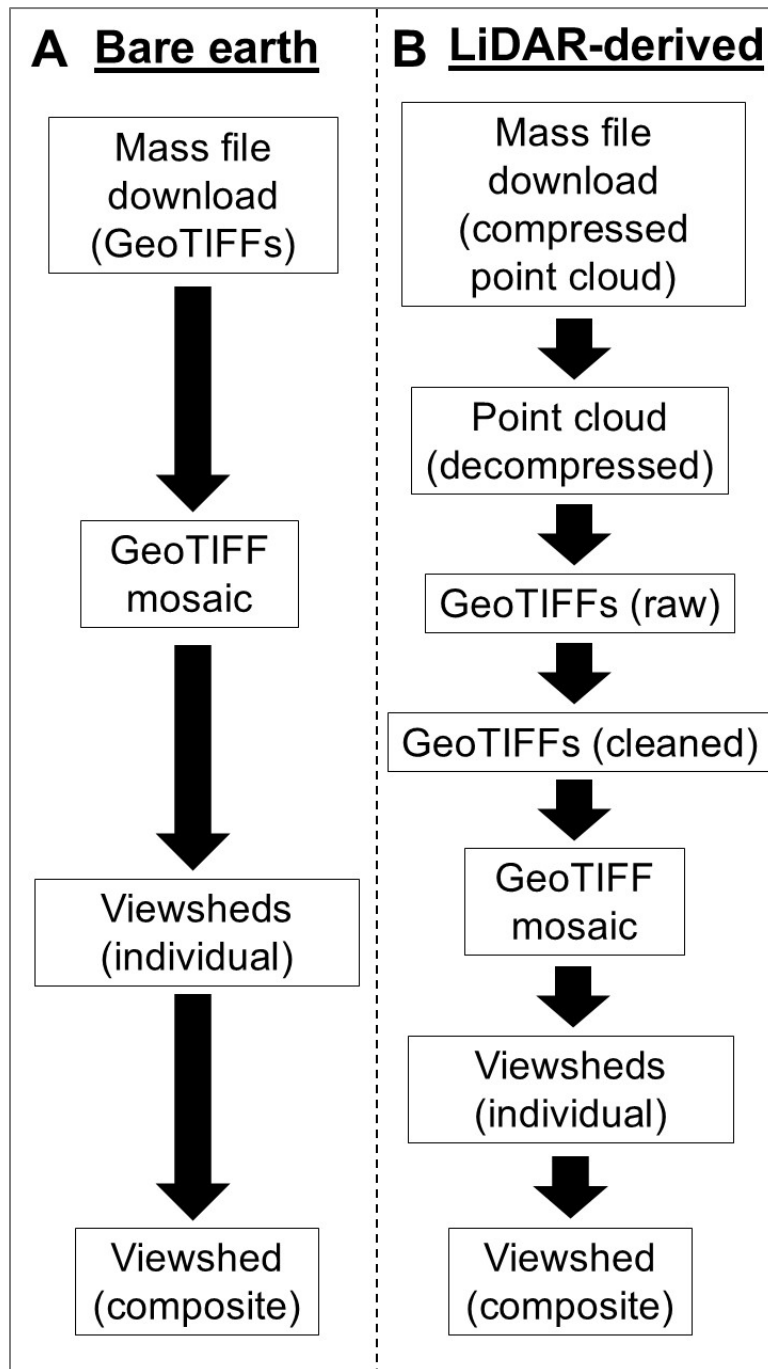


Figure 2. Workflows for generating single observation point and composite (combined observation points) viewsheds from bare earth (A) and LiDAR (B) data layers.

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High resolution LiDAR data layers that account for the presence of aboveground objects over the entirety of the study area could not be located. Therefore, for the entirety of the 40-mi observation point radius, LiDAR point cloud layers in .laz file (i.e., compressed) format were downloaded from the USGS The National Map website (Figure 2). GeoTIFFs that account for the presence of aboveground objects were derived from the LiDAR point cloud data through a series of processing steps. The four existing quadrants of the 40-mi radius of HOME were further subdivided to accommodate the larger number and size of LiDAR point cloud files requested/downloaded simultaneously. All subdivided quadrants were exported as individual shapefiles. To access a list of available LiDAR point cloud .laz files within each of the subdivisions of the 40-mi radius, zipped shapefiles of the subdivisions were uploaded and lists of available .laz layers for the geographies were downloaded as .txt files. The .txt files were then manually filtered to include only data collected in years 2016, 2017, and 2018, as these were the most recently available data layers with complete coverage of the study area. The uGet download manager was used to mass download all .laz files listed in each of the .txt files.

An additional intermediate data processing step in deriving GeoTIFF data layers that account for aboveground objects involves decompressing LiDAR point cloud files, which converts them from .laz to .las format (Figure 2). To decompress LiDAR point cloud files, the LAStools Toolbox for ArcPro was downloaded from the rapidlasso website (<https://rapidlasso.de/arcgis-lastools-toolbox-for-LiDAR-processing/>) and added to ArcPro. ArcPro Model Builder was used to construct a workflow linking Model Builder's Iterate Files tool and the "laszip" tool from the LAStools package for mass-decompression of .laz files (Figure 3). Decompressed LiDAR point cloud files retained original file names and were stored in .lasd.las format. Within the workflow, the laszip tool was parameterized as follows: the only report size box was checked, the also compress/decompress waveforms box was checked, and the output format was specified as las.

After all LiDAR point cloud files within the 40-mi radius had been decompressed, the "LAS Dataset to Raster" tool from the LAStools Toolbox was used to generate 1-meter LiDAR layers from them in ArcPro. For mass processing of files, a batch version of the "LAS Dataset to Raster" tool that accepts multiple .las file inputs and generates corresponding GeoTIFF outputs with original file names was created. The LAS Dataset to Raster batch tool was parameterized as follows: elevation was the value field, floating point was the output data type, cell size was the sampling type, 1 meter was the sampling value, and the z-factor was set at the default value of 1. This produced a set of raw, high-resolution LiDAR GeoTIFF layers that account for aboveground objects over the entirety of the 40-mi radius (Figure 2).

