MORVERN DMG – OPEN RANGE POPULATION MODEL

1.1 Historic Count and Cull Data (see PDF)

1.2 Forward Looking Population Model

	2019				2020		
	Stags	**Hinds**	**Calves**		**Stags**	**Hinds**	**Calves**
West	450-470	590-700	244		490-510	650-660	230
North East	262-292	355-365	100-120		262-292	345-355	115-120
South East	460-465	670	240-260		470-480	620-630	235-240
Summed Catchment	1190-1210	1715- 1730	600-625		1250-1265	1620-1640	580-590
Whole Catchment model	1110	1690	610		1155	1630	580-590
	2021				**2022**		
	Stags	**Hinds**	**Calves**		**Stags**	**Hinds**	**Calves**
West	525-540	640	224		550-570	600-610	212
North East	260	330-350	113-118		260-290	320-335	108-114
South East	480-490	570-580	215-220		475-480	600-610	230
Summed Catchment	1270-1285	1545-1560	550-560		1300-1320	1530-1545	550-560
Whole Catchment model	1190	1560	560		1200	1480-1490	530-540

1.3 Explanatory Document

***The process*:**

1. OK. In reading through all this please be aware that population modelling is not a precise science (particularly where some of the input variables may change through time as the populations respond to what is being done to them).

2. Further: the models developed here are inevitably constrained by the data available to me as inputs, which in places remained patchy. For some properties I have had to work around the fact that there were no count or cull data available at all; in other cases there were formidable gaps between counts (especially when combined to try and arrive at composite estimates for a wider, regional area - when absence of one property in one year makes the 'group' count incomplete). Finally, even where counts were available, as I worked through the figures it became clear that some of them were obviously inaccurate – or strongly influenced by immigration into and area or emigration from that area of groups of animals on that particular day of the count, such that counts were not representative of what was more typically resident on the ground. [This becomes obvious when numbers counted in a given year, whether of stags or hinds, simply cannot be biologically possible, given previous numbers counted and known culls].

3. **Thus although outputs appear rather precise (exact figures) this precision is illusory and figures are indicative approximations at best.**

4. By way of preamble: My 'concerns' about the model currently used by SNH is that for correct application it requires information about summer calving rates and calf mortality over the first year of life. Neither metric is commonly recorded by managers and thus in common usage, SNH staff insert end of winter recruitment rates in the model place of the actual summer calving rate. This is in practice a) applied to the wrong population of hinds; and b) means that in effect they remove overwinter mortality of calves twice (since a later element of the model asks for that mortality).
In consequence the modelling offers an underestimate of the rate at which hind populations in particular will grow under given circumstances. My models are based instead on application of the actual end of winter recruitment rate (surviving calves per 100 hinds in end of winter counts) applied to the end of winter population of hinds. This avoids the above error and actually, by the same token avoids the need to estimate calving rate, or overwinter mortality of calves (whether natural mortality or imposed (cull) mortality, since it conveniently integrates the whole lot.

5. In addition the SNH model makes no allowance for immigration or emigration (or other unexplained losses). My models attempt to take account of that immigration and emigration and indeed to make an estimate of additional 'unexplained' losses from a population. In our case here, this enables us to get around the issue that we have no count or cull figures for some properties within the catchment and also makes some adjustment for animals 'caught up' in Forestry Commission culls where they may have got into FC enclosures.

6. In effect one can make an estimate for these 'unexplained losses' by running the model over a period of known counts and culls, making adjustments to certain of the parameters until the predictions accurately track the actual counts recorded in successive years. This is known as 'training' of the model over a period of known counts until it 'fits' a run of known counts satisfactorily.

7. The process also highlights years (as above) where counts must be inaccurate or unrepresentative since they are simply not biologically consistent with counts of the preceding and succeeding years (indeed in some cases counts are simply not biologically possible given the counts of the immediately preceding years and known culls).

8. The way it works is this: If you take as a starting population the actual count recorded in Year X, you can estimate what should be the expected population count in Year X+1 by adding the average calculated level of expected recruitment (which we know from long runs of count data for each subGroup area) and removing the known culls. From any starting point using this same recruitment rate and known culls in successive years, you can roll forward and project expected population counts in Year X+1, X+2, X+3, X+4 and so on.

You cannot be sure that the actual recorded count in any start year X was accurate/representative of the true resident population, so it pays to do these projections forward from a number of different start years.

