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Manatū Ahu Matua

Splitting Emissions Intensity Values between Venison and Velvet Antler in the Deer Industry

Methodology for assigning animals in the deer industry to the production of venison or velvet antler

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David Stevens and Jamie Ward

31 October 2023

Report for Ministry for Primary Industries

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Contents

1. Executive Summary

This document provides a methodology to split the national deer herd between the enterprises of venison and velvet antler production to provide a mechanism to develop appropriate Emissions Intensity Values (EiV) to be applied to venison and velvet antler as two separate products. Once the national herd is assigned to the primary purpose of either venison or velvet antler production, the emissions intensity values for venison and velvet antler can then be calculated.

The methodology has been tested against available data sets to provide confidence that the outcomes are robust and reflect the current industry. The methodology has provided sensible results when compared with those estimates.

The methodology reflects the rapid shift in production enterprises that have been recorded in velvet antler and venison production, using data from 2015 to 2022. This suggests a shift in emissions allocation from approximately 79:21 to 63:37 for the venison and velvet antler enterprises respectively, over that timeframe.

Initial estimates of emission intensity values for venison demonstrate a reduction of EiV from the current value of 35.14 to 24.55 (compared to sheep at 22.4) kg CO2 equivalents/kg product. Estimates for velvet antler varied depending on which production database was used. The use of Statistics NZ data would result in an EiV of 350 while use of the Deer Industry NZ data would result in a value of 232 kg CO2 eq/kg product. These estimates have used proxy values of intake for calculation to indicate the relative difference, rather than full inventory calculations, therefore final values calculated using the full AIM methodology will vary slightly from these results.

During the examination of data three areas of potential concern have arisen. The first is the calculation of an EIV for velvet antler based on Statistics NZ data. Currently there appears to be significant under-reporting of velvet antler harvest, such that the EiV calculated from this data set would be approximately 1.8 times greater than the Deer Industry statistics, taken from levy payment, would indicate. Levy take data should replace Statistics NZ data for this metric.

The mature size of hinds appears to be too high in the AIM model. Estimates of mean carcass weight data from the DeerPro slaughter statistics suggest that a mature weight of 110 kg should replace the 140 kg estimate currently used in AIM. This would see a reduction in maintenance feeding of approximately 18% and would materially affect the emissions calculation.

Both hinds and stags reach peak mature liveweight between 3.5 and 4 years of age, being 1.5-2 and 0.5-1 year later than currently calculated, respectively. This may translate into a reduction in maintenance requirement of approximately 2% for hinds and 3% for stags. Again, this data provides the opportunity to improve the precision of the current AIM model, though this should be tested within the model to accurately assess the material impact.

2. Recommendations

1. **That MPI considers instituting a population model that splits emissions between venison and velvet antler production.**

The evidence provided here, and in Stevens & Ward 2023 a, b and c, demonstrates that a methodology can be applied to current population statistics provided by Statistics NZ to MPI to calculate populations of deer primarily dedicated to the production of venison or velvet antler. This methodology will provide the ability to assign greenhouse gas emissions to either enterprise and calculate an emissions intensity value for each enterprise as required in the future. A full set of equations to implement this split are provided, along with a spreadsheet for consideration.

2. **That MPI considers using the Deer Industry record of velvet antler production, rather than the Statistics NZ Agricultural Survey data for velvet antler production.**

The evidence produced by Stevens & Ward 2023 b demonstrated that the Deer Industry levy take information was a more accurate record that would improve the precision of the AIM calculations.

3. **That MPI considers updating the values used for hind liveweight in the AIM calculations as the predictions of increasing hind size, provided by Suttie 2012 have not eventuated.**

Examination of the carcase weight and age statistics collected by Deer Pro (a Deer Industry NZ subsidiary) demonstrated that hind live weight has remained at approximately 110 kg (Stevens & Ward 2023c) leading to an over-estimate of hind feed requirements by approximately 18%, materially altering GHG predictions for deer.

4. **That MPI considers adding a further slaughter date for stags to reflect the significant supply of stags after their second birthday at 25 months of age.**

Examination of slaughter profiles and ages supplied by Deer Pro (a Deer Industry NZ subsidiary) demonstrated that, while current slaughter dates for stags 1-2 years of age occurs at approximately 12 months of age, there is a significant cohort (approximately 25%) that are held for evaluation of velvet antler production potential of which approximately 40% are slaughtered at 25 months of age. This would improve the precision of current calculations.

5. **That MPI considers replacing the Suttie (2012) methodology to assign animals to age cohorts with direct calculations from the Statistics NZ data supplied.**

The Methodology provided here indicates that direct calculation of animals entering each age cohort can be done from the current data supplied by Statistics NZ. Consideration to the potential fluctuations in numbers between years would need to be given to ensure that the values were robust when calculating the aging of animals between classes.

3. Background

3.1 The New Zealand Deer Industry

The New Zealand deer industry, established in 1970, has developed with both venison and velvet antler as product streams. As the industry expanded venison production increased, peaking in 2005 at approximately 42,000 t/annum. At this time velvet antler production had stabilised at approximately 450-500 t/annum and represented approximately 10% of industry receipts. The total deer herd was estimated at approximately 1,750,000 head and it was estimated that approximately 1% of the deer population were stags specifically used for velvet antler production. Much of the velvet antler production was a by-product of antler removal from the breeding sires (approximately 8% of the population).

In 2012, a report was commissioned to review the population and productivity of the deer industry (Suttie 2012). This review updated and verified statistics used in the national Agricultural Inventory Methodology (AIM) inventory calculations. This review (Suttie 2012) identified a problem of lack of specificity in the data collected by Statistics NZ and proposed a methodology to assign animals to the required age classes within AIM to enable calculations to be completed. This methodology was based on historical trends within the deer industry. At that time the venison value chain had dominated production, with velvet antler being a byproduct of the breeding stag population used for venison production.

3.2 Changing dynamics of production

A shifting dynamic in the value and stability of markets since 2012 has resulted in a significant shift in both production and relative contributions of the deer herd to each product. Shocks from the Global Financial crisis and then Covid-19 have driven the production of venison down to approximately 16,000 t/annum. The development of new markets has seen the increase in velvet antler production to greater than 1000 t/annum, by Deer Industry NZ estimates.

This means that a significant part of the deer herd now directly supports only velvet antler production. Most recent estimates of population suggest that 16% are velveting stags. This then infers that a significant proportion of the female herd are also specifically retained for producing those stags. This then means that the methodology developed by Suttie (2012) and implemented with AIM, is no longer fit for purpose.

Rebalancing this change in population dynamics is crucial to ensuring equity when allocating GHG emissions to appropriate product streams.

