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Productivity (On Farm) & Feedlot Evaluation Group Impact Assessment (2015–2020)

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Abstract

Meat and Livestock Australia (MLA) works in partnership with industry and government to deliver research and development (R & D) activities that contribute to producer profitability, sustainability and global competitiveness, in addition to provision of marketing services to facilitate growth in consumer demand for red meat.

In undertaking these activities, MLA is required to conduct a 5-year impact assessment of all marketing and R & D investments as part of their Statutory Funding Agreement (SFA). This report provides an independent impact assessment of the potential (*ex-ante*) and actual (*ex-post*) productivity impact from the adoption of key product investments in the on-farm productivity (including producer adoption) and feedlot programs during the period 2015-2020. This information will subsequently be utilised for MLA's SFA and performance review in 2020.

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1.0 Background

Meat and Livestock Australia (MLA) works in partnership with industry and government bodies to deliver research and development activities (R & D) that contribute to producer profitability, sustainability and global competitiveness, in addition to provision of marketing services to facilitate growth in consumer demand for red meat.

In undertaking these activities, MLA is required to conduct a 5-year impact assessment of all marketing and R & D investments as part of their Statutory Funding Agreement (SFA). The next impact assessment is for the period 2015-2020. As part of this impact assessment process, MLA required an independent evaluation of the potential (*ex-ante*) and actual (*ex-post*) productivity impact from the adoption or implementation of key product investments in the on-farm productivity (including producer adoption) and feedlot programs during the period 2015-2020. This information will subsequently be utilised for MLA's SFA and performance review in 2020.

Investments made in the following MLA sub-programs were included in the impact assessment:

- Producer Adoption;
- Productivity (On Farm) which includes the Beef Productivity, Sheep Productivity and Feedbase Production & Infrastructure sub-programs; and
- Feedlot related sub-program areas.

The list of products evaluated for this impact assessment are provided in Tables 1 to 3 below for the producer adoption, productivity (on farm) and feedlot investment areas.

Table 1: Producer adoption products evaluated.

Product Category	Product Code	Output (Product)
Producer Adoption – Category C	p00308	Producer Demonstration Sites (PDS)
Producer Adoption – Category C	p00405	Profitable Grazing Systems (PGS)
Producer Adoption – Category A	p00567/p00410	Awareness forums & activities (BeefUp, It's Ewe Time Forums)
Producer Adoption – Category B	p00386/p00138	Influence & motivate activities (BredWell FedWell, EDGEnetwork)

Table 2: Productivity (On-Farm) products evaluated.

Product Category	Product Code	Output (Product)
Biological control	P00608	Parthenium biological control
Biological control	P00283	Parkinsonia biological control
Leucaena	P00187	Redlands leucaena
Pig control	P00149	HOG-GONE® feral pig baiting system
Plant genetics	P00513	Novel low rainfall pasture legumes
Plant variety	P00302	Tedera legume
Plant variety	P00280	Legume best management practices in the Brigalow Belt bio-region
Rabbit control	P00392	Rabbit RHDV calicivirus
Reproductive efficiency	P00606	Oestrogenic clover

Table 3: Feedlot related products evaluated

Product Category	Product Code	Output (Product)
Feed efficiency	P00435	Feed truck auto-delivery system
Feed efficiency	P00457	Autonomous LIDAR feedlot bunk scanning & management system
Feedlot health management	P00611	Graded woodchip bedding for feedlot pens
Slaughter (processing)	P00639	Short duration lairage (feedlots)

2.0 Scope

This impact assessment calculated values for estimated impact of product adoption on farm/feedlot profitability based on benefits associated with increased production/reduced losses and savings in input costs. Other potential benefits, including improved environmental outcomes, increased social/management benefits (e.g. improved sustainability of local communities, reduced stress on producers) and increased social license to operate relating to improved animal welfare were identified but not evaluated. The assessment involved a combination of *ex ante* and *ex post* R & D evaluation depending on the stage of product delivery. The impact assessment did not assess if the product was 'fit for purpose' or if the adoption pathway was the best way to achieve adoption of research outcomes and best practice on farms.

3.0 Methodology

This evaluation involved a 'bottom up' assessment approach to capture adoption outcomes and productivity impacts at a product (output) level and then aggregated outputs to determine the overall impact of both extension based and non-extension programs over the period from 2015/16 to 2039/40.

An initial period of data assessment involved a review of all available internal MLA data for each product with an associated identification of gaps in availability of required data. Where possible, the results of the monitoring and evaluation (M & E) programs in place for each product were utilised for the assessment. However, in most cases, these had not been designed to collect data suitable for estimating impact and adoption. Information gaps were filled via a combination of the following processes:

- Wider literature review of relevant external data.
- Consultation with industry researchers, project managers and subject experts.
- Phone interviews conducted with participating producers (for adoption products).
- Consultants' own knowledge, experience and network of resources.

A sensitivity analysis of the impact assessment was undertaken for each product.

4.0 Results

4.1 Overview of products

Producer Adoption

4.1.1 Producer Demonstration Sites

Estimated impact: High

Producer Demonstration Sites aim to increase the rate of adoption of key management practices and technologies that improve business profitability, productivity and sustainability. This is achieved through supporting livestock producers working in peer to peer groups to pursue new skills, knowledge and management practices applicable to their own commercial livestock production systems. Producer Demonstration Sites offer a producer focused and driven process for increasing the rate of adoption of existing and newer technologies and management practices.

4.1.2 Profitable Grazing Systems

Estimated impact: High

Profitable Grazing Systems (PGS) is a group-based delivery program that uses Supported Learning Programs (SLPs) to deliver training and coaching over a number of months and up to a year to improve producer skills and knowledge. The aim is to achieve on-farm practice change in areas of farm production and management covered by the SLP. Each SLP aligns to the curriculum areas of People, Business, Reproduction and Genetics, Value Chain and Feedbase.

PGS was designed to fill the gap between obtaining information and skills and putting them into practice on farm to achieve benefits. PGS SLPs are designed to increase participant knowledge and skills in addition to encouraging adoption while the program is in progress in one or more of the five curriculum areas. Each SLP is designed to offer a mix of group skills training, knowledge acquisition and one on one coaching in the context of adoption. This mix is considered to be more effective at achieving adoption than other extension methods as producers are able explore an area of farm production or management in depth and to test and refine their skills with the support of a group and a coach. It thus allows producers to problem solve and resolve issues with adoption as well as refine approaches and monitor results. This approach is suited to complex multi-factorial changes that take time (years) to implement and where benefits may not manifest immediately or be easily measurable.

To date, 130 producers have participated in 10 PGS pilot SLPs (all completed in 2017) and 240 producers have or are currently involved in 22 PGS SLPs (14 completed).

4.1.3 Awareness forums and activities (BeefUp and Its Ewe Time)

BeefUp

Estimated impact: Medium

'BeefUp' is a one-day forum aimed at creating awareness of key issues, MLA programs, best practice and new research data. It is run in northern Australia and began in 2010. The forums utilise leading industry experts and consultants to deliver key messages. Participants are sign-posted to other programs and sources of information for follow-up afterwards. It is considered to be a 'feeder activity' to other programs i.e. creates awareness and appetite for other MLA programs. These events are low cost one day activities held in regional locations that allow northern cattle producers to easily engage with MLA in their local areas. Since 2015, 1,878 people have participated in 33 forums across the northern cattle producing regions of Australia.

