Guide to Using FORAGE

Grazing Land Systems

June 2023 / Version 1.15

Queensland Government

Prepared by

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Attribution

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June 2023

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Guide to Using FORAGE

1 Background

FORAGE is an online, web and email-based system which generates and distributes climate and pasture related information in customised reports for a requested location. FORAGE is also a delivery mechanism for satellite imagery developed by DES's Remote Sensing Centre (https://www.qld.gov.au/environment/land/vegetation/mapping/remote-sensing/).

Information which has been incorporated in individual FORAGE reports includes, for example, property scale mapping, remotely sensed imagery of tree cover and ground cover, pasture growth model output, historical climate data, seasonal climate outlooks and longer-term climate projections. FORAGE allows rural landholders, graziers and extension officers to readily gain access to such information for a location of interest. The information is presented in easy to understand PDF reports which are emailed directly to a nominated email address. Information generated through FORAGE can be used to facilitate both land condition assessment and decision support for grazing and environmental land management practices (see Zhang and Carter, 2018 for a full description of the system).

2 How FORAGE works

The FORAGE system (Figure 1) includes:

- a user interface on the Long Paddock website
- a background information-processing system on government servers
- an email delivery system.

Individual FORAGE reports are requested from the Long Paddock website on forms which require specific information including the type of report requested, location of interest (e.g. Lot on Plan) and a return email address. Once a form is filled out and submitted on the website, a request is sent to the DES high performance computer which then accesses data to generate the report from relevant databases and models. The requested report is then generated and sent to the nominated email address. Various types of remote sensing imagery can also be requested in a similar manner on the Long Paddock website.

Unless otherwise stated, FORAGE reports are available for any location in Queensland (excluding urban areas). Some reports are, however, currently restricted to specific regions due to availability of data.

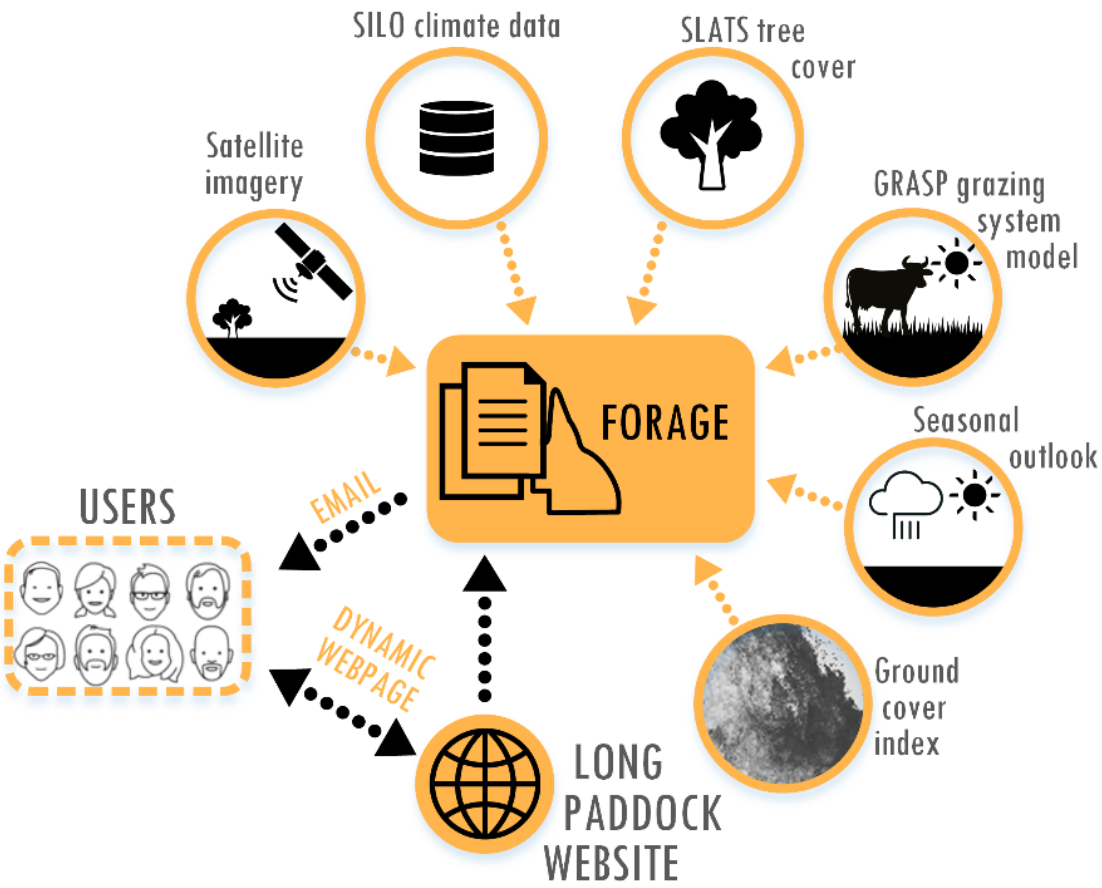


Figure 1. The FORAGE framework.

3 Obtaining FORAGE products

3.1 How to request FORAGE reports

FORAGE reports, satellite imagery and derived products can be accessed through the DES Long Paddock website: http://www.longpaddock.qld.gov.au/forage/

You can now select multiple reports at the same time, by using the drop-down menu in 'Select FORAGE reports' (see illustration below).

There are several ways to locate and select the property of interest for requesting:

- Provide the Lot(s) on Plan by typing in the Lot(s) on Plan in the space under "Enter lot(s) on plan" (e.g. 3MZ594 for Lot 2, Plan MZ594) and select from list. Select 'add' and continue to select if required; or
- Use the geolocation tool, the address bar to add the property name, road address, town or just zoom in on the map to find your Lot(s) on Plan and click to select (one or more).
- Select information such as start year and end year if required (report specific), enter your email address, add a label (optional) and then click on the 'submit' button to submit the request.
- A PDF report (or link to product requested) will be emailed to the email address provided.
- Completing requests can range from 10 minutes to a few hours, depending on the complexity of the report and number of request running on the system.
- Short awareness videos are available on how you might use FORAGE for grazing land management decision making https://www.longpaddock.qld.gov.au/forage/videos/.
- A 2-page "Quick guide" is available at https://data.longpaddock.qld.gov.au/static/forage_2pager.pdf

FORAGE delivers visual satellite images, ground cover and Foliage Projective Cover (FPC) images but, unlike other FORAGE products, the satellite imagery is not sent by email, due to file size limitations. On completion of your satellite Imagery request you will receive a notification email. This email contains a link to a compressed '.zip' file containing the images. Click the link in the email to download the zip file. You will need decompression software, such as WinZip, to open the compressed file.

3.2 Help information and materials

FORAGE currently provides a suite of reports along with purpose-built satellite images. Two-page quick guides and a comprehensive User Guide and collection of Frequently Asked Questions (FAQ) are provided on the FORAGE website to assist users in requesting and interpreting the reports.

A series of webinars (https://www.longpaddock.qld.gov.au/forage/webinar-videos/), awareness and explanatory videos (https://www.longpaddock.qld.gov.au/forage/videos/) are also available from the FORAGE website.

4 FORAGE products

4.1 FORAGE Report: Rainfall and Pasture by Land Type

The *FORAGE Report: Rainfall and Pasture by Land Type* (Figures 2 and 3) provides both recent and historical rainfall, pasture growth and pasture cover for a selected Lot on Plan or adjoining Lots on Plan. Rainfall is estimated from surrounding stations, pasture cover from both satellite imagery and modelling, and pasture growth from modelling alone. Time series of pasture growth and cover are shown for the entire Lot on Plan. Summary statistics are also shown for individual land types on the selected Lot on Plan for simulated (modelled) pasture growth and pasture cover.

The information presented on the first page of the report (Figure 2) includes:

- a map showing the location of the requested Lot on Plan
- summary statistics for rainfall, simulated pasture growth and simulated ground cover
- time series graphs showing annual rainfall, simulated annual pasture growth and monthly ground cover (both simulated and measured by satellite).

Rainfall and pasture statistics shown on the front page of the report include the most recent twelve-month totals for both rainfall and pasture growth and the most recent twelve-month average for pasture cover. These recent statistics can be contrasted with historical statistics including the long-term mean, median, 30th percentile and 70th percentile values. The percentile rank indicates where a value lies in the range of historically measured or simulated records. For example, if last year's rainfall was ranked in the 20th percentile, then last year's rainfall was higher than the lowest 20% of annual rainfall values on record but lower than the remaining 80% of values.

Three time series graphs (from 1970 to current) indicate:

1. simulated average monthly ground cover and, for comparison, ground cover derived from satellite imagery for specific dates for which this information is available.
2. annual rainfall (April to March).
3. simulated annual pasture growth (April to March).

Rainfall is estimated for the specified location, based on regional Bureau of Meteorology (BoM) rainfall records obtained from DES's SILO database. Regional rainfall stations may not be located on or near the selected property so rainfall values are best considered approximations only.

Pasture growth and ground cover values for the selected location are simulated for those individual land types which represent more than one percent of the total area of the Lot on Plan. Values for the entire Lot on Plan are based on an area-weighted average of all land types meeting this criterion.

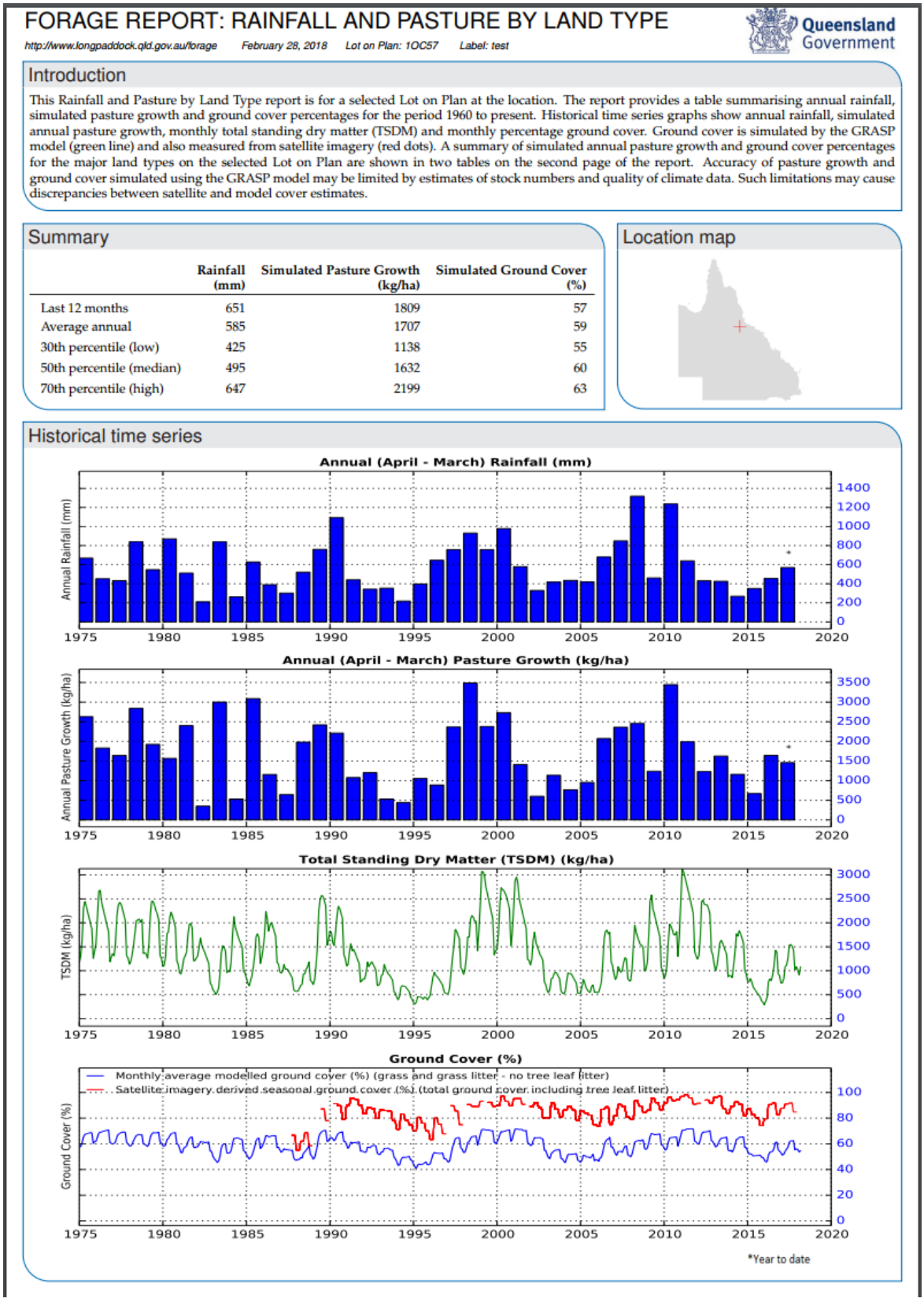
Pasture growth is calculated using DES's GRASP (Grass Production) model from daily inputs of interpolated rainfall, solar radiation, minimum and maximum temperature, vapour pressure and potential evapotranspiration. Other inputs to the GRASP model include, for example, the water holding capacity of the soil, tree density and livestock numbers. Unlike satellite derived cover values, the model calculates cover under trees as well as in the open. Tree density is based on Foliage Projective Cover values derived from satellite imagery and has a strong influence on pasture growth and, in turn, pasture cover.

Livestock numbers have a strong influence on pasture cover in particular. The livestock numbers used as input to the model may not be indicative of actual livestock numbers on the specified Lot on Plan, being based on regional averages derived from Australian Bureau of Statistics (ABS) livestock numbers reported on a local statistical area basis.

Except for the climate data, livestock numbers and tree density, the GRASP model uses parameter sets calibrated for each of the GLM land types within the Lot on Plan.

Pasture growth for GLM land types across Queensland is based on modelling conducted by Department of Agriculture and Fisheries (DAF). This modelling was the best available at the time of release and will be periodically updated as improvements are made based on comparison with available data sets.

The information presented on the second page (Figure 3) of the report includes simulated pasture growth and ground cover statistics, calculated on the same basis as on the front page, but summarised for those individual land types with an area representing more than one percent of the total land area of the Lot or Lots on Plan.



FORAGE REPORT: RAINFALL AND PASTURE BY LAND TYPE

http://www.longpaddock.qld.gov.au/forage February 28, 2018 Lot on Plan: 1OC57 Label: test

Queensland Government

Introduction

This Rainfall and Pasture by Land Type report is for a selected Lot on Plan at the location. The report provides a table summarising annual rainfall, simulated pasture growth and ground cover percentages for the period 1960 to present. Historical time series graphs show annual rainfall, simulated annual pasture growth, monthly total standing dry matter (TSDM) and monthly percentage ground cover. Ground cover is simulated by the GRASP model (green line) and also measured from satellite imagery (red dots). A summary of simulated annual pasture growth and ground cover percentages for the major land types on the selected Lot on Plan are shown in two tables on the second page of the report. Accuracy of pasture growth and ground cover simulated using the GRASP model may be limited by estimates of stock numbers and quality of climate data. Such limitations may cause discrepancies between satellite and model cover estimates.

Summary

	Rainfall (mm)	Simulated Pasture Growth (kg/ha)	Simulated Ground Cover (%)
Last 12 months	651	1809	57
Average annual	585	1707	59
30th percentile (low)	425	1138	55
50th percentile (median)	495	1632	60
70th percentile (high)	647	2199	63

Location map

Historical time series

Figure 2. An example of the first page of the Rainfall and Pasture by Land Type report.

FORAGE REPORT: RAINFALL AND PASTURE BY LAND TYPE

http://www.longpaddock.qld.gov.au/forage *February 27, 2018* *Lot on Plan: 1OC57* *Label: test*

Queensland Government

Simulated annual pasture growth summary for major land types

The table summarises historical pasture growth (kg/ha/year) for the period from 1960 to present, for each major land type on the selected Lot on Plan. Calculations of plant growth are from the GRASP model based on calibration consistent with information from Grazing Land Management (GLM) and Stocktake. The table shows the total pasture growth (kg/ha) in the last 12 months (from February 2017). Calculations are provided for long-term average annual pasture growth; annual pasture growth in low growth (30th percentile*); median (50th percentile); and high growth (70th percentile) years.

				Pasture growth (kg/ha)				
Expected Land Type	**Code**	**Area (ha)**	**Area (%)**	**Last 12 months**	**Average**	**30th percentile***	**50th percentile***	**70th percentile***
Lancewood - bendee - rosewood (BD)	BD12	2200	31.8	431	638	402	577	733
Narrow-leaved ironbark on deeper soils	BD14	1581	22.9	1921	1841	1076	1855	2428
Goldfields country - black soils	BD10	1225	17.7	3481	2854	2119	2699	3454
Loamy alluvials	BD13	1045	15.1	1912	1927	1233	1854	2590
Yellowjacket with other eucalypts	BD20	786	11.4	1809	2338	1291	2075	2807
Range soil (NG)	NG08	81	1.2	1240	1382	1159	1349	1552

Simulated ground cover summary for major land types

The table summarises historical percentage ground cover for the period 1960 to present, for each major land type on the selected Lot on Plan. Calculations of pasture cover are from the GRASP model based on calibration consistent with information from Grazing Land Management (GLM) and Stocktake. The table shows the average ground cover (%) in the last 12 months (from February 2017). Estimates are provided for long-term average annual ground cover; annual ground cover in low growth (30th percentile*); median (50th percentile); and high growth (70th percentile) years.

				Pasture ground cover (%)				
Expected Land Type	**Code**	**Area (ha)**	**Area (%)**	**Last 12 months**	**Average**	**30th percentile***	**50th percentile***	**70th percentile***
Lancewood - bendee - rosewood (BD)	BD12	2200	31.8	46	49	46	48	50
Narrow-leaved ironbark on deeper soils	BD14	1581	22.9	59	59	56	60	66
Goldfields country - black soils	BD10	1225	17.7	72	71	70	71	74
Loamy alluvials	BD13	1045	15.1	62	64	61	63	68
Yellowjacket with other eucalypts	BD20	786	11.4	58	62	55	63	71
Range soil (NG)	NG08	81	1.2	57	58	56	58	60

*What is a percentile?

A percentile is used to indicate where a value lies within the range of historically measured or simulated records. For example, if last year's rainfall was ranked in the 30th percentile, then last year's rainfall was higher than the lowest 30% of annual rainfall totals on record, but lower than the remaining 70% of records.

Disclaimer

Figure 3. An example of the second page of the Rainfall and Pasture by Land Type report.

4.2 FORAGE Report: Ground Cover

The *FORAGE Report: Ground Cover* (Figures 4-7) provides monthly ground cover, minimum ground cover and percentile ground cover images for the selected Lot(s) on Plan, as well as a graph of satellite imagery derived historical seasonal ground cover for the entire property being reported on (i.e. the mean ground cover level). In addition, there are accessory files providing time series and tabulated ground cover level information on a monthly basis; as well as seasonal satellite-based ground cover data. A paddock(s) / Lot(s) on Plan information accessory report (Figures 8-9) is also provided along with the ground cover report to present more detailed information on a paddock (or Lot on Plan) level.

The maps and historical time series graph are generated from the ground cover products which are produced by the Queensland Government's Remote Sensing Centre using Landsat satellite image data from the United States Geological Survey and Sentinel-2 data from the European Space Agency. For more information on how ground cover products are created, visit https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/groundcover.

The information presented in the main report and the paddock information accessory report includes:

1. Main report

- Background information for the selected Lot(s) on Plan:
    - location (map and lat/long)
    - land area
    - long-term annual mean temperature
    - last 12-month rainfall
    - the Local government area
    - the average woody vegetation cover
    - long-term annual mean rainfall
    - last month rainfall.

- **Page 1:** a map (Figure 4), showing the monthly ground cover (30m pixel) for the month and year selected by the user, along with the boundary of the Lot(s) on Plan selected from the Digital Cadastral Data Base (DCDB, https://data.qld.gov.au/en/dataset/cadastral-data-queensland-series). A summary of the data in the image is given at the bottom of the map (the percentage of the total area for six ranges of ground cover levels for the Lot(s) on Plan that have less than 60% tree cover.

- **Page 2:** A second map (Figure 5), showing the minimum ground cover for the selected Lot(s) on Plan from 1990-2020. The minimum ground cover is the 5th percentile (i.e. within the bottom 5 percent of all data) ground cover for each 30m pixel recorded during the period from 1990 -2020.

- **Page 3:** A third map (Figure 6), showing the total ground cover percentile for the month selected relative to the same months from 1990-current for the selected Lot(s) on Plan. For each 30m pixel, all cover values over the entire time-series of monthly images are classified into percentiles (from lowest 1 to highest 100). The cover value for the pixel in the month indicated is then classified according to the percentile in which it falls. The map helps to identify areas of low, medium or high total cover, for the month indicated.

- **Page 4:** a seasonal ground cover time series graph (Figure 7).

The time series graph shows the seasonal levels of ground cover for the Lot on Plan from 1988 to last season. The ground cover level is also separated in the green and non-green components of the total level of ground cover. Gaps may occur on the graph where there was insufficient satellite data to derive a valid seasonal estimate of ground cover (e.g. due to persistent cloud over a season).

Note: Cropped and burnt areas may show up as low cover in monthly and seasonal ground cover images.

2. Paddock information accessory report

The paddock information accessory report includes:

- a time series graph generated for each requested Lot on Plan (or each MyFORAGE-generated paddock; Figure 8). The time series graph shows the monthly levels of ground cover from 2017 to the most recent month. The red dot shows the user-specified month (recent and previous) for quick identification.
- a summary table (Figure 9) showing the ground cover percentage area for six levels of ground cover ranges for requested Lot(s) on Plan (or paddocks).

3. A data accessory file

The data accessory file is a csv file (opens in Excel) for the requested Lot(s) on Plan (or paddocks), containing the seasonal satellite-based values from Figure 7 (page 4 of the main report):

- green cover (%)
- non-green cover (%)
- total cover (%)
- bare ground (%).

FORAGE REPORT: GROUND COVER

http://www.longpaddock.qld.gov.au/forage *13/06/2023* *Lot on Plan: 1OC57,4835CP858256,3RP841848,4SP etc.* *Label: test*

Queensland Government

Introduction

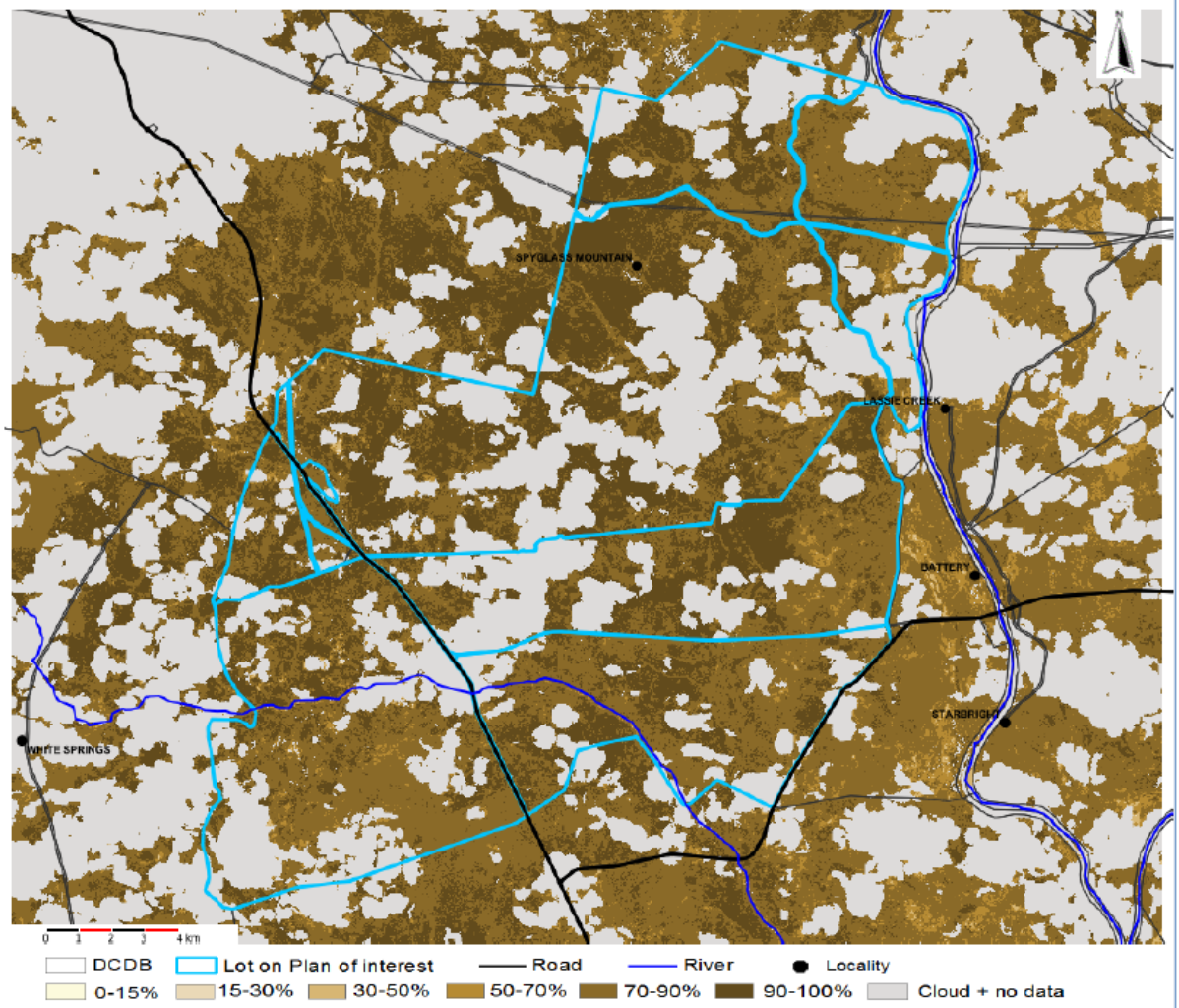
This report presents three ground cover information products: (1) a ground cover map for the chosen month; (2) a minimum ground cover map for the period 1990 to 2016; (3) a total cover percentile map, and (4) a graph showing the historical time series of seasonal ground cover. The maps and historical time series graph are generated from the ground cover products which are produced by the Queensland Government's Remote Sensing Centre using Landsat satellite image data from the United States Geological Survey and Sentinel-2 data from the European Space Agency. For more information on how ground cover products are created, visit https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/groundcover.

