Independent biostatistical report on the Brumby population in the Kosciuszko National Park

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Disclaimer

While the author endeavours to provide reliable biostatistical information and believes the content of this report is accurate the author will not be liable for any error, loss, consequences or claim by any party acting on such information.

REPORT: Brumby population

This report is prepared in full by myself, Claire Galea, biostatistician. I declare that I have no conflict of interest and have undertaken this report independently. I have been a statistician for over 25 years and have analysed all forms of data ranging from military to biological, educational and medical, specialising in teaching, lecturing and scrutinising complex time-based data and examining trends. I have published over 50 peer reviewed papers, including my Masters dissertation, which was based on trends over time, as are the documents that I have reported on in my submission to this inquiry. All key findings, summaries and recommendations are focussed on the mathematical and statistical aspects of the reports listed below.

Documents covered

1. S. C. Cairns. (2019) Feral horses in the Australian Alps: The Analysis of Aerial Surveys conducted in April-May 2014 and April-May 2019. A report to the Australian Alps Liaison Committee. Unpublished.
2. E. J. Curtis and S. R. McLeod. (2021) Western Plains Aerial Kangaroo Survey Results. Unpublished.
3. S. C. Cairns, D. Bearup & G. W. Lollback. (2016) A report to the New South Wales Office of Environment and Heritage on the consultancy: Design and analysis of helicopter surveys of the kangaroo populations of the Northern Tablelands kangaroo management zones, 2016.
4. S. C. Cairns, D. Bearup & G. W. Lollback. (2019) A report to the New South Wales Office of Environment and Heritage on the consultancy: Design and analysis of helicopter surveys of the kangaroo populations of the Northern Tablelands kangaroo management zones
5. S. C. Cairns. (2022) A survey of the wild horse population in Kosciusko National Park, November 2022.
6. Department of Planning, Industry & Environment 2021 Quota Report New South Wales Commercial Kangaroo Harvest Management Plan 2017-2021 and the updated (error corrected) version
7. P.D. Moloney, D.S.L. Ramsey and M.P. Scroggie. (2017) *A state-wide aerial survey of kangaroos in Victoria (December 2017).* Arthur Rylah Institute for Environment, Research Technical Report Series No 286. NOTE: Referred to in this report as the Technical Report 2017
8. S. C. Cairns, D. Bearup & G. W. Lollback. (2019). A report to the Biodiversity and Conservation Division, New South Wales Department of Planning, Industry and Environment on the consultancy: "Design and analysis of helicopter surveys of the kangaroo populations of the Northern Tablelands kangaroo management zones, 2019.

Summary of Analysis

There are concerning flaws in methodology and statistical modelling of the population estimates of wild horses in the Kosciuszko.

Based on this analysis it is impossible to have any confidence in the population estimates provided.

Key findings

1. The survey methodology contains significant flaws that put in question the counting of wild horses.
2. Insufficient numbers of wild horses were seen to apply statistical modelling techniques to estimate populations.

   For example: Values from surveys conducted in 2014 and 2019 were combined together as insufficient numbers were seen and population estimates done from this one single value which means that population estimates over time are fundamentally flawed.

Recommendation

Immediate moratorium on the killing of all wild horses in the Kosciuszko National Park and an independent investigation into all population trends and subsequent control needs to be urgently undertaken.

This report on wild horses is prepared as I presented at the NSW Parliamentary Inquiry on the Health and Wellbeing of Macropods as a key witness on the concerns surrounding the methodology, statistical modelling and reliability of population estimates for kangaroos. S. C. Cairns counts both the kangaroos and wild horses. This report presents findings outlining consistent concerns across the population estimates for both wild horses and kangaroos.