9. In many cases projected numbers in future years may be slightly higher (for hinds) or substantially higher (for stags) than the numbers actually counted on the ground. This mis-match then gives you an estimate for losses which must be occurring in the population from other causes. Natural mortality (at about 2% per year) usually accounts for most of the 'unexplained' losses in hinds, but stag losses are often substantially higher than this and contain a measure of the losses through emigration. For the models introduced below I can estimate these and "train" the model by using counts (and known culls) from 2010 to 2016 and then 2018. I adjust the figure included for 'unexplained losses' until there is a reasonably

good match between the models' predictions for any year and actual counts. This then allows us to calculate some "average" estimate for net losses and gains other than through recruitment and known culling.

10. As above, it also allows us to highlight years where the counts simply are not biologically credible, or consistent with counts of years immediately prior or immediately following, allowing us to exclude these counts from model training and forward projections. These will be noted below

11. OK, we now have estimates for rates of unexplained losses to stag and hind populations under stable conditions which can be added to known culls and makes the model more realistic. [The only caveat I might offer is that they are calculated under management for stable state. The values MAY alter as things change. For example, as Ardtornish start their reduction culls rates of emigration of hinds may rise in the short term due to the disturbance. Similarly, changing population of hinds and changing distribution of those hinds on Ardtornish may affect movement of stags within the catchment. But we simply cannot predict these changes we have to go with what we have got for now].

12. Using those figures (and with the model thus "trained" on annual population counts from 2008 to 2018), we can then project forwards. But remember (and I must emphasise) that the model is now fixed and we are assuming that rates of recruitment as well as rates of immigration and emigration do not change from those established as averages over the period 2010-2018. We cannot be sure that this is valid: models are only as good as the assumptions you insert!

13. Models presented relate only to the discrete area north of Lochaline, thus do not extend to Drimnin or Killundine. In addition, they exclude consideration of Kilmalieu and Inversanda as marginal to the main Group area. The properties included are therefore those of Ardtornish, Kingairloch, Glensanda, Laudale, Carnoch, Kinlochteacuis and the Rahoy Hills Reserve. Rahoy Estate are no longer members of the Group; this ground and that of SNH Glencripesdale were excluded because they are purportedly independent populations separated by secure fences from the main hill area. No data were made available from Glencripesdale Estate and I have had to accommodate that by adjustment of the "unexplained losses".

14. Models are separately developed for the discrete subpopulations identified in the MDMG management plan. It is accepted that there may be some movement between these areas at times, but argued that they are primarily comparatively self-contained – sufficient to allow separate models to be developed for the separate areas. In this case

- **West** includes that part of Ardtornish West of the road through the White Glen, Rahoy Hills Reserve, Kinlochteacuis, (Glencripesdale) and the West part of Laudale (west of the road)
- **South East** includes that part of Ardtornish to the East of the road through the White Glen, Glensanda and Kingairloch South
- **North East** includes the North part of Kingairloch, Carnioch and the East side of Laudale

[I have in fact tried other variations including combining North and South parts of Kingairloch into a single entity, but the above structure produced the most intelligible results]

I further developed predictions for the **Entire Catchment** both from developing a specific, catchment-wide, model and also by combining the predictions for the sub-areas listed above.

Model training and future projections:
15. By using runs of data between 2010 (sometimes 2012) and 2018, in each case trying to predict each subsequent count year, from a range of different starting points, I was able to establish:

West: Counts were in fact highly variable. Counts in years 2015 and 2016 were inconsistent with the rest of the population trajectory through time, suggesting significant undercounting of hinds over that period. A start year of 2012 gave the best prediction for 2014 and 2018 with an average 'unexplained loss rate' [natural mortality and other losses] at 0.035 of summer populations of hinds and 0.07 of summer stag populations [SNH usually accord a loss rate through natural mortality of 0.02].

South East: In this case (and despite it having been a helicopter count) the count of 2018 is simply not credible given counts and culls of earlier years. By converse the count in 2010 is broadly consistent with the shape of the population trajectory in 2011, 2012, 2014 (remembering that 2014 was also a helicopter count in this area). In future models therefore I have used the 2010 starting year and subsequent trajectory rather than begin from what appears to have been an unrepresentative 2018 count. Unexplained losses were set at 0.04 for hinds and 0.11 for stags since such figures gave best fit to actual counts between 2010 and 2014. This high figure for 'export' of stags is consistent with models developed previously for both Ardtornish and Kingairloch as individual Estates and suggests significant losses of stags into the Forestry grounds.

