STAGE 1 - NRM SPATIAL HUB – underpinning better management decisions in the Rangelands INNOV-068-SISR-DAFF

Final Report

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Summary

The Stage 1 – Natural Resource Management (NRM) Spatial Hub development and demonstration of the Online Property Planning and Information System (OPPIS) was part of a $1.6M investment over two years from Caring for Country, Meat & Livestock Australia, and the Cooperative Research Centre for Spatial Information (CRCSI). As part of Stage 1 – NRM Spatial Hub project, the Department of Agriculture and Fisheries (DAF) agreed to provide tables of long-term carrying capacities for participating properties within the rangeland NRM regions in Queensland. For a subset of these properties, DAF agreed to present and discuss with land managers the property mapping; paddock and property carrying capacity for different development, land condition and tree cover scenarios; and the time-series ground cover products to assist managers develop grazing plans to achieve sustainable production outcomes. The concurrent development of OPPIS, including its capacity to receive modelled stocking rate data, necessitated the development of processes and products by DAF in order to deliver mapping, spatial ground cover products and long-term carrying capacity information to participating properties in Queensland.

Cedar version (Cedar.exe version 1.1.45 March 2012) of the GRASP pasture growth model was used to simulate long-term pasture growth of native grass and buffel grass pastures for specific land types and tree cover. Land type pasture growth was simulated for 15 tree cover classes over a 100-year period (1914-2014) for each participating property. Long-term stocking rates for the 15 tree cover classes were calculated using median pasture growth, recommended "safe" utilisation rates for the Grazing Land Management (GLM) land types, and animal intake of 2% for a 450 kg steer or 2.2% for a 50 kg wether. Discounts for land condition and distance to water were applied. The approach used to calculate long-term carrying capacity was consistent with that advocated in the GLM and Stocktake extension programs. Long-term stocking rates were linked with property data to derive carry capacity products using the ArcGIS spatial software.

Long-term stocking rates were calculated for 185 land types (150 native, 35 buffel) on 20 grazing properties across 5 NRM rangeland regions. With producer-provided information, re-naming mapped GLM land types, including buffel pastures, and / or re-mapping of new land types was required for three properties in the Burdekin, one property in South West Queensland and two properties in each of the Northern and Southern Gulf regions.

Modelled carrying capacity estimates were greatly improved by adjusting "desktop" data (GLM land type mapping, base land type parameters) to take into account the influence of location on land type, pasture growth, tree-balance and runoff, and the property-specific information provided by managers (re-naming, re-mapping and the inclusion of buffel pastures).

DAF staff visited five pastoral properties to demonstrate the range of grazing land management information that is now accessible to land managers through the NRM Spatial Hub. The Spatial Hub products included: long-term carrying capacity information; the capabilities of OPPIS; and the range of satellite imagery tree and ground cover products.

Demonstration of this information was to assist managers evaluate the effectiveness of their current infrastructure and grazing land management practices, to plan modifications to these, and to monitor future outcomes.

As OPPIS was under development for most of the property visits, ArcGIS was the main tool used for demonstrating the information to property managers. Producers were encouraged to provide feedback on the accuracy and utility of Spatial Hub products.

Infrastructure and water point grazing circles mapping were highly valued by property managers. Managers were very interested in the satellite imagery products, with fractional ground cover imagery being most highly valued. All managers found the demonstration and discussion of Spatial Hub products interesting and useful, and in many cases confirming their management decisions. They all could see that OPPIS offered great potential for the management of their properties. The informative comments and suggestions provided by the managers of these properties regarding the Spatial Hub products, and their recommendations for improvements to OPPIS are presented.

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1 Introduction

The Natural Resource Management (NRM) Spatial Hub is a central element of the 15-year blueprint of the Australian Rangelands Initiative which provides guidance for ongoing management and protection of the natural resources of Australia's rangelands. The Hub, through developments in geospatial technologies, satellite remote sensing and rangeland science, sought to provide land managers with systems, tools, data and skills needed to improve access to property scale information and knowledge.