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A. SURVEY METHODOLOGY

1. Cluster size

When conducting surveys, it is essential to determine the minimum number of sightings that are needed in order to make a reliable population estimate. Cairns (2019) and Cairns (2022) cites Buckland et al. (2001) stating that *"the recommended number of observations, of clusters of horses in this instance, should be 60-80 for reliable modelling of the detection function".* This is also the case when counting kangaroos where Clancy et al. stated that a minimum of 60-80 clusters was needed in order to determine a population estimate. Note a cluster is considered to be more than 1 animal.

- The table below is taken from Cairns (2019) where circled in red the number of clusters of wild horses is well below the 60-80 as recommended.

Table 3. The numbers of clusters of horses and the total numbers of individual horses observed within these clusters in the 2014 and 2019 surveys of the strata within of the three feral horse survey blocks. Given in association with these values are the areas of the respective survey strata actually surveyed (therefore excluding Steep terrain and freehold land).

Survey block	Area (km^2)	2014 No. of clusters	2014 No. of horses	2019 No. of clusters	2019 No. of horses
North Kosciuszko	1,366				
Open habitat	618	84	305	226	1,125
Medium terrain habitat	748	20	64	43	173
Bago-Maragle	847	38	97	29	76
Byadbo-Victoria	3,237				
Medium terrain habitat	3,098	149	366	152	362
Snowy River Valley	139	10	15	5	12

- The table below is taken from Cairns (2016) where circled in red is the *individual number of wallaroos*, not clusters, as the number of animals seen were small and therefore are well below the 60-80 clusters as recommended.
  (Wallaroos are used here purely to identify a consistently flawed methodology)

Table 3. Number of transects flown, total survey effort (km) and raw counts of macropods for each of the two survey strata within the three kangaroo management zones.

Kangaroo management zone	Number of transects	Survey effort (km)	Raw counts: Eastern grey kangaroos	Raw counts: Common wallaroos	Raw counts: Red-necked wallabies	Raw counts: Swamp wallabies
Glen Innes						
High	30	225.0	910	107	84	46
Medium	34	255.0	951	101	53	30
Armidale						
High	37	277.5	1,030	54	11	19
Medium	22	165.0	667	118	13	.123
Upper Hunter						
High	35	175.0	534	58	16	30
Medium	37	277.5	506	70	21	13

CONCERN: Given insufficient clusters of wild horses or individual numbers of wallaroos were seen as per the requirements stated by S. C. Cairns, no reliable population estimates can be determined in either case.

Following on from this Cairns (2019) outlined that as there *"were not enough observations of clusters made during each of the two surveys conducted in the Bago-Maragle block for separate analyses to be undertaken, the results from the 2014 and 2019 surveys were combined to ensure an adequate number of replicate observations for modelling the detection function".*

Therefore, taking Table 3 (horses) above, in North Kosciuszko (Medium terrain habitat) 24 clusters were observed in 2014 and 43 clusters observed in 2019. Both of these are well below the minimum 60 required for statistical modelling. However, Cairns (2019) then sums these two values to get 43+24 = 67 clusters and undertakes the modelling based on a combined total. Of note, when looking at the Snowy River Valley (Table 3 horses), even adding the two years together only gives 10 + 5 = 15 clusters which is extremely below the minimum required.

It is not statistically appropriate to merge different surveys over time when insufficient numbers are seen for population estimation. Literature has shown concerns surrounding this methodology where Roberts and Binder (2009) have outlined:

- When combining samples, the contribution of each sample must be taken into consideration and weighting applied
- If the sample sizes are small then there will be insufficient power to undertake the modelling
- Variance estimation from the individual and pooled sample may be difficult especially if the samples are not independently selected.

Further to this and of even greater concern: when you pool samples from two different time periods, the interpretation of the value obtained changes and becomes the mean value of the two time periods (Lewis, 2017). That is, the population estimate is not from either 2014 or 2019 but rather 2016. It provides only one value and this cannot be used for population estimates and trends over time

CONCERN: Given that insufficient clusters of wild horses were seen as per the requirements stated by S. C. Cairns no reliable population estimates can be determined.

