

Survey of Gau Graig

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1) Introduction

Gau Graig (Hill Number 2143, Section 30F, OS 1:50000 Map 124, OS 1:25000 Map 23W, Grid Ref. SH743140) is listed as a Hewitt, Nuttall and P30 hill (Tump) in the Database of British and Irish Hills (DoBIH) with just 30m of drop. Myrddyn Phillips had listed this hill with c 28m of drop in his Sub-Twmpau which is more consistent with current mapping and suggests that previous estimates of drop may have been optimistic.

The purpose of this survey is to measure accurately the drop for Gau Graig to determine if it exceeds 30m or not and thereby resolve its classification. However it is almost certain that the drop will not be less than 15m and hence the Nuttall classification would remain unchanged.

2) Equipment used and Conditions for Survey

A Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a “1m” E-staff extendable to 5m were used to determine the positions of the bowlch and summit, and also to line survey between these two points.

Absolute heights were measured using a Trimble GeoXH 6000 GNSS receiver. This receiver is a dual-frequency, multi-channel instrument, which means it is capable of locking on to a maximum of 12 GPS and 8 GLONASS satellites as availability dictates, and receive two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signals. As a stand-alone instrument it is capable of giving position and height to an accuracy of about two metres and five metres respectively. Note that small hand-held GPS receivers used for general navigation can only receive up to 12 GPS satellites and each at a single frequency and therefore these instruments have a poorer positional accuracy of +/-5metres and a height accuracy of no better than +/-10 metres. Some recently produced hand held GPS Garmin receivers can also receive signals from GLONASS satellites which greatly improve the speed at which these units can achieve a satellite “fix”. Despite the on-board features of the GeoXH 6000 receiver, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the GNSS (Global Navigation Satellite System) data via imported RINEX data from the Ordnance Survey which were post-processed using Trimble GPS Pathfinder Office processing software for the GeoXH 6000 data. Repeated measurements with this instrument made on the same point suggest height accuracy between +/-0.15m and +/-0.20m.

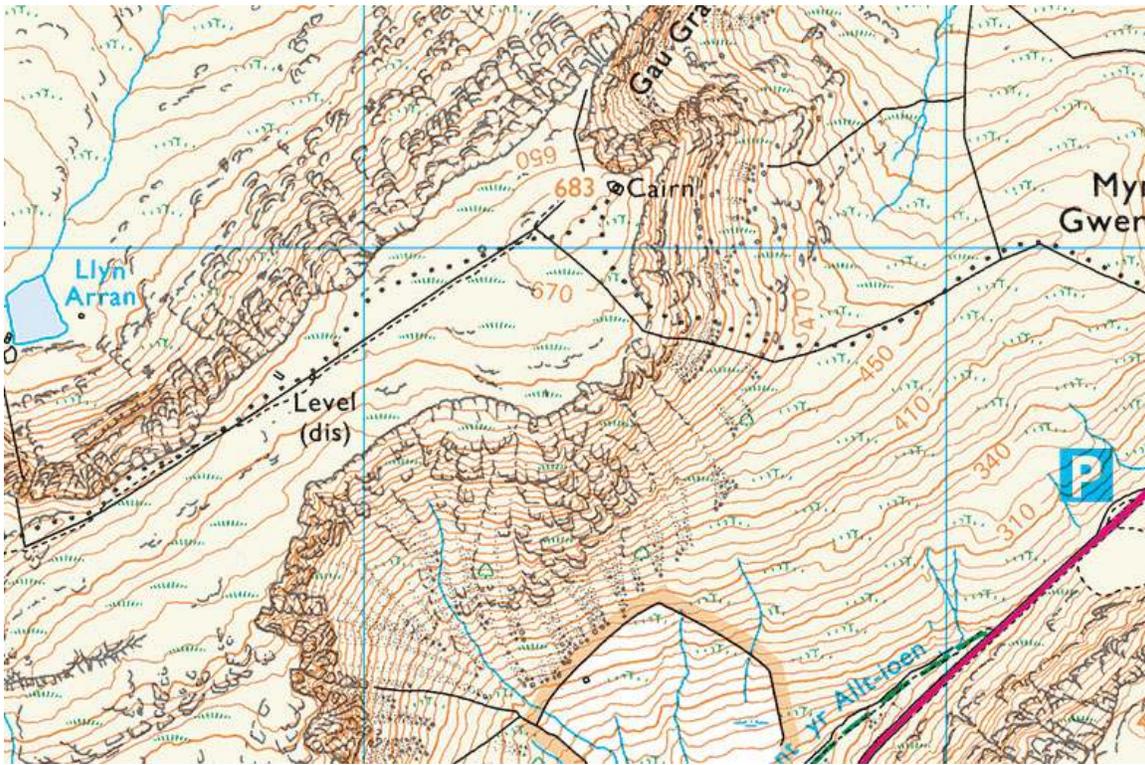
Conditions for the survey, which took place between 11.00hr and 15.30hr BST, were good. The weather was cold, sunny, 10 degrees Celsius with a light wind in exposed areas and visibility was excellent.