Background information of the Lot on Plan

Latitude/longitude: -19.42/145.73
Total land area : 36182 ha
Long-term annual mean temperature : 23.3 °C
Last 12-month rainfall : 709.2 mm
Local government: Charters Towers Regional
Average woody vegetation cover: 19.3%
Long-term annual mean rainfall : 635.2 mm
Last month rainfall: 0.6 mm

Location map

Ground cover map (The image is for January 2023)

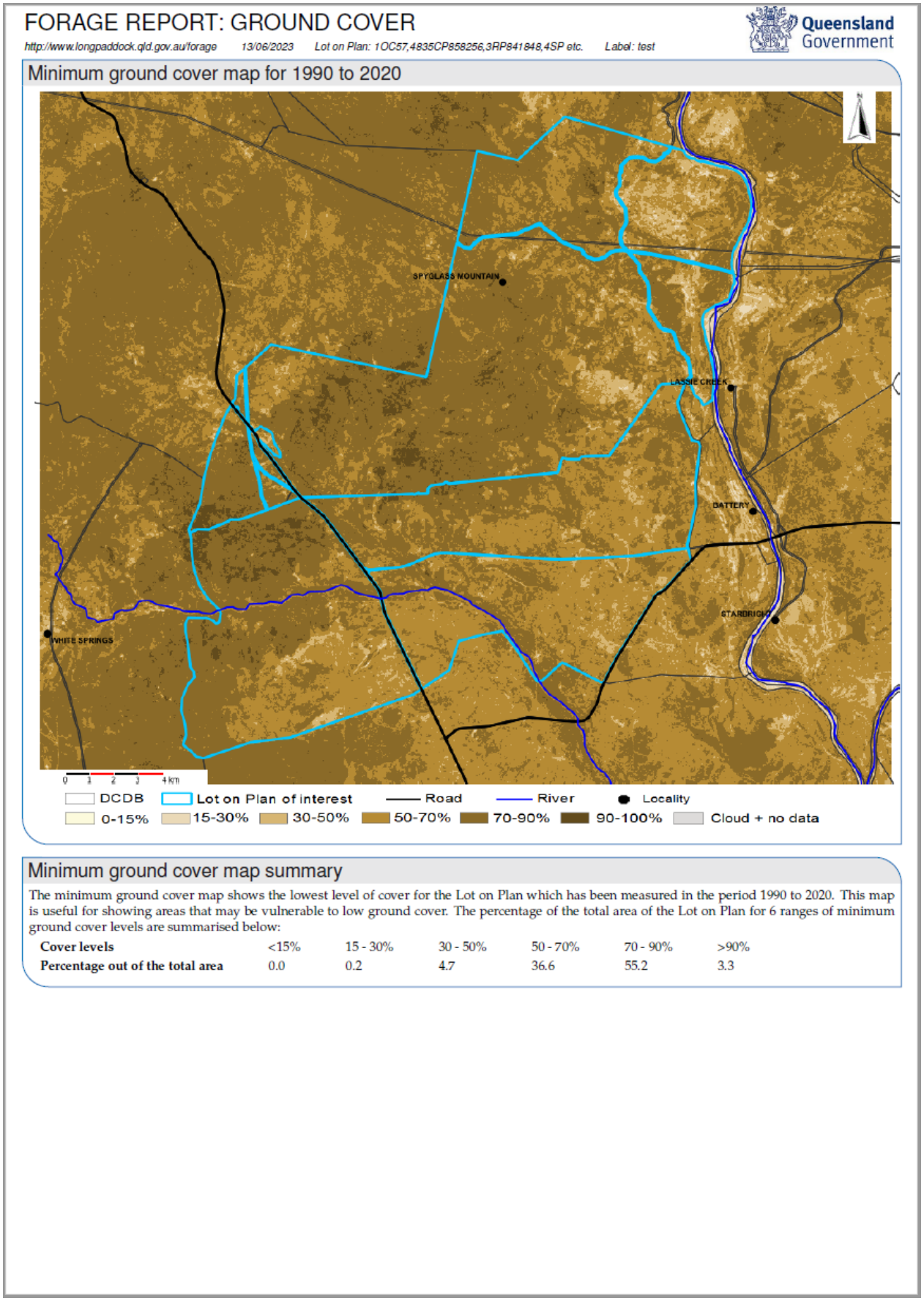


Ground cover map summary

The monthly ground cover map shows the level of ground cover for areas on the Lot on Plan with less than 60% tree cover. The image is for January 2023. The percentage of the total area of the Lot on Plan for 6 ranges of ground cover levels are summarised below:

Cover levels	<15%	15 - 30%	30 - 50%	50 - 70%	70 - 90%	>90%
Percentage out of the total area	0.0	0.0	0.2	2.2	56.2	41.4

Figure 4. An example of the first page of the Ground Cover report.



FORAGE REPORT: GROUND COVER

http://www.longpaddock.qld.gov.au/forage 13/06/2023 Lot on Plan: 1OC57,4835CP858256,3RP841848,4SP etc. Label: test

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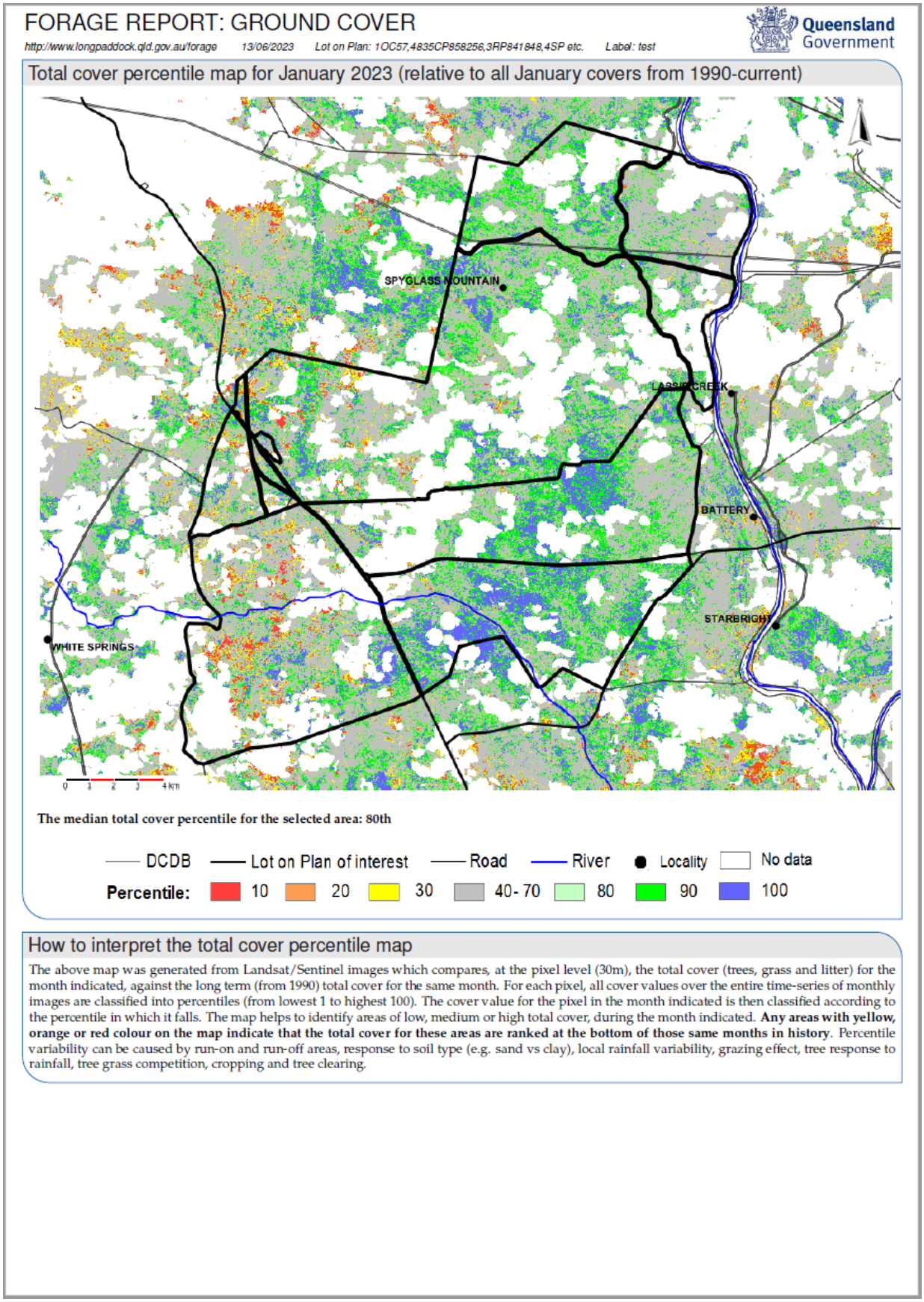
Minimum ground cover map for 1990 to 2020

Minimum ground cover map summary

The minimum ground cover map shows the lowest level of cover for the Lot on Plan which has been measured in the period 1990 to 2020. This map is useful for showing areas that may be vulnerable to low ground cover. The percentage of the total area of the Lot on Plan for 6 ranges of minimum ground cover levels are summarised below:

Cover levels	<15%	15 - 30%	30 - 50%	50 - 70%	70 - 90%	>90%
Percentage out of the total area	0.0	0.2	4.7	36.6	55.2	3.3

Figure 5. An example of the second page of the Ground Cover report.



FORAGE REPORT: GROUND COVER

http://www.longpaddock.qld.gov.au/forage 13/06/2023 Lot on Plan: 1OC57,4835CP858256,3RP841848,4SP etc. Label: test

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Total cover percentile map for January 2023 (relative to all January covers from 1990-current)

The median total cover percentile for the selected area: 80th

DCDB | Lot on Plan of interest | Road | River | Locality | No data

Percentile: 10 | 20 | 30 | 40-70 | 80 | 90 | 100

How to interpret the total cover percentile map

The above map was generated from Landsat/Sentinel images which compares, at the pixel level (30m), the total cover (trees, grass and litter) for the month indicated, against the long term (from 1990) total cover for the same month. For each pixel, all cover values over the entire time-series of monthly images are classified into percentiles (from lowest 1 to highest 100). The cover value for the pixel in the month indicated is then classified according to the percentile in which it falls. The map helps to identify areas of low, medium or high total cover, during the month indicated. **Any areas with yellow, orange or red colour on the map indicate that the total cover for these areas are ranked at the bottom of those same months in history**. Percentile variability can be caused by run-on and run-off areas, response to soil type (e.g. sand vs clay), local rainfall variability, grazing effect, tree response to rainfall, tree grass competition, cropping and tree clearing.

Figure 6. An example of the third page of the Ground Cover report, showing the total ground cover percentile for the selected Lot(s) on Plan from 1990-current.

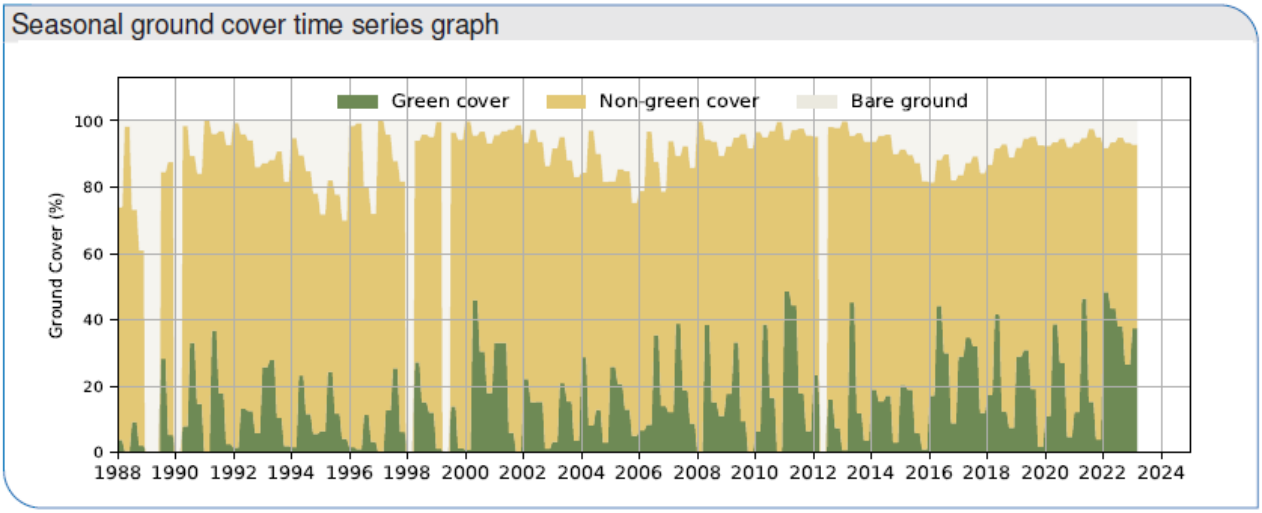


Figure 7. An example of the time series graph of modelled monthly standing grass cover vs. satellite imagery derived seasonal ground cover.

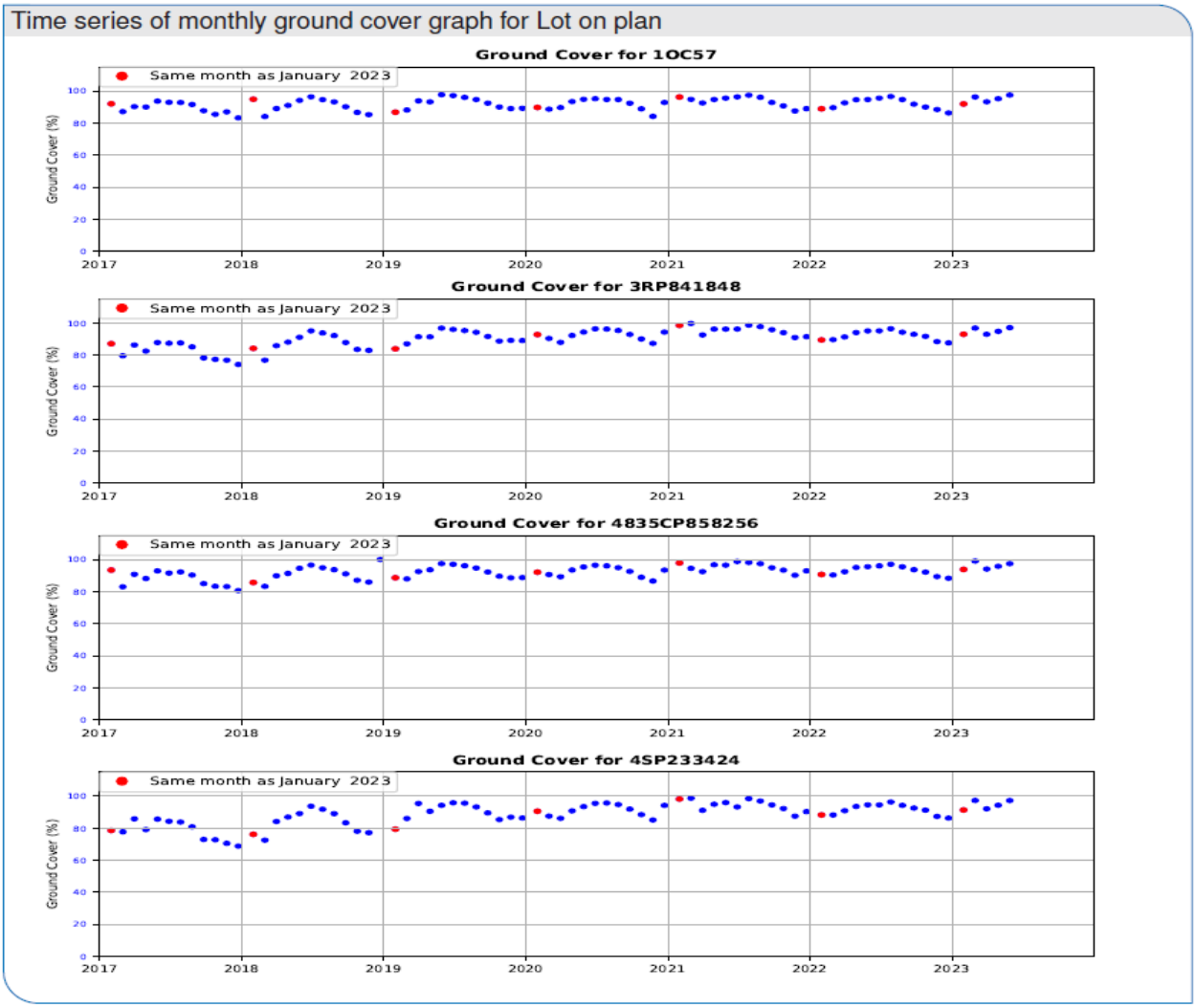


Figure 8. An example of the time series graph from the paddock information accessory file, showing the monthly levels of ground cover for requested Lot(s) on Plan (or paddocks) from 2017 to the most recent month. The red dot shows the user-specified month (recent and previous) for quick identification.

Ground cover percentage area summary for Lot on plan

The table below shows the percentage area of each ground cover level within a Lot on plan (out of the total area of the Lot on plan) as at January 2023 for six ranges of ground cover levels.

		Cover levels (%)					
Lot on plan	**Area (ha)**	**<15%**	**15 - 30%**	**30 - 50%**	**50 - 70%**	**70 - 90%**	**>90%**
1OC57	6919.6	0.0	0.0	0.4	3.8	67.7	28.1
3RP841848	5650.1	0.0	0.0	0.0	2.3	55.2	42.5
4835CP858256	18990.4	0.0	0.0	0.2	1.7	49.5	48.6
4SP233424	4621.7	0.0	0.0	0.1	2.1	65.4	32.4

Figure 9. An example of the summary table from the paddock information accessory report, showing the ground cover percentage area for six levels of ground cover ranges for requested Lot(s) on Plan (or paddocks).

4.3 FORAGE Report: Ground Cover – Regional Comparison

The *FORAGE Report: Ground Cover – Regional Comparison* (Figures 10-12) shows ground cover levels over time for the dominant land types for a selected Lot(s) on Plan in Queensland, relative to the same land types on similar land tenures in the local region. The local region for comparison is defined as being within a 25 km radius (or 50 km for larger properties) around the selected Lot(s) on Plan. The use of a localised radius is intended to reduce the influence of regional climate variability on any comparisons. Any differences between the ground cover levels on the selected Lot(s) on Plan and the local region are therefore assumed to be due to land and grazing management. An accessory data file is also included to provide the data used in the report.

The regional ground cover levels are represented in the graph in real value (i.e. percentage) and as percentiles. This enables direct comparison of the trend and the level of ground cover for the selected Lot(s) on Plan to the range of ground cover levels for the region at the same point in time, and over time.

As a guide to 'percentiles', an animation showing the calculation and interpretation of 'percentiles' for property decision-making (using rainfall and pasture data) can be viewed here https://www.longpaddock.qld.gov.au/forage/videos/understanding-percentiles-in-climate-data/.

Note: If there are limited satellite data available for periods when there is too much cloud, ground cover is estimated based on the long-term pattern of cover compared with the surrounding area.

The Ground Cover – Regional Comparison report includes:

- **The main Ground Cover - Regional Comparison report (two sections):**

Each page of the report includes:

- a map showing the Lot(s) on Plan
- a 25 km (or 50 km) radius around the Lot(s) on Plan (the region for comparison)
- the relevant dominant land type or types in question.
- percentage and percentile time series graphs – explained below.
- optional 'user-nominated' lines repeated on each time series graph to show 'change in management' and/or 'change in ownership' for the selected Lot(s) on Plan.

Section 1 - A regional comparison for the dominant land types for the Lot(s) on Plan:

- **Page 1** (Figure 10): provides an overview of the ground cover rankings for *all* dominant land types (black line) and each contributing dominant land type (multi-colour) on a single percentile time series to compare against the cover level on the same land types in the local region over time.

- **Page 2** (Figure 11): the top graph shows the ground cover percentage (left y-axis) for *all* dominant land types as a red line (median of property land types), with a background of the 'regional' percentile range as four percentile classes (5-20, 20-50, 50-80, and 80-95). The bottom graph shows the ground cover ranking against the surrounding region over time for four percentile classes (5-20, 20-50, 50-80, and 80-95).

Section 2 - A regional comparison of ground cover for *each* individual dominant land type for the Lot(s) on Plan.

- **Page 3** (Figure 12): the top graph shows the ground cover percentage (left y-axis) for the land type shown as a red line (median of property land types), with a background of the 'regional' percentile range as four percentile classes (5-20, 20-50, 50-80, and 80-95). The bottom graph shows the ground cover ranking against the surrounding region over time as four percentile classes (5-20, 20-50, 50-80, and 80-95). As a report is produced for *each* of the dominant land types for the Lot(s) on Plan, there may be a number of pages to this section (i.e. one page for each land type).

- **A Data accessory file**
  - A csv (comma delimited) file is generated which provides the data (percentile and percentage) for each time series within the report.

More about how the calculations are made

The Ground Cover – Regional Comparison is based on seasonal ground cover data using the most representative fractional cover measurement from the season. Seasons are defined by the standard calendar months for each regular season (i.e. summer, autumn, winter, spring). Extremes may not be represented by this product and therefore may not been apparent in the time series of the report. The user is directed to the single date ground cover product for information about particular points in time or known single events (e.g. fire, an extreme dry period, flood, etc.).

Per pixel levels of seasonal ground cover are ranked into percentiles for the local region within a 25 km or 50 km radius of the centre of the selected Lot on Plan depending on the size of the Lot on Plan area. Areas *not* included in the calculation of regional comparisons include:

- non-dominant land types (see below for explanation of a dominant land type)
- non-grazing land uses: based on Queensland Land Use Mapping Program data and including National Parks and other conservation areas, urban areas etc.
- travelling stock routes
- areas with higher tree cover (i.e. FPC >60%).

Note: If there are additional areas of the property that should be excluded for the best possible outcomes, then it is suggested that the MyFORAGE online mapping tool is used to excise areas as exclusion zones.

The median ground cover for the selected Lot on Plan is derived by calculating the median ground cover for the dominant land types on the Lot on Plan for each seasonal ground cover image in the time series from 1986 to present.

Land type data are based on the Grazing Land Management (GLM) land types https://futurebeef.com.au/resources/land-types-of-queensland/ . Dominant land types for the selected Lot on Plan are determined by selecting the least number of land types which constitute at least 80% of the area of the selected Lot on Plan.

