

Surveys of Beinn a' Chlaidheimh, Beinn Dearg Mor and Ruadh Stac Mor

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1) Introduction

The background to The Munro Society's heighting programme has been described in our report for heighting surveys carried out on 15 and 16 May 2009 for Beinn Teallach and Ben Vane. In summary it is a multi-phase project the aim of which is to measure accurately the heights of Corbetts and Munros from 910m to 918m. Due to logistical reasons and access issues, the plan for the latter phases has had to be changed. So this year we have focussed on the three mountains in the Fisherfield Forest; Beinn a'Chlaidheimh 916m (NH061775), Beinn Dearg Mor 910m (NH032799) and Ruadh Stac Mor 918m (NH018756). This part of the project has been sponsored generously by Alan Haworth (Lord Haworth of Fisherfield).

The Fisherfield Forest is a very remote and wild part of the Highlands, and arguably contains some of the finest mountain scenery in Scotland. Because of the difficulty of access to these mountains, the original expedition plan was to base the team in a bothy within the Fisherfield Forest with assistance from the Estates to carry the equipment by all-terrain vehicle or other suitable transport. However, assistance from the Estates was not forthcoming, and therefore the final plan involved separate survey days for each mountain via suitable access with the team based at Sail Mhor Hostel. A large team of volunteers enabled an adequate quorum of strong walkers to be present on each of the surveys so that all the equipment (12kg) could be carried. In the event, each survey presented a significant challenge and no expedition was shorter than 12 hours! Beinn a'Chlaidheimh and Beinn Dearg Mor were both reached by access from the North starting at Corrie Hallie and each survey involved the climb over the pass both to and from Strath na Sealga. This meant a total of about 2000feet of ascent in addition to the climb to the summit of the mountain. Ruadh Stac Mor was reached from the West, and by kind permission of the Factor, Mrs Barbara MacDonald, of the Letterewe Estate, we were able to park cars at Kernsary thereby saving about 6 miles of walking.

2) Equipment used and Conditions for Survey

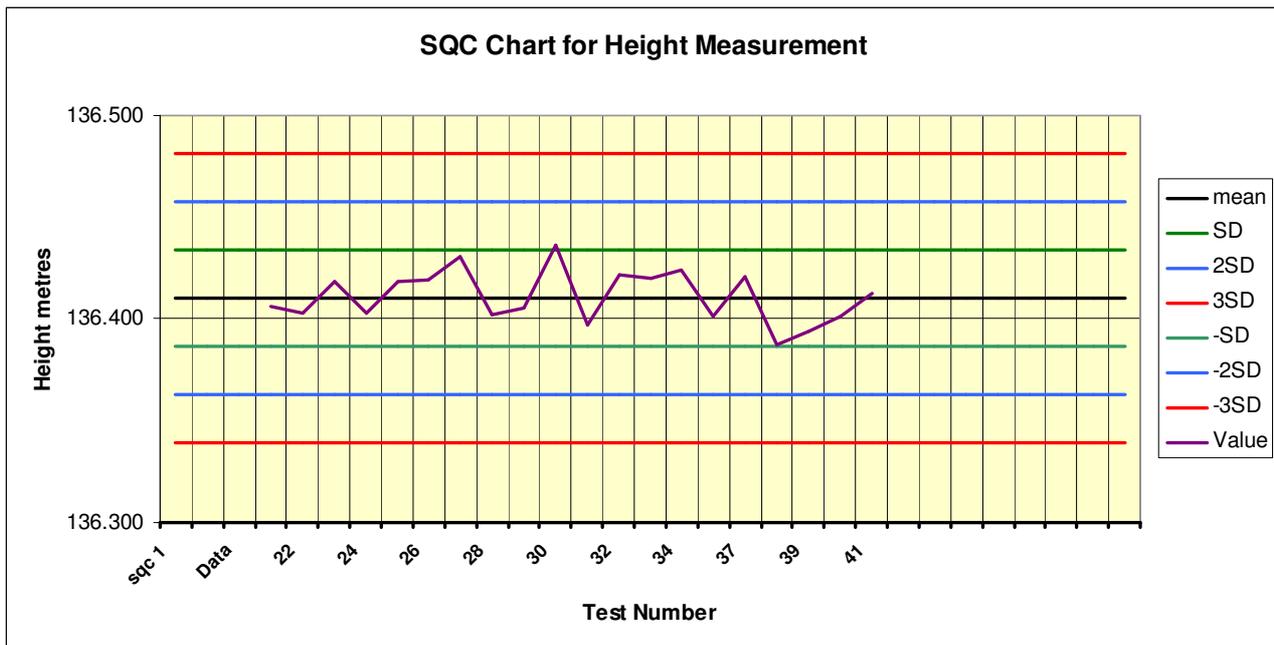
The summit positions were identified using a Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a "1m" E-staff extendable to 5m.