3) The Survey

3.1) Character of Hill

Gau Graig lies about 4km ENE from the summit of Cadair Idris. It is the last significant summit on the ridge that leads down from Cadair Idris and then over Mynydd Moel. After leaving Gau Graig the ridge drops steeply before passing over lower insignificant summits before terminating at the

minor road about 2km East of Dolgellau. An extract of the OS 1:25000 map showing the summit and bwlch to the West of the ‘Cairn’ is presented below.



The 683m spot height marked on this map corresponds with a rocky outcrop which is crowned with a small cairn but visually there seem to be at least two points 100-200m further West which are higher. There is a fence that leads from the summit area to the bwlch, and apart from some wet areas, this is an easy walk down a grassy slope on either side of the fence.

The North, East and South flanks of Gau Graig are very steep with crags that would make access very difficult and inadvisable. For the ascent of Gau Graig on its own, access to the hill is best gained from the car park on the main road about 1km ESE of the hill. Although not marked on the map, a path leads East from there to join the main path that ascends in a North Westerly direction by a fence. As height is gained the path becomes steeper and scrubby in places but reaches a flatter grassy area that leads to the hill’s summit.

3.2) Summary of Survey Method

The survey commenced at the summit whose position was identified with the Leica NA730 level and staff. Having collected data at that point with the Trimble, we then followed the route down to the bwlch noting any difficulties that might be encountered on a subsequent line survey. Again using level and staff, the lower of two possible bylchau was located and that was then surveyed in detail to find the correct position. This position was marked with flags. The line survey was then carried out from bwlch to summit and finally we returned to the bwlch to retrieve the flags and collect GNSS data with the Trimble directly over the bwlch position.

3.3) The Summit

The summit area for Gau Graig is shown in the photograph in Appendix 1. Visual inspection showed three possible contenders for the highest point. The first is about 40m from the fence and the other two are in a North Easterly direction from this point and are 65m and 95m distance respectively from it. With suitable placements of level and staff we identified each of the individual highest positions at these points. Having positioned the level on its tripod near the middle of these three points, we took staff readings at each of the highest points. The results are presented in the table below.

Feature	Grid Ref (Garmin)	Staff reading m.	Height difference m
Rounded rock	SH 74379 14027	0.270	0.000
Edged rock	SH 74421 14079	0.452	-0.182
Pointed rock near cairn	SH 74445 14099	0.962	-0.692

The rounded rock about 40m from the fence is 0.69m higher than the pointed rock next to the cairn. It is the latter that is currently listed in the Database of British and Irish Hills and “The Mountains of England and Wales” Vol. 1 by John and Anne Nuttall as the highest point.