How to use the report

The *FORAGE Ground Cover – Regional Comparison Report* is intended for comparative purposes. It allows the user to compare the current and past levels of ground cover on their selected Lot on Plan with the current and past levels of ground cover for their local region. This can help indicate, for the particular land types on the Lot on Plan, what the lower and higher levels of ground cover were in the local region at any point in the time series. The user may then compare the ground cover levels for the land types on their selected Lot on Plan with those of the local region.

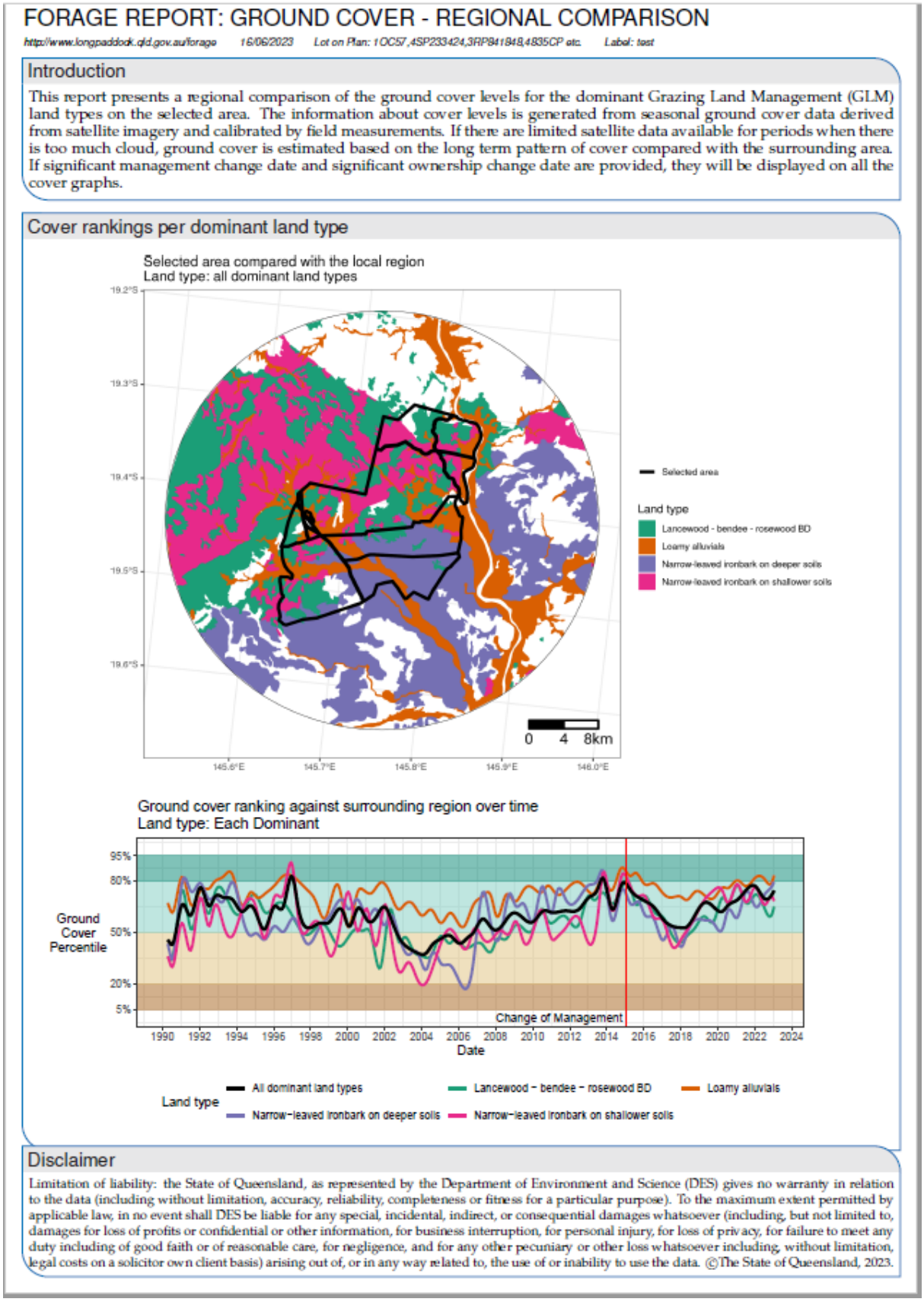
This can be used to identify, for example:

- potential levels of ground cover possible for particular land types during each season and climate period. These may be useful as benchmarks for the region.
- impacts of different management practices (e.g. stocking rates, use of fire) on the ground cover levels on different land types.
- particular land types which may be more resilient in dry times, or which may be more susceptible to lower levels of cover or greater variability. This can help with adjusting stocking rates.
- areas in the local region with higher fuel loads and therefore more likely to represent a fire hazard.

The Ground Cover – Regional Comparison report is intended for comparative purposes only. It is important to consider actual ground cover levels as well as the percentile rank. For instance, ground cover levels could be high across the region but cover for the Lot on Plan could be in a lower percentile range, showing that the cover levels for the Lot on Plan are generally high, but are lower in comparison to the region.

It is important to note that this report is based on ground cover data derived from satellite imagery. The satellite imagery can separate ground cover into the green and non-green fractions (and bare ground). For this report, the green and non-green fractions are summed to obtain total cover, therefore the ground cover levels reported may include high litter or non-green fractions which are useful for protection of the soil against erosion, but may not offer useful nutritional content to livestock. Likewise, the green fraction may have a high proportion of undesirable pasture species or weeds. The satellite imagery does not distinguish between pasture composition, biomass or feed on offer.

It is also important to note that the GLM land type data included in the report has limitations due to the scale and accuracy of the base data used to derive the land types.



FORAGE REPORT: GROUND COVER - REGIONAL COMPARISON

http://www.longpaddock.qld.gov.au/forage 16/06/2023 Lot on Plan: 1OC57,4SP233424,3RP841848,4835CP etc. Label: test

Introduction

This report presents a regional comparison of the ground cover levels for the dominant Grazing Land Management (GLM) land types on the selected area. The information about cover levels is generated from seasonal ground cover data derived from satellite imagery and calibrated by field measurements. If there are limited satellite data available for periods when there is too much cloud, ground cover is estimated based on the long term pattern of cover compared with the surrounding area. If significant management change date and significant ownership change date are provided, they will be displayed on all the cover graphs.

Cover rankings per dominant land type

Selected area compared with the local region
Land type: all dominant land types

Ground cover ranking against surrounding region over time
Land type: Each Dominant

Disclaimer

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Figure 10. An example of the Ground Cover – Regional Comparison report showing ground cover levels over time for each of the Lot on Plan dominant land types relative to the same land types in the local region.

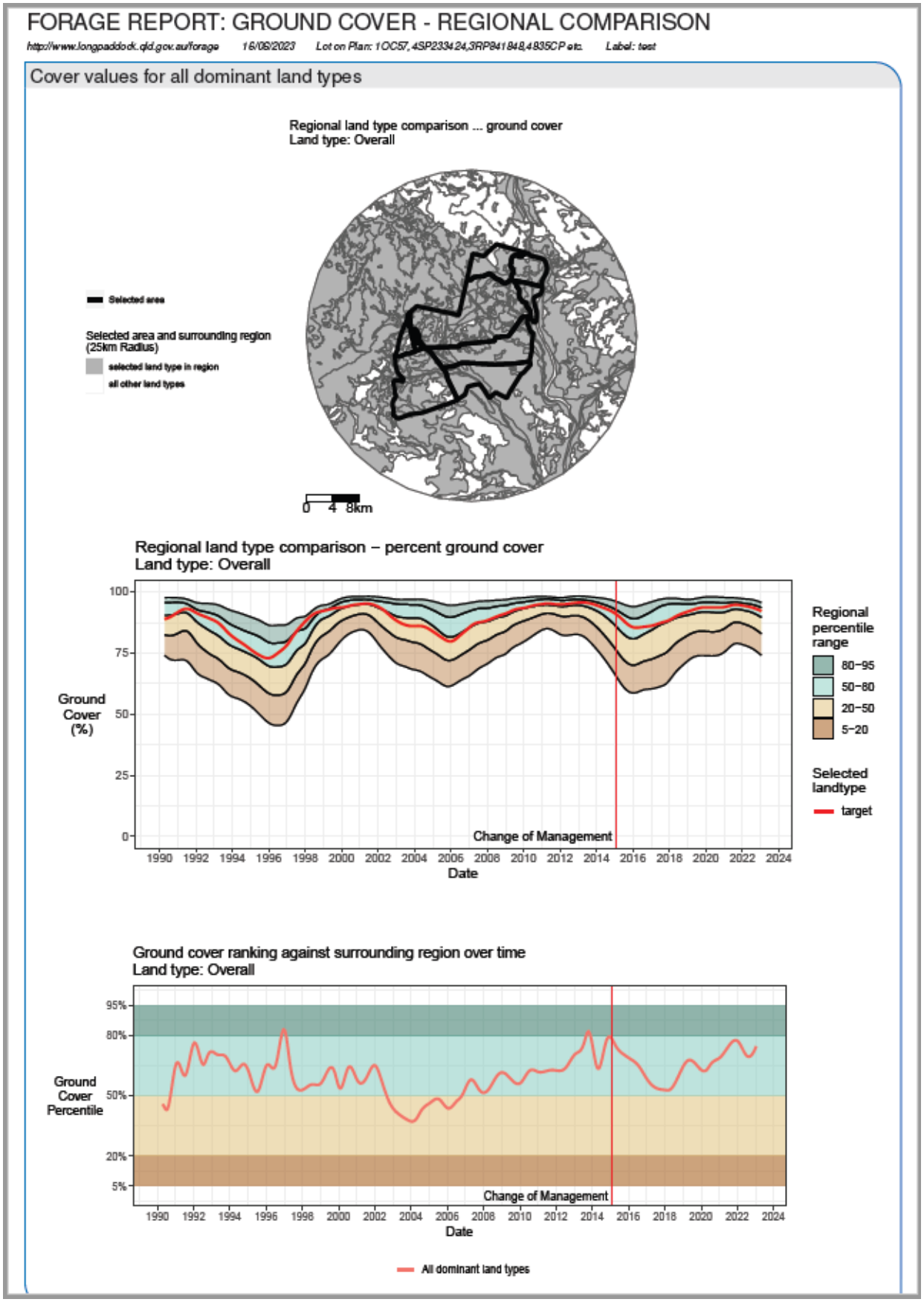


Figure 11 . An example of the Ground Cover – Regional Comparison report. Graphs show ground cover levels over time for all Lot on Plan dominant land types relative to the same land types in the local region.

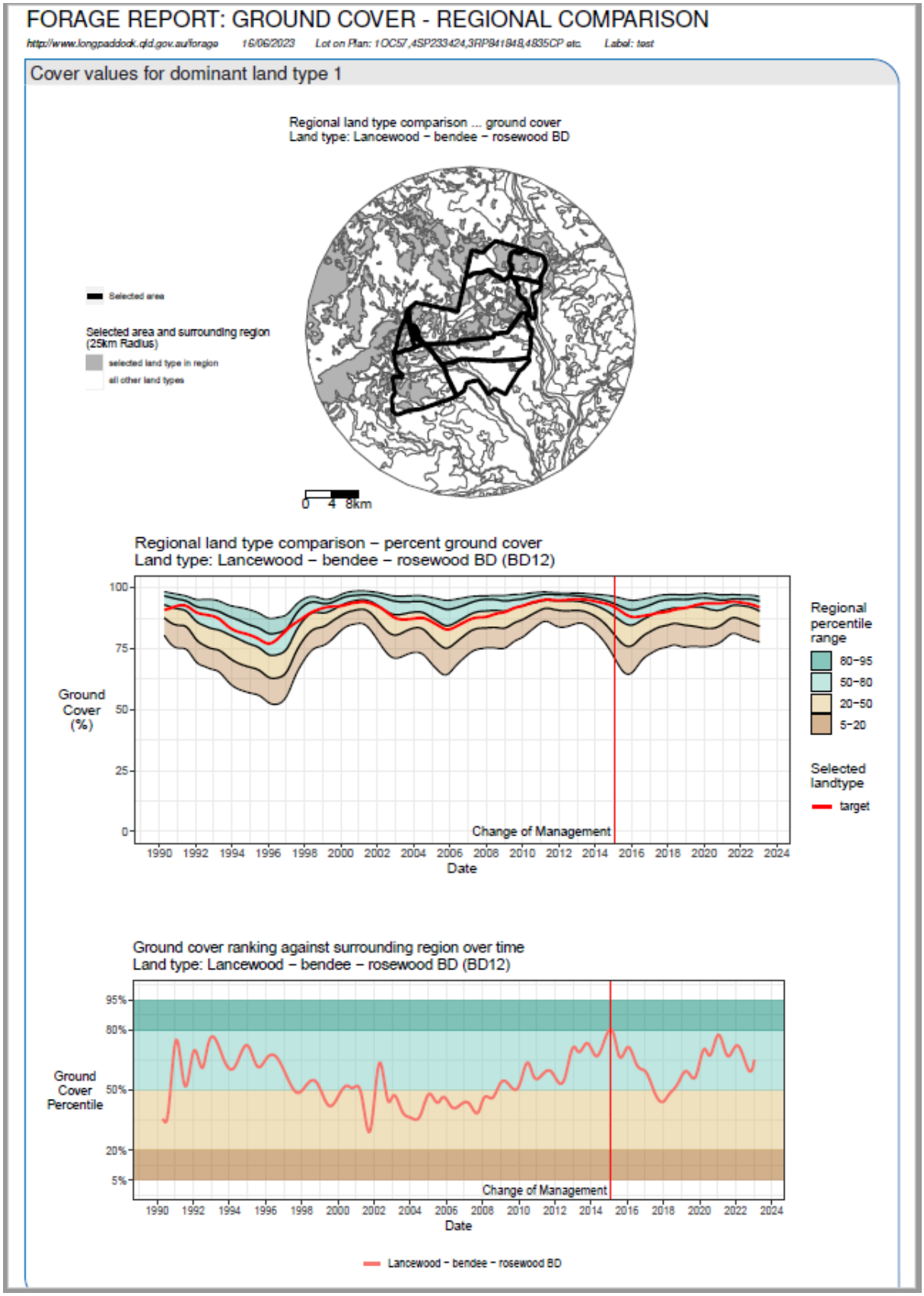


Figure 12. An example of the Ground Cover – Regional Comparison report. Graphs show ground cover levels over time for an individual land type for a selected Lot on Plan relative to the same land type in the local region.

4.4 FORAGE Report: Indicative Land Type

The *FORAGE Report: Indicative Land Type* shows the current version of Grazing Land Management (GLM) land types in Queensland for a selected Lot on Plan (Figure 13) including the approximate area and proportion of each land type within a selected Lot on Plan (Figure 14).

GLM land types have been derived for regions in Queensland, being broadly based on major river catchments. Local grazier knowledge has been useful in identifying local land types.

Land types are areas of grazing land with similar soil, vegetation and capacity to produce useful feed. An understanding of land types is important when calculating carrying capacity and forage budgets for a property, for example through the Stocktake © computer package (see Glossary).

The GLM land types were developed to support grazing land managers to help:

- identify areas that differ in their capacity to produce forage
- determine how these differences affect productivity
- assess management options.

The **Land Type Summary table** (Figure 14) shows, for land types that make up a minimum area of one hectare:

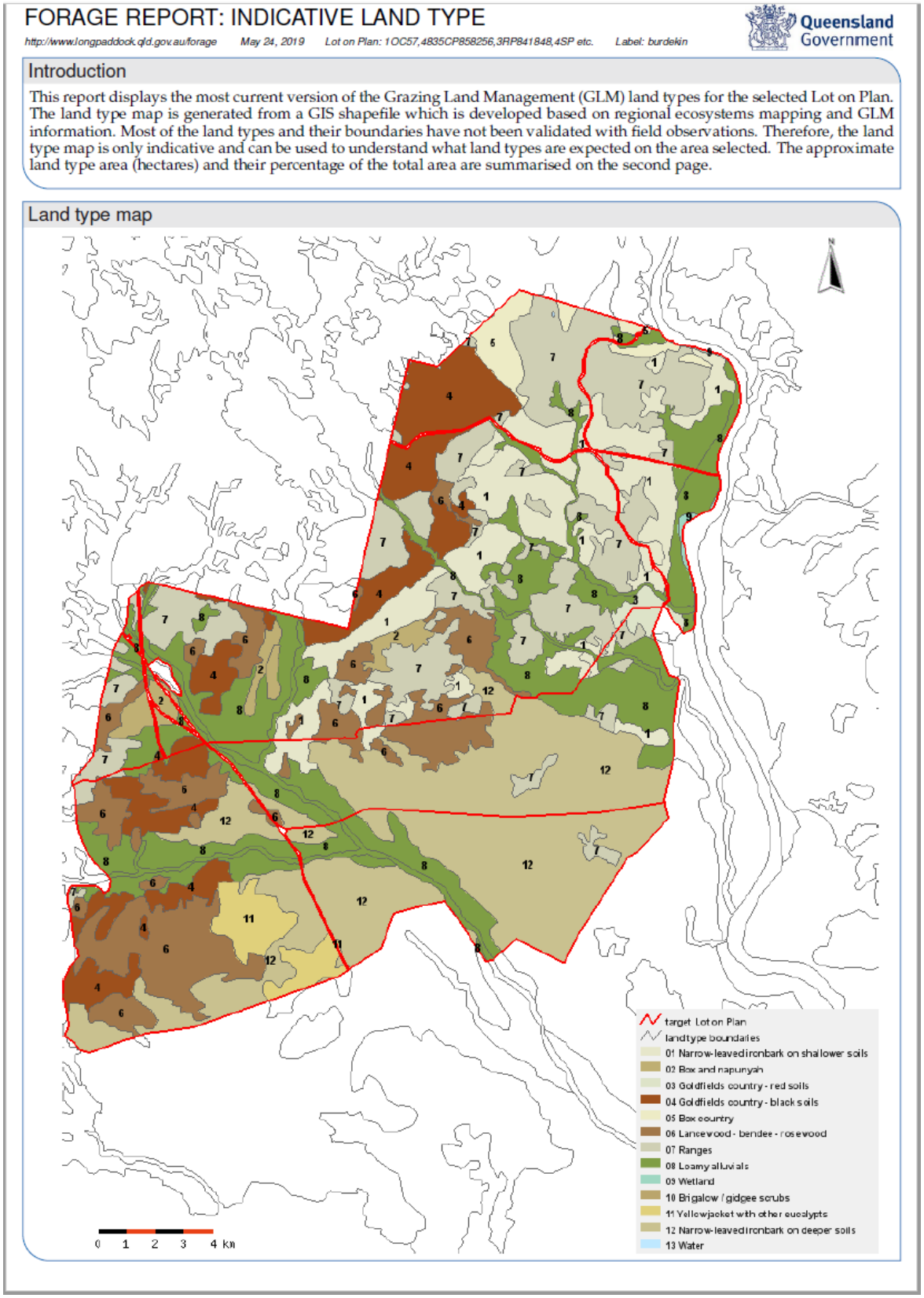
- land types in order of dominance by area
- land type codes
- estimated area occupied by a land type, both as number of hectares and percentage of the total area of the Lot/s on Plan.

Users should be aware that land type classification or boundaries may change between mapping versions. The DES updates land type mapping on an ongoing basis. FORAGE accesses the most recent version available at the time a report is requested. The 'Data Sources' heading on the front page of the report shows the version of land type mapping used. The mapping data will be periodically updated and implemented in the report. The land type mapping data are also attached in the email with the report as a zipped shapefile which can be used in GIS applications (inc. VegMachine).

Users should also be aware that this report shows only dominant land types and other land types may also be present on the selected Lot/s on Plan.

It is recommended that the information in the report is verified by field inspection. For the majority of Queensland, land types have been mapped at a scale from 1:50 000 to 1:100 000. The accuracy of land type data mapped at this scale is +/- 100m. For areas along the east coast, land types have been mapped at a scale of 1:50 000 and the accuracy is +/- 50m. Line work shown on the land type map should be used as a guide only as most of the land types and their respective boundaries have not been validated with field investigations. Therefore, while the land type map is only indicative, it provides the user with useful information about the expected land types for the property in question.

For further information on land types of Queensland, visit the FutureBeef website at http://www.futurebeef.com.au



FORAGE REPORT: INDICATIVE LAND TYPE

http://www.longpaddock.qld.gov.au/forage May 24, 2019 Lot on Plan: 1OC57,4835CP858256,3RP841848,4SP etc. Label: burdekin

Queensland Government

Introduction

This report displays the most current version of the Grazing Land Management (GLM) land types for the selected Lot on Plan. The land type map is generated from a GIS shapefile which is developed based on regional ecosystems mapping and GLM information. Most of the land types and their boundaries have not been validated with field observations. Therefore, the land type map is only indicative and can be used to understand what land types are expected on the area selected. The approximate land type area (hectares) and their percentage of the total area are summarised on the second page.

Land type map

Figure 13. An example of the front page of an Indicative Land Type report.

FORAGE REPORT: INDICATIVE LAND TYPE

http://www.longpaddock.qld.gov.au/forage May 24, 2019 Lot on Plan: 1OC57,4835CP858256,3RP841848,4SP etc. Label: burdekin

Queensland Government

Land type summary

Expected land types (for land types more than 1 hectare)	Land type code	Estimated area (hectare)	Estimated area (%)
12 Narrow-leaved ironbark on deeper soils	BD14	8518	24.1
08 Loamy alluvials	BD13	7097	20.1
07 Ranges	BD16	5886	16.7
06 Lancewood - bendee - rosewood	BD12	4079	11.5
01 Narrow-leaved ironbark on shallower soils	BD15	4033	11.4
04 Goldfields country - black soils	BD10	3499	9.9
11 Yellowjacket with other eucalypts	BD20	790	2.2
02 Box and napunyah	BD04	598	1.7
05 Box country	BD05	553	1.6
03 Goldfields country - red soils	BD11	198	<1
09 Wetland	AL10	81	<1
10 Brigalow / gidgee scrubs	BD06	2	<1
13 Water	AL09	1	<1

Data sources

The land type information is based on "SIRQRY.DAF_GLM_Land_Types_V5" dataset.

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Figure 14. An example of the second page of an Indicative Land Type report.

4.5 FORAGE Report: Foliage Projective Cover

The *FORAGE Report: Foliage Projective Cover* (FPC; Figures 15 and 16) report shows tree and shrub FPC classes obtained from the most recent satellite imagery available for a selected Lot on Plan or adjoining Lots on Plan in Queensland. As a guide for most users more familiar with TBA as a measure of tree density, the FPC thresholds used in the report (15, 30 and 70 per cent) equate to a TBA of approximately six, twelve and thirty-two square metres per hectare for mature tree communities (Armston *et al.* 2009).

Woody vegetation can have a major impact on grass production. Basal area (m^2/ha), either of trees alone or both trees and shrubs, is the most commonly used and convenient measure of woody vegetation density. Tree Basal Area (TBA), for example, is simply the cross-sectional area of all the trees at breast height per hectare. However, a better indication of the influence of woody vegetation on grass productivity can be gained by measuring Foliage Projective Cover (FPC), which is defined as the vertically projected percentage cover of photosynthetic foliage from trees and shrubs greater than two metres in height (see Glossary). This is because FPC is more closely related to light interception and tree water use than basal area.