3.3 Emissions Intensity Values (EiV)

Current deer industry Emissions Intensity Values attribute all GHG emissions to venison production. The growth of velvet antler from 10% to greater than 40% of the industry receipts has led to a significant proportion of the deer herd directly supporting that industry, rather than contributing to venison production. Population statistics suggest that between 25 and 35% of the current deer population now directly supports the velvet antler industry. This has led to an inflated EiV for venison, as this single product carries all the emissions

from the deer industry, while only attributing 60% of the revenue. It also misaligns the EiV for venison from other red meats, potentially causing unintended consequences of shifts in livestock enterprise if costing of GHG become based on the EiV calculations.

3.4 Final Methodology

Three previous reports (Stevens and Ward 2023 a, b, c) have been used to develop the thinking, methodology and evidence to provide confidence of separating the national deer herd into populations that support venison or velvet antler production.

This report documents the full methodology to calculate those populations and demonstrates the potential allocation of emissions to venison and velvet antler enterprises. A spreadsheet is provided to assist in implementing the equations which are documented in Section 5.

4. Current evidence

4.1 Population Statistics

Population statistics, collected by Statistics NZ (Table 1) provide some insight into the shift in production focus between venison and velvet antler. Non-breeding stag numbers have increased steadily since 2012, increasing by nearly 50% over that time. An associated reduction in hind numbers, down by approximately 30% indicates that there has been a significant shift in GHG emissions from venison to velvet antler production enterprises over that time.

Table 1. Population statistics provided by Statistics NZ to MPI for GHG calculations for the deer industry.

	deer females mated 2 years and over	deer females mated over 1 year but under 2 years	deer females NOT mated 2 years and over	deer females NOT mated over 1 year but under 2 years	deer females under 1 year old (include fawns still on the farm)	deer males under 1 year old (include fawns still on the farm)	non-breeding males 2 years and over	non-breeding males over 1 year but under 2 years	breeding males 2 years old and over	breeding males over 1 year but under 2 years
2011										
2012	441348	76306	14868	20746	192963	184800	68974	36051	18924	5714
2013	420731	77223	8325	18548	181954	186485	74021	38560	18446	4090
2014	396495	71477	8825	26697	165133	164881	63208	38424	17898	5181
2015	357519	72981	6746	20671	153271	150916	81310	37607	14094	4983
2016	337599	68259	6375	15786	139922	138869	77110	31607	15838	3243
2017	327770	66652	5211	13344	142427	143624	88232	30970	17274	5244
2018	324195	77569	4308	12239	137389	147617	92562	32994	17748	6515
2019	313685	64907	3016	10254	131747	136922	100373	29024	16218	4297
2020	308868	65202	6268	11255	142538	142493	103009	34232	15717	3676
2021	299106	61567	6752	12650	132295	140983	107281	34874	14165	4307

4.2 Velvet antler production

Statistics NZ uses the Agricultural Production Survey to collect velvet antler production, recording the same metric as the Deer Industry, green weight of harvested velvet antler, summed to tonnes/annum. The figures collected by each method are reported in Figure 1.

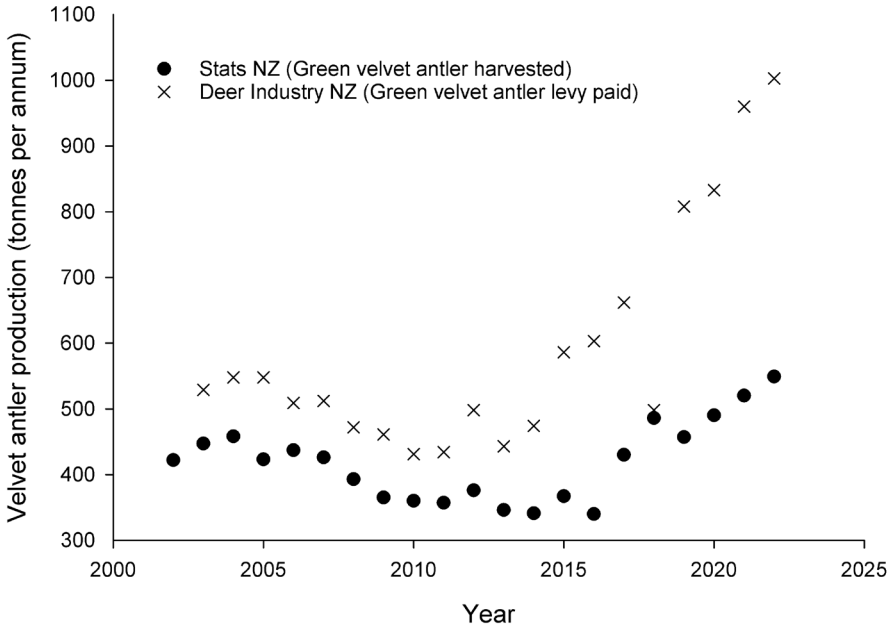

Figure 1: *Estimates of velvet antler production from the Statistics NZ Agricultural Production Survey or the Deer Industry NZ levy paid register for the period 2002 to 2022.*

The velvet antler industry has flourished in recent years, because of low venison prices and the creation of new velvet value chains using the successful integration of marketing and science (Stevens et al. 2020). While some of this increase has been captured by the Statistics NZ Agricultural Production Survey[1] (Figure 1), it is well short of the gains captured by the Deer Industry NZ levy income (Figure 1). The Deer Industry NZ estimates are a direct reflection of the amount of velvet antler produced and sold within any single year, as farmers pay the levy at point of sale to wholesalers. There is a single anomaly in this data set where levy collection of the 2017/18/19 years saw in some transfer between years, resulting in an unusually low estimate of

[1] Source: Statistics New Zealand, Agricultural Production Survey. Table reference: AGR001AA; Last updated: Velvet antler harvested green weight in kg (during year ended 30 June): 22 May 2023 10:45am:

production in 2018. The Statistics NZ data come from voluntary reporting by farmers and have exhibited a consistent differential of approximately 90 t/annum until 2014. Since 2014 this gap has opened significantly, by approximately 33 t/annum (R^2=0.95) to now be a difference in reported tonnage of approximately 450 t/annum. Using the logic that farmers will only pay a levy on a product harvested, the Deer Industry NZ data is the most accurate representation of the productivity of velvet antler enterprises.

4.3 Slaughter statistics and liveweight

Deer Pro, a subsidiary of Deer Industry NZ, has collected slaughter statistics across the industry since 2018. The database has matched slaughter data with NAIT electronic identification data to provide a profile of age at slaughter alongside carcase weight. This data was used to develop an age profile at slaughter, and to identify the current carcase weight, and by calculation the current liveweight of deer across their lifetime.

4.3.1 Stag slaughter profiles

The pattern of slaughter statistics from 2018-2022 (Figure 2), derived from the Deer Pro dataset, demonstrates the profile of slaughter age (from birth). We clearly see a differentiation in slaughter numbers for the over-1-but-under-2-years-of-age class entering the venison enterprise and the later slaughter of over-2-year-olds being culled as they enter the velvet antler production system. This differentiation is categorised in the Statistics NZ data set due to the reporting date being at the equivalent of 20 months of age for the over-1-but-under-2-year-old category.