Absolute heights were measured using a Leica Geosystems 530 GPS receiver. It is a dual-frequency, 24channel instrument, which means it can lock on to a maximum of 12 satellites 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 signal. As a stand-alone instrument it is capable of giving position and height to an accuracy of about 1 and 3 metres respectively. Note that a hand-held GPS receiver can only receive up to 12 satellites and each at a single frequency and therefore it has a poorer positional accuracy of 5m at best and a height

accuracy of no better than 10 metres. Despite the on-board features of the 530 GPS receiver, there are still sources that create residual errors.

To obtain accurate positions and heights, corrections were made to the GPS data via imported RINEX data from the Ordnance Survey which was post-processed using Leica Geo Office Version 7 software. If confirmation of the height were required by the Ordnance Survey, then this work was carried out by Mark Greaves who processed the data using his Bernese Software. This software is recognised as producing definitive results, but the differences between this and results calculated by Leica Geo Office are only up to 2-3cm for height measurements.

The Leica NA730 level is routinely checked to make sure that the line of sight is correct when the instrument is set up horizontally; there is a standard surveying method to do this described in the users' manual for these instruments. We also regularly check the functioning of the Leica 530 GPS against Statistical Quality Control (SQC) charts generated for a marked position. The chart associated with height measurement is shown below. The mean height above sea level for a fixed point (measured on 20 different occasions for 30mins of data collection at each time) was calculated to be 136.410m. Further height measurements have been made on separate occasions over a period of 18 months using the same process parameters. The last and penultimate measurements were carried out after and before the mountain surveys described in this report. The results shown on the graph are all within a range of +/- one SD (Standard Deviation), in this case +/-0.024m. This demonstrates that our Leica 530 GPS is giving consistently precise results within the expected errors for the measurements.



In addition, we check the instrument periodically by taking measurements on an Ordnance Survey Fundamental Bench Mark, processing the data and comparing it with the OS derived values. Height should agree within about 0.02-0.03m.

Checks were carried out on 20 June 2011 and 14 July 2011 at the Daresbury Fundamental Bench Mark and the results in the table below show excellent agreement between the Ordnance Survey measurement and our own.

Processing	Date	Height(m)
OS measurement		73.24
JB/GVJ GeoOffice 7	20-06-2011	73.24
JB/GVJ GeoOffice 7	14-07-2011	73.23

Conditions for the survey of Beinn a'Chlaidheimh, which took place between 10.45hr and 14.30hr BST, were satisfactory. The temperature was about 12 degrees Celsius on the summit and the wind speed was 15 to 20mph. We took the precaution of reducing the antenna height to 1 metre rather than employing the usual 2 metres to ensure the stability of the equipment during the survey. Visibility was good and conditions were sunny with occasional cloud cover above the tops.

Conditions for the survey of Beinn Dearg Mor were less pleasant. The sky was overcast with a cloud base of about 900m, although this lowered to 700m for the last 30min of the survey. The temperature was 8 to 10 degrees Celsius and the wind speed was 5 to 10 mph. On the inward and outward journeys from Shenavall there was persistent rain. The survey took place between 13.00hr and 15.30 hr BST.

Conditions for the survey of Ruadh Stac Mor improved. The temperature was 10 to 15 degrees Celsius and most of the day was sunny. A brief shower of rain that lasted about 20 minutes provided, towards its end, an excellent view of a rainbow below us! Visibility was good and wind speed was low. The survey took place between 13.15hr and 16.00hrs BST.