Visual inspection of a subset of raw LiDAR layers revealed instances of erroneously low and high elevation values associated with landscape factors such as standing water or steam emitted from processing plants and noise in LiDAR point cloud layers (especially year 2017), revealing the need for additional processing (i.e., cleaning) of the LiDAR layers (Figure 4).

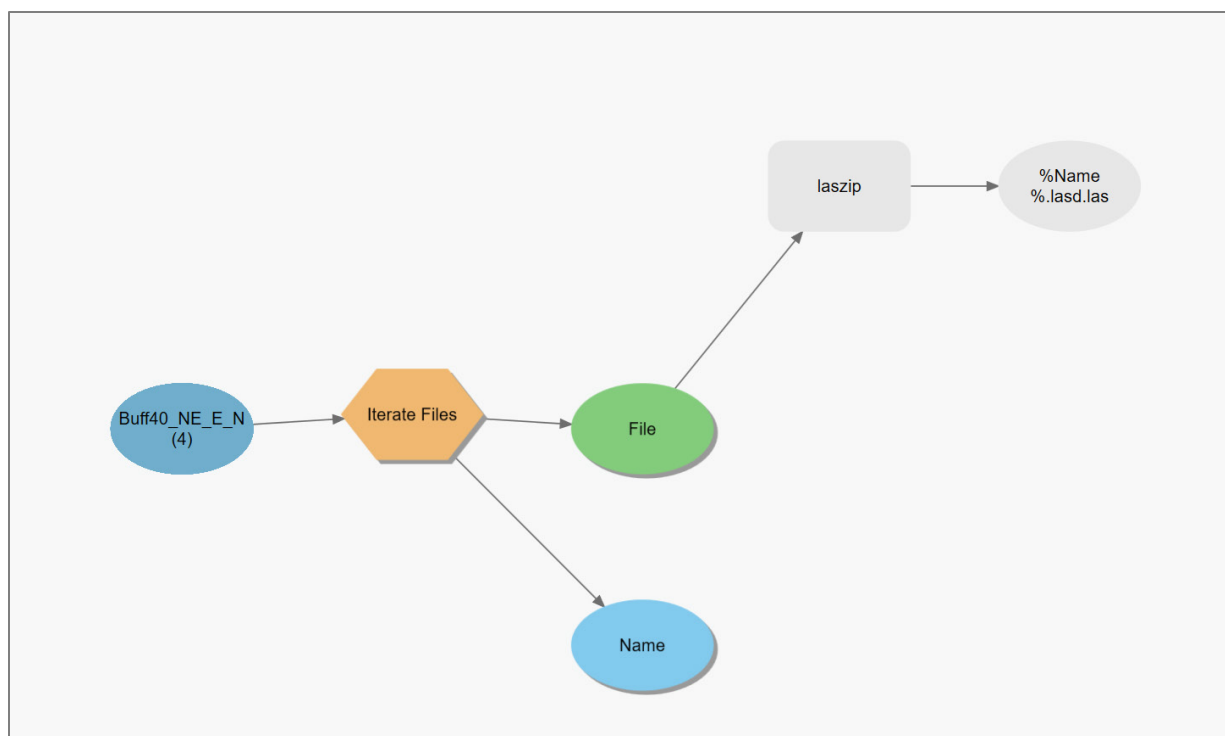


Figure 3. ArcPro Model Builder workflow for mass-decompression of .laz files.
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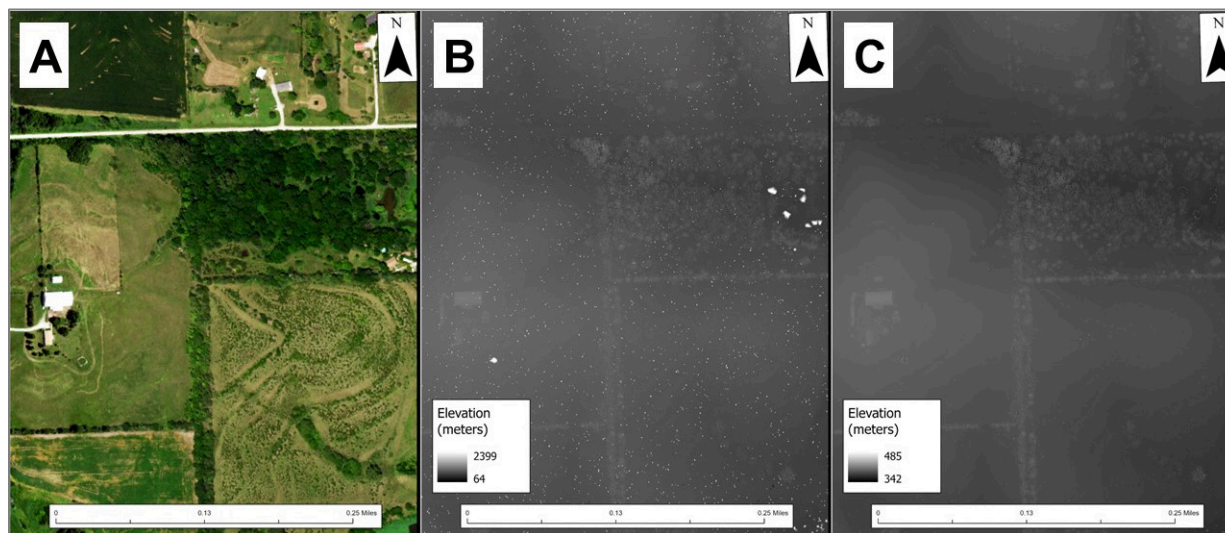