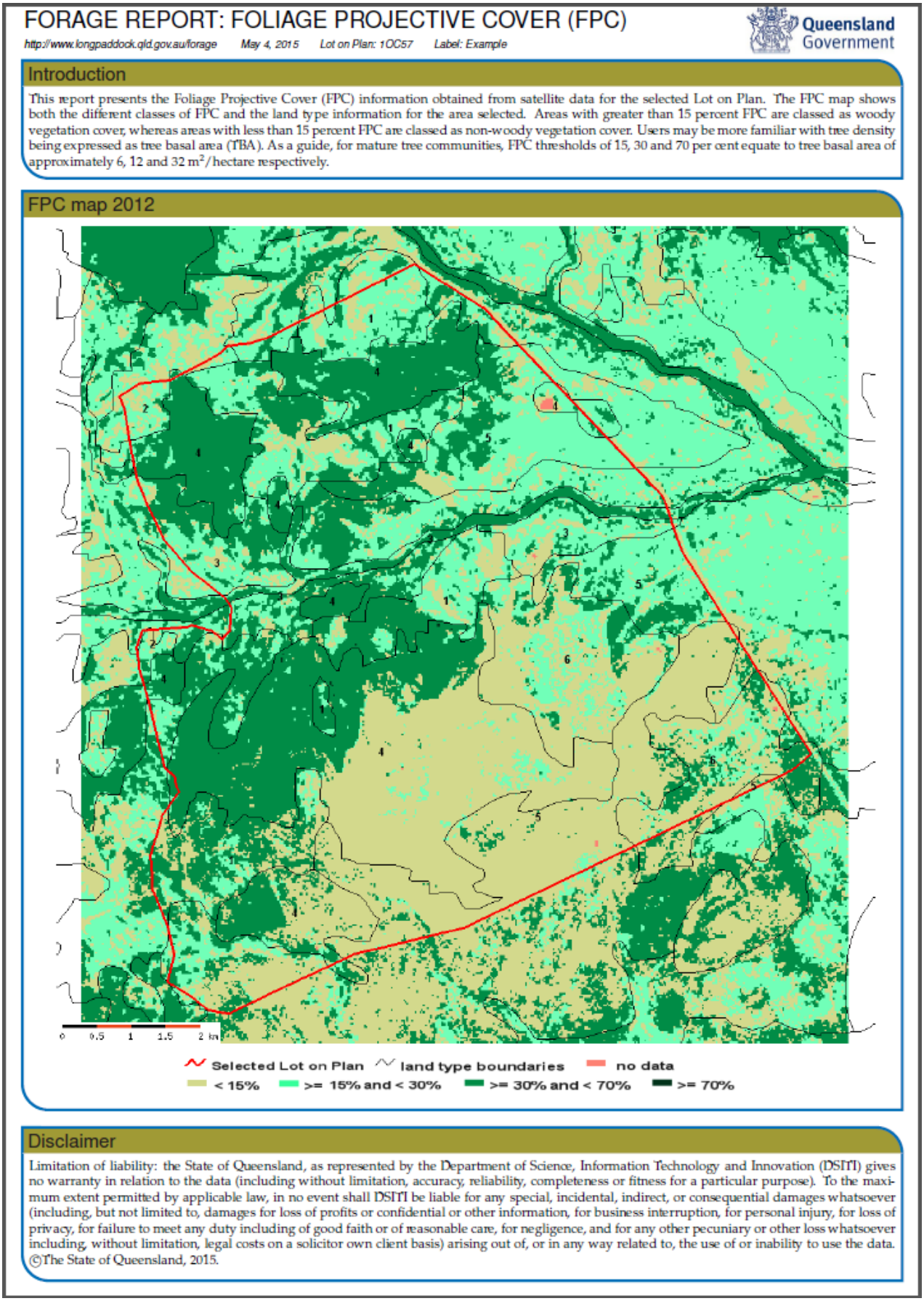
An FPC report includes:

- a map (Figure 15) showing FPC calculated from satellite imagery overlaid on:
  - the selected Lot on Plan boundaries
  - Grazing Land Management (GLM) land types
- a summary of FPC statistics for each GLM land type within the Lot on Plan (Figure 16).

For further information about GLM land types go to: http://www.futurebeef.com.au

FPC levels are modelled from satellite imagery. The purpose of modelling is to minimise the influence of grass cover on FPC estimates and 'smooth' short term fluctuations in FPC due, for example, to wet or dry conditions (Kitchen *et al.* 2010). However, it is not possible to smooth all short term fluctuations.

The FPC information presented in this report is for general use only. It is recommended that the information provided in this report be supported by further field investigation for accuracy.



FORAGE REPORT: FOLIAGE PROJECTIVE COVER (FPC)

http://www.longpaddock.qld.gov.au/forage May 4, 2015 Lot on Plan: 1OC57 Label: Example

Queensland Government

Introduction

This report presents the Foliage Projective Cover (FPC) information obtained from satellite data for the selected Lot on Plan. The FPC map shows both the different classes of FPC and the land type information for the area selected. Areas with greater than 15 percent FPC are classed as woody vegetation cover, whereas areas with less than 15 percent FPC are classed as non-woody vegetation cover. Users may be more familiar with tree density being expressed as tree basal area (TBA). As a guide, for mature tree communities, FPC thresholds of 15, 30 and 70 per cent equate to tree basal area of approximately 6, 12 and 32 m^2/hectare respectively.

FPC map 2012

0 0.5 1 1.5 2 km

Selected Lot on Plan | land type boundaries | no data

< 15% | >= 15% and < 30% | >= 30% and < 70% | >= 70%

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Figure 15. An example of the front page of the Foliage Projective Cover report.

FORAGE REPORT: FOLIAGE PROJECTIVE COVER (FPC)

http://www.longpaddock.qld.gov.au/forage May 4, 2015 Lot on Plan: 1OC57 Label: Example

Queensland Government

Summary of FPC for land types

This table indicates the area and percentage area of FPC for each land type on the selected Lot on Plan. Four FPC classes are shown (FPC<15% , FPC 15-30%, FPC 30-70% and FPC>70%)

Expected land type (for land types > 1 hectare)	Code	Land type area (ha)	FPC <15 ha (%)	FPC 15-30 ha (%)	FPC 30-70 ha (%)	FPC >70 ha (%)
04 Lancewood - bendee - rosewood (BD)	BD12	2185	849 (38.8)	146 (6.7)	1189 (54.4)	< 1 (<1)
05 Narrow-leaved ironbark on deeper soils	BD14	1570	841 (53.6)	448 (28.5)	281 (17.9)	< 1 (<1)
01 Goldfields country - black soils	BD10	1217	234 (19.2)	465 (38.2)	518 (42.6)	< 1 (<1)
03 Loamy alluvials	BD13	1037	135 (13.0)	473 (45.6)	429 (41.4)	< 1 (<1)
06 Yellowjacket with other eucalypts	BD20	781	469 (60.0)	190 (24.3)	122 (15.7)	< 1 (<1)
02 Range soil (NG)	NG08	80	30 (37.1)	43 (53.6)	7 (9.3)	< 1 (<1)
Total		6869	2557 (37.2)	1764 (25.7)	2548 (37.1)	1 (0.0)

Data sources

The land type information is based on "SIRQRY.QLD-GLM-LANDTYPE-RLL-V2" dataset. The FPC information (product id: cht) is derived from the satellite data which was developed by Remote Sensing Centre, Department of Science, Information Technology and Innovation (DSITI).

Figure 16. An example of the second page of the Foliage Projective Cover report.

4.6 FORAGE Report: Regional Climate Projections

The *FORAGE Report: Regional Climate Projections* (Figures 17 and 18) can be generated for the immediate district surrounding a selected Lot/s on Plan in Queensland. The report provides historical and projected climate information for 2030, 2050 and 2070 using the SILO climate dataset and Consistent Climate Scenarios (CCS) projections data developed by DES. The climate information presented in the Regional Climate Projections report includes rainfall, evaporation, temperature (mean, minimum, maximum) and vapour pressure (a measure of humidity).

The projected climate information is based on an aggregate of information from 28 Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Global Climate Models (GCMs) deemed to be most reliable for the Australian region (Suppiah et al. 2007; Smith and Chiew, 2009). For each GCM, three model warming sensitivities to CO_2 rise (high, medium and low) have been used. Furthermore, the FORAGE Regional Climate Projections incorporate four Representative Concentration Pathways (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5) that have been recommended in the CCS Project. The GCMs, model warming sensitivities to CO_2 rise, Representative Concentration Pathways and the methodology DES has used to produce the projected climate information are all outlined in the CCS User Guide on the Long Paddock website.

The front page of the Regional Climate Projections report (Figure 17) includes:

- an introduction summarising the projection years, GCMs, model warming sensitivities to CO_2 rise, Representative Concentration Pathways and baseline climate period
- a tabular summary of the historical and projected annual climate
- a map showing the location of the selected Lot on Plan
- bar-dot graphs showing the historical and projected monthly median climate.

The second page of the Regional Climate Projections report (Figure 18) includes:

- information on how to interpret the annual climate summary plot
- box and whisker plots of historical and projected annual climate range.

The **tabular summary** on the front page of the report (Figure 17) shows historical (1960-2015) median annual values for rainfall, evaporation, temperature and vapour pressure and projected values for those climate variables for 2030, 2050 and 2070.

The **series of bar-dot graphs** on the same page show historic median monthly values and future climate projections. This information provides the user with a visual indication of the seasonal patterns of both historical climate and projected climate under the different global warming rates and Representative Concentration Pathways in 2030, 2050 and 2070. The bars in each graph represent the historical median monthly value for the listed climate variable (e.g. rainfall) and the coloured dots in each graph represent the projected monthly median values of the that climate variable in 2030 (blue dot), 2050 (red dot) and 2070 (brown dot).

The **series of box and whisker plots** on the second page of the report show the annual historical (1960-2015) range and the projected range of possibilities for selected climate variables in 2030, 2050 and 2070 (Figure 18). The plots for historical and projected climate include annual values for rainfall, evaporation, vapour pressure, maximum temperature, mean temperature and minimum temperature. In each plot, the top horizontal bar represents the highest historical value and highest projection and the bottom horizontal bar represents the lowest historical value and lowest projection. The box represents the data range

between the 10th and 90th percentiles. The red line in each box represents the median value of the data range which, for the projections data, could be interpreted as the best estimate for 2030, 2050 and 2070.

Further information on DES's Consistent Climate Scenarios project is available on the Long Paddock website (http://www.longpaddock.qld.gov.au/climateprojections/).

FORAGE REPORT: REGIONAL CLIMATE PROJECTIONS

Queensland Government

http://www.longpaddock.qld.gov.au/forage *October 19, 2016* *Lot on Plan: 1OC57* *Label: test*

Introduction

This report is for the location indicated by the red crosshair symbol on the map below. The report presents information based on SILO historical climate data and Consistent Climate Scenarios (CCS) projections data (developed by the Department of Science, Information Technology and Innovation, DSITI). Annual and monthly climate projections data for 2030, 2050 and 2070 have been generated using 28 AR5 global climate models (GCMs), three model sensitivities to CO_2 rise (low, medium and high warming rates) and four Representative Concentration Pathways (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5) which specify CO_2 levels from 435 to 449 ppm for 2030 and from 478 to 677 ppm for 2070. The baseline climate is the period between 1960 and 2015.

The monthly median values for the historical climate (1960 -2015) and climate projections for 2030, 2050 and 2070 are presented in the bar-dot graphs (below) which indicate the seasonal patterns of historical climate and projected climate under the different global warming rates and scenarios in 2030, 2050 and 2070.

The results for annual projections as shown by the projected annual climate range plots (next page) indicate a range of possibilities of projected temperature, rainfall and other parameters under the different global warming rates and scenarios. For more information, see https://www.longpaddock.qld.gov.au/climateprojections/guide.html.

Historical and projected annual climate summary

Climate Variable (Median Annual)	Historical 1960-2010	Projection 2030	Projection 2050	Projection 2070
Rainfall (mm)	523.1	514.0	508.9	503.3
Evaporation (mm)	2074.3	2179.9	2240.7	2289.5
Mean Temperature (°C)	23.3	24.3	24.8	25.3
Maximum Temperature (°C)	29.4	30.3	30.9	31.4
Minimum Temperature (°C)	17.2	18.1	18.7	19.2
Average Vapour Pressure (kPa)	19.3	20.2	20.8	21.4

Location map

Historical and projected monthly median climate

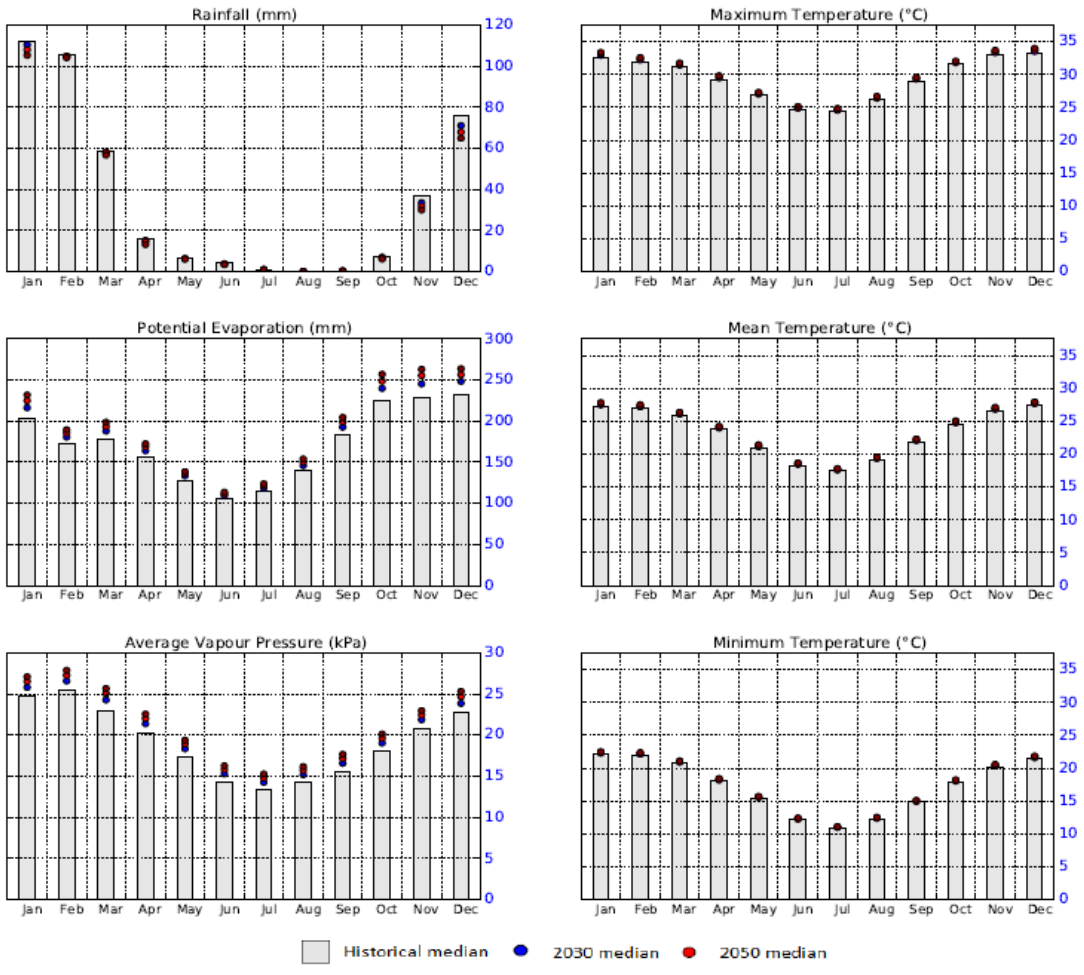
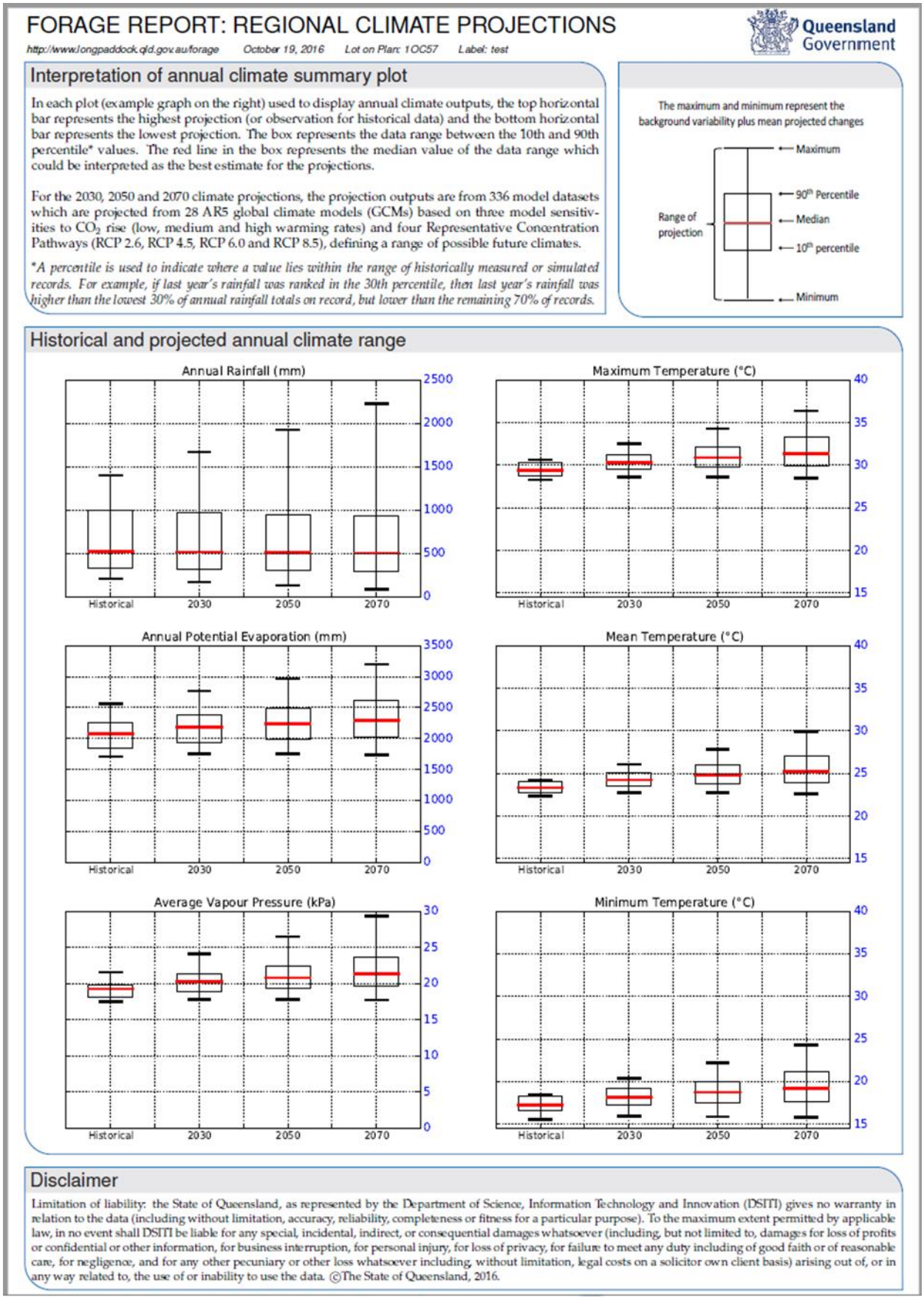


Figure 17. An example of the front page of the Regional Climate Projections report.



FORAGE REPORT: REGIONAL CLIMATE PROJECTIONS

http://www.longpaddock.qld.gov.au/forage October 19, 2016 Lot on Plan: 1OC57 Label: test

Queensland Government

Interpretation of annual climate summary plot

In each plot (example graph on the right) used to display annual climate outputs, the top horizontal bar represents the highest projection (or observation for historical data) and the bottom horizontal bar represents the lowest projection. The box represents the data range between the 10th and 90th percentile* values. The red line in the box represents the median value of the data range which could be interpreted as the best estimate for the projections.

For the 2030, 2050 and 2070 climate projections, the projection outputs are from 336 model datasets which are projected from 28 AR5 global climate models (GCMs) based on three model sensitivities to CO_2 rise (low, medium and high warming rates) and four Representative Concentration Pathways (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5), defining a range of possible future climates.

**A percentile is used to indicate where a value lies within the range of historically measured or simulated records. For example, if last year's rainfall was ranked in the 30th percentile, then last year's rainfall was higher than the lowest 30% of annual rainfall totals on record, but lower than the remaining 70% of records.*

The maximum and minimum represent the background variability plus mean projected changes

Historical and projected annual climate range

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Figure 18. An example of the second page of the Regional Climate Projections report.

4.7 FORAGE Report: Crop Frequency

The *FORAGE Report: Crop Frequency* provides a range of maps showing the presence and frequency of crops for the selected Lot on Plan (Figure 19). The estimated total crop frequency map shows locations where active crops have been detected three or more times in the summer and winter growing seasons (coloured areas on the map), for a ten year period. The 'total crop frequency' is a count of number of years in which an active crop was detected.
Two additional maps show the summer and winter crop frequency. This is a count of the number of times an active crop was detected in each of those growing seasons. The detection of active crops is based on a within season time-series analysis of satellite imagery. Due to potential limitations of the automated method used to detect active cropping, you should also view the seasonal maximum green vegetation satellite imagery to confirm the presence or absence of cropping (Pringle *et al.* 2018).

This crop mapping is a further development of the superseded version 1 (Schmidt *et al.* 2016).

FORAGE REPORT: CROP FREQUENCY

http://www.longpaddock.qld.gov.au/forage *02/08/2022* *Lot on Plan: 10BLM499* *Label: test*

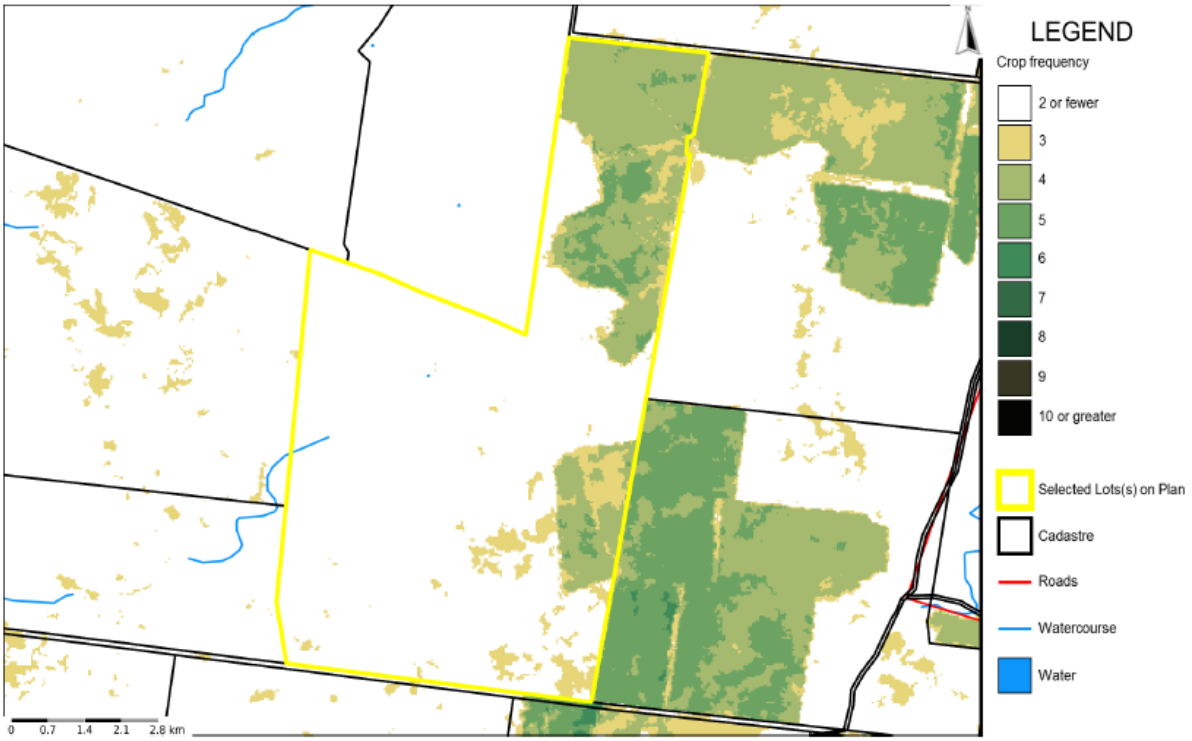
Queensland Government

Introduction

This report presents maps of crop frequency for your chosen area, and chosen time period. Maps are based on time-series analysis of satellite imagery (30m spatial resolution), for both the summer and winter growing seasons, aimed at detecting cycles of vegetation greenness. Composite satellite images that display the maximum greenness within a summer or winter growing season for each year are also provided, as a visual reference. For further information refer to the FORAGE User Guide (https://data.longpaddock.qld.gov.au/static/forage_user_guide.pdf).

Location map

Estimated total crop frequency map (2012 - 2021)



How to interpret the information

Crop-frequency mapping: Coloured areas on the maps indicate locations where actively growing crops have been detected three or more times for the time period specified.

The map on this page shows the "Total Crop Frequency". For example, a total crop frequency value of 5 indicates that there have been 5 crops for the entire time period which can be made up of either summer crops or winter crops or combination of both seasons. The maps on the following page show the summer and winter crop frequency, respectively. Analysis of satellite imagery can result in some misclassification, so it is recommended to view the composite imagery (see below) to help confirm the presence of a crop in a given season.