3) **The Survey of Beinn a'Chlaidheimh**

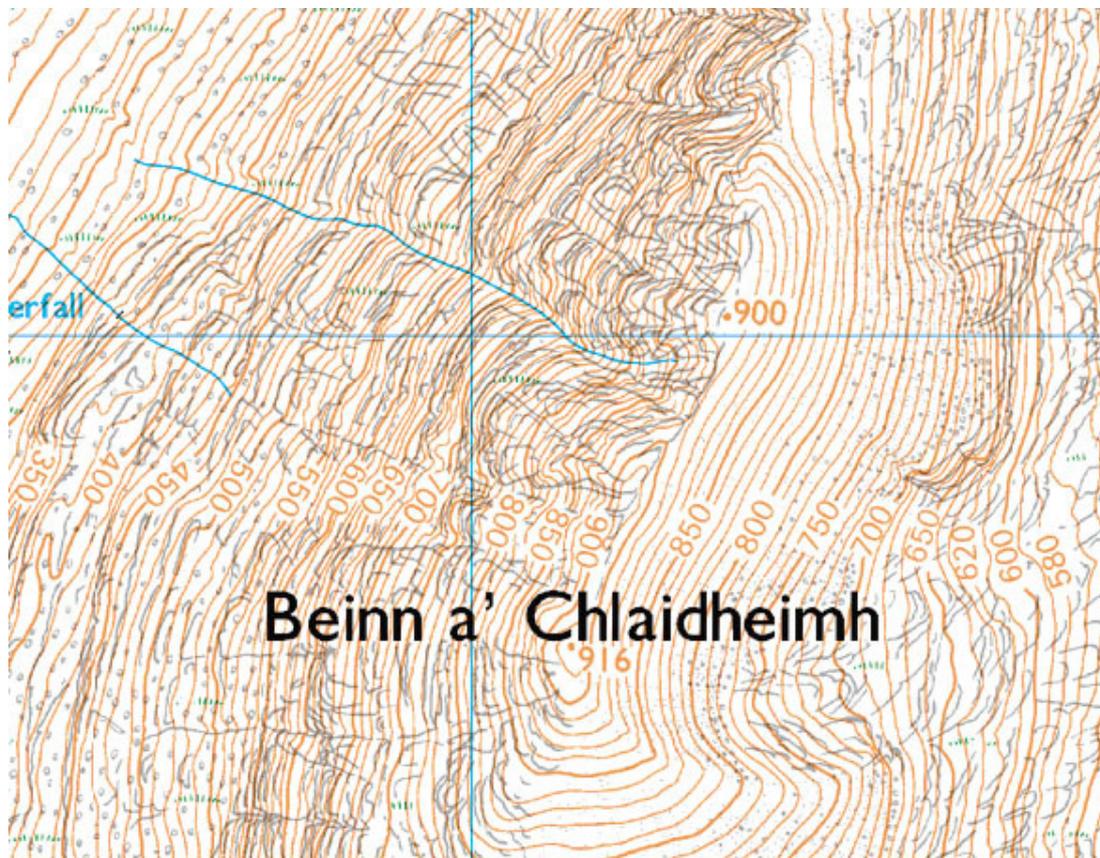
3.1) **Character of Mountain**

Beinn a'Chlaidheimh is the most northern of the group of Munros known as the Fisherfield Six or the "Big Six" of Fisherfield and Letterewe. Its height is very close to 3000 feet and it was not until the 1974 edition of Munros Tables that this mountain entered the list. Previously it was classified as a Corbett. The whole area of the Fisherfield Forest is remote, and the usual route for walkers wishing to ascend this mountain is from the bothy at Shenavall. The easiest access is from the North on the A832 at Corrie Hallie where the track leads over a pass and down to the private bothy at Achneigie. From the foot of the pass the track can then be followed South along the bank of the Abhainn Loch an Nid. The river may be crossed at a suitable point and then the easterly flank of the mountain is ascended to gain the ridge. From here it is a short walk north along the ridge to reach the summit. Another possibility is to walk in from the East along the northern bank of Loch a'Bhraoin to reach the bothy at Lochivraon. The track is then followed West and North, past Loch an Nid to ascend the easterly flank as described previously.

Compared with the other mountains in Fisherfield, Beinn a'Chlaidheimh contains more sandstone and this can be seen from the characteristic terracing associated with this type of rock, particularly on the northern face. The northern flanks of the mountain are very steep and only provide an ascent route for masochists!! The north eastern flank of the mountain is covered with a long steep scree field but further south the terrain becomes grassier and the gradient gentler. The western side of the mountain is also very steep with the amount of rock and scree increasing with height, and is never considered as an ascent route.

The summit ridge is undulating, rocky and has three distinct high points two of which appear to be the same height. Generally the most southerly of these is considered to be the mountain's summit

and on the latest 1:25000 and 1:50000 OS Maps is marked with a spot height of 916m. This point is marked with a cairn. The ridge continues South along a faint track, descends to a bealach and then rises up to the summit of the next Munro, Sgurr Ban, 3km distant.



3.2) Summary of Survey

The first task was to identify which of the three high points along the summit ridge was the highest. The Leica NA730 automatic level was set up on the tripod about 10m from the cairn of the South Top and on the southern side of it. Using the staff, we determined the highest point on the South Top which was a rock adjacent to the cairn. The staff reading at this point was 0.750m. The staff reading taken at the highest point on the middle top was 1.455m. We were thus able to confirm that the South Top is higher by $(1.455\text{m} - 0.750\text{m})$ 0.705m. Although staff readings were not taken on the North Top, observation through the level quickly showed this was several metres lower than the other two tops and therefore not a contender for the summit of the mountain. Summit photographs are shown in Appendix 1.

For the absolute height measurement, the Leica 530 GPS was set up with tripod support to hold it firmly over the highest point. The AT502 antenna was mounted on a 1.000 metre pole and data were collected for 3 hours with an epoch time of 30 seconds.