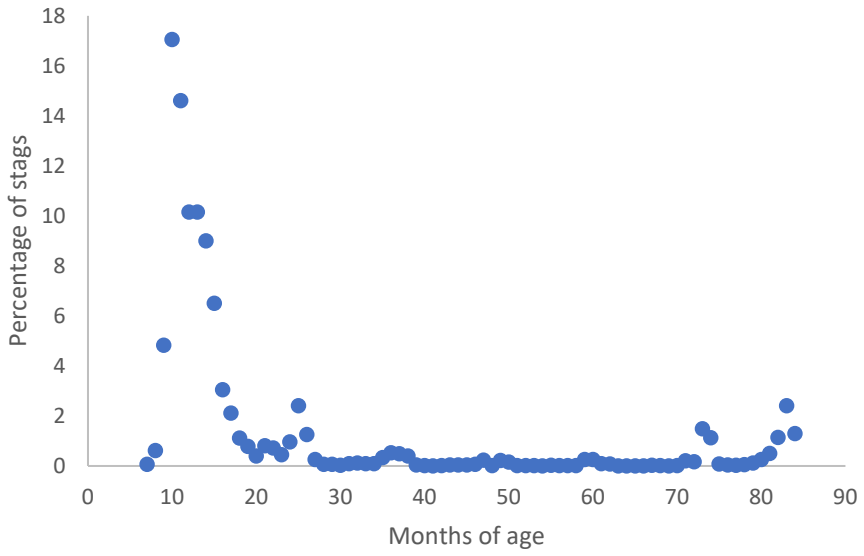

***Figure 2**: Proportion of stags slaughtered by months of age from the Deer Pro data set. Data of seven-years-of-age and greater pooled in the periods 79-84 months.*

Further analysis of the data for stags over 4 years of age (48 months) indicates that the average slaughter age of mixed age stags is approximately 7 years of age. This translates into a net replacement rate, after the initial selection at 24 months of age, of approximately 14%.

4.3.2 Hind and Stag liveweights derived from slaughter statistics.

Analysis of the Deer Pro data sets collected from industry was used firstly to develop the profile of age at slaughter (example in Figure 2) and then to estimate liveweight across the lifetime of the animal, to provide information regarding current mature liveweights of both hinds and stags. Carcase weight is converted to liveweight using a dress-out of 55% as per AIM calculations.

Stag carcase and liveweight

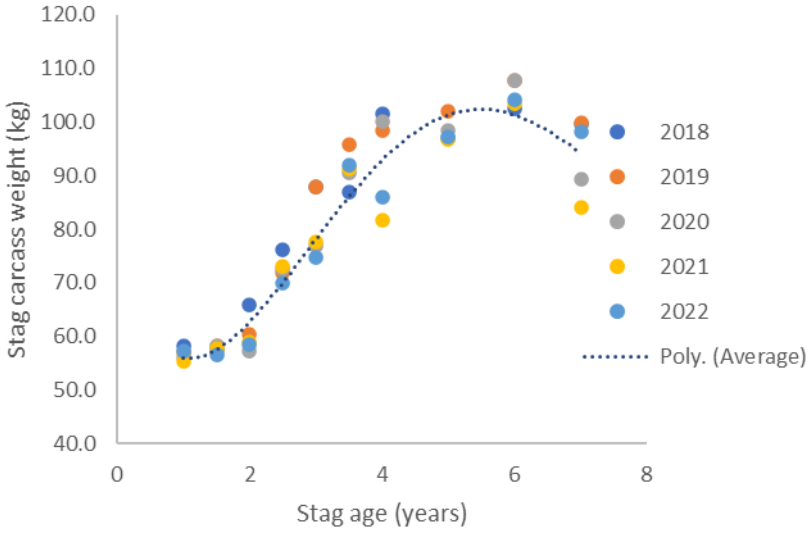

***Figure 3**: Carcase weight of stags slaughtered by age from the Deer Pro data set. Data of seven-years-of-age and greater pooled in the periods 79-84 months.*

The carcase weight profile of stags as they age (Figure 3) demonstrates that stags are approaching their mature liveweight from approximately 3.5 years-of-age. Average liveweight of mixed age stags is approximately 175 kg (Appendix 8.1)

Hind carcase and liveweight

The carcase weight profile of hinds as they age (Figure 4) indicates that hinds have reached mature weight by between 3 and 4 years-of-age. This is later that the AIM methodology which is at 772 days-of-age or approximately 2 years-of-age.

Average live weight of mixed age hinds is approximately 110 kg (Appendix 8.2). This is lower than the 142 kg currently calculated in the AIM methodology and materially impacts on the calculations for both liveweight gain to mature liveweight and the maintenance requirements during the hind's lifetime.

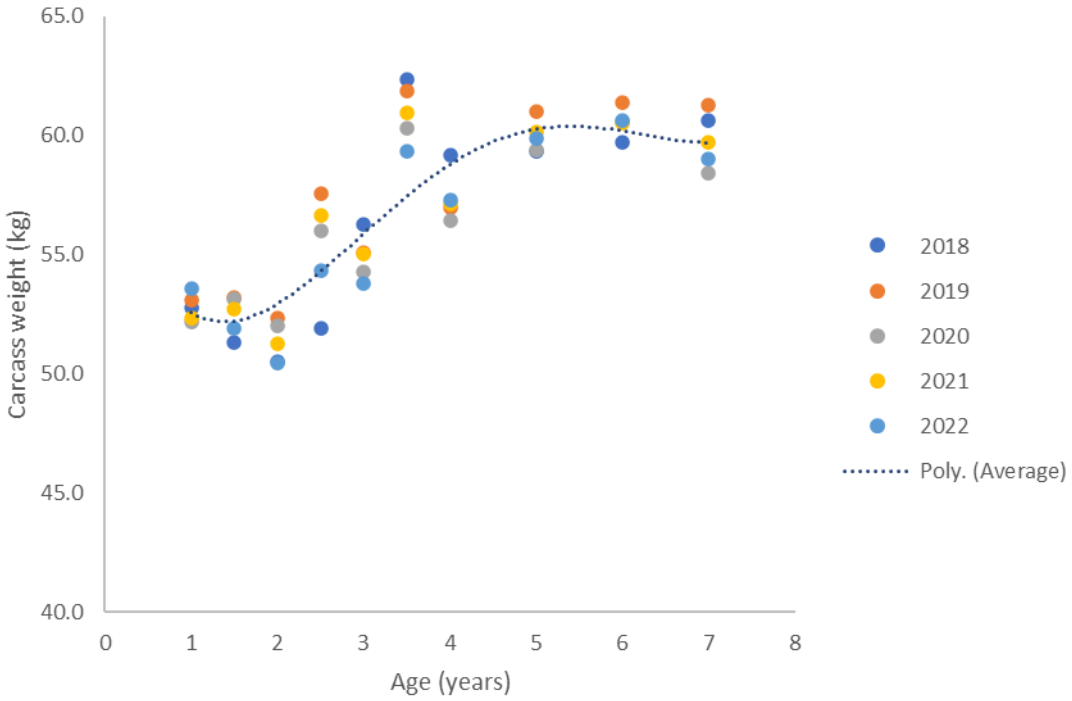

***Figure 4**: Carcase weight of hinds slaughtered by age from the Deer Pro data set. Data of seven-years-of-age and greater pooled in the periods 79-84 months.*

5. Methodology

This report proposes a methodology to separate the national deer population into populations primarily supporting, or supplying, the venison value chain or the velvet antler value chain. Once the populations are identified, then emissions intensity values can be assigned to the primary product from those value chains. The underlying principle applied here is that, while all animals, barring deaths, finally enter the venison value chain, there is a significant cohort of the population whose primary purpose is to generate velvet antler, rather than venison. Thus, the principle of primary purpose is then applied to all the emissions that are generated by the animal population associated with that value chain.