2. Cluster observation

In 2016, Cairns stated that an *"expected value of cluster size based on the relationship between observed cluster size and the estimated probability of detection (g(x)) was used to estimate density instead of the mean cluster size"* and in 2019 Cairns cites Buckland (2001) referring to the bias in using the mean size of clusters detected *"If larger clusters are more detectable at greater distances from the survey transect than are small clusters,* *then mean size of detected clusters will become a positively-biased (rather than an unbiased) estimator of expected cluster size".*

CONCERN: Raw count data should be used for population estimates as averages are affected by outliers (extreme values). As an insufficient number of wild horses were counted the mean size or an expected value should not have been applied as the minimum number of observations was not met to undertake reliable modelling.

3. Lack of precision

The coefficient of variation is a statistical measure which determines sampling variability associated with survey estimates. It involves using the average of the population estimates and the standard deviation (a measure of how the population estimates differ from the mean). The coefficient of variation is calculated by dividing the standard deviation of the population estimate by the mean and is expressed as a percentage. The higher the percentage the less accurate the precision.

Witczuk and Pagacz (2021) state that a coefficient of variation (CV) of 20% or less is a commonly acceptable level of precision for wildlife population estimates.

As can be seen from tables 7 through to 9 the level of precision as measured by the CV is greater than 20%:

- Table 7: 10/12 = 83% of the surveys do not meet the required precision
- Table 8: 6/10 = 60% of the surveys do not meet the required precision
- Table 9: 3/4 = 75% of the surveys do not meet the required precision
- Table 10: 1/4 = 25% of the surveys do not meet the required precision

Table 7. Results of the helicopter line transect surveys of feral horses conducted in the three Australian Alps survey blocks in April-May, 2014. Given for each block is the area of the strata surveyed, the density of clusters of horses sighted (D_s) and the horse population density (D). Given in association with the two density estimates are the empirically-estimated and bootstrap-estimated coefficients of variation (CV %), and the bootstrap confidence intervals.

Survey block/stratum	Area (km^2)	Cluster density (km^{-2})				Population density (km^{-2})			
		D_s	CV (%)	95% bootstrap confidence interval	CV_{boot} (%)	D	CV (%)	95% bootstrap confidence interval	CV_{boot} (%)
North Kosciuszko									
NK Open	618	1.31	29.1	0.55-3.65	55.2	3.45	30.6	1.73-6.44	46.0
NK Medium	748	0.47	37.7	0.17-1.67	64.8	1.50	38.3	0.67-2.97	63.7
NK Combined	1,366	0.85	27.9	0.43-1.86	55.7	2.38	28.7	1.35-4.32	43.7
Bago-Maragle	847	0.74	29.3	0.45-1.30	27.1	1.91	30.7	1.09-3.31	28.3
Byadbo-Victoria									
Byadbo	3,098	0.70	12.7	0.52-1.04	21.9	1.34	14.2	0.98-2.30	27.0
Snowy River Valley	139	0.80	45.5	0.25-1.50	39.6	1.29	47.9	0.33-2.29	43.2
BV Combined	3,237	0.71	-	0.52-1.03	21.0	1.33	-	1.00-2.26	26.2

Table 8. Results of the helicopter line transect surveys of feral horses conducted in the three Australian Alps survey blocks in April-May, 201 Given for each block is the area of the strata surveyed, the density of clusters of horses sighted (D_s) and the horse population density (D). Given in association with the two density estimates are the empirically-estimated and bootstrap-estimated coefficients of variation (CV %), an the bootstrap confidence intervals.