The Stage 1 development and demonstration of the Online Property Planning and Information System (OPPIS) was part of a $1.6M investment over two years from Caring for Country, Meat & Livestock Australia, and the Cooperative Research Centre for Spatial Information (CRCSI). OPPIS provides property managers with direct access to satellite data products in combination with easy-to-use tools that allow land managers to create digital property plans and to analyse changes in ground cover. It was expected these capabilities would help producers to understand the impacts of their management, underpin better management decisions and lead to improvements in livestock productivity and resource sustainability.

Grazing land management (GLM) extension recognises the importance of climate variability, long-term safe carrying capacity, and adjusting stocking rates according to the season to assist sustainable management of rangelands. Bio-economic modelling has been used to demonstrate that a conservatively stocked beef grazing operation can achieve positive production, environmental and economic outcomes (e.g. Whish et al. in press). Remote sensing methods are increasingly used to complement ground-based methods of monitoring land condition, and when considered within the framework of long-term safe carrying capacity, can assist land managers to adjust stock numbers on given areas and increase utilisation and production of the land.

As part of Stage 1 – NRM Spatial Hub project, the Department of Agriculture and Fisheries (DAF) undertook a 12 month agreement to provide tables of long-term carrying capacity information for participating properties within the rangeland NRM regions in Queensland. For a subset of these properties, DAF agreed to present and discuss with land managers the property mapping; paddock and property carrying capacity for different development, land condition and tree cover scenarios; and the time-series ground cover products to assist managers develop grazing plans to achieve sustainable production outcomes. During this 12 month period, the concurrent development of OPPIS, including its capacity to receive modelled stocking rate data, necessitated the development of processes and products by DAF in order to deliver mapping, spatial ground cover products and long-term carrying capacity information for participating properties in Queensland. This report outlines the modelling approach, and the processes and products used to deliver long-term carrying capacity information to participating properties in Queensland, and the outcomes, feedback and insights gained from the property visits.

2 Methods

There were three components to the work undertaken by DAF to provide carrying capacity information to grazing properties in Queensland participating in Stage 1 of the NRM Spatial Hub. These components included:

- Modelling long-term carrying capacity

- Deriving and displaying potential and actual carrying capacity

- Delivering property mapping, carrying capacity, and ground cover time-series information.

2.1 Modelling long-term carrying capacity

The approach used to calculate long-term carrying capacity for participating properties in Queensland was consistent with that used in the GLM (Quirk and McIvor 2003) and Stocktake (Aisthorpe et al. 2004) extension programs (see also www.futurebeef.com.au). Long-term "safe" carrying capacity is the number of livestock that an area of land can carry over the long-term (>10 years) without causing a decline in land condition. Long-term carrying capacity was calculated as:

Long-term carrying capacity = pasture growth x pasture utilisation / animal intake x area

2.1.1 Information required for modelling

The grazing management area was defined by GLM land types, tree cover and distance to water. Grazing land types (GLM land types) with characteristic patterns of soil, vegetation and land form have been described (Whish 2011), spatially represented (DERM 2011), and represented in land type parameter files.

Information required for the simulation of long-term pasture growth for participating properties included:

- property infrastructure, water points and grazing circles as an ArcGIS database provided by the Spatial Hub team (comprising of personnel from CRCSI, Australian Rangeland NRM Alliance, Department of Science, Information Technology and Innovation (DSITI))

- GLM land types using regional ecosystem mapping accessed 2010 (State of Queensland 2010) and 2014 – the latter spatial data included identification of non-remnant vegetation

  o re-naming and updating boundaries of GLM land types and / or producer-specified land types occurred if sufficient information was provided

- foliage projective cover (FPC) spatial dataset (State of Queensland 2013)

- historic climate records accessed from Scientific Information for Land Owners (SILO) climate database (Jeffrey et al. 2001)

- property specific information (land type identification, estimated safe carrying capacities, clearing history, pasture improvements, identification of weeds and non-grazed areas) – see Table 1.