3.3) Results for Beinn a'Chlaidheimh

The ten-figure grid references for the summit (South Top) recorded with hand-held GPS units were:-

Garmin Map 60CSx NH 06138 77568 Accuracy 3m Height = 918m

Garmin Etrex NH 06138 77568 Accuracy 5m Height = 921m

The ten-figure grid reference for the Middle Top recorded with a hand-held GPS unit was:-

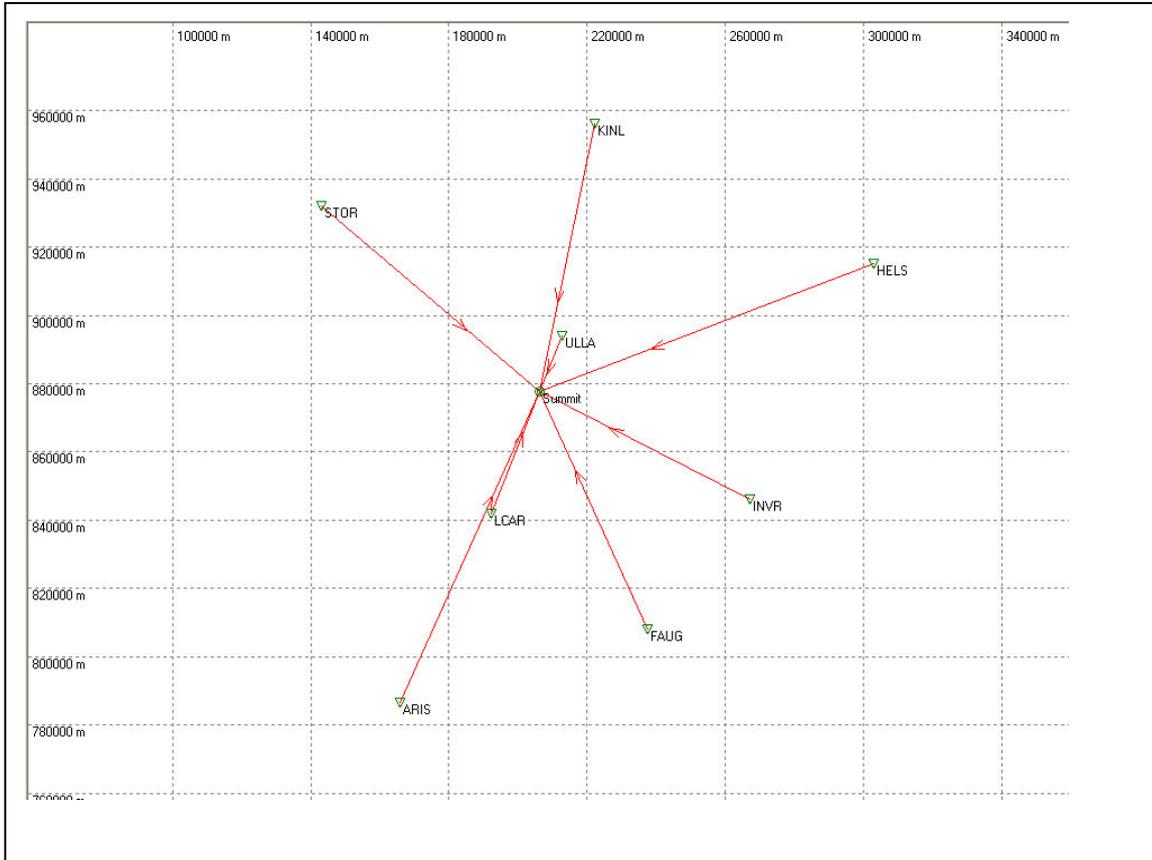
Garmin Etrex NH 06204 77744 Accuracy 5m Height = 922m

The ten-figure grid reference for the North Top recorded with a hand-held GPS unit was:-

Garmin Etrex NH 06344 78009 Accuracy 5m Height = 908m

The GPS data were processed with the Leica GeoOffice Version 7 Software using a “dongle”, an electronic key that is needed to unlock the processing modules of the software. RINEX correction data were imported from the Ordnance Survey Website for the 8 nearest Active Base Stations (Ullapool – ULLA 18km, Loch Carron – LCAR 38km, Inverness – INVR 68km, Fort Augustus – FAUG 76km, Kinlochbervie – KINL 81km, Stornaway – STOR 84km, Arisaig - ARIS 99km and Helmsdale- HELS 104km). We used Broadcast Ephemeris data received by the GPS during the survey rather than Precise Ephemeris data, since we have found this makes little difference to the height results. The computed Tropospheric model was chosen for the calculations to suit the data collection times and the wide difference in height between the base stations and the summit of the mountain.

The distances and directions of the base stations from Beinn a’Chlaidheimh are shown in the scaled diagram below. As far as is possible, the base stations are evenly distributed around the survey point with heights measured from each base station within +/-0.03m of the mean result.



Since our measurement for the height of Beinn a'Chlaidheimh was below 914.4m (3000.0 feet), we sought confirmation of the result from Mark Greaves at Ordnance Survey. He ran our data file through his Bernese software to obtain the definitive height.