Survey block/stratum	Area (km^2)	Cluster density (km^{-2})				Population density (km^{-2})			
		D_s	CV (%)	95% bootstrap confidence interval	CV_{boot} (%)	D	CV (%)	95% bootstrap confidence interval	CV_{boot} (%)
North Kosciuszko									
NK Open	618	3.95	14.1	2.87-5.27	15.7	19.64	15.2	13.18-25.76	17.4
NK Medium	748	1.18	40.9	0.54-2.08	34.7	4.75	42.4	2.17-8.63	37.8
NK Combined	1,366	2.43	-	1.78-3.38	16.7	11.48	-	7.75-15.06	17.0
Bago-Maragle	847	0.64	32.5	0.31-1.061	31.3	1.31	35.7	0.65-3.14	40.8
Byadbo-Victoria									
Byadbo	3,098	1.31	13.0	1.01-1.78	14.1	2.68	14.1	2.00-3.97	18.0
Snowy River Valley	139	0.64	61.7	0.13-1.43	50.7	1.53	72.8	0.10-2.61	61.7
BV-SRV	3237	1.28	-	0.98-1.70	14.0	2.63	-	1.95-3.85	17.8

Table 9. The population estimates (N) and density estimates (D), adjusted for the area of the whole survey block, of feral horses in each of the three survey blocks in the Australian Alps in April-May 2014. Given with these estimates are the 95% bootstrap confidence intervals and the bootstrap coefficients of variation (CV_{boot}).

Survey block	Area (km^2)	N	95% bootstrap confidence interval	D (km^{-2})	95% bootstrap confidence interval	CV_{boot} (%)
North Kosciuszko						
NK Open		2,131	1,071-3,984			
NK Medium		1,124	413-2,728			
NK Combined	1,549	3,255	1,846-5,900	2.10	1.19-3.81	43.7
Bago-Maragle	948	1,616	782-2,574	1.70	0.82-2.72	28.3
Byadbo-Victoria						
Byadbo		4,150	3,043-7,111			
Snowy River Valley		166	46-318			
BV-SRV	4,946	4,316	3,316-6,577	0.87	0.67-1.33	26.2
Australian Alps	7,443	9,187		1.23		19.0

Table 10. The population estimates (N) and density estimates (D), adjusted for the area of the whole survey block, of feral horses in each of the three survey blocks in the Australian Alps in April-May 2019. Given with these estimates are the 95% bootstrap confidence intervals and the bootstrap coefficients of variation (CV_{boot}).

Survey block/stratum	Area (km^2)	N	95% bootstrap confidence interval	D	95% bootstrap confidence interval	CV_{boot} (%)
North Kosciuszko						
NK Open		12,139	8,416-15,918			
NK Medium		3,547	1,320-6,657			
NK Combined	1,549	15,687	10,598-20,569	10.13	6.84-13.38	17.0
Bago-Maragle	948	1,113	463-2,364	1.17	0.49-2.49	40.8
Byadbo-Victoria						
Byadbo		8,305	6,196-12,288			
Snowy River Valley		213	14-362			
BV-SRV	4,946	8,518	6,321-12,464	1.72	1.28-2.52	17.8
Australian Alps	7,443	25,318		3.40		12.3

These coefficients of variation are of statistical concern. There is even a case where the precision is more than three times above the acceptable level for wildlife monitoring (see Table 8 Snowy River Valley).

These concerns are also consistent with the kangaroo surveys conducted by Cairns et al. on the kangaroo management zone of the Northern Tablelands. It can be seen from the table below that 50% of the surveys had a coefficient of variation greater than 20% with one having more than double this value.

Table 2. Results of the helicopter line-transect surveys of eastern grey kangaroos conducted in the three Northern Tablelands kangaroo management zones

Given along with the areas of the two strata surveyed within each zone, are the survey efforts, the numbers of clusters of kangaroos sighted (n), the detection function models, the probabilities that a cluster of kangaroos is detected if it is in the covered region (P_a) and the estimated densities (±1 s.e.) along with their associated coefficients of variation (CV%). Where two detection function models are listed for a stratum, the data have been post-stratified by either observer (DB or PM) or side-of-aircraft in relation to the east–west direction of the survey transects (N = north, S = south)