The Trimble GeoXH 6000 was placed on top of the highest point and GNSS data were collected for 5 minutes once the receiver accuracy measurement had reached 0.1m. The data for the Trimble GeoXH 6000 were processed in Trimble GPS Pathfinder Office using the five nearest base stations and the results are given in the table below:-

System	Easting	Northing	Height(m)
Trimble GeoXH 6000	74373.489	14023.169	683.724

The height of Gau Graig was measured to be 683.7m

3.4) The Bwlch

Analysis from Geograph indicates two possibilities for the position of the bwlch. The Grid references for these positions were: SH 73909 13775 and SH 73777 13695. These Grid References were entered into a Garmin Montana 600 and the positions were identified on the ground. A small mound was found to separate the two bylchau. Visually these two positions seemed approximately correct and it was clear that each would need to be surveyed more accurately with level and staff.

The first task was to carry out a height comparison of the two bylchau so that if there was a significant height difference further surveying at the higher bwlch would be unnecessary. The positions of each of the bylchau were located visually and marked with flags. It was anticipated that a staff measurement from a single level setup would be adequate to differentiate the bylchau but the distance between them was too great and the significant wind here did not allow us to be able to take these direct measurements. Instead a line survey was carried out between the two bylchau in

the manner described in Section 3.5 although in this case only readings from the horizontal line of the level were taken. The results are shown in Appendix 2. The West bwlch is 0.5m higher than the East bwlch and therefore only the East bwlch needed to be surveyed in detail.

At the East bwlch on the South side of the fence there is a small stagnant pool. On either side of this pool there are shallow channels that are roughly in the valley to valley direction and clearly drop away several metres away from the fence. At first sight it appears that this line of channels could contain the exact bwlch position. We set out a line of flags two metres apart up to about 20m from the fence along this channel and took staff readings at these points with the level set up on its tripod at a suitable position on the North side of the fence. Surprisingly the highest point was some 12m away from the fence and on its North side. On closer inspection of the terrain we concluded that the line of flags had not been set up exactly in the valley to valley direction and that the true bwlch was not within this shallow channel. To verify this we set up another line of flags parallel to the first row but approximately 10m from it and again took staff readings at these flag positions with the level set up in the same place as previously. In this case the highest point was found to be on the opposite side of the fence and about 4m from it. This reading was the same as the highest point for the first row and therefore we concluded that the valley to valley direction at the bwlch was more at a diagonal angle to the fence rather than perpendicular to it. This was confirmed with additional interpolated staff readings where the actual line of the bwlch in the hill to hill direction was only found to vary by a few centimetres over a 20m length. Finally the exact position of the bwlch was chosen as a point next to the fence and on its North side (see photograph in Appendix 1).

The Trimble GeoXH 6000 was placed on an improvised tripod (with a 0.18m correction made for its height) directly at the bwlch and GNSS data were collected for 5 minutes once the receiver accuracy measurement had reached 0.1m. The data for the Trimble GeoXH 6000 were processed in Trimble GPS Pathfinder Office using the five nearest base stations and the results are given in the table below:-

System	Easting	Northing	Height(m)
Trimble GeoXH 6000	73913.024	13777.255	658.341

The height of the bwlch for Gau Graig is 658.3m.

3.5) The Line Survey

This procedure commenced at the bwlch which had been marked with flags. Having set up the NA730 level on a tripod at a suitable distance in the direction of the hill's summit, staff readings were taken with the staff placed on the bwlch. Once a set of readings had been taken (Backsights BS) the staff was then moved to an uphill position, but the level not moved apart from a rotation through 180 degrees to take another set of readings (Foresights FS). This process of alternately moving the staff and level was repeated uphill until the final reading was taken with the staff on the summit position. Readings were taken from the horizontal and also the lower and upper stadia lines of the level to provide a check on any staff misreadings and to improve accuracy. If in any set of three readings the average was greater than 1mm different from the horizontal reading, then that set was remeasured. This procedure was repeated until the final reading was taken on the summit rock.