It's Ewe Time

Estimated impact: Medium

'Its' Ewe Time' is a half day forum aimed at creating awareness of key issues, MLA and Australian Wool Innovation (AWI) programs, best practice and new research data. It is run in conjunction with AWI and utilises leading industry experts and consultants to deliver key messages. Participants are sign-posted to other programs and sources of information for follow-up afterwards. It is considered to be a 'feeder activity' to other programs i.e. creates awareness and appetite for other AWI/MLA programs. These events are low cost half day forums in regional locations and allow sheep producers to easily engage with MLA/AWI in their local areas. 'It's Ewe Time' forums had previously been held as part of the Making More from Sheep program and were considered to be a good vehicle for promoting MLA/AWI activities due to their previous popularity and reach. The program was reinstated in 2017, and since then 1,113 people (820 producers) have participated in 23 forums across the sheep producing regions of Australia.

4.1.4 Influence and motivate activities (BredWell FedWell and EDGEnetwork)

BredWell FedWell (Sheep and Southern Beef)

Estimated impact BW FW Sheep: Medium

Estimated impact BW FW Southern Beef: Low

BredWell FedWell (BW FW) is a practical, one day workshop focused on the key production benefits of genetics with improved feed management to improve reproduction. It focuses on the importance of combining genetics and feed management to enable optimal improvement in performance and therefore farm profit. For industry to benefit from the results of research and development into sheep/cattle genetics and feeding, a pathway to adoption is required that tailors the relevant information within the context of sheep and beef farming systems to allow rapid uptake. The BW FW Sheep and Southern Beef workshops allow producers to explore the usefulness of genetic tools (ASBVs and indexes) combined with setting of breeding objectives and best practice feeding of ewes/cows to achieve optimal reproductive performance in their enterprises.

Phase 4 of delivery has involved 1,007 participants from 625 businesses in 53 BW FW Sheep workshops across Australia. The project has delivered 41 BW FW Southern Beef workshops involving 998 participants across southern Australia.

EDGEnetwork (Northern and Southern)

Estimated impact EDGEnetwork Northern: High

Estimated impact EDGEnetwork Southern: Medium

EDGEnetwork® (EDGE) is a suite of specialised training workshops that have been developed and targeted primarily to northern Australian beef, sheep and goat producers to improve livestock production and enterprise profitability and sustainability. These workshops have been used for more than a decade to lift the awareness of MLA and collaborator–funded research and development outcomes and to accelerate the adoption of best management practices. In recent years, Business EDGE has been adapted for the southern region for beef and sheep producers.

MLA requires an extension pathway to adoption that allows northern beef, sheep and goat producers to access the latest information and skills to improve their livestock enterprises. The suite of EDGE workshops allows participants to develop skills in business, nutrition, grazing, land management and breeding. In this assessment period, 1,475 participants representing 824 businesses have participated in 132 workshops (Southern EDGE = 140 businesses).

Productivity (On Farm)

4.1.5 Parthenium biological control

Estimated Impact: Medium

Parthenium (*Parthenium hysterophorus*) is a Weed of National Significance and is declared a noxious weed in all mainland states and territories of Australia. It is regarded as one of the worst weeds in the country due to its invasiveness, potential for spread, and economic and environmental impacts. Parthenium is also a health problem for humans, as contact with the plant or the pollen can cause serious allergic reactions, such as dermatitis and hay fever, and it is also known to be toxic to cattle.

Management and control techniques for parthenium weed include a combination of biological control agents, pasture management, cultivation and herbicides. Small infestations are typically eradicated by early detection and monitoring. An integrated approach to control has resulted in the extent of the weed in New South Wales significantly reduced, with all known roadside infestations suppressed and all known infestations on private land under active control. Although the area infested with parthenium weed is being reduced, the number of new infestations is increasing. Of particular concern over recent years has been the spread of parthenium into southern Queensland (Dhileepan, 2018).

The emerging southern Queensland infestations are isolated from the core infested areas of central Queensland and are thought to have occurred due to the movement of contaminated stock feed, cattle and machinery. Due to this isolation, many of the effective and highly damaging biological agents that are prevalent and effective in central Queensland have not yet extended their distribution at the same rate into southern Queensland (Callander and Dhileepan, 2016). There is therefore concern that if proactive action is not taken to curb the spread of the weed that it will continue to spread throughout southern Queensland.

In 2015, concern over the control of southern Queensland infestations resulted in the commencement of a program to redistribute five biological agents from central Queensland into the southern and south-eastern areas of the state. The program relied heavily on these five agents having already adapted to Australian environmental conditions and thus smaller scale releases could be utilised successfully (Dhileepan, 2018). Since release, periodic site surveys have indicated strong evidence of establishment at many sites.

4.1.6 Parkinsonia biological control

Estimated Impact: Medium

Parkinsonia (*Parkinsonia aculeata*) is a declared weed in all states and territories of Australia, and is considered a Weed of National Significance. Infestations occur mainly throughout coastal, central and western Queensland, central and Northern Territory, and the Kimberley and Pilbara regions of Western Australia. Small outbreaks have also been recorded in isolated areas of South Australia and far western New South Wales. If left untreated, parkinsonia displaces native vegetation and reduces access to land and waterways. Parkinsonia infestations also provide refuges for feral animals, particularly feral pigs, which have further negative impacts on the environment and the productivity of affected land.

In addition to direct economic impacts on landholders, parkinsonia also has significant negative environmental impacts. Wetlands are particularly vulnerable as parkinsonia can dam watercourses, cause erosion, lower water tables and infest vast tracts of floodplain. Threatened areas include national parks and other regions of high aesthetic, indigenous and tourist value. The economic costs of control are high once parkinsonia becomes established, however the benefits include recovered pasture, increased production, reduced mustering costs, and the protection of natural ecosystems.

Parkinsonia control efforts have largely focused on an integrated approach to preventing the spread of the weed within and between catchments, early detection and control of small manageable outbreaks. Research into biological control agents for parkinsonia commenced in 1983 via a joint study between the Queensland, Western Australian and Northern Territory governments. This research culminated in the release of three insects between 1989 and 1995: a sap sucking bug (*Rhinacloa callicrates Herring*) and two seed feeding beetles (*Mimosetes ulkei* (Horn) and *Penthobruchus* *germaini*). The seed feeding beetle, *P. germaini*, killed large populations of seeds soon after it was first released in central Queensland, however the beetle's eggs were attacked by a native wasp, thus reducing its potential impact on parkinsonia (Raghu *et al*., 2016).

CSIRO commenced native range surveys in 2002 to identify new potential biocontrol agents for parkinsonia. Several species were imported from Mexico and Argentina which were then studied for their host specificity to assess the risk associated with potential release in Australia. Three successive MLA projects (2006-2010, 2010-2013, 2014-2016) funded the discovery and testing of biological control agents. Based on the results of detailed safety testing, CSIRO received approval to release two closely related leaf-feeding moths, *Eueupithecia cisplatensis* (UU1) and *Eueupithecia vollonoides* (UU2) in 2012 and 2014 respectively. A further MLA and Department of Agriculture and Water Resources project (2015-2018) enabled rearing and widescale release across northern Australia of these biocontrol agents.