The methodology described here uses the Statistics New Zealand Agricultural Survey results which are provided to MPI for calculation to assign animals in the national deer herd to the value chains of either venison or velvet antler. These statistics are collected each year and describe the national herd on 30 June. The categories collected, that are used in this methodology, are presented in Table 2. Extra categories represented here, and not in Table 1, are Fawns (lc7696), which enables reproductive success to be calculated, Velvet (lc7640) and total deer (lc7699).

Table 2: *Statistics NZ Deer Population categories reported to MPI at 30 June each year.*

Code	lc7696	lc7640	lc7600	lc7605	lc7610	lc7615	lc7618	lc7630	lc7620	lc7625	lc7645	lc7648	lc7699
Descriptor	Fawns born on farm and alive at four months	Velvet (all grades) removed (green weight kg)	Deer females mated 2 years and over	Deer females mated over 1 year but under 2 years	Deer females NOT mated 2 years and over	Deer females NOT mated over 1 year but under 2 years	Deer females under 1 year old (include fawns still on the farm)	Deer males under 1 year old (include fawns still on the farm)	Deer non-breeding males 2 years and over	Deer non-breeding males over 1 year but under 2 years	Deer breeding males 2 years old and over	Deer breeding males over 1 year but under 2 years	TOTAL deer

5.1.1 Current methodology (AIM version 8, MPI 2022)

"The July populations of these different classes are calculated by multiplying the total deer population from the agricultural production census by proportions specified in appendix 15. 2–3-year-old stags have an additional adjustment in July to account for two slaughter dates in the same year.

The proportions in appendix 15 for the years from 1990-2011 were specified in the report by Suttie (2012). Population data directly from the APS is used to calculate the proportions for 2012 onwards. Table 3 shows the line codes that are used for each class. The populations of these line codes are divided by the total deer population (line code 7699) to calculate the proportion for each class. The proportions for 2–3-year-old stags and the mixed age breeding stags are calculated using equations 3.81 and 3.82, which follows the methodology outlined by Suttie (2012)." (MPI 2022; pg 42)

***Table 3**: Table 3.1 from AIM version 8, MPI 2022: Line codes used to calculate deer proportions in the inventory, creating those proportions based on the total deer population reported, as lc7699.*

	Deer class	Linecodes used to calculate proportions	Calculation
1	Hind 0-1 years old	lc7618	
2	Hind 1-2 years old	lc7605 + lc7615	
3	Hind Mixed age/breeding	lc7600 + lc7610	
4	Stag 0-1 years old	lc7630	
5	Stag 1-2 years old	lc7625	
6	Stag 2-3 years old	lc7620+lc7645+lc7648	$\mathrm{P}ds3jul(t)$ = 1/8 × (($POPlc7620(t)$ + $POPlc7645(t)$ + $POPlc7648(t)$) / $POPdeer(t)$)
7	Stag Mixed age/breeding	lc7620+lc7645+lc7648	$Pdsmajul(t)$ = 7/8 × (($POPlc7620(t)$ + $POPlc7645(t)$ + $POPlc7648(t)$) / $POPdeer(t)$)

The current Inventory calculations uses a formula to calculate the proportions of animals assigned to each class. The Inventory uses the Statistics NZ Agricultural Survey results and converts these into proportions of the total population. These values are then used to re-calculate populations in each class. This recalculation may remove the propensity for

negative numbers, if reporting varies from year to year, especially when calculating between year changes. If this is the case, then continued application of this approach may need to be applied to the new methodology.

Calculations specific to changing the assignment of animals to velvet antler and venison enterprises are for categories 6 and 7, which are used to split stags between the two categories. The addition of lc7648 to this calculation may no longer be needed. The proportional split that is currently used will be explored to examine its suitability for the proposed methodology.

5.2 Category Descriptors

These category descriptors provide information about the age of each cohort. Fawns are born in November, and so each age class can be referenced back to this birth date. As each cohort is a recording of animals at that date the number accounts for death rates in the previous 12 months.

Total Population (lc7699) = Total Male + Total Female: used to develop proportional representation of the other classes.

Fawns born (lc7696) = fawns surviving to 15 March (approximately 4 months of age): can be used to estimate hind reproductive rate.

Hind 0-1 years old (lc7618) = Hinds approximately 8 months of age: these hinds will be destined for slaughter or entry into the replacement herd for either venison or velvet antler.

Hind 1-2 years old (lc7605 +lc7615) = Hinds approximately 20 months of age which may be bred (lc7605) or unbred (lc7615): bred hinds (lc7605) can contribute to either the velvet antler or venison herd replacement hind numbers. Unbred hinds will usually be slaughtered in the following spring.

Hinds mixed age/breeding (lc7600 + lc7610) = all hinds over 2 years-of-age in the reporting year: can be used to estimate hind reproductive rate.

Stag 0-1 years old (lc7630) = Stags approximately 8 months of age: these stags will be destined for slaughter, entry into the velvet antler selection process, or as venison sire replacements.

Stag 1-2 years old (lc7625) = Stags of approximately 20 months of age remaining unsold: these stags will be destined for entry into the velvet antler selection process, or as sires for venison production.

Stag 2-3 years old (to be calculated) = Stags of approximately 32 months of age: these stags will be velvet antler stags or sires for venison production.

Stag Mixed age/breeding (to be calculated) = Stags greater than 44 months of age: these stags will be either velvet antler stags or venison sire stags.

The age of each cohort and its origin are important in defining the progression of cohorts and the contributions to the venison or velvet antler value chains.

5.3 Overall methodology

The methodology relies on the transfer of animals between age cohorts, and the seasonal nature of the growth and subsequent venison slaughter of animals to estimate the numbers of deer assigned to the venison and velvet antler value chains.

