Ministry for Primary Industries
Manatū Ahu Matua

Dairy cattle population model

Improving estimates of within-year population changes used in the inventory

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Prepared for Ministry for Primary Industries
By V Burggraaf, C Benson, M Rollo

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1 Executive summary

This project has reviewed the current methodology in the Agricultural greenhouse gas Inventory Model (AIM) for determining changes in dairy cattle populations within a year, as well as investigating the feasibility of moving to regional population dynamics. The scope was to use the existing starting populations on 1 July and determine monthly changes for each stock class over the following year. Whilst reviewing dairy industry data, a range of inconsistencies were noted amongst data sources. Potential areas to better align these data sources to the needs of AIM are documented. The uncertainty of the robustness of some data, along with gaps in data, led to recommendations in population dynamics being based on long-term averages in birth, death and slaughter timing, combined with monthly data for each year for heifer exports. The recommendations for changes to AIM for each dairy stock class are described below. The industry data, associated equations and potential impacts of these changes are detailed in the body of the report.

For breeding dairy bulls, we recommend retaining the current methodology in AIM.

For calves aged 0-1-year-old, we recommend changing the birth date to 13 August. Based on post-weaning death rates, we also recommend adding 1% to the starting population on 13 August and adding an annual death rate of 1% to the population that is spread evenly across months from September to June. This then enables the population on 30 June, when nearing one year old, to match the population in the source data from the Agricultural Production Survey (APS) on that date. Pre-weaning deaths are ignored, as milk-fed calves do not currently add to enteric methane emissions in AIM.

For dairy heifers aged 1-2-years old we recommend they remain in this category until 30 June, rather than moving to mature cows on 1 May. Although outside of the scope of this project, the starting population for this category could be derived from the ‘R1 heifer’ category in APS from 30 June of the preceding July to June year, plus adding 47% of the ‘not-in-calf and not-lactating cows and heifers’ (as is currently done). From the starting population on 1 July, we recommend removing 1% to deaths, split evenly over the year, and removing the exported heifers monthly, based on cattle export data from MPI. Exported heifers are calculated as 95% of cattle exports up to 2018, and 90% of cattle exports after this date. These exports are to be first removed from the 47% of ‘not-pregnant and not lactating cows and heifers’ category, with any remaining cattle from this 47% of ‘not-pregnant and not lactating cows and heifers’ removed at the start of the same year (July).

For mature cows, we recommend a total loss of 16.9% of the population from 1 July of each year. This includes deaths and culls to slaughter of both empty and lactating cows. The percent of the initial population remaining at the end of each month is to be calculated as: 99.1% July, 98.2% August, 97.3%, September, 96.4% October, 95.8% November, 95.1% December, 94.3% January, 93.0% February, 91.0% March, 88.5% April, 84.9% May, 83.1% June.

The proposed changes to methodology resulted in a drop of enteric methane emission estimates from the dairy population of approximately 2.6%. The methods used are also less complex than the current algorithms.

In addition, data on regional variation in dairy cattle population dynamics (timing of births, deaths and culling) were compiled. Although the median calving date is typically several weeks earlier in the North Island than the lower South Island, this is partially balanced by earlier culling dates in the North Island. There is a lack of readily available robust dairy cattle population data from 1990 to present for all of the regions as currently specified in AIM. Based on this, and the likely minor overall impact on emissions estimates of regional population dynamics, we concluded that regional-based equations for the dairy cattle population model are not feasible at this stage.

The methods applied here could be reviewed again in the future once the uncertainties around data sources are overcome and more data are available to determine variability across years in population dynamics.

2 Introduction

The agricultural greenhouse gas inventory model ("the inventory", or AIM) calculates annual dairy cattle derived emissions separately based on four subcategories of dairy cattle: milking cows, females <1-year-old, females 1-2 years old and dairy breeding bulls (MPI 2021a). The inventory currently uses livestock population data derived from the Agricultural Production Survey (APS) for animals present on 30 June of each year for each region. A production year using this population as a baseline is then modelled from 1 July to the following 30 June.

Emission calculations are undertaken on a monthly timestep based on energy requirements per head for the given level of animal performance, then monthly population estimates are applied to give total national emission estimates. The number of animals present each month for the remainder of the production year (July to June) are then based on assumptions on timing and number of deaths, culling to slaughter and birth dates (with assumptions applied at a national level), along with the number present on 30 June the following year.

It is currently assumed that there is no difference between years or between regions in calving date or proportion and timing of animal losses. The assumptions associated with monthly population changes are described in Clark (2008a), with updated methodology proposed in Thompson et al. (2010) and are described in more detail in the following sections for each livestock class.

This project aimed to review the current methodology used to determine timing of births and animal losses for each dairy cattle stock class across a year. Reviewing of the data used for the number of animals in each livestock class on 30 June is outside of the scope of this project. Proposed changes to the algorithms for population changes within a year are made to reflect industry data. A number of discrepancies were identified amongst data sources in classification of stock classes and recording of animal fates. These are further discussed in this report to ensure that these are considered in the future and appropriate data sources are used for inventory purposes.

3 Industry data sources

In reviewing industry data to contribute to inventory population dynamics, focus was placed on sources with data from 1990 to present, in-line with the timeline required for national greenhouse gas reporting. The suitability of each of these data sources is discussed below.

3.1 NAIT

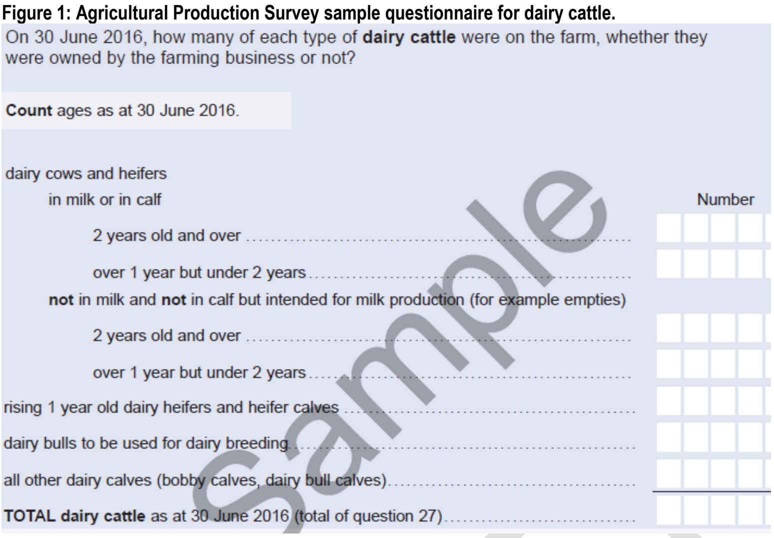
NAIT (National Animal Identification and Tracing) was introduced in 2012 to record the location and movement of New Zealand cattle and deer. Although it is a legal requirement to record these movements, issues were noted with recording in a review released in 2018 (OSPRI 2018). This has resulted in a number of recommendations to ensure that this database is more robust in the future. This data was therefore not used in the current project. The current level of compliance in recording is uncertain, but this should be a useful source of tracing monthly population data in the future. Other data would be required from 1990 to a time where recording was deemed sufficiently accurate from this source.

3.2 AGRICULTURAL PRODUCTION SURVEY (APS) – SOURCED VIA STATSNZ

This data source forms the basis of the animal populations in AIM. The Agricultural Production Survey (APS) collects data from across farm types in New Zealand, with the number of animals in each stock class on 30 June of each year documented. The data come from a full census in the years 1990, 1996, 2002, 2007, 2012 and 2017, with sample surveys in other years, and no data collected in 1997, 1998 and 2001. An example of the survey from 2016 is shown in Figure 1. However, survey questions are reviewed regularly, and the data available has changed over time.

For farmers that do not return a completed questionnaire, missing data are imputed (replaced with values based on other data available). For the 2020 survey, the imputation level was 24% for total dairy cattle, with an estimated sampling error of 4% (StatsNZ 2020).