Figure 4. Example of the need for additional processing (i.e., cleaning) of LiDAR GeoTIFF layers, with National Agriculture Imagery Program (NAIP) imagery of a portion of the focal landscape (A) and corresponding raw (B) and cleaned (C) LiDAR layers.
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Raw LiDAR layers were cleaned through further processing that filters out extremely low and extremely high elevation values (Figure 2). In this data cleaning step, the “Extract by Mask” tool in ArcPro and the full (i.e., mosaicked) regional bare earth layer were used to generate a bare earth

layer with the same geographic extent and resolution as each LiDAR layer. Next, the “Raster Calculator” tool in ArcPro was used to generate a new GeoTIFF of pixel-level elevational differences (meters) between each LiDAR layer and its corresponding bare earth layer with the following formula:

$$\text{Elevation Difference} = \text{LiDAR elevation} - \text{Bare earth elevation}$$

Next, elevation difference GeoTIFFs were reclassified with the “Reclassify” tool in ArcPro, so that any pixels with values less than -10 meters or greater than 25 meters were assigned a new extremely negative value of -5000 , while any pixels with values between -9.99999 and 25 meters were assigned a new extremely positive value of 10000 . In effect, this reclassification created a binomial mask differentiating between presumed erroneous and non-erroneous map pixels. Each binomial mask layer was then mosaicked with its corresponding LiDAR layer using the Mosaic to New Raster tool, with the following parameterization: 32-bit float Pixel Type, 1-meter cell size, 1 band, and the mosaic operator set as negative. This generated a set of intermediate GeoTIFFs, in which map pixels marked as erroneous retained the extremely negative mask value of -5000 and non-erroneous pixels were assigned their LiDAR layer values. Finally, each resulting GeoTIFF was mosaicked with its corresponding bare earth layer, with the following parameterization: 32-bit float Pixel Type, 1-meter cell size, 1 band, and the mosaic operator set as positive. This generated a final set of cleaned LiDAR layers, in which map pixels that had been marked as erroneous were assigned their corresponding bare earth layer elevation values and non-erroneous pixels retained their LiDAR layer elevation values (Figure 4).

All cleaned LiDAR layers across each of the subdivided quadrants of the 40-mi radius were combined using the “Mosaic to New Layer” tool (Figure 2), with the following parameterizations: 32-bit float pixel type, 1-meter cell size, 1 band, and the mean mosaic operator, which averages the values of overlapping map pixels. The resulting LiDAR layers for each of the subdivided quadrant extents were then mosaicked within and across years to produce a cleaned, high-resolution LiDAR layer for the entirety of the 40-mi radius. Lastly, the “Extract by Mask” tool in ArcPro was used to clip the extent of the LiDAR layer to the combined 30-mi radius of the four HOME observation points (Figure 2). All intermediate and final files were securely stored on the University of Nebraska-Lincoln Holland Computing Center’s Attic system.

Following finalization of both the bare earth and LiDAR elevation layers for the 30-mi buffer of the observation points, a series of viewshed maps were generated for each elevation dataset with the viewshed tool in the terra Package (Hijmans 2023) for program R (R Core Team 2023) (Figure 2). Viewshed analyses were performed in R for improved performance with large file input and output sizes. For each of the four observation points, the viewshed tool was used to generate two GeoTIFF layers containing minimum height values (meters) for aboveground object visibility across the 30-mi buffer extent—one with the bare earth layer as the elevation input and one with the LiDAR layer as the elevation input. Each run of the viewshed tool was parameterized as follows: the bare earth or LiDAR layer was the input spatial raster, the observation point coordinate was the observation location, the assumed height of the observer was set to 1.80 meters (~ 5 ft and 11 inches), the

coefficient for representing the curvature of the Earth was set at the default value of 0.85714, and the output type was set to “land”. This resulted in eight viewshed GeoTIFF layers (two per observation point) of the minimum height for aboveground object visibility across the study area, which formed the basis for individual viewshed map exports.

In addition to bare earth and LiDAR viewshed GeoTIFFs for each of the four HOME observation points, composite viewsheds that integrate (i.e., combine) the minimum height for aboveground object visibility for each of the four observation points into a single GeoTIFF were generated (Figure 2). For both the set of four bare earth viewshed layers and the set of four LiDAR viewshed layers, this was accomplished by using the Reclassify tool in ArcPro to generate new GeoTIFFs, in which original minimum height for aboveground object visibility ranges were assigned new ordinal values associated with seven height classes specified by HOME staff (Table 2). For both the set of four bare earth viewshed layers and LiDAR viewshed layers, integration was accomplished with the Mosaic to New Raster tool in ArcPro, with the following parameterizations: 32-bit float Pixel Type, 1-meter cell size, 1 band, and the mosaic operator set as negative. This produced two final composite viewshed GeoTIFFs (one bare earth and one LiDAR) of minimum height class for aboveground object visibility across the four observation points.

Table 2. Original minimum height for aboveground object visibility (feet) value ranges and new ordinal value classes used in reclassification of bare earth and LiDAR viewshed maps for each of the four observation points.

Original Values	New Values
< 10	1
10–20	2
20–100	3
100–200	4
200–300	5
300–400	6
> 400	7

Individual and composite viewshed GeoTIFFs and supporting spatial data layers were used to produce viewshed maps (Figure 2). For visualization, continuous viewshed GeoTIFF values for individual observation point viewsheds were grouped into seven minimum height classes for aboveground object visibility: < 10 ft, 10–20 ft, 20–100 ft, 100–200 ft, 200–300 ft, 300–400 ft, and > 400 ft. These were the same set of values used for reclassification in development of composite GeoTIFF layers (Table 2). Although values were converted to standard measurements (ft and miles) in maps, the underlying data layers retained the metric values (meters) associated with the NAD 1983 UTM Zone 14 North projection. Composite viewshed maps contained ordinal values associated with classes of aboveground object visibility. The following supplementary data layers for the States of Nebraska and Kansas were added to individual and composite map layouts: state boundaries, county boundaries, municipalities, and roads. Transparency of GeoTIFF layers was set so that other map

features were visible behind them. Map layouts were exported in both .jpeg and .pdf file format at 600 dpi resolution and dimensions 11" × 17" and delivered to HOME staff via a secure cloud link. The aforementioned data layers were exported as ArcPro Layer Packages for delivery to HOME staff. All data layers, map outputs, and Layer Packages were securely stored on an external hard drive and the University of Nebraska-Lincoln Holland Computing Center's Attic system.