The methodology works because the classes are reported at 30 June each year. This means that animals in each category, except for the split between classes 6 and 7 (older stags), can be classified by age, because birth date is strongly seasonal and cannot be altered in red deer. Secondly, stags destined for the venison value chain are slaughtered under 20 months of age. Thus, any stags reported as being in the 1–2-year-old category (lc7625; Deer non-breeding males over 1 year but under 2 years) are by definition 20 months of age and so can be classified as entering the velvet antler selection process. Under the current methodology breeding stags in the 1–2-year-old category (lc7648) are currently added to categories 6 and 7. These stags can be removed from those categories and put into a new category to represent over 1 but under 2 years of age that are retained for breeding in either the venison or velvet antler enterprise.

The methodology progresses in stages:

- The number of young stags entering the velvet antler herd is regarded as known (lc7625).
- The number of young stags 0-1 years of age needed to be retained as replacements for the velvet antler herd (a proportion of lc7630) is calculated.
- The number of young stags available for slaughter (a proportion of lc7630) is calculated.
- The number of hinds needed to produce stags entering the velvet antler herd is calculated.
- The number of hinds needed to provide replacement hinds for the velvet antler hind herd is calculated.
    - By difference the number of hinds producing fawns for the venison value chain is calculated.
- The number of young hinds (Hinds 0-1) needed to be retained as replacements for both the venison and velvet antler breeding herds is calculated.
- The number of stags needed to service the venison and velvet antler hind herds are calculated.
    - By difference the number of stags in the dedicated velvet antler herd are calculated.

5.3.1 Estimating young stag numbers entering the velvet antler herd and venison value chain

The Statistics NZ values provided for the 1–2-year-old category (lc7625; Deer non-breeding males over 1 year but under 2 years) can be classified as entering the velvet antler selection process. This is defined as those stags which are taken to at least 24 months of age for velveting, when an assessment of suitability for long-term velvet antler production is made. Calculating the number of stags required to get to the point of selection is required to enable the calculation of the number of hinds that are needed to support the production of

that cohort, thus the number of hinds that are directly engaged in servicing the velvet antler herd.

Data from the DeerPro dataset (Stevens and Ward 2023, Figure 2) identifies this clear distinction between stags bred for venison production and those slaughtered after evaluation for velvet antler production potential. This data also indicated that approximately 40% of those stags taken to that point are then slaughtered at an age of approximately 25 months of age and a mean slaughter date of mid-December. As previously noted, the category lc7625 (deer non-breeding males over 1 but under 2 years) represents the group that are grown on for this purpose. A new slaughter category should be considered to account for this practice.

Equation 1: 1–2-year-old Stags entering the Velvet Antler herd = lc7625

By calculation Stags under 1 year of age that have been bred for velvet antler production can also be calculated from the category lc7630 (Deer males under 1 year old (include fawns still on the farm)) by the following equation:

Equation 2: Velvet antler Stags under 1-year-of-age = lc7625/0.98

Where 0.98=1-death rate of 1–2-year-old stags.

Equation 3 Venison stags under 1-year-of age = lc7630-Equation 2

These stags are available for slaughter before 20 months of age.

5.3.2 Calculating the number of hinds required to provide the velvet antler stags

The number of hinds required to produce velvet antler stags is divided into several parts. Firstly, the number of hinds to directly provide stags is calculated, then the number of hinds required to produce replacement hinds is calculated. These numbers are adjusted to include the future death rates of fawns as they age through the process, using the standard death rates reported in the AIM calculations. The number of hinds is also adjusted for the current reproductive success of the national herd. This methodology assumes that hinds in class lc7610, deer females not mated 2 years and over, should be considered part of the breeding herd and therefore included in calculation of reproductive success and breeding stag requirements. This allows that class to be equally represented in allocation to venison or velvet antler enterprises.

Equation 4: Velvet antler Hinds mated for stag replacements = Stags kept for replacement / Reproductive success[3]/(1-stag death rate up to 2 year old)[4]

[3] Reproductive success = Fawns born lc7696 (n) / Hinds mated lc7600 + lc7610 +lc7605 (n-1)

Where n= current year

Equation 5: Velvet antler hinds mated to breed replacement hinds for the velvet antler herd = Velvet antler hinds (Equation 4) *Hind replacement rate[5]/(1- hind death rate up to 2 year old)[4]/Reproductive success

[4] Note that reproductive success, by using the number of hinds mated and the number of fawns recorded at June 30 (lc7696), already includes death rate in the first 8 months of life. Therefore, no adjustment is made for death rate of stags or hinds in the first year of life.

[5] Replacement rate estimated to be 20% of mixed age hinds or 0.2 in these calculations, as estimated by expert opinion.

Equation 6: Velvet antler hinds mated to generate replacements for the replacement hind herd = Velvet antler hinds mated for hind replacements (Equation 5) * Hind replacement rate/(1- hind death rate up to 2 year old)/Reproductive success

Equations 5 and 6 can be combined as the replacements rate of 20% can be applied to both, resulting in a combined replacement rate of 24%, or [6]0.24 in the replacement equation, **Equation 7**

Equation 7: Velvet antler hinds mated for replacements **=** Velvet antler hinds (Equation 4) *Hind replacement rate[6]/(1- hind death rate up to 2 year old)[4]/Reproductive success

All hinds required are added together.

Equation 8: Total velvet antler hinds required = Equation 4 + Equation 7

The number of mated hinds can be reallocated to age categories.

Equation 9: Velvet antler herd Deer females over 2 (part of lc7600); Hind mixed age breeding) = Equation 8 * ((lc7600+lc7610)/(lc7600+lc7605+lc7610))

Equation 10: Velvet antler herd deer females 1-2 years old mated (part of lc7605) = Equation 8 * (lc7605/(lc7600+lc7605+lc7610))

Hind fawns also need to be allocated as future replacements for the velvet antler hind herd, from the Hinds aged 0-1 category.

Equation 11: Replacement female fawns required for the velvet antler hind herd = Equation 10 / (1- death rate up to 2-year-old)

This sets aside an appropriate number of hind fawns (as 8-month-olds at June 30; lc7618) to enter the velvet antler hind herd as rising 2-year-olds, again noting that the death rate of up to 1-year-olds is already counted in the Statistics NZ data, as per note 4.

5.3.3 Hinds required for the venison herd

The number of deer females over 2 now remaining to produce venison is calculated by difference.

Equation 12: Venison hinds over 2 years old = (lc7600+lc7610) – Equation 9

The number of deer females 1-2 mated is calculated by difference.

Equation 13: Venison hinds 1-2 years mated = lc7605 – Equation 10

As per the velvet antler herd, hind fawns need to be allocated as replacements for the venison hind herd.

Equation 14: Replacement female fawns required for the venison herd (as 8-month-olds at June 30; lc7618) = Equation 12 / (1-death rate up to 2 year old)

All remaining hinds in lc7618 are available for slaughter.

5.3.4 Stags required for breeding.

The emissions from stags required for breeding of progeny can be allocated to either the venison or velvet antler value chains. The most pragmatic way to allocate breeding stags is directly, based on the relative populations of breeding hinds. It is common industry practice to mate older males to older females, and to mate younger males to younger females. This would be represented by the following approach.

