The north-west Queensland Monsoon event of 26 January – 9 February 2019:

report of a landholder survey into impact and recovery

December 2019

Queensland Government

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North-west Queensland Monsoon impact and recovery survey report

Executive summary

Forty percent of north-west Queensland's grazing lands were exposed to an extreme weather event in early 2019. Flooding and inundation resulted from record rainfall associated with a Monsoonal trough between 26th January and 9th February 2019. This flooding, wet conditions and cold weather caused the death of an estimated 457,000 head of cattle, 43,000 sheep, 710 horses and over 3,000 goats across 11.4 million ha. Approximately 22,000 km of fencing and 29,000 km of farm roads and tracks were destroyed or damaged in conjunction with riverine and landscape erosion. Further damage to infrastructure included 2,320 km of poly pipe and 1,350 tanks and troughs destroyed or damaged, the loss of farm machinery such as motorbikes and graders, equipment such as tools and generators, stock and domestic dams, livestock handling facilities, sheds and houses.

Primary producers have been accessing Special Disaster Assistance Recovery Grants (SDARG), and find these simple to access and very useful. Some survey respondents indicated they were not able to access grants as they did not qualify as primary producers, despite owning livestock.

Survey respondents identified a lack of pasture growth following the flooding as a key issue, and a limitation to their ability to restock. Most had replaced and repaired fences but had not yet moved onto other infrastructure. Nearly 70% of destroyed or damaged fences had been replaced by the end of September 2019, and 24% of cattle and 20% of sheep restocked. Few horses (3%) and no goats had been replaced. The majority of restocking and repairs had been conducted by respondents who had already received a grant.

Respondents were interested in receiving more information on pasture recovery, erosion control, technology and general businesses information. They also identified concern over the spread and increase of weeds such as prickly acacia, parthenium, noogoora burr and rubber vine. Their strong preference was to receive information by email, whilst websites, small groups and property visits were also preferred. They would prefer to be provided this information by the Department of Agriculture and Fisheries (DAF), Queensland Rural and Industry Development Authority (QRIDA), AgForce, Local Government, Natural Resource Management (NRM) groups and the North Queensland Livestock Industry Recovery Agency (NQLIRA).

Background

Severe weather conditions across north-west Queensland persisted from 26th January – 9th February 2019 leading to flooding, livestock losses, infrastructure damage, erosion, environmental impacts and economic disruption. These conditions were due to a slow moving Monsoonal trough which developed to the north of Australia and intensified as it moved over Cape York Peninsula towards Townsville and then inland towards Mt Isa. Once this trough was to the west of Cloncurry, it became almost-stationary. The resulting rainfall totals were the highest on record over much of this area (Figure 1), extended for a week to 10 days, and led to extensive flooding across the region (Figure 2).

These wet conditions were coupled with low day-time temperatures (Figure 3) and strong winds under thick and low cloud cover[1]. Pastures were severely damaged and there was limited to no natural fodder for livestock within paddocks. The Shires of the Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton were disaster declared to ensure people isolated by the flooding were safe, to provide assistance to deliver hay and other fodder to surviving livestock, for the disposal of livestock carcasses before diseases became a problem, and enable the region to begin the recovery process.

[1] http://www.bom.gov.au/climate/current/statements/scs69.pdf

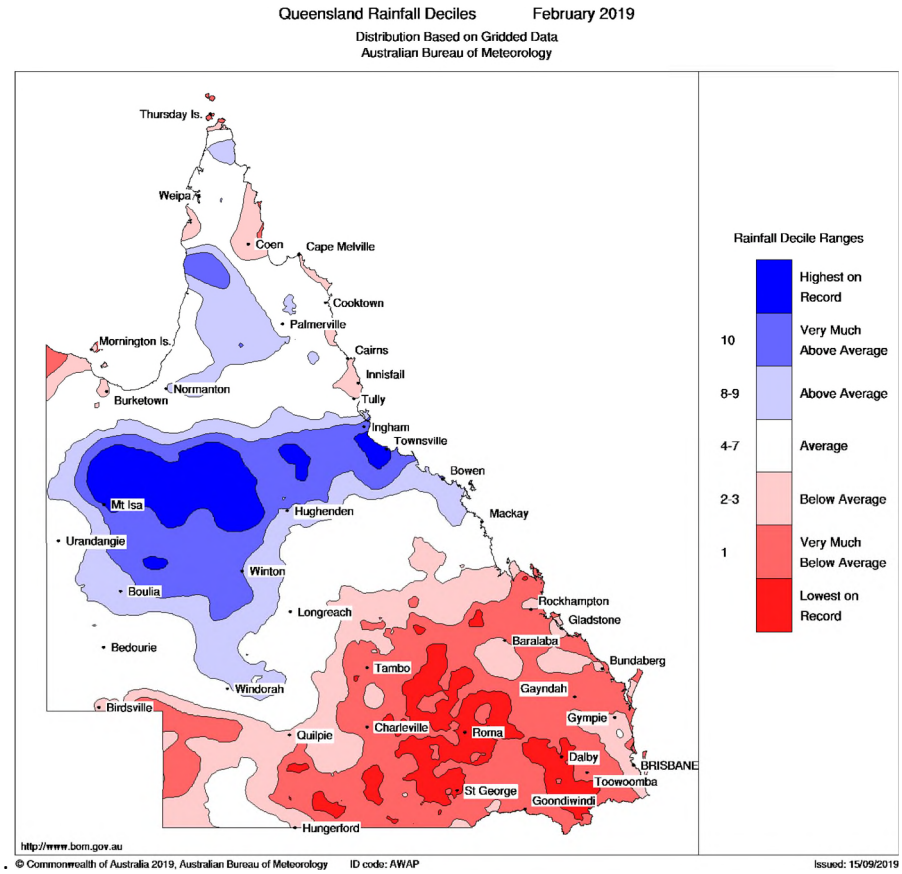

Figure 1. Rainfall totals were the highest on record under the Monsoon trough across north-west Queensland in February 2019.

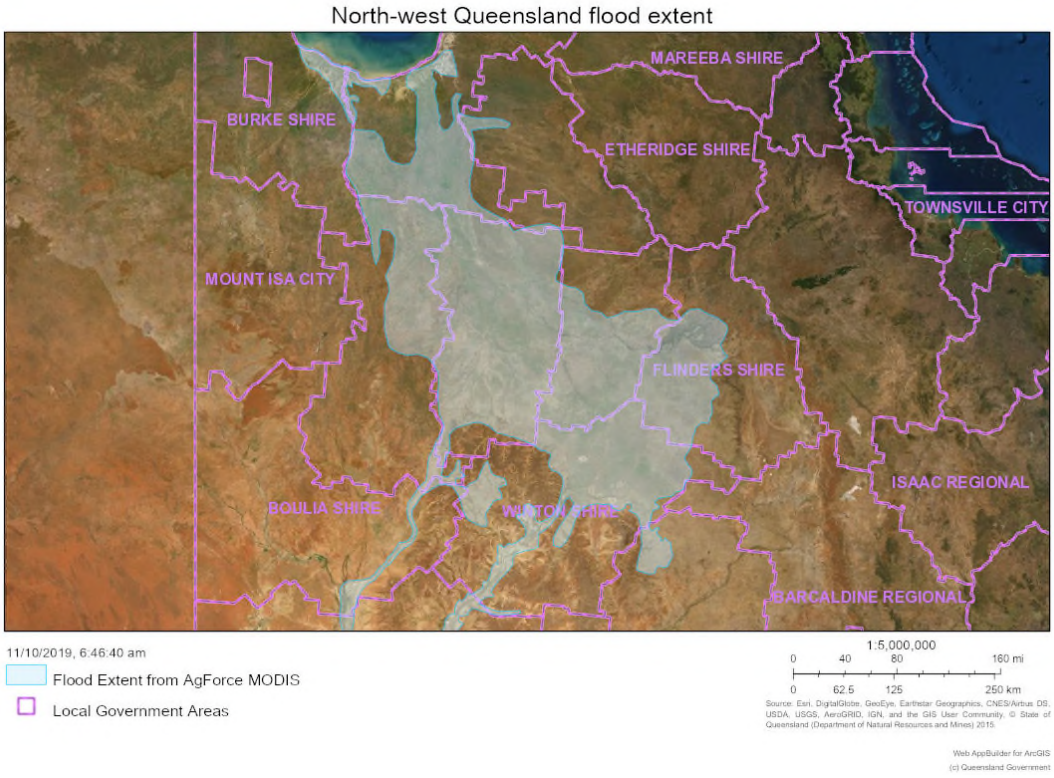

Figure 2. Record rainfall totals led to extensive flooding across north-west Queensland in February 2019. Data source: AgForce Queensland.

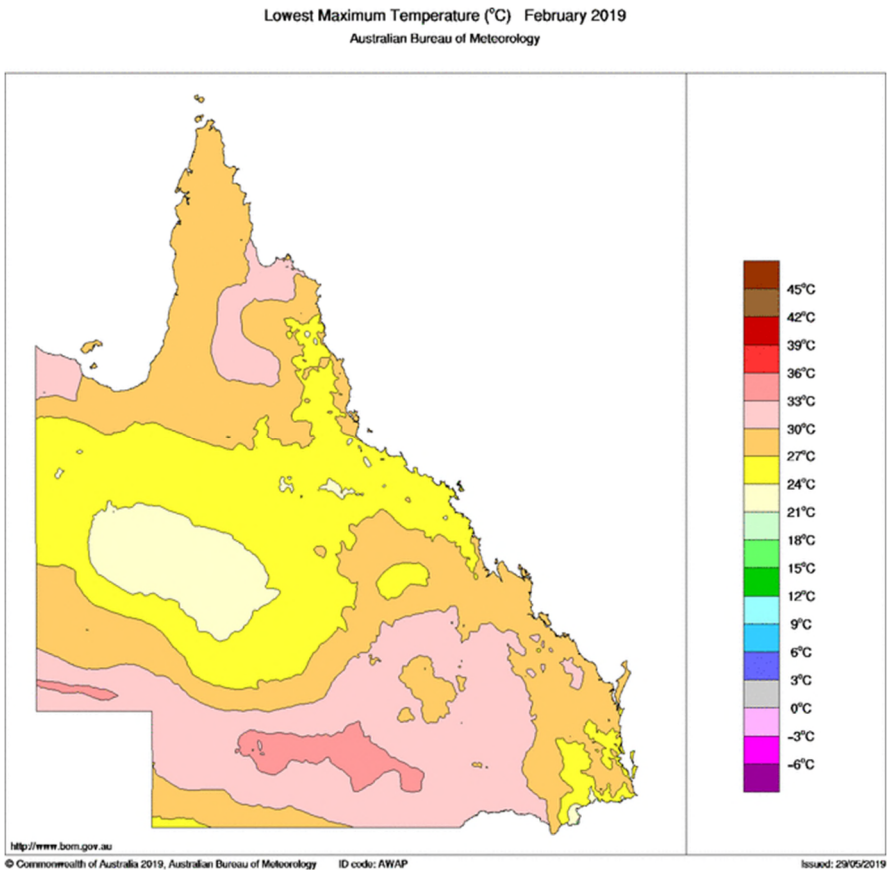

Figure 3. Day-time temperatures were very low for the middle of summer under the Monsoon trough across north-west Queensland in February 2019.