Composite satellite imagery: Due to the limitations of the automated method used to detect active cropping, it is recommended to view the seasonal composite images (pages 3 onward), compiled to represent the maximum greenness (per pixel) within a growing season. Cropped areas will generally appear bright green in the imagery compared with the surrounding landscape. Even if the frequency mapping does not indicate cropping in an area, it is important to check each composite image to confirm that cropping has not been undertaken. Sometimes it will not be possible to clearly identify cropped areas in the imagery, e.g in relative wet seasons the entire landscape might appear green. In such a case we recommended to undertake further investigation with other information sources.

Figure 19. An example of the first page of the Crop frequency report.

4.8 Satellite imagery and derived products

FORAGE offers automated web-based delivery of Landsat 5 TM and Landsat 7 ETM+ satellite imagery derived products through DES's Remote Sensing Centre. The Remote Sensing Centre provides an extensive archive of Landsat satellite imagery dating back to 1986, with at least annual dry season coverage for all of Queensland. The imagery products are commonly referred to as SLATS satellite imagery and are used extensively in land management activities.

FORAGE provides four satellite based image products:

1. Multispectral Landsat 5 Thematic Mapper (TM) and/or Landsat 7 Enhanced Thematic Mapper (ETM+), Landsat 8 Operational Land Imager (OLI) imagery for specified dates (Visual Image, a true colour composite) (Figure 20).
2. Foliage Projective Cover (FPC) (Figure 21).
3. Seasonal ground cover (Figure 22).
4. Summary ground cover statistics including 5th, 50th and 95th percentile derived from the entire collections of the ground cover images from 1988 to a year approximately before current year.

Further information on the Remote Sensing Centre and remote sensing products is available on: http://www.qld.gov.au/environment/land/vegetation/mapping/remote-sensing/. The products are based on radiometric and geometrically calibrated sequences of Landsat TM ETM+ and OLI imagery. The primary FPC and ground cover images are produced from regression against a large number of field observations across Queensland and are regularly recalibrated as more field data are collected. FORAGE uses the most recent calibration of the ground cover images to generate the ground cover report.

The visual image (Figure 20) provides a landscape background of the selected property. The FPC image (Figure 21) indicates woody density. Generally if the FPC value is greater than 20%, the area has a high tree density.

Please note that the FPC value on the image is not an exact FPC. It is a value of 100 plus the actual FPC. For example, if the FPC value on a pixel is 145, the actual FPC is 45%. Similarly the value presented in the seasonal ground cover and the summary ground cover statistics images is the ground cover plus 100. For example, if the pixel value is 155, the real ground cover is 55%.

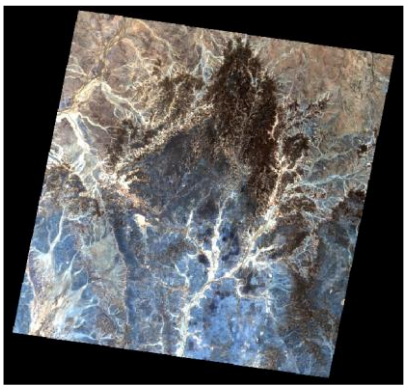


Figure 20. An example of a Landsat reflective image obtained from FORAGE.

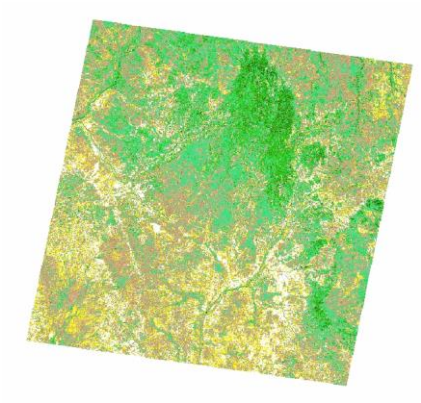


Figure 21. An example of a Foliage Projective Cover (FPC) image obtained from FORAGE.

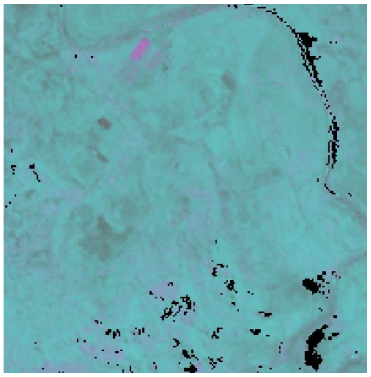


Figure 22. An example of a seasonal ground cover image obtained from FORAGE.

For help in interpreting the imagery, visit:

http://www.qld.gov.au/environment/land/vegetation/mapping/remote-sensing/.

4.9 FORAGE Report: Fire Scar

The *FORAGE Report: Fire Scar* (Figure 23-26) is a four-page report providing a range of fire scar maps and time series graphs describing fire scar seasonal distribution, fires detected in different years and fuel load information for Lots on Plan, located in Queensland.

The information presented in a Fire Scar report includes:

- a "cumulative fire scar" map for the period from 1997 to current;
- a "years since burnt" map showing how long ago the latest fire scar was detected;
- a "fire scars detected in each month" of current year;
- a “Fire scar distribution among different months” time series graph;
- a “Percentage fire scar area” time series graph; and

a “Modelled time series of curing Index” time series graph.

The fire scar maps and bar graphs were generated using information obtained from NOAA (1992 to 2018) and Sentinel (2019 to current) satellite imagery. The NOAA satellite imagery is sourced from Landgate, Government of Western Australia (http://srss.landgate.wa.gov.au/fire.html), which has broad scale resolution (approximately 1.1km x 1.1km) but provides daily revisits for a site. Sentinel imagery is produced by the Queensland Government’s Remote Sensing Centre, which has a high (10m x 10m) resolution and is reported on a monthly basis (https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/firescar).

The curing index and fuel load data (Figure 26) were sourced from the AussieGRASS model outputs. The AussieGRASS model simulates regional scale historical time-series of rainfall and pasture growth, as well as projections for the season ahead, which are useful for forage budgeting and assessing impacts of drought and bushfire risk (see https://www.longpaddock.qld.gov.au/aussiegrass/about/).

Summary of maps

Each map displays a scale, the Digital Cadastral Database (DCDB) of Lots on Plan, the Lot on Plan of interest, roads, rivers and localities (e.g. properties and features).

Page 1: The "cumulative fire scar" map (Figure 23), shows how many times fire scars were detected for an area during the period nominated in the title (e.g. 1992-current). The range is from 0 to >10 fires. A statement relates what the available NOAA and Sentinel satellite data indicates, for example, that since 1992 there were 131 fire scars detected on the Lot on Plan of interest. The most recent fire scars were detected in Oct 2021, Nov 2021, Dec 2021, Jan 2022, Feb 2022, Mar 2022, Apr 2022, Jun 2022, Jul 2022, Aug 2022.

Page 2: The "years since burnt" map (Figure 24), shows how long ago the latest fire scar was detected for the period nominated in the title (e.g. 1992-current). The range is from 0 to >10 years. Longer periods without fire (i.e. > 4 years) indicate possible low fire fuel loads (due to overgrazing/drought etc) or woody weed encroachment, preventing pasture growth.

Page 3: The "fire scars detected in each month" of current year map (Figure 25), shows for the current year, the fire scars detected in each month. In this example, fire scars were detected in Jan, Feb, Mar, Apr, Jun, Jul, Aug. Note: The fire scars in most recent month may not be available due to lag from sourcing to processing satellite imagery.

Time series graphs

An example of the time series graphs of the Fire Scar report (found on page 4) is shown in Figure 26.

The first graph is the “Seasonal fire scar distribution” graph, which indicates the number of fire scars that occurred in different months in the past. The months are allocated into three seasonal groups: wet season (Dec, Jan, Feb and Mar), warm season (Aug, Sep, Oct and Nov) and cool season (Apr, May, Jun and Jul). This group allocation relates fires in different seasons that bring varying impacts, for example: burning during the cool season may restrict damage to woody plants and help reduce greenhouse gas emissions; while fires in the warm season are generally more effective and are often used to control woody plants.

The second graph is the “Percentage fire scar area” graph, which indicates the cumulative percentage fire scar area out of the total property area within an individual year.

The third graph, “Modelled time series of curing index” indicates the historical time series of curing index and fuel load for the property of interest. The curing index is defined as “the percentage of dead pasture out of the total modelled pasture biomass”. The coloured lines indicate the time period when the pasture condition was estimated at a “low”, “medium” and “high” level for fire to occur (see the legend in Figure 26):

- Curing index <30% or curing index >=30% but fuel load <500kg/ha (i.e. low curing or low biomass conditions)
- 30%<= Curing index <60% and fuel load >500kg/ha (i.e. moderate curing and moderate or higher biomass conditions)
- Curing index >=60% and fuel load >500kg/ha (i.e. high curing and moderate or higher biomass conditions)

FORAGE REPORT: FIRE SCAR

http://www.longpaddock.qld.gov.au/forage *18/10/2022* *Lot on Plan: 11WG840323,1SP151931,3SP151931* *Label: new*

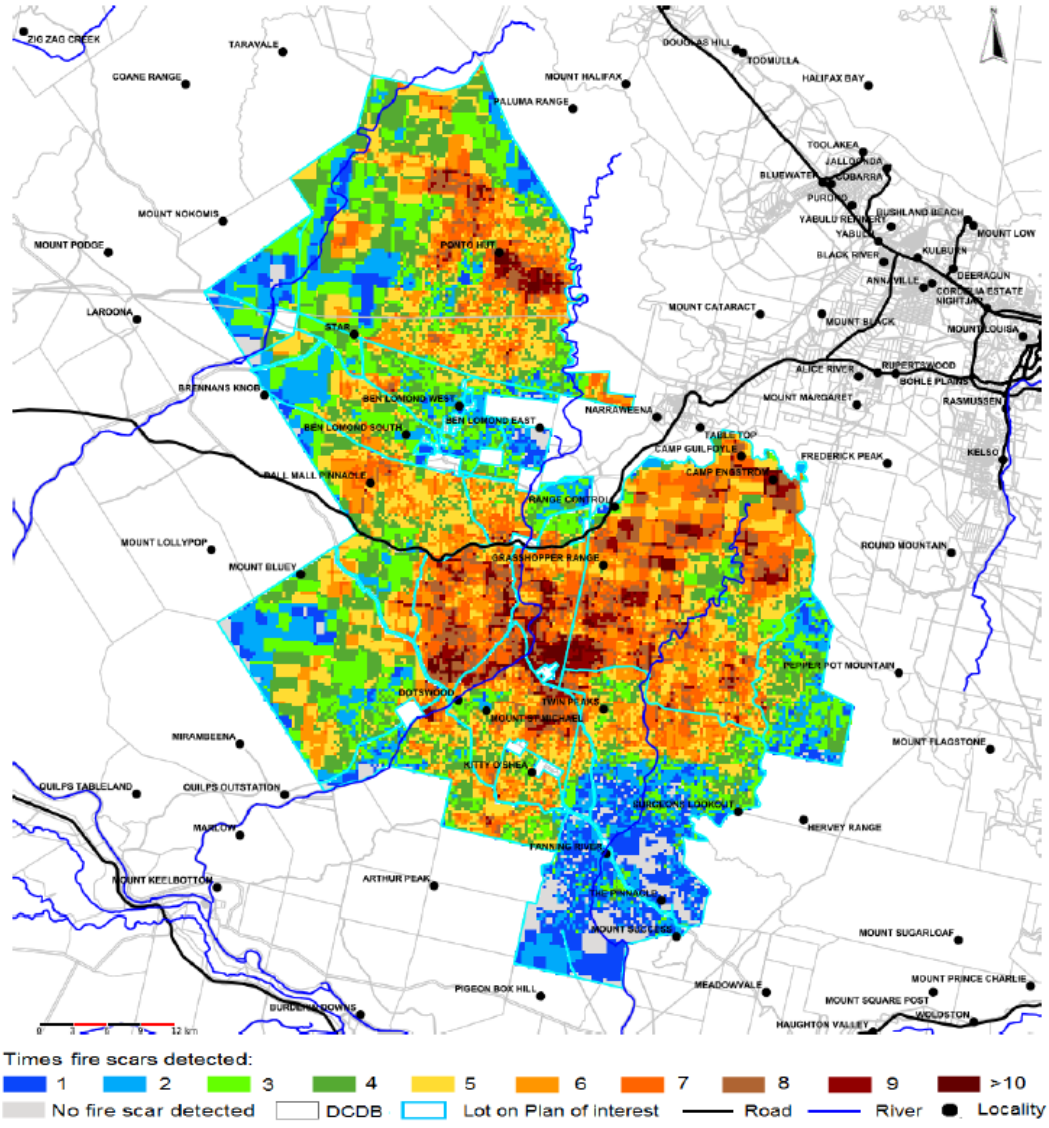
Queensland Government

Introduction

This report presents a range of maps and graphs describing fire scars detected for a Lot(s) on Plan of interest. The maps include: 1) a "Cumulative fire scar" map; 2) a "Years since burnt" map; and 3) a "Fire scars detected in each month of current year" map. Fire scars may be undetected by satellites due to: 1) spatial or temporal limitation; 2) "cool fires" under trees that don't affect tree leaves; and 3) cloud cover. "False fire scars" are also possible where land becomes dark due to cloud shadows or inundation of water. Therefore, all of the above factors need to be taken into consideration when interpreting the information presented in this report.

Location map

Cumulative fire scar map (1992 - current)



Summary of cumulative fire scar map

This map is for the period from 1992 to current, showing how many times fire scars were detected for an area during the period. The orange, red and brown colours indicate higher fire frequency. The available satellite data indicated that since 1992 there are 131 fire scars detected on the Lot on Plan of interest. The most recent fire scars were detected in Oct 2021, Nov 2021, Dec 2021, Jan 2022, Feb 2022, Mar 2022, Apr 2022, Jun 2022, Jul 2022, Aug 2022.

Figure 23. An example of the Fire Scar report - page 1.

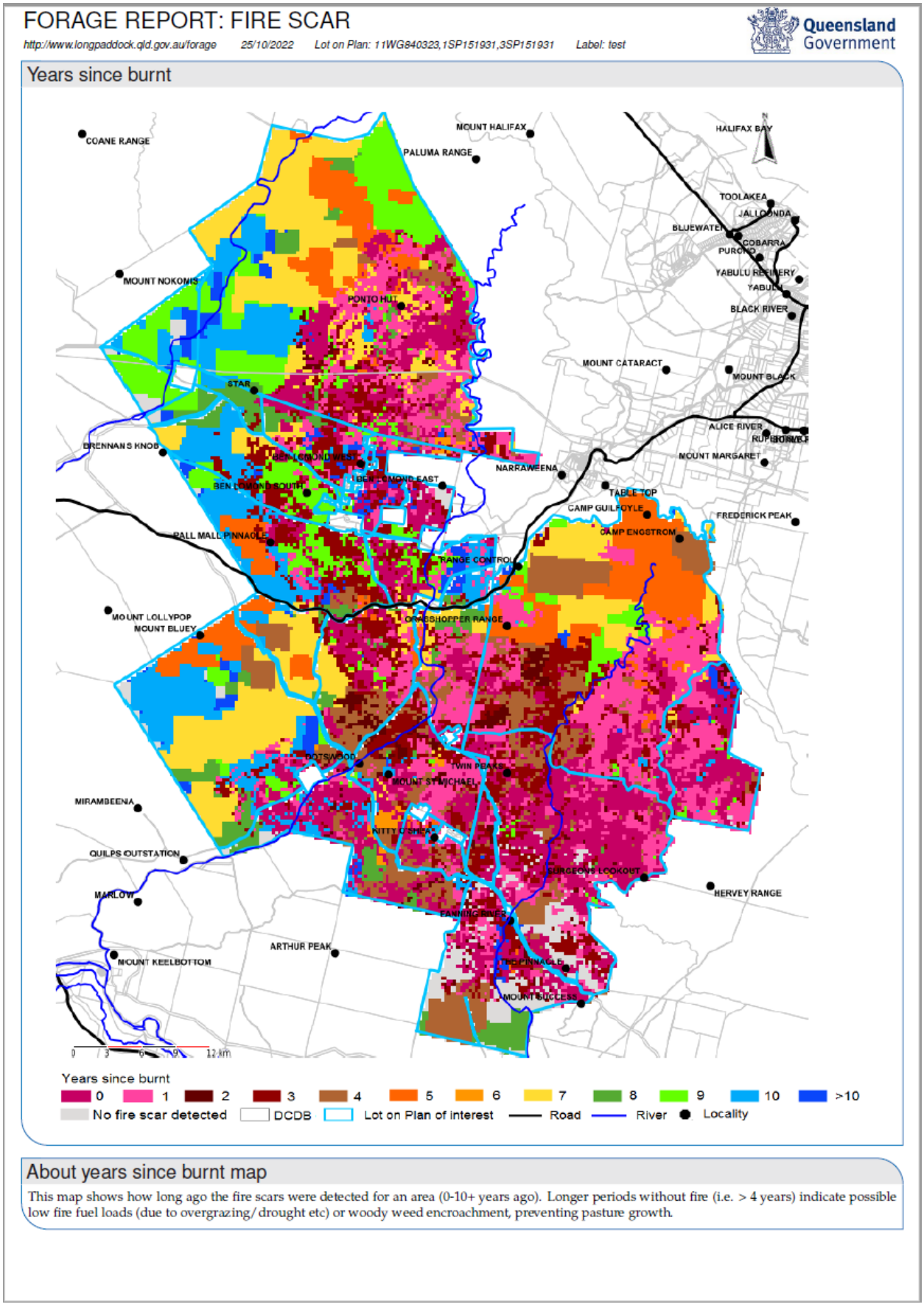


Figure 24. An example of the Fire Scar report – page 2.

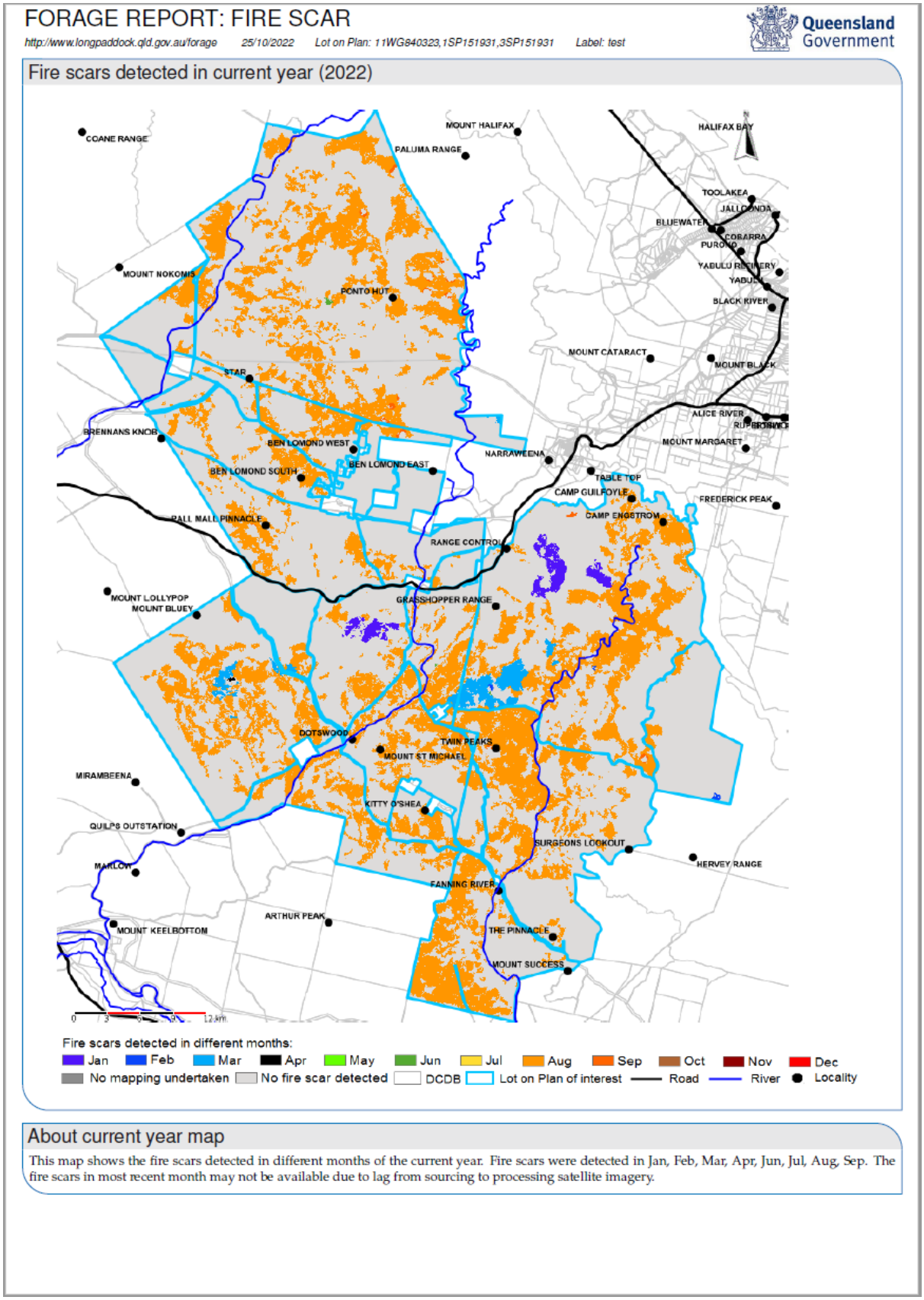


Figure 25. An example of the Fire Scar report – page 3.

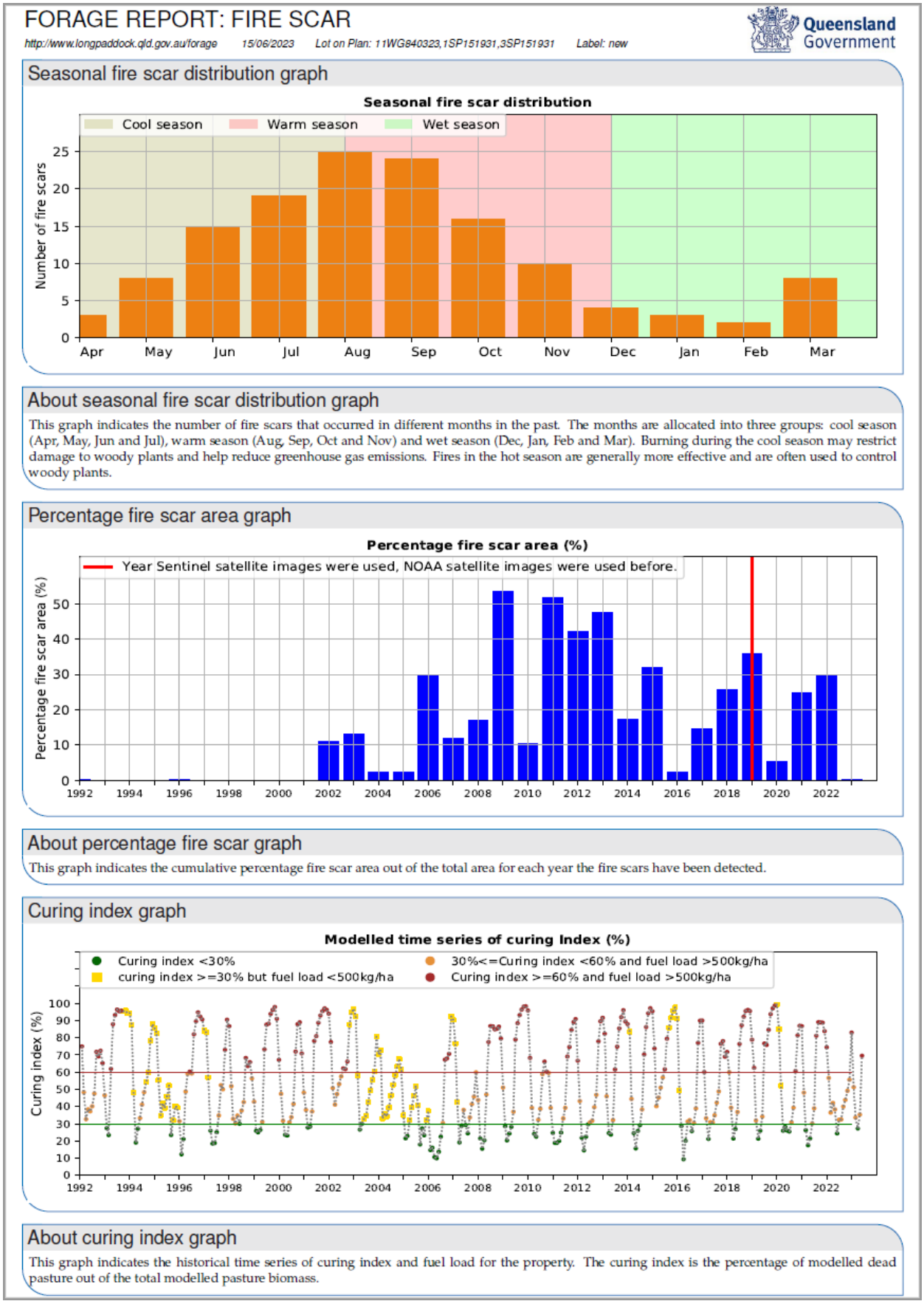


Figure 26. An example of the Fire Scar report - page 4.