Deer breeding males over 1 and under 2 years (lc7648) should be allocated to deer females over 1 and under 2 years (lc7605). Deer breeding males 2 years old and older (lc7645) should be allocated to the deer females 2 years and older (both mated lc7600, and non-mated lc7610).

The current inventory methodology acknowledges that stags continue to grow until they reach the age of three. This then requires some splitting of the dee male population over 2 years of age into a further cohort, category 6 stags 2-3 years old. Currently the inventory assumes that 1/8 of stags over 2 years of age are categorised in the 2–3-year-old category [see equation 3.81 MPI 2022; $Pds3jul(t)$ = 1/8 × (($POPlc7620(t)$ + $POPlc7645(t)$ + $POPlc7648(t)$) / $POPdeer(t)$)]. We provide a different approach based on potential culling rates as stags are approximately 40%, leaving 60% of the cohort to age into the ‘deer males over 2’ category (lc7645).

Equation 15: Velvet antler breeding stags 1-2 years old = lc7648*(Equation 10/lc7605)

Equation 16: Velvet antler breeding stags 2 years and older = lc7645 *(Equation 9/(lc7600+lc7610))

Equation 17: Velvet antler breeding stags 2-3 years old = Equation 15 * 0.6

Equation 18: Velvet antler breeding stags Mixed age = Equation 16 - Equation 17

Equation 19: Venison breeding stags 1-2 years old = lc7648 *(Equation 13/lc7605)

Equation 20: Venison Breeding stags 2 year and older = lc7645 *(Equation 12/(lc7600+lc7610))

Equation 21: Venison Breeding stags 2-3 years old = Equation 19 * 0.6

Equation 22: Venison breeding stags Mixed age = Equation 20 - Equation 21

5.3.5 Stags retained for velvet antler production.

In addition to the stags identified as entering the velvet antler herd (Equations 1 and 2), and for breeding in the velvet antler herd (Equations 15,17 and 18), the cohorts that are assigned to the velvet antler herd are as follows:

Equation 23: non-breeding Stags aged 2-3-year-old (velvet antler) = 0.6 *Ic7625

Equation 24: non-breeding stags aged over 3 (velvet antler) = Ic7620 – Equation 23

A full example is provided in Appendix 8.3 to demonstrate the separation of each reported class into cohorts representing velvet antler or venison production.

5.4 Allocating emissions

The equation described in section 4.3 provide the basis to allocate proportions of the populations to the primary roles of either venison or velvet antler production.

Emissions for the venison value chain can be applied to populations calculated in:

Equations 3, 12, 13, 14, 19, 21 and 22

Emissions for the velvet antler value chain can be applied to populations calculated in:

Equations 1, 2, 9, 10, 11, 15, 17, 18, 23 and 24

5.4.1 Estimating Emissions Intensity Values (EiV)

An example calculation of Emissions Intensity Values for venison and velvet antler are provided here to illustrate the changing emissions from the respective populations serving the velvet antler or venison industries. These calculations use intake proxies for deer to estimate the proportion of the total feed intake of the deer population and apply the relative contribution of the velvet antler or venison populations to the estimated GHG production from the AIM calculations. A more complete analysis is warranted to provide a more accurate calculation of EiV.

The change in proportions of emissions is calculated in Table 4, using total industry emissions values to demonstrate relative differences as the Velvet antler herd has increased in importance. Values of total GHG emissions from the deer industry (supplied by MPI) are simply divided by the populations represented for each enterprise. Emissions intensity values are then calculated by dividing these relative emissions by the kg product reported. Values calculated using the full AIM methodology will vary from these results. This table has used the equations in the Methodology to split the population between venison and velvet antler production. It demonstrates the rapid shift in emissions from venison to velvet antler production since 2015, increasing from a split between venison and velvet antler of approximately 79:21 to 63:37.

While values calculated using the full AIM methodology will vary from these results, we have provided some calculations (Table 4) to demonstrate the relative change in EiV. Emission intensity values calculated are relatively stable for each enterprise (Table 4). Values for venison, which have been calculated at 35.14 kg CO_2 eq/kg product, would

become 24.55 (+/-0.76 std error) kg CO_2 eq/kg product. This is more closely aligned to the value for sheep which is currently estimated to be 22.4 kg CO_2 eq/kg product.

Values calculated for velvet antler demonstrate the variance between Statistics NZ and Deer Industry NZ collected data. Both data sources provide a relatively stable estimate for EiV. The Statistics NZ data provides a mean EiV of 350.4 (+/-2.8) while the Deer Industry NZ data provides a value of 231.7 (+/- 21.9) kg CO_2 eq/kg product. Regardless of the difference between the calculated values, each value is consistent across years.

Table 4: *A demonstration of the relative proportions of GHG emissions and Emissions intensity Values (EIV, kg CO_2 eq/kg product)) from the venison and velvet antler herds, as predicted by the methodology to split populations between the two enterprises. Values of total GHG emissions from the deer industry (supplied by MPI) are simply divided by the populations represented for each enterprise. Emissions intensity values are then calculated by dividing these relative emissions by the kg product reported. Values calculated using the full AIM methodology will vary from these results.*

Year	Current	Venison		Velvet antler		
	EIV (Venison only)	Population (%)	EIV	Population (%)	EIV (StatsNZ)	EIV (DINZ)
2015	29.15	0.786	22.91	0.214	355.39	222.84
2016	34.42	0.792	27.27	0.208	353.62	199.35
2017	34.16	0.731	24.97	0.269	358.73	233.21
2018	35.73	0.714	25.51	0.286	345.24	336.95[1]
2019	33.84	0.728	24.62	0.272	339.94	192.07[1]
2020	31.42	0.701	22.03	0.299	349.56	205.71
2021	Na[2]	0.667	na	0.333	na	na
2022	na	0.627	na	0.373	na	na

[1] Note that these values are affected by reporting anomalies which underreported velvet antler levy take in 2018 and attributed a proportion of that take to 2019.

Year	Current	Venison
	EIV (Venison only)	Population (%)
2015	29.15	0.786
2016	34.42	0.792
2017	34.16	0.731
2018	35.73	0.714
2019	33.84	0.728
2020	31.42	0.701
2021		0.667

[2] not available at the time of compilation

5.4.2 Interactions between the venison and velvet antler value chains

This methodology, while based on primary purpose, acknowledges that there will be some cross over between the two enterprises, as stags bred for velvet antler production will eventually enter the venison value chain, as will hinds dedicated to generating velvet antler

replacements. To address this anomaly the allocation of the feed required for the growth of these animals to the venison value chain could be applied. This would represent the emissions required to generate venison, while the emissions associated with the maintenance of these animals would remain part of the velvet antler value chain emissions.