North East: Counts were, again, highly variable between years (2014 returned an improbably high count of hinds, 2015 an artificially low hind count for consistency with all other count years). In this case I have run models forward into the future from both the 2012 and 2018 start points, with, in both cases, 'unexplained losses' at 0.01 of the summer hind population and 0.02 of summer stag numbers.

Whole Catchment: Here again, reported counts were somewhat erratic. On paper there appears to have been a sudden drop in populations between 2014 and 2015 with those lower figures sustained in 2016. But one simply cannot get to the reported 2018 figures from either 2015 or 2016 so one must suspect these were underestimates on the day. Predicting future populations, I have rolled forward from both 2010 and 2018 counts using an unexplained loss rate of 0.02 for hinds and o.09 for stags. I have also prepared predictions based on summation of the separate outputs for models of the separate subpopulations (West, South East and North East) described from their individual models. Note that the 'additive' model predicts slightly inflated stag numbers when compared to the actual model run explicitly for the Whole Catchment, but hind numbers are broadly identical.

16. For all projections into the future I have used proposed cull figures presented by individual Estates or, where these were not available (in some cases Estates volunteered proposed culls for stags but not for hinds), I have inserted average culls taken on those Estates over the past 5 years.

17. I have presumed that while Ardtornish has proposed increased hind culls over the next 3 years in order to effect a reduction in hind population number and overall density, culls will return to maintenance in the season 2021/2022. In a similar way I have presumed that the small hind cull to be imposed on the Rahoy Hills Reserve over the next few years will not be sustained after 2021/22.

Results:
18. I have spreadsheets recording all the 'training runs' and (separately) the forward predictions in each area for 2019, 2020, 2021, 2022 if anyone needs them, but summarise the results in the table attached. Note that because in some cases I have projected forward from 2010/2012 and separately from the count in 2018, I offer approximate ranges within which numbers might be expected to fall. [I have NOT offered estimates for individual properties]; see table attached.

Interpretation: Working on the actual long-term sporting aspirations declared by each property (total number of stags to be shot each year added together for the component properties in each area), we can see that in the long term.

19. The **West subGroup** wishes to sustain a sporting harvest (total) of 40 stags per year. Presuming that this is to be met by mature stags of 7 years or older this would require from 2021 a stag population of the order 280; in practice predicted populations are well in excess of this requirement
Long term support of such a quota would require a hind population of around 250 mature hinds; once again projected numbers are well in excess of this minimum requirement.

20. The **North East subGroup** wishes to sustain a combined sporting harvest of 54 stags per year. By the same calculation this would require from 2021 a stag population of 375 - 380 to sustain a harvest of stags older than 7 years or around 325 stags if stags are harvested once past age 6. Projected numbers are slightly below this target required numbers are actually well within the margin of error associated with the model's predictions. Hind populations required to sustain this level of offtake in the longer term are calculated at between 330 and 350 mature hinds, which is virtually what the model is predicting will be present from 2021.

21. The **South East subGroup** wishes to sustain in the longer term (and after the reduction culls on Ardtornish are completed) a combined harvest of 48 stags per year. Equivalent calculations suggest a minimum requirement from 2021 of between 286 and 336 stags and some 300 hinds. Numbers projected from 2021 lie comfortably above these levels.

22. When considered at the level of the **Whole Catchment** as defined at paragraph 13, a total stag harvest is required of around 200 stags per annum. This would require populations from 2021 of 1200 stags (if harvests are to be based on animals of 6 years or older) or 1400 stags if harvests are taken only of animals of 7 years and older. Required hind populations are of the order of 1270 for the catchment as a whole. Projected stag numbers fall towards the lower end of this requirement, but once again are well within the margins of error necessarily associated with any predictive model. Numbers of hinds projected (at around 1560 are slightly in excess of overall requirement, but again we should remember that there are inevitable margins of error associated with any forward projection given the necessary assumptions made in the model, and thus we might be comfortable that projections are broadly on target.

23. Overall, looking at the model projections through from 2019 to 2022, we may be reassured that proposed hind culls from 2022 are appropriate for stability at 2021 levels.

Rory Putman, December 2018