

# Global Positioning System (GPS)



*GPS enables users to easily record the location of natural and man-made features on the land. It allows users to identify where a photo or video is taken, revisit previously recorded features, and more.*

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## What is GPS?

Global Positioning System (GPS) is a space-based navigation system that uses a constellation of satellites to determine the location of the receiving unit on Earth. GPS satellites circle the globe in a precise orbit, transmitting coded radio signals; at least four of their signals can reach any given point on Earth at one time. These signals can pass through clouds, glass, and plastic; the signals weaken when passing through solid objects such as buildings and cannot pass through objects that contain high levels of metals. For land conservation purposes, it is important to note that a GPS unit will not receive satellite signals when under thick forest canopies, underground, or underwater.

Although GPS was originally developed in the 1980s for military purposes, today the technology provides positioning, velocity, and navigation information for a wide range of users.

## Using GPS for Conservation

GPS helps conservation organizations and municipalities manage land by recording positional data in the form of points (e.g., location of a tree or property corner), lines (e.g., a trail), or areas (e.g., a lake). By importing the data into Geographical Information System (GIS) software, users can create maps of this data.

To use GPS effectively, an organization must invest in some combination of equipment and software, and either train or hire staff to operate it.

### Mapping Landscape Features

GPS enables users to map the location of a wide variety of features in the field, such as mature forest, specimen trees, invasive species, soil erosion, fire-disturbed areas, riparian buffers, and waterways. Users can also map human-made features like trails, benches, buildings, roads, driveways, and fences. Once mapped, these features can be easily located with a GPS device on return visits to the property.

### Linking Photos to GPS Coordinates

Users can take digital photos in the field and link them to GPS coordinates in the GIS database. This allows users to establish a visual record of important features and their precise locations. By comparing photos of the same location taken at different times, users can notice changes to the property. (This can be particularly helpful for monitoring easements and identifying potential violations.)

### Documenting Property Boundaries

GPS allows users to document the coordinates of property boundaries. In the past, surveyors used landmarks (which can be destroyed or moved over time) to define boundaries. Since GPS uses exact coordinates rather than relational landmarks, it produces measurements that remain accurate no matter what happens to the surrounding land or physical objects used as landmarks. (Note that accurate surveying of property boundaries necessitates the use of survey-

grade equipment; see the heading “Survey-Grade” below. Also, depending on the purpose of the survey, the law may require the work to be completed by a licensed surveyor.)

### Documenting Other Boundaries

Land trusts can use GPS to document boundaries between areas subject to different levels of restrictions under a conservation easement, for example, the border between an area that is to remain in a largely wild state and an area where farming is permitted.

## Choosing a GPS Receiver

A GPS receiver is the electronic unit that receives satellite signals and produces positional data, which can then be analyzed using mapping software. GPS devices vary greatly in price and quality. Since technology is always improving, it is best to research current receivers before making a purchase. Some companies rent receivers, which gives organizations the chance to test different receivers before making an investment.

### Types of GPS Receivers

#### Basic/Recreational

These units are the least expensive. Designed for outdoor recreation activities like hiking and camping, they provide basic latitude and longitude coordinates while plotting points of interest and straight-line routes. Most are accurate within five to 10 meters. Users can only identify points with a short name and ID number; additional attributes must be recorded manually and entered into GIS software. Basic units generally cost between \$200 and \$500.

#### Map-Grade

These units are more sophisticated. They allow for enhanced data collection, greater map detail, and more precise navigation. When enabled with WAAS (Wide Area Augmentation System), they are accurate within three meters; with the use of differential GPS<sup>1</sup>, accuracy can be as close as one meter. Some can also receive additional signals from GLONASS<sup>2</sup> satellites for even

greater accuracy. Most come with base maps installed; more detailed maps are available for purchase. Units may have additional features like touch screens or built-in cameras. [Garmin](#), [Trimble](#), and [Magellan](#) are the leading companies offering map-grade units; Trimble offers the most advanced (and expensive) units. Units can cost from \$500 to thousands of dollars depending on level of accuracy and other features.

Smartphones and tablets are another option. With built-in software or downloadable GPS applications like [MotionX](#), [GPSLogger](#), and [GPX Viewer](#) (recommended by multiple land trusts), they can perform some of the same functions as a commercial-grade handheld GPS. An internet search reveals a wide variety of GPS applications for both Apple and Android devices, and most of them only cost a few dollars.

#### Survey-Grade

Used by surveyors for precise measurements, these units are extremely accurate, sometimes to within a centimeter. They can cost tens of thousands of dollars and require extensive training and expertise, making them impractical for most land trusts and municipalities.

#### Aerial

A recent development in GPS technology for land trusts is the use of unmanned aerial vehicles (UAVs, also known as drones) to collect data-enabled aerial imagery of properties. Since UAVs receive GPS signals, each video image they collect is linked to a specific location. Platforms like [Survae](#) allow land trusts to use this data in a variety of ways, from creating GIS map layers to monitoring easements over time. They also allow users to create customized routes, which UAVs can fly at specified elevations. Land trusts may hire licensed pilots to conduct the flights, eliminating the need to train staff or purchase UAVs themselves.

### Purchasing Considerations

There are several factors to consider when purchasing a unit:

- **Accuracy.** Different receivers provide different levels of accuracy.

