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The 3D Elevation Program—Supporting Missouri's Economy

Introduction

Because of its geography, Missouri is frequently subject to natural disasters. Ice storms, severe thunderstorms, tornadoes, and flooding are all common occurrences. Since 1990, Missouri has received 40 Federal major disaster declarations (Missouri State Emergency Management Agency, 2022). Floods and droughts severely affect the State's agriculture, which is a leading industry. Another potential major hazard is the New Madrid seismic zone (NMSZ), located in southeastern Missouri. According to the Missouri Seismic Safety Commission (2007, p. 11, 12), "During the winter of 1811–1812, three earthquakes estimated to have been magnitude 7.5 or greater were centered in the southeastern part of Missouri. * * * Minor, but potentially damaging, earthquakes can occur anywhere in the State." Because Missouri is a major producer of lead, manufacturing and mining are very important to the State's economy, as are restoring and reclaiming lands damaged by historical mining activities. Critical applications that meet the State's management needs depend on light detection and ranging (lidar) data that provide a highly detailed three-dimensional (3D) model of the Earth's surface and aboveground features.

The 3D Elevation Program (3DEP; refer to sidebar) is managed by the U.S. Geological Survey (USGS) in partnership with Federal, State, Tribal, U.S. territorial, and local agencies to acquire consistent lidar coverage at quality level 2 or better (table 1) to meet the many needs of the Nation and Missouri. The status of available and in-progress 3DEP baseline lidar data in Missouri is shown in figure 1. 3DEP baseline lidar data include quality level 2 or better, 1-meter or better digital elevation models, and lidar point clouds, and must meet the Lidar Base Specification version 1.2 (https://www.usgs.gov/3dep/lidarspec) or newer requirements. The National Enhanced Elevation Assessment (Dewberry, 2012) identified user requirements and conservatively estimated that availability of lidar data would result in at least $11.35 million in new benefits annually to the State. The top 10 Missouri business uses for 3D elevation data, which are based on the estimated annual conservative benefits of 3DEP, are shown in table 2.

Table 1. Data quality levels, pulse spacing, and pulse density. Quality level 2 or better lidar data meet 3DEP requirements.

[Specifications for quality level 0 (QL0) are from Heidemann (2012, p. 3 and table 1); for quality levels 1 and 2, specifications are from Sugarbaker and others (2014, table 1). In the quality level column, QL0 represents the highest level of quality. $RMSE_z$, root mean square error in the elevation (z) dimension; cm, centimeter; m, meter; pls/m², first return pulses per square meter; ≤, less than or equal to; ≥, greater than or equal to]

Quality level	$RMSE_z$ (cm)	Aggregate nominal pulse spacing (m)	Aggregate nominal pulse density (pls/m²)
QL0	≤5	≤0.35	≥8.0
QL1	≤10	≤0.35	≥8.0
QL2	≤10	≤0.71	≥2.0

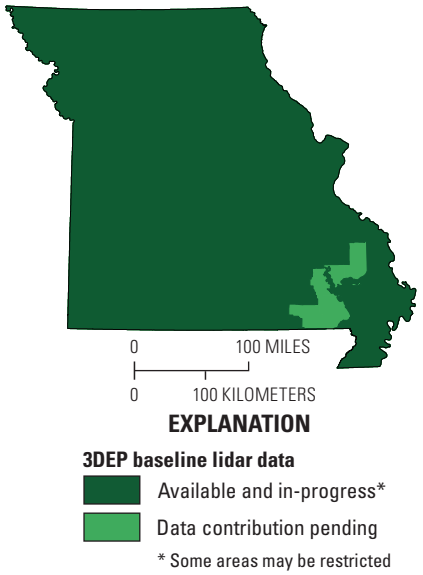

Figure 1. Map of Missouri showing status of 3D Elevation Program (3DEP) baseline lidar data as of May 2023. Visit https://usgs.gov/NationalMap/LidarExplorer to find and download currently available data.

Status of 3DEP in Missouri

The Missouri Department of Conservation and the Missouri Geological Survey, within the Department of Natural Resources, have a need for quality levels 1 and 2 lidar data, respectively. Lidar acquisitions by these agencies began in 2022 and are continuing.

Agriculture and Precision Farming

Missouri's agribusiness and related industries produced $82.6 billion in annual revenue in 2021 (Missouri Agricultural and Small Business Development Authority, 2021). Soybeans, cattle, corn, hogs, poultry, dairy, cotton, and rice are the top agricultural commodities. Lidar data can provide a more accurate depiction of terrain and substantially improve precision farming activities, which helps improve crop yields, prevent soil degradation, and reduce agricultural chemical runoff—factors that help farmers realize a larger return on their investments. The flood risk management business use is also very important to the agricultural community of Missouri because of farmland flooding.

Flood Risk Management

One of the hallmarks of Missouri's 2018 Hazard Mitigation update plan (Missouri State Emergency Management Agency, 2018) has been the concerted effort to integrate as much available geospatial data as possible and to take advantage of emerging worldwide technologies for data display (fig. 2). Lidar is one of the emerging technologies that can be used to create flood inundation maps produced from flood-plain modeling software. These maps help users understand the geographic extent of flooding and associated water depths.