Kangaroo management zone	Area (km^2)	Effort (km)	n	Model	P_a	Density (km^{-2})	CV (%)
Glen Innes							
High	4774	243.6	271	Uniform/cosine (N) Hazard-rate/cosine (S)	0.61 0.43	11.89 ± 1.49	12.5
Medium	12476	145.4	96	Half-normal/cosine	0.50	7.46 ± 2.62	35.2
Armidale							
High	9078	117.3	74	Half-normal/cosine	0.41	11.26 ± 4.05	36.0
Medium	5945	93.8	86	Uniform/polynomial	0.51	10.01 ± 1.64	16.4
Upper Hunter							
High	3552	194.0	121	Half-normal/cosine (DB) Half-normal/cosine (PM)	0.30 0.43	15.74 ± 3.09	19.6
Medium	4431	76.9	17	Half-normal /cosine	0.46	2.61 ± 1.21	46.3

Cairns (2019) discusses the concerns around the precision in the wild horse surveys and states that *"the overall levels of precision of future surveys could be improved by increasing the survey effort. This could be done either by increasing the number of transect lines across the survey area, something that would be possible in the Bago-Maragle block but perhaps not possible in the North Kosciusko block because of the* *already closeness of the transects of the current survey, or by repeat sampling of existing transect lines".*

The concerns continue in the 2022 wild horses survey conducted by Cairns where the coefficients of variation are higher than the accepted 20% in 50% of the density calculations (Table 5 below) and the population estimates (Table 6 below).

Table 5. Results of the helicopter line transect surveys of wild horses conducted in the four survey blocks in November, 2022. Given for each block is the number of clusters of horses detected (n), the estimated density of clusters of horses (D_c) and the horse population density (D) along with their 95% bootstrap confidence intervals and coefficients of variation (cv%). Note that there were no horses detected in the survey of the Cabramurra block.

Survey block	n	Cluster density (km^{-2})			Population density (km^{-2})		
		D_c	95% confidence interval	cv (%)	D	95% confidence interval	cv (%)
Northern Kosciuszko	288	2.38	1.75 – 3.02	13.5	10.39	7.63 – 13.20	14.0
Snowy Plains	47	1.19	0.66 – 1.95	27.9	4.38	2.13 – 7.59	32.3
Cabramurra	–	–	–	–	–	–	–
Southern Kosciuszko	84	1.15	0.72 – 1.68	29.5	4.66	2.60 – 7.32	26.7
Kosciuszko NP	419	1.66	1.32 – 2.04	11.4	7.03	5.42 – 8.80	12.4

Table 6. The population estimates (N) for each of the survey blocks. Given along with these estimates of abundance are their 95% bootstrap confidence intervals and coefficients of variation (CV %). Given also are the areas surveyed, including the total area of the four blocks.

Survey block	Area (km^2)	N	95% confidence interval	cv %
Northern Kosciuszko	1,229	12,774	9,379 – 16,862	14.0
Snowy Plain	161	705	343 – 1,222	32.3
Cabramurra	139	–	–	–
Southern Kosciuszko	1,146	5,335	2,979 – 8,384	26.7
Kosciuszko NP	2,675	18,814	14,501 – 23,535	12.4

CONCERN: When the coefficient of variation is unacceptable, the results of the survey should be suppressed.

4. Bias sample location

Cairns (2019) refers to bias sample location whereby the report states *"that the Open plains habitat, where horse density was highest (Table 8), could well be thought of as being preferred habitat for large grazing animals such as horses".*

CONCERN: Sample choices should be reflective of the entire population distribution zone with no selection bias applied when transect locations are determined.

5. **Use of line transects with respect to speed of wild horses**

In 2019 Owusu outlined how the use of line transects is not appropriate if the object is moving at roughly half the speed of the observer or faster. Cairns (2019) states that the helicopters were flown at speeds of 93km per hour however literature has shown the horses can run at least as fast as 64 km per hour (AMNH, 2023) which is well over half the speed of the helicopter.