Figure 1: Agricultural Production Survey sample questionnaire for dairy cattle.


On 30 June 2016, how many of each type of **dairy cattle** were on the farm, whether they were owned by the farming business or not?

Count ages as at 30 June 2016.

	Number
dairy cows and heifers	
in milk or in calf	
2 years old and over	
over 1 year but under 2 years	
not in milk and **not** in calf but intended for milk production (for example empties)	
2 years old and over	
over 1 year but under 2 years	
rising 1 year old dairy heifers and heifer calves	
dairy bulls to be used for dairy breeding	
all other dairy calves (bobby calves, dairy bull calves)	
TOTAL dairy cattle as at 30 June 2016 (total of question 27)	

Sample

The publicly available APS data on the StatsNZ Infoshare website (http://infoshare.stats.govt.nz/) aggregates cows and heifers together, so that only data from the following relevant classes are currently available:

- Rising 1 year old dairy heifers and heifer calves (0-1 year on 30 June)
- Dairy cows and heifers not in milk or in calf (1+ years on 30 June)
- Dairy cows and heifers in milk or in calf (1+ years on 30 June)
- Dairy bulls to be used for dairy breeding (assumed 1+ years on 30 June)
- Total dairy cattle (including bobby calves on-farm)

Between 1990 and 1996, the dairy cows and heifers not in milk or in calf were split into heifers and cows.

3.3 SLAUGHTER STATISTICS (STATSNZ)

Livestock slaughtering statistics for New Zealand are available on the StatsNZ Infoshare website (http://infoshare.stats.govt.nz/). Data are available by month, quarter or year and either nationally or by region. However, for many regions monthly data are not publicly available for the stock classes required in AIM.

Also, the definition of stock classes used in AIM do not closely align with those used by abattoirs. For example, dairy bulls slaughtered would include not just those used for breeding, but Friesian bulls also used for beef production, whereas for dairy populations in AIM, we are only interested in dairy bulls used for breeding.

Similarly, there is discrepancy in age classes, for example the definition of a heifer. In APS and AIM, dairy heifers are differentiated as being female dairy cattle between 1 and 2 years old on 30 June. However, for cattle processed for meat, a dairy heifer is defined as a dairy breed female animal, having no more than 6 permanent incisor teeth (New Zealand Meat Classification Authority 2004). This could therefore include animals younger than one year old, but weaned off milk, so not classified as bobby calves, and could also include animals greater than two years old that have no more than 6 permanent incisors (Meat and Livestock Australia 2017).

Also, for mature cow slaughter statistics, data have only been separated into beef and dairy breeds since 2016.

Commented [TF1]: Regional data can also be impacted by animals from one region being processed in another region. This can occur where there is regional feed issues, limited processing capacity or during shoulder/non-peak seasons where certain plants may be closed.

3.4 DAIRY INDUSTRY GOOD ANIMAL DATABASE (DIGAD)

3.4.1 Description

NZAEL, a subsidiary of DairyNZ, manages the Dairy Industry Good Animal Database (DIGAD). The database (https://www.dairynz.co.nz/animal/animal-evaluation/animal-database/data-access/) is the largest source of NZ dairy industry data and includes collaboration with the industry organisations LIC and CRV ~~Ambreed~~, with records for approximately 90-95% of dairy herds in New Zealand. It includes herd-testing data for milk quality and yield, as well as data supplied by farmers on animal movements, start and end of lactation, parentage, birth dates, gender and other events. A full list of fields is available on the website above.

Commented [TF2]: Ambreed has been dropped from their official name

Each animal in the database is tracked from birth to death (whilst on a dairy farm), with its final fate (and the timing) recorded as one of the following:

- Died
- Culled
- Went to works
- Moved with change of owner (sold, bobbied, leased)
- Moved without change of owner (lent, shifted)
- Renumbered within same herd (it has just received a new ID)

For each of these fates above, a description may also be included as to the cause of this fate, e.g. specific health issues.

3.4.2 Data short-comings

When extracting data from this database, recording errors were found. Approximately 1-5% of the data were 'cleaned' to rectify some of these issues or remove data. It is uncertain, however, how many additional recording errors were undetected. Compton (2018) removed a much larger proportion of atypical data from the same data set, as discussed in a later section, however, the data was used for a purpose with different requirements. Discrepancies we addressed included animals being recorded as dead, but then a later birth date appears with the same animal identification, bulls being recorded as pregnant, calves giving birth, or cows lactating for many years without being recorded as giving birth.

Fates of animals also had some degree of overlap, and it was noted that the number recorded as 'sent to the works' was very low, but if combined with the total deaths and culls recorded, total monthly losses aligned well with slaughter statistics for dairy cows (see later section on mature cows). The monthly distribution of losses was therefore used from this source for mature cows.

For 1-2-year-old heifers, StatsNZ slaughter data did not align well with culling data in DIGAD. This could be attributed to a combination of some incorrect recording of birth dates in DIGAD, combined with differences in classification of a dairy heifer between DIGAD and slaughter statistics).

3.4.3 Seasonal calving spread

Our initial data request from DIGAD asked for spring-calving herds only, to align with how the inventory is modelled. However, a clear definition of spring-calving was not possible, given that calving occurs throughout the year. As most 'spring-calving' cows would give birth from June to October, this represents 96% of cows (

Table 1~~Table 1~~). It was therefore decided to include all herds in the data analysis, as the additional 4% of total cows would have a minor impact on averages. This will also align with the Agricultural Production Survey data used in the inventory, which does not categorise population data by timing of calving.

Table 1: Calving spread of New Zealand dairy cows from 1990 to present. Sourced from DIGAD.

Month	Total calvings	Percent of total
January	120,898	0.1
February	208,172	0.2
March	1,071,331	0.9
April	1,363,855	1.2
May	684,084	0.6
June	905,843	0.8
July	22,846,433	19.7
August	58,137,799	50.3
September	24,563,407	21.2
October	5,171,991	4.5
November	493,806	0.4
December	126,542	0.1

Commented [TF3]: Did you look at 1990 spread vs 2020? Not sure if it would show any change over time or if any change would have significance. Migration of cows south are mostly all spring calving but possibly an increase in autumn calving cows in the upper North Island.

3.5 OTHER LITERATURE

A range of other New Zealand dairy industry studies are referred to in this report. For example, Compton (2018) which uses the DIGAD database as a source of data. Compton (2018) also noted similar challenges associated with DIGAD data.

4 Dairy bulls used for dairy breeding

4.1 CURRENT METHODOLOGY

AIM uses the population of dairy bulls used for dairy breeding from the APS survey on 30 June each year and assumes a linear relationship between values for consecutive years. In APS, the dairy bulls used for breeding appears to include all bulls over 1 year old. This agrees with what happens on a dairy farm, where it is recommended to use yearling bulls for mating with yearling heifers and older bulls for dairy cows. All non-breeding dairy bulls are modelled as part of the beef population. It is of no consequence to AIM whether the breeding bull is on the dairy farm or on the bull breeding farm for part of the year. All dairy breeding bulls to be used for dairy breeding are modelled as part of the dairy cattle population.