The “Time series of curing index” together with the “Percentage fire scar area graph” can be used by land managers to compare conditions that were present with fires (i.e. existent/non- existent). The curing index and fuel load data were sourced from the AussieGRASS model outputs (https://www.longpaddock.qld.gov.au/aussiegrass/about/).

Uses for the Fire scar report

Fire scar information (spatially and temporally) can be used in land management for:

- assessing adequacy of fire frequency for woody plant maintenance
- monitoring of carbon farming activities
- checking reduced fire frequency as an indicator of inadequate fuel load (e.g. signs of overgrazing)
- bushfire risk – monitoring fuel load build-up in woody areas
- general knowledge of past fire regime
- possible cause of low ground cover identified in imagery
- pasture species management and maintenance.

Caveats for the Fire scar report

It should be noted that some fire scars may still be undetected by satellites due to:

- spatial or temporal limitation;
- "cool fires" under trees that don’t affect tree leaves; and
- cloud cover.

"False fire scars" are also possible where land becomes dark due to cloud shadows or inundation of water. Therefore, all of the above factors need to be taken into consideration when interpreting the information presented in the Fire Scar reports.

4.10 FORAGE Report: Pasture Growth Alert

The *FORAGE Pasture Growth Alert report* (Figure 27-30) is a four-page report providing reduced pasture growth and pasture resilience risk for the selected Lot(s) on Plan located in Queensland. The report presents the likely future pasture growth and the risk to pasture resilience through an assessment of the last 12 months pasture growth, the most recent monthly total cover and the next 6 months pasture growth forecast for the property of interest. The information presented in this report can be used to inform stocking management decisions to enable early action and to help reduce the impact of drought and to identify pasture recovery opportunities.

The information presented in a Pasture Growth Alert report includes:

- Background information for **current and historical property context**
- A **pasture growth and resilience indicator** showing the risk level of reduced pasture production and property resilience for the next 6 months.
- **Modelled pasture growth graph** for the last 12 months
- **Modelled pasture growth graph** for the next 6 months**.**
- A most recent **monthly percentile cover map** showing how the property compares with the historical cover record for the same month.
- **12-month regional rainfall and modelled pasture growth percentile maps** (i.e. relative to history) to provide spatial context of the property to the local and surrounding shires.
- Suggested **management considerations** to support each different **level of risk**.

Pasture growth data were calculated from the GRASP pasture growth simulation model. The pasture growth forecast is simulated by the GRASP model through incorporating the rainfall seasonal forecast and taking into account the current soil and pasture conditions (e.g. soil water status, soil nitrogen availability and ground cover). The rainfall forecasts are developed from the ENSO forecasts provided by the International Research Institute for Climate and Society (IRI), Columbia University, New York (Barnston *et. al.* 2004), https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/.
Note: other forecast systems may be implemented in the future.

Report pages in detail
Page 1 (see Figure 27)
The **Introduction** provides the aims and overall summary of the report, while the **Background information** section displays a summary of current and historical property statistics for context, including:

- Property location (a thumbnail map)
- Total property land area
- Median total cover percentile
- Mean Foliage Projected Cover (%FPC)
- Last 6-months rainfall and pasture growth
- Last 12-months rainfall and pasture growth
- Long-term annual rainfall and pasture growth (i.e. 1890-current year)

A Pasture Growth and Resilience Indicator uses a 'fire hazard warning' sign to provide the level of reduced pasture production and pasture resilience risk for the property of interest for the next 6 months. There are 6 levels of possible risk, as shown by the indicator (very low – very high risk) on page 1. The risk position is based on three key factors which are listed in a summary with details of the risk status and three statements that are used to reach the current position, along with additional three statements that contribute to overall state of knowledge.

FORAGE REPORT: PASTURE GROWTH ALERT

http://www.longpaddock.qld.gov.au/forage *August 27, 2019* *Lot on Plan: 1OC57,4SP233424,3RP841848,4835CP858256* *Label: spyglass*

Queensland Government

Introduction

This report presents, for the selected Lot(s) on Plan, the risk of reduced pasture growth and pasture resilience for the next 6 months. The purpose of the report is to provide an assessment on pasture growth and resilience through assessing information of the last 12 months pasture growth, the pasture growth forecast for the next 6 months and the most recent monthly total cover. Pasture growth forecasts are produced using the GRASP pasture growth model in combination with the rainfall forecasts and the current pasture conditions with regard to soil moisture, nutrients and ground cover. The rainfall forecasts are developed from the El Niño - Southern Oscillation (ENSO) forecasts provided by the International Research Institute for Climate and Society (IRI), Columbia University, New York (Barnston, *et al.* 2004). The information presented in this report can be used to facilitate stocking management.

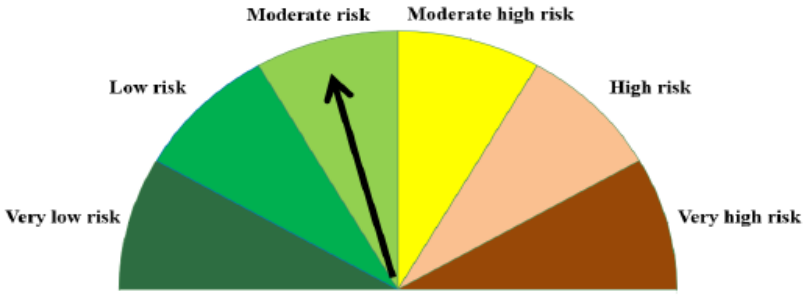
Background information

Total land area: 35336 ha
Median total cover percentile: 80th
Last 6-month pasture growth: 1350 kg/ha
Last 12-month pasture growth: 1790 kg/ha
Long-term* annual pasture growth: 1540 kg/ha
*1890-2019

Mean foliage projective cover (FPC): 14.9%
Current month to date rainfall: 2 mm
Last 6-month rainfall: 648 mm
Last 12-month rainfall: 986 mm
Long-term* annual mean rainfall: 620 mm

Location map

Pasture growth and resilience risk for the next 6 months (Aug 2019 to Jan 2020)



Summary for the selected area (Lot(s) on Plan)

The reduced pasture growth and resilience risk level for the Lot(s) on Plan of interest in the next 6 months is **moderate**. This is based on the rainfall and pasture growth in the last 12 months, the rainfall and pasture growth forecast for the next 6 months and the last month total cover percentile level.

The key factors are as follows:

- Pasture growth in the last 12 months was **between the 33rd and 66th percentile** of the long-term record for the same period.
- The pasture growth forecast for the next six months is **between the 33rd and 66th percentile** of the long-term record for the same period.
- The median total cover for Jul 2019 across the Lot(s) on Plan is **higher than the 66th percentile** of the long-term (1990 to current) record for the same month.

Other relevant factors are:

- Rainfall in the last 12 months was **higher than the 66th percentile** of the long-term record for the same period.
- The rainfall forecast for the next six months is **between the 33rd and 66th percentile** of the long-term record for the same period.
- The forecast of ENSO probability for the next three months (starting from current month) are: **El Niño** 30% (likely dry), **Neutral** 68%, **La Niña** 2% (likely wet).

*For information about percentiles, see: https://longpaddock.qld.gov.au/forage/videos/understanding-percentiles-in-climate-data

Management considerations due to the above conditions

Monitor stocking numbers and adjust to ensure end of season dry reserve and adequate ground cover is conserved. Keep monitoring seasonal outlooks for adverse forecasts. Assess areas potentially vulnerable to loss of ground cover prior to next summer season rain and carefully allocate livestock accordingly.

Reference

Barnston, A. G. *et al.* (2003), Multimodel ensembling in seasonal climate forecasting at IRI, Bull. Am. Meteorol. Soc., 84, 1783-1796.

Disclaimer

Figure 27. An example of the *Pasture Growth Alert* report – page 1.

The key factors are as follows:

- Pasture growth in the last 12 months relative to the long-term record of the same period;
- The forecasted pasture growth for the next six months relative to the long-term record of the same period; and
- The most recent monthly total cover across the Lot on Plan relative to the long-term (1990 to current) record of the same month.

Three additional relevant factors are:

- Rainfall in the last 12 months relative to the long-term record of the same period.
- The rainfall forecast for the next six months relative to the long-term record of the same period.
- The forecast of ENSO probability for the next three months (starting from current month): **El Niño** (% likely dry), **Neutral (**% uncertain outcome), **La Niña** (% likely wet).

An example of the summary for the pasture growth and resilience risk for the next 6 months is as follows:

> "The reduced pasture growth and resilience risk level for the Lot on Plan of interest in the next 6 months is **moderate**. This is based on the historical rainfall and pasture growth in the last 12 months, the rainfall and pasture growth forecast for the next 6 months and the current total cover percentile level".

The key factors leading to the example of "low" risk in Figure 27 are as follows:

- Pasture growth in the last 12 months was **between 33rd and 66th** of the long-term record for the same period.
- The pasture growth forecast for the next six months is **between the 33rd and 66th percentile** of the long-term record for the same period.
- The median of the most recent monthly total cover across the Lot on Plan is **higher than the 66th percentile** of the long-term record for the same period.

Other relevant factors contributing to the outcome of "low" risk in Figure 27 are:

- Rainfall in the last 12 months was **higher than 66th percentile** (i.e. top third of all years) of the long-term record for the same period.
- The rainfall forecast for the next six months is **betwen the 33rd and 66th percentile (i.e. the bottom and middle third** of all years**)** of the long-term record for the same period.
- The forecast of ENSO probability for the next three months (starting from current month) are: **El Niño** 30% (likely dry), **Neutral** 68% (uncertain outcome), **La Niña** 2% (likely wet).

A decision tree model is used to determine the pasture growth and resilience risk level. Terciles (definition below) are used to direct a decision from the 3-branch decision tree splitting into terciles at each level using the three key factors (i.e. the last 12 months pasture growth, the pasture growth forecast for the next six months and the median of the most recent monthly total cover), which results in 27 possible outcome states – these are directed to the six levels of risk shown on the page 1 (see Pasture Growth and Resilience indicator).

Tercile explanation: A set of data arranged in order with values that partition the data into three groups, each containing one-third of the total data. To define these terciles, the historical data (for example, historical annual rainfall data) is arranged in order from lowest to highest and then the data is partitioned into three equal groups. The lowest third of the data values are defined as the lowest tercile (0 - 33rd percentile), the middle third of the values are the middle tercile (33rd- 66th percentile), and the upper third of the values are known as the upper tercile (33rd - 66th percentile).

For further information about percentiles, see: https://longpaddock.qld.gov.au/forage/videos/understanding-percentiles-in-climate-data

The **level of risk** shown in the indicator is estimated by using:

- The interpolated property rainfall and modelled pasture growth for the past 12 months.
- the forecasted property rainfall and modelled pasture growth for the next 6 months.
- the forecast of ENSO probability for the next three months.
- the most recent monthly cover for the property compared with the historical record of the same month.

Suggested **Management considerations** support each different **level of risk**. These consideration options are guides only and more detailed advice may be required to achieve best management practice. There are 12 management consideration messages that coincide with the 6 risk levels and time of season (summer vs winter). These are to give broad considerations for the user to reflect on – to consider in context with the local situation.

Page 2: (see Figure 28)

Accumulated pasture growth graphs, providing detailed information, to assist in explaining how the **level of risk** estimation (page 1) has been reached.

The first graph in Figure 28 shows **Pasture growth history** for the property including:

- The long term average pasture growth, accumulated for 12 months (shaded area).
- Past 12 months accumulated pasture growth (black line).

In this graph, the shaded area is the long-term average for 12-month accumulative pasture growth, which is the middle third of the historical record (between 33rd to 66th percentile). The black line is the accumulated pasture growth for the last 12 months.

The second graph in Figure 28 is the **Pasture growth forecast**, it features:

- a moving 12-month time series, but with the long term average pasture growth accumulated for 6 months (shaded area) onwards from the month of report request.
- circles (o o) indicating the accumulated forecasted pasture growth for the next 6 months (with solid/hollow showing significance difference).
- bars to relate the range of variation.
- current month pasture growth to date (green bar).

In the pasture growth forecast graph, the shaded area is the long-term average for the 6-month accumulative pasture growth (which again is the middle third of the historical record – between 33rd to 66th percentile), corresponding to the 6 months being forecast. The vertical green line at the current month indicates the growth to date from the beginning of the current month (it will only be present if growth has occurred in current month). The circles (solid or hollow) are the monthly forecasts of accumulated pasture growth for the next six months (starting from current month) with error bars representing one standard deviation.

Statistical test (i.e. t-test) results between the forecasted cumulative mean and the long-term cumulative mean for the forecasted months are indicated by the solid or hollow dots. If the t-test is significant (solid dot shown) for a month, the forecast for that month is significantly different (higher or lower) from the cumulative long-term mean of the month; otherwise (hollow dot), the forecast for that month mainly reflects "climatology" occurring and is not statistically significantly different from average conditions. In the absence of forecast skill, following the long term climatology is a good strategy.

The historical pasture growth and the pasture growth forecast is simulated by the GRASP model. The rainfall seasonal forecast is calculated based on ENSO probabilities forecast sourced from International Research Institute for Climate and Society (IRI) with the forecast made by more than 20 dynamical and statistical models for SST in the Nino 3.4 region (http://iri.columbia.edu/our-expertise/climate/). The forecasts provide the probability for El Niño, Neutral and La Niña conditions for the next six months. The skill generally decreases

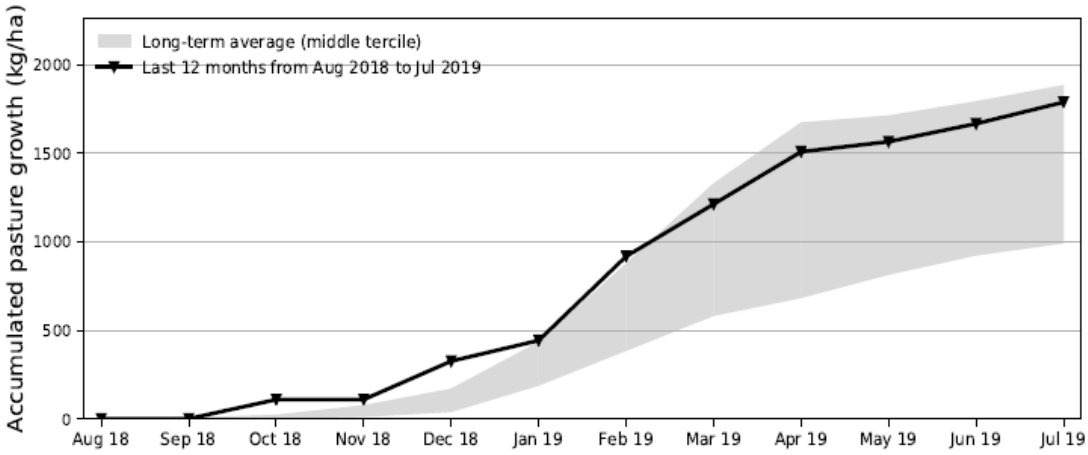
as the lead time increases. Forecasts made between June and December can be used with more confidence, while ENSO forecasts made between February and May have less skill.
The IRI forecast is currently used for its capacity to represent the ENSO signal. Other forecasts will be added in future updates for the report to provide the user with a choice of pasture growth outlooks.

FORAGE REPORT: PASTURE GROWTH ALERT

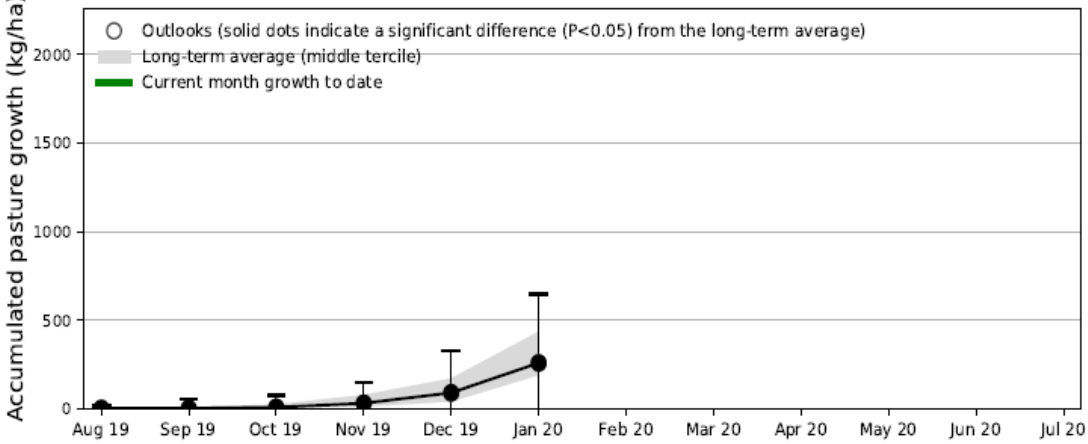
http://www.longpaddock.qld.gov.au/forage August 27, 2019 Lot on Plan: 1OC57,4SP233424,3RP841848,4835CP858256 Label: spyglass

Queensland Government

Pasture growth history - accumulative



Pasture growth forecast - accumulative (based on current conditions + IRI forecast)



How to interpret the above graphs

In the top graph, the shaded area is the long-term average for 12-month accumulative pasture growth, which is the middle third of the historical record (between the 33rd percentile and 66th percentile, i.e. middle tercile). The black line is the accumulated pasture growth over the last 12 months.

In the bottom graph, the shaded area is the long-term average for 6-month accumulative pasture growth corresponding to the 6 months forecast. The vertical green line at the current month indicates the growth to date from the beginning of the current month. The dots are the forecasts of accumulated pasture growth for the next six months (starting from current month) with error bars representing ± one standard deviation. The t test results between the forecasted cumulative mean and the long-term cumulative mean for the forecasted months are indicated by the solid or open dots. If the t test is significant (solid dot) for a month, the forecast for that month is significantly different (higher or lower) from the cumulative long-term mean of the month; otherwise (i.e. open dot), the forecast is not significantly different from average conditions.

The historical pasture growth is simulated by the GRASP model. The pasture growth forecast is also simulated by the GRASP model through incorporating the rainfall seasonal forecast and taking into account of current soil and pasture conditions (e.g. soil water status, soil nitrogen availability and ground cover). The rainfall seasonal forecast is calculated based on ENSO probabilities forecast, sourced from International Research Institute for Climate and Society (IRI) with the forecast made by more than 20 dynamical and statistical models for SST in the Nino 3.4 region (http://iri.columbia.edu/our-expertise/climate/). The forecasts provide the likely probability for El Niño, Neutral and La Niña conditions for the next six months. The skill generally decreases as the lead time increases. Forecasts made between June and December can be used with more confidence while ENSO forecasts made between February and May have less skill.

About the rainfall

Rainfall data used in this report were sourced from SILO database (https://www.longpaddock.qld.gov.au/silo) which were interpolated from the rainfall records provided by the Bureau of Meteorology (BoM). The accuracy of the rainfall data (and therefore the simulation of pasture growth) depends on how close BoM's rainfall stations are to the centre of the Lot(s) on Plan of interest. Last month, there were 0, 1 and 6 stations (reporting quality controlled data) located within approximately 25 km, 25-50 km and 50-75 km of the centre of the selected Lot(s) on Plan.

Figure 28. An example of the *Pasture Growth Alert* report – page 2.

Page 3: (see Figure 29)

A map of the most recent monthly percentile cover for the property shows how the property compares with the historical record of the same month. The map can identify areas that may need remediation (e.g. changing stocking density), fencing, or additional watering points to disperse grazing pressure.

The map in Figure 29 was generated from Landsat and Sentinel 3 images which compares, at the per-pixel level (30m), the level of total cover (trees, grass and litter) for the month indicated against the long term (from 1990) total cover for the same month. For each pixel all cover values over the entire time-series of monthly images are classified into percentile (from lowest 1 to highest 100). The cover value for the pixel in the month indicated is then classified according to the percentile in which it falls. The map helps to identify areas of low or high total cover, relative to history (i.e. since 1990) for the month indicated. At times satellite failure or persistent cloud cover may compromise data availability. The median total cover percentile value for the property of interest is provided in the **Map title bar** and in the **Background information** section on page 1 of the report.

Any areas with yellow, orange or red colour on the map indicate that the total cover for these areas are ranked at the bottom of all the same months in history. Percentile variability in cover can be caused by run-on and run-off areas, response to soil type (e.g. sand vs clay), local rainfall variability, grazing effect, response to rainfall (e.g. tree, weed and annual grass *spp.*,), tree grass competition, cropping and tree clearing.

About the rainfall

The rainfall data used in this report were sourced from the SILO database (https://www.longpaddock.qld.gov.au) which were interpolated from the rainfall records provided by the Bureau of Meteorology (BoM). The accuracy of the rainfall data (and therefore the simulation of pasture growth) depends on how close BoM's rainfall stations are to the centre of the Lot(s) on Plan of interest. For the example used in this guide, there were 0, 0 and 3 stations last month (reporting quality controlled data) that were located within approximately 25 km, 25-50 km and 50-75 km (respectively) of the centre of the selected Lot(s) on Plan.

Page 4: (see Figure 30)

Regional rainfall and modelled pasture growth maps (12-month relative to history) provide context of the immediate property setting with the local and surrounding shires. This information may be useful to gain perspective, for buying or selling livestock and property sales/purchases or to source agistment.

The maps below in Figures 28 show, for the Lot on Plan of interest (indicated by the cross and red circle), the percentile of total rainfall (or pasture growth) for the last 12-month period compared to the total rainfall (or pasture growth) for the same periods in history. For example, If the total rainfall (or pasture growth) for the period indicated is lower than 30th percentile, then the total rainfall for this period is within the lowest 30% of years in history (1890 for rainfall; 1957 for pasture growth to current). The map data are sourced from AussieGRASS.

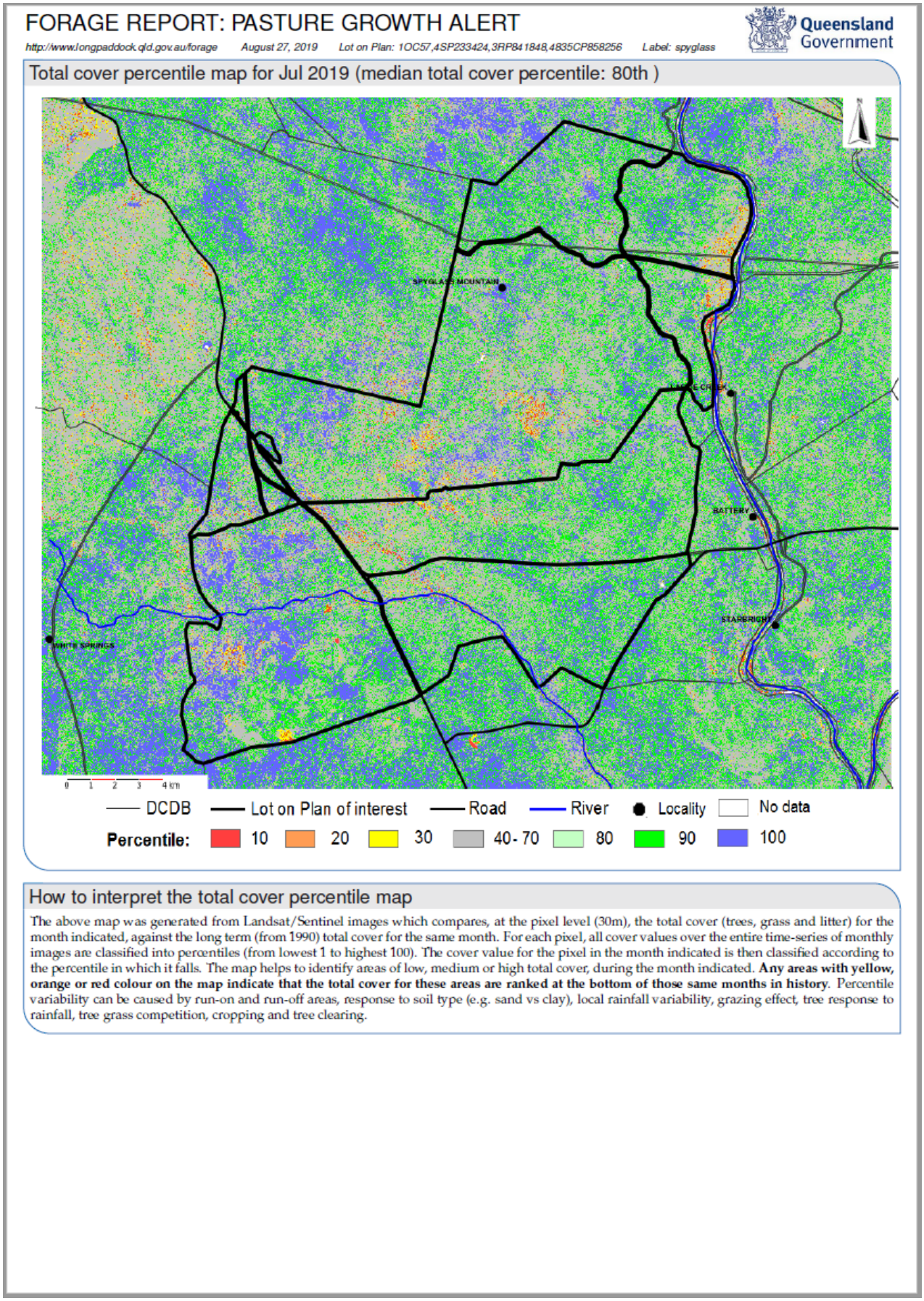


Figure 29. An example of the *Pasture Growth Alert* report – page 3.

