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Prepared by: Sarah McDonald
New South Wales Department of Primary Industries

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Quantifying spatial and temporal changes in feed supply and demand

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Executive summary

Unmanaged grazing pressure is recognised as a significant threat to production and sustainability of extensive livestock enterprises across the southern Australian rangelands. Early detection of an impending imbalance between feed supply and demand from total grazing pressure (TGP) management will allow producers to undertake timely, more informed management decisions (e.g. removal of livestock, control of unmanaged goats and kangaroos), avoid production losses and mitigate negative environmental impacts.

This project sought to assess the feasibility of using remotely-sensed and on-ground data to assess changes in feed supply and demand in the southern Australian rangelands and to deliver an implementation plan for the development of a tool that provides producers an early warning of an imbalance between feed supply and demand. Recommendations and delivery needs were also identified through the project.

Technical experts in fields of remote sensing, herbivore monitoring, grazing systems and natural resource management were consulted to identify technically and practically feasible solutions to monitor feed supply and demand in rangeland environments and scope resourcing requirements for the development of a tool. An AgTech developer was engaged to develop a dashboard design for a TGP Tool and identify additional inputs and analytics required. Throughout the project a producer group comprised of eight producers located throughout the southern Australian rangelands were consulted to identify industry needs, identify key design requirements of the TGP Tool to monitor feed supply and demand, and provide feedback on a prototype TGP Tool design. A broader industry group (representing producers and extension staff) provided feedback on the final designs and requirements.

Key information required by producers to inform decisions regarding total grazing pressure management and to be provided by the TGP Tool included (1) feed on offer, (2) fractional ground cover, (3) feed demand, (4) interaction of feed supply and demand (5) weather and climate, and (6) spatial data, at paddock and property scales.

Feed on offer can be determined using producers' on-ground estimations, remotely sensed satellite data or biophysical modelling. However, validation of remote sensing data and biophysical modelling methods to estimate feed on offer are required for much of the southern Australian rangelands. Fractional ground cover can be reliably estimated using satellite data and producer on-ground assessments. Information regarding livestock can be obtained from producer records, however, no practically feasible methods currently exist to estimate unmanaged herbivore grazing pressure. Producer estimations, supported by annual regional aerial survey data, is the most feasible approach for providing unmanaged herbivore data. Weather, climate and spatial data is available from multiple public and private providers.

Key activities, time, costs and outputs of five phases for the development of the TGP Tool are outlined in the Implementation Plan: (1) requirements gathering, (2) development of prototype, (3) validation of prototype, (4) broad scale implementation of TGP Tool and (5) maintenance and ongoing improvement of TGP Tool. Three options for the TGP Tool development and potential providers are also recommended.

Identified risks and barriers to the TGP Tool development include a lack of feasible methods to accurately, cheaply, frequently and efficiently monitor unmanaged TGP at a property and paddock level in rangelands, a lack of validation of remotely sensed pasture information and biophysical models in the southern Australian rangelands, costs of obtaining and analysing satellite imagery, achieving accurate feed on offer and utilisation information in large heterogenous rangeland paddocks and potential lack of market traction after development.

Recommendations for future research and TGP Tool development to overcome these barriers include validation of remotely sensed technology, development of feasible options to monitor and control unmanaged herbivores across the southern rangelands and improving understanding relationships between generalist herbivores (e.g., livestock, goats, kangaroos) and impact in rangelands. Also of central importance is continued development of the TGP Tool in close consultation with producers.

Overall, a tool to allow producers in the southern Australian rangelands to monitor for an imbalance in feed supply and demand and inform management decisions will contribute to improved production, environmental and animal welfare outcomes across the region. The majority of industry representatives consulted with during this project were supportive of the development of a tool to better manage total grazing pressure and of the design prototype that was presented to them. While there are some limitations surrounding availability and accuracy of remotely gathered information on feed supply and demand in the southern Australian rangelands, technology is advancing and input data can be obtained by producer estimations where necessary (albeit, with potential trade-offs surrounding accuracy and simplicity of tool).

Based on producer interest and technical feasibility of obtaining necessary information to input into the TGP Tool, we recommend the development of the TGP Tool proceed, as per the Implementation Plan. Additional recommendations regarding the development of the TGP Tool include ensuring close involvement with producers throughout all phases of development with iterative feedback processes, incorporating flexibility into the TGP Tool design to allow for different levels of detail and functionality, and ensure the TGP Tool has the ability to incorporate new technologies for monitoring feed supply and demand as they become available. In addition, education and training of producers in using the TGP Tool and making TGP decisions are recommended, and where possible, inputs and outputs of the TGP Tool should be linked with existing products to increase the adoption of the TGP Tool.