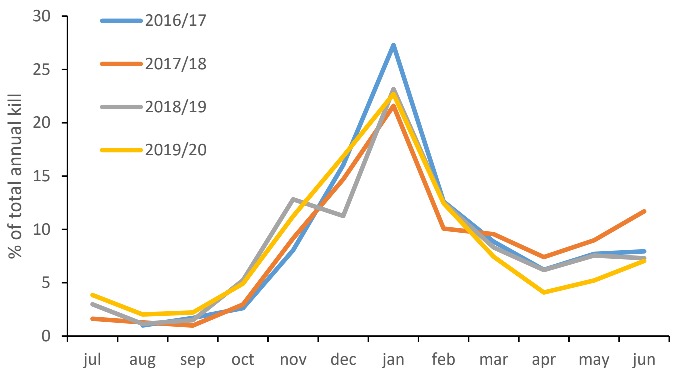
4.2 DISCREPANCIES WITH OTHER DATA SOURCES

Neither the data described by DIGAD or the data described by StatsNZ dairy bull slaughter statistics have the same definition of a dairy bull used for breeding as used in AIM. DIGAD dairy bulls will include all bulls on the dairy farm (including beef-breed bulls used for mating). Population changes in dairy bulls used for dairy breeding is also complicated by the movement of dairy breeding bulls between the beef and dairy farm, as most dairy farms do not rear their own bulls for breeding and may purchase or lease bulls for a short period over the mating season. As the AIM data is based on the APS population on 30 June, many bulls used for dairy breeding could still be on a bull-breeding farm until closer to mating, so are not present in DIGAD. When leased bulls leave a dairy farm and return to a beef farm in the same year, DIGAD data also does not capture if they are then slaughtered within the same year. Similarly, for StatsNZ slaughter statistics, dairy bulls would also include, for example, Friesian bulls (which are a dairy breed) that are used for beef production as opposed to dairy mating.

Commented [TF4]: I disagree with this statement. Some farmers will record all breeding bulls (dairy and beef) into the DIGAD database whereas other farmers will not record any of their breeding bulls (regardless of breed) into DIGAD. I agree that DIGAD is not a good source of natural mating breeding bull data. The following sentence about short term purchase or lease I think would have a far greater significance on the complexity of the number of animals in this population

A previous review of AIM population methodology (Thomson et al. 2010), noted that slaughter of dairy breeding bulls would typically occur in January, after mating. It is likely that the decision-making regarding timing of slaughter of dairy bulls used for breeding differ to the timing of slaughter of dairy bulls used solely for meat, which are also included in slaughter statistics. Although the monthly slaughter of dairy bulls in StatsNZ slaughter statistics peaks in January, this only represents 23% of the total kill (Figure 2). It is uncertain what proportion of the dairy bull slaughter should be attributed to dairy breeding bulls versus bulls for beef production at different times of the year.

Figure 2: Monthly distribution of slaughter numbers for dairy bulls (for breeding or meat production) from New Zealand from July 2016 to June 2020. Data from StatsNZ.



4.3 RECOMMENDATIONS

In the 2019/20 season, the numbers of bulls >1 year old in DIGAD (all bulls on a dairy farm), are at their lowest in June/July, and peak in September, as bulls are purchased or leased for the breeding season and as male calves age into this category. Less than 30% of the dairy bull population present in DIGAD on 30 June 2019 were classified as died, slaughtered or sent to the works over the following year. As bulls contribute approximately 1% of the total dairy cattle population, this loss is less than 0.3% of the total dairy cattle population.

The current methodology of a linear monthly population change between the 30 June APS population each year therefore appears reasonable, given the lack of appropriate data sources to justify changing this and the negligible impact on emissions of any potential changes.

5 Growing females < 1 year old

5.1 CURRENT METHODOLOGY

The calf population is derived by subtraction of breeding bulls, cows and 1-2-year-old heifers from the total dairy population in APS for each year. This would therefore include heifer calves (that are approximately 11 months old in the case of spring-calving herds), and also include any male calves that are on farm on 30 June. In AIM, the calf population remains constant (as the death rate is set to zero) from birth in August, until aging into the 1-2-year-old heifer category 12 months after birth.

5.2 CALVING DATE DATA

An appropriate average birth date for retained heifers was determined using the following data provided by Jessie Berends (Information Analyst, LIC). Median calving date was not calculated prior to the 2003/04 season. The mixed age spring-calving (1 June to 31 October) cow data from 2003 to 2020 (Table 2) shows negligible deviation from the median of 16 August. Note that calvings outside of this spring period are excluded, but only make up an average of less than 5% of the national herd since 1990 (Table 1.) First calving heifers are also excluded, which had a median and mean calving date in 2019/20 of 4 August, 11 days earlier than the mixed age cows. In 2019/20, for mixed age cows, mean spring calving date was also recorded, and this was only 1 day earlier than the median.

Table 2: New Zealand national median spring (June to October) calving dates for mixed age cows (i.e. excluding first-calving heifers) from 2003 to 2019.

2003/04	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**
16-Aug	15-Aug	16-Aug	15-Aug	16-Aug	15-Aug
2009/10	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**
18-Aug	17-Aug	18-Aug	15-Aug	15-Aug	15-Aug
2015/16	**2016/17**	**2017/18**	**2018/19**	**2019/20**	
14-Aug	14-Aug	17-Aug	15-Aug	15-Aug	

5.3 CALVING DATE RECOMMENDATIONS

Considering first-calving heifers contribute approximately 20% of the milking herd, the mean and median calving date when including these early calving heifers (herd average = 11 days x 20% earlier than the mixed age cows) would be 12 and 13 August, respectively, for the 2019/20 season. Therefore, given the median calving date for cows >2 years old between 2003 and 2020 was 16 August**, we recommend setting the weighted average calving/birth date in AIM as 13 August**, to represent the weighted average of first-calving heifers and multiparous cows.

In recommending this, we are aware that the retained heifer calves that become dairy replacements have an earlier than average birth date, as they are typically the high breeding worth calves that are sired through artificial insemination, which occurs at the start of the breeding season, before bulls are typically put in the herd. However, the same date is currently used for calving and the start of lactation of all cows in AIM and start of lactation requires all births to be accounted for. With an increase in the use of sexed semen, the mean birth date of replacement dairy calves is likely getting earlier compared to the average birth date of all calves. The impact of this may need reviewing in the future.

5.4 CALF LOSS DATA

It is acknowledged that calves that die between weaning and one year old are not captured in the base population in AIM. Similarly, there are currently no losses modelled between 1 and 2 years old, potentially overestimating the 1-2-year-old population in AIM by a similar amount.

Cuttance et al. (2017) undertook a study of 32 spring-calving pasture-based dairy farms in the Waikato and Canterbury. For the calf population, there was an average of 4.1% mortality from 24 hours of age to weaning at 13 weeks, with a greater loss for males relative to females (odds ratio of 1.39), equal to a 2.9% loss for females. Greater loss rates occurred in Canterbury compared with the Waikato. The risk of loss from birth to weaning is greatest in the first week of life (Figure 3). This is when calves are milk fed and no methane emissions are calculated (due to the lack of rumen development) from them in AIM.

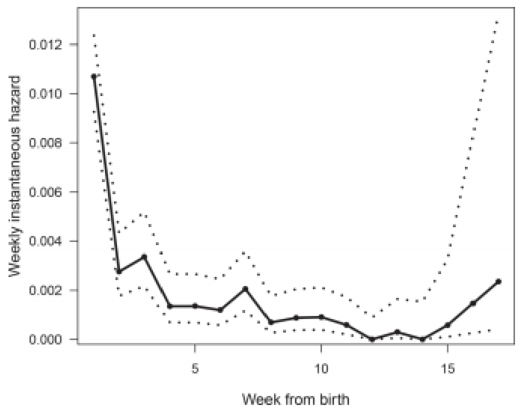


Figure 3: Mean hazard of mortality for calves from 24 hours of age to weaning from 30 New Zealand dairy farms in Canterbury and the Waikato. From Cuttance et al. (2017).

Dairy heifer mortality was recorded (Mason et al. 2020) between weaning and 27 months of age on 24 spring-calving New Zealand dairy herds, with a 2.7% mortality rate spread across the time period (Figure 4). This is similar to the 2.8% mortality of 0–2-year-old heifers reported by Compton (2018) from a population of 18,048 New Zealand dairy heifers that survived the peri-natal period. It must be noted that Mason et al.'s (2020) data includes the transition period around the heifers first calving at 2 years old, when mortality risk is increased. At calving they would have moved into the mature cow population in AIM. Mortality from weaning to 22 months of age (approximately 80 weeks post-weaning) would be just under 2% (Figure 4).