To date, defoliation of parkinsonia plants is evident at all sites where establishment has occurred, and over time it is anticipated that this will translate into impacts on plant health and reproduction that suppress parkinsonia populations. However, the full impacts of the moths in the field are expected to take up to a decade to become fully apparent (Raghu, 2018). There has been no data collected to date to accurately quantify the impact that UU1 and UU2 are likely to have on increasing pasture production or on reducing current levels of control.

4.1.7 Redlands leucaena

Estimated impact: None (2015-20 assessment period only)

Leucaena (*Leucaena leucocephala* ssp. *Glabrata)*, when sown into improved pasture, has been shown to significantly increase beef production and economic returns per hectare in northern Australia (Bowen *et al*., 2015). Adoption of leucaena in the high rainfall coastal areas of northern Australia (>800mm) has largely been limited due to the prevalence of a sap-sucking psyllid (*Heteropsylla cubana*), which has been shown to reduce leucaena production by between 50 and 70% in humid regions and by 20-50% in sub-humid environments (Bray 1994, Mullen and Shelton 2003).

With the aim of expanding the potential area suitable for adoption of leucaena in northern Australia, MLA invested in a breeding program in 2002 to develop a psyllid-resistant leucaena variety. Research conducted by the University of Queensland produced forty new breeding lines of the psyllid-resistant leucaena which were progeny tested and selected for level of psyllid resistance (Shelton *et al*., 2017). Four of the original 40 breeding lines were then selected for possible release to industry. These lines were identified for their psyllid resistance, moderate seed production and high *in vitro* digestibility relative to that of the existing commercial cultivars. Further field work was undertaken to assess psyllid resistance, forage yield and palatability as a precursor to allocating Plant Breeders Rights (PBR) to a new leucaena variety.

Based on the outcomes of this research and field trials, breeding line #12 (named Redlands) was ultimately selected for PBR application and approved for commercial release in May 2019. Distribution of Redlands seed has been licensed to two commercial providers, Leucseeds Pty Ltd and Bruce Mayne from Bandana Station Carnarvon Pastoral in Queensland. Redlands seed has now been harvested and is available for purchase by graziers.

The estimated impact for Redlands leucaena has been classified as 'none' for the current assessment period because the benefits attributed to this product in the previous assessment period were over-estimated.

4.1.8 HOG-GONE® feral pig baiting system

Estimated impact: Medium

Feral pigs cause considerable damage with associated production losses to producers via predation of newborn lambs, reducing crop yields, damaging fences and water sources, and consuming or damaging pasture. Feral pigs also have negative impacts on the environment through habitat modification, in addition to predation and competition for food and habitat resources. They are also considered a major threat to livestock as a potential carrier of exotic diseases, with the biggest concern being their role as a reservoir for Foot-And-Mouth Disease should it ever become established in Australia. They have been linked with the spread of the rootrot fungus (*Phytophthora cinnamomi*) responsible for the dieback disease in native vegetation (Choquenot *et al*. 1996), and more recently there has been concern over the role that feral pigs could play in the potential spread of the Panama Tropical Race 4 (TR4) fungus, discovered in far north Queensland in 2015.

Feral pigs are currently controlled using a range of methods including baiting, dogging, trapping and ground and aerial shooting. Baiting typically involves the use of 1080 (sodium monofluroacetate) as the active toxin, which is presented to feral pigs in a substrate, typically pellets, grain, meat or offal, depending on state laws regarding the use of these substrates. While 1080 is considered to be a very cost effective means of feral pig control, field preparation of baits made from poisoned grain and fresh meat or offal can pose problems with dosing accuracy (high risk of sub-lethal dosing and learned aversion), occupational health and safety risks for operators in handling the baits, stability of the bait, and risks to non-target species (ACTA, 2017).

In an effort to address some of these issues, a new feral pig baiting system, licenced as PIGOUT®, was developed and approved for use in 2007. PIGOUT® is simple to handle, contains a reliable dose of 1080, and is highly effective for the control of feral pigs. Most importantly, its use reduces the risks to livestock, farm dogs and native non-target species, without the need for construction of bait stations or other protective measures.

Despite the benefits provided by the PIGOUT® system, 1080 is still considered by many to be an inhumane and indiscriminate poison for the culling of pest animals. 1080 is banned or restricted for use in many countries, and its use is regularly reviewed by the Australian Pesticides and Veterinary Medicines Authority (APVMA). There is concern that it may also be banned or restricted for use in Australia in the future, thus severely limiting the ability of many producers to control feral pigs on their properties. A further limitation to the value of 1080 is that it is a schedule 7 poison, and depending on local state regulations, it may only be available from authorised government officers and only authorised for use by individuals who have completed the required training. These regulations limiting availability provide a significant barrier to the usage of poison baits for many producers.

Research into the development of an alternative feral pig toxin to 1080 commenced in 2005 through the then Invasive Animals CRC (now Centre for Invasive Species Solutions), Animal Control Technologies Australia (ACTA) and MLA. The HOG-GONE® baiting system is the result of that research effort, utilising microencapsulated sodium nitrite as the lethal toxin in a peanut paste matrix. The HOG-GONE® product is currently awaiting approval by APVMA for commercial use. When HOG-GONE® does become available for commercial use it will provide the following advantages over existing baiting systems:

- Ease of use, particularly in warmer northern locations, as the product has greater stability than PIGOUT®.
- Increased effectiveness in controlling feral pigs – highly lethal and target specific.
- Less hazardous for operator use (though care still required).
- More accessible, assuming it is rated at less than the current schedule 7 for 1080, and therefore available to trained users. HOG-GONE® baits are considered most likely to be classified Schedule 6 under the Standard for the Uniform Scheduling of Medicines and Poisons and the Agricultural and Veterinary Chemicals Code Regulations.
- Less attractive to non-target species than 1080 grain and meat-based baits.
- Environmentally friendly and will degrade readily in the environment.
- Fast acting (2 hours until death compared to 6-8 hours for 1080) and more humane.

4.1.9 Novel low rainfall pasture legumes

Estimated impact: Medium

Inclusion of annual pasture legumes in cereal rotations has provided many businesses in the higher rainfall cereal-livestock zones of southern Australia with the opportunity for reducing business risk and improving farm productivity and profitability, however suitable cultivars and management systems are not as readily available for many of the low rainfall zones. The cereal-livestock zone in southern Australia is characterised by a large range in annual rainfall, in addition to diverse soil types both within and between regions. This diversity, combined with the requirement for variable lengths of pasture and crop phases, presents difficulties with identifying pasture legumes suited to all conditions where they could be of value.

The only widely sown perennial legume in the low rainfall cropping zone of southern Australia is lucerne, which may not persist well in areas with acid soils, low summer rainfall, or winter waterlogging (Ward, 2006). In many low and variable rainfall cropping-livestock areas, hard seeded annual legume species offer advantages over lucerne based pastures in that they do not dry out the soil profile prior to cropping in the same way that lucerne can, thus reducing the risk associated with the transition between pasture and cropping phases. Another advantage of hard seeding legumes is that they allow for the pasture to regenerate after the cropping phase without having to be re-sown, thus reducing establishment costs.