CONCERN: The use of line transects is not appropriate methodology for estimating wild horse populations.

B. STATISTICAL MODELLING

1. **Statistical modelling for trends over time require a minimum of three time points**

When applying statistical modelling techniques that investigate population trends over time it is essential to have a minimum of three time periods (Curran et al., 2010) of data that are of similar time distance apart. For example, 2014, 2016 and 2018.

However, in Cairns (2019) only two time periods were used to apply complex statistical modelling techniques.

CONCERN: Given that insufficient time periods to model the population estimates of wild horses were used no reliable population estimates can be determined.

2. **Transformation of the data to apply the modelling techniques**

When applying statistical modelling techniques there are various assumptions that the data need to meet in order to apply the techniques. The main one used is for the data to be what is called "normal", that is the raw data follows a normal distribution. When the data does not adhere to this then it is common practice to apply a transformation to the data depending on the shape of the original data. Cairns (2019) states that the *"estimates of cluster density and population density were slightly positively skewed, indicating that the data were not normally distributed".*

In both the wild horse and kangaroo surveys the method of "log-transformation" is being applied. Although this method is very common it can only be applied to an actual value of 1 or more and not to the value of 0. So, if the observers see 0 animals then these raw counts of 0 cannot be included or an integer of 1 or more must be added to the 0 count. In Kangaroo counting raw data has shown that sightings of 0 kangaroos is more common than sightings of actual animals when considered along the entire flight line.

Curtis and McLeod (2021) state the following in their report:

A quota has been calculated based on the best red and grey kangaroo population models. Long-term population records (since 2001) are log-transformed to the normal scale before mean and standard deviation can be calculated. The upper and lower threshold values are then calculated and divided by KMZ area. This calculation is carried out within a normal distribution before a natural exponential function is used to back transform to the log-normal distribution once again to determine where estimated density sits in relation to these thresholds. The log-transformation is necessary to ensure that the calculation of the threshold is carried out using an appropriate distribution for the data. Failing to do so will allow biologically impossible values (such as negative abundances) and the calculated threshold values will be incorrect. Tables outlining estimated and threshold density values are included for red kangaroos (Table 9) and grey kangaroos (Table 11). A quota summary for red kangaroo is given in Table 10. The proportion of eastern grey kangaroos (EGK) and western grey kangaroos (WGK) in each management zone are given in Tables 12 & 13 respectively, in addition to quota. The ratios of EGK:WGK were determined from spotlight surveys of representative areas of each management zone (Cairns and Gilroy 2001).

CONCERN: If log-transformations are being applied to the raw counts, then all 0 counts will need to be increased and could significantly overestimate the population. Appropriate transformations should be applied that take into consideration 0 counts.

3. Use of covariates in the modelling

It is unclear throughout the report from Cairns (2019) as to what covariates were included and when. On page 19 it states that *"there is no capacity to include any covariates other than the perpendicular distance of a cluster of horses from the transect centreline in the modelling process"* yet on page 21 it states that *"The covariates used in these analyses were related to individual detections of clusters of horses and were identified as observer, cloud cover score and habitat cover at point-of-detection. All these covariates were categorical. There were three observers (DS, MS and SS), three grades of cloud cover (1 = clear to light, 2 = medium, 3 = overcast to dull) and two categories of habitat cover at point-of-detection (1 = open, 2 = timbered), indicating that horses were either sighted in the open or in timbered habitat. The three covariates were included in the analysis either singly or in pairs".*

In 2022, the report outlines that *"The inclusion of a covariate such as observer in the model has the effect of altering the scale of the detection function, but not its general form (Marques & 18 Buckland 2004). The probability of detecting an object (cluster of horses) in the nominal survey strip therefore differs between observers".*

This confusion in the reporting is also present in the kangaroo management report by Cairns et al. (2016) where it outlines that *"there were only three covariates, namely observer, habitat cover at point-of-detection and cloud cover".* However, in Glen Innes and the Upper Hunter only the covariate "observer" was included yet in Armidale no covariates were included in the modelling. All modelling should take into consideration any covariates which may predict / interact with the outcome.

