Annals of Tropical Research 29(1): 33-38 (2007)

Appropriate Surveying Methods in the Philippines: Can Modern GPS Units Help?[1]

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ABSTRACT

An investigation was undertaken to test the effectiveness of two procedures for recording boundaries and plot positions for scientific studies on farms on Leyte Island, the Philippines. The accuracy of a Garmin 76 Global Positioning System (GPS) unit and a compass and chain was checked under the same conditions. Tree canopies interfered with the ability of the satellite signal to reach the GPS and therefore the GPS survey was less accurate than the compass and chain survey. Where a high degree of accuracy is required, a compass and chain survey remains the most effective method of surveying land underneath tree canopies, providing operator error is minimised. For a large number of surveys and thus large amounts of data, a GPS is more appropriate than a compass and chain survey because data are easily up-loaded into a Geographic Information System (GIS). However, under dense canopies where satellite signals cannot reach the GPS, it may be necessary to revert to a compass survey or a combination of both methods.

Keywords: global positioning system, geographic information system, compass and chain survey

INTRODUCTION

One of the activities of Australian Centre for International Agricultural Research (ACIAR) project ASEM/2003/052, *Improving Financial Returns to Smallholder Tree Farmers in the Philippines* in Leyte Island is to gather tree inventory data from sample plots which are located on farms. This involves recording boundary positions of both farms and plots. The most cost-effective and convenient way to collect survey data

[1] A previous version of this paper was published in Suh *et al.* (2005).

depends on factors such as the spatial extent of farms being surveyed and the accuracy required. This article investigates the possibility of reducing the cost and time needed for boundary surveys by comparing the accuracy of a survey undertaken with a modern global positioning system (GPS) unit with a survey undertaken with a compass and chain.

A GPS is a hand-held instrument which records coordinates on the earth's surface by receiving signals from satellites orbiting the earth. The GPS system is maintained by the US Department of Defence and uses 24 satellites which circle the earth in different orbits. An uninterrupted line-of-sight to at least three satellites is necessary for the GPS unit to be able to triangulate positions on the earth's surface. Consequently, dense tree canopy often inhibits the usefulness of hand-held GPS units. Positional accuracy of the GPS receiver is also affected by cloud cover (Li *et al.* 2005). In recent years, the cost of basic GPS units has decreased to several hundred US dollars with advanced models having greater accuracy and functionality but costing more (Theiss *et al.* 2005). In recent years, GPS units have become popular for navigation and surveys where absolute accuracy is not required.

GPS units are also highly convenient for storing information about position, elevation and bearings in a format which can be downloaded to a computer to incorporate into a geographic information system (GIS). The GPS to GIS interface has been simplified in recent years as the popularity of GPS units has increased (Kevany 1994) and this is essential for the efficient handling and storing of large amounts of GPS data (Neményi *et al.* 2003). In contrast, data from a compass and chain survey must be manually entered into the computer or recorded on paper maps.

Questions remain as to the precision of GPS-derived position estimates under less than ideal operating conditions, such as variable amounts of canopy closure. Therefore, the aim of this investigation has been to compare the performance of a GPS with the traditional compass and chain survey. The results of the comparison have been used to train field crews so that they may choose the most appropriate survey method for farm and sample plot location in conditions of variable canopy density.

RESEARCH METHOD

In order to mimic the procedures for measuring the boundary of a typical small Filipino farm, a route was selected on the Leyte State University campus which traversed forested land and open spaces (Figure 1). The route followed a road line and then traversed a polygon of land approximately 1 ha in area before returning to the start point.

A Garmin 76 GPS (Figure 2a) was used to survey the boundary of the route and four replicates of the survey were made under identical (sunny) weather conditions. Also, the coordinates of a position which was not covered by tree canopy were measured 12 times with the GPS.

A chain and compass survey of the route was also undertaken. Instead of a traditional surveyor's chain, distance was measured with a Chainman® distance measuring device (Figure 2b) which clips to the operator's belt and measures the distance the operator walks by unwinding a cotton thread which passes over a calibrated wheel. The chain and compass survey was undertaken over the same route as the GPS survey. Bearings were measured with a prismatic compass (Figure 2c) and the closing error of the survey was recorded. For purposes of comparison, data from both surveys were downloaded into ArcGIS® software and depicted as a map (Figure 1).