To supplement and enhance visual interpretability of viewshed maps, four photographs of the horizon at each of the four observation points were taken in June and August of 2024. At each observation point, a photograph was taken in each of the four cardinal directions (north-facing, east-facing, south-facing, and west-facing). For each observation point, the bare earth viewshed map, LiDAR viewshed map, and four photographs of the horizon were combined in single figures in the results chapter of this report.

Lastly, summary statistics were computed to supplement visual interpretations of single-point and composite (i.e., multi-point) viewshed maps and figures. Specifically, the proportional area of each of the seven minimum height for aboveground object visibility classes within the 10-mi, 20-mi, and 30-mi observation point radius polygons were calculated.

Study Results

The minimum height for aboveground object visibility varied across the 30-mi radius, among the four HOME observation points, and between bare earth and LiDAR elevation data inputs (Figures 5–8). As expected, viewshed maps produced with bare earth elevational data had lower minimum heights for aboveground object visibility than LiDAR viewshed maps, which incorporate visual obstruction from trees, buildings, and other aboveground objects (Table 3). At each of the observation points, comparison of bare earth viewshed maps, LiDAR viewshed maps, and photographs of the horizon reveal the role of aboveground objects in limiting landscape visibility.

At the Freeman School observation point, aboveground objects less than 100 ft tall are visible for ~10–20 mi to the northeast and southwest (Figure 5). Meanwhile, views to the northwest and southeast are largely obstructed by topography and a tall line of trees.

The Heritage Center Patio observation point exhibits a broad area of visibility in the bare earth viewshed, but this visibility is notably reduced in the LiDAR viewshed, especially to the north, due to complete obstruction from the Heritage Center building (Figure 6). However, views in other directions are largely intact, with objects of heights 100 ft or less visible for ~20 mi to the east and ~10 mi to the west.

Visibility from the Prairie Plaza observation point differs markedly between the bare earth and LiDAR viewshed maps, due primarily to trees and tree lines in the immediate vicinity (Figure 7). In the LiDAR viewshed maps, objects 100 ft tall are only visible for a few miles in small slivers of the northeastern and southwestern horizons.

The Trail observation point exhibits broad visibility to the north in both the bare earth and LiDAR viewshed maps, with objects of height 10 feet or less visible for ~10 mi across much of the northern horizon (Figure 8). Meanwhile, there is substantially less visibility to the southeast and southwest in the LiDAR map, due largely to visual obstruction from an adjacent tree line. Objects with heights of 100 ft are visible for less than 10 mi across a portion of the southern horizon.