CONCERN: Determining what covariates were included and what impact they had on the accuracy of the models cannot be determined from the reports given the conflicting information provided and therefore the generalisability of the results across the entire four blocks should be interpreted with caution.

4. Assumptions

In Cairns (2019) an implicit assumption is given that *"the horse population in a block would be aggregated in its distribution and that the density of horses in the very steep country within the survey blocks would be at trace levels; i.e. near to zero. This assumption could be open to challenge, but could only be refuted with comparable survey results".*

CONCERN: The report itself raises the concern that this assumption is open to challenge and without comparable survey results there is no way of knowing if this assumption had a significant impact on the modelling and subsequent population estimates.

5. Grouping of the zones together for modelling

In both the 2019 and 2022 reports the populations across the blocks are merged with a global detection function model applied and a single estimate determined. However, it is clearly evident from the report that the blocks provide significant differences in the wild horse counts along with the sizes and expected detection being different.

The size and survey effort of the blocks is considerably different as is the number of samplers which range from 26 to 188 (see table 2 below from 2019 and Table 1 below from 2022).

CONCERN: Independent modelling of the four blocks should be undertaken and no overall population estimate reported.

Table 2. The total survey effort and the number of samplers (transects) for each of the realised survey designs conducted in 2014 and repeated in 2019. Given in association with these values are the areas of the respective survey strata and the totals for all entries.

Survey block	Area (km^2)	2014 Survey effort (km)	2014 No. of samplers	2019 Survey effort (km)	2019 No. of samplers
North Kosciuszko	1,366				
Open habitat	618	403.9	27	403.6	32
Medium terrain habitat	748	267.5	26	256.2	29
Bago-Maragle	847	409.1	30	408.9	30
Byadbo-Victoria	3,237				
Medium terrain habitat	3,098	1,588.0	188	1,544.2	188
Snowy River Valley	139	86.5	42	77.1	42
Survey totals	5,420	2,755.0	313	2,690.0	321

Table 1. The target level of precision, the number of transects and the total survey effort for each of the realised survey designs. Given along with these values are the areas of the survey blocks and the reference surveys used to determine the required survey effort using the method given in Buckland *et al.* (2001).

Survey block	Area (km^2)	Target precision (%)	No. of transects	Survey effort (km)	Reference survey
Northern Kosciuszko	1,299	20.0	34	663	KNP (2020b)*
Snowy Plain	161	40.0	23	232	AALC (2019)**
Cabramurra	139	25.0	34	157	AALC (2019)**
Southern Kosciuszko	1,146	20.0	25	444	AALC (2019)**

*Cairns (2020b)
**Cairns (2019b)

6. No increase in the overall population over the last 2 surveys

From 2020 to 2022 there was no statistically significant increase (p=0.289) in the wild horse population. Even in the largest zone *"the population in the Northern Kosciuszko block had remained essentially unchanged over the last two years; being estimated to be 12,511 (7,111-20,761) in 2020 and 12,774 (9,379-16,862) in 2022 (z = 0.07; P = 0.944)"*

Note: Cairns (2022) states that *"there was no significant change in the total population. This is likely due to the dominance of the large population in the Northern Kosciuszko block as a component of the total population in both 2020 and 2022"*

CONCERN: There is no statistical evidence of a population increase and therefore population management should be undertaken.

7. Implausible population estimates

In 2019 the overall number of wild horses seen in North Kosciuszko was 1374 yet the population estimate was 15,687 which is over 1000% higher than the original count.

(This is also evident in kangaroo population estimates where only 508 animals were sighted yet a population estimate of 296,555 was reported as seen in Cairns et al. (2019) and the 2021 Quota report.)

CONCERN: As mentioned previously the modelling techniques being applied to the raw counts are of serious concern and the population estimates determined from these models are therefore unreliable.