There was strong and sustained media attention of the event, as stories started to emerge of the extent of the flooding and weather conditions[2]. Initial estimates of total cattle losses were difficult to ascertain, with landholders/livestock owners unable to access their paddocks due to flooding and boggy conditions. Early estimates were between 300,000[3] and 500,000[4] head with more than 660,000 head possible[5].

There was a need to refine the estimate of livestock losses and infrastructure damage once landholders had mustered their livestock between April and July, started repairs to fences and roads and were able to view other infrastructure damage across their properties. The Department of Agriculture and Fisheries (DAF) collaborated with Local Governments, AgForce, Queensland Rural and Industry Development Authority (QRIDA) and the North Queensland Livestock Industry Recovery Agency (NQLIRA) [6] to develop an on-line survey of livestock owners as the basis for a more accurate damage assessment. These partners also identified the need to ask about current progress of repairs and recovery on properties, the ability for primary producers to access grants and loans and their information needs to assist them recover. This information was designed to help deliver targeted services and support.

This report represents the best available information and estimates based on livestock owner survey responses between 25 June and 30 September 2019.

[2] https://www.northqueenslandregister.com.au/story/5887687/producers-fear-stock-losses/
[3] https://www.brisbanetimes.com.au/national/queensland/floods-kill-up-to-300-000-cattle-costing-drought-ravaged-farmers-300-million-20190208-p50wjf.html
[4] https://www.bbc.com/news/world-australia-47274662
[5] https://www.abc.net.au/news/rural/2019-04-16/cattle-deaths-tallied-in-north-west-queensland/11002938
[6] Now the National Drought and North Queensland Floods Response and Recovery Agency

Methods

Survey questions (Appendix 1) were developed by DAF in collaboration with Local Governments, AgForce, QRIDA and NQLIRA to meet the information needs of each agency's recovery plans. It was recognised by all partners that a single survey administered by one agency was preferable to industry receiving multiple surveys from different organisations. Questions on livestock losses, infrastructure damage, flood extent and erosion were asked at the property level to allow for spatial analysis and Shire level estimates. Questions on service delivery and recovery were asked at the individual response level to allow for estimates of overall recovery progress and information needs. The survey design balanced organisational information needs with brevity, recognising that livestock owners had limited time to respond as they were occupied by disaster recovery actions such as fencing.

The link to the on-line Survey123 survey was distributed by email by DAF to all registered livestock owners (based on Registered Biosecurity Entity information), with follow-up emails, newsletter and social media articles across the region in partnership with Local Government, Southern Gulf NRM, AgForce and NQLIRA. DAF Industry Recovery Officers (IROs) appointed at the start of August made phone calls and property visits to encourage and assist people to complete the survey. The IROs also recorded secondary information where surveys were not completed to verify spatial analysis, extrapolated estimates and to guide assumptions within the analysis.

Survey data were extrapolated to the Local Government Area (LGA) and regional level based on the following steps:

- LGA grazing area (ha) was estimated from digital cadastral maps
- Flood extent area (ha) was estimated based on AgForce digital mapping
- Pre-flood Stocking Rate (ha/head; SR) and livestock losses (%) were estimated by
  a) Averaging individual property responses within each LGA (see Appendix 2)
  b) Validating these data using a spatial surface derived from all surveys, averaged within each LGA
- Total pre-flood livestock numbers were calculated based on SR and the area of grazing land within each LGA (see Appendix 3)
- Sheep, horse and goat numbers were adjusted using an estimate of the proportion of holdings running these livestock within each LGA
- Minor livestock losses e.g. camels and poultry were not included in the totals
- LGA pre-flood livestock numbers were cross-checked with publically available Australian Bureau of Statists, Queensland Government Statisticians Office and Meat and Livestock Australia information
- The ranking of impacted LGAs was cross-checked with the proportion of properties receiving SDARG grants provided by QRIDA
- Average pro-rata infrastructure impact (km/ha or number/ha) was estimated for properties within the flood extent area (Figure 2, Appendix 4), and extrapolated to the LGA level based on the flood extent area within each LGA i.e. responses outside the flood extent were excluded from the LGA average
- Fence losses were cross-checked with the fence length within the AgForce flood extent intersected with the 2006 Geoscience Australia Topographic 250K dataset
- Road damage was cross-checked with road length within the AgForce flood extent intersected with the Queensland Baseline Roads and Tracks – QDNRME March 2019 dataset
- Survey respondents were provided a number of opportunities to enter comments. These free-form answers were collated as examples of industry's observations
- Statistical analysis was conducted to check for normal distribution and variability of key data (Appendix 5).

Results

Survey return rate

Responses were received for 24% of the 778 properties across north-west Queensland, representing 5.3 million ha of grazing lands (Table 1). There were 126 individual respondents, with half owning multiple properties.

Table 1. Survey return rate for Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Number of properties	Grazing land area (ha)	Response land area (ha)	Response land area (%)	Total responses (property no.)	Property return rate (%)
Burke Shire	21	3,327,837	728,410	22%	4	19%
Carpentaria Shire	43	5,305,941	844,187	16%	10	23%
Cloncurry Shire	59	4,668,724	536,226	11%	15	25%
Flinders Shire	205	3,958,541	425,559	11%	29	14%
McKinlay Shire	157	3,880,829	1,259,053	32%	50	32%
Richmond Shire	131	2,569,030	739,186	29%	47	36%
Winton Shire	162	5,106,000	755,474	15%	34	21%
TOTAL	778	28,816,903	5,288,095	18%	189	24%

Area flooded

An estimated 11,412,736 ha of grazing land (39.6% of total grazing land) was within the AgForce flood extent area. One-hundred and fifty-nine of the property-level responses were within the flood extent.

Most properties reported at least some flooding, with 47% reporting more than a quarter of their area affected, 43% reporting less than a quarter of their area affected and 10% reporting no flooding (Figure 4). Some properties were entirely inundated.

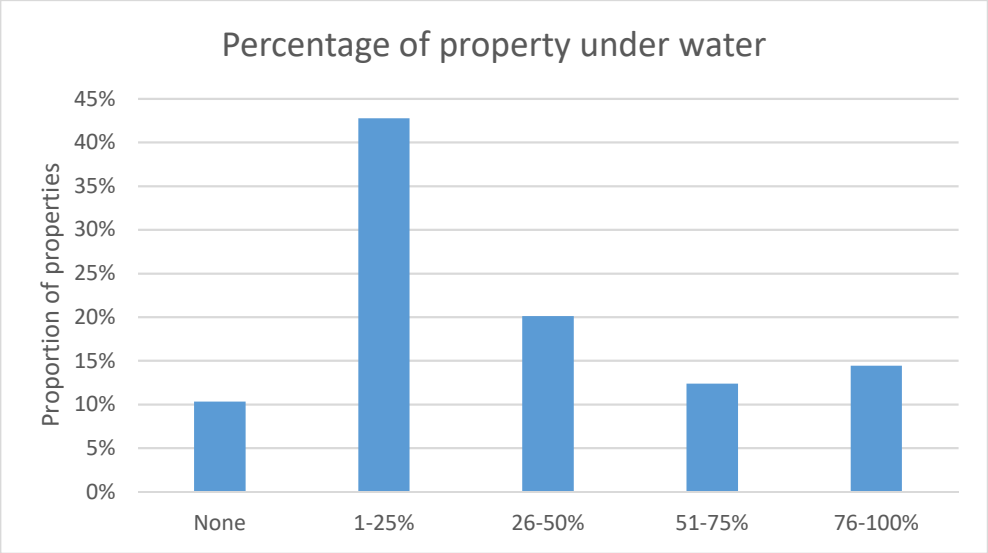

Figure 4. The proportion of properties with no flooding, or 1-25%, 26-50%, 51-75% and 76-100% of the area under water.

Livestock losses

An estimated 504,479 livestock perished across north-west Queensland during the flood event (Table 2). Cattle represented 91% of total livestock losses.

Table 2. Estimated livestock losses within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires based on extrapolated averages from the 189 property survey responses. Values with the ≥ symbol are actual reported data and indicate low confidence in extrapolation of results.

LGA	Total cattle losses	Total sheep losses	Total horse losses	Total goat losses	Total livestock
Burke Shire	0	0	0	0	0
Carpentaria Shire	79,513	0	13	0	79,526
Cloncurry Shire	85,899	0	109	0	86,008
Flinders Shire	21,573	4,002	153	0	25,728
McKinlay Shire	132,614	11,073	57	≥915	144,658
Richmond Shire	68,494	≥2,220	87	≥56	70,857
Winton Shire	69,098	26,208	297	≥2,100	97,702
TOTAL	457,191	43,503	714	≥3,071	504,479

Infrastructure damage

Fences, roads and waters

An estimated 10,200 km of fence were destroyed and 11,800 km were damaged (Table 3). This compares with approximately 28,700 km of fencing within, and 19,500 km outside, the flood extent area based on Geoscience Australia data. Approximately 29,300 km of farm roads were damaged, including graded fence-line and fire-breaks which are used for property access. There were too few damaged bores reported to extrapolate to the LGA or north-west level. Bore drain and tank and trough estimates have not been cross-checked with other datasets.

Table 3. Estimated infrastructure damage within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires based on extrapolated averages from the 189 property survey responses. Values with the ≥ symbol are actual reported data and indicate low confidence in extrapolating results.

LGA	Fences destroyed or damaged (km)	Roads damaged (km)	Poly pipe damaged or destroyed (km)	Bore drains damaged or destroyed (km)	Bores damaged or destroyed (no.)	Tanks and troughs damaged or destroyed (no.)
Burke Shire	0	0	0	0	0	0
Carpentaria Shire	2,721	1,716	136	0	0	72
Cloncurry Shire	2,643	4,000	96	0	≥2	135
Flinders Shire	2,359	4,625	215	117	≥6	187
McKinlay Shire	6,411	8,097	694	836	≥2	488
Richmond Shire	6,087	6,149	893	157	≥0	362
Winton Shire	1,735	4,745	285	0	≥3	103
TOTAL	21,955	29,331	2,318	1,110	≥13	1,348

Other damage

Just over 50% of all properties had additional damage to infrastructure. Of these, the majority were damaged dams, dam by-washes and dam wings. About 10% of all properties had damage to motorbikes, stock yards, sheds, the main house and other dwellings (Figure 5).