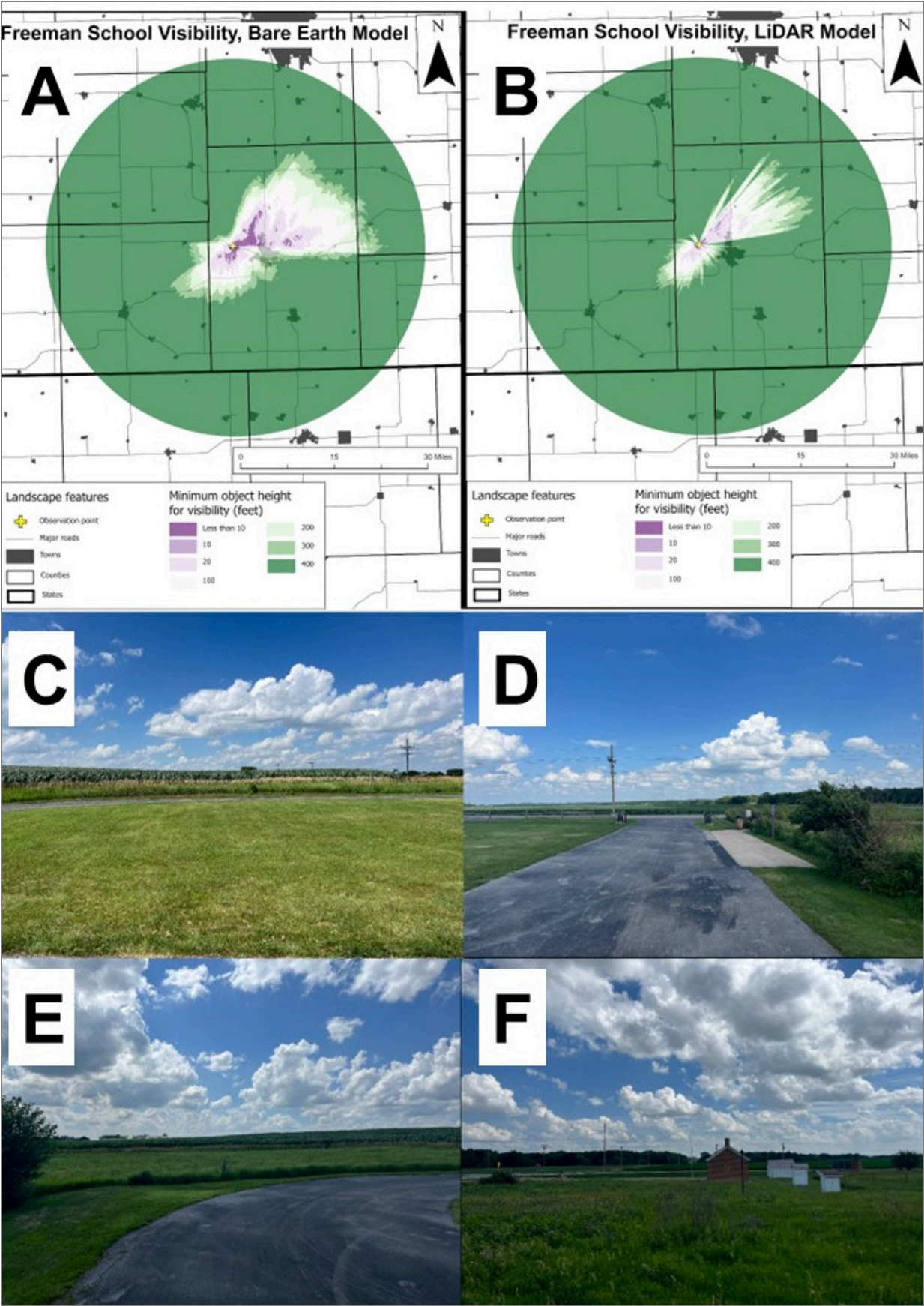


Figure 5. Freeman School observation point bare earth (A) and LiDAR (B) viewshed maps, as well as north-facing (C), east-facing (D), west-facing (E), and south-facing (F) photos taken from the observation point.

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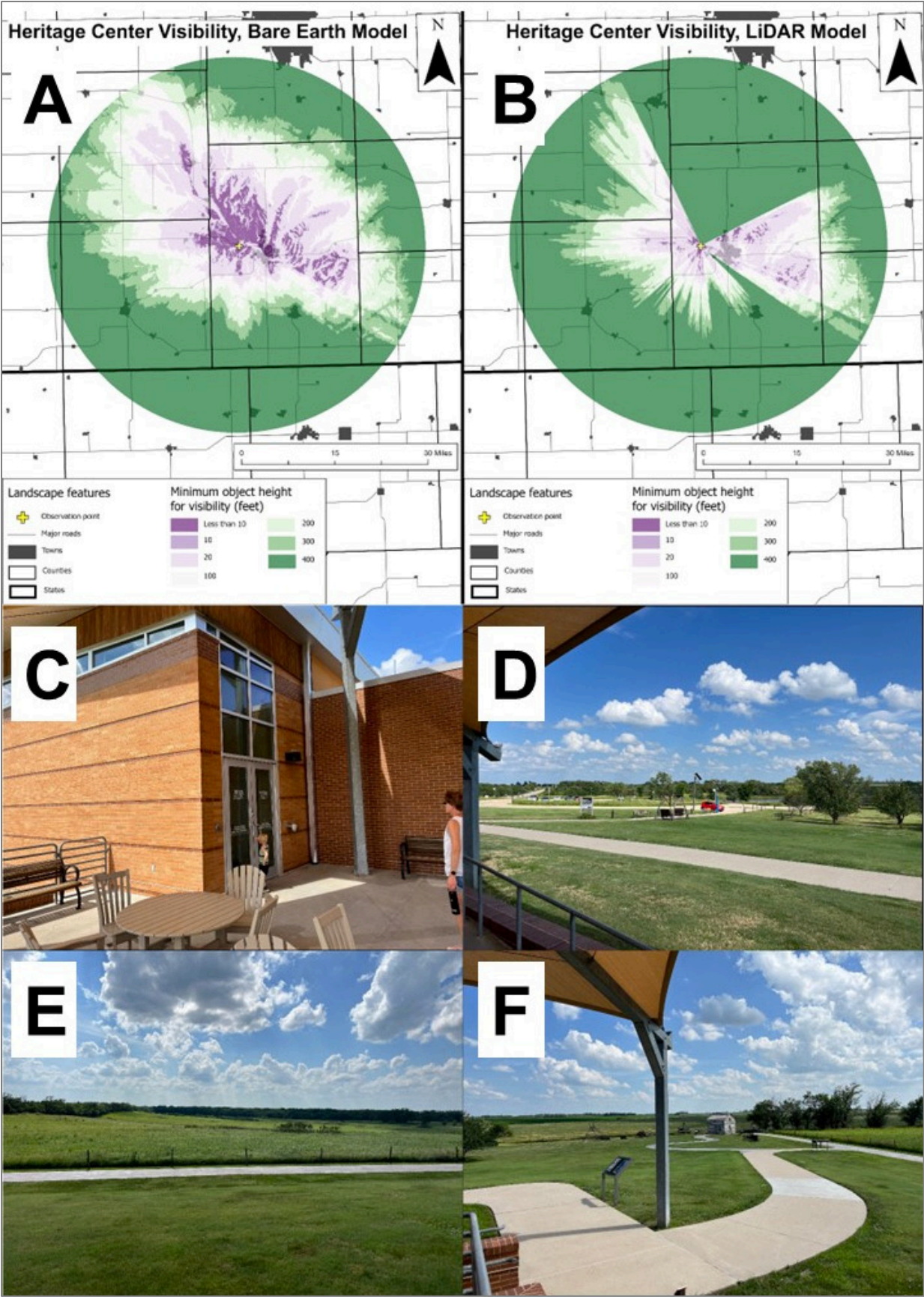


Figure 6. Heritage Center observation point bare earth (A) and LiDAR (B) viewshed maps, as well as north-facing (C), east-facing (D), west-facing (E), and south-facing (F) photos taken from the observation point.