Despite the potential benefits of pasture legumes within these systems, challenges with lack of persistence in the longer term have been an issue in low rainfall areas compared to higher rainfall zones. For many soils in low rainfall areas no suitable legume cultivars exist, and even where well adapted cultivars become available, farmers require evidence that the introduction of the pasture legume can be achieved at low economic risk and that the resulting system will have profit advantages over alternative land uses. A large-scale pilot project in the medium rainfall zone in 2013 (project B.PSP.0013) with MLA and AWI in WA and southern NSW demonstrated how novel pasture legumes such as serradella, biserulla and bladder clover can improve livestock production while reducing nitrogen requirements, weeds and diseases for subsequent crops.

Following on from the success of the B.PSP.0013 pilot, further industry collaborative investment in the mixed farming zone of southern Australia aims to further develop the "new" pasture legumes together with innovative management techniques that benefit both animal and crop production systems. The extension component of this investment aims to promote improved management of legume pastures within existing pasture/crop rotations and adoption of legume pastures into currently continuously cropped systems. Research and extension activities are ongoing.

4.1.10 Tedera legume

Estimated impact: Low

The profitability and sustainability of livestock industries in southern Australia is severely constrained by the quality and quantity of feed available during summer and autumn. Sheep are often fed grain and/or conserved fodder supplements during late summer and autumn to fill the feed gap. Lucerne is grown in some areas with the aim of producing feed in late spring and summer to assist with providing carryover feed into autumn, thereby reducing the need for supplementation or reducing stocking rate during this period. The limitation of lucerne for this role in some regions is that it is susceptible to prolonged dry conditions. Leaf drop by lucerne is highest in locations where the summers are hotter and drier, thus limiting the potential benefits of lucerne to fill the summer and autumn feed gaps in these areas (Finlayson *et al*., 2012). An alternative source of fodder which is less susceptible to dry conditions would assist many producers to reduce the costs of supplementation and to increase the potential value of fodder crops for bridging the autumn feed gap.

Tedera (*Bituminaria bituminosa* C.H. Stirt. var. *albomarginata* and var. *crassiuscula)* has been identified as having the potential to fill the summer and autumn feed gap that is currently filled by lucerne in some areas, and by supplementation, or lowering stocking rate, in other areas. Tedera is an herbaceous deep-rooted perennial legume that exhibits high drought tolerance relative to other legumes, and subject to moisture availability in summer and cold temperatures in winter, has the ability to produce good quality feed throughout the year (Finlayson *et al*., 2012). While tedera has been shown to have considerable potential in the target environments in terms of quality and quantity of production, there has been concern regarding its persistence in competition with weeds and other species, particularly during early establishment (Real, 2017).

The first commercial release of the tedera variety, T15-1218 Lanza™, occurred earlier in 2019 in Western Australia. The variety is licensed to Landmark seed business, Seednet, under the Dyna-Gro Seed label. Research and extension activities involving tedera are ongoing.

4.1.11 Legume best management practices in the Brigalow Belt bio-region

Estimated impact: Medium

Well adapted sown pastures in northern Australia enable higher productivity and profitability in grazing enterprises by providing a greater amount of higher quality feed for a longer period of time relative to native pastures. Of the total area planted to sown pasture in northern Australia, around 70% has been sown with tropical grasses, of which buffel grass is the predominant species (Walker *et al*., 1997). While these sown species provide greater productivity relative to native pasture, their potential value has been limited by 'pasture rundown', whereby the annual dry matter production from sown grass pastures typically declines by 50 – 60% within five to ten years of establishment (Radford *et al*., 2007). Research indicates that beef production shows a similar trend, with a linear decline of 20-70% in live weight gains over the first five years of pastures when stocking rates are held constant (Radford *et al*., 2007). Producers are able to maintain Individual animal performance, however a reduction in stocking rate is required, with a consequent reduction in production per hectare.

A high percentage of producers in the Brigalow belt bio-region have attempted to increase pasture production by establishing legume pastures, however few have been successful in terms of achieving good density, yield and persistence outcomes (Peck *et al*., 2015). Part of the problem has been that earlier legume varieties were not persistent with aggressive sown grasses on the clay soils of the Brigalow Belt, however more persistent varieties, including Desmanthus (*Desmanthus virgatus*) and Caatinga stylo (*Stylosanthes seabrana*), were released in the mid to late 1990s (Peck *et al*., 2015).

Relative to results achieved during trials and demonstrations for these newer varieties, establishment in commercial pastures has been poor. The reasons for poor establishment have been suggested to include a lack of sufficient knowledge among producers and their advisors regarding both establishment and management practices of these legumes (Peck *et al*., 2015). According to Peck *et al*. (2015), graziers have generally used low cost legume establishment methods which have a high chance of failure, or poor legume establishment, resulting in little or no increase in production and therefore negative economic returns from the investment.

The Brigalow Belt bio-region occupies approximately 36 million hectares of Queensland and New South Wales, stretching from Dubbo in the south to Townsville in the north. Approximately 80% of the bio-region is in Queensland. The Brigalow Belt carries approximately 30% of the northern Australian beef herd on 15% of the grazed land area. Given the recognised potential that legumes have to improve the productivity of the northern Australian beef industry, investment by MLA and the Queensland Department of Agriculture and Fisheries (DAF) during the current investment period has been aimed at identifying and communicating more reliable legume establishment techniques and management practices for graziers and their advisors in the region. Investment has involved development of a coordinated extension program to support landholders to assess and implement on-farm options to successfully adopt legumes, and a coordinated R&D program to develop management practices to improve establishment reliability and long-term performance of legumes in grass pastures.

4.1.12 Rabbit RHDV calicivirus

Estimated impact: Low

Rabbits compete with livestock for pasture, destabilise the structural integrity of the soil and contribute to soil erosion. Rabbit haemorrhagic disease virus (RHDV) was introduced into Australia as a biological control agent for rabbits in 1996 and proved highly effective in reducing rabbit abundance, especially in parts of Australia with a Mediterranean or semi-arid climate. In those areas, rabbit populations commonly fell by 90% or more as the disease spread (Bowen and Read, 1998). However, in cooler, more humid areas, disease impact was reportedly lower (Richardson *et al*., 2007). In 2009 a native benign calicivirus, called RCV-A1, was identified as a factor for RHDV being less effective in these cooler and wetter climates. Studies revealed that prior exposure of rabbits to RCV-A1 causes a non-pathogenic infection of the small intestine which is capable of providing temporal partial cross protection to RHDV, thus hindering effective RHDV mediated rabbit biocontrol measures (Strive *et al*. 2013).

In response to the decline in effectiveness of RHDV in the more humid areas of the country, research efforts focused on the identification of new strains of the virus suitable for these conditions. After testing 38 variants of RHDV over a 5-year period, this research culminated in the national release of a Korean strain of RHDV, known as RHDV1-K5, in early March 2017. This was the first time in 20 years that a new rabbit biocontrol agent had been released into Australia.