2.1.2 Simulation of pasture growth

Cedar version (Cedar.exe version 1.1.45 March 2012) of the GRASP pasture growth model (McKeon et al. 2000, Rickert et al. 2000) was used to simulate long-term pasture growth of native and buffel grass pastures for specific land types and tree cover. Cedar was used as the tree water use routine is able to use FPC rather than tree basal area (TBA) as the functional unit to determine tree transpiration rates. The advantage of using FPC is that it represents the transpiring / radiation

Table 1 – Property specific information (land type identification, estimated safe carrying capacities, clearing history, pasture improvements, identification of weeds and non-grazed areas) sought to assist modelling of long-term pasture growth estimates

Property	Land type	Pdk	Land type mapping			Estimated long-term carrying capacity			Cleared areas			Improved pastures			Indian couch	Non-usable grazing areas	Significant weed areas	
Preferred units	ha AE^{-1}; acres AE^{-1}; AEkm^{-2} (circle)		Version (if known)	Correct boundaries	Correct name	how many animals	class of animal	over what time period	Method - mechanical or herbicide	Time since clearing	Any regrowth	Sown or naturalised	If sown, time since sowing	Estimated proportion of sward	Estimated proportion of sward		Weed type	% of pdk

intercepting element of trees and that it is readily available from satellite data. Tree basal area as the functional unit is limited when trees become partially defoliated in drought or from fires but TBA remains constant; and where there are many small stems but a large canopy such as occurs in suppressed stands and regrowth.

Land type parameter files used to derive pasture growth for Stocktake (updated July 2014) provided the initial values to simulate pasture growth for the mapped land types. Adjustments to these 'base' parameter files occurred to ensure pasture growth was locally relevant and in accordance with current literature, productivity rankings, producer information and expert advice.

Changes to the parameters that relate to the following were undertaken as required:

- rainfall intensity co-efficients aligned with Charters Towers, Capella or Brian Pastures as appropriate to location

- soil water, grass basal area, potential regrowth, transpiration, nitrogen availability, and temperature

- tree density impacts on pasture production appropriate to location, based on the empirical data from central Queensland (Scanlan and Burrows 1990) and tropical semi-arid woodlands (Scanlan & McKeon 1993, Scanlan et al. 1994)

- representation of buffel pastures.

Land type pasture growth was simulated for 15 tree cover classes over a 100-year period (1914-2014) for each participating property. Tree cover classes were defined to effectively capture the negative exponential effect trees have on pasture production. Percentage FPC values were converted to TBA m^2 ha^{-1} using the function developed by Armston et al. (2009). The 15 tree classes modelled are as follows:

FPC %	TBA m^2 ha^{-1}
0	0
3	1
5	2
8	3
10	4
13	5
15	6
20	8
25	10
30	12
34	14
39	16
43	18
47	20
72	>20

2.1.3 Calculation of long-term stocking rates

Long-term stocking rates for the 15 tree cover classes were calculated using the following approach:

Long-term stocking rates = pasture growth x pasture utilisation / animal intake

where pasture growth was the median of 100 years,

where pasture utilisation was as described in GLM land types (Whish 2011),

where animal intake was 2% (or 9 kg/day) for a 450 kg steer, 2.2% (or 1.1 kg/day) for a 50 kg wether.

The resultant stocking rates were considered to be for land in A condition (refer to Quirk and McIvor 2003) and fully-watered. Grazing Land Management standard land condition discounts were applied to derive long-term stocking rates for B, C and D condition. The land condition discounts applied to pasture growth were as follows:

- B condition – 0.75 of A condition

- C condition – 0.45 of A condition

- D condition – 0.20 of A condition

2.2 Potential and actual carrying capacity

2.2.1 Calculation within ArcGIS

The concurrent development of OPPIS with delivering long-term carrying capacity information to Queensland properties necessitated the development of processes within ArcGIS to calculate and tabulate carrying capacity information.

Grazing land management areas for long term carrying capacity were defined by the following variables:

1. Potential carrying capacity - Land type x tree cover class

2. Actual carrying capacity - Land type x tree cover class x distance to water

Subsequent to a review of distance to water discounts by colleagues from DSITI, the Northern Territory Department of Primary Industry and Fisheries and DAF, the following distance to water discounts were applied:

0-3 km from water point – no discount

3-5 km from water point – 0.5 discount

5 km from water point – no grazing

The processes developed by DAF to determine the potential and actual carrying capacity for each participating property are outlined below:

1. Access geodatabase for property

2. Access FPC data, land type shapefile, non-remnant shapefile, buffered water points – grazing circles, paddock shapefile