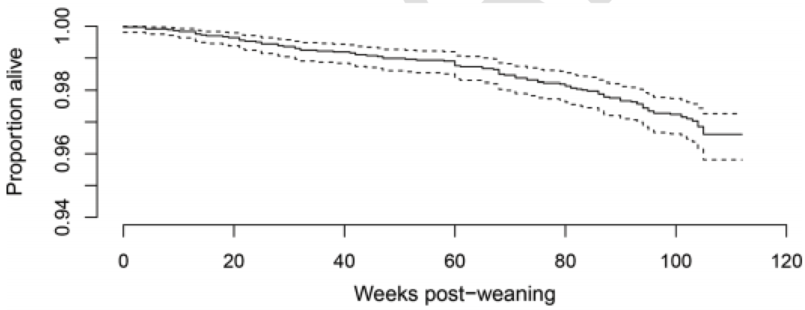


Figure 4: Post-weaning survival curve (with 95% confidence intervals) of dairy heifers from 24 New Zealand farms (From Mason et al. 2020).

5.5 CALF LOSS RECOMMENDATIONS

Pre-weaning deaths do not need adding to the base population given that they do not contribute to methane emission estimates. To represent post-weaning calf deaths, there is potential to add 1% to the population from birth and then gradually lose these additional calves from weaning to 1-year-old, to then reach the values currently in AIM for 0-1-year-old dairy cattle.

We recommend the following approach is used to represent post-weaning calf deaths:
August population = current calf population in AIM *1.01
September = August population * 0.999
October = August population * 0.998
November = August population * 0.997
December = August population * 0.996
January = August population * 0.995

February = August population * 0.994
March = August population * 0.993
April = August population * 0.992
May = August population * 0.991
June = August population * 0.990
July population = 0-1-year-old dairy heifer population in APS on 30 June

6 Females aged 1-2-years old

6.1 CURRENT METHODOLOGY

Currently in AIM, 1-2-year-old heifer numbers remain constant throughout the year (as the death rate is set to zero), and are not modelled from May onwards, as the population is moved to the mature cow population at this time (back calculated as part of the July mature milking cow population).

In the methodology documentation (MPI 2021a), the 1-2-year-old heifer population is equivalent to the 0-1-year-old population the previous year, plus the empty (non-pregnant) heifers (47% of the empty dry cows and heifers on 30 June in APS; Clark 2008a).

Current methodology does not consider removal of exported live heifers from the population.

6.2 INDUSTRY DATA FOR 1-2-YEAR HIEFERS

Approximately 1% of heifers die between the age of 1 and 2 years old (Figure 4). In addition, those that fail to get pregnant are typically removed from the herd (either sold or culled to slaughter). Empty 1- to 2-year-old heifers in APS on 30 June currently comprise an average of 13% (range 6 to 19%) of the 1–2-year-old population in AIM for the following 1 July to 30 June. Compton (2018) noted a lower incidence of culling to slaughter (4.4%) compared to sale (15.8%) of replacement heifers between 0 and 2 years old for the 2008/09 dairy season (113 herds) and attributed the higher proportion of sales to the export of heifers.

6.2.1 Live heifer export

Heifers that are exported are also lost from the national population, typically between one and two years old as non-pregnant heifers.

Live cattle exports (predominantly dairy heifers) from New Zealand peaked in 2020/21 (Table 3), with a total of 134,858 cattle exported in the year from July to June. This export is currently looking to be phased out by 2023 (MPI 2021b). Monthly cattle export data are available on the MPI website (https://www.mpi.govt.nz/export/animals/live-animals-including-livestock/resources-for-exporting-live-animals/) from 2011 to present. Data are not reported on the sex, breed or age, however, more than 95% of the total prior to 2018 were dairy cattle, but beef-breed cattle exports have increased since then, possibly at around 10% of the total (Bernd Hay, MPI, Pers. Comm). New Zealand has exported cattle for breeding since 2008, but breeding bulls are a very small proportion of total exports. Cattle exported to China (the dominant market) must be at least 6 months old and no more than 5 months pregnant, with those exported recorded as being between 10 and 24 months old (Bernd Hey, MPI, Pers Comm). If we assume these are part of the empty 1-2-year-old heifer population in APS on 30 June, the exported heifers would contribute between 11 and 69% of the empty 1-2-year-old heifers in APS.

The timing and number of heifer exports varies markedly between years and months (Table 3). Ninety percent (i.e., the proportion of exported cattle assumed dairy heifers) of the total cattle exports for each of the four years in Table 3 is equivalent to 12% of the total R1 (0–1-year-old) heifers in APS on 30 June 2017, 2% of R1 heifers in 2019, 5% of R1 heifers in 2019 and 14% of R1 heifers in June 2020.

Table 3: Live cattle export numbers from New Zealand. Extracted from the MPI website. Annual totals are calculated for the 1 July to 30 June year (https://www.mpi.govt.nz/export/animals/live-animals-including-livestock/resources-for-exporting-live-animals/)

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
2020/21	17,292	32,503	0	0	23,566	5,763	8,402	0	4,276	29,087	13,969	0	134,858
2019/20	0	5,400	3,983	7,104	3,978	6,700	6,700	3,520	7,079	7,724	0	0	52,188
2018/19	3,678	0	0	0	3,810	3,671	0	220	6,393	5,711	0	0	23,483
2017/18	20,970	37,903	3,983	7,104	31,354	16,134	0	2,675	0	3,300	0	185	123,608

6.3 RECOMMMENDATIONS FOR 1-2-YEAR-OLD HEIFERS

As there is no culling of 1-2-year-old heifers currently in AIM, we recommend culling the 47% of the not-in calf and non-lactating cows and heifers (i.e. the proportion assumed heifers) as part of the monthly heifer export numbers, with any remaining empty heifers culled to slaughter in July of the same production year (30 June to 1 July). A 1% death rate is also subtracted, spread across the year, with the population changes calculated as follows:

July population = current July population in AIM
August population = July population minus number of heifer exports in July. Then if annual heifer exports are less than 47% of the not in-calf and not-lactating cows and heifers, subtract the difference between 47% of the not in-calf and not-lactating cows and heifers and the annual heifer exports
September = August population * 0.999 minus number of heifer exports in August
October = September population * 0.998 minus number of heifer exports in September
November = October population * 0.997 minus number of heifer exports in October
December = November population * 0.996 minus number of heifer exports in November
January = December population * 0.995 minus number of heifer exports in December
February = January population * 0.994 minus number of heifer exports in January
March = February population * 0.993 minus number of heifer exports in February
April = March population * 0.992 minus number of heifer exports in March
May = April population * 0.991 minus number of heifer exports in April
June = May population * 0.990 minus number of heifer exports in May

Commented [TF5]: This is compounding the death rate to far greater than 1%. Should it not read for every month August population * 0.99X – minus total heifer exports August to (month-1) e.g. June = August Population *0.990 minus heifer exports total (August to May)

Where annual heifer exports (1990 to 2018) = total cattle exports x 0.95
Where annual heifer exports (2019 onwards) = total cattle exports x 0.90
Where heifer exports for each month (January 1990 to December 2018) = monthly exports x 0.95
Where heifer exports for each month (January 2019 onwards) = monthly exports x 0.90
Where data are sourced from the MPI website for heifer exports referenced above and in Table 3.

As the peak of dairy cow slaughter occurs in May (Table 5), with some still occurring in June for later calving herds, it is recommended that these heifers are not moved through to mature cows until after this time, on 1 July. The following years mature cow population is then started on 1 July from mature cow data in APS.

Although out of the scope of this review, the starting population on 1 July of 1-2-year heifers could be derived from the R1 heifer category in APS from 30 June of the preceding July to June year.

6.4 IMPACT OF RECOMMENDATIONS ON POPULATIONS IN AIM

Reviewing the starting population for each year was outside of the scope of the project, so the following analyses were undertaken using the same starting population as in AIM currently but applying the suggested death rate and method for removal of exported heifers and empty 1-2-year-old heifers as above. Using this methodology, if the remaining heifers in this class in June moved into the milking herd as two-year-olds the following year, they would make up 17.5 to 19.5% of the milking population in the seasons 2018/19, 2019/20 and 2020/21, at a time when the national dairy herd population is gradually declining. Note, this is hypothetical, as the milking population in AIM is based on the in-milk or in calf population for that year in APS. The impacts on methane emissions are discussed in a later section.