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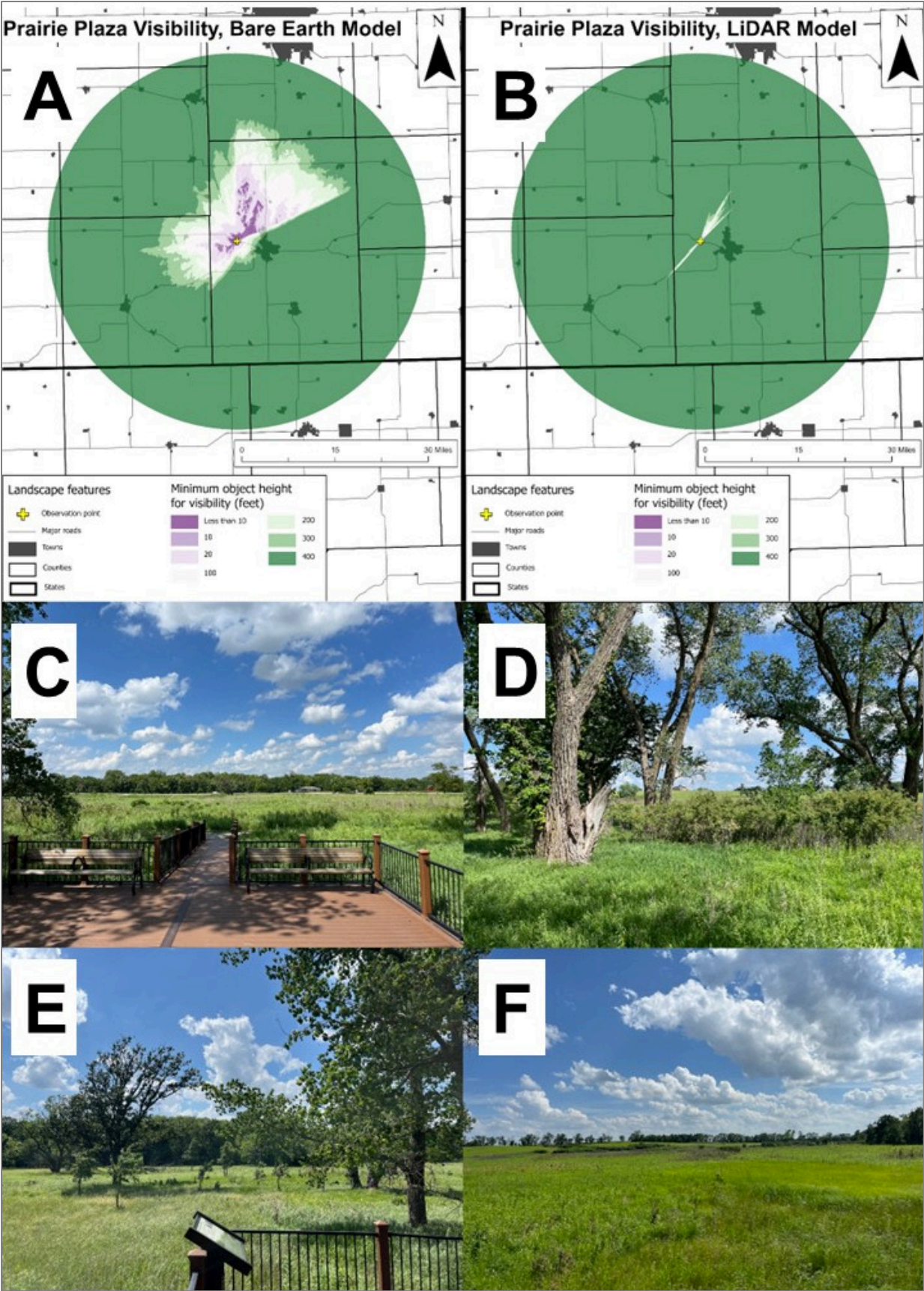


Figure 7. Prairie Plaza observation point bare earth (A) and LiDAR-derived (B) viewshed maps, as well as north-facing (C), east-facing (D), west-facing (E), and south-facing (F) photos taken from the observation point.

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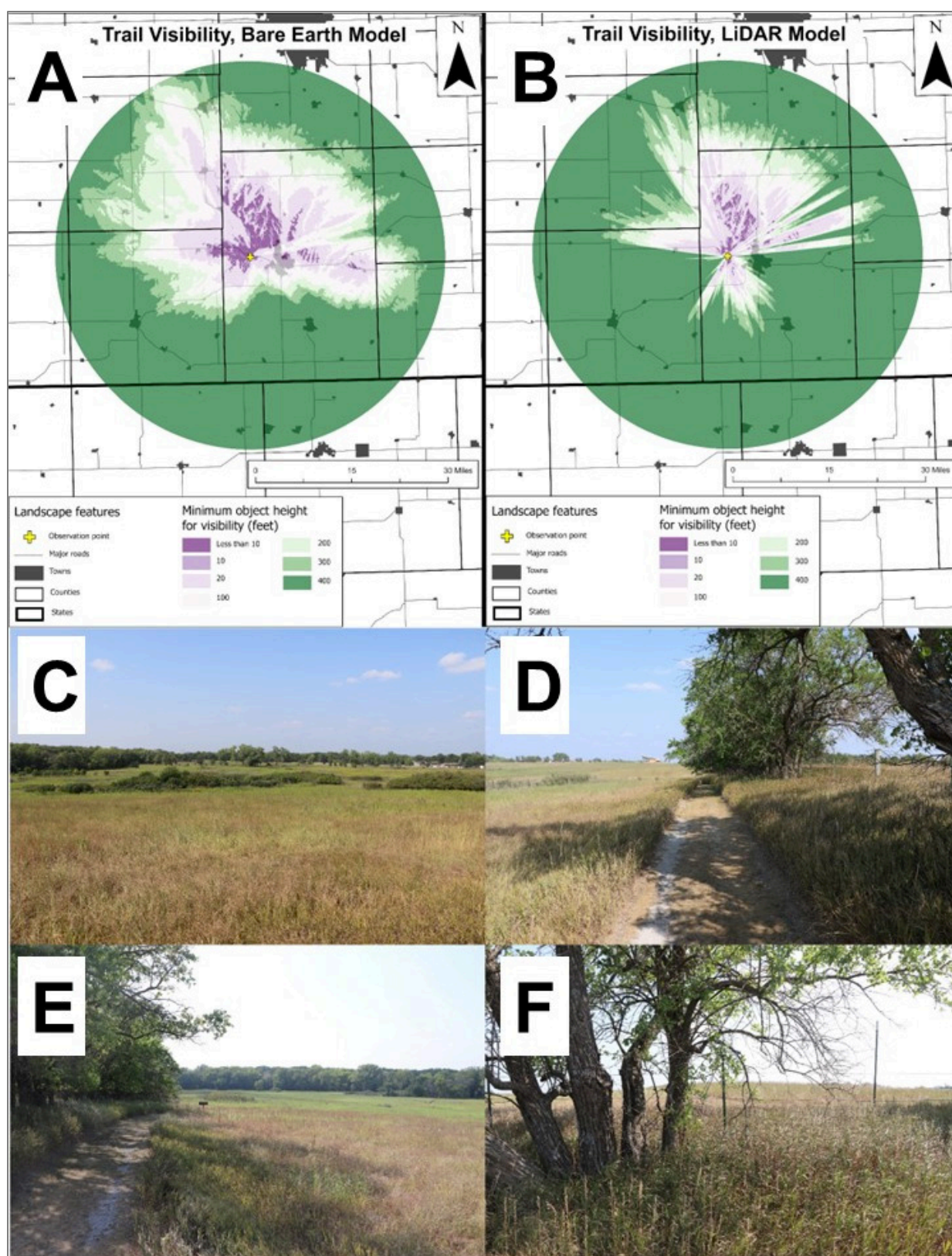