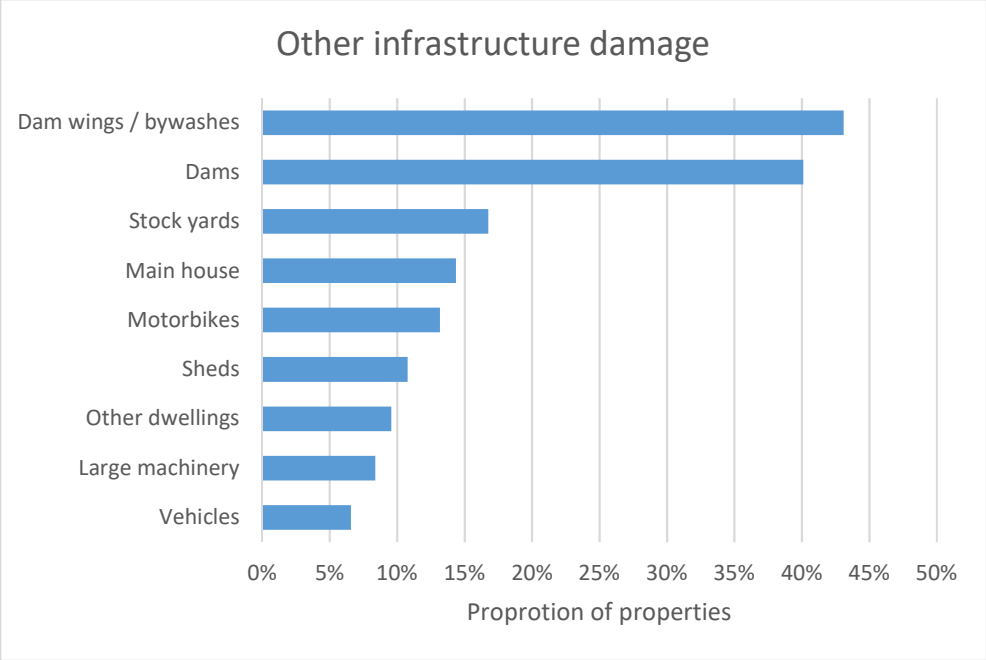

Figure 5. The proportion of properties with damage to other infrastructure.

Five properties reported damage to irrigation or cropping, such as pumps, weirs and earthworks. Others reported the loss of tools and machinery in conjunction with sheds flooding, damage to solar pumps at dams and stored hay.

Soil erosion

Nearly 90% of all properties reported at least some soil erosion, with two-thirds reporting moderate to severe erosion (Figure 6).

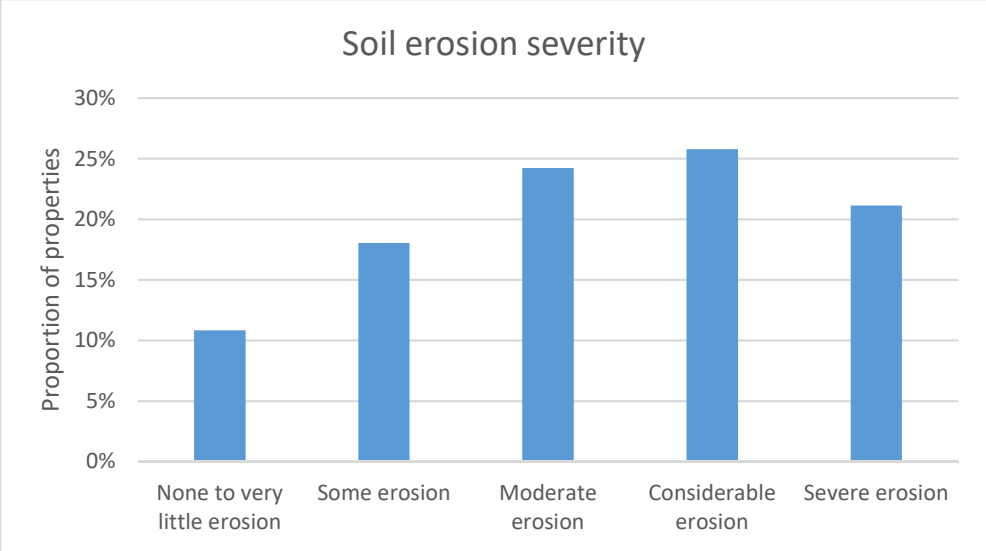

Figure 6. The proportion of properties with none to very little, some, moderate, considerable or severe soil erosion.

Recovery progress

Recovery progress was recorded for each respondent, rather than at the property level. Nearly 70% (2,963 km) of the damaged and destroyed fences were reported to be replaced and repaired. Nearly a quarter of livestock were reported to be replaced, and 46% of people were not currently restocking. Many respondents commented that they have insufficient pasture to restock. An estimated 109,000 cattle and 8,700 sheep had been restocked in total, and 14,500 km of fences replaced or repaired (Table 4).

The majority of restocking and repairs had been conducted by respondents who had already received a grant. For example, respondents who had also received a grant had replaced a total of 23,053 cattle (96%), 2,250 sheep (99%) and 2,458 km of fences (83%).

Table 4. Reported and estimated livestock replacement and fencing repairs completed across north-west Queensland by the end of September 2019.

	Cattle replaced	Sheep replaced	Horses replaced	Goats replaced	Fences replaced or repaired
Proportion reported in survey	24%	20%	3%	0%	66%
Total reported in survey	24,171	2,268	5	0	2,963 km
Estimated total across the north-west	109,030	8,704	21	0	14,558 km

There was an almost even split between livestock for trading and breeding for those who had restocked (Figure 7).

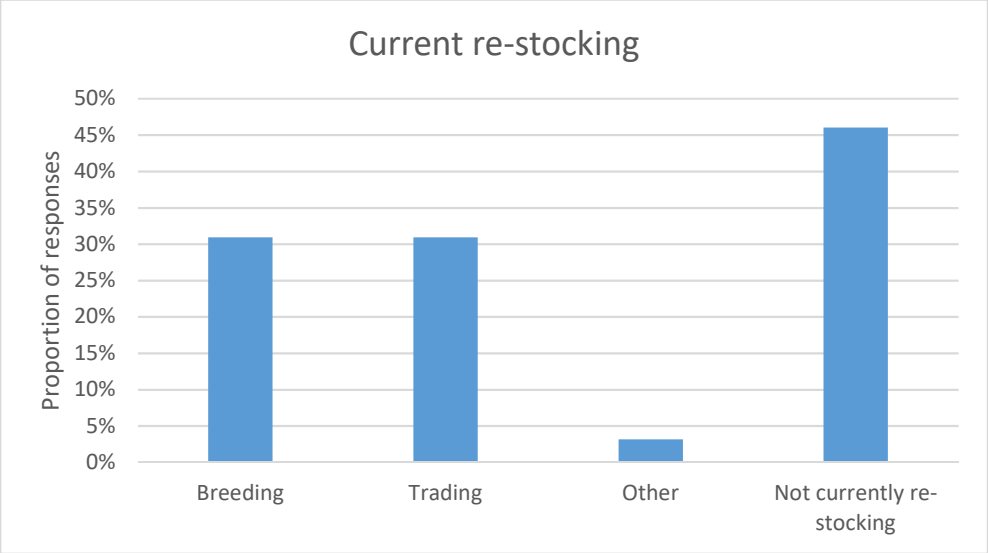

Figure 7. The number of respondents replacing livestock for breeding, trading or other purposes, or not currently restocking.

About 20% of people reported that they had completed the repairs to damaged infrastructure (not including fencing). A further 12% indicated that they had not yet started and the remaining 40% had made some repairs (Figure 8). Nearly a third of people did not respond to this question.

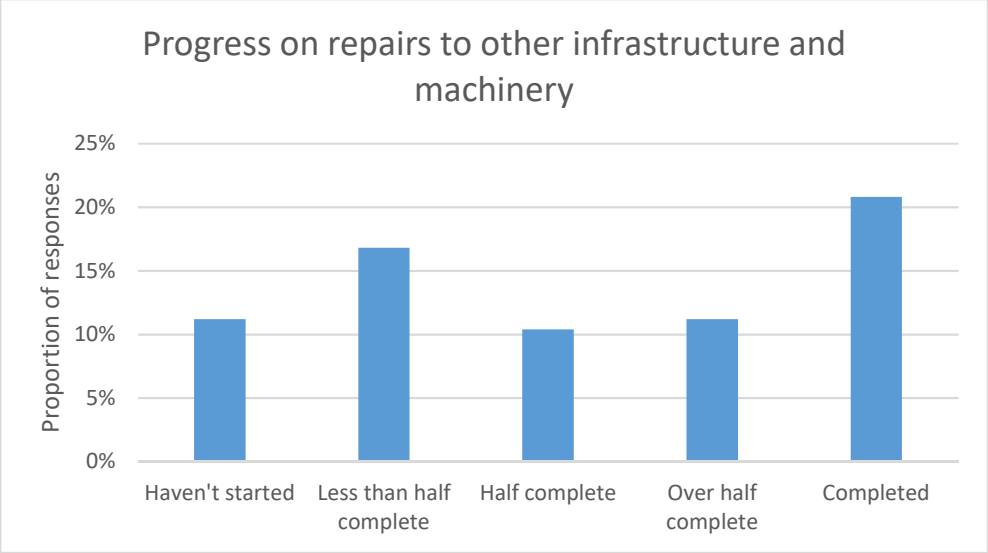

Figure 8. The percentage of people having not yet started, having completed less than half, half, over half or fully completed repairs to their damaged infrastructure.

Grants and loans

Most (83%) people indicated that they had applied for grants, loans or other assistance. The timing of the survey suggests these will have predominantly been SDARG grants of up to $75,000. The majority of people indicated that it was very easy to access these grants and loans and very few reported access being too hard (Figure 9). More than half of the respondents rated the grants and loans as 'excellent' with very few indicating they were 'not very useful' (Figure 10). Disgruntlement was expressed by a small number of respondents who indicated they did not qualify as primary producers under the assessment criteria.

This is consistent with the SDARG approvals as of 1 October 2019, with applications predominantly received within the high-impacted LGAs of McKinlay, Richmond, Flinders and Winton (Table 5). The number of applications also reflects the number of eligible properties within each LGA.

