

GPS TRAVERSE EXPERIMENT

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Objectives.

1. We wanted to determine if one or more of the available models of sportsman and sub-meter grade GPS units could be used to determine the acreage of a forested area to an accuracy equivalent to one gained by doing a conventional compass & chaining perimeter traverse of the same area.

The difficulty in doing a perimeter traverse, with even a sub-meter mapping grade GPS unit, has always been overcoming the error introduced to the satellite data from “multipath” signal obstructions caused by overhanging forest canopy. We wanted to determine if GPS data, **collected at distant off-set points** around the perimeter of a forested unit, could be processed by GIS software to allow us to calculate an accurate acreage for the unit of land.

2. We wanted to determine and compare the accuracy of a sportsman grade GPS unit to a mapping grade GPS for determining point locations at both open off set points and points under light to moderate forest canopies.

Equipment used.

- A trimble pathfinder mapping grade GPS unit. This is a older model sub-meter grade gps unit. This unit was employed with the external antenna and supporting TDC-1 data collector. This unit originally sold for \$14,000 when new. This GPS unit allows differential correction of the raw data.
- A Trimble Geo XT mapping grade GPS unit. This unit retails for approximately \$5,000. This unit was employed for these field tests without the optional external “backpack” antenna. This GPS unit allows differential correction of the raw data.
- A Garmin 60CS sportsman grade GPS unit. This unit may be purchased on EBAY used for approximately \$300. This GPS unit does not allow differential correction of the raw data.
- A LaserTech Impulse laser hypsometer and rangefinder.
- A Silva Ranger hand compass.
- ESRI GIS Arcview software
- Traverse PC software

Test preparations.

We completed conventional compass and chaining perimeter traverses around each of the units used in these tests. These conventional traverses served as comparison “**controls**” for the GPS traverses done during the tests. The Laser Tech Impulse rangefinder and a silva hand compass were the tools used for these traverses. The bearing and distance data was then processed in the Traverse PC software to determine the acreage of the unit. All of the compass & chain traverses closed to under 1% error.

Field Tests.

The unit of land selected to function as the control for the first GPS perimeter traverse test is a roughly rectangular **24-acre** area, adjacent to a flood control levee along the lower Eel River in the Redwood forest region of northern California. This unit offered really clear lines-of-sight to the 360-degree horizon and represented the least potential for multi-path errors of any of the three areas in this series of tests.

We ran 2 tests with the Garmin unit, in which we collected 500 readings at each of the four main turning points on the unit perimeter. We employed the instrument in these tests with the “averaging” feature, rather than the “acreage” feature available from the menu suite

Results.

Traverse	Acreage	Error vs Control
Control	24.15	N/A
Garmin- 1 st test	24.01	0.58%
Garmin- 2 nd test	24.88	2.9%

The unit of land selected for the second GPS traverse test is a square **5-acre** area located on a wide alluvial flat, next to the Eel River, in the center of the Redwood forest region, along the coast in northern California. The hills surrounding the unit have ridge top elevations ranging from several hundred to 1,500'. The unit was covered by a 30-year old young growth Redwood stand, with a stand density of approximately 300 trees per acre and an extremely dense overhead canopy. There are 2-lane access roads along both the east and west edges of the unit. The north edge of the unit is adjacent to a large meadow and the south edge of the unit is adjacent to a recently thinned timber stand that had a moderately dense overhead canopy. The other two sides had tree lines within 100-300'. Also, two of the four turning points around the perimeter of the unit had a number of old railroad rolling stock parked nearby, that offered a lot of potential for local magnetic attraction to our compass. We ran two traverse tests each of the Trimble GeoXT and the Garmin around this unit.

Results.

The control acreage calculated from the laser traverse was **4.7** acres for this unit. Both tests with the Trimble GeoXT resulted in acreage figures that were less than **1%** off of the control acreage. Both tests with the garmin resulted in acreage figures that were less than **2%** off of the control acreage.

The final GPS traverse test was done on an approximately 24-acre forested unit located on a wide, low ridge top in the Freshwater area of Humboldt County, California. The unit had a very tall forest canopy, with a standing timber volume exceeding 65 MBF per acre.