The results are tabulated below:

Processing	Feature	Easting	Northing	Height(m)
JB/GVJ GeoOffice 7	Rock near Cairn	206135.314	877580.937	913.984
OS Bernese	Rock near Cairn	206135.315	877580.937	913.958

3.4) Discussion of Results

The measured height for Beinn a'Chlaidheimh is 913.96m, and is 2metres LOWER than the spot height of 916m that currently appears on the Ordnance Survey 1:25k & 1:50k maps. The measured height is below 914.4m (3000.0feet). This is in agreement with the 914m spot height that was printed on OS maps pre 1990 and it would seem that the earlier classification of this mountain as a Corbett was correct.

The agreement between our results processed by GeoOffice7 and Bernese software is excellent. The East and North Coordinates are identical to 0.001m and the height for our calculation is 0.026m higher. We have found that the Bernese software gives a result usually 2-3cm LOWER than the calculation made by GeoOffice. This arises from subtle differences in the Tropospheric models employed by the two software programmes that calculate corrections to the satellite signals. However, the model the Bernese software uses is considered to be superior.

Since 3 hours of data were collected, we would estimate the error for the Bernese calculated height to be about +/-0.05m.

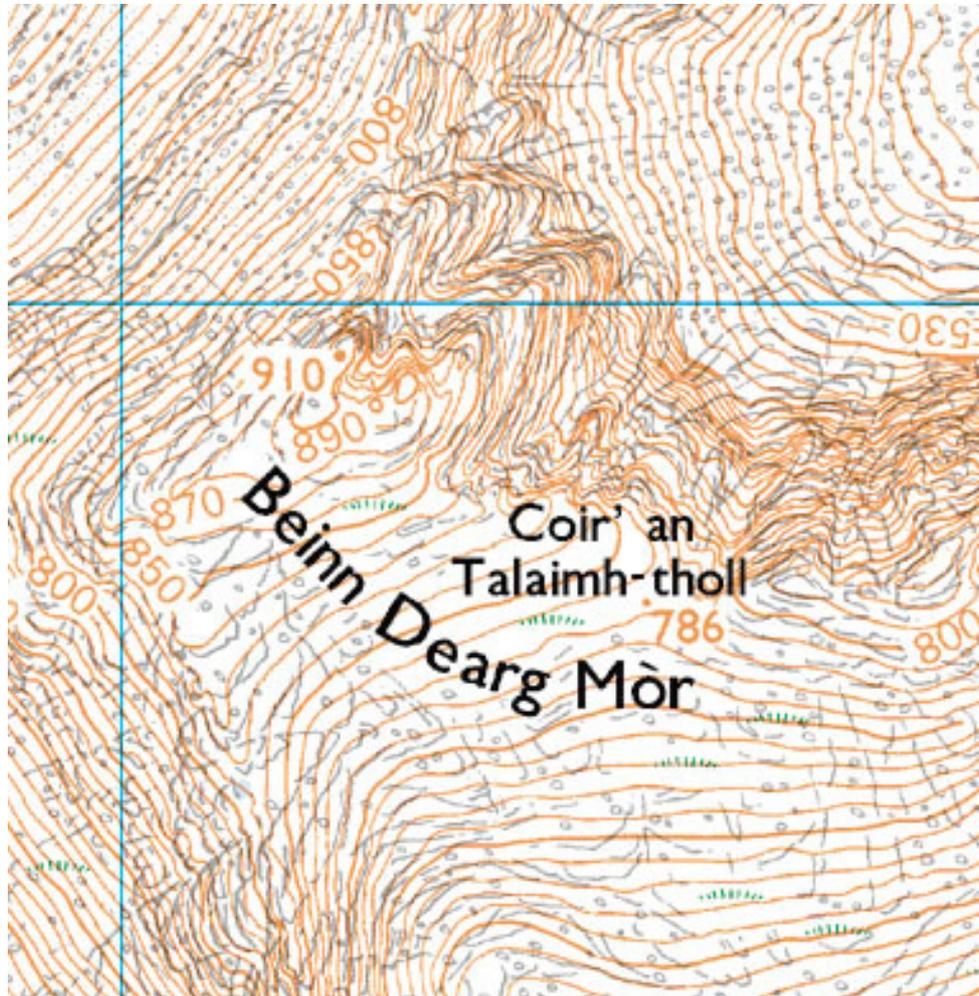
4) Survey of Beinn Dearg Mor

4.1) Character of Mountain

Beinn Dearg Mor lies in the Fisherfield Forest about 5km South West of An Teallach with Loch na Sealga midway between in the bottom of the glen. Combined with Beinn Dearg Bheag, the two mountains provide a spectacular “mountain island” surrounded by glens and lochs on all sides. Beinn Dearg Mor is undoubtedly one of the finest Corbetts with narrow ridges and steep cliffs. The view from the summit of the mountain across the corrie to the adjacent top is considered to be a mountain classic. The mountain is steep on all sides and rocky, particularly on the higher slopes. However, there is now a track that ascends through steep broken ground from the bealach between Beinn Dearg Mor and Beinn Dearg Bheag.