Geologic Resource Assessment and Hazard Mitigation

The flat-lying, southeasternmost section of Missouri—the "Bootheel"—is most susceptible to earthquakes because it overlies the NMSZ, an area that also covers parts of Arkansas, Illinois, Kentucky, and Tennessee. According to the Missouri Seismic Safety Commission (2007, p. 12), the Bootheel "has the highest risk because its subsurface conditions—loose sediments and a high water table—tend to amplify earthquake ground shaking. The immediate vicinity of the Ozarks is also at risk from earthquakes in the NMSZ. As in the Bootheel, subsurface conditions of the Mississippi and Missouri River valleys tend to amplify earthquake ground shaking. As a result, these areas, including much of metropolitan St. Louis, are also at high risk from earthquakes. Earthquake hazards in the western part of the State also exist because of historical earthquakes

3DEP by the Numbers: Missouri

Expected annual benefits	$11.35 million
Estimated cost for quality level 2 completion[1]	$1.99 million
Payback	0.18 year

[1]Quality levels 0 and 1 collection is at additional cost.

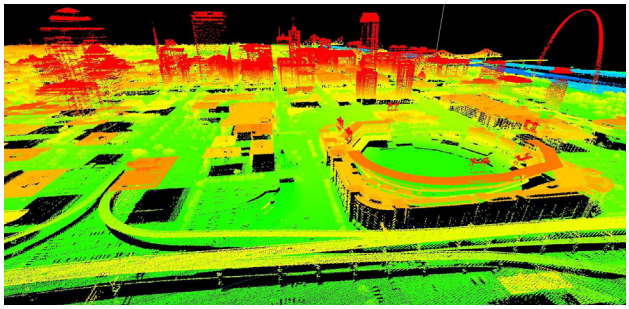

Figure 2. Image derived from lidar point-cloud of downtown St. Louis, Missouri. Colors represent elevation above the ground surface, with dark blue representing the lowest elevations and warmer colors representing higher elevations. Point-cloud and bare-earth lidar data are important tools in analyses of flood risk management, agriculture and precision farming, geologic resource assessment and hazard mitigation, and other business uses. Graphic by David Nail, U.S. Geological Survey.

in eastern Kansas and Nebraska. No area of Missouri is immune from the danger of earthquakes." The use of lidar data can assist in the creation of hazard maps, in identifying natural geologic features, and in monitoring ground surface changes.

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Table 2. Conservative benefits estimates for the top 10 Missouri business uses of the proposed 3DEP data identified in the National Enhanced Elevation Assessment (Dewberry, 2012).

Rank	Business use	Annual benefits (millions)
1	Agriculture and precision farming	$3.30
2	Natural resources conservation	2.84
3	Flood risk management	2.25
4	Homeland security, law enforcement, and disaster response	1.25
5	Infrastructure and construction management	0.60
6	Water supply and quality	0.38
7	Forest resources management	0.20
8	Urban and regional planning	0.20
9	Geologic resource assessment and hazard mitigation	0.13
10	Aviation navigation and safety	0.11
	Other	0.09
	Total	11.35

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By David Nail

3D Elevation Program (3DEP)

The 3D Elevation Program is managed by the U.S. Geological Survey (USGS) on behalf of the community of Federal, State, Tribal, local, and other partners and users of elevation data. In response to growing needs for high-quality elevation data, the goal of 3DEP is to complete acquisition of nationwide light detection and ranging (lidar) data (interferometric synthetic aperture radar [IfSAR] data in Alaska) to provide the first-ever national baseline of consistent, high-resolution topographic elevation data—both bare-earth digital elevation models and 3D point clouds.

Benefits

- Economies of scale by acquiring data for larger areas.
- Predictable and flexible Federal investments that reduce costs and allow better planning.
- Consistent national coverage that provides data for applications that span project, jurisdictional, and watershed boundaries.
- Simplified data acquisition that provides contracts, project management, quality assurance, and published data specifications.
- National benefits of $690 million per year conservatively, with the potential to generate $13 billion per year in additional benefits through applications that span the economy (Dewberry, 2012).

High-Quality Data and Products

3DEP lidar data provide coverage with a minimum of two points per square meter and a vertical error not to exceed 10 centimeters, measured as root mean square error in the elevation (z) dimension ($RMSE_z$) (table 1). 3DEP baseline lidar data products include all data points collected (point clouds) and bare-earth digital elevation models with a 1-meter or better resolution. The USGS integrates the elevation data into The National Map. Data are available free of charge and without use restrictions. To download 3DEP products visit https://apps.nationalmap.gov/downloader/.

Ways to Participate

Participation in 3DEP is open to Federal, State, Tribal, U.S. territorial, and local government partners, as well as private sector partners, and offers the option to acquire higher quality data. Partners may contribute funds toward projects managed by the USGS, or they may receive cooperative funds to manage their own projects. An annual Broad Agency Announcement is the mechanism used to establish partner agreements. Organizations and the private sector may contribute existing data that meet 3DEP requirements. For more information refer to the 3DEP website at https://usgs.gov/3DEP/collaborate/.

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