3. Access lookup table of GRASP modelled stocking rates

4. Convert tree cover groups to shapefile of complex polygons

5. Union of tree cover and land types

6. Union of tree cover and land types and cleared areas

7. Shapefile of land types x tree cover x ha/AE

8. Calculate area utilised based on distance to water

9. Union with paddock shapefile

10. Calculate Potential and Actual long-term carrying capacity of pasture per polygon

11. Lump up all LTCC polygons by attribute of interest.

2.2.2 Carrying capacity products

As OPPIS was under development, DAF developed a range of maps and tables that enabled the delivery of the long-term carrying capacity information to land managers of the participating properties in Queensland. The following maps and tabular data were provided for each property:

1. Physical description of property - landscape and infrastructure
   a. Paddocks (names, areas), water points   MAP - pdf
   b. Grazing circles   MAP - pdf
   c. Mapped land types   MAP - pdf
   d. Mapped land types + non-remnant areas if needed   MAP – pdf
   e. Tree cover classes   MAP - pdf

   Physical description of property - landscape and infrastructure   TABLE 1
   Summation of the area of land types, tree classes, and distance from water for property

2. Potential carrying capacity of fully watered property for A,B,C land condition
   a. Property with paddocks and A carrying capacity   MAP - pdf
   b. Property with paddocks and B carrying capacity   MAP - pdf
   c. Property with paddocks and C carrying capacity   MAP – pdf

   Potential carrying capacity of fully watered property in A condition   TABLE 2
   Summation of carrying capacities for land types and tree classes for fully watered property in A condition.

3. Potential carrying capacity of fully watered paddocks   TABLE 3
   Summation of carrying capacities for land types and tree classes for fully watered paddocks for A, B, C, D condition.

4. Actual carrying capacity of paddocks   TABLE 4
   Summation of carrying capacities for land types and tree classes for actual watered paddocks for A, B, C, D condition.

5. Summation of property carrying capacities for land types for
   a. fully watered A,B,C,D condition
   b. Actual watered A,B,C,D condition
   c. Current condition and actual watered areas
   d. Planned condition and planned watered areas   TABLE 7

A further two tables were produced to capture any current condition and planned developments indicated during property visits. These tables include:

6. Current condition and carrying capacity of paddocks   TABLE 5a,b
   Summation of producer-estimated condition and carrying capacities for land types and tree classes for actual watered paddocks and producer-estimated condition
   a. Table a – nominated condition
   b. Table b – LTCC AE for nominated condition

7. Estimated condition and watered area changes due to planned management and carrying capacity of paddocks   TABLE 6

   Summation of producer-estimated condition and carrying capacities for any "planned" management changes (e.g. new waters, spelling to improve condition).

   a. Table a – nominated condition, watered area change
   b. Table b – LTCC AE for "planned" management change

2.3 Delivery of property mapping, carrying capacity and ground cover time-series information – pastoral property visits

The purpose of the Spatial Hub pastoral property visits conducted by DAF staff was to demonstrate the range of grazing land management information that is now accessible to land managers through the NRM Spatial Hub. The Spatial Hub products information included:

- the long-term carrying capacity information
- the capabilities of OPPIS
- the range of satellite imagery tree and ground cover products.

Pastoral property visits usually involved both demonstrating Spatial Hub products (3-4 hours) and visits to parts of the property (1-2 hours). At the beginning of each property visit, team members described the Spatial Hub project, their roles in this project, and the purpose of the visit. Property managers/owners were then invited to describe their property and business. Topics covered during property visits included:

- Physical description of the property
- Modelled long-term carrying capacity
- Spatial images of total cover on the property
- Ground cover on the property compared with 50 km radius
- Spatial images of fractional ground cover on the property
- Application of spatial products for changes in infrastructure or management
- Evaluation and recommendations.

Demonstration of the property mapping, the range of carrying capacity products (outlined previously), and satellite imagery was to assist managers evaluate the effectiveness of their current infrastructure and grazing land management practices, to plan modifications to these, and to monitor future outcomes. Producers were encouraged to provide feedback on the accuracy and utility of Spatial Hub products, with particular importance placed on the value of changes in ground cover over space and time that may be due to long-term stocking rates, livestock preferences for land types, and the location of waters and fences.

3 Outcomes

3.1 Carrying capacity products

Long-term stocking rates were calculated for 185 land types (150 native, 35 buffel) on 20 grazing properties across 5 NRM rangeland regions (Table 2). With producer-provided information, re-naming mapped GLM land types, including buffel pastures, and / or re-mapping of new land types was required for three properties in the Burdekin, and one property in each of the South West Queensland, Northern Gulf and Southern Gulf regions.