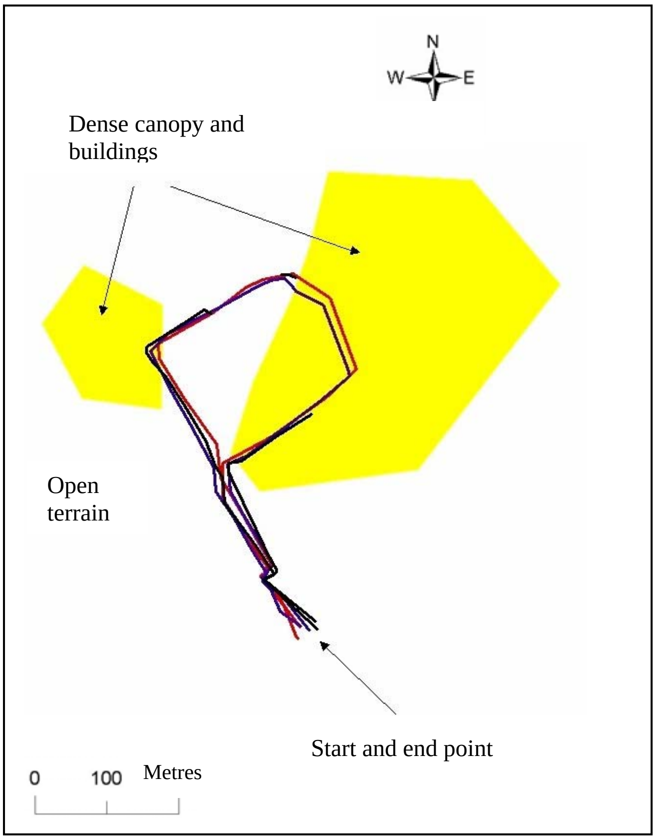

Figure 1. Path of four replications of a survey using a GPS and one survey using a compass


2a


2b


2c

Figure 2a, 2b and 2c. Garmin 76 GPS (2a), Chainman® distance measuring device (2b) and prismatic compass (2c)

COMPARISON OF ACCURACY OF BOUNDARY LOCATION

Dense canopy decreased the accuracy of the GPS and resulted in a different path being recorded for each of the four replicates of the GPS survey. Therefore, under dense canopy and in open terrain, the GPS was unable to record precise[2] position locations. Also, several segments of the GPS surveys under the dense canopy were not recorded because the GPS lost contact with the satellites. The accuracy of the compass

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[2] Whereas *accuracy* refers to the correct location of a position, *precision* refers to the proximity of a number of position locations to one another (Levine *et al.* 1998). Hence, greater accuracy of surveys helps achieve greater precision amongst replicates.

and chain survey depended on the care taken by the operator and the measurement errors of the instruments. No accuracy specifications were available for these instruments but in this case the closure error was approximately one metre. If the survey had been conducted in dense undergrowth, it could be expected that this closure error would be larger. The standard deviation of the coordinates of 12 position estimates (taken at the start point of the survey) with the GPS was 7.9 m for the easting and 6.8 m for the northing, which is within the manufacturer's specifications (GARMIN International 2001).

CONCLUDING COMMENTS

Canopy cover adversely affected the precision of the GPS survey due to interference with the satellite signal to the GPS. Therefore, in this case, the GPS was not capable of recording the precise location of features for surveys where sub-metre accuracy was required. Consequently, compass and chain surveys still appear to be a useful low-cost option. However, using a GPS is a highly time-efficient and convenient way of recording boundaries where a lower degree of precision is acceptable. In particular, GPS surveys only require one person to operate the instrument whereas compass and chain surveys require one person to take compass bearings and distance measurements and another person to walk ahead and locate boundary corners. GPS position coordinates can also be recorded in geographic coordinate units (degrees of latitude and longitude) or in projected coordinate units (metres).

In some circumstances, a combination of both survey methods may be appropriate. For example, if tree cover is dense, it may be possible to locate a start point (a boundary post) with a GPS in an open space and then use compass and chain measurements to provide precise boundaries from that point through areas of dense canopy to open terrain or the end of the survey. This would be appropriate where the survey area is small and there are few corners. However, one incorrect measurement in a compass and chain survey distorts the shape of the entire boundary, whereas the location measurements of all corner positions (vertices) measured with a GPS are independent of each other.

The challenge for GPS technology is to increase the accuracy of point measurements and new technology – such as the European Galileo satellite radio navigation program – are promising in this regard. The Galileo global navigation system will use 30 satellites instead of the 24 of the current GPS system and when this system is fully operational in 2010 it is envisaged that ground positions will be located with an error of less than a metre (ESA 2005). If these improvements in the accuracy of position location are matched with improvements to the penetration of satellite signals through partial canopies, then this new technology will increasingly replace compass and chain surveys.

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