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1 Background

Total grazing pressure (TGP) is defined as the combined pressure exerted by all managed and unmanaged herbivores on vegetation, soil and water resources of landscapes. On average, less than half the grazing pressure in the southern Australian rangelands is managed by pastoralists (Waters et al. 2018). Kangaroos and unmanaged goats are the principal unmanaged herbivores in rangelands, totalling an estimated 15.57 million DSE in 2016-18, though their density relative to livestock numbers can vary considerably over space and time (Waters et al. 2018). Other common unmanaged herbivores throughout the southern Australian rangelands include rabbits, feral pigs, donkeys and camels.

Both land managers and service providers in the southern rangelands have indicated that a decrease in the demand for forage from unmanaged herbivores is required (Atkinson et al. 2020). While TGP management has been identified as a major issue in rangelands for some time, these issues are not confined to these areas as other more productive regions face increases in macropod numbers and recent widespread drought conditions.

The quantity and quality of forage available for all herbivores within the southern Australian rangelands is frequently low but as seasonal conditions become drier, animal performance and profitability is reduced (Hacker et al. 2004) and pastures risk being degraded (Wilson and Edwards 2019; Deo et al. 2017). Various forms of rotational grazing and pasture spelling are being practiced by land managers, however grazing by unmanaged herbivores reduces the benefits pastoralists gain from early destocking and resting pastures. This results in a lower quantity and quality of forage available for livestock. Improved methods for TGP management need to facilitate the rest and recovery of pastures.

Central to TGP management is ensuring demand for feed does not exceed feed supply, as an imbalance in feed demand and supply can result in detrimental outcomes for livestock productivity, resource condition and animal welfare. Management of TGP needs to be underpinned by an ability to quantify the spatial and temporal distribution of all herbivores, due to the considerably large fluctuations in unmanaged herbivore populations and regional movement of unmanaged herbivores. Real-time information coupled with accurate projections to identify in advance when an imbalance between forage supply and demand is imminent could support pastoralists to better manage TGP and allow land managers to make more timely and cost-effective decisions about livestock and unmanaged herbivore management.

Improved management of TGP will result in environmental benefits including increases in ground cover, pasture biomass, biodiversity, landscape function, soil carbon, soil structure and prevent degradation of pasture quality and resource condition. Overall, this will result in improvements to production and profitability of livestock enterprises in southern Australian rangelands. A reliable method to quantify impacts of TGP may also underpin a defensible case for the pastoral industry to undertake kangaroo population control (Wilson and Edwards 2019), demonstrate environmental stewardship (Australian Beef Industry Sustainability Framework 2019) and increase the livestock sectors social licence to operate (Sinclair et al. 2018).

This project will identify feasible mechanisms to monitor changes in herbivore populations and their impacts on feed base and resource condition and will provide a costed implementation plan to develop a decision support tool for use by producers. The TGP Tool will be informed by industry needs to provide paddock-scale, real-time, temporal and spatial changes in feedbase and herbivore (livestock/unmanaged

goat & kangaroo) populations. This TGP Tool will provide an early warning system to inform paddock-scale management decisions regarding TGP (e.g., destocking paddocks, goat and kangaroo harvesting or culling) and provide a means for producers to weigh up potential costs and benefits of investment in infrastructure for TGP management (e.g., exclusion fencing or controlling waterpoint access).

This project is a key component of the larger investment plan developed by NSW DPI for MLA which identifies TGP research and development priorities in the southern Australian rangelands. In this plan, three key themes are identified as subprograms:

1. Technical capacity for industry to manage all herbivores
2. Realising the production and environmental benefits of TGP management
3. Widespread adoption of evidence-based, effective TGP management

The TGP tool to be developed through this project fits within the first subprogram. This project is to determine the 'proof of concept' and design of a tool. Future funded projects will develop the TGP Tool prototype and then pilot and validate this prototype

2 Project objectives

By 3 August 2020,

- (i) Determine the technical and practical feasibility of using remotely-sensed and on-ground monitoring data to assess changes in feed supply relative to feed demand for producers to manage TGP in southern Australian rangelands
- (ii) Deliver a costed implementation plan to develop a tool that provides producers an early warning of an imbalance between feed supply and demand, allowing producers to manage livestock and unmanaged herbivores
- (iii) Recommendations to MLA on development actions, and subsequent delivery needs.