Modelled carrying capacity estimates were greatly improved by adjusting "desktop" data (GLM land type mapping, base land type parameters) to take into account the influence of location on land type, pasture growth, tree-balance and runoff, and the property-specific information provided by managers (re-naming, re-mapping and the inclusion of buffel pastures).

Carrying capacity products (tables and maps) were produced for all 20 grazing properties. These products were provided to the Spatial Hub team for delivery of information to all the properties. Feedback from the properties visited by DAF staff indicated that all managers found the long-term carrying capacity information very interesting and useful, even if the modelled estimates were lower than the manager's estimates.

Table 2 – Manager-provided information, land type mapping outcomes, land type models, and carrying capacity products developed for the participating properties in Queensland.

Region	Property	Manager provided property information	Land type mapping "No" indicates re-naming or re-mapping was undertaken			Land type models		Carrying capacity products
			Attributes	Boundaries	Buffel	Native pastures	Buffel pastures	
Burdekin	Rainmore	Yes	OK	OK	Yes	14	24	Yes
	Mt Pleasant	Yes	No	No	No	4		Yes
	Virginia Park	No	OK	OK	No	5		Yes
	Spyglass	Yes	No	No	No	9		Yes
SWQ	Alice Downs	No	OK	OK	Yes	7	3	Yes
	Maryvale	No	OK	OK	Yes	4	2	Yes
	Victoria Downs	Yes	OK	OK	Yes	9	2	Yes
	Wyoming	No	OK	OK	Yes	5	2	Yes
DC	Royston / Hazel Downs	Yes	OK	OK	No	5	0	Yes
SGulf	Augustus	No	OK	OK	No	13	0	Yes
	Dunluce	No	OK	OK	No	6	0	Yes
	Fort Constantine	No	OK	OK	No	11	0	Yes
	Kamilaroi							
	Lorraine	No	OK	OK	No	13	0	Yes
NGulf	Alehvale	Yes	No	No	No	11	0	Yes
	Miranda	Yes	No	No	No	7	0	Yes
	Werrington	No	OK	OK	No	7	0	Yes
	Yappar River	No	OK	OK	No	10	0	Yes
	Ellavale	No	OK	OK	No	5	0	Yes
		No	OK	OK	No	5	0	Yes

3.2 Pastoral property visits

DAF demonstrated Spatial Hub products to five pastoral properties between June and December 2015. These properties were:

• Rainmore near Emerald – Burdekin NRM region
• Victoria Downs near Morven – South West Queensland NRM region
• Royston near Longreach – Desert Channels NRM region
• Alehvale near Croydon – Northern Gulf NRM region
• Lorraine near Four Ways – Southern Gulf NRM region.

The managers of these properties were all highly experienced, had excellent knowledge of modern grazing management practices, and had already made many adjustments to their infrastructure and grazing management practices. Most of these managers had used hard copies of maps and images for planning the development of their properties. Only one manager used the Google mapping tools.

Infrastructure and grazing circles information were highly valued by property managers. Managers were very interested in satellite imagery products, with fractional ground cover imagery being most highly valued.

All managers found the demonstration and discussion of Spatial Hub products interesting and useful, and in many cases confirmed their management decisions. They all indicated that OPPIS offered great potential for the management of their properties.

Of the five properties visited, one manager indicated he would continue to use OPPIS regularly, and one manager is likely to use OPPIS once its capacity is demonstrated to him. The other property managers appeared less likely to use OPPIS, although their children who work on the properties are likely to be more motivated and capable of using the system.

The outcomes of the property visits, comments and suggestions regarding the Spatial Hub products provided by the managers, and insights subsequent to these demonstrations and discussions are outlined in Table 3.