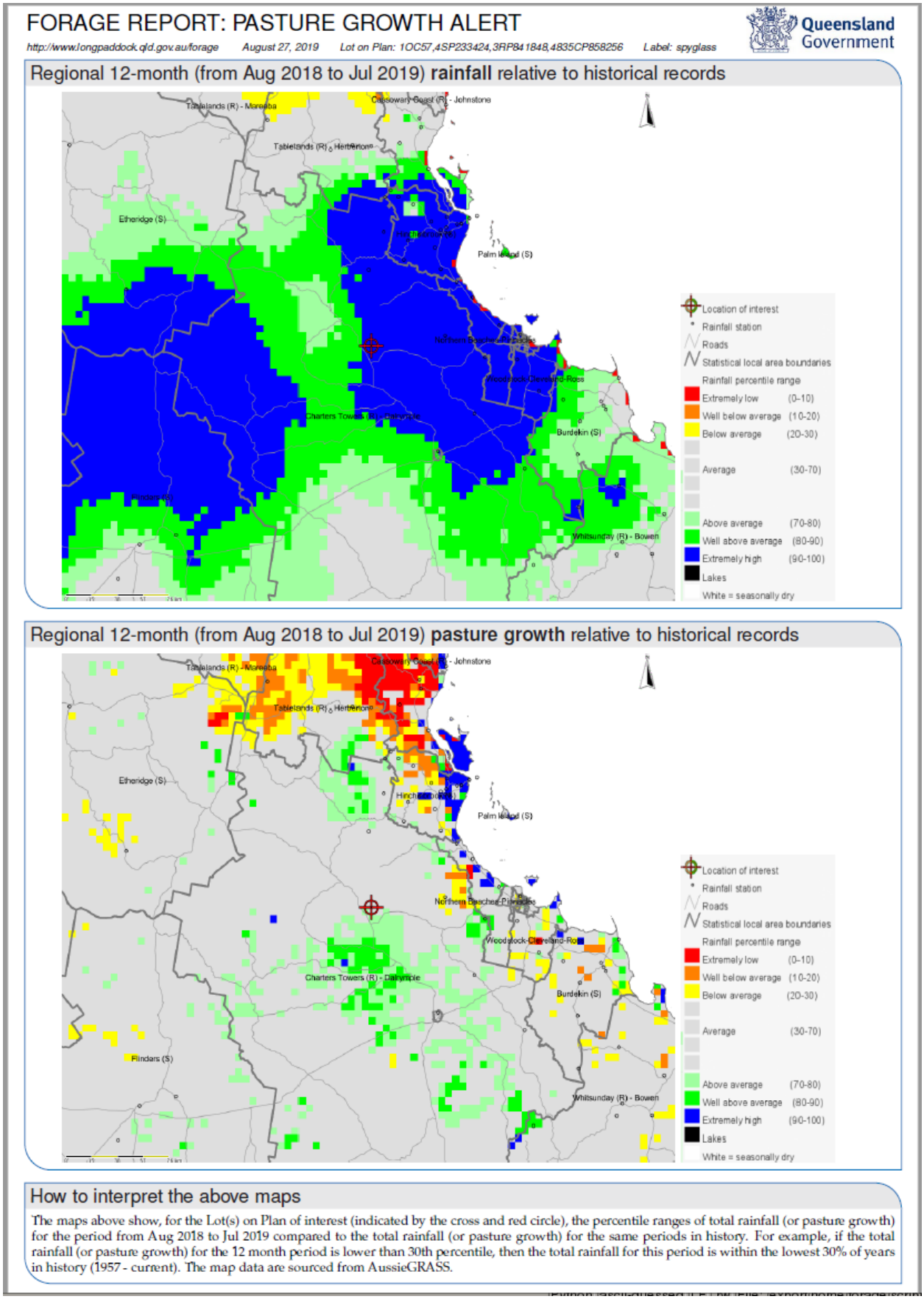


Figure 30. An example of the *Pasture Growth Alert* report - page 4.

Uses for the Pasture Growth Alert report

The Pasture Growth Alert report provides a risk assessment of reduced pasture growth and pasture resilience risk for a property for the next six months – a unique combination of analyses that incorporate the past 12 months rainfall and pasture growth, the rainfall and pasture growth forecast for the next six months and the most recent monthly percentile cover, averaged for the property of interest. There are also 12-month percentile rainfall and pasture growth regional maps supplied.

Extension providers, consultants and land managers can use the Pasture Growth Alert report to analyse a situation to add to their on-ground property knowledge, when making decisions on stocking rates or infrastructure investment. For example, the report can be used to quickly sum up the current and upcoming 6-months using the risk indicator on the front page of the report. It is then possible to use the report summary and to see in further detail how the past 12 months pasture growth, forecast six months pasture growth and monthly cover percentile for the property compares with history. If these are in the middle or upper tercile, then there is a degree of positive outlook (n.b. management suggestions should always reflect conservative actions).

If the summary and time series indicate that pasture growth and cover percentile values are in the middle or lower tercile areas, then there is a need for concern; and revealed in the risk indicator on the front page of the report. The 12-month rainfall and pasture growth percentile maps (page 4) should confirm the local and adjoining shire areas. Decisions to adjust domestic stock numbers should coincide with the management suggestions offered on page 1 of the report.

Note: All modelling analyses should verified and ground-truthed before making land management decisions. Caveats as described below should be read carefully to understand and avoid misinterpretation and potential inappropriate decisions.

Caveats for the Pasture Growth Alert report

It should be noted that rainfall data and maps are constructed using SILO datasets (https://www.longpaddock.qld.gov.au) (Jeffrey *et al.* 2001) from point location observational records provided by the Bureau of Meteorology (BoM). SILO interpolates the raw data to derive datasets which are both spatially and temporally complete. However, the low density of observing stations in some regions and changes in the observation network over time may, at times, lead to lower quality mapping. Significant rainfall events at times may 'slip' through the BoM gauging network and not be detected, especially in those regions where storm rainfall is common and official rain gauges are sparse.

Pasture growth data and maps are constructed using the GRASP and AussieGRASS models (https://www.longpaddock.qld.gov.au/aussiegrass/about/). AussieGRASS (Carter *et al.* 2000), is an advanced spatial water balance and plant growth model, producing output on a daily time-step across Australia that should be accurate at regional scales.

The accuracy of the rainfall data (and therefore the simulation of pasture growth) depends on how close BoM's rainfall stations are to the centre of the Lot(s) on Plan of interest. See the **About the rainfall section** above for the example used, describing the stations reporting quality controlled data for last month that were located within approximately 25 km, 25-50 km and 50-75 km (respectively) of the centre of the selected Lot(s) on Plan.

The accuracy of climate data used to drive the pasture models may limit accuracy of the pasture growth results in some circumstances. Absolute values should be interpreted in relative terms (i.e. degree of change

in values rather than actual values) to avoid model scaling and averaging. As the maps are relative (0-100 percentile scale), the influence of these systematic errors are therefore minimised.

4.11 FORAGE Report: Carrying Capacity (prototype)

Introduction

The *FORAGE Long-Term Carrying Capacity (LTCC) report* (Figure 31-37) is a multi-page report together with two accessory spreadsheets, to provide the estimated long-term "safe" carrying capacity for the selected Lot(s) on Plan located in Queensland. The LTCC estimates provided in the report are intended as a guide for long-term grazing capacity assessment. Management of property grazing pressure is still required on a season-to-season basis (i.e. forage budgeting).

The LTCC of a property or paddock in this context, is the number of stock that can be carried over a long period of time through good and poor seasons, including extended periods of drought, with no decline in land condition. For this reason, the period of time considered must be a number of decades that include at least 2-4 wet and dry cycles (https://www.longpaddock.qld.gov.au/rainfall-poster/). LTCC is not to be confused with the seasonal or annual stocking rate, which is a short-term measure that is used with seasonal carrying capacity or annual forage budgeting. In this report, the LTCC is measured as the total adult equivalents (AEs; 450 kg cattle consuming 8kg DM/day) that can be safely carried for a paddock or property (also shown as hectares required per AE unit).

LTCC calculations take into account the property's climate, land types, tree cover and infrastructure, such as watering points (if provided as a shapefile). Land condition, a measure of how well the grazing system is functioning, also has an impact on LTCC. As land condition declines, so too does production, drought resilience, carrying capacity, potential earnings and property resale value.

The FORAGE LTCC report also provides an "objective estimate of the number of livestock" for a property in good condition around which seasonal stocking rates can be adjusted. This information can be used as a starting point for grazing land management discussions and can be enhanced with additional user input.

Note: The LTCC estimates from the prototype version accessed from the Long Paddock website is for a full property and/or Lot(s) on Plan, which assumes a "native pastures" base, along with fully rundown (i.e. soil fertility) pastures following clearing. The property/area selected is considered fully watered. A dynamic property mapping tool (MyFORAGE Map) is under development, so that the user can include information (such as buffel pastures and distance to water) that is more specific at the property location.

Many years of grazing lands research including field data collection from many sites across Queensland; remotely-sensed data (e.g. ground cover and tree density); and learning from successful graziers has improved our understanding of grazing land management in Queensland. The calculation of the LTCC for a property (land parcel or paddock) is based on a number of factors, including:

- the long-term median annual native pasture growth – native pasture growth is calculated from the GRASP model using parameters for the Grazing Land Management (GLM) land types (Figure 32), the tree density on the property measured as FPC (Figure 33) and the historical climate data for the property of interest (sourced from the SILO climate database - https://www.longpaddock.qld.gov.au/silo/).

- the safe utilisation rate of the pastures – utilisation of pasture growth by livestock is set at a rate that is not likely to cause long-term property degradation and to allow recovery after drought. For some “Mulga” GLM land types, livestock consumption of "topfeed" (i.e. feeding mulga leaves) is considered in the calculation of the LTCC.

- the property topography – where a digital elevation model (i.e. for steepness) is used to discount grazing access.

Note: Introduced pasture species such as buffel grass and stylos along with pasture irrigation, flooding and fertiliser application are not considered in the pasture growth calculation.

What information is provided in the **LTCC** report?
On requesting a LTCC report you will receive 3 files by email. The files are:

- a “Long-Term Carrying Capacity” report (PDF) which will be shown in detail below;

- an Excel spreadsheet (Figure 34) showing the LTCC for all Lot(s) Plan/ paddocks. The spreadsheet can be used to calculate LTCC for Lot(s) Plan/ paddocks under different land conditions; and

- an Excel spreadsheet (Figure 35) showing LTCC and pasture growth on a paddock and land type basis.

Uses for the LTCC report

Estimates of “carrying capacities” for grazing properties have been used for many years by property owners, extension providers, agents, valuers and banks for estimating the number animals that can be run on an area of land. LTCC estimates are critical for long-term planning and property investment by helping to understand what a property can carry over a long period of time without damaging the natural resource base.

The FORAGE LTCC report provides an “objective estimate of the number of livestock” for a property in good condition around which seasonal stocking rates can be adjusted. This information can be used as a starting point for grazing land management discussions and can be enhanced with additional user input.

Note: All modelling analyses should be verified and ground-truthed before making land management decisions. Caveats as described (below) should be read carefully to understand and avoid misinterpretation and potential inappropriate decisions.

The LTCC PDF report pages

Page 1. (Figure 31)

On page one of the LTCC report (Figure 31) there is a location map and a “summary of estimated LTCC”. The summary provides both total stock AE and stocking density (Ha/AE) values for land condition classes (A-D). Upper and lower ranges are given for the total LTCC for “A” (good) land condition (ranges = ± 1 standard deviation of simulated mean). An estimation of the long-term average feral animal and kangaroo density for selected property or areas is also supplied as total AEs.

A map is also provided of the estimated LTCC (AE) for selected areas under “A” (good) land condition. An LTCC estimate is given for each separate area provided by the user. An information section located at the bottom of Page 1 relates “key” information about the LTCC report – in keeping with the explanation above.

FORAGE REPORT: LONG-TERM CARRYING CAPACITY (LTCC)

http://www.longpaddock.qld.gov.au/FORAGE October 23, 2020 Label: spyglass Latitude/Longitude: -19.42/145.73 prototype v1.0

Queensland Government

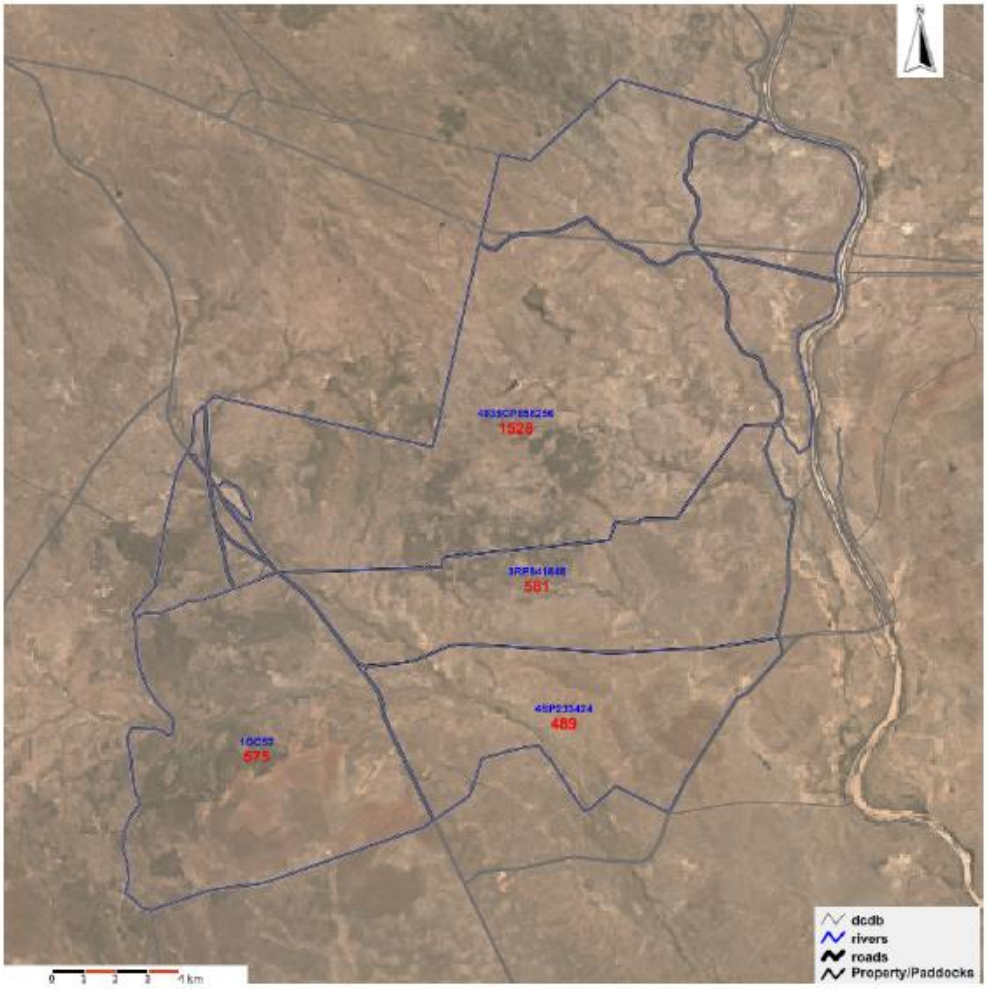
Summary of estimated LTCC (fully watered)

Land condition	LTCC (AE)	LTCC (Ha/AE)
A	3174 (2748 to 3600)	11.3 (9.8 to 12.9)
B	2381	15.1
C	1428	28.3
D	635	56.7

Estimated long-term average feral animal and kangaroo equivalents for selected property or areas: 297 AE

Location map

Estimated LTCC (AE) for selected areas under best ('A') land condition



About the report

This report presents the estimated **"long-term carrying capacity" (LTCC)** for the property of interest. LTCC in this report refers to "number of livestock that a paddock or property can support over a long period (decades) without causing land degradation".

In this report, the LTCC is measured as the total adult equivalents (AE - 450 kg dry cattle with about 150kg annual liveweight gain) that can be safely carried for a paddock or property and is also shown as hectares required per AE unit. The calculation of the LTCC is based on a number of factors, including: the long-term median annual pasture growth; the safe utilisation rate of the pastures; the distance to watering points; topography and tree density. Pasture growth is calculated from the GRASP model using parameters for grazing land management (GLM) land types, the tree density on the property and the historical climate data for the property of interest (sourced from the SILO climate database - https://www.longpaddock.qld.gov.au/silo/).

Pasture utilisation by livestock is set at a rate that is not likely to cause long-term property degradation and to allow recovery after drought. For Mulga land types, livestock consumption of "topfeed" (i.e. feeding mulga leaves) is considered in the calculation of the LTCC. However, introduced pasture species such as buffel grass and stylos along with pasture irrigation and fertiliser application are not considered in the pasture growth calculation. It is assumed that livestock have full water access adjacent to pastures. The annual feed intake for an AE is set as 2920 kg/year.

The purpose of the report is to provide an objectively estimated LTCC for the property which can be used as a starting point for discussion and to add input for further analysis (i.e. use spreadsheet supplied along with this report to improve the LTCC estimates). Values given for the LTCC are an indication only, significant management of property grazing pressure is still required on a season to season basis (i.e. forage budgeting).

Figure 31. An example of the LTCC report - Page 1.

Page 2. (Figure 32)

Page two of the LTCC report has three time series panels. Extension providers, consultants and land managers can use these time series to further support their on-ground property knowledge, when making decisions on stocking rates or infrastructure investment. For example, the first time series graph can be used to identify how stocking rates have related to the long-term sequence of modelled 'safe' stocking rates to ensure that land condition is not being compromised.

The **first** time series is a graph showing the modelled historical annual safe stocking rates (green line) and estimated LTCC (blue line) for the property. The safe stocking rate calculations are based on a number of factors including: the modelled LTCC; the safe utilisation rate defined for each land type; and a set of conservative rules to increase/decrease the stocking rate in response to changing climate.

The **second** time series shows the historical annual and summer season rainfall graph for the requested property derived from the SILO database (https://www.longpaddock.qld.gov.au/silo/). Total annual rainfall (April-March) is shown by the collective light and dark blue lines. Summer season rainfall (light blue line) is defined as rainfall during October to March. The long-term mean rainfall (green line) is for a period from 1975 to the current year.

The **third** time series shows the historical annual pasture growth (kg Dry Matter/ha) for April – March. Pasture growth is given as an area-weighted average across the property for each land type and foliage projective cover level (i.e. tree effect). The overall rainfall use efficiency for the property is also provided (kg Dry Matter/ha/mm rainfall).

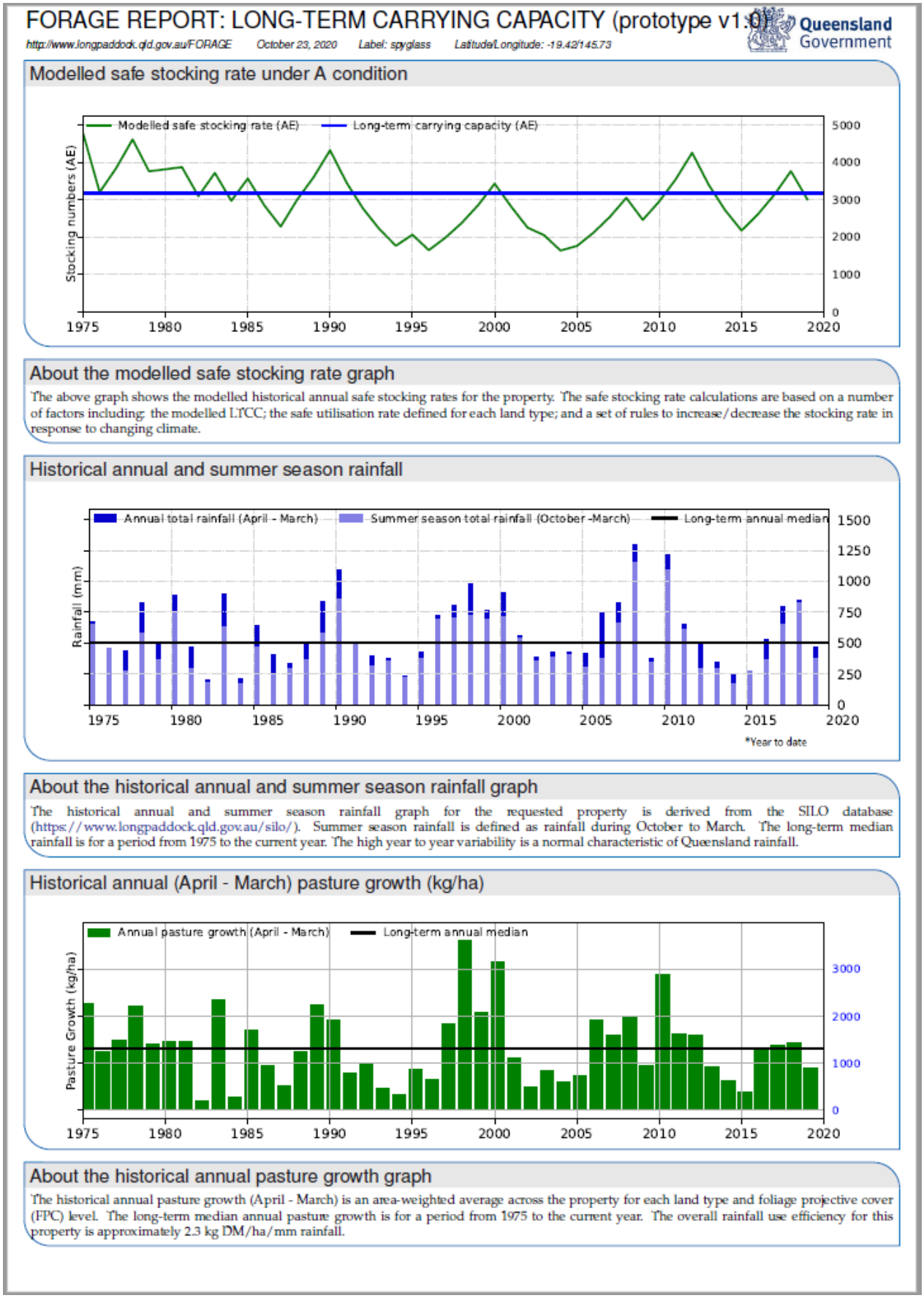


Figure 32. An example of the modelled stocking rate, historical rainfall and historical pasture growth timeseries graphs found on Page 2.

Page 3. (Figure 33)

Page three of the LTCC report is a LTCC summary table for paddocks/land parcels. The property is separated into paddock/lot plan names and areas for land condition states (A, B, C, D) with:

- total area (ha)
- area considered not to be grazed (ha)
- the LTCC as adult Equivalents (AE)
- the LTCC stocking densities (Ha/AE).

