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# The 3D Elevation Program—Supporting the Texas Economy

## Introduction

High-resolution elevation data for Texas inform decision making to improve the State's economy. Existing elevation data coverage is used to improve resiliency to natural disasters, manage energy infrastructure, and assess natural resources. The expanding availability of current and more accurate elevation data helps better support natural resources conservation, agriculture and precision farming, flood risk management, infrastructure and construction management, geologic resource assessment and hazard mitigation, coastal zone management, and identification of features of interest or concern, such as archaeological and historic sites. 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 Texas. The status of available and in-progress 3DEP baseline lidar data in Texas 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 $53.1 million in new benefits annually to the State. The top 10 Texas 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/m$^2$, 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/m$^2$) |
|---|---|---|---|
| QL0 | ≤5 | ≤0.35 | ≥8.0 |
| QL1 | ≤10 | ≤0.35 | ≥8.0 |
| QL2 | ≤10 | ≤0.71 | ≥2.0 |

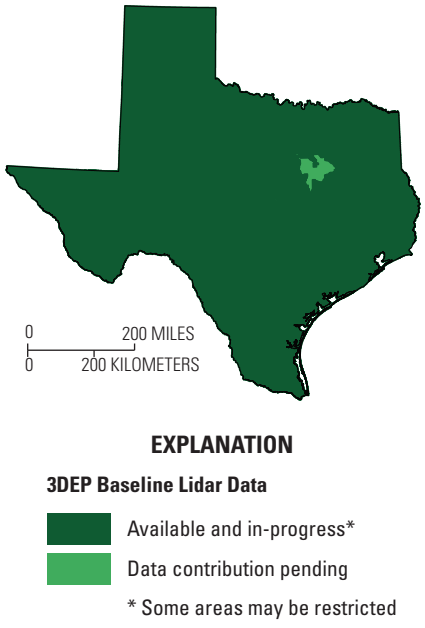


**Figure 1.** Map of Texas showing status of 3D Elevation Program (3DEP) baseline lidar data as of May 2024. Visit https://usgs.gov/NationalMap/LidarExplorer to find and download currently available data.

## Status of 3DEP in Texas

The Texas Geographic Information Office (formerly Texas Natural Resources Information System), a division of the Texas Water Development Board (TWDB), acquires lidar data through the State-funded Strategic Mapping Program (StratMap), which partners with other State, local, and Federal agencies through the Strategic Mapping Program Contracts. Since 2009, 39 partner agencies have contributed to 40 projects with a total value of $19.6 million. These projects, along with 3DEP acquisitions by Federal partners such as the Federal Emergency Management Agency, the Natural Resources Conservation Service of the U.S. Department of Agriculture, and the USGS, achieved completion of statewide lidar coverage in 2020. Next steps for the State include obtaining higher resolution (quality level 1) data in certain areas, maintaining quality level 2 coverage across Texas, and improving the quality and density of hydrography data based on lidar data.

## Water Supply and Quality

Texas is experiencing tremendous population growth, along with a recurring threat of severe drought. The mission of the TWDB is "to lead the State's efforts in ensuring a secure water future for Texas" (Texas Water Development Board, 2023). Lidar data are used to help fulfill this mission as base data for reservoir flood-pool modeling, hydrodynamic modeling, reservoir capacity determinations, sedimentation studies, and determinations of freshwater inflow requirements.

**Figure 2.** Bridge destroyed by flooding of the Blanco River at Fischer Store Road near Wimberley, Texas, in May 2015. Photograph taken June 1, 2015. Courtesy of U.S. Geological Survey Oklahoma-Texas Water Science Center.

## Flood Risk Management

Texas experiences significant coastal and riverine flooding, such as the Blanco River flood (fig. 2) which killed 12 people and caused severe infrastructure damage. High-resolution lidar can be used to improve the accuracy of flood-plain mapping and hydrologic modeling, enabling flood planners to better identify area of high risk, which could lead to mitigating the costs of flood events and possibly saving lives.

## Coastal Zone Management

As a frequent target of tropical storms, Texas coastal communities experience cycles of storm impact and recovery, costing billions of dollars. According to the National Oceanic and Atmospheric Administration, Office for Coastal Management, Hurricane Harvey in 2017 was the most significant tropical cyclone rainfall event ever recorded in U.S. history, both in scope and in peak rainfall amounts. The highest total rainfall reported from Harvey was 60.58 inches and the estimated total cost of the storm was $125 billion (Blake and Zelinsky, 2018, p. 6, 9) in losses. Lidar data are used by State, regional, and local governments to mitigate coastal storm threats, identify areas at risk, and improve Texas citizens' resilience to storms.

### 3DEP by the Numbers: Texas

| | |
|---|---|
| Expected annual benefits | $53.1 million |
| Estimated cost for quality level 2 completion[1] | $0.60 million |
| Payback | 0.01 year |

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

## Wildlife and Habitat Management

The Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service utilize high-resolution elevation data for modeling wildlife habitat, to accurately map ecosystems and natural resources in the State. This application of lidar data contributes to increased confidence in map accuracy (fig. 3) and program effectiveness, provides information for public applications such as state park usage, and leads to improved management of natural and cultural resources (Mueller and Sesnie, 2020).

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

| Rank | Business use | Annual benefits (millions) |
|---|---|---|
| 1 | Natural resources conservation | $13.79 |
| 2 | Wildfire management, planning, and response | 13.28 |
| 3 | Flood risk management | 12.70 |
| 4 | Agriculture and precision farming | 7.08 |
| 5 | Infrastructure and construction management | 2.57 |
| 6 | Water supply and quality | 1.39 |
| 7 | Geologic resource assessment and hazard mitigation | 0.50 |
| 8 | Aviation navigation and safety | 0.42 |
| 9 | Coastal zone management | 0.39 |
| 10 | Sea-level rise and subsidence | 0.33 |
| | Other | 0.65 |
| Total | | 53.10 |

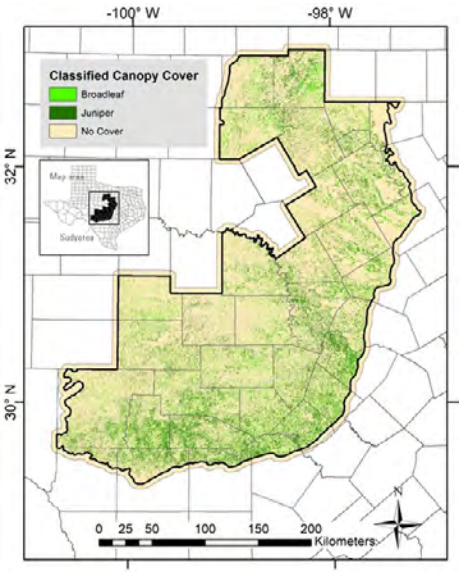


**Figure 3.** Lidar is used to model habitat relationships for the endangered golden-cheeked warbler (*Setophaga chrysoparia*) across its breeding range in the juniper-oak woodlands of central Texas. Map showing lidar-derived 3-meter tree canopy classification, which is more accurate than tree canopy classification derived from orthoimagery. Graphic courtesy of U.S. Fish and Wildlife Service, DOI Remote Sensing Reports.

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## 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 can 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 even 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 Data Collaboration 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://www.usgs.gov/3DEP/collaborate/.