3 Methodology

Six key steps were undertaken during this project,

- i. Identifying producer priorities for the TGP Tool: consultation with eight producers located throughout the southern Australian rangelands (NSW, Qld, SA and WA) to identify industry needs, key design requirements and ensure industry relevance and need for a tool. Consultation occurred via one-on-one telephone conversations during January 2020, following a semi-structured interview format. The following questions were addressed during the conversation with each producer:
 1. Context of TGP management on their property
 - a. Background of their experience/management
 - b. Key issues & challenges faced regarding TGP management
 - c. How they currently manage TGP, how they make decisions regarding TGP management, and what they would like to be able to do
 2. What information they use to make grazing decisions
 3. What existing feed budgeting/grazing management tools do they use

- a. What do and don't they like using these tools
 4. What information is needed in a tool to help manage TGP on their property?
 5. Design requirements for the TGP Tool
 - a. Preference for app or computer program
 - b. Preferences for subscription, once-off and free products
 - c. Look and feel requirements
 - d. Scale information presented in (e.g., paddock, sub-paddock, 1ha etc.)
 - e. Data sharing
 6. Barriers experienced towards using tools
- ii. Development of a Primer document that:
 1. Informed the technical workshop (Step 3)
 2. Provided workshop participants with key background information and prepared participants for the technical workshop activities
 3. Outlined a 'straw man' for the TGP Tool, to be worked through in the workshop
- iii. Technical workshop: A two day workshop was held on the 3 & 4 March 2020 at the Stamford Plaza Sydney Airport Hotel, Sydney, with 15 experts from the fields of wildlife monitoring, feedbase management, remote sensing and spatial analysis, and natural resource management. The purpose of this workshop was to develop a technically feasible TGP Tool design and scope resourcing requirements for the development of the TGP Tool and Tool validation. Key outcomes of this workshop included:
 - A re-design of the 'straw-man'
 - Validation of the necessary modules and indicators to be included in the TGP Tool
 - Identification of technically feasible methods and data sources to assess managed and unmanaged herbivore populations, feedbase and resource condition in the rangelands
 - Identified options to integrate these methods & data sources into a tool producers can use to better manage TGP, these included the use of an application programming interface (API), dashboard designs and key contacts
 - Identification of resourcing, consultation and validation requirements for the TGP Tool
 - Identification of assumptions and constraints
- iv. Development of options for a dashboard design of the TGP Tool following the workshop. The dashboard was developed with assistance of an AgTech developer (Pairtree - who specialise in creating innovative 'farmer friendly' dashboards which centralise data sets across farm operations and allow easy decision making). During this process necessary inputs, analytics and outputs from the TGP Tool were identified. The dashboard design was further refined following further consultation with industry (step v).
- v. Industry validation: Validation with the eight producers previously involved in consultation to sense check key elements of the TGP Tool dashboard design prototype against industry needs and ability to integrate with grazing management decisions. This consultation occurred via group discussion, one-on-one conversations and email throughout April, May and June 2020.

This was an iterative process working with both the producers and relevant technical experts until a suitable design for the TGP Tool was achieved.

A broader group of industry representatives (producers, extension staff and technical experts) were invited to provide feedback after further refinement of the dashboard design in June 2020. These representatives were identified via MLA advisory panels (SALRC, NABRC, WALRC), local agricultural extension staff (NSW LLS, QLD DAF, WA Landcare, NRM SA and PIRSA) and the producer consultation group. In total, 16 additional responses were received from the broader consultation group.

- vi. Development of the Implementation Plan: This plan details industry needs, key design requirements, technical requirements and potential providers for developing and building the TGP Tool. The plan also outlines a path for future industry validation and testing required, broadscale implementation and ongoing maintenance.

4 Results

4.1 Review of technical and practical feasibility of using remotely sensed and on-ground data to monitor feed supply and demand in southern Australian rangelands

A summary of the technical and practical feasibility to monitor feed on offer (FOO), fractional ground cover and feed demand on properties in the southern Australian rangelands is provided below. A detailed summary of strengths and weaknesses of existing sources of data and commercial products is provided in **Appendix 1**. Suggested development and research recommendations to overcome limitations identified are provided in the discussion of this report.

Feed on offer

There are multiple established methods to estimate FOO, including on-ground assessments, use of remote-sensing data or biophysical models.

Existing methods to undertake on-ground assessments of FOO include pasture cuts, photo standard comparisons or height and density measurements of pasture, however the reliability of these estimates will be impacted by number of samples in representative locations in a paddock, and the experience and skill of the producer undertaking the assessment. Some support or education may be required to improve accuracy of producers on-ground estimates.

While satellite technology (e.g., Sentinel, Landsat and MODIS) is available Australia-wide, products to remotely assess biomass are yet to be validated across much of the southern Australian rangelands and there is limited capacity for remote sensing products to estimate feed quality. Currently, only one commercial provider (Cibolabs) provides validated estimates of FOO in rangelands. Despite these limitations, significant developments in utilising satellite data to estimate FOO are occurring.