Beinn Dearg Mor is a very remote mountain and Sir Hugh Munro described it as being “a long way from anywhere”. For those not based at the Shenavall bothy, access can either be gained from Corrie Hallie on the A832 to the North or from Gruinard, again on the A832, to the North West. Either route involves a long hard walk with the added difficulty of river crossings that could become impossible very quickly after rain. Whichever route is chosen, the easiest ascent to the summit is via the bealach between the two mountains, accessed either from Loch na Sealga or Loch Beinn Dearg.

The top of Beinn Dearg Mor consists of a small corrie facing North East with very steep drops into it. The end of the more westerly edge has a large cairn and this is generally recognised as the summit of the mountain and is marked with a spot height of 910m on the latest OS 1:50000 and 1:25000 maps. It is not visually obvious that this is higher than the high point across the corrie in an East South East direction. Summit photographs are shown in Appendix 2.



4.2) Summary of Survey

The first task in the survey was to locate the highest point which we did using the Leica NA730 level and staff. The level was set up a few metres away from the large cairn and staff readings were taken around the cairn. The highest point in this area was identified as being the top of an embedded rock on the south side of the cairn. We could not tell if the cairn covered any higher point since it would have been undesirable and indeed an impossible task to dismantle and re-assemble it. However, close inspection revealed no obvious embedded boulder within the cairn and we are confident there is no hidden ground more than 30cm higher within it. We noted that the cairn was between 1.5 and 2.0m high. The highest visible point, the embedded rock on the south side of the cairn, gave a staff reading of 0.145m. A staff reading was also taken on the alternative top on the other side of the corrie. The reading was 0.755m on its highest point proving that this top is 0.61m LOWER than the mountain's summit.

For the absolute height measurement, the Leica 530 GPS was set up with tripod support to hold it firmly over the highest point. The AT502 antenna was mounted on a 2.000 metre pole and data were collected for 2 hours with an epoch time of 30 seconds.

4.3) Results for Beinn Dearg Mor

The ten-figure grid references for the summit rock recorded with hand-held GPS units were:-

Garmin Map60CSx NH 03221 79929 Accuracy 3m Height = 913m
 Garmin Etrex NH 03220 79929 Accuracy 5m Height = 912m

As for Beinn a'Chlaidheimh, the GPS data were processed with Leica GeoOffice Version 7 Software. RINEX correction data were imported from the Ordnance Survey Website for the 8 nearest Active Base Stations (Ullapool – ULLA 18km, Loch Carron – LCAR 39km, Inverness – INVR 72km, Fort Augustus – FAUG 79km, Kinlochbervie – KINL 80km, Stornaway – STOR 80km, Arisaig - ARIS 100km and Helmsdale- HELS 106km). Because of the close proximity of Beinn Dearg Mor to Beinn a'Chlaidheimh, 3.75km, the same base stations have been used and the scaled diagram shown in Section 3.3 is nearly identical. Again Broadcast Ephemeris data picked up by the GPS during the survey were employed in the processing, rather than Precise Ephemeris data. The computed Tropospheric model was chosen for the calculations to suit the data collection times and the wide difference in height between the base stations and the summit of the mountain.

Although our measured height did not exceed 914.4m (3000 feet), it differed from the current map heights by more than the Ordnance Survey tolerance for spot heights, so therefore Mark Greaves at Ordnance Survey also processed these data through his Bernese software.

The results are tabulated below:

Processing	Feature	Easting	Northing	Height(m)
JB/GVJ GeoOffice 7	Rock near Cairn	203216.955	877938.741	906.334
OS Bernese	Rock near Cairn	203216.943	879938.750	906.284

4.4) Discussion of Results

The measured height for Beinn Dearg Mor is 906.28m, which is 3.7m LOWER than the spot height of 910m that appears on the latest Ordnance Survey maps. Despite this measured height difference, it has no effect on Beinn Dearg Mor's status and it retains its Corbett classification. It is possible that the photogrammetrist at Ordnance Survey spotted to the top of the cairn although this would only overestimate the height of Beinn Dearg Mor by about 2m.

The agreement between the two sets of processed data in the table above is good for position, about 0.01m. However the difference for height is 0.05m which is about twice the 0.02/0.03m difference usually obtained. Since the data used in both calculations are the same, the difference must be reflected in the tropospheric conditions that existed on the day and GeoOffice's ability to model them as effectively as Bernese software. The collection of data for 2hours on Beinn Dearg Mor rather than the 3 hours for Beinn a'Chlaidheimh would also make the difference larger, if atmospheric correction were proving difficult to model.