8. Width of the confidence intervals

One way to understand confidence intervals is to imagine that if a survey was performed 100 times and a 95% confidence interval calculated each time, then 95% of those computed confidence intervals would contain the population parameter. They do not provide the actual population value. Narrow confidence intervals (ie. Closest to 100%) indicate greater precision - wider intervals (furthest from 100%) indicate less precision (Trafimow, 2018).

The width of the the confidence intervals for 2022, 18,814 (95% CI 14,501-23,535) was a concerning 46%. A confidence interval this wide suggests that the sample from the survey does not provide a precise representation of the population mean (Bonham, 1989).

CONCERN: Given the lack of precision obtained from the surveys and the extremely wide confidence intervals the population estimates are unreliable.

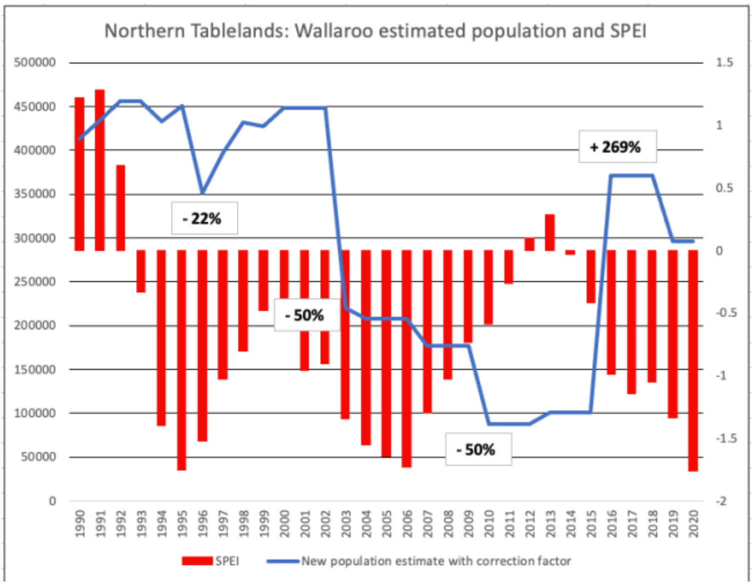
C. ANIMAL SPECIFIC CONCERNS

1. **Implausible population increases**

The concerns surrounding implausible population increases are evident in both the kangaroos and wild horse population estimates provided by Cairns. In the 2019 report it states that *"a particularly high annual finite rate of increase of 1.370 (i.e. 37%)"* was evident, and *"the annual population growth rates for wild horse populations are often reported to be in the range 10-22%".*

The references given to justify these population increases in the report were not from Australia but rather from Argentina and France.

These significant population increases are also evident in the kangaroo where the population of Wallaroos was said to have increased at 90% per year even during times of drought.



The red kangaroo was also said to have had an implausible population increase of 265% in one year in the Lower Darling kangaroo harvest management zone of NSW.

CONCERN: As mentioned previously the modelling techniques being applied to the raw counts are of serious concern and the population estimates determined from these models are unreliable.

2. Movement of horses

The zones are not closed areas and therefore movement is possible. Without specific photographic / video evidence of wild horses the possibility of double counting cannot be eliminated. Cairns (2019) outlines that population increases between surveys could have been attributed to *"substantial movement of horses into it from outside the survey area over the period between the two surveys".*

CONCERN: As mentioned previously, the statistical concerns surrounding the methodology of obtaining the raw counts is questionable and without photographic evidence of all horses at the same point in time a true count cannot be determined.

3. Foals and Joeys

The reports for both wild horse counts and kangaroos conducted by Cairns make no distinction or provide any counts of the number of foals or joeys in the surveys.

CONCERN: The impact of these animals and subsequent death of these animals if the mother is killed influences the population over time and therefore should be taken into consideration.

Independent statistical investigations into wild horse populations and management plans should be urgently undertaken.

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