Products offering estimates of feed supply and future feed supply utilising biophysical modelling are becoming increasingly common, however are yet to be validated in rangeland environments, and are

unable to provide information at paddock or property scale, instead being better suited to regional estimates.

There are currently no products available to incorporate and reliably estimate availability and contribution of browse to herbivore diet. In addition, some limitations exist in the southern Australian rangelands in regard to ability to predict future FOO given climatic and landscape variability and sparsely located weather stations. Lastly, there are concerns surrounding the ability to accurately estimate what animals are eating (palatable biomass) in heterogeneous rangelands. Not all biomass, or even green biomass is useable feed and linked to the requirements of animals.

Fractional ground cover

Fractional ground cover can be estimated using satellite data (e.g., Sentinel, Landsat, MODIS) at a relatively fine scale, with historical (>30 years) data also available. There are currently multiple existing products that provide remotely-sensed fractional cover information either freely or fee for service (with additional services and analytics available). Use of remotely-sensed information may be limited in heavily wooded areas, and some concerns exist surrounding the accuracy of the data in rangelands, with further refinement and validation of the data required in some areas.

Producers can assess ground cover via on-ground assessments, with multiple established methods available for monitoring ground cover including quadrat surveys, photo standards or step point surveys, for example. As with assessing feed on offer, reliability is impacted by sampling intensity and sampling in representative locations across paddocks and the skill of the observer.

Feed demand

Information on type of animal, numbers, class/DSE equivalent and location of domestic livestock across a property is usually known and able to be readily provided by producers. Properties with little internal fencing and/or limited management activities throughout the year have less ability to monitor location of animals, or to provide accurate numbers of livestock. Emerging smart-tag technology and walk-over-weighing has potential to provide the ability to remotely monitor location and condition of animals, although this technology is not currently widely used throughout the industry and is not suitable for all locations.

There are currently no commercial products available to quantify unmanaged herbivore species on rangeland properties. Various technically-feasible methods exist for producers to estimate density or relative change in unmanaged TGP across their paddocks or properties, however, there are trade-offs associated with accuracy, efficiency and cost (**Appendix 1**), with few being practically feasible for the purposes of the TGP Tool. During consultation, producers indicated they had little interest and saw little value in paying to achieve more accurate estimates of unmanaged TGP across their properties. Most were comfortable with using their own estimates if it meant it did not cost and was convenient.

4.2 Implementation Plan

A costed Implementation Plan for the development of the TGP Tool that provides producers an early warning of an imbalance between feed supply and demand is provided in **Appendix 2**. This plan details a framework depicting how inputs, analytics and outputs of the TGP Tool can be used to inform decisions regarding TGP management, and the key design requirements for the TGP Tool. Five suggested phases of development (Fig. 1) are described:

- 1) Requirements gathering
- 2) Development of TGP Tool prototype
- 3) Validation of TGP Tool prototype
- 4) Broad scale implementation
- 5) Maintenance and ongoing TGP Tool improvement.

4.2.1 TGP Tool requirements and dashboard design

A detailed outline of the TGP Tool requirements and a prototype dashboard design is presented in **Appendix 2**. In summary, information on six key ‘themes’ is required by producers to aid decisions regarding management of TGP across their properties. These themes include:

1. Feed supply (FOO): including information on historical trends, current level and future estimates, with ability to compare with benchmarks
2. Feed demand: including information on historical trends, current level and future predicted demand for both managed and unmanaged herbivores
3. Fractional ground cover: including information on historical trends, current level and future estimates, with ability to compare with benchmarks
4. Interaction of feed supply and feed demand: including ability to detect risk of an imbalance in feed supply and demand, and test effect of management actions in mitigating this risk
5. Weather: including information seasonal rainfall outlooks and current and historical rainfall trends
6. Spatial information: including data obtained via satellite imagery (e.g., fractional ground cover, feed on offer, NDVI), spatial data sets (e.g., soil type, land type) and property infrastructure (e.g., paddock boundaries, water points) presented in a visual map format.

Information for each theme can may be provided by either manual entry/alteration by user or automatic entry based on regional default values and linking with remote technologies or existing farm management products in use.

4.2.2 Phases of TGP Tool development

Phase 1. Requirements gathering. Collation of all raw information sources to input into the TGP Tool, and determination of critical algorithms to develop the TGP Tools required functionality. Also during this phase, licence and IP agreements with collaborators need to be confirmed, a user interface and

experience review for functionality and useability should be generated, and pricing/support model approach should be decided.