The virus was released at 323 sites nationally as part of the 20-year national biocontrol plan for rabbits. It was initially anticipated that RHDV1-K5 would be spread by insect vectors, such as bushflies and blowflies, and via direct contact between rabbits and other animals with rabbit carcasses. However, to date, there is little evidence that this has occurred and it appears that the K5 strain has only been effective as a biocide at the site of release (T. Cox pers comm.). It is uncertain as to why the RHDV1-K5 virus has not spread as anticipated, however it is suspected that the cause may be linked with the RHDV2 strain, which emerged in wild rabbit populations in 2015. It is considered possible that the K5 virus may start to spread on its own in the future via flies as vectors.

RHDV1-K5 is available to purchase as a commercial product but is classified as a Schedule 4 restricted chemical product and can only be supplied to persons who are authorised for its use under the laws of their state or territory. Different states and territories have different authorising systems. Research into the possible impact of RHDV2 on RHDV1-K5 efficacy is currently underway.

4.1.13 Oestrogenic clover

Estimated impact: Low

Sub clover (*Trifolium subterraneum* L) is the dominant annual pasture legume in Australia, with an estimated 42 million sheep grazing sub clover pastures. It has long been known that high levels of oestrogens found in older varieties of sub clover can interfere with sheep reproduction, with the effects often referred to as 'clover disease'. Bennetts *et al*. (1946) first described severe clinical symptoms in sheep grazed on highly oestrogenic clover pastures that included ewe infertility, prolapsed uteri, dystocia and increased lamb mortality. Lamb mortality rates are a major cost to Australia's sheepmeat industry, particularly as we try to rebuild the national flock.

Many pastures sown after World War II contained varieties with the potential to develop high levels of the oestrogen, formononetin, in their green leaves, including Yarloop, Dwalganup, Geraldton, Tallarook and Dinninup. These older varieties have high levels of hard seed, so persist in the soil in the longer term and can become dominant after a long cropping phase or a run of dry seasons. Through these high hard seed levels or low palatability, the high-oestrogen varieties have persisted in most paddocks across southern Australia. All cultivars released from our National Breeding Programs in recent times have been screened for low formononetin with no reported cases of any problems.

While newer varieties do not have high levels of oestrogens, many properties still have a clover base that contains a high percentage of the older varieties, which if producers are not aware of, can pose a threat to ewe fertility and lamb survival. Although rare, cattle may also be affected. It is thought that old highly oestrogenic varieties will only impact sheep flocks if they provide more than 30 per cent of their diet (Walker *et al*., 2002). However, this figure is not definitive and it is possible that there could be a problem with only 20% oestrogenic clover.

The best form of detection is to assess pastures for their content of oestrogenic clover cultivars and/or to test leaf samples in a laboratory. The current concern is, however, that new generation farmers may be less aware of the potential risk associated with oestrogenic clover, and be unfamiliar with the identification of these cultivars in pastures. Anecdotal evidence also indicates that many consultants and advisors are also unable to identify high oestrogen cultivars or to advise clients on the management of clover disease. In spite of the magnitude of the animal welfare issue and the economic losses, there are few producer guidelines focussed on how to prevent acute or cumulative long-term effects on ewe reproduction.

MLA has invested in the 'Oestrogenic clover removal extension program for sheep reproduction' project in an endeavour to increase the awareness among producers and advisors of the existence of oestrogenic clovers and their potential impacts on sheep reproduction, to encourage producers to test pastures for the presence of oestrogenic clovers and to provide information regarding management strategies to minimise the impact of known oestrogenic clover in pastures. Simply identifying clovers will not necessarily predict if the clover is oestrogenic, or if oestrogen levels are potent. The most accurate measure is to get a sample of the clover tested at a laboratory and for the farmer to assess the prevalence of the high oestrogenic clovers in their paddocks. If the presence of oestrogenic clover is confirmed and above 20%, the program provides producers with recommended options for reducing the impacts of the clover on reproduction.

Feedlots

4.1.14 Feed truck auto-delivery system

Estimated impact: Low

Aside from the cost of cattle purchased, the highest costs associated with running feedlots are labour and feed. A large part of the labour required involves delivery of feed rations to bunks, typically twice daily via morning and afternoon delivery runs. The feed delivery process requires a certain level of skill to accurately deliver the correct ration in a uniform and consistent quantity along the full length of the bunk line. This ensures that all cattle have equal access to the ration to optimise feed intake and minimise waste. Overfeed events can sometimes require the driver to shovel out surplus feed from the bunk, adding considerable time to the length of delivery. Additional time and wastage can also occur when a driver mistakenly delivers a ration to the incorrect pen.

When delivering feed to the bunk, drivers do a first forward pass, and more often than not, need to reverse the truck back along the bunk line to complete the effective ration delivery to the standard required. This reversing process represents an inefficiency in the system which costs feedlots in time and truck operating costs that would not be required if effective delivery of the ration was completed on the first pass. Reversing along the bunk also occasionally results in collision between the truck and the bunk, which adds additional unproductive repair costs.

In an effort to improve the efficiency of feed delivery systems in their Myola feedlot, the Bindaree Beef Group (BBG) expressed interest in collaborating with industry to investigate an automated feed delivery system. This resulted in the development of a joint project between MLA and the BBG to develop and test a prototype automatic feed delivery system for retrofitting to mixer bins of commercial grade delivery trucks. The prototype was designed by automation and robotics solutions company, Manabotix Pty Ltd, and the protype was trialled at the BBG Myola feedlot in north western NSW.

Based on successful trialling of the system, it is due to become commercially available in October 2019 via leasing arrangements between feedlots and the Manabotix company. The key design features of the technology include its high-accuracy positioning solution based on global navigation satellite system technology, it is retrofittable to feed trucks and scale heads that are commercially available, it can be switched between automatic and manual feeding modes, and the feed gate has an interlock preventing feeding errors if the feed truck arrives at the incorrect pen (McCarthy and Mcleod, 2019). Once available, it is expected that these features will assist feedlots to save both labour and input costs during the feed delivery process.

4.1.15 Autonomous LIDAR feedlot bunk scanning and management system

Estimated impact: High

Feed bunk management in feedlots involves determining and delivering the feed ration allocated for each pen for a 24-hour feeding cycle. Objectives of successful bunk management include consistently maximising feed intake, whilst minimising feed wastage and digestive disorders. Traditional bunk management is largely subjective due to the bunk calling task involving human estimations of feed remaining in bunks. Feedlot managers report skill variation between bunk callers in estimation of feed remaining, which is influenced by previous training, skill level, and focus on any given day (McCarthy *et al*., 2018a).

The best bunk managers strive to strike a balance between high feed intake for performance and minimal feed waste, while maintaining consistent intake. Poor feed bunk management can result in erratic cattle intake patterns that reduce dry matter intake and average daily gain by as much as 10-15% (Lundy *et al*., 2015). Sub optimal feed bunk management where cattle are consuming less than they are capable of or more than they need will therefore result in lower feed conversion efficiency and reduced profits.

The Australian feedlot industry identified automation of the human bunk calling activity as a potential means of increasing the accuracy of feed bunk management. A subsequent partnership between MLA and automation and robotics solutions company, Manabotix Pty Ltd, involved development and testing of a prototype automatic bunk scanning system to objectively measure feed remaining in bunks. After initial tests showed that the prototype was consistently able to conduct bunk calls with greater accuracy and precision than human callers, further investment was made to trial the prototype system in a commercial feedlot setting (McCarthy *et al*., 2018a). The results of the commercial trials confirmed the initial trial in that the prototype system was demonstrated to more accurately and precisely estimate feed remaining in bunks, particularly at higher feed masses (McCarthy *et al*., 2018b).