The average hind weighs approximately 110 kg, while a stag averages 175 kg (Stevens & Ward 2023). If required, the dry matter required to grow these animals to this weight can be calculated, from birth weights of 9% and 10% of mature hind liveweight for hind and stag fawns respectively. This can then be calculated using AIM (Section 4.6.3; MPI 2021) and subtracted from the velvet antler emissions total.

6. Summation of findings

This study is documented in three prior reports (Stevens & Ward 2023 a, b and c). These reports investigated the source of population data and its relative fitness for purpose (Stevens and Ward 2023a), which included a draft methodology, velvet antler production to estimate the relative fit of population data to changes in velvet antler production, and stag and hind slaughter statistics to understand changing liveweights and age at slaughter, to confirm the methodology.

The outcome of the three reports provided detail with which the methodology was refined. The refined methodology is that reported here in Section 5. A spreadsheet is provided to assist in implementing those calculations. Those reports also provided confidence that the methodology would track changes in the distribution of populations between the venison and velvet antler value chains and reflect the reality of the situation.

Proxy values for Emissions intensity Values are calculated and bring venison in line with estimates for sheep meat production, shifting the EiV from the current value of 35.14 to 24.55 (compared to sheep at 22.4) kg CO_2 eq/kg product. Estimates for velvet antler varied depending on which production database was used. The use of Statistics NZ data would result in an EiV of 350 while use of the Deer Industry NZ data would result in a value of 232 kg CO_2 eq/kg product. Please note that final values calculated using the full AIM methodology will vary from these results.

Several points came to light as the examination of the databases progressed. These included the relative underreporting of velvet antler harvest to the Statistics NZ Agricultural Production survey, a consistent estimate of both mature hind and stag liveweights, from slaughter data, and the attainment of final mature liveweight.

The under-reporting of velvet antler production (Stevens & Ward 2023 b) has a material impact on generating an Emissions Intensity Value (EIV; kg CO_2 eq/kg product) as the ascribed value will be greater than what may be occurring. The Agricultural Production survey in the 2022 year reported 529 t of velvet antler harvested, while the Deer Industry NZ levy take reported 1003 t. This discrepancy inflates the EIV by 1003/529 or approximately 1.9 times the potential actual value.

Hind and stag carcase weights are both reported through the DeerPro database, along with age at slaughter (Stevens & Ward 2023 c). This data highlighted an over calculation of mature liveweights in the AIM calculations. These calculations are based on projections provided by Suttie (2012). However, the actual increase in hind size has not materialised. Hind liveweights plateau in liveweight after 4 years of age. Here hinds have an average liveweight of approximately 110 kg, which has been stable over the 5 years reported. This is significantly lower than AIM estimates of 140 kg. This value is applied once the hind is over 2 years of age. As with the stags, a more graduated approach should be used to allow for growth through to 3.5 years of age.

Estimates for hind intake at maintenance would reduce by approximately 18%. These variations in liveweight will have a substantive impact on the emissions intensity values for both venison and velvet antler enterprises.

Stag liveweight calculations are consistent with the AIM methodology. However, increases in live weight between 2 and 4-years-of-age are consistent across years, increasing from approximately 110 to 170 kg over that time. The AIM methodology applies a maximum stag liveweight from 3 years of age, while this data set provides evidence that there should be an extra step to account for growth during the 4th year of a stag's life. While the value of energy required to achieve the final liveweight will not vary, the calculated energy requirement for maintenance will be lower in the years leading up to peak liveweight, and therefore will have a material impact on GHG emission calculations.

7. Industry feedback

Industry feedback was sought as a cross-check to ensure that the methodology provided an appropriate reflection of industry directions and current practice. The following is the direct transcript of the response to the four documents in the series.

> "Deer Industry New Zealand has reviewed the analysis undertaken in the Spitting Emissions Intensity Values between Venison and Velvet antler production in the Deer Industry by Stevens and Ward. DINZ has not peer reviewed the reports received, yet, from our perspective, the conclusions drawn on the appropriate allocation of emissions from deer to their respective commercial farming purposes seems appropriate and in line with our view on the balance between venison and velvet antler herds in New Zealand.
>
> The conclusion on stag and hind liveweight aligns strongly with our knowledge based on the real data from farms and that provided through slaughter returns, and we urge the keepers of the national inventory to adjust their figures accordingly.
>
> We note the discrepancy between the Statistics New Zealand figures for velvet antler production and the Deer Industry New Zealand figures for velvet antler production. We would suggest that audited figures for production based on levy collection is more accurate measure of total velvet antler production in New Zealand than the estimate provided by samples of deer farmers completing their annual forms. We know that the survey does not collect information on velvet antler production from all deer farms. For example, the continued conclusion that in the Statistics New Zealand report that there are no deer farms in Taranaki or Nelson comes as an annual surprise to the members of the Taranaki and Nelson Deer Farmers Associations."
>
> Attributed to Innes Moffat, CEO, Deer Industry NZ.

8. Acknowledgements

Many thanks to Deer Industry NZ for providing statistics regarding velvet antler production from levy take information and carcase weight and age from the DeerPro database.

References

Clark H. 2008. *Guidelines to accompany computerised inventory*. MAF Technical Paper No. 2011/85. Report prepared for Ministry of Agriculture and Forestry by AgResearch. Wellington, New Zealand.

MPI 2022. *Methodology for calculation of New Zealand's agricultural greenhouse gas emissions. Version 8*. MPI Technical Paper. Prepared for the Ministry for Primary Industries by Andrea Pickering, Joel Gibbs, Simon Wear, James Fick and Hazelle Tomlin. 221 pp. Retrieved on 2 July 2022 from https://www.mpi.govt.nz/dmsdocument/13906/direct.

Statistics New Zealand. 2023. *Infoshare* (https://infoshare.stats.govt.nz/).

Stevens DR, Ward JR. 2023 (a). Splitting emissions intensity values between venison and velvet in the deer industry. Milestone 1: Population statistics. *Report to MPI. 13pp.*

Stevens DR, Ward JR. 2023 (b). Splitting emissions intensity values between venison and velvet in the deer industry. Velvet production. *Report to MPI. 22pp.*

Stevens DR, Ward JR. 2023 (c). Splitting emissions intensity values between venison and velvet in the deer industry. Stag replacement numbers. *Report to MPI. 23pp.*

Suttie J. 2012. *Report to Deer Industry New Zealand: Estimation of Deer Population and Productivity Data 1990-2012*. Report# SCL 12/2 prepared for Deer Industry NZ by Suttie Consulting, Wellington, New Zealand.

Appendices

8.1 Carcass weight of stags of different age, and their estimated liveweight (calculated using a dressing out percentage of 55%) between 2018 and 2022.