Figure 8. Trail observation point bare earth (A) and LiDAR (B) viewshed maps, as well as north-facing (C), east-facing (D), west-facing (E), and south-facing (F) photos taken from the observation point.
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Table 3. Acres within 30 miles where objects of various heights are visible. Potential for aboveground objects of seven minimum height classes to impact historic views across the 30-mile radius of four Homestead National Historical Park observation points and their composites (i.e., combinations), based on viewshed analyses conducted with bare earth and LiDAR elevation data inputs.

Observation Point	Minimum Height for Visibility	Bare Earth (Acres Within 30 Miles Visible From Observation Point)	% Of Area Visible Within 30 Miles	Lidar (Acres Within 30 Miles Visible From Observation Point)	% Of Area Visible Within 30 Miles
Freeman School viewshed	Less than 10	7006	0%	748	0%
	10 ft	10933	1%	1454	0%
	20 ft	49937	3%	15679	1%
	100 ft	119006	6%	44232	2%
	200 ft	178025	10%	78176	4%
	300 ft	239909	13%	113441	6%
	400 ft	1847434	100%	1847411	100%
Heritage Center Patio viewshed	Less than 10	59344	3%	5947	0%
	10 ft	90189	5%	12415	1%
	20 ft	318739	17%	120025	6%
	100 ft	560499	30%	246981	13%
	200 ft	783289	42%	378640	20%
	300 ft	997553	54%	518838	28%
	400 ft	1847434	100%	1847411	100%
Prairie Plaza viewshed	Less than 10	8282	0%	9	0%
	10 ft	13441	1%	13	0%
	20 ft	51878	3%	380	0%
	100 ft	114121	6%	1727	0%
	200 ft	184851	10%	4369	0%
	300 ft	256514	14%	7210	0%
	400 ft	1847434	100%	1847411	100%
Trail viewshed	Less than 10	32120	2%	9804	1%
	10 ft	48611	3%	17200	1%
	20 ft	208775	11%	104738	6%
	100 ft	414300	22%	216787	12%
	200 ft	608150	33%	316259	17%
	300 ft	797843	43%	428929	23%
	400 ft	1847434	100%	1847411	100%
Composite viewshed	Less than 10	59344	3%	14822	1%
	10 ft	90189	5%	27495	1%

Table 3 (continued). Acres within 30 miles where objects of various heights are visible. Potential for aboveground objects of seven minimum height classes to impact historic views across the 30-mile radius of four Homestead National Historical Park observation points and their composites (i.e., combinations), based on viewshed analyses conducted with bare earth and LiDAR elevation data inputs.

Observation Point	Minimum Height for Visibility	Bare Earth (Acres Within 30 Miles Visible From Observation Point)	% Of Area Visible Within 30 Miles	Lidar (Acres Within 30 Miles Visible From Observation Point)	% Of Area Visible Within 30 Miles
Composite viewshed (continued)	20 ft	318740	17%	189396	10%
	100 ft	560500	30%	380640	21%
	200 ft	783290	42%	561242	30%
	300 ft	997553	54%	755051	41%
	400 ft	1847434	100%	1847411	100%

Despite substantial differences in landscape visibility between the bare earth and LiDAR viewshed maps of all four observation points, there was a notable degree of similarity between the bare earth composite and LiDAR composite maps, although the LiDAR composite map provided less visibility in all directions (Figure 9, Table 3). This is largely due to portions of the landscape that are less visible from the Heritage Center Patio observation point being more visible from the Trail observation point, and vice versa. Meanwhile, the viewsheds of the Freeman School and Prairie Plaza observation points are mostly contained by the viewsheds of the Heritage Center Patio and Trail observation points. Overall, as indicated by a previous viewshed analysis, visibility is greatest to the southeast and northwest, lesser to the northeast, and lowest to the southwest. Both the bare earth and LiDAR composite maps indicate that aboveground objects with heights of 20 ft are likely to be visible from at least one of the four observation points if they are within 10 mi of HOME. Between 10 mi and 20 mi from HOME, aboveground objects with heights of 20–100 ft are likely to be visible north of HOME, but not south of HOME. Between 20 mi and 30 mi from HOME, aboveground objects less than 400 ft tall are unlikely to be visible, with the exception of small proportions of the southeastern and northwestern study area (Figure 9). Collectively, these findings can help inform future viewshed management within HOME and the surrounding landscape.