Based on previous experience with a 2 hour data set and the fact that the summit position outside the cairn was clearly identifiable, we would estimate the accuracy of the height to be +/-0.08m

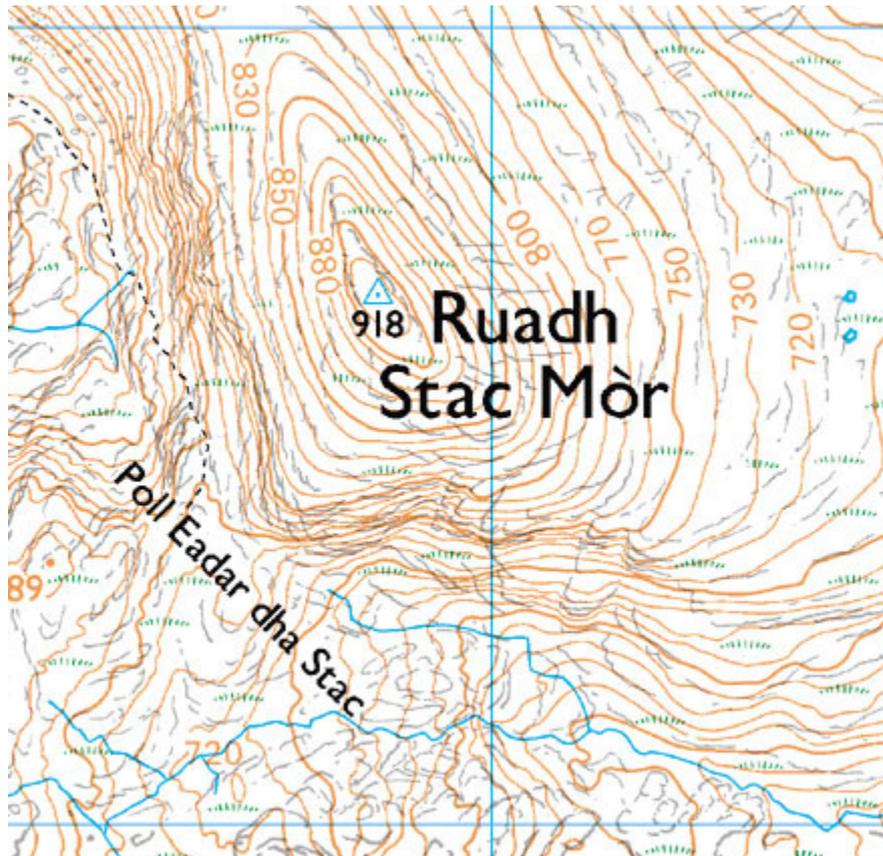
5) Survey of Ruadh Stac Mor

5.1) Character of Mountain

Ruadh Stac Mor is one of the Fisherfield Six Munros lying with A'Mhaighdean on the western side of Gleann na Muice. The latter is recognised as the most remote Munro yet the summit of Ruadh Stac Mor is only about 1km North East. Again this is another fine mountain and the views from it have been described many times as "The finest in Scotland". All around are corries, ridges, lochans and many more mountain features that compel one to remove the camera from the case! Ruadh Stac Mor is largely composed of sandstone on the upper slopes which gives it its red appearance (and its name) but this rock changes to grey gneiss on the route to A'Mhaighdean.

Access to Ruadh Stac Mor is difficult. It is interesting to note that when the original survey was carried out, the landowner limited the Ordnance Survey's access to this mountain, as well as A'Mhaighdean and Beinn a'Chlaidheimh, and so the original maps showed the tops as very flat. It was not until some time later that a re-survey revealed the true nature of these mountains. Apart from using Shenavall Bothy as a base and starting point, probably the best day route to Ruadh Stac Mor is from the West starting at Poolewe. Although this route is 22km in distance, most of it is on good tracks with relatively little ascent until the final attack on the mountain itself. We were fortunate in receiving permission to park cars at Kernsary as this saves about 11km of walking for the out and return journeys. The route is also very scenic, as it passes under the northern faces of the two Corbetts, Beinn Airigh Charr and Beinn Lair, before dropping down to and then crossing the causeway between Fionn Loch and Dubh Loch. After passing by the recently renovated and isolated house at Carnmore, the track rises at a comfortable gradient to the bealach between the Corbett, Beinn a'Chaisgein Mor, and Ruadh Stac Mor. Before the three lochans the route turns South East to ascend on a good track to the South West flanks of Ruadh Stac Mor. At a convenient point it is possible to ascend the steep scree slopes or continue to the highest point of the path before turning up to the summit of the mountain. This route also has the added advantage that no river crossings are required.

The top of Ruadh Stac Mor consists of a broad ridge covered with sandstone blocks. At its South Eastern end there is an OS trig point constructed of stone, rather than the usual white-painted concrete, and it is surrounded by a stone shelter. The OS maps mark the trig point as the summit of the mountain with a spot height of 918m. The OS trig point database gives the height of the Flush Bracket on the trig point as 918.67m. Summit photographs are shown in Appendix 3.



5.2) Summary of Survey

The Leica NA730 was set up on a tripod, not far from the trig point, and staff readings were taken from likely candidates for the highest point. Since the summit area was covered with broken sandstones blocks we had to choose a point that felt permanent. If any block could be moved or displaced then it was not considered in the survey. The summit was finally identified as a rock about 10m south of the trig point. Two staff readings were then taken to measure the height of the summit point relative to the Flush Bracket on the trig point.