<sup>1</sup> Differential GPS overcomes GPS errors by using a series of base stations in combination with satellite data.

<sup>2</sup> The Russian version of GPS; its constellation of 24 satellites provides global coverage.

- **GIS Data Integration.** Some units convert GPS points to specific GIS or Google Earth formats, which may or may not be compatible with certain mapping software.
- **Attributes.** Many GIS users have found that accurate attribute<sup>3</sup> collection is just as crucial as location acquisition. Only the more advanced map-grade GPS units allow users to collect and input detailed attribute information.
- **Device Compatibility.** Some GPS units can wirelessly synch with digital cameras, rangefinders, or other field devices to receive additional data; this might require additional hardware or software. Other models have built-in cameras.
- **Memory Capacity.** Units that use auxiliary memory cards in addition to internal storage allow users to purchase more memory capacity in the future, if necessary. Some unit/software combinations allow users with an internet connection to upload data directly from the unit to the cloud for storage.
- **Durability.** Some units are designed for use in rugged environments, with features like water-resistant screens, push-button controls, and protective outer casing.
- **Battery.** Some units use standard batteries, while others use internal rechargeable batteries. A device that includes a sleep mode or battery-save function will extend battery life while in the field.

For general information about choosing a GPS receiver, see:

[“Tips on Selecting the Right GPS Receiver, for Your Job”](#) (Resource Analysis)

[“Recreational Versus Professional GPS: What’s the Difference?”](#) (Esri)

[“Maps & Geospatial: Global Positioning System \(GPS\)”](#) (Penn State)

For product comparisons and reviews, see:

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<sup>3</sup> “Attribute” refers to non-spatial information about a feature. For example, attributes of a stream could include its name, length, and sediment load.

[“Best Handheld GPS Review”](#) (Outdoor Gear Lab)

[“Handheld GPS for Surveyors”](#) (Land Surveyors United)

[“Handheld GPS Buyers Guide”](#) and [“Garmin Handheld GPS Comparison Chart”](#) (GPS Tracklog)

## Mapping Software

There are many GPS software packages available on the market. Many are free. These are some of the most prominent applications.

### Installed on GPS Unit

#### ArcPad

ESRI software for GPS units that allows mobile field mapping and data collection. Purchase required; free trial available.

<http://www.esri.com/software/arcgis/arcpad>

#### Trimble GPS Pathfinder

Office software that supports all aspects of GIS data collection and maintenance for most Trimble GPS receivers. Purchase required.

<http://www.trimble.com/mappingGIS/PathfinderOffice.aspx>

#### Garmin BaseCamp

Previously known as MapSource, a free mapping software compatible with most Garmin GPS units.

<http://www.garmin.com/en-US/shop/downloads/basecamp>

### Installed on Computer or Other Device

#### Google Earth

Free virtual globe, map, and geographic information program. Google Earth Pro is available for desktop; in early 2017, Google Earth for Chrome was released as a non-desktop version. Some GPS units have a direct download to Google Earth. See the [user’s guide](#) for more information.

<https://www.google.com/earth/>

#### DNRGPS

Free application developed by the Minnesota Department of Natural Resources that allows users to

transfer data between GPS receivers and GIS software. Users can upload or download waypoints, tracks, and routes; calculate shape attributes; hyperlink images; and more. It is compatible with most Garmin GPS units and NMEA-output units from other companies.

<http://www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html>

### MapGuide Open Source

Free platform that enables users to create their own maps and mapping applications. Includes an XML database for storing and managing content, and supports most geospatial file formats, databases, and standards.

<https://mapguide.osgeo.org/>

### TopoFusion

Free GPS mapping software with a variety of features that allow users to geotag photos, blend different map types, and visualize multiple routes simultaneously.

<http://topofusion.com/>

## Data Collection

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Organizations should create protocols for collecting data, focusing on consistency and accurate documentation. GPS users should always record the source of and expected precision of data, which allows it to be combined with other data and ensures that future users will know exactly how it was collected. If not documented appropriately, data might be unusable in the future.

## Legal Implications

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The admissibility of GPS data in a court of law varies depending on who collected the data and how they collected it. A court will accept a property boundary determined by a licensed surveyor using a survey-grade GPS. It is less certain how a court might view geographic information recorded by land trust staff using a non-survey-grade GPS unit, for example, the boundary between areas that have different levels of protection in a case where a newly constructed building appears to encroach on an area in which it is not permitted.

For more information about legal risks and implications, organizations should discuss GPS practices with their legal counsel.

## Additional Information

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See [“Stewardship Tools: Who’s Using What?”](#), published in LTA’s *Saving Land* magazine, to see comments from different land trusts about their preferred GPS units and applications (as of 2016).

See the website [GPS Tracklog](#) for GPS-related news, reviews, buyer’s guides, and more.

See the website [GIS Lounge](#) for information about GIS mapping software, GPS tutorials, and more.

## Resources at ConservationTools.org

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To find experts and other resources, see the right column of the on-line edition at

<http://conservationtools.org/guides/43>.

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### **Submit Comments**

Help improve the next edition of this guide. Email your suggestions to the Pennsylvania Land Trust Association at [aloza@conserveland.org](mailto:aloza@conserveland.org). Thank you.

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