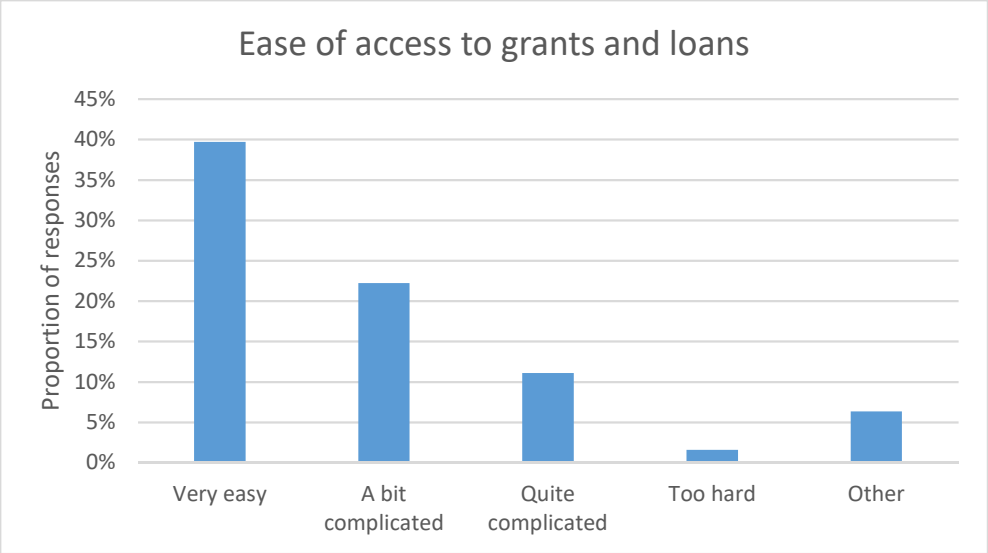

Figure 9. The number of respondents indicating that accessing government grants and loans is very easy, a bit complicated, quite complicated, too hard or 'other'.

Table 5. Number and value of Special Disaster Assistance Recovery Grant (SDARG) approvals within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires as of 1 October 2019.

LGA	SDARG applications (no.)	Total approved ($)
Burke Shire	4	$300,000.00
Carpentaria Shire	22	$1,703,410.00
Cloncurry Shire	40	$3,648,497.82
Flinders Shire	118	$8,479,953.21
McKinlay Shire	132	$12,241,988.46
Richmond Shire	103	$9,131,645.75
Winton Shire	133	$8,725,445.88
TOTAL	638	$44,230,941.12

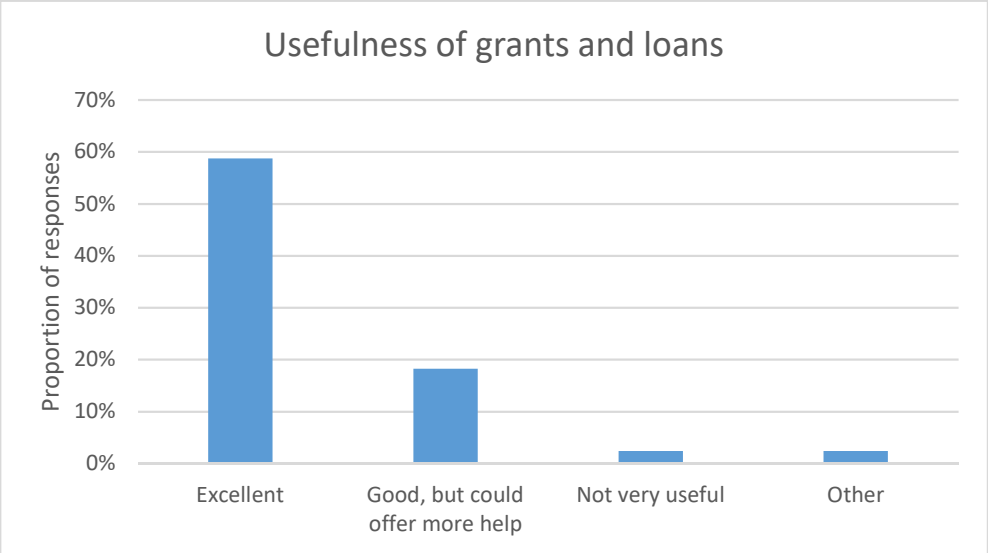

Figure 10.The number of respondents indicating that government grants and loans are providing excellent, good (but could offer more), not very or 'other' support.

Complaints, compliments and comments

Respondents were give a number of opportunities to provide more information or comment on available services. Common themes within these comments included:

- The $75,000 SDARG grants are being used and are highly regarded (Figure 11)
- Some people have accessed donations and volunteers for assistance with fencing and restocking, with both financial and skilled labour assistance highly regarded
- Farm Management Deposit (FMD) liquidation clauses were perceived as preventing access to loans
- The issue of perceived inequities in eligibility criteria was raised a number of times, especially for livestock owners with off-farm income or not owning their own land
- The issue of not being able to value their own labour was also raised.

There were a large number of unsolicited compliments, which can be summarised through the quote "Compliments to all aid givers from physical helpers, food vouchers and governments".

Figure 11. Survey123 word cloud of complaints, compliments and comments on services typed in by respondents.

Information for the future

Information needed for recovery

Livestock owners were asked to nominate what type of information will be most useful to assist them recover. Pasture recovery advice was the top information need (Figure 12), which matches respondents' comments of not having enough pasture to restock. Other highly rated information needs were soil erosion management, technology and general business information.

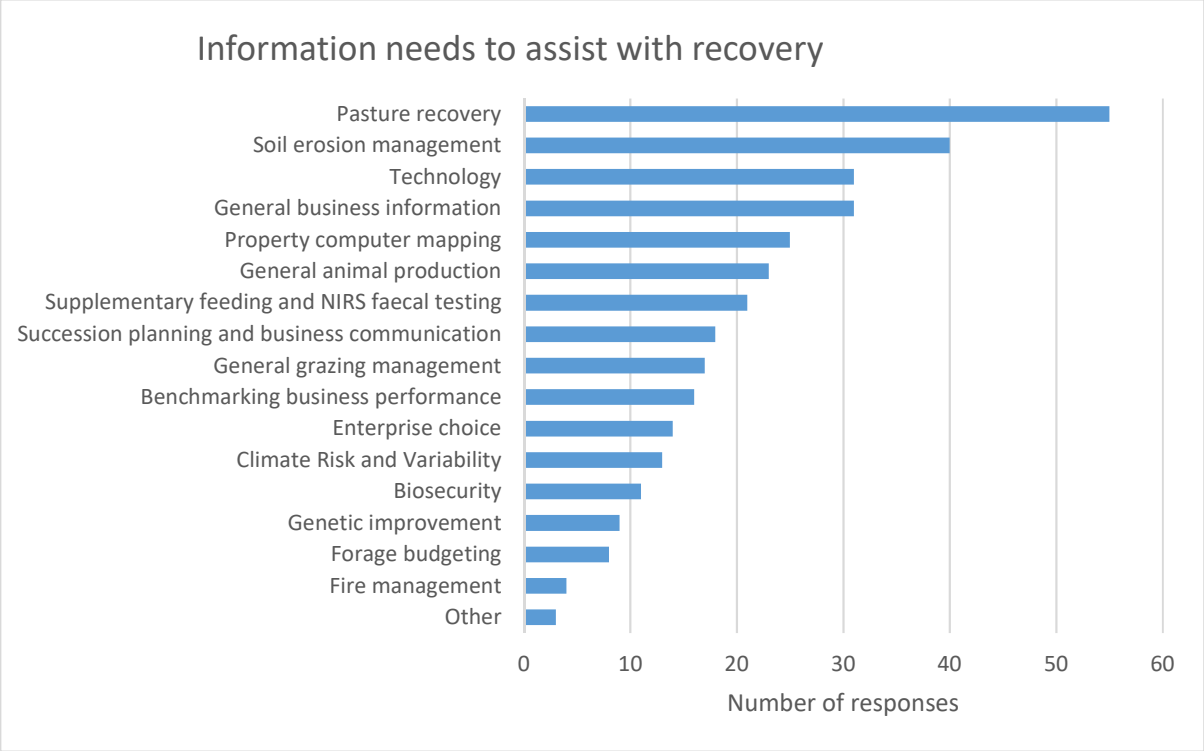

Figure 12. The main information needs identified by survey respondents. People could chose to indicate as many as relevant from a list provided.

Preferred information providers

Livestock owners were asked to nominate who they would prefer to receive information from. DAF, AgForce, Local Government, QRIDA, NRM groups and NQLIRA all rated highly (Figure 13).

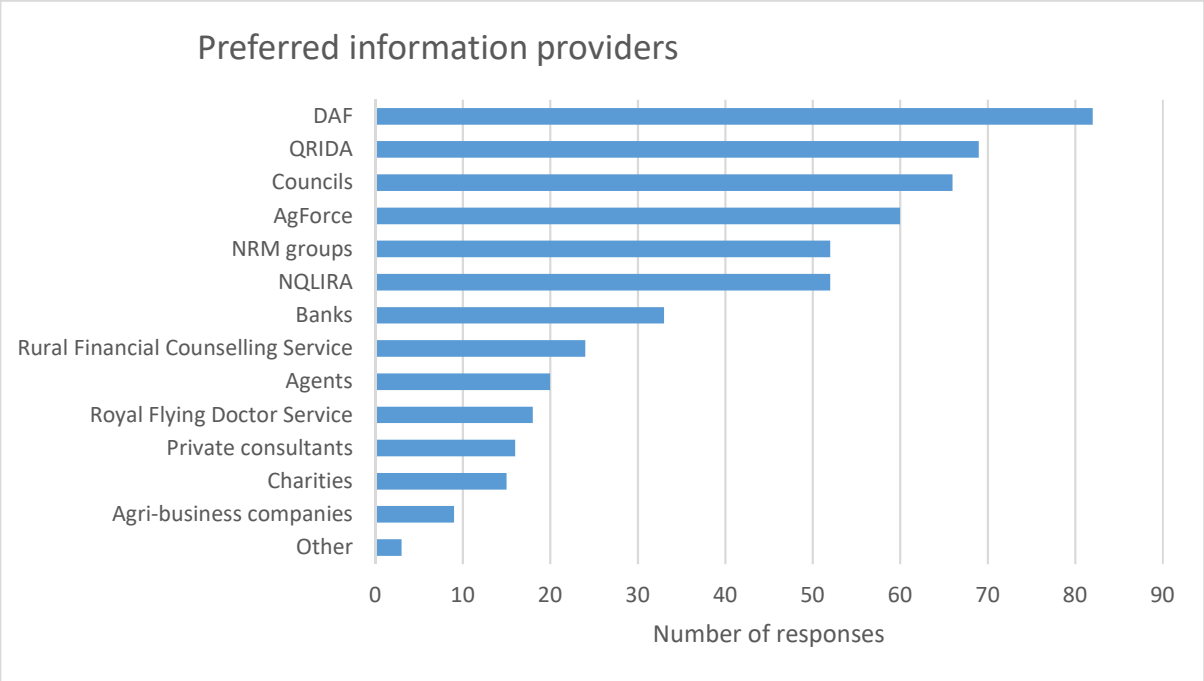

Figure 13. The preferred information providers identified by survey respondents. People could chose to indicate as many as relevant from a list provided.