7 Mature cows

7.1 CURRENT METHODOLOGY

AIM assumes an annual 2.1% death rate for mature cows, based on a NZ dairy industry survey of 98,000 NZ dairy cows over 3 years (Xu and Burton 2003), as reported in Thompson et al. (2010). Half of these deaths occur in August, with the remainder split evenly across the year (May of the same calendar year to April of the following calendar year), weighted for the number of days in each of the remaining months.

At the start of July, 53% of the 'not in-calf nor in-milk cows and heifers' from 30 June are added to the mature cow population (as described in Clark 2008a) and are then assumed to be slaughtered in July. This 53% is derived from APS data between 1990 and 1996, when this category was split into mature cows and heifers. At that time the range was 47 to 55% of the 'not in-calf or in-milk cows and heifers'.

No culling rate is specified for the mature dairy cows, as the model currently assumes that culling to slaughter would occur at the end of April, with the mature cow population on 1 May including replacements for these culls, derived from the in-calf or in-milk cow and heifer population from the following year.

7.2 INDUSTRY DATA

7.2.1 Context

Culling and losses from death occur throughout the year on New Zealand dairy farms. The number and timing of culling of dairy cows can be affected by climate, milk price, timing of calving and many other factors. In dry years, or when milk prices are low, a portion of the herd may be culled in summer, before the end of lactation, so that more feed is available for remaining milkers. Capturing this spread enables a more accurate reflection of the impact of populations at different times of the year on total energy requirements. As the pasture quality data used for dairy farms in AIM differs in metabolisable energy (ME/kg DM) for every month of the year, it is important to know numbers of animals removed from the national population each month, rather than taking an average date. This is because a difference in ME means there is a difference in dry matter requirements (and therefore methane emissions) for the animals to maintain the modelled level of productivity. The same principle of staggered birth dates could be applied (using the spread reported in Milestone report 2), but that is more complex to change in the model, causing differential aging of animals and also affecting timing of pregnancy and lactation and growth curves.

7.2.2 Mortality rate

The 2.1% mortality rate (Figure 5) of mixed age cows reported by Compton (2018) matches that reported by Xu and Burton (2003), which is the source of the mortality rate currently used in AIM. Compton (2018) also notes that 45% of these losses occur in the calving transition period. Hence, the current methodology used in AIM, where half of the mature cow deaths occur in the calving period and the remainder are split evenly across the year is consistent with this data. In the analysis of Compton (2018) national mortality rates fluctuated between 2.0 and 2.5% (Figure 5).

We propose however, including this death rate as part of the total deaths plus culls to slaughter, as described in the following sections. This is to eliminate potential errors in recording of animals that died on farm as sent to slaughter and vice versa when assessing the monthly distribution of losses in DIGAD.

7.2.3 Percentage replacements, culls, deaths and sales from DIGAD

A widely reported typical New Zealand dairy herd replacement rate (% of milking herd as first calving 2-year-olds) is 22% (DairyNZ 2017). This is derived from cows having an average of 4.5 lactations over their life-time (100/4.5 = 22.2). This number was derived from the DIGAD database for spring-calving dairy herds between June 1990 and May 2003 (Compton 2018). There was a large increase in the national dairy herd size over that time from 2.4 to 3.9 million cows (Livestock Improvement Corporation and DairyNZ Limited 2020), and hence a larger proportion of dairy heifers may have been reared than normal. The replacement rate is only equal to the percentage of death plus culls to slaughter when the milking herd population is stable across years. It is therefore important to determine the number or percentage of culls to slaughter and deaths from the milking herd for population changes in AIM, rather than relying on replacement rates.

Compton (2018) assessed the split of culling (to slaughter), sales and mortality of mixed age dairy cows from 113 dairy herds in four regions of New Zealand in the 2009/2010 season. There was a reported 15.6% of the herd culled to slaughter, 3.4% sold and 2.1% deaths over that year. This gives an annual loss (deaths plus culls to slaughter as required in AIM) of 17.7%. Compton's (2018) total of culls to slaughter plus sales that year of 19% is on the higher end of his reported longer term (1990 to 2012) range for the national spring-calving herd (approximately 15 to 20%; Figure 5). We can therefore assume that Compton's (2018) reported death + culls to slaughter of 17.7% in the 2009/10 subpopulation is also likely slightly higher than the long-term national average.

For the 1990 to 2012 dairy seasons, the rate of culling to slaughter plus sales was inversely related to the inflation-adjusted milk price, fluctuating between approximately 15 and 20% of the herd (Cullen 2018; Figure 5). If the 2.0 to 2.5 death rate (Figure 5) is added to this, it would give an average total removal from a herd, including sales, of 17 to 22.5%. If the 2009/10 sales of 3.4% is then subtracted, it would provide a total loss from the national herd (deaths plus culls to slaughter) of 13.6 to 19.1%. We undertook an analysis of mature cows (including those non-pregnant and non-lactating) with DIGAD data from 1990 to 2019 and calculated a similar range of 11 to 20% of the herd dying or culled to slaughter per year, averaging 15.9%. This is described further below.

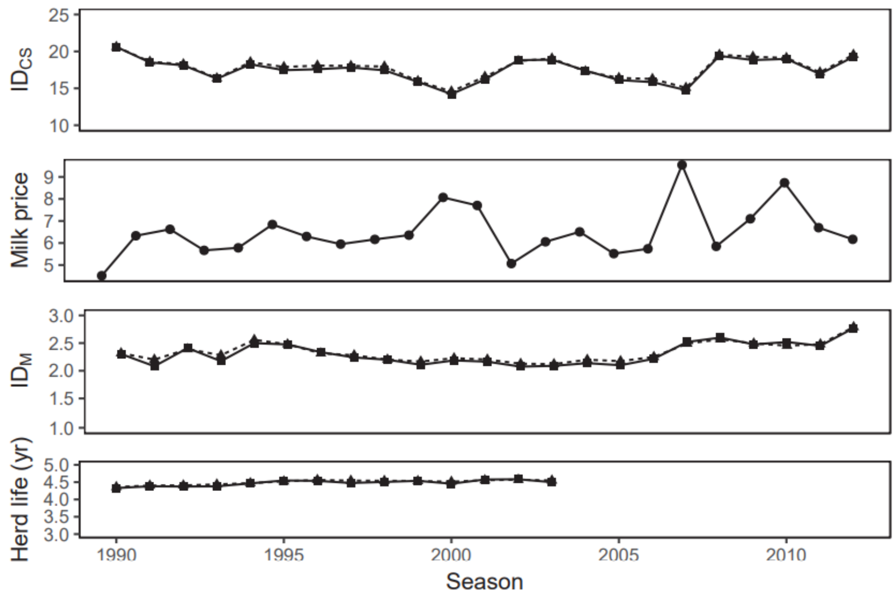


Figure 5: Incidence density (% of herd) of culling to slaughter plus sales (ID_{CS}) and mortality (ID_M) and median herd life (number of lactations per cow) in spring-calving New Zealand dairy herds, and inflation-adjusted milk price, by dairy season from 1990 to 2012. From Compton (2018).

7.2.4 A comparison of industry data with population statistics from AIM

Prior to 2017, national cow slaughter statistics were compiled as a combined total of beef and dairy cows, and as noted in a previous section, the classification of a cow by age for those statistics also differs from that used in AIM. Similarly, the total number of mature cows in DIGAD do not match those sourced from APS and used in AIM.