Reading for Flush Bracket = 0.636m

Reading for Summit = 0.671m

The summit of Ruadh Stac Mor is 0.035m LOWER than the Flush Bracket height. Therefore, based on the database Flush Bracket height of 918.67m, Ruadh Stac Mor's summit is at 918.63m

The Leica 530 GPS was set up with tripod support to hold it firmly over the highest point. The AT502 antenna was mounted on a 1.000 metre pole and data were collected for 2 hours with an epoch time of 30 seconds.

5.3) Results for Ruadh Stac Mor

The ten-figure grid references for the summit rock recorded with hand-held GPS units were:-

Garmin Map60CSx NH 01858 75647 Accuracy 3m Height = 927m

Garmin Etrex NH 01854 75643 Accuracy 6m Height = 926m

The ten-figure grid references for the trig point recorded with hand-held GPS units were:-

Garmin Map60CSx	NH 01856 75649	Accuracy 3m	Height = 927m
Garmin Etrex	NH 01856 75651	Accuracy 6m	Height = 923m

As for Beinn a'Chlaidheimh, the GPS data were processed with Leica GeoOffice Version 7 Software. RINEX correction data were imported from the Ordnance Survey Website for the 8 nearest Active Base Stations (Ullapool – ULLA 22km, Loch Carron – LCAR 34km, Inverness – INVR 72km, Fort Augustus – FAUG 76km, Kinlochbervie – KINL 84km, Stornaway – STOR 81km, Arisaig - ARIS 95km and Helmsdale- HELS 110km). Because of the close proximity of Ruadh Stac Mor to Beinn a'Claidheimh, 4.70km, the same base stations have been used and the scaled diagram shown in Section 3.3 is nearly identical. Again Broadcast Ephemeris data picked up by the GPS during the survey were used in preference to Precise Ephemeris data. The computed Tropospheric model was chosen for the calculations to suit the data collection times and the wide difference in height between the base stations and the summit of the mountain.

Our measured height differed by only 0.02m from the levelled height measured from the OS database for the flush bracket on the trig point, so therefore no request was made to Mark Greaves at Ordnance Survey to process our data through Bernese software.

The results are tabulated below:

Processing	Feature	Easting	Northing	Height(m)
JB/GVJ GeoOffice 7	Rock	201853.002	875655.253	918.650

5.4) Discussion of Results

The measured height for Ruadh Stac Mor is 918.65m and is in excellent agreement with the height levelled from the trig point flush bracket at 918.63m. Therefore, Ruadh Stac Mor, easily exceeding 914.4m in height, retains its Munro classification. With a 2 hour data set we would expect the uncertainty in the measurement to be +/-0.08m

6) Summary of Heighting Results

Beinn a'Chlaidheimh was measured to be **913.96m +/-0.05m**, the summit being a rock on the South Top at NH 06138 77568. This height is below **914.4m (3000.0 feet)**.

Beinn Dearg Mor was measured to be **906.28m +/-0.08m**, the summit being a rock on the South side of the cairn at NH 03221 79929. Although this is 3.7m lower than the current spot height, the mountain **retains its Corbett classification**.

Ruadh Stac Mor was measured to be **918.65 +/-0.08m**, the summit being a rock about 10m South of the trig point at NH 01856 75650. The mountain **retains its Munro classification**.

Note that the quoted measurement uncertainties in this report refer to the data sets and not the overall survey. For Beinn a' Chlaidheimh and Ruadh Stac Mor overall measurement uncertainties would be +/-0.1m. For Beinn Dearg Mor, where the possibility of higher ground under the cairn cannot be discounted, the true summit height could be up to 0.3m higher than that given.

7) Acknowledgements

Many people contributed to the success of these three surveys.

We would first like to thank Alan Haworth (Lord Haworth of Fisherfield) for generously sponsoring this project and showing an active interest in its execution.

We would especially like to thank Mark Greaves of the Ordnance Survey, who calculated the heights for Beinn Dearg Mor and Beinn a'Chlaidheimh to obtain the definitive results and also for his support and advice that has helped us carry out our mountain heighting work.

Finally, we would like to thank members of the Munro Society who assisted with this survey and in particular, Iain Robertson, who coordinates the Heighting Project for The Munro Society and has continued to choose us to carry out the required survey work.

John Barnard and Graham Jackson, 31 July 2011.

Appendix 1

Leica 530 GPS set up on the Summit (South Top) of Beinn a'Chlaidheimh looking South.



The Summit of Beinn a'Chlaidheimh looking North.



Appendix 2

The summit of Beinn Dearg Mor looking North.

(GPS set up on summit position on rock in front of cairn)



Alternative summit of Beinn Dearg Mor across the Corrie is 0.61m Lower



Appendix 3

Summit of Ruadh Stac Mor looking South



Summit of Ruadh Stac Mor looking North West