Table 3 – Outcomes, feedback and insights from pastoral property visits

Topic covered	Outcome	Feedback-general	Feedback-specific to OPPIS	Insight

Physical description of property	• Successfully displayed with ArcGIS and / or OPPIS
	   o Infrastructure
	   o Land types
	   o Tree cover
		• Maps of paddocks, water point locations and grazing circles, and paddock areas were highly valued
		   o Area and water points generally accurate
		   o Grazing circles- a few errors due to missing point or permanency status
		   o Capacity of OPPIS to measure distances and elevation between water sources is highly valued
		
		 • Land type mapping of less value
		   o At best broadly accurate
		   o Renaming to more appropriate land types common
		   o Complete re-mapping (names and boundaries) required (also refer to Table 2)
		   o Inclusion of non-remnant data required to identify potential buffel pastures
		
		 • Tree cover mapping less valuable than infrastructure
		   o Images and maps generally accurate to 2013
		   o Tree cover was considered to exaggerate the density of trees in some parts of properties
			• Land managers value the capacity of OPPIS to print maps of property, paddocks, water points
			 • Relatively easy for OPPIS user to add, turn on or off, and change access to water points
			 • Time-lag (~ 2 days) in changed water point scenarios being completely captured in OPPIS
			 • Unable to delete unwanted grazing circle scenarios
			 • Need functionality to allow the colour of grazing circles to be different colours for the different distances
			
			 • Changed land type name within OPPIS did not flow through to polygons nor tabular outputs
			 • OPPIS needs more user-friendly legends to automatically appear on maps and images
			 • Need capacity to allow the default colour of land type labels – currently red – to be changed
			 • Currently, OPPIS only has functionality to change land type names but not boundaries. Opportunity to include capacity for service providers to be able to change boundaries
			
			 • "Tree thickening" spatial data that indicates percentage of change in tree cover over time should be in OPPIS
				• Considerable effort is required to ensure infrastructure, water points and land types are accurate – ensuring functionality of OPPIS enables changes to these attributes to be user-friendly and quickly captured would add to the value of the tool
				 • The GLM land type spatial data has acknowledged errors in both boundaries and attributes
				 • There is an urgent need to revise and update the GLM land type spatial data
				 • Thickening of trees and shrubs is an issue of considerable interest for many producers, and one which has a large influence on livestock carrying capacity

Topic covered	Outcome	Feedback-general	Feedback-specific to OPPIS	Insight

Long-term carrying capacity	• Successfully produced long-term carrying capacity information
	• Modelled carrying capacities were revised (to include buffel, correlate with improved estimates) and updated for 4 of the 5 visited properties
		• Managers found estimates very interesting and useful
		• < 10% difference for A condition fully watered but up to 20-30% lower than producer-estimates when distance to water and condition were considered
			• Challenging but beneficial for OPPIS to have functionality to handle modelled data for different development / condition scenarios
			• Potential to link with PaddockGRASP
			• Property specific modelling that can account for the influence of location on land type, pasture growth, tree-balance and runoff will provide "more accurate" carrying capacity estimates"
				• Differences in carrying capacity estimates may be due to:
				  o Modelled outputs based on median growth over 100 years
				  o Periods of destocking may not be included in producer –estimates
				  o Median rainfall less than average rainfall in central and southern Queensland
				  o Higher utilisation of pastures than the modelled "safe" utilisation rates (10-30%)
				  o Based on incorrect land types and / or out-of-date tree cover data
				  o Areas where trees have thickened which managers are unaware of
				  o Producers may not take into account distances from water points and loss of land condition
				  o Buffel component of pastures may be under-estimated