In the analysis of death, culling to slaughter and sale rates, Compton (2018) removed a large proportion of atypical herd data from DIGAD to derive the numbers reported in Figure 1 and quoted elsewhere in this report. This included data from herds in their last season of production, herds of 50 or fewer cows, or where it appeared there was inaccurate recording of culling, with no calvings within 30 months of the previous, or 0 or >60% of the herd culled. However, AIM needs to represent all herds, rather than just typical herds. We therefore undertook similar analyses, but only removed data that appeared to be recorded inaccurately rather than also removing unrepresentative herds.

For July 2017 to June 2020, we compared our calculations from DIGAD data with potential losses from the mature cow population in APS. The data required for calculating losses (removal) from the mature cow population in APS over 2017/18 are shown in Figure 6.

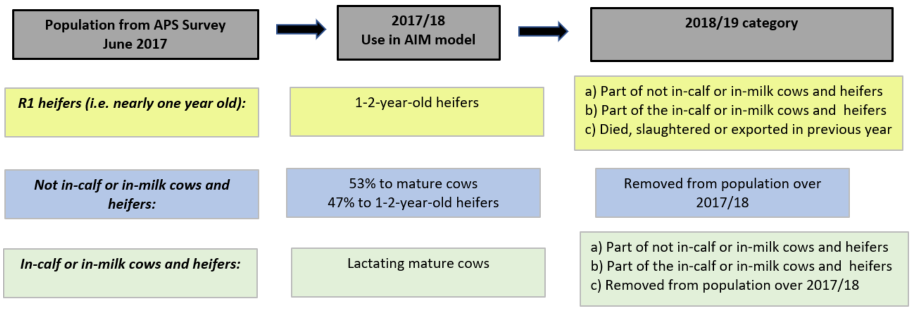


Figure 6: Flow of dairy heifers and cows from the APS survey in June 2017 and their use in AIM in 2017/18 and fate for the following production year (2018/19).

The initial population of mature cows in AIM for 2017/18 for example, is equivalent to "the total in-calf or lactating cows and heifers" + 53% of the "not in-calf or lactating cows and heifers" from APS on 30 June 2017. **The total mature cow losses** from this population over the 2017/18 year is 53% of the 'not in-calf or not in-milk cows and heifers' + category c in the green box in Figure 6.

The population of mature cows in 2018/19 (i.e., in-calf or in-milk cows and heifers plus 53% of the not in-milk or in-calf heifers) is equal to the lactating mature cows in 2017/18 that did not die or get culled to slaughter plus the 1-2-year old heifers in 2017/18 that did not die, get slaughtered or exported. We can therefore back-calculate **losses from the in-calf or in-milk cow and heifer population** over 2017/18 (category c in the green box of Figure 6) by determining the remaining 1-2-year heifers on 30 June 2018 (as per section 6 of this report) and adding this to the in-calf or in milk population from APS on 30 June 2017, then subtracting the 'in-calf or in-milk cows and heifers' in APS or 30 June 2018 and 53% of the 'not in-calf or in-milk heifers' in APS on 30 June 2018.

Table 4 shows such analyses of losses from the mature cow population in AIM from July 2017 to June 2020 compared to losses calculated from DIGAD. Although the percent lost in DIGAD is more consistent than that calculated from APS, the average over the years 2017 to 2019 reported here is similar for both data sources.

Compton (2018) notes that the DIGAD database was designed primarily to store records on calving, breeding and milk production, for the purposes of genetic evaluation. Farmers have not been required by law to record removed animals until the National Animal Identification and Tracing (NAIT) Act was introduced in 2012, and hence data on animal removals prior to this are likely to be less accurate than present. We therefore propose using APS data as a source of data to estimate losses of dairy cows from the national herd to overcome these data discrepancies and to align with the data source currently used in AIM.

The APS data only represent a full census for six years from 1990 to present, with intermediate years using a survey, and no survey for three of those years. Given this, and that the proportion of 'not in-milk or in-calf cows and heifers' that are cows is only known for 6 of these years, we suggest using an average culling to slaughter plus death rate across all years from APS data of 16.9. This is to be combined with the average timing of culling from DIGAD, as described in the following section.

Table 4: Calculated annual loss rates (% of initial population culled to slaughter plus deaths) from the national mature dairy cow population (including empties) on 1 July calculated from APS data and compared to DIGAD mature cow loss.

Year starting 1 July	Initial mature cow population	In-calf or in-milk cows and heifers	Remaining 1-2-year-old heifers on 30 June	Following year initial mature cow population	APS calculated mature cow loss (total)	APS calculated total mature cow loss (%)	DIGAD mature cow loss (%)
2017	5,263,649	5,043,813	819,424	5,218,700	864,372	16.4	18.0
2018	5,218,700	5,010,334	822,551	5,052,842	988,410	18.9	17.9
2019	5,052,842	4,876,113	887,319	4,932,086	1,008,074	20.0	17.9
	Average 2017 to 2019:					**18.4**	**18.0**
	Average 1990 to 2019:					**16.9**	**15.9**

7.2.5 Monthly distribution of mature cow losses

When comparing StatsNZ dairy cow slaughter statistics with DIGAD dairy cow culls for 2019/20 (Table 5), there is a strong alignment with both the total numbers and the proportion in each month. The higher number of culls in DIGAD compared to StatsNZ slaughter statistics is a reflection of the difference in classification of heifers between the two data sources, with every female aged two or over being classified as a mature cow in the data we collated from DIGAD. We therefore propose to use the sum of “went to the works, died and culled” in DIGAD to determine the spread of total mature dairy cow losses from the national herd over a year.

The timing of losses from the national herd has become earlier since the early 1990’s, with a smaller proportion in June and a higher proportion in March, April and May (Table 6). Although it is acknowledged that the percentage of losses from the initial population varies across years and this should ideally be captured in AIM, it is currently difficult to capture this data accurately and have it readily available each year. The recorder errors in DIGAD would require considerable effort to ‘clean up’ each year, and this could also potentially introduce bias. Table 7 shows that when applying the 5-year average loss distribution from Table 6 to a 16.9% total annual loss rate, the monthly remaining population as a percentage of the initial population varies little across the 5-year periods shown.

Table 5: Losses of New Zealand dairy cows from July 2019 to June 2020, based on StatsNZ slaughter statistics and DIGAD data. Total loss is the sum of "went to works", died and culled. Here culled is as specified by those inputting data in DIGAD, and is therefore open to misinterpretation, potentially not only including those sent for meat processing but in some cases, potentially including some euthanised on farm or sold to another farm.

Month	DIGAD Went to works	DIGAD Died	DIGAD Culled	DIGAD Total loss	StatsNZ Slaughter
July	53	16,021	34,392	50,466	42,483
August	41	26,492	23,401	49,934	24,545
September	16	21,784	30,142	51,942	30,745
October	36	18,721	36,736	55,493	37,393
November	23	9,336	25,418	34,777	30,286
December	21	8,417	26,630	35,068	27,008
January	88	9,173	41,656	50,917	41,082
February	150	9,286	87,253	96,689	91,239
March	216	11,756	134,539	146,511	136,807
April	111	14,585	118,157	132,853	108,427
May	292	21,404	167,745	189,441	143,772
June	259	15,183	94,114	109,556	91,392
Total	1,306	182,158	820,183	1,003,647	805,179

Table 6: Five year mean monthly distribution (% of annual total losses) of dairy cows (aged 2 years or older) slaughter (went to works), deaths plus culls from July 1990 to June 2020. Sourced from the Dairy Industry Good Animal Database (DIGAD). Dairy cow slaughter statistics (StatsNZ) distributions are also presented for July 2016 to June 2020 averages as a comparison.