Phase 2. Development of TGP Tool prototype. Bringing together all necessary inputs and/or suppliers of inputs and software/technology/program developers to build a functional TGP Tool prototype. Focus of this stage is in coding and design to deliver necessary requirements within the TGP Tool. Three options for development of TGP Tool are considered:

1. Utilising technology developers to link information from existing providers into a single platform that allows producers to access information in once place, while also providing capability to manually input information where producers do not wish to subscribe to additional products.
2. Modification of existing product/s which provide many of the needs that the TGP Tool requires, to include the additional functionalities that producers require for managing supply and demand and total grazing pressure.
3. a. Development of a new stand-alone product (not reliant on other commercial products) using listed sources (Appendix 1) for input information.
b. Development of stand-alone modules to link with existing products via APIs

Phase 3. Validation of TGP Tool. Field validation of prototype Tool to be undertaken at multiple field sites throughout the southern Australian rangelands, in a co-learning environment with producers, service providers (including commercial providers of inputs and industry extension staff) and researchers to inform further TGP Tool design and refinement

Phase 4. Broad-scale implementation of TGP Tool. Adoption of the TGP Tool by broader industry. This phase will include marketing of the TGP Tool and education to use the TGP Tool to inform management actions, including demonstration of pathways for management options to respond to early warning signals of an imbalance in feed supply and demand. This phase will also include technical support to address consumer issues in purchasing and operating the software

Phase 5. Maintenance and ongoing improvement of TGP Tool. Ongoing maintenance and improvement of TGP Tool to include software upgrades, fix bugs/errors, incorporation of new technology, information and changing needs, undertaken as necessary. For this to occur, the TGP Tool must be linked to a service provider to provide the necessary ongoing maintenance and development.