The compass & chain traverse consisted of 42 specific shots, for a total perimeter distance of 5,491'. We achieved closure error of 14' or 0.25%. As with the other field

tests, the acreage calculated from this traverse was used as a control figure to compare to the GPS traverses. In addition, we used segments of the perimeter traverse to tie to 3 of the 10 main turning points of the unit boundary; these three points were completely obstructed by heavy forest canopy. We were then able to calculate a single bearing & distance to each of these 3 turning points, which was then used to set the actual points from the nearest GPS off set point.

We then proceeded to collect GPS data at each of the 8 points around the perimeter of the unit both the Garmin model 60CS sportsman grade unit and a Trimble Pathfinder mapping grade unit. For the Pathfinder, we collected data for 10 min or 100 data readings with the PDOP Mask set at 6. For the Garmin we collected 500 data readings at each point.

Two of the GPS off set points were in relatively small openings of approximately 75' in diameter, along the access roads in the otherwise heavy forest canopy.

Results.

Traverse	Acreage	Error vs Control
Control	28.44	N/A
Garmin 60CS	28.47	0.1%
Trimble Pathfinder	28.68	0.8%

In our next series of tests, we wanted to compare the performance of the Garmin unit to the older Trimble mapping-grade Pathfinder unit. The raw satellite data collected by the Trimble Pathfinder was later differentially corrected and the raw data collected by the Garmin unit was not differentially corrected.

The first test was simply a comparison between the two instruments at 12 points out in the open. The locations of the points differed between the 2 instruments by as little as 3' and as much as 44', with the average difference being 23.5' and a standard deviation of 11%.

The next test was to compare the two units in collecting point data under forest canopies. In the several attempts we made, the Trimble Pathfinder was unable to collect any satellite data at points under the various density canopies. We considered dropping the PDOP mask on the Pathfinder to make the instrument accept lower quality satellite data, but previous experience has shown us that the time to collect 500 points of data could have required up to an hour of time. The Garmin, however, collected 500 points in only a little more amount of time than both of the units would have required at points in the open.

At 2 points under a fairly open canopy the Garmin point was off 57' & 38', respectively, from the points determined from off-set points taken in the open.

At 3 points, under fairly heavy canopies, the error ranged from 39' to 59'.

Finally, we tried using the Garmin to collect data in a very small opening in the forest canopy(maybe 20' in diameter) and determined an error of 36'. The Trimble Pathfinder could not collect data in this small opening.

Summary points.

- GPS traverses appear to be a very viable method of determining acreages of units.

An error of 1%, as achieved in many of our field tests, means that a GPS traverse of a 24-acre area might only be off by a **quarter-acre**.

- For determining acreages of units, the Garmin sportsman-grade GPS unit seems to provide a really impressive accuracy.
- For determining locations of points under forest canopies, either from distant off-set points out in the open and in nearby small openings, the Garmin unit can provide satisfactory accuracy, especially considering the cost difference of several thousand dollars between the different grades of instruments and the delay required to differentially correct the mapping grade raw data.

California land managers regularly have to commission traverses on specific units of timberland, in order to verify the acreage of these units. An accurate acreage is needed in order to support various land management activities, which commonly include completing timber cruises to determine the value of standing timber and verifying that government-mandated harvest acreage limits are adhered to. In addition, a land manager may want to verify a discrepancy in the county's assessed acres for a specific unit of land, in order to later justify commissioning a more expensive licensed survey of a property. Indeed, a licensed survey traverse of a property could run **\$65 per acre**. Even a less accurate compass & chain traverse of a property could cost **\$32 per acre**. So, a land manager might have to spend **\$1,500** determining the acreage of a single **25-acre** harvest unit.

We realize the importance of being able to offer land managers a much cheaper alternative to these conventional traverse methods. Our test verified that the GPS traverse method could achieve an equivalent accuracy to the more expensive compass & chaining method and **cost only \$13 per acre**. This could mean that a GPS traverse of a 25-acre of land could only end up costing **\$250**

Of course, we realize that there may often be situations where the nearest acceptable satellite reception point (the off set point) might be further away from the unit edge than a single traverse shot. In those cases where the off set point is a long way off, it might still be necessary to employ the laser traverse method for a segment of the unit perimeter. However, even if a third of a 25-acre unit required compass & chaining (with the other two thirds permitting GPS traversing), because of a lack of nearby forest openings; the cost would still be less than **half the cost** to laser traverse the entire unit perimeter.

Land managers, interested in saving time and money, should evaluate every unit-to-be-traversed to determine a traverse plan that would allow the best blend of the GPS and compass & chaining traverse methods.

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