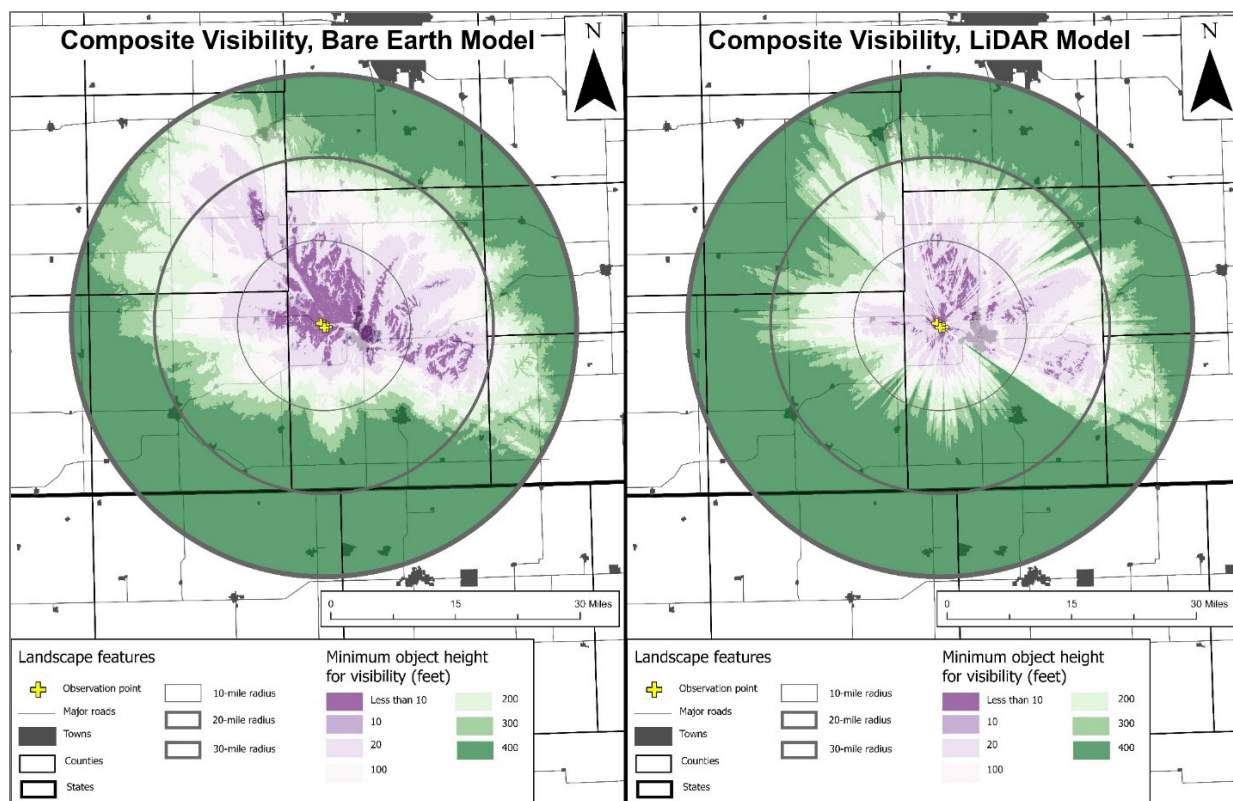


Figure 9. Composite bare earth (A) and LiDAR (B) viewshed maps, each of which account for visibility from all four observation points. Both maps also include 10-mile, 20-mile, and 30-mile observation point radii.

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Summary and Recommendations

This study generated a series of high-resolution viewshed maps for gauging the potential impacts of landscape changes on historic views at HOME in southeast Nebraska. Viewshed maps covered the 30-mi radius of four observation points within HOME: the Freeman School, the Heritage Center Patio, the Prairie Plaza, and a Trail. For each individual observation point, two maps showing the minimum height for aboveground object visibility were produced. One map was based on bare earth elevation data, which does not account for the effects of trees, buildings, and other aboveground objects on landscape visibility. Another map was based on LiDAR elevation data, which does account for the effects of aboveground objects. Minimum height for aboveground object visibility values across the entirety of the 30-mi observation point radius were grouped into the following seven classes: < 10 ft, 10 ft, 20 ft, 100 ft, 200 ft, 300 ft, 400 ft, and > 400 ft.

Comparison of viewshed maps among observation points and between bare earth and LiDAR elevation data revealed substantial variation in landscape visibility. As expected, LiDAR viewshed maps exhibited less visibility than viewshed maps generated with bare earth elevation data. When visual obstruction from aboveground objects was accounted for in the LiDAR elevation layers, the observation points with the greatest degrees of landscape visibility were the Heritage Center Patio, which provides a moderate degree of visibility for 10–20 mi in every direction except north, and the Trail, which provides a moderate degree of visibility for 10–20 mi to the north. The viewsheds of the Freeman School and Prairie Plaza observation points were largely subsumed by the viewsheds of the Heritage Center Patio and Trail observation points.

For more robust representations of landscape visibility, composite viewshed maps were developed across the four observation points with bare earth and LiDAR elevation data. Despite the high degree of variability in viewsheds displayed among observation points and between bare earth and LiDAR viewsheds, the composite bare earth and LiDAR viewshed maps are similar in several regards, and similar conclusions about the potential effects of landscape change on multi-point visibility can be drawn from them. First, both maps show that within 10 miles of HOME, aboveground objects that are at least 100 feet tall are likely to be visible from at least one of the four observation points. This is in part due to portions of the landscape that are less visible from the Heritage Center Patio observation point being more visible from the Trail observation point, and vice versa. Both the composite bare earth and composite LiDAR maps also show that from 10–20 miles from HOME, there is a relatively low likelihood that aboveground objects shorter than 400 ft and located to the south of HOME will be visible from any of the four observation points. However, aboveground objects 10–20 miles to the north, east, or west of HOME are likely to be visible from at least one of the four observation points at heights of 20–100 ft. Aboveground objects further than 20 mi from HOME have a low likelihood of being visible from any of the four observation points at heights of 400 ft or less, with the exception of selected areas to the southeast and northwest of HOME.

Collectively, the results of these high-resolution viewshed analyses at multiple observation points and different elevation data sources broadly align with the conclusions of a prior viewshed analysis conducted at moderate (10 m) resolution, from one observation point, and with bare earth elevation

data. However, the map products in this study provide more detailed data products for informing land management decisions.

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