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1990-95	6.3	5.9	6.2	5.7	4.3	4.9	6.7	6.8	9.8	12.8	15.1	15.5
1995-00	4.6	5.8	6.0	5.1	4.5	4.7	5.7	7.7	12.0	15.9	18.6	9.4
2000-05	5.2	5.4	5.5	4.9	3.5	3.2	4.1	6.2	10.6	16.8	24.7	10.1
2005-10	5.5	5.2	4.8	4.6	3.5	3.4	4.3	6.5	12.7	15.5	24.2	9.8
2010-15	4.9	4.5	4.6	4.8	3.8	4.0	4.6	8.0	13.6	14.1	23.6	9.6
2015-20	5.3	5.3	5.3	5.0	3.6	3.6	5.0	8.2	12.7	14.5	21.9	9.7
Slaughter	4.5	3.3	3.7	4.3	3.9	3.8	5.1	9.6	15.7	15.6	20.2	10.4
Average	**5.3**	**5.3**	**5.4**	**5.0**	**3.9**	**4.0**	**5.1**	**7.2**	**11.9**	**14.9**	**21.4**	**10.7**

Table 7: Monthly population changes, with data in each month representing the percentage of the 1 July population still remaining at the end of the month, using an average annual loss (deaths plus culls) of 16.9% applied to the long-term average distribution of losses from Table 6.

Year(s)	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
1990-95	98.9	97.9	96.9	95.9	95.2	94.4	93.3	92.1	90.4	88.3	85.7	83.1
2000-05	99.2	98.2	97.2	96.4	95.6	94.8	93.9	92.5	90.5	87.8	84.7	83.1
2005-10	99.1	98.2	97.3	96.5	95.9	95.3	94.6	93.6	91.8	89.0	84.8	83.1
2010-15	99.1	98.2	97.4	96.6	96.0	95.4	94.7	93.6	91.5	88.9	84.8	83.1
2015-20	99.2	98.4	97.6	96.8	96.2	95.5	94.7	93.4	91.1	88.7	84.7	83.1
Average	**99.1**	**98.2**	**97.3**	**96.4**	**95.8**	**95.1**	**94.3**	**93.0**	**91.0**	**88.5**	**84.9**	**83.1**

Commented [TF6]: Was 1995-2000 deliberately missed from this table? May need to check for follow on errors if these averages are used further in the analysis. Also this goes into the executive summary.

7.2.6 Proposed method for culling from the mature cow population

Due to the uncertainties pertaining to DIGAD data on total culls prior to 2012, we propose using the proposed average loss (deaths plus culls to slaughter) of 16.9% calculated from long-term APS data (Table 4) to represent the total loss of the initial population of dairy cows present on 1 July for all years. This has been combined with the long-term average monthly distribution of losses (Table 6), to produce information to be used in AIM in Table 7.

AIM can then use the long-term average shown in bold in Table 7 to determine the proportion of the starting population of mature cows (including the 53% of the empty cows and heifers) still present each month. This approach could be reconsidered in future years if effort is made to address availability of robust data on an annual basis.

The starting population would begin on 1 July, with lactating or in-calf cows and 53% of the not in-calf or lactating cows and heifers from 30 June of the same calendar year, with losses (culls to slaughter and deaths) subtracted each month based on the remaining population using the reported long-term average in Table 7.

8 Impacts of suggested changes on enteric methane emissions from the dairy population

8.1 0-1-YEAR-OLD CALVES

Given calves are less than 20% of the dairy population and that they consume less than half of what a mature cow eats, the suggested change would have a negligible effect on total dairy population methane emissions (<0.1%). We therefore did not test the effects in the model, given we know it is this small.

8.2 1-2-YEAR-OLD HEIFERS AND MATURE COWS

The AIM model was used and the code altered to incorporate the suggested changes for all female dairy cattle over 1-year old. Note that the two age classes were modelled in unison, as the suggested changes included changing the timing in which they change age class. The APS population data from 30 June 2018 was used, and losses from that population from 1July 2018 to 30 June 2019 were modelled as described in the previous sections (excluding the changes suggested for calves <1 year old).

Using the current methodology, enteric methane emissions from the New Zealand dairy cattle population for July 2018 to June 2019 were 13613.1 kT CO_2-e/year. The suggested changes result in a 2.6% reduction in these emissions, of 355.7 kT CO_2-e/year, resulting in a revised annual enteric methane emission estimate of 13257.3 kT CO_2-e/year from the New Zealand dairy cattle population.

9 Feasibility of regional estimates

In AIM, regional data on dairy cattle populations at the start of the season (1 July in this case) are supplied by StatsNZ and regional productivity data (annual milk yield and average composition) are supplied by LIC. The regions used in the inventory are: Northland, Auckland, Waikato, Bay of Plenty, Gisborne, Hawkes Bay, Taranaki, Wanganui-Manawatu, Wellington, Tasman, Nelson, Marlborough, West Coast, Otago and Southland (MPI 2021a). However, monthly population changes within a year, pasture quality data and milk distribution curves are based on national level methodology.

Various datasets are available at a regional level, although they do not necessarily define regions as in AIM. In general, the later average birth date in the South Island is to a large degree compensated by later culling dates. Also, when collecting data by region, the bias from missing and incorrect data for some herds in DIGAD or other data sources would increase as the number of herds used in any analysis decreases. We therefore conclude that it is unfeasible to model population dynamics at a regional level at this stage. Previous work showed no advantage at the time to using regional soil drainage classes in AIM (Clark 2008b).

Working with industry to better align data sources such as APS, DIGAD, NAIT and slaughter statistics to the requirements in AIM could enable more reliable regional data in the future. Here we provide some indication of the current and historical data on regional dairy population dynamics.

9.1 FEED QUALITY DATA

The availability of representative data on feed quality would require representative sampling from each region. There are historical data available on the quality parameters required for the inventory (metabolisable energy, nitrogen and digestibility). However, pasture quality changes across years, dependant on management, pasture species and climate. A thorough review of existing regional data would need to determine sampling technique, the reason for collection (i.e., was it typical pasture or was it experimental data for a novel pasture mix) and year. Further pasture data collection would need to occur across multiple years to account for the inter-year variability in pasture quality.

9.2 MEDIAN CALVING DATE

The median calving date summarised annually by LIC does not currently breakdown regions at such a fine scale as used in AIM, although data may be available to do so. However, LIC data shows variation across regions in median calving date of approximately 3 weeks (Figure 7). If calving date was applied at a regional level, the milk supply distribution and feed quality would also need to be considered by region.

The effects on emissions of the regional variation in calving date would be partially cancelled out by similar variation in culling date. Although we see variation across regions, and across years within regions in calving date (Figure 7), this variation appears to cancel each other out when looking at a national scale (Table 2). This can be attributed to the earlier calving date within regions over time occurring while the proportion of cows in the South Island (which have a later median calving date) has increased.

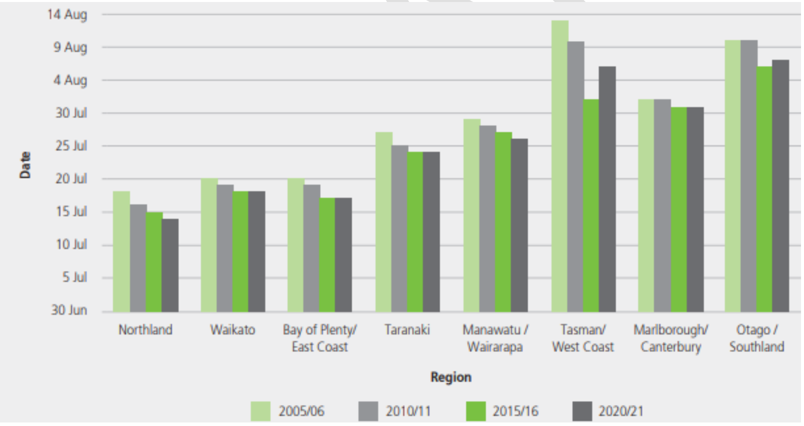


Figure 7: Trend in planned start of calving date for cows (excluding first calvers) by region. From Livestock Improvement Corporation Limited and DairyNZ (2020).

9.3 REGIONAL VARIATION IN TIMING OF ANIMAL LOSSES

9.3.1 DIGAD data

The DIGAD database collects data for individual animals, identifying what herd they are from. This can be combined with additional tools and information to determine what region the herd is from. Such data could not be provided in the time frame and budget of the current project.