Preferred information approach

Livestock owners were asked to nominate how they would prefer to receive information. Email was the clear preference, followed by websites, in small groups and face-to-face visits (Figure 14). Large events and in combination with social events were not favoured.

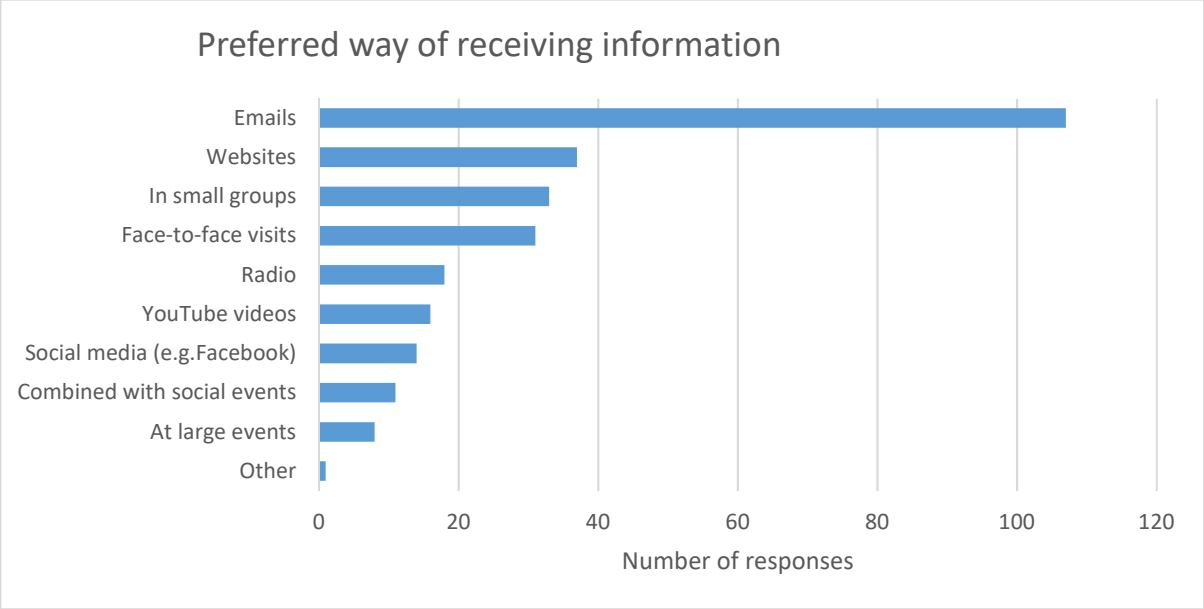

Figure 14. The preferred ways to receive information identified by survey respondents. People could chose to indicate as many as relevant from a list provided.

Other survey information

People completing the survey were given the opportunity to provide other information, such as the spread of pests and weeds. Prickly acacia and the spread of weeds was the dominant issue, with 24 respondents specifically referring to prickly acacia (Figure 15). This indicates concerns over a high risk of increase in density in established areas and spread along flooded areas. Other weeds of concern were rubbervine, noogoora burr and neem trees. Some respondents suggested that specific funding is needed for weed control and eradication programs, and others that biosecurity officers are needed to inspect cattle and fodder for weed seeds and monitor the spread of weeds. A number of respondents also noted the loss of kangaroos and other wildlife. Anecdotally, many people noted the lack of any wildlife, including birds and insects, immediately after the event.

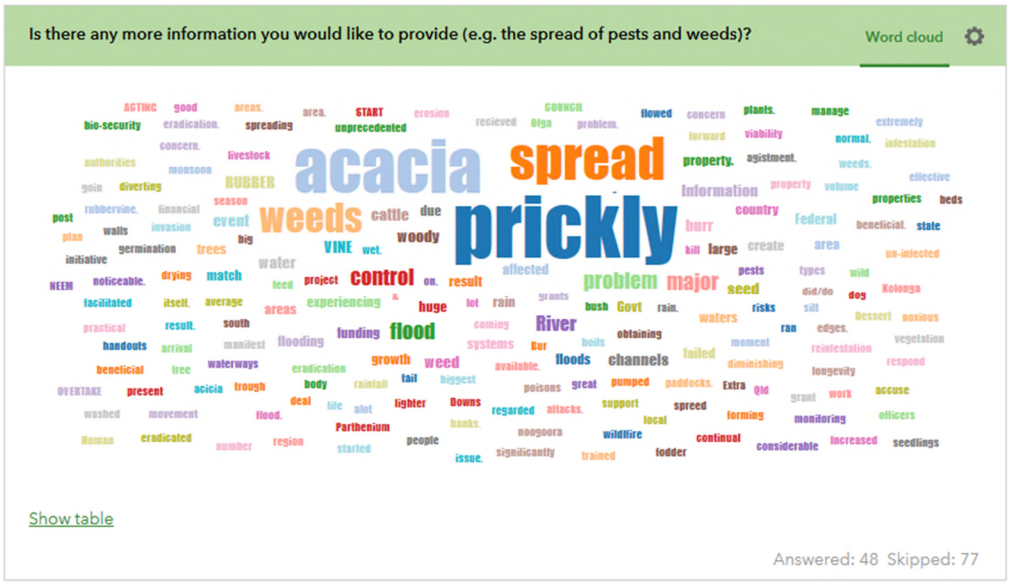

Figure 15. Survey123 word cloud of additional information typed in by respondents.

Discussion and conclusions

The extrapolated estimates for impact at LGA level and overall recovery appear to be accurate based on preliminary statistical analysis and compared with other available data. Given the survey data reported here was obtained after beef producers had time to further assess their damage and muster livestock, these are the best available estimates at the time of publication.

Cattle losses were 30% lower than some early estimates (of up to 660,000 head), but within the bounds of other reported losses (350,000-500,000). Early post-event estimates were relatively accurate when the difficulty in accessing livestock and infrastructure during the first few weeks is considered. Additional data sets, such as summarised livestock losses, the cost of repairs and the value of infrastructure damage from grant and loan schemes, will provide additional validation of impact data in the future.

Approximately one-quarter of cattle had been replaced by October 2019, but nearly half of survey respondents were not seeking to restock. Landholders reported concerns over poor pasture growth and recovery as a key reason for this, and anecdotal evidence indicates the 2019-20 wet season will be crucial for decisions on livestock numbers and hence herd and business recovery. These reported concerns match a relatively low pasture biomass (Total Standing Dry Matter, TSDM kg/ha) across much of the north-west (Figure 16) at the end of September 2019. Observations and local information suggest that a number of properties have sold across the region and been restocked with cattle from drought affected areas.

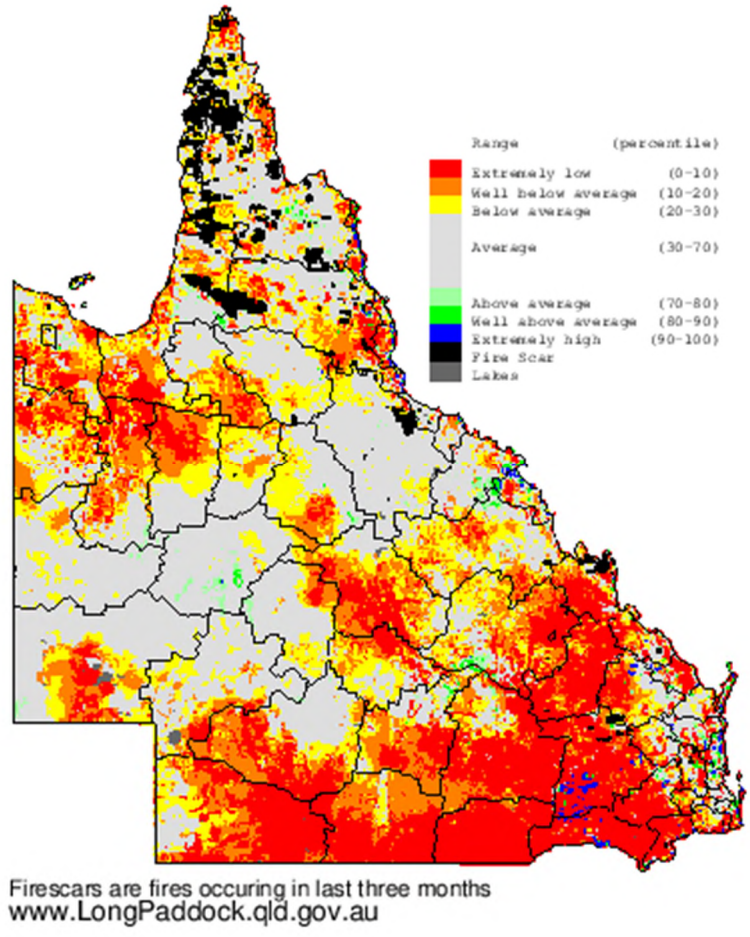

Figure 16. Pasture biomass (Total Standing Dry Matter, TSDM) percentiles across Queensland at 30 September 2019 relative to historical records from 1957. Source: www.longpaddock.ald.gov.au

Landholders clearly indicated a need for information on pastures, erosion, technology and general business management to aid their recovery. They indicated a strong preference for this information to come from DAF, LGAs, QRIDA, AgForce and NRM groups (such as Southern Gulf Catchments) and to be delivered by e-mail as well as websites, in small groups and through property visits. Discussions with landholders and staff indicate this is consistent with the more pressing need for industry to repair fences, water infrastructure, roads and yards to be able to recommence their livestock business. Many landholders stated they are working in excess of 10 hours per day on repairs, and e-mails allow them to access information at a time that suits them. The desire to engage with DAF and other professionals on technical issues remains strong, especially in a coordinated and timely manner that suits client work calendars and information needs.