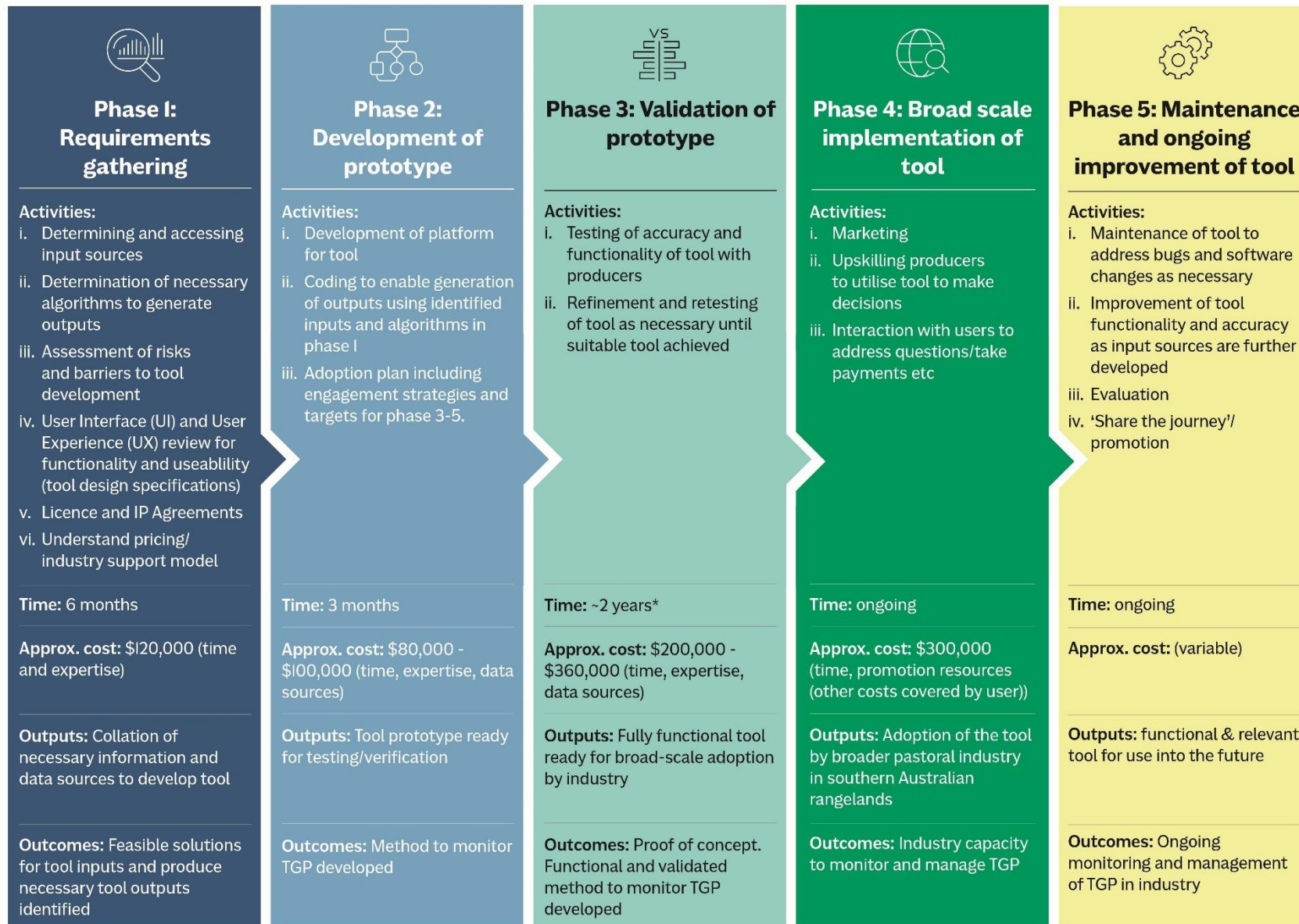


Fig 1. Phases of TGP Tool development

5 Discussion

5.1 Industry feedback on Tool design

A summary of the questions posed and responses received during consultation with industry representatives (producers, NRM staff and technical experts) throughout the project is provided in **Appendix 3**.

The majority of industry representatives were supportive of the TGP Tool development and expressed positive feedback in regard to the design, functionality and ability to improve decision making related to TGP management on their property. In general, producers indicated they would potentially use the TGP Tool on a monthly basis inform decision making. Producers stressed their use of the TGP Tool would be dependent upon its ease of use, simplicity, and capacity to function with low data speeds. Some producers also expressed interest in utilising data collected for regulatory purposes such as reporting to Pastoral Boards. The ability to tailor the dashboard to meet individual farmer preferences was also identified as important for increased utility of the TGP Tool.

Potential limitations to uptake of the TGP Tool identified by industry representatives included potential high costs associated with subscription products that provide real-time information, and difficulty in estimating density of unmanaged herbivores across their properties. In addition, producers whose properties have little to no internal fencing expressed concern over the ability to accurately estimate numbers of both domestic and unmanaged herbivores across their property, and the locations of animals. Resolution and accuracy of data provided by satellite imagery was also identified by producers as an important requirement that would affect their use of the TGP Tool. Some producers expressed confidence in their existing estimations of relationships between feed supply and demand, and as a result do not see a need to adopt the TGP Tool within their enterprise, however these producers were in a minority.

The survey of the broader industry group revealed approximately 70% of respondents saw access to feed supply and ground cover estimations via remote sensing technology in the TGP Tool as important or very important. Similarly, 70% also saw the ability to track and predict an imbalance in feed supply and demand and visualise spatial data across their property using the TGP Tool as important or very important. Most (60%) also thought the ability to track current and historical trends in feed supply, feed demand and ground cover as important or very important. Views on the importance of information on rainfall and seasonal forecasts were divergent. Regarding the dashboard design prototype, most (65% - 75%) agreed that the information depicted using graphs and maps was easy to understand and interpret, while the remainder were neutral. Overall, most (70%) agreed they would use the TGP Tool to improve management of total grazing pressure across their property. Additional detailed comments are provided in **Appendix 3**.

5.2 Recommendations for TGP Tool development

Industry consultation throughout this project highlighted an interest and need by producers to monitor and better manage changes in feed supply and demand across their properties. In particular, producers indicated the importance of access to feed supply and ground cover information via remote sensing

technology, the ability to track and predict feed supply versus feed demand, and to track current and historical trends in feed supply and demand. The TGP Tool design outlined in the Implementation Plan (**Appendix 2**) addresses these needs.

Although there are technical limitations associated with remote monitoring of feed supply and unmanaged TGP across much of the southern rangelands, it is possible to provide this information from producer assessments and manual input to the TGP Tool, and producers noted they were willing to manually enter this information as best estimates if necessary.

Based on producer interest and technical feasibility of obtaining necessary information to input into the TGP Tool, we recommend the development of the TGP Tool proceed, following the Implementation Plan. Additional recommendations to ensure success of the future TGP Tool development include:

- Close involvement with a range of producers in the southern Australian rangelands throughout all phases of the TGP Tool development, with an iterative feedback process to ensure industry relevance, functionality and useability of the TGP Tool. While only a small group of producers were involved in consultation for this project, they often held considerably divergent views, highlighting the value of further on-ground validation of the TGP Tool
- Inclusions of stop-go's between Phases 1 to 4 of the TGP Tool development, and in consultation with MLA
 - Phase 1-2: If the necessary algorithms and inputs are unable to be sourced (e.g., necessary scientific data does not exist or providers are unwilling to share/link their data, unable to use cost-effective data sources), the development of the TGP Tool prototype (Phase 2) cannot proceed
 - Phase 2-3: Validation of the TGP Tool cannot proceed until a suitable design that meets requirements are achieved
 - Phase 3-4: TGP Tool should not proceed to broad scale adoption until algorithms are verified and user groups are satisfied with the prototype design and functionality, and broader industry has indicated interest in using the TGP Tool
- Ability incorporate new and/or improved data sources as TGP Tool inputs as they become available
- Include on-going validation of data capability to improve the accuracy and reliability of data and subsequent producer decisions
- Provision of education and training for producers and service providers in using the TGP Tool and making TGP management decisions in the southern rangelands
- Consideration of barriers to TGP Tool development, and where possible, planning for or overcoming these
- Flexibility in TGP Tool design to appeal to a greater market of producers in the southern Australian rangelands (e.g., levels of detail and/or functionality at paddock versus property or regional scale, and customisable graphics)
- Ability to link the TGP Tool outputs with and into existing products used by producers

5.3 Barriers to TGP Tool development

The following limitations, barriers and risks have been identified in regards to development of the TGP Tool:

- Lack of feasible methods to accurately, inexpensively, frequently and efficiently monitor unmanaged TGP at a property and paddock level in rangeland environments. While there are

multiple options to monitor kangaroo and other unmanaged herbivore density in rangelands, including aerial surveys, camera traps, on-ground surveys, assessment of change in relative measures and development of predictive models, these options are currently not practically feasible for producers to use on a frequent basis for the purpose of the TGP Tool. While producers expressed their comfort in using their own estimates, accuracy of these estimates is unknown and may limit overall accuracy of information presented in the TGP Tool

- Limited kangaroo management options in the southern rangelands. During consultation, producers expressed concern surrounding a lack of options to control kangaroos once density is known. Current popular methods of commercial harvesting and erection of TGP fencing are not effective or feasible for large-properties in the southern Australian rangelands
- Lack of validation of remotely sensed pasture information and biophysical models in the southern Australian rangelands. While technology and commercial providers to estimate feed supply and quality is improving, these products and models are yet to be validated throughout much of the southern rangelands, limiting accuracy and producer confidence in this information
- Costs and technical limitations of obtaining and analysing satellite imagery. While satellite imagery can be obtained for free or relatively low cost via government providers (for example, Geoscience Australia), additional costs and time are associated with ‘cleaning’, processing and validating data
- Unknown accuracy of FOO and utilisation information in large heterogenous rangeland paddocks (including feed quality and patch selection dynamics)
- Lack of motivation or interest by producers in adopting the TGP Tool or ongoing use of the TGP Tool. While consultation revealed overwhelmingly positive feedback and support by industry for development of a TGP Tool, on-going evaluation of producer interest and use of the TGP Tool is necessary to maximise success of achieving outcomes of the TGP Tool development and adoption. Multiple decision support tools have previously been developed with limited interest and uptake after development, though few have been suitable for use in rangelands
- Lack of technical capacity and skill by producers to use and interpret information provided in the TGP Tool and make informed decisions.

5.4 Future research recommendations

The following research recommendations were identified throughout this project as having potential to improve management of total grazing pressure in the southern Australian rangelands:

- Improved methods to estimate kangaroo density at paddock or property scale in rangelands
- Feasible options to control kangaroos across southern rangelands
- Validation and refinement of remote imagery capability for ground cover, pasture quantity and quality monitoring in rangelands
- Understanding of relationship between density of generalist herbivores (e.g. livestock, goats, kangaroos) and impact in rangelands, including production and impact in heterogeneous versus homogenous landscapes
- Evaluation of usefulness of existing tools that provide information on feed supply and demand (**Appendix 1**), how they can fit together and what is missing – case studies to provide insight into what can currently be achieved and what needs further development.

5.5 Extent to which each project objective was met

Objective i. Technical and practical feasibility of using remotely-sensed and on-ground monitoring data to assess changes in feed supply relative to feed demand for producers to manage TGP in southern Australian Rangelands

Technical and practical feasibility of using remotely sensed and on-ground information was assessed in consultation with technical experts and commercial providers of existing products, with results presented in section 4.1 and **Appendix 1** of this report. Overall, it was deemed possible to monitor changes in feed supply and demand using on-ground assessments, with some trade-offs in accuracy and effort required. Remote sensing technology is available to monitor feed supply and ground cover, although there is a requirement for further validation in some regions (woodlands and shrublands) throughout the southern Australian rangelands. Multiple methods to estimate unmanaged herbivore numbers were identified, although none were considered as having greater feasibility than by the methods currently used by producers to estimate herbivore numbers. High costs and/or effort with little perceived value in knowing more accurate numbers were the predominant reasons provided by producers for this view.