In order to value add to this outcome, MLA has continued to collaborate with Manabotix to develop and trial a mobile robotic system to carry the bunk scanner along the bunks and to develop and test software algorithms to support more accurate feed allocation decisions. Work in these two areas is currently underway, with final project outcomes due for completion later in 2019.

4.1.16 Graded woodchip bedding for feedlot pens

Estimated impact: None

Problems with muddy pens and keeping cattle clean has been identified as one of the three most serious animal welfare issues related to outdoor feedlot beef production (Cowley *et al*., 2019). The comfort of cattle in feedlots is not only considered to impact on animal health and welfare, but in doing so, can also result in improved weight gain due to increased feed intake and/or improved feed conversion efficiency. The perceived relative comfort of cattle is also important for enhancing consumer perception of the welfare of cattle in feedlots.

In response to increasing industry interest in various types of pen surface amendments, MLA funded a scoping study in 2013 to assess the impact of bedding materials on the health and welfare of lot fed cattle. The study found that bedding is widely used in overseas animal production systems to increase animal comfort and performance, reduce odour, and to minimise the deterioration of earthen pen surfaces resulting from frequent animal traffic and/or persistent wet conditions (O'Keefe *et al*., 2013).

A follow-on case study analysis by Watts *et al*. (2015) reported industry interest in pen bedding, and that woodchips (broadly defined) were the most widely tested bedding type in the Australian feedlot industry. Watts *et al*. (2015) recommended that bedding be targeted towards key areas of high traffic, or for use in specific pens such as for sick/injured livestock, induction or post washing pens. Watts *et al*. (2015) concluded that bedding would not be economically viable for broad use in production pens, except as mounds in cold, wet environments. Further research was recommended to characterise bedding responses and return on investment in Australian feedlots (Watts *et al*. 2015).

More recently, Cowley *et al*. (2019) investigated the production and management costs and benefits of providing woodchip bedding to feedlot cattle during wet feedlot conditions in an experimental scenario. The study concluded that there was a numerical net economic benefit of the woodchip bedding treatment over the unbedded control cattle, but that this result was highly variable and sensitive to input costs. The current impact assessment took a more moderate approach to assessment of costs and benefits than that taken by Cowley *et al*. (2019) with an overall finding of no net economic benefits of adoption of woodchip bedding in the context of the woodchip depth and stocking rate parameters for the experimental trial results. However, it was recognised that other non-quantified benefits associated with adoption of this product exist, most notably in the area of improved animal welfare, along with an associated increase in the social license to operate for adopting feedlots.

4.1.17 Short duration lairage

Estimated impact: High

Lairage is where cattle are held and rested after arrival at the slaughter facilities. Time in lairage enables cattle to recover and settle after transport to reduce stress prior to slaughter. The Australian Standing Committee on Agriculture and Resource Management (SCARM) model code of practice for the welfare of livestock at slaughtering establishments recommends that for carcase quality purposes, a minimum of 2 hours rest period between arrival and slaughter is desirable (Anon, 2002). Longer lairage periods are recommended when livestock have travelled for more than 6 hours or are stressed. The code requires that animals be provided with feed if they have been off feed for more than 24 hours. In practice, the standard lairage time for slaughter cattle in Australia typically ranges between 12 and 24 hours (Ferguson *et al*. 2007).

The impact of time in lairage on various physiological aspects of cattle metabolism has been the subject of various research experiments to understand how time in lairage may impact upon final HSCW and carcase quality aspects. In terms of carcase quality, of most interest is the impact of time in lairage on the incidence of dark cutting meat. It has been hypothesised that increased duration in lairage results in a greater incidence of dark cutting meat (Janloo, 1999, Kreikemeir *et al*.,1998). This is proposed to occur as a greater proportion of muscle glycogen is metabolised as the duration of lairage increases, such that reduced levels of antemortem muscle glycogen lower post mortem lactic acid accumulation which impedes pH decline, resulting in potentially more dark cutting meat (Ashmore *et al*., 1973, Scanga *et al*., 1998).

Investment by the Australian feedlot industry into research to quantify the impact of duration of lairage on meat quality and carcase yield was made via an MLA funded project delivered in collaboration with feedlot veterinary and nutrition services company, Bovine Dynamics Pty Ltd. While the primary focus of the research was to assess timing of transport and slaughter on the incidence of dark cutting, the results also revealed significant differences in yield between treatments, such that shorter duration lairage was associated with higher dressing percentage and HSCW. The findings of this research thus present opportunities for increasing carcase value in terms of both quality and quantity by reducing the average duration of time in lairage.

The extension message which is currently being promoted by MLA and the Australian Lot Feeders Association for this product is that duration in lairage of less than 4 hours will increase final dressing percentage and HSCW of cattle.

4.2 Parameter estimates for the impact assessment

Key results for the impact assessment analysis are provided in **Table** .

Table 4: Key impact assessment results by product.

Product	Category	Adoption start and peak year	Peak number and units adopted	Annual net benefit (per unit undiscounted by time)	Likelihood of attribution or impact current assessment period	% benefit due to cost savings and productivity increase	% benefit Split between zones and species
Producer Adoption							
Profitable Grazing Systems	Producer Adoption – Category C	Start: 2016/17 Peak: 2021/22	Units: Ha No.: 508,701	$17.47	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 0% Southern beef: 48% Sheep: 52%
Producer Demonstration Sites	Producer Adoption – Category C	Start: 2016/17 Peak: 2020/21	Units: Ha No.: 1,528,858	$6.71	100%	Cost savings: 2% Productivity increase: 98%	Northern beef: 0% Southern beef: 24% Sheep: 76%
EDGEnetwork - Northern	Producer Adoption – Category B	Start: 2017/18 Peak: 2021/22	Units: Ha No.: 26,373,499	$0.45	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 99% Southern beef: 0% Sheep: 1%
EDGEnetwork - Southern	Producer Adoption – Category B	Start: 2017/18 Peak: 2021/22	Units: Ha No.: 125,706	$6.74	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 0% Southern beef: 73% Sheep: 27%

Product	Category	Adoption start and peak year	Peak number and units adopted	Annual net benefit (per unit undiscounted by time)	Likelihood of attribution or impact current assessment period	% benefit due to cost savings and productivity increase	% benefit Split between zones and species
BredWell FedWell Sheep	Producer Adoption – Category B	Start: 2016/17 Peak: 2021/22	Units: Ewe No.: 996,487	$2.48	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 0% Southern beef: 0% Sheep: 100%
BredWell FedWell Cattle	Producer Adoption – category B	Start: 2018/19 Peak: 2022/23	Units: Cow No.: 132,192	$2.98	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 0% Southern beef: 100% Sheep: 0%
BeefUp	Producer Adoption – category A	Start: 2018/19 Peak: 2024/25	Units: Head No.: 1,700,921	$1.19	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 100% Southern beef: 0% Sheep: 0%
It's Ewe Time	Producer Adoption – category A	Start: 2018/19 Peak: 2021/22	Units: Ewe No.: 763,443	$4.44	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 0% Southern beef: 0% Sheep: 100%
Productivity (On Farm)							
Parthenium biological control	Biological control	Start:2018/19 Peak: 2032/33	Units: Ha No.: 912,549	$3.41	100%	Cost savings: 0% Productivity increase: 100%	Northern beef: 0% Southern beef: 95% Sheep: 5%