Planning for potential future events in the north-west and other similar regions could be enhanced through further analysis of the data presented in this report. More detailed spatial analysis is recommended to refine the flood extent and to understand the conditions that led to the greatest stock losses e.g. floodplain flooding compared with bogging of livestock in the heavy clay soil Mitchell grass downs. This will help define potential future mitigation strategies. For example, property level inundation and erosion data will help refine the boundaries of the flood extent. Visual inspection of patterns in inundation, erosion, livestock losses and infrastructure damage at the individual property level were closely aligned with the AgForce flood extent which suggests a high level of accuracy of that dataset.

An analysis of the flood waters travelling down the Flinders and Norman River floodplain was conducted by Queensland Department of Natural Resources Mines and Energy based on available remote sensing data (Figure 17). This approach highlights the main body of flood water north of the Flinders Highway (mainly within the Finders River flood plain). At its maximum extent the floodwaters covered an area of about 25,600 km^2 (as cumulatively mapped up to 21 February). However, this under-represents the impacted area due to a lack of cloud free satellite imagery during the early stages of flooding. In addition, broader impacts (e.g. exposure and bogging) cannot be directly assessed by remote sensing techniques. Large scale and long duration floods, however, can be mapped using remote sensing when conditions are optimal (i.e. relatively cloud free).

Pasture surveys were conducted by DAF staff over the 3-weeks post-flooding. These data could be coupled with NDVI or fractional cover data to provide a clearer understanding of the impact of the event on pasture response. Comparisons with the AgForce flood extent and the DNRME flood duration mapping should provide valuable insights for landscape and floodplain pre-flood conditions and impacts.

A Chill factor model was developed by the Queensland Department of Environment and Science (Figure 18, Appendix 6) to capture the cumulative effects of cold and wet conditions for the duration of the event. Visual inspection of the patterns of livestock losses at the individual property level were closely aligned with the chill index surface, suggesting there could be value in basing alerts on this approach.

Further detailed spatial analysis should incorporate the following information to better understand the event:

- Pre-flood ground cover and biomass
- Rainfall intensity (mm/hr) and totals (mm) (daily, weekly and full period)
- Soil type and Queensland Grazing Land Management land types
- Digital Elevation Model derived slope and drainage patterns
- Chill Index data
- Australian Defence Force photographic surveys conducted during the event

Additional data sources that could provide further useful validation of the impact estimates include:

- Current ABS/ABARE gridded livestock data
- The National Livestock Identification System (NLIS)
- Livestock Trading Accounts lodged with the Australian Tax Office for 2018-19 deaths and losses.

Further analysis will reveal greater insight and refinement of the extrapolated data contained in this report.

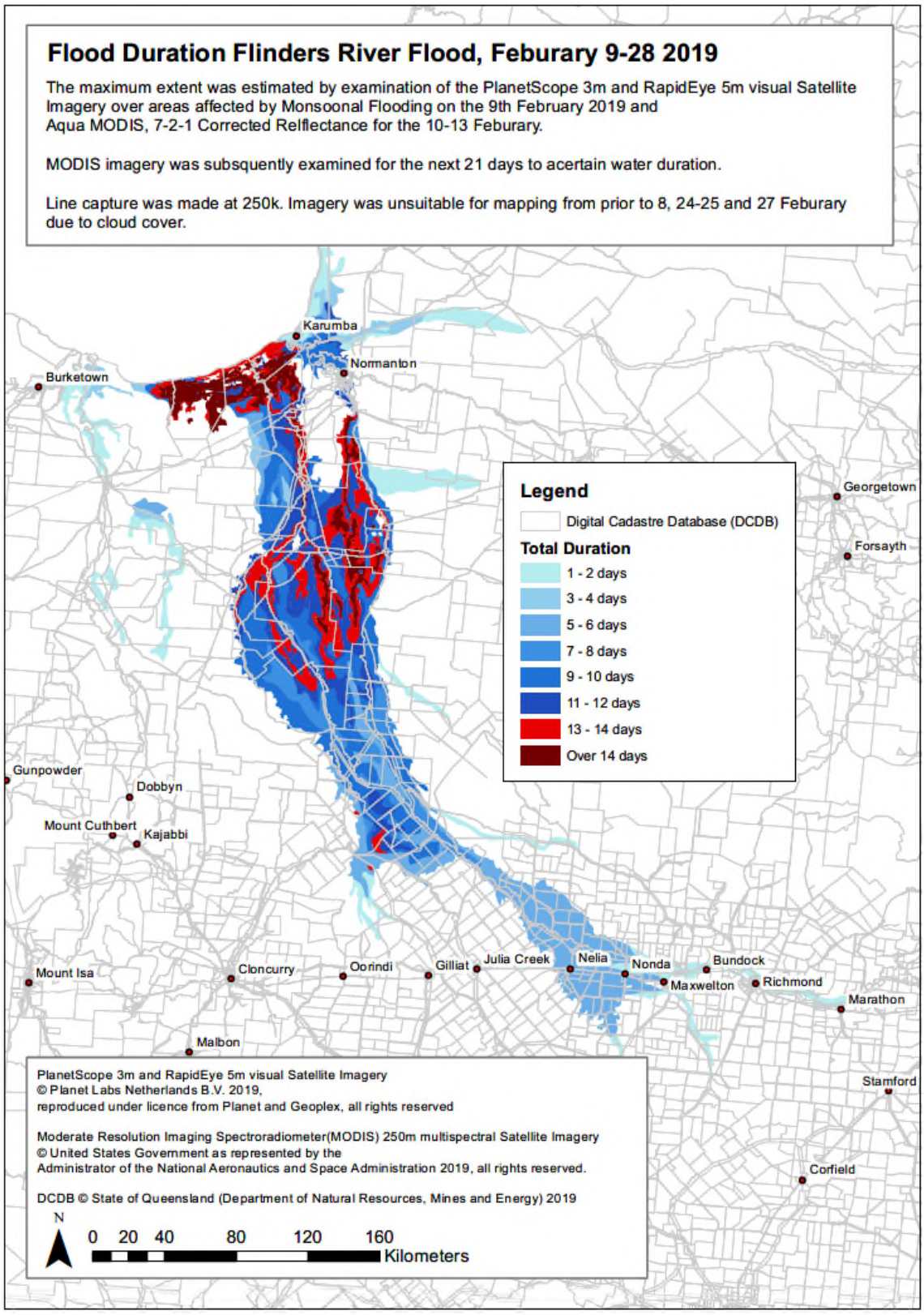

Figure 17. Flood duration and extent mapping within the Flinders and Norman River floodplains. Data source DNRME.

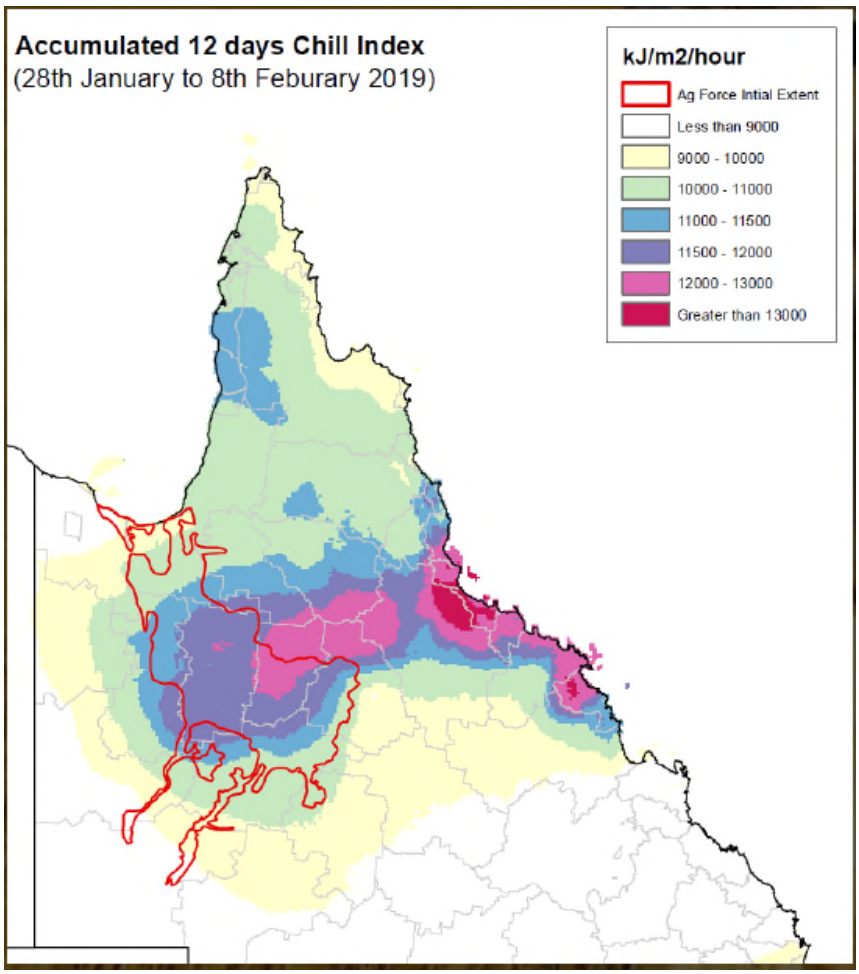

Figure 18. Chill Index modelling conducted by the Queensland Department of Environment and Science, showing the accumulated chill stress over the 12 days of the event (Appendix 6).

Caveats and limitations

Every effort has been made to ensure the on-ground accuracy of the extrapolated data across the region and at LGA level, including consultation with local landholders, Mayors, LGA staff, on-ground DAF staff, other Queensland Government agencies, NQLIRA staff and from direct observation. Comparisons have been made with other datasets, such as ABS, QGSO and ABARE livestock numbers and value of production data, and summarised QRIDA SDARG approvals. The pre-flood and livestock losses presented are as accurate as possible, being based on first-hand information from landholders. Nevertheless, a degree of error always exists when extrapolating information from individual survey responses to a larger area. This section discusses the reliability and limitations of the data and the approach.

Statistical analysis indicates that cattle and sheep data were suitable to extrapolate, that horse data should be treated with some caution and that goat data were unsuitable to be extrapolated (Appendix 4). The accuracy of the LGA level estimates depend on the pre-flood livestock numbers and the percentage of these livestock that were lost from the Monsoonal flooding event.

The estimated losses provided in this report are based on reported pre-flood stock numbers and stock losses. To extrapolate across each LGA and the region, stocking rates were calculated by extrapolating the property-level survey responses across the region and LGAs. Two approaches were used: averaging of the stocking rate for each property within a LGA; and interpolated spatial surface average and property-size weighted average. The comparison between the average and spatial average was minimal (data not presented) and estimates from the simpler averaging approach is presented in this report.