Topic covered	Outcome	Feedback-general	Feedback-specific to OPPIS	Insight
Spatial imagery of tree and ground cover	• Successfully displayed with ArcGIS and / or OPPIS o Total cover - decile o Fractional total cover o Persistent green o Percentile ground cover o Fractional ground cover	• Managers were able to quickly interpret images of cover across property and paddocks • Readily identified fire scars, recently cleared areas, cover differences between wet and dry years • Total cover considered interesting but not useful • Persistent green considered interesting but not useful • Total cover images were limited in their capacity to inform management decisions, although acknowledged these images did highlight extensive bare areas on neighbouring properties which were known to be over-stocked • High interest in ground cover images, particularly fractional cover, viewed as a good indicator of how country was responding to grazing o Will be used to support managers recommendation to shareholders to decrease stocking rates o Able to impact of old water points and old fence lines o Identified bare areas on high ground where cattle congregate during wet season o Winter and spring ground cover useful in identifying parts of the property where cover had declined due to water access or stocking rates	• OPPIS is a simple to use property mapping system that is far ahead of alternative systems • Be able to identify the proportions of paddocks which contained percentiles or deciles of total cover • Useful to include the ArcGIS "swipe tool" in OPPIS as easy to view between images • Useful to add objectivity to cover images and desire to have easily accessed quantitative data for pixels and paddocks o Akin to summary statistics for total cover, green cover, bare ground or dry cover for parts or whole paddocks o Capacity to allow click on location and obtain data o This would enable property calibration of on-ground measurements with imagery assisting in forage budgeting and management of stocking rates	• Manager noted that the evidence of "high levels of cover" on cattle properties would be useful to show to external parties and general public • Including the capacity of OPPIS to provide site-specific quantitative data thereby enabling managers to calibrate monitoring sites to imagery ,will provide invaluable information to progress the "Estimation of Biomass from Space" objective • There was not a huge benefit from spatial imagery for infrastructure / management changes for these managers as most had near or fully developed their properties using more traditional and manual methods (hard copies of aerial photographs and satellite images) o One manager plans to continue spreading water points to reduce distance that cattle need to walk to water, perhaps requiring subdivision of paddocks – OPPIS would be invaluable for accurately calculating length of new fences and water piping required o One manager would use winter and spring imagery to monitor how pastures were responding to grazing o One manager will continue to use OPPIS to aid his management

Topic covered	Outcome	Feedback-general	Feedback-specific to OPPIS	Insight

Ground cover on the property compared with 50 km radius	• Information provided to managers	• Comparison of ground cover with surrounding properties considered to be very useful
		• Explanations of ground cover differences ranged from unable to explain why cover was lower than surrounding properties to linking with events or specific management practices such as:
		  o Holding stock longer than they wanted to during a recent dry period
		  o Recently chained and ploughed country
		  o Carrying capacity had been exceeded, with cover increasing with recent reductions in herd size
		  o Recent addition of waters and subdivision of larger paddocks spread grazing into parts of the property that were previously under-grazed
		  o Increases in cover due to narrow strip of rain together with tree thinning		

4 Conclusion and recommendations

Through the development of processes and carrying capacity products, DAF has met its objectives of producing long-term carrying capacity information for 20 grazing properties across 5 NRM regions in Queensland; and demonstrating the capabilities of OPPIS, the range of satellite imagery and ground cover products, and carrying capacity information to 5 of these pastoral properties.

Long-term carrying capacity data is essential for planning and decision-making. Carrying capacity estimates for properties were greatly improved through the adjustment of model parameters to account for location and property-specific information. There is an urgent need to revise and update the Statewide GLM land type data.

Property mapping and satellite imagery products accessible through OPPIS are highly valued and provide managers with information that can assist in their planning and decision-making.

Recommendations to ensure OPPIS is user-friendly and an informative tool that will assist land managers in Australia's rangelands to understand the impacts of their management and underpin their planning and decision-making include:

- Ensure the system is user-friendly
  - Reduce potential confusion by limiting the number and type of imagery available in OPPIS, with fractional ground cover being the most important
  - Ensure changes to infrastructure, water points, land types attributes (colours of grazing circles, deletion of unwanted scenarios, colours of land type labels) are completed with ease and captured quickly
  - Ensure legends are easily viewed
- Additional data
  - Herbarium plant/weed species
  - North Australian Fire Information (NAFI)
  - "Tree thickening" spatial data that indicates the percentage of change in tree cover over time
- Additional functionality
  - To provide site-specific quantitative data and summary statistics to enable managers to calibrate their monitoring sites to imagery, and assist in undertaking forage budgets
  - To store photos that relate to specific parts of paddocks (i.e. a photo-point tool) providing visual assessment of areas or features that are of particular interest
  - To provide estimates of pasture yields at particular points in time to assist managers conduct forage budgets
  - To ensure OPPIS is a stand-alone system for property mapping and planning and viewing imagery – currently some mapping tasks need to be completed in other spatial environments and then brought back into OPPIS
- OPPIS user support
  - Provide case-studies demonstrating OPPIS capabilities
  - Provide telephone support for property managers
  - Send alerts for any changes in how the system operates
  - Provide, as a minimum, one day of training and a user manual
  - Provide updates on how the system was being used by others and plans for the future

5   References

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