Product	Category	Adoption start and peak year	Peak number and units adopted	Annual net benefit (per unit undiscounted by time)	Likelihood of attribution or impact current assessment period	% benefit due to cost savings and productivity increase	% benefit Split between zones and species
Parkinsonia biological control	Biological control	Start: 2017/18 Peak: 2026/27	Units: Ha No.: 500,000	$12.18	64%	Cost savings: 98.5% Productivity increase: 1.5%	Northern beef: 100% Southern beef: 0% Sheep: 0%
Redlands Leucaena	Leucaena	Start: 2020/21 Peak: 2039/40	Units: Ha No.: 105,186	$129	0%	Cost savings: 0% Productivity increase: 100%	Northern beef: 100% Southern beef: 0% Sheep: 0%
HOG-GONE® feral pig baiting system	Pig control	Start: 2022/23 Peak: 2031/32	Units: Pig culled No.: 70,000	$111	33%	Cost savings: 100% Productivity increase: 0%	Northern beef: 0% Southern beef: 0% Sheep: 100%
Novel low rainfall pasture legumes	Plant genetics	Start: 2019/20 Peak: 2028/29	Units: Ha No.: 532,667	$9.15	27%	Cost savings: 30% Productivity increase: 70%	Northern beef: 0% Southern beef: 10% Sheep: 90%
Tedera legume	Plant variety	Start: 2019/20 Peak: 2039/40	Units: Ha No.: 97,500	$35	42%	Cost savings: 13% Productivity increase: 87%	Northern beef: 0% Southern beef: 25% Sheep: 75%
Legume best management practices in the Brigalow Belt bio-region	Plant variety	Start: 2020/21 Peak: 2036/37	Units: Ha No.: 92,077	$65	81%	Cost savings: 0% Productivity increase: 100%	Northern beef: 100% Southern beef: 0%

Product	Category	Adoption start and peak year	Peak number and units adopted	Annual net benefit (per unit undiscounted by time)	Likelihood of attribution or impact current assessment period	% benefit due to cost savings and productivity increase	% benefit Split between zones and species
							Sheep: 0%
Rabbit RHDV calicivirus	Rabbit control	Start: 2017/18 Peak: 2020/21	Units: Ha No.: 13,205,152	$0.59	10%	Cost savings: 2% Productivity increase: 98%	Northern beef: 13% Southern beef: 52% Sheep: 35%
Oestrogenic clover	Reproductive efficiency	Start: 2019/20 Peak: 2039/40	Units: Ha No.: 62,435	$33	44%	Cost savings: 25% Productivity increase: 75%	Northern beef: 0% Southern beef: 0% Sheep: 100%
Feedlots							
Feed truck auto-delivery system	Feed efficiency	Start: 2020/21 Peak: 2029/30	Units: Head No.: 1,790,739	$0.18	100%	Cost savings: 100% Productivity increase: 0%	100% Feedlot
Autonomous LIDAR feedlot bunk scanning & management system	Feed efficiency	Start: 2020/21 Peak: 2029/30	Units: Head No.: 1,790,739	$12.15	90%	Cost savings: 23% Productivity increase: 77%	100% Feedlot
Graded woodchip bedding for feedlot pens	Feedlot health management	Start: N/A Peak: N/A	Units: Head No.: N/A	No net benefit	100%	Cost savings: 0% Productivity increase: 100%	100% Feedlot
Short duration lairage	Slaughter (processing)	Start: 2019/20 Peak: 2033/34	Units: Head No.: 1,706,982	$18.38	100%	Cost savings: 0% Productivity increase: 100%	100% Feedlot

5.0 Uncertainties and Limitations

There are various uncertainties and limitations associated with both the estimates of impact and adoption for the products evaluated during this impact assessment. The following range of uncertainties and limitations have been identified:

- Uncertainty regarding the transfer from experimental and trial results to impacts on commercial farms/feedlots.
- Uncertainty regarding the actual level of producer adoption occurring relative to producer stated intentions to adopt.
- Uncertainty regarding the degree to which producer survey results are likely to represent the target population.
- Uncertainty regarding timing and occurrence of expected product commercialisation.
- Uncertainty regarding future producer capacity to continue receiving expected benefits due to unknown seasonal/climate change impacts and personal situations e.g. retirement, selling the business, enterprise changes.
- Limitations associated with making estimates of impact/adoption where little empirical and/or intent to adopt data exists.
- Limitations associated with a lack of data available for some elements of potential benefit associated with product adoption. In these situations, only part of the full potential benefit was able to be assessed, however possible additional areas of benefit were highlighted for further assessment in the future.
- Limitations due to a lack of available data to capture environmental, social/management and social license to operate benefits associated with some products. Although not quantified, these benefit areas were identified where relevant.
- Limitations due to lack of available methodology to measure impact of genetic changes on farm. This was an area that was unable to be assessed in the current period.

Efforts have been made to address key limitations and areas of uncertainty wherever possible by taking a conservative approach to making estimates of both impact and adoption and by conducting a sensitivity analysis around the key risks associated with measurement of product impact.

In situations where no data was available to provide a reasonable estimate of impact, the product was removed from the impact assessment and will be assessed in future when more accurate data becomes available. In some cases, research and extension activities are ongoing and new data will become available in the future to update current estimates of impact and adoption.

6.0 Issues and Recommendations

The evaluation of adoption and impact for the on-farm adoption products was hindered by the following issues:

Issue 1: Existing M & E for products was incomplete or inadequate for the purposes of measuring adoption and impact for the majority of products.

M & E for adoption programs can be thought to have two aims:

1. *To evaluate the success of the event/program against the project aims and plan* i.e. did it engage the right audience, did the event/program deliver a quality experience, did the audience learn from it what was intended, did the program utilise resources effectively? Was it fit for purpose?
2. *To determine the impact of the event/program on participants* i.e. did they take the action the program was designed to deliver and if not, why not, and did the action result in the economic impact intended?

For the most part, M & E plans in current adoption programs collect data that reports on the success[1] of the event/program but not on its impact (i.e. 1 not 2 above). In Bennett's Hierarchy terms, programs generally focus on collecting Level 2 (activities – description, location, date), Level 3 (participation – numbers, demographics of participants), Level 4 (reactions to events/program i.e. likes/dislikes), Level 5 (KASA change i.e. knowledge, skills, attitudes and aspirations) and in some cases, Level 6 (practices changed, or in most cases, intent to change).

Level 1 (inputs i.e. $ and resources), Level 7 – (impact or results) are often missing from program evaluations, yet underpin the ability to demonstrate that the program outcomes were achieved and enable calculation of the return on investment.

In addition, the consistency in data collection was generally low. Some programs record participation as numbers of people in attendance regardless of who they are (producers, service providers, others), others record this in detail but fail to register/account for members from the same business so that participation can be measured as number of businesses rather than individuals. Age demographics, gender and role in the business also provide useful information for program planning and comparing to target audience demographics but are often left out.