When compared with Agricultural Census Statistics for Selected Queensland LGAs, 2015-16 data[7] (Appendix 3) there discrepancies at LGA level for each livestock category.

Cattle estimates were comparable at the total regional level, with a difference of less than 10%. There were larger discrepancies at the LGA level which could be due to sample size, actual differences between the seasonal conditions in the 2015-16 census period and the start of 2019, or other inaccuracies in either approach.

Sheep were stocked on 22 properties across Flinders, McKinlay, Richmond and Winton Shires. To account for not all properties running sheep, the proportion of respondents with sheep was used as a multiplier after calculating LGA sheep numbers based on the survey averaged stocking rate. This was cross-referenced against a weighted average using the proportion of the survey area running sheep. Overall, the weighted average estimates were of a similar magnitude with a total of 125,925 sheep pre-flood and 28,810 of sheep loses, compared with 189,281 pre-flood and 42,911 sheep losses.

When sheep estimates were compared with Agricultural Census Statistics for Selected Queensland LGAs, 2015-16 data, there are notable differences. The raw survey pre-flood sheep numbers (i.e. not extrapolated) for Flinders and Winton Shires approximated the 2016 census data (Appendix 3). This suggests higher overall sheep numbers across the region in 2019 than reported in 2016, and that the estimates based on the survey data are the best currently available.

Horses were stocked on 37% of properties across the north-west, with the highest proportion in Burke and Cloncurry (60% of respondents). Anecdotally, horses retain an important role in mustering across this region as well as for competition (e.g. camp-drafts) and pleasure riding (e.g. pony club). The number of horses, and hence the derived stocking rate, varied considerably between properties. There are no publically available data for comparison at the LGA or regional level, although the 'other' livestock category within the Agricultural Census Statistics for Selected Queensland LGAs, 2015-16 dataset could be assumed to be predominantly horses.

Goat numbers were not extrapolated to the LGA level and raw survey data are instead reported. The total numbers reported by the survey respondents exceeded the ABS estimate from 2015-16.

Infrastructure damage was extrapolated by estimating the total length or number reported per property within each LGA, and multiplying across the flood affected LGA area. It was assumed that fences, roads, waters and buildings were not damaged outside of the flood and inundation zone. Using this approach, an estimated 29,300 km of roads were damaged compared with only 16,200 km of roads mapped within the Queensland Baseline Roads and Tracks – QDNRME March 2019 dataset. This discrepancy could be due to landholders reporting fence-line and narrow fire-breaks as roads, which are unlikely to be mapped. Bore-drains, bores, tank and trough estimates were not cross referenced with other datasets. Follow-up spatial analysis would validate damage to this infrastructure.

The estimated pre-flood numbers and losses for cattle, sheep and horses the best currently available despite some limitations of the extrapolated data. It was not possible to extrapolate goat information. Infrastructure damage is also the best currently available, with spatial validation recommended.

Acknowledgments

This report benefited greatly from input by: Terry Buetel, DAF for spatial analysis of livestock data; John Carter of the Department of Environment and Science for modelling and providing the chill index; Lauren Power, Chris Pollard, Monica Finlayson and colleagues at NQLIRA for providing general spatial analysis and feedback; Noel Brinsmead, Vol Norris and Dale Miller of AgForce for the initial flood extent mapping and survey input; and the grazing industry of north-west for taking time to complete the survey during a difficult time.

[7] https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02015-16?OpenDocument

Appendix 1. North-west Monsoon flood disaster survey questions

CONTACT INFORMATION

Name

Main rural address (e.g. 10357 Landsborough Highway)

Phone number

Email address

Would you prefer a DAF staff member to call you to complete this survey? (NB if the answer was yes, only the next two questions were asked).

What time of day would you prefer to be called?

Indicate other time if applicable.

(If the answer was no, the following questions were asked)

How many properties do you own, manage, or run livestock on within the north-west?

PROPERTY IMPACT INFORMATION

What is the property name?

What is the rural address of this property?

Size of this property?

How many cattle were you running on this property immediately before the flooding event?

How many cattle did you lose due to the flooding event?

How many sheep were you running on this property immediately before the flooding event?

How many sheep did you lose due to the flooding event?

How many horses were you running on this property immediately before the flooding event?

How many horses did you lose due to the flooding event?

How many goats were you running on this property immediately before the flooding event?

How many goats did you lose due to the flooding event?

Please list any other livestock losses.

How many kilometres of fence were destroyed beyond repair due to flooding?

How many kilometres of fence were damaged but repairable due to flooding?

How many kilometres of roads were damaged due to flooding?

How many kilometres of poly pipe were damaged or destroyed due to flooding?

How many kilometres of bore drains were damaged or destroyed due to flooding?

How many bores were damaged or destroyed due to flooding?

How many tanks and troughs were damaged or destroyed due to flooding?

What other damage did you incur? Please select all that apply.

Please list any other infrastructure damaged here.

If possible, can you provide an estimate of the cost to repair or replace these damaged buildings, infrastructure and vehicles?

What percentage of this property was under water from flooding or excessive rainfall?

How would you rate the soil erosion on this property due to the flood?

Would you like to add any other information about flood impacts on this property?

Do you have a second property to provide information for?

NB these questions were repeated for subsequent properties.

GRANTS AND SERVICES FEEDBACK

Have you applied for grants, loans or other assistance to help with recovering from the flooding

How easy was it to access government grants and loans for flood recovery?

Could you please tell us why you gave this rating?

How useful are the government grants and loans for flood recovery?

Could you please tell us why you gave this rating?

RECOVERY TO DATE

Are you currently re-stocking for?

How many cattle have you been able to replace so far?

How many sheep have you been able to replace so far?

How many horses have you been able to replace so far?

How many goats have you been able to replace so far?

How many other livestock have you been able to replace so far?

Have you had help with your re-stocking?

What has helped you the most in your re-stocking (e.g. grants, loans , freight rebates)?

Would you like help with your re-stocking?

What would be the best re-stocking support for you?

How many kilometres of damaged and destroyed fence have you been able to repair or replace so far?

Have you had help with your fencing?

What has helped you the most in getting your fencing restored (e.g. volunteers, grants, loans)?

Would you like help with your fencing?

What would be the best fencing support for you?

How are you going with repairs or replacements of buildings, infrastructure and machinery?

Is there anything that could help you with these repairs? If so, what would be the best support for you (e.g. faster insurance payments, grants, loans, volunteers)?

Have you accessed any other assistance or services (e.g. the Royal Flying Doctor Service, Sisters of the North, volunteers)? If so, please list the main groups.

Please let us know if you have any complaints or compliments for any specific services.

INFORMATION NEEDS

What are the main types of information that will best help with your recovery process (select all that apply):

Other (not listed above)

What are your preferred way(s) of receiving information?

Other (not listed above)

Who do you like to receive information from (select all that apply)?

Other (not listed above)

Do you have any suggestions about information or events to help with the recovery process?

Is there any more information you would like to provide (e.g. the spread of pests and weeds)?

Would you like to be kept up-to-date about future information and events on flood recovery?

Appendix 2. Total pre-flood livestock, and livestock losses and infrastructure damage reported for 189 properties across north-west Queensland following the Monsoonal trough of early 2019

Reported pre-flood livestock

There were a total of 513,560 pre-flood livestock reported across the 189 properties, primarily cattle (Table A2.1). Other livestock reported in small numbers included camels, pigs and poultry.

Table A2.1. Reported pre-flood livestock totals for the 189 property level survey responses within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Total cattle	Total sheep	Total horses	Total goats
Burke Shire	37,800	0	105	0
Carpentaria Shire	71,501	0	98	0
Cloncurry Shire	43,555	0	221	0
Flinders Shire	47,829	13,987	142	0
McKinlay Shire	115,468	3,469	306	1,030
Richmond Shire	76,855	6,196	186	833
Winton Shire	47,035	23,700	184	2,500
TOTAL	460,543	47,352	1,302	4,363

Reported livestock losses

There were a total of 115,775 livestock losses reported across the 189 properties, primarily cattle losses (Table A2.2). Other livestock deaths reported in small numbers included camels, pigs and poultry.

Table A2.2. Reported livestock losses for the 189 property survey responses within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Total cattle losses	Total sheep losses	Total horse losses	Total goat losses	Total livestock losses
Burke Shire	0	0	0	0	0
Carpentaria Shire	6,850	0	3	0	6,853
Cloncurry Shire	9,428	0	26	0	9,454
Flinders Shire	2,371	1,717	15	0	4,103
McKinlay Shire	39,977	2,055	19	915	42,966
Richmond Shire	26,233	2,220	25	56	28,534
Winton Shire	16,496	5,190	79	2,100	23,865
TOTAL	101,355	11,182	167	3,071	115,775

Reported infrastructure damage

Extensive damage to fences, roads, waters and other infrastructure was reported for the 189 properties within the survey, including 4,468 km of fences and 6,769 km of farm roads and tracks (Table A2.3).

Table A2.3. Reported infrastructure damage for the 189 property survey responses within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Fences destroyed or damaged (km)	Roads damaged (km)	Poly pipe damaged or destroyed (km)	Bore drains damaged or destroyed (km)	Bores damaged or destroyed (no.)	Tanks and troughs damaged or destroyed (no.)
Burke Shire	0	0	0	0	0	0
Carpentaria Shire	651	341	157	0	0	23
Cloncurry Shire	289	725	13	0	2	27
Flinders Shire	353	840	28	18	6	23
McKinlay Shire	1,325	1,638	144	263	2	86
Richmond Shire	1,483	2,164	136	57	0	74
Winton Shire	367	1,061	44	0	3	25
TOTAL	4,468	6,769	522	338	13	258

Appendix 3. Estimated pre-flood total livestock and stocking rate, and associated data for north-west Queensland

Table A3.1. Estimated pre-flood livestock totals within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Total cattle	Total sheep	Total horses	Total goats
Burke Shire	84,056	0	319	n/a
Carpentaria Shire	394,916	0	387	n/a
Cloncurry Shire	267,064	0	1,326	n/a
Flinders Shire	143,331	55,831	698	n/a
McKinlay Shire	279,267	19,390	221	n/a
Richmond Shire	172,678	5,629	468	n/a
Winton Shire	218,040	108,430	837	n/a
TOTAL	1,559,353	189,281	4,257	n/a

Table A3.2. Australian Bureau of Statistics (ABS) cattle, sheep, goat and 'other' livestock totals within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires (Agricultural Census Statistics for Selected Queensland LGAs, 2015-16 data)[8]