Compton (2018) noted that the incidence of culling and mortality in New Zealand dairy herds recorded in DIGAD could be biased due to missing or incorrect recording and suggests this bias would increase as the number of herds used in any analysis is decreased, hence comparing different regions or years could increase this bias. His analysis did not indicate regional differences in rates of culling or mortality.

9.3.2 Industry expert estimate

Some indication of regional variability in losses from the dairy herd were estimated by Jack Hooper (LIC) for spring calving herds (Table 8). In line with the earlier calving in the North than South Island, losses also occur earlier in the North Island, with peak culling approximately one month earlier.

Table 8: Estimated timing of loss of cows (deaths, culls plus sales) from the dairy herd, as a percentage of total annual losses.

Region	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
North Island*	3	8	2	1	1	8	3	19	47	5	2	1
South Island**	1	8.5	4	0.5	1	1	1	0	3	57	19	4

* Assumes a System 2 dairy farm.
** Excludes the West Coast and Nelson/Marlborough. Assumes a System 4 (more intensive) dairy farm.

9.3.3 Slaughter statistics

For slaughter statistics, historical mixed age dairy cow data are not available per region. Data where regions are combined are available for dairy plus beef cows as, shown in Figure 8. Note that the beef cow population is only approximately 20% that of dairy cows, and as discussed earlier, the definition of a cow here differs to that of a mature cow in AIM. Peak cow slaughter (dairy + beef) was in May at both ends of the country (Figure 8), agreeing with data in DIGAD (Table 5). The extended peak, considering the three highest slaughter volume months, was a little earlier in the upper North Island (March to May) than the lower South Island (April to June), reflecting the earlier calving and drying off in the North Island.

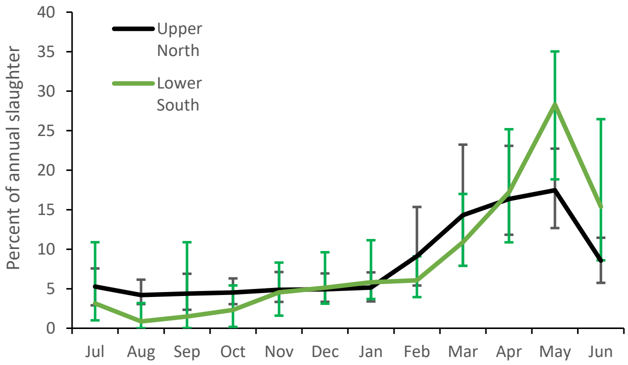


Figure 8: Regional comparison of monthly cow slaughter (average of July 1990 to June 2020). Upper North represents all cows (dairy plus beef) from Northland, Auckland, Waikato and the Bay of Plenty regions, while Lower South represents cows from Otago and Southland. Error bars show range. Data from StatsNZ.

Figure ~~Figure~~ 9 shows the monthly distribution of total bull (includes dairy plus beef bulls) slaughter for major dairy regions in the Northern North Island (Northland, Waikato, Auckland, Bay of Plenty) and South Island (Canterbury). The Northern North Island total numbers are divided by 10 to allow comparison on the same scale, and regional data were not available specifically for dairy bulls from StatsNZ.
Both regions show a roughly similar pattern, peaking in December/January for the Northern North Island and January/February for Canterbury.

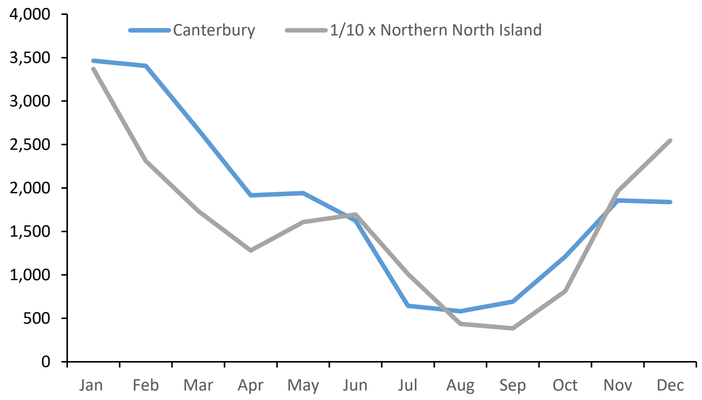


Figure 9: Regional comparison of monthly bull (beef plus dairy) slaughter numbers (average of 1990 to 2018). 1/10 x Northern North Island represents the total kill for Northland, Auckland, Waikato and the Bay of Plenty regions, divided by ten.

10 Future considerations for industry data

Although this work has used industry data to provide a closer representation of dairy population dynamics in AIM, there are a number of inconsistencies amongst data sets and opportunities to clarify how animals are classified that could enable further improvements to, and confidence in, the dairy population methodology in AIM in the future. As noted earlier in this report, base population data are derived from the APS survey, but the imputation levels for dairy cattle can be rather high.
There is a need to investigate how this aligns with other industry data sources and the definitions used for different stock classes and their fates and to ensure that data are recorded as accurately as possible and are available each year. All of the issues noted in this report would need investigation before consideration of modelling of population changes at a regional level or to consider inter-year variability in the timing of culling.

It would be useful to discuss with managers of these databases the potential to better align these data to fit the needs of the inventory model to capture population dynamics that will have a major impact on emission estimates. Then, once any changes are implemented, the best source of future data can be determined. Potential incentives for farmers to undertake accurate record keeping should also be considered. Farmers need to be convinced that any additional effort required for accurate recording will be of benefit to them. Some questions regarding data sources are outlined below.

10.1 APS SURVEY

The proportion of "in-calf or lactating cows and heifers" compared to those that are "not in calf or lactating" on 30 June appears high. It is unclear why they were not culled when the herd was dried off or after pregnancy testing. Given they are not lactating, we assume they are most likely to be culled. Amending the APS survey questionnaire could help clarify how these cattle could best be represented and modelled in AIM, e.g. split into heifers versus cows and whether from spring or autumn or split-calving herds and their likely fate (e.g. to be slaughtered or other fate).

Similarly, with the survey taken on 30 June, the age of calves born February to end of June that are only a few months old end up being classed as 1 year-old from 1 July. It would be useful to understand the proportion of autumn-born cattle in each age class each year.

Some clarity on how or if farmers are recording dairy heifers to be exported is also required.

Some clarity is needed on whether dairy bull calves to be used for breeding at a later age are classified as part of the "dairy bulls to be used for dairy breeding" or as part of the "all other dairy calves", as they would not be used for breeding until they are at least one year old.

Commented [TF7]: I wonder if this is unrealistic to think that we can get to one source of the truth? Although NAIT may be our best hope, but still has a long way to go to be sound on accuracy? The main reason is always going to be conflicting uses of the data and historically reference. While I agree to aim for full alignment is the best outcome I wonder if there could not just be a process for better estimates from looking at multiple data sets aligned and creating a process to calculate this more accurately. Dairy Stats already uses some of these processes on an annual basis to get the best estimate of values across the country with various breakdowns. Could this be calculated at the same time as Dairy Stats?

Commented [TF8]: Carry over cows can often be part of this data. Not sure on the numbers nationwide but certainly some enterprises have these as part of their operations. Some use them as they have shifted from traditional sheep and beef to sheep and dairy grazing as part of pasture management.

10.2 SLAUGHTER STATISTICS

Determine if there is potential to provide more clarity on the cut off age between heifers and cows at slaughter to align with APS data.

10.3 DIGAD

Ensure the animal fates to select are clearly define with no potential for overlap. Consider how to prevent farmers re-using ear tags on different animals and undertake accurate record keeping.

10.4 NAIT

Determine how much certainty is there now and going forward in the accuracy of data on the fate of dairy cattle such as timing of births, deaths and slaughters for each stock class and the availability of this data in a form and in a time frame suitable for use in AIM.

Commented [TF9]: Stock are defined as dairy or beef in the NAIT system. Can this information be extracted in the future to differentiate dairy and beef cows for example.

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