There is also inconsistency when it comes to collecting basic demographics i.e. property size (grazing ha/cropping ha/total ha), enterprise mix and stock numbers (i.e. breeders or total stock numbers or both) and almost no demographics from service providers/non-producers or others in attendance i.e. why are they there, do they intend to use this information with clients, what is their client reach? To enable accurate impact to be measured, it is important that standards are set for basic participation

[1] In some cases, this information was only collected and collated per event and not collated up for the entire program. Interpretation of this data was also lacking i.e. was the activity successful in achieving the event outcomes, what was learnt by the organisers about the event structure and process, what would be done differently next time, how could engagement be improved, and most importantly, was it delivering the desired impact on participants i.e. were they learning what was intended, did the information translate to their farming system, did it 'make sense' or was it coming up against barriers that need to be addressed.

measurement to give an accurate picture of who is participating and what part of the industry they represent.

Collecting Level 7 (Impact data) necessitates follow-up processes with participants as the majority of adoption programs are short term and impact is not achieved until sometime after the program ends. For this assessment it was difficult in some cases to obtain firstly permission to contact participants for follow-up evaluation, and secondly to obtain contact details for participants. This was an issue for the PDS projects in particular. This made follow up analysis of whether participants have made changes to their business problematic, and ex-ante information was used to best estimate impact in lieu.

For category C programs that have a longer engagement i.e. PGS and PDS, depth of reporting was an issue for estimating impact and adoption. For instance, a proportion of PGS participants had made changes before they had completed the program, but no data was collected as to what these changes were or what the likely impact would be. While it is proposed that in the future PGS SLP participants will use KPIs to monitor impact during the life of the SLP, consistency in measuring these KPIs is key. NZ Red Meat Profit Partnerships program (https://beeflambnz.com/your-levies-at-work/farming-profit) provides guidelines (https://beeflambnz.com/knowledge-hub/PDF/kpi-booklet) and online tools (https://beeflambnz.com/data-tools) to enable consistency in data recording and reporting so that comparisons can be made across the whole program. This process allows better evaluation of the success of the delivery and impact of the program.

In the case of PDS, there was large variation in the depth of data presented in final reports, including pre, mid-term and post analysis of changes and impacts.

For Category A and B events, the data collected and collated was generally inadequate for estimating impact for all products except Bred Well Fed Well Sheep, which was the only product that provided sufficient data to estimate impact from the final report with some follow up for clarification purposes only.

Recommendations for the improvement of data collection, collation, analysis and reporting are outlined in Table 5. The overarching recommendation is for a consistent approach to be used for all adoption projects. Specific recommendations for each adoption product have been provided in the individual product evaluation reports.

Issue 2: Non-producer participants in adoption products are not represented in M&E

Current M & E plans for all adoption products do not estimate impact or adoption for non-producer participants such as livestock advisors, agribusiness professionals (agronomists, rural banking representatives, stock agents, rural merchandisers etc), financial counsellors, government extension staff, researchers etc. In some programs, such as BeefUp and It's Ewe Time, these participants form up to 30% of the audience, and depending on the reason for their participation, these participants may be in a position to influence their clients through extension of information, knowledge and skills. While non-producer participants are not the primary targets of MLA's on-farm adoption products, their position as 'trusted advisors' with their clients can influence adoption and successful implementation of on-farm practices. It would therefore be prudent for MLA to consider how the non-producers influence adoption through their clients and what impact this is having on the industry.

The recommendation in this area (Table 5) is for MLA to explore how non-producer participants are utilising the information, knowledge and skills they are obtaining from participating in all categories of adoption activities and how it may be contributing to on-farm practice change and impact. If shown to be significant, it is recommended that MLA develop a process to monitor and evaluate their participation in the future.

Table 5: Issues and recommendations for future gathering and reporting of impact and adoption data from on-farm adoption products.

Issue	Products	Recommendation
Insufficient collection, collation, analysis and reporting of existing data for **participation** in product activities.	All	**Recommendation 1:** MLA develop standards for collection, collation and reporting of **participation data**: • # of participants per program, per impact area, per zone, per year and total. • # of businesses represented by participants per program, per impact area, per zone, per year and total. • # of ha (grazed and total), sheep (breeders/total) and cattle (breeders/total) per business (not per participant) (by program, per type of impact area, per zone, per year and total). • # of non-producer participants including their potential to influence producers (by program, per impact area/client reach, per zone, per year and total). **Recommendation 2:** MLA collate a database of **all** participant details and demographics including whether they have agreed to take part in follow up program/project evaluations.
Insufficient collection, collation, analysis and reporting of existing data measuring **adoption.**	All	**Recommendation 3:** MLA develop standards for collection, collation and reporting at the **end** of the activity for **adoption**: • # of businesses who are considering making a change including types of change (program, impact area, per zone, per year and total). **Recommendation 4:** MLA develop standards for collection, collation and reporting **post activity** i.e. 6 months – 2 years later on: • # of businesses who made a change including details of the types of change (program, per impact area, per zone, per year and total). • Whether they would have made this change anyway without the activity
	Category C	**Recommendation 5:** MLA develop standards for collection, collation and reporting **during** activity of adoption of practice change including types of changes being made.

Insufficient collection, collation, analysis and reporting of existing data measuring **impact.**	All	**Recommendation 6:** MLA develop standards for collection, collation and reporting post activity i.e. 6 months – 2 years after adoption for **impact**: • Impact of changes made by businesses including costs/benefits and non-dollar benefits.
	Category B & C	**Recommendation 7:** MLA develop standards and processes to develop **longitudinal case studies for key changes** identified in post workshop interviews to track impact over time. Especially for genetics and northern grazing systems changes where little data is currently available. These case studies would need to cover the following: • Baseline data for farm performance (using a recognised farm analysis method i.e. Victorian Monitor Farm or Holmes and Sackett farm analysis) that is updated annually. • Details of changes made with cost:benefit analysis based on actual data. • Attribution to program i.e. what else influenced the decision, where else did information/advice/skill building come from. • Exploration of perceived barriers to change i.e. what else was happening in the environment such as seasonal, market, human interactions.
	Category C	**Recommendation 8:** MLA develop standards and processes to **measure impact** of changes being made **during** the activity.
No process to measure adoption and impact for non-producers (e.g. advisors, agribusiness etc)	All	**Recommendation 9:** MLA explore adoption and impact relating to non-producers and their clients with the aim of developing standards and processes to measure this area of impact in the future.
Deliverer/coordinator training for collection, collation, analysis and reporting of required data.	All	**Recommendation 10:** MLA invest in training of program deliverers/coordinators in how to collect, collate, analyse and report data to improve consistency, quality and storage of data for evaluation purposes.

7.0 Conclusion

This impact assessment has revealed a range of likely levels of product impact and adoption over the assessment period. The assessment process has highlighted key areas where MLA can implement improved monitoring and evaluation processes to assist with more timely and accurate impact assessments of this kind in the future. In this regard, a series of recommendations for future actions have been made. These recommendations relate to a broad approach to M & E rather than providing specific detailed recommendations which would involve further assessment and piloting of new approaches for different types of adoption pathways.

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