LGA	Total cattle	Total sheep	Other	Total goats
Burke Shire	187,451	58	211	4
Carpentaria Shire	303,651	95	342	6
Cloncurry Shire	242,883	34	539	103
Flinders Shire	234,538	17,386	353	244
McKinlay Shire	231,930	17,193	349	242
Richmond Shire	151,343	11,219	228	158
Winton Shire	88,440	27,133	156	269
TOTAL	1,440,236	73,118	2,178	1,026

Table A3.3. Australian Bureau of Statistics (ABS) cattle, sheep, goat and 'other' livestock totals within the Carpentaria, Mount Isa Region, Northern Highlands and Far Central West Statistical Divisions (ABS 2016 census)[9]

Statistical Division	LGAs included	Cattle number	Sheep number
Carpentaria	Burke, Carpentaria	555,229	167
Mount Isa Region	Mt Isa, Cloncurry	432,301	59
Northern Highlands	Flinders, McKinlay, Richmond	625,360	45,798
Far Central West	Winton, Boulia, Barcoo, Diamantina	459,097	149,355
TOTAL		2,072,057	195,379

[8] https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02015-16?OpenDocument

[9] https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1270.0.55.001~July%202016~Main%20Features~Statistical%20Area%20Level%202%20(SA2)~10014

Table A3.4. Estimated pre-flood livestock stocking rates (ha/hd) within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Average of Pre-flood cattle SR (ha/hd)	Average of Pre-flood sheep SR (ha/hd)	Average of Pre-flood horse SR (ha/hd)	Average of Pre-flood goat SR (ha/hd)
Burke Shire	39.6	0.0	6256.4	n/a
Carpentaria Shire	13.4	0.0	6853.7	n/a
Cloncurry Shire	17.5	0.0	2112.0	n/a
Flinders Shire	27.6	9.8	3128.0	n/a
McKinlay Shire	13.9	24.0	4207.9	n/a
Richmond Shire	14.9	77.7	2219.0	n/a
Winton Shire	23.4	9.7	1864.5	n/a

Appendix 4. Estimated pro-rata infrastructure damage across north-west Queensland following the Monsoonal trough of early 2019

Table A4.1. Estimated pro-rata fence and road damage rates (km/ha or number/ha) within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Average of fences destroyed pro-rata	Average of fences damaged pro-rata	Average of total fences impacted	Average of road damage pro-rata
Burke Shire	0	0	0	0
Carpentaria Shire	0.00062959	0.00120862	0.00183821	0.001159435
Cloncurry Shire	0.00066106	0.00113886	0.00179992	0.002724765
Flinders Shire	0.00072758	0.00140530	0.00213289	0.004182557
McKinlay Shire	0.00095578	0.00084629	0.00180207	0.002275804
Richmond Shire	0.001956559	0.00183977	0.00379633	0.003834587
Winton Shire	0.00041106	0.00039186	0.00080292	0.0021953

Table A4.2. Estimated pro-rata water infrastructure damage rates (km/ha or number/ha) within Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton Shires.

LGA	Average of poly pipe damage pro-rata	Average of bore drain damage pro-rata	Average of bores damaged pro-rata	Average of tank and troughs damaged pro-rata
Burke Shire	0	0	0	0
Carpentaria Shire	9.16721E-05	0	0	4.84569E-05
Cloncurry Shire	6.55515E-05	0	5.05051E-06	9.22649E-05
Flinders Shire	0.000194359	0.00010588	0.000137041	0.000169517
McKinlay Shire	0.000195051	0.00023499	5.81395E-07	0.000137047
Richmond Shire	0.000556657	9.77788E-05	0	0.000225731
Winton Shire	0.000131893	0	1.35667E-06	4.78831E-05

Appendix 5. Statistical analysis

Data were analysed for normal distribution and error terms using Genstat (18th edition) to validate the use of survey averages in extrapolating to the LGA level. Results for cattle, sheep, horse and goat percentage loss are presented as an example.

Cattle losses (%)

Preliminary statistical analysis of cattle losses (%) suggest these data are slightly skewed due to zero losses reported for properties outside the flood extent. Nevertheless, extrapolation based on these data should be reasonable.

Sample statistics

Sample Size	177
Mean	0.32
Variance	0.07
Skewness	0.47
Kurtosis	-0.80

Quartiles:

25%	50%	75%
0.1	0.3	0.5

Summary of analysis

Observations: Order_St
Parameter estimates from individual data values
Distribution: Normal (Gaussian)
X distributed as Normal(m,s**2)
Deviance: 53.73 on 10 d.f.

Estimates of parameters

	estimate	s.e.	correlations	
m	0.3209	0.0201	1.0000	
s	0.2672	0.0142	0.0000	1.0000

Test for Cattle_loss_% following a Normal distribution

Critical values of test statistics (marginal tests)

Test statistic	15%	10%	5%	2.5%	1%
Anderson-Darling	0.576	0.656	0.787	0.918	1.092
Cramer-von Mises	0.091	0.104	0.126	0.148	0.178
Watson	0.085	0.096	0.116	0.136	0.163

Marginal tests

Variate	Anderson-Darling		Cramer-von Mises		Watson	
1	4.3196	**	0.6463	**	0.6105	**

?, *, ** indicate significance at 10%, 5% and 1% levels respectively

Sheep losses (%)

Preliminary statistical analysis of sheep losses (%) suggest these data have a normal distribution and the preliminary extrapolation should be reasonable. However, the sample per LGA is relatively small and errors may be introduced by assuming the proportion of properties running sheep within each LGA is similar to the proportions of properties running sheep within the survey responses.

Sample statistics

Sample Size	22
Mean	0.29
Variance	0.06
Skewness	0.23
Kurtosis	-1.51

Quartiles:

25%	50%	75%
0.0	0.3	0.6

Summary of analysis

Observations: Order_St
  Parameter estimates from individual data values
Distribution: Normal (Gaussian)
  X distributed as Normal(m,s**2)
Deviance: 6.93 on 2 d.f.

Estimates of parameters

	estimate	s.e.	correlations	
m	0.2858	0.0512	1.0000	
s	0.2399	0.0362	0.0000	1.0000

Test for Sheep_loss_% following a Normal distribution

Critical values of test statistics (marginal tests)

Test statistic	15%	10%	5%	2.5%	1%
Anderson-Darling	0.576	0.656	0.787	0.918	1.092
Cramer-von Mises	0.091	0.104	0.126	0.148	0.178
Watson	0.085	0.096	0.116	0.136	0.163

Marginal tests

Variate	Anderson-Darling		Cramer-von Mises		Watson	
1	1.0244	*	0.1456	*	0.1440	*

?, *, ** indicate significance at 10%, 5% and 1% levels respectively

Horse losses (%)

Statistical analysis of horse losses (%) suggest these data are skewed due to a large number of properties with zero horse losses, and the preliminary extrapolation should be treated with some caution.

Sample statistics

Sample Size	70
Mean	0.21
Variance	0.10
Skewness	1.62
Kurtosis	1.19

Quartiles:

25%	50%	75%
0.0	0.1	0.2

Summary of analysis

Observations: Order_St
  Parameter estimates from individual data values
Distribution: Normal (Gaussian)
  X distributed as Normal(m,s**2)
Deviance: 35.54 on 3 d.f.

Estimates of parameters

	estimate	s.e.	correlations	
m	0.2062	0.0380	1.0000	
s	0.3178	0.0269	0.0000	1.0000

Test for Horse_loss_% following a Normal distribution

Critical values of test statistics (marginal tests)

Test statistic	15%	10%	5%	2.5%	1%
Anderson-Darling	0.576	0.656	0.787	0.918	1.092
Cramer-von Mises	0.091	0.104	0.126	0.148	0.178
Watson	0.085	0.096	0.116	0.136	0.163

Marginal tests

Variate	Anderson-Darling		Cramer-von Mises		Watson	
1	9.7271	**	1.6547	**	1.4663	**

?, *, ** indicate significance at 10%, 5% and 1% levels respectively

Goat losses (%)

Statistical analysis of goat losses (%) determined the sample size is too small to extrapolate these data. Accordingly, only losses reported within survey results are presented in this report. It may be assumed that actual loses were greater than reported.

Summary statistics for Goat_loss_%

Number of values =	191
Number of observations =	3
Number of missing values =	188
Mean =	0.599
Median =	0.84
Minimum =	0.0672
Maximum =	0.889
Lower quartile =	0.260
Upper quartile =	0.877
Standard deviation =	0.461

Not enough valid units for a probability plot.

Appendix 6. Chill index modelling methods

A chill index (nominal hourly heat loss from animal) was constructed using the AussieGRASS framework. The output data is a daily 0.05 degree grid (approximately 5km by 5km). The chill index was designed for sheep in southern Australia (Nixon-Smith 1972) and was used because of its simplicity in implementation. The index was calculated for all days between 25/01/2019 to 11/02/2019. The chill index was accumulated over 12 days for the period 28th January to 8th February inclusive (with rainfall based on Julia Creek Airport data).

The chill index formula was developed by Nixon-Smith (1972) for sheep graziers alerts issued by the Australian Bureau of Meteorology and was modified by Donnelly (1984). Various hazard classes for sheep are suggested Table A5.1.

This formula calculates the potential heat loss (C) in kJ/m^2.hr using mean daily wind velocity (v; m/sec), the average daily temperature (T; degrees C) and daily rainfall (x; mm) as below:

$$C = (11.7 + 3.1v^{0.5})\ (40-T) + 481 + (418(1-e^{-0.04x}))$$

The climate input variables were modified a spatial basis to account for tree microclimate as per DuPont (1996, 1997) using tree foliage projective cover (FPC). Increasing FPC acts to reduce wind speed, increase minimum temperature and decrease maximum temperature. Daily climate data was extracted from SILO (Jeffrey *et al*. 2001) with wind data based on interpolated < 3m wind run derived from daily anemometer measurements.

Table A5.1. Hazard Classes for Sheep as Per Victorian Department of Agriculture

Chill index (kJ/m2/h heat loss)	Severity (for Sheep)
0-900	No chill
900-1000	Mild
1000-1100	Moderate
1100-1200	High
>1200	Severe

Caveats

- The sheep chill index may not apply well to cattle and represents a generalisation of climate impacts on livestock. The index does not directly include humidity or solar radiation impacts
- Daily time step data and analysis may not fully explain animal stress that happens at finer time scales
- The quality of climate data is restricted by the density and location of observing stations available at the time of the analysis and interpolation algorithms applied to point data
- Prior animal condition is not taken into account
- Bogging is not considered in energy loss, which is an important factor across soils with a high clay content (e.g. across McKinlay and Richmond Shires)
- Feed quality and availability within the event is not considered in this index
- Effects of chill may vary with age, sex and breed.