The line survey results are shown in Appendix 2. Using this technique the drop for Gau Graig was measured to be 25.47m. As this is 5m different from the 30m drop criterion for Hewitt/Sim status, a

repeat line survey from summit to bwlch was considered unnecessary. Also the result was backed up with the Trimble GeoXH 6000 measurements for drop which gave a value of 25.4m

4) Discussion of Results

The more accurate method for measuring the drop will be the line survey rather than the difference between the summit and bwlch measurements made with the Trimble GeoXH 6000. Usually for line surveys we carry out the method in both the bwlch to summit and summit to bwlch direction in order to obtain a closing error which gives an indication of the accuracy of the result. However, since the line survey measurement indicated a result about 5m less than the 30m drop criterion needed for this hill to retain its classification, we considered a repeat line survey unnecessary. The main uncertainty in the single line survey probably arose from the uncertainty in the height of the bwlch which we estimated to be $\pm 0.05\text{m}$. We would also estimate the uncertainty in the line survey measurement itself from experience of other surveys based over the same height and distance to be $\pm 0.03\text{m}$. Therefore the uncertainty in the drop measurement is calculated to be $\pm 0.06\text{m}$.

The drop of 25.47m measured by line survey compares very well with that of 25.38m as the difference in height of the summit and bwlch as measured by the Trimble GeoXH 6000. Bearing in mind that each measurement made with the Trimble has an uncertainty of $\pm 0.2\text{m}$; the agreement with the drop for the line survey clearly indicates that no significant errors had been made in the carrying out of this process.

5) Summary and Conclusions

The **summit of Gau Graig** is at grid reference * SH 74376 14027 and is the top of a rounded rock. Its height is **683.7 \pm 0.2m**.

The **bwlch of Gau Graig** is at *SH 73916 13781 and is unfeathered grass. Its height is **658.3 \pm 0.2m**.

The **drop for Gau Graig** is **25.47 \pm 0.06m** and therefore this hill **loses its Hewitt/Sim/Tump status**.

- NB Trimble Grid references “corrected” to Garmin are quoted in the summary.

John Barnard, Graham Jackson and Myrddyn Phillips, 11 May 2015

Appendix 1



Trimble GeoXH 6000 collecting data on the summit of Gau Graig - looking North-east to the cairn in the distance.



Trimble GeoXH 6000 collecting data at the bwlch position – looking towards Gau Graig.

Appendix 2

Title:- Survey of Gau Graig

Instrument:- Leica NA370 Automatic level

Date:-

01/05/2015

Point Number	Horizontal Line		Lower Stadia Line		Upper Stadia Line		Mean BS metres	Mean FS metres	Height Difference metres
	Backsight BS metres	Foresight FS metres	Backsight BS metres	Foresight FS metres	Backsight BS metres	Foresight FS metres			
Bwlich West to Bwlich East (JB Level and Data recording, MP Staff)									
1	1.885	1.870					1.885	1.870	
2	1.678	2.185					1.678	2.185	
							SUM =	4.055	-0.492
Bwlich to Summit (JB Level and Data recording, MP Staff)									
1	1.483	0.437	1.305	0.267	1.661	0.606	1.483	0.437	
2	2.918	0.444	2.735	0.314	3.102	0.574	2.918	0.444	
3	3.638	0.192	3.354	0.103	3.925	0.280	3.639	0.192	
4	4.249	1.865	3.835	1.549	4.663	2.180	4.249	1.865	
5	3.176	0.243	2.865	0.165	3.485	0.321	3.175	0.243	
6	4.207	0.155	4.019	0.052	4.395	0.259	4.207	0.155	
7	3.982	0.536	3.903	0.439	4.060	0.634	3.982	0.536	
8	4.576	0.740	4.450	0.593	4.704	0.890	4.577	0.741	
9	2.426	0.575	2.353	0.565	2.499	0.585	2.426	0.575	
							SUM =	5.188	25.468