	Age at Slaughter (years)									
Year	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**7**
2018	58.4	57.7	66.0	76.1	88.0	87.0	101.5	96.9	102.6	99.6
2019	57.2	58.3	60.5	71.9	88.0	95.7	98.4	101.9	107.8	99.8
2020	56.2	58.4	57.2	72.5	77.0	90.5	100.0	98.4	107.7	89.4
2021	55.5	57.9	58.9	73.1	77.7	91.3	81.6	96.8	103.4	84.1
2022	57.4	56.7	58.6	69.9	74.8	92.0	86.1	97.3	104.2	98.2
Average	**56.6**	**57.9**	**59.0**	**71.5**	**78.8**	**90.1**	**91.0**	**97.4**	**104.7**	**93.3**
Liveweight	**103.0**	**105.3**	**107.2**	**130.0**	**143.3**	**163.9**	**165.5**	**177.1**	**190.3**	**169.7**

8.2 Hind carcass weights and estimated live weights using a dress-out percentage of 55% (kg)

	Age (years)									
Year	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**7**
2018	52.8	51.3	50.5	51.9	56.3	62.4	59.2	59.3	59.7	60.7
2019	53.1	53.2	52.4	57.6	55.1	61.9	57.0	61.0	61.4	61.3
2020	52.2	53.2	52.0	56.0	54.3	60.3	56.4	59.4	60.6	58.4
2021	52.3	52.7	51.2	56.6	55.0	61.0	57.1	60.2	60.5	59.7
2022	53.6	51.9	50.5	54.3	53.8	59.3	57.3	59.9	60.6	59.0
Average	**52.6**	**52.7**	**51.5**	**55.4**	**54.6**	**60.2**	**57.0**	**60.0**	**60.6**	**59.6**
Liveweight	**95.6**	**95.9**	**93.6**	**100.8**	**99.3**	**109.5**	**103.7**	**109.1**	**110.3**	**108.3**

8.3 Example set of calculations demonstrating the separation of reported classes into cohorts to primarily represent velvet antler or venison production.

__Table 8.1__: Data supplied to MPI from Statistics NZ each year

Year	lc7696 Fawns born on farm and alive at four months	lc7640 Velvet (all grades) removed (green weight kg)	lc7600 Deer females mated 2 years and over	lc7605 Deer females mated over 1 year but under 2 years	lc7610 Deer females NOT mated 2 years and over	lc7615 Deer females NOT mated over 1 year but under 2 years	lc7618 Deer females under 1 year old (include fawns still on the farm)	lc7630 Deer males under 1 year old (include fawns still on the farm)	lc7620 Deer non-breeding males 2 years and over	lc7625 Deer non-breeding males over 1 year but under 2 years	lc7645 Deer breeding males 2 years old and over	lc7648 Deer breeding males over 1 year but under 2 years	lc7699 TOTAL deer
2018 (data from this year is used to calculate reproductive success)			324195	77569	4308								
2019	304621	456516	313685	64907	3016	10254	131747	136922	100373	29024	16218	4297	810443
2020	313649	490200	308868	65202	6268	11255	142538	142493	103009	34232	15717	3676	833258
2021	298709	519809	299106	61567	6752	12650	132295	140983	107281	34874	14165	4307	813980

Table 8.2: Section 5.3.1 *Calculating the number of young stags bred for the velvet herd*

Estimating young stag numbers entering the velvet antler herd and venison value chain		Stags retained for velvet (lc7625)	Stags under 1 retained for velvet (calculated from stags over 1 but under 2 retained for velvet, adjusted for survival rate)	Stags under 1 available for slaughter
Equation		1	2	3
	2019	29024	29616	107306
	2020	34232	34931	107562
	2021	34874	35586	105397
Allocation		Velvet Antler	Velvet Antler	Venison

Table 8.3: Section 5.3.2 *Number of females required for velvet breeding*

Calculating the number of females required to support the velvet antler herd		Hinds required for velvet stags (lc7625 adjusted for reproductive efficiency and survival rate)	Hinds for replacement herd (hind requirements adjusted for replacement rate, reproductive success and survival rate)	Velvet females 2 years and over (Total hind requirements adjusted for relative proportions of hinds in each age class)	Velvet females mated over 1 but under 2 (total numbers adjusted for proportions of hinds in each age class)	Velvet female replacements under 1 year (calculated from over1 but under 2 mated replacements, adjusted for survival rate)
	Equation	4	7	9	10	11
	2019	39480	12889	43461	8907	9089
	2020	42499	12663	45706	9457	9650
	2021	45310	14129	49479	9960	10163
Allocation				Velvet Antler	Velvet Antler	Velvet Antler

Table 8.4: Section 5.3.3 *Number of females required for venison breeding*

Calculating the number of females required to support the venison herd		Venison females 2 and older (calculated by difference from lc7610+lc7600)	Venison females Mated over 1 under 2 (calculated by difference from lc7610)	Female replacement under 1 year venison (calculated from over 1 but under 2 mated venison replacements, adjusted for survival rate)
Equation		12	13	14
	2019	273240	56000	57143
	2020	269430	55745	56883
	2021	256379	51607	52660
Allocation		Venison	Venison	Venison

Table 8.5: Section 5.3.4 *Stags required for breeding*

Calculating the number of stags required for breeding to support velvet antler or venison herds	Velvet breeding males over 2 (calculated from lc7645, adjusted for relative contributions of velvet antler and venison enterprise hinds)	Velvet breeding males over 1 but under 2 (calculated from lc7648, adjusted for relative contributions of velvet antler and venison enterprise hinds over 1 but under 2)	2-3 yo velvet antler breeding stags (calculated as 0.6 * velvet antler breeding stags 1-2)	MA Breeding Velvet antler stags (calculated by difference from lc7645 - 2-3 yo stags)	Venison breeding males over 2 (calculated from lc7645, adjusted for relative contributions of velvet antler and venison enterprise hinds)	Venison breeding males over 1 but under under 2 (calculated from lc7648, adjusted for relative contributions of velvet antler and venison enterprise hinds over 1 but under 2)	2-3 yo Venison Breeding stags (calculated as 0.6 * venison breeding stags 1-2)	MA Breeding Venison stags (calculated by difference from lc7645 - 2-3 yo stags)
Equation	16	15	17	18	20	19	21	22
2019	2226	590	354	1872	13992	3707	2224	11768
2020	2280	533	320	1960	13437	3143	1886	11552

	2021	2291	697	418	1873	11874	3610	2166	9707
Allocation			Velvet Antler	Velvet Antler	Velvet Antler		Venison	Venison	Venison

Table 8.6: Section 5.3.5 *Velvet antler stags (non-breeding)*

Calculating the number of velvet antler stags (non-breeding)		Stags under 1 retained for velvet (calculated from stags over 1 but under 2 retained for velvet, adjusted for survival rate)	Stags over 1 and under 2 retained for velvet (lc7625)	2-3 year old velvet antler stags (calculated as 0.6 * lc7625)	MA Velvet Antler Stags (calculated by difference lc7620 - 2-3 year old velvet antler stags)
	Equation	2	1	23	24
	2019	2060	29024	17414	82959
	2020	2061	34232	20539	82470
	2021	2062	34874	20924	86357
Allocation		Previously identified	Previously identified	Velvet Antler	Velvet Antler