Objective ii. Deliver a costed implementation plan to develop a tool that provides producers an early warning of an imbalance between feed supply and demand, allowing producers to manage livestock and unmanaged herbivores

A costed Implementation Plan is provided in **Appendix 2**, with a summary in section 4.2 of this report. Design requirements are outlined, potential sources and providers for inputs are identified and three potential options for future development are proposed.

Objective iii. Recommendations to MLA on development actions, and subsequent delivery needs

Recommendations on future development actions, research priorities and delivery needs are discussed in sections 5.2-5.4 of this report.

6 Conclusions/recommendations

A TGP tool to allow producers in the southern Australian rangelands to monitor for an imbalance in feed supply and demand and inform TGP management decisions will contribute to improved production, environmental and animal welfare outcomes across the region. Most industry representatives consulted with during this project were supportive of the development of a tool to enable producers to better manage total grazing pressure and the design prototype presented.

While there are some limitations surrounding availability and accuracy of remotely gathered information on feed supply and demand in the southern Australian rangelands, technology is advancing rapidly and input data can be obtained by producer estimations where necessary (albeit, with potential trade-offs surrounding accuracy and simplicity of the TGP Tool).

Based on producer interest and technical feasibility of obtaining necessary information to input into the TGP Tool, we recommend the development of the TGP Tool proceed, following the Implementation Plan. Recommendations for future research and TGP Tool development to overcome identified barriers include validation of remotely sensed technology, development of feasible options to monitor and control unmanaged herbivores across the southern rangelands and better understanding relationships between generalist herbivores (e.g. livestock, goats, kangaroos) and impact in rangelands.

7 Key messages

- Management of total grazing pressure represents a significant challenge to the productivity and sustainability of pastoral enterprises across the southern Australian rangelands
- A tool to monitor changes in feed supply and demand and identify potential future imbalances in feed supply and demand will allow rangeland producers to make more informed and timely management decisions regarding total grazing pressure
- Key requirements by producers for a tool for the management of TGP include information on current, historical and future feed supply, feed demand, the interaction of feed supply and demand and fractional ground cover, along with weather and climate information and spatial data at a paddock or property scale
- Use of the TGP Tool by producers across the southern rangelands to identify an impending imbalance in feed supply and demand and make informed decisions regarding management of both livestock and unmanaged herbivores across their property has potential to result in economic benefits including improved livestock productivity, environmental benefits including increased ground cover, biodiversity and landscape function, and improved animal welfare. The TGP Tool will also provide a means to verify minimal negative environmental impacts and demonstrate continual environmental improvement through the management of TGP. This will enable a defensible case for the increasing social licence of the red meat industry and ensure sustained industry productivity growth.

8 Bibliography

Atkinson, T., Hacker R.B., Melville, G. and Reseigh, J. (2020). Land managers and service providers perspectives on the magnitude, impact and management of non-domestic grazing pressure in the southern rangelands of Australia. *The Rangeland Journal*. 41(6), 461-476.

Australian Beef Industry Sustainability framework (2019). Australian Beef Sustainability Annual Update 2018. <https://www.sustainableaustralianbeef.com.au/annual-update>

Deo RC, Byun HR, Adamowski JF and Begum K (2017). Application of effective drought index for quantification of meteorological drought events: a case study in Australia. *Theoretical and Applied Climatology* 128: 359-379

Hacker R, McLeod S, Druham J, Tenhumberg B and Pradhan U. (2004). Kangaroo Management Options in the Murray-Darling Basin. Murray Darling Basin Commission, Canberra.

Sinclair, K., Atkinson, T., Curtis, A. and Hacker, R. (2018). Social acceptability of pest animal management in meeting TGP targets. Final Report. Meat and Livestock Australia, North Sydney.

Accessed from: <https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Social-acceptability-of-pest-animal-management-in-meeting-TGP-targets/3862>

Waters, C., Reseigh-O'Brien, J., Pahl, L., Atkinson, T., Burnside, D., and Revell, D. (2018). Addressing feed supply and demand through total grazing pressure management. NSW Department of Primary Industries. Accessed from: <https://www.mla.com.au/download/finalreports?itemId=3842>

Wilson GR and Edwards, M. (2019). Professional kangaroo population control leads to better animal welfare, conservation outcomes and avoids waste. *Zoologist* 40(1), 181-202.

9 Appendix

Appendix 1 – Potential input sources and existing products

Appendix 2 – Implementation Plan

Appendix 3 – Summary of industry consultation