Long-term carrying capacity summary for paddocks/land parcels

Paddock name	Total area (ha)	Area considered not grazed (ha)	LTCC (AE) A	B	C	D	LTCC (Ha/AE) A	B	C	D
1OC57	6919.6	0.0	575	431	259	115	12.0	16.0	26.7	60.2
3RP841848	5650.1	0.0	581	436	262	116	9.7	13.0	21.6	48.6
4835CP858256	18144.4	0.0	1528	1146	688	306	11.9	15.8	26.4	59.4
4SP233424	4621.7	0.0	489	367	220	98	9.4	12.6	21.0	47.2
Total/mean	35336	0	3174	2381	1428	635	11.3	15.1	25.2	56.7

Figure 33. An example of the LTCC summary for paddocks/land parcels found on page 3.

Page 4. (Figure 34)

Page four of the LTCC report is a LTCC summary for GLM land types and land condition states (A, B, C, D). For more detailed information regarding land types, see FORAGE Indicative Land Type report. The table includes:

- the GLM land types within the property (name, code and area; Ha)
- the LTCC per the GLM land types, as adult Equivalents (AE)
- the LTCC densities for “A” land condition (Ha/AE) per the GLM land types
- the modelled annual “dry matter” pasture growth (kg/ha/year)

Page 5. (Figure 35)

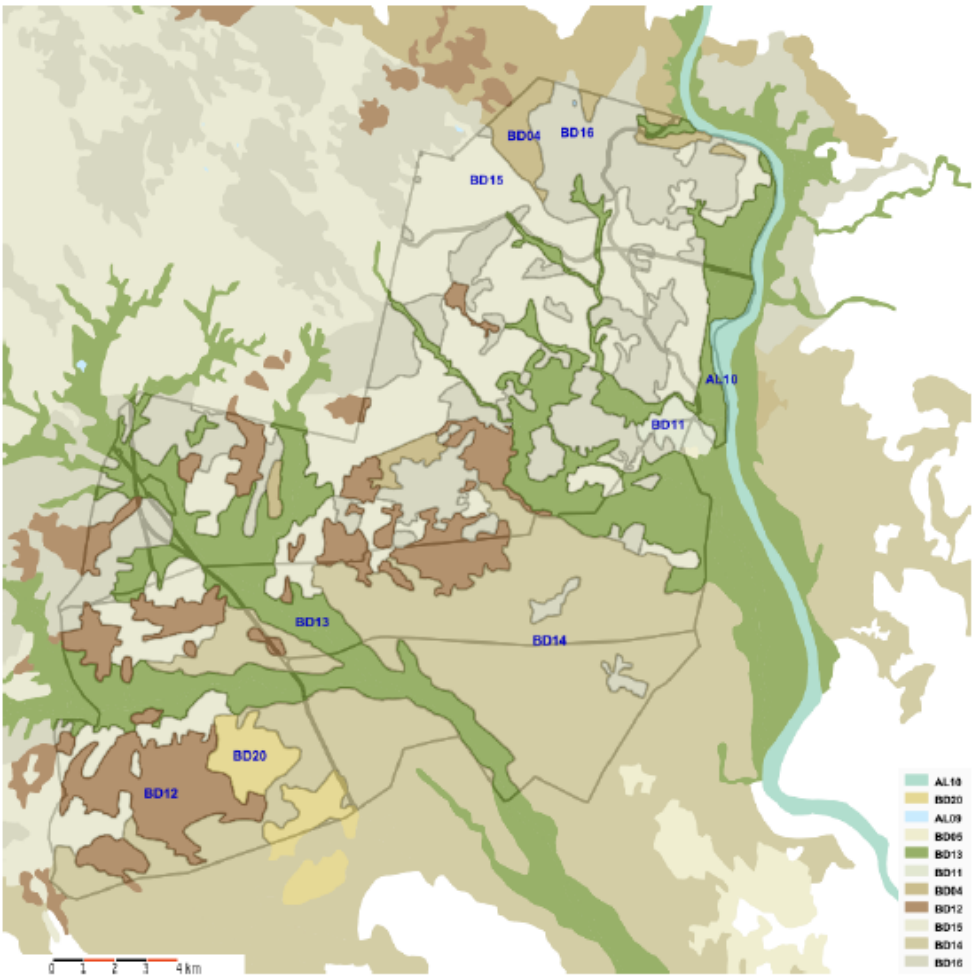
Page five of the LTCC report shows the estimated foliage projective cover (FPC) information map obtained from satellite data (2014) for the selected paddocks/land parcels (for more detailed information see FORAGE FPC report https://longpaddock.qld.gov.au/forage/report-information/foliage-projective-cover/). The map shows both the different classes of FPC and the land type information for the area selected. Areas with greater than 15 percent FPC are classed as woody vegetation cover, whereas areas with less than 15 percent FPC are classed as non-woody vegetation cover. Users may be more familiar with tree density being expressed as tree basal area (TBA). As a guide, for mature tree communities, FPC thresholds of 15, 30 and 70 percent equate to tree basal area of approximately 6, 12 and 32 m^2/ha respectively.

FORAGE REPORT: LONG-TERM CARRYING CAPACITY (prototype v1.0)

Queensland Government

http://www.longpaddock.qld.gov.au/FORAGE October 23, 2020 Label: spyglass Latitude/Longitude: -19.42/145.73

Property land types



Summary of the land types and corresponding long-term carrying capacity

Land type code and name	Land type area (ha)	Percent area FPC<15	LTCC (AE) A	B	C	D	LTCC (Ha/AE) A	Pasture growth (kg/ha/year)
BD11 - Goldfields country - red soils	198.2	94.6	33	24	15	7	6.3	1913
BD13 - Loamy alluvials	7097.3	33.2	1197	898	539	239	6.6	1642
BD05 - Box country	1.8	50.0	0	0	0	0	8.8	1382
BD20 - Yellowjacket with other eucalypts	790.8	61.9	90	67	40	18	9.3	1665
BD14 - Narrow-leaved ironbark on deeper soils	8517.1	32.5	819	614	368	164	10.9	1125
BD15 - Narrow-leaved ironbark on shallower soils	7530.0	53.8	629	472	283	126	12.3	1221
BD16 - Ranges	6244.3	68.4	293	220	132	59	21.8	1360
BD04 - Box and napunyah	793.3	21.8	34	25	15	7	24.2	826
AL10 - Wetland	81.2	5.8	3	2	1	1	29.3	716
BD12 - Lancewood - bendee - rosewood	4080.4	22.8	78	58	35	16	53.5	561
Water	1	N/A	0	0	0	0	0	0
Total/mean	35336	45	3174	2381	1428	635	11.3	1234

Figure 34. An example of the LTCC summary for land types found on page 4.

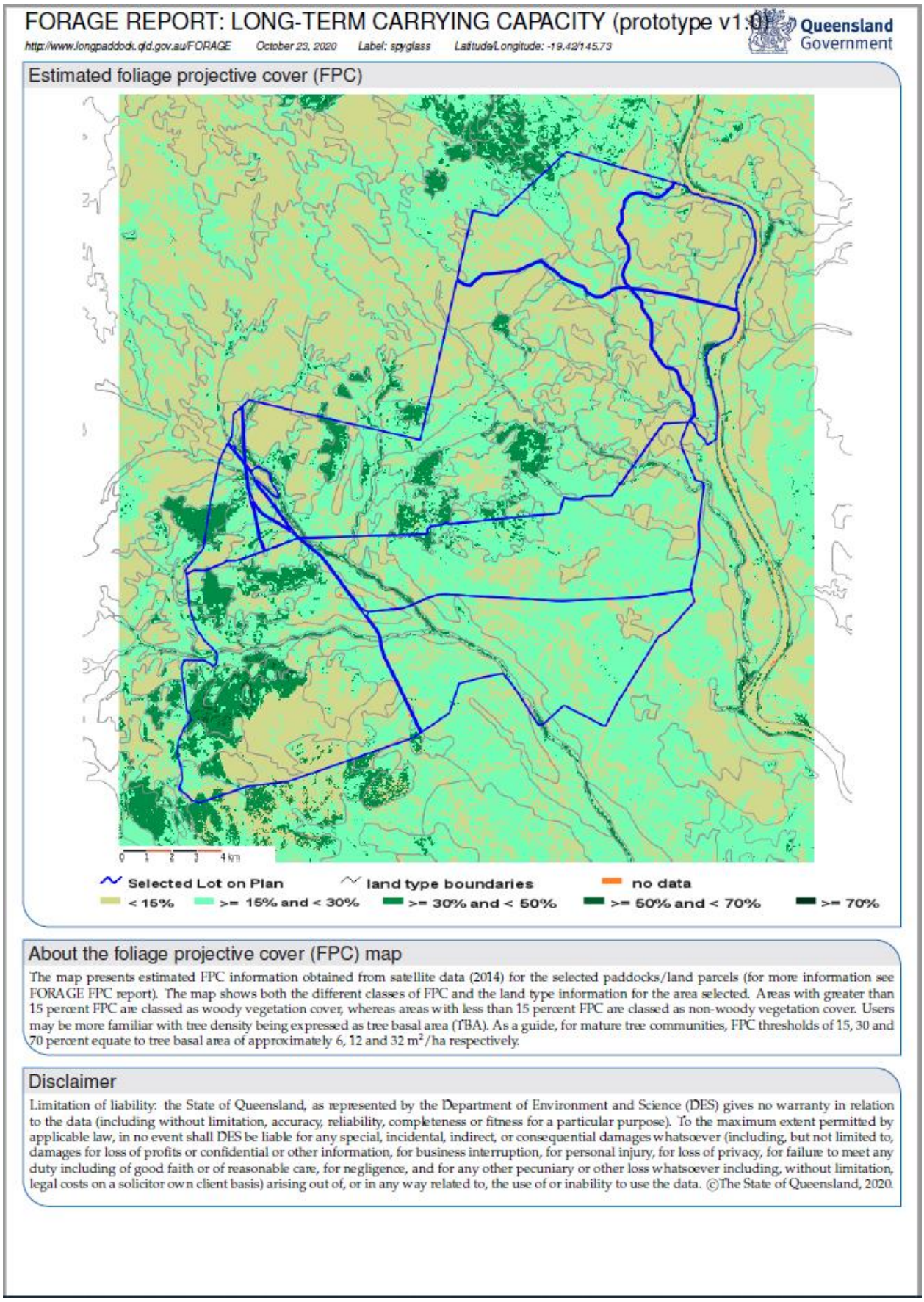


Figure 35. An example of the estimated foliage projective cover (FPC) for lot(s)/plan on page 5.

Accessory spreadsheet files

The first accessory file (CarryingCapacityFor_Paddocks_adjustLandCondition) that accompanies the LTCC report (Figure 36) is an Excel spreadsheet, which provides paddock level LTCC under different conditions (A-D).

Users can modify: 1) the area available for grazing/ungrazed; 2) the land condition state to reflect actual paddock/parcel condition state, rather than the default "A" condition shown in the automated report. The percentages across "A-D" land condition must sum to 100%. The adjusted LTCC can then be compared to "A" condition in the automated report.

Note. It is instructive to show how raising percentage areas of the paddock/land parcel/property condition can lift the LTCC total AEs. By improving land condition higher productivity can be achieved.

Paddock Name	Paddock Area (ha)	Considered Ungrazed (ha)	LTCC A condition (ha/AE)	LTCC A condition (AE)	% area A condition	% area B condition	% area C conditon	% area D conditon	Total %	Adjusted LTCC (AE)
1OC57	6919.6	0.0	9.8	703.3	100.0	0.0	0.0	0.0	100.0	703.3
3RP841848	5650.1	0.0	10.7	525.7	100.0	0.0	0.0	0.0	100.0	525.7
4SP233424	4621.7	0.0	10.4	445.3	100.0	0.0	0.0	0.0	100.0	445.3
4835CP858256	18144.4	0.0	10.8	1678.6	0.0	10.0	40.0	50.0	100.0	595.9
Total	**35335.9**	**0.0**		**3353**						**2270**

Figure 36. Example of an accessory interactive Excel spreadsheet showing the LTCC for all Lot(s) Plan/ paddocks adjustable for land condition (A-D).

The second Accessory file (CarryingCapacityFor_Paddock_LandTypes_dataOutput) that accompanies the LTCC report is an Excel spreadsheet, which provides the user with LTCC and pasture growth data for each Lot/Plan (or paddock) x land type combination (Figure 37). On a land parcel (or paddock) and land type basis it includes:

- land type name, area (ha) and percentage paddock area (%);
- the weighted average FPC (%);
- the LTCC as AEs if the land area was in "A" condition;
- the LTCC density (Ha/AE) if the land area was in "A" condition;
- the median (middle value) pasture growth based on a weighted average FPC for that paddock; and
- the median pasture growth at zero FPC.

Note. These averaged pasture growth values are indicative only and should not be used for calculating total pasture growth.

Paddocks	Land type code	Land type name	Land type area (ha)	Percentage area (%) of paddock	Average FPC (%)	Long-term carrying capacity in A condition (AE)	Long-term carrying capacity in A condition (ha/AE)	Median pasture growth (kg/ha)	Median pasture growth at 0 FPC (kg/ha)
1OC57	BD10	Goldfields country - black soils	1226.5	17.7	21.5	193.4	6.3	1812	3437
	BD12	Lancewood - bendee - rosewood	2199.9	31.8	22.8	81.1	27.1	1124	1367
	BD13	Loamy alluvials	1043.6	15.1	20.3	129	8.1	903	3226
	BD14	Narrow-leaved ironbark on deeper soils	1582.2	22.9	10.9	187.7	8.4	1187	2379
	BD16	Ranges	80.9	1.2	10.9	3	26.6	1074	1686
	BD20	Yellowjacket with other eucalypts	786.6	11.4	9.1	109	7.2	2004	2901

Figure 37. Example of an accessory Excel spreadsheet showing LTCC on a paddock and land type basis.

Caveats for the LTCC report

It should be noted that rainfall data and maps are constructed using SILO datasets (https://www.longpaddock.qld.gov.au) from point location observational records provided by the Bureau of Meteorology (BoM). SILO interpolates the raw data to derive datasets which are both spatially and temporally complete. However, the low density of observing stations in some regions and changes in the observation network over time may, at times, lead to lower quality mapping. Significant rainfall events at times may 'slip' through the BoM gauging network and not being detected, especially in those regions where storm rainfall is common and official rain gauges are sparse.

Pasture growth data are estimated using the GRASP model. GRASP (McKeon et al. 1990) is an advanced spatial water balance and plant growth model, producing output on a daily time-step for the selected area. The accuracy of climate data used to drive the pasture models may limit accuracy of the pasture growth results in some circumstances (as related above).

Many environmental factors may be important at a locality which may influence pasture growth over the longer term and therefore the LTCC. Some of these factors cannot be accounted and may include (not exhaustive): flooding, tree clearing, improved pastures, pasture dieback and insect plagues.

Please Note:

1) The LTCC report is still in the prototype stage with ongoing refinements being made.
2) The report is designed as a starting point for discussion on the number of livestock a property can carry in the long-term (decades) without reducing land condition.
3) The current report considers the grazing systems to consist of native pastures and fully rundown pastures (i.e. soil fertility) following clearing. The property/area selected is considered fully watered.
4) A dynamic property mapping tool (MyFORAGE Map) is under development, so that the user can include information (such as buffel pastures and watering point location) that are specific to the property.

4.12 FORAGE Report: Indicative Soil Phosphorus Report

The *Indicative Soil Phosphorus* report (Figure 38-40) is a 3-page report that provides the 'inherent' (i.e. natural soil with no phosphorus (P) fertiliser treatment) 'plant-available' soil P concentration and the areas of different soil P categories for different Grazing Land Management (GLM) land types for the selected Lot(s) on Plan. The map of soil P in the report can assist graziers to improve the efficiency of supplementation for livestock production, fertiliser application and legume development through improved awareness of soil P availability for their properties.

Note: The map shows the extent for which the report is currently available (i.e. the Gulf and Cape York regions are unavailable). The current map will be superseded when new analyses are completed and reviewed and will include all of Queensland.

The status of soil P affects the P concentration in pastures which plays an essential role for conversion of grass to energy in livestock body, growth and the development of body tissue, development of foetus and production of milk in pregnant and lactating cows. Extremely low or very low available P soils may result in low plant P and hence P deficiency in cattle. Symptoms of P deficiency include bone chewing, which also increases the risk of cattle contracting botulism. More comprehensive details and symptoms on P deficiency can be found in the Reference list (below).

The information presented in the Indicative Soil Phosphorus report includes:

- A soil P map (Page 1) - showing the soil P concentration that has been estimated.
- A summary of soil P for land types (Page 2) - listing the areas of different soil P categories for different GLM land types for the selected Lot(s) on Plan.
- Map of soil P data relative uncertainty (Page 3) - indicating the relative uncertainty of soil P data in the Soil P Map (page 1).
- A reference list (Page 3) - for publications containing detailed phosphorus information

Report pages in detail

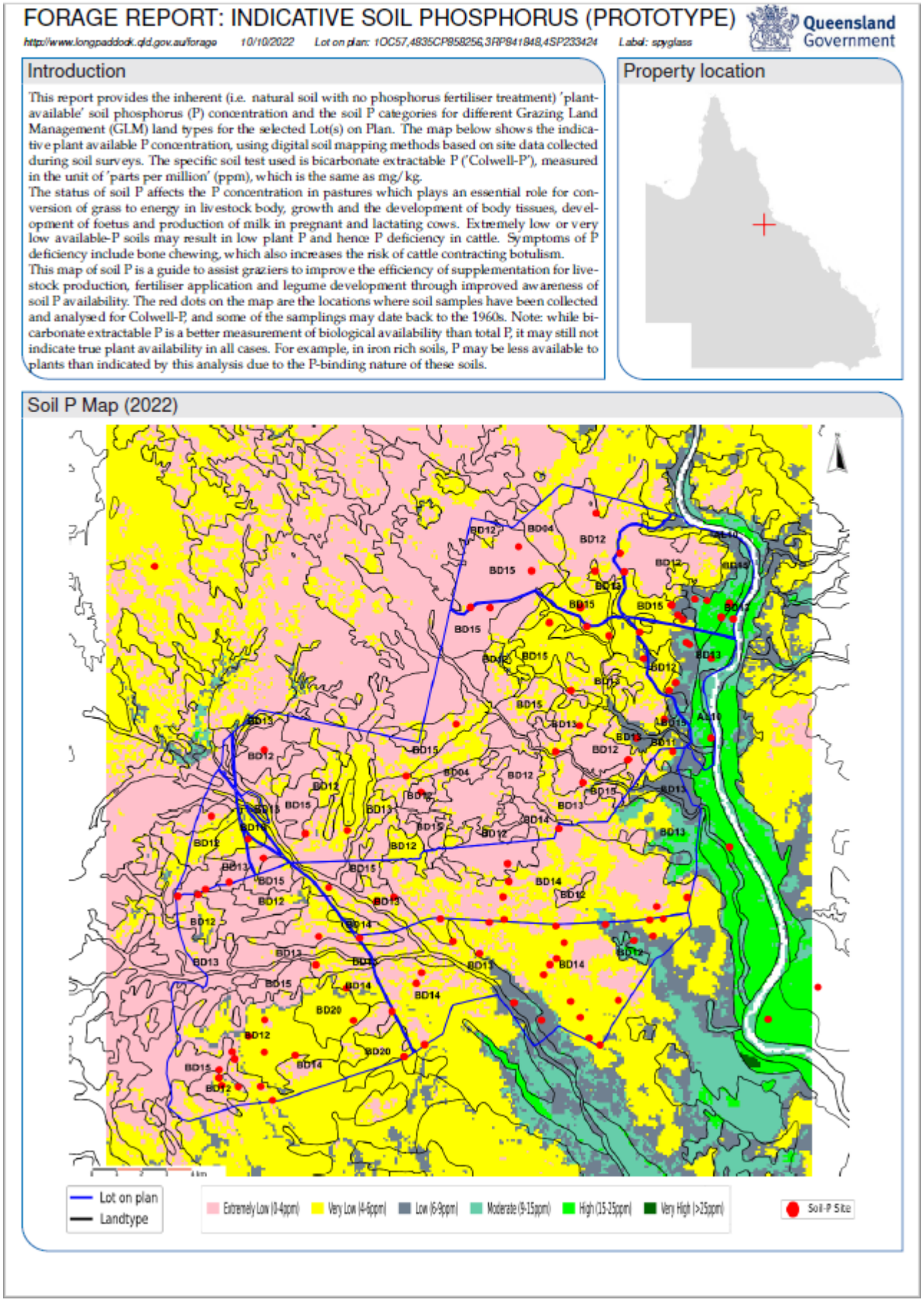
Page 1 - Map of soil P (see Figure 38).

The map of soil P shows the indicative plant-available P concentration, using digital soil mapping methods based on site data collected during soil surveys. The specific soil test used is bicarbonate extractable P ('Colwell-P'), measured in the unit of 'parts per million' (ppm), which is the same as mg/kg. The red dots on the map show the locations where soil samples have been analysed for Colwell-P. The P samples have been collected by soil surveyors since the 1960s.

Note: while bicarbonate extractable P is a better measurement of biological availability than total P, it may still not indicate true plant availability in all cases. For example, in iron rich soils, P may be less available to plants than indicated by this analysis - due to the P-binding nature of these soils.

Page 2 - Classification of Soil P for Land Types (see Figure 39).

The table shows the indicative area (ha) and percentage of different soil P categories that are present for each GLM land type in the selected Lot(s) on Plan. The categories are classified based on soil available P concentrations and include: Extremely Low (0-4ppm); Very Low (4-6ppm); Low (6-9ppm); Moderate (9-15ppm); High (15-25ppm); and Very High (>25ppm).



FORAGE REPORT: INDICATIVE SOIL PHOSPHORUS (PROTOTYPE)

Queensland Government

http://www.longpaddock.qld.gov.au/forage 10/10/2022 Lot on plan: 1OC57,4B35CP858256,3RP841848,4SP233424 Label: spyglass

Introduction

This report provides the inherent (i.e. natural soil with no phosphorus fertiliser treatment) 'plant-available' soil phosphorus (P) concentration and the soil P categories for different Grazing Land Management (GLM) land types for the selected Lot(s) on Plan. The map below shows the indicative plant available P concentration, using digital soil mapping methods based on site data collected during soil surveys. The specific soil test used is bicarbonate extractable P ('Colwell-P'), measured in the unit of 'parts per million' (ppm), which is the same as mg/kg.

The status of soil P affects the P concentration in pastures which plays an essential role for conversion of grass to energy in livestock body, growth and the development of body tissues, development of foetus and production of milk in pregnant and lactating cows. Extremely low or very low available-P soils may result in low plant P and hence P deficiency in cattle. Symptoms of P deficiency include bone chewing, which also increases the risk of cattle contracting botulism.

This map of soil P is a guide to assist graziers to improve the efficiency of supplementation for livestock production, fertiliser application and legume development through improved awareness of soil P availability. The red dots on the map are the locations where soil samples have been collected and analysed for Colwell-P, and some of the samplings may date back to the 1960s. Note: while bicarbonate extractable P is a better measurement of biological availability than total P, it may still not indicate true plant availability in all cases. For example, in iron rich soils, P may be less available to plants than indicated by this analysis due to the P-binding nature of these soils.

Property location

Soil P Map (2022)

Figure 38. An example of the Indicative Soil Phosphorus report – page 1.

FORAGE REPORT: INDICATIVE SOIL PHOSPHORUS (PROTOTYPE)

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Soil P Categories for Land Types

This table shows the indicative areas (ha) and percentage of different soil P categories present for each GLM land type for the selected Lot(s) on Plan.
The categories are classified based on soil P concentrations and include: Extremely Low (0-4ppm); Very Low (4-6ppm); Low (6-9ppm); Moderate (9-15ppm); High (15-25ppm); and Very High (>25ppm).

Land type code and name	Area (ha)	Extremely Low (ha) (%)	Very Low (ha) (%)	Low (ha) (%)	Moderate (ha) (%)	High (ha) (%)	Very High (ha) (%)
BD12 - Lancewood - bendee - rosewood BD	10224	6843 (66.9)	3042 (29.8)	280 (2.7)	50 (<1)	9 (<1)	<1 (<1)
BD14 - Narrow-leaved ironbark on deeper soils	8518	3424 (40.2)	4619 (54.2)	349 (4.1)	120 (1.4)	6 (<1)	<1 (<1)
BD15 - Narrow-leaved ironbark on shallower so	7958	4717 (59.3)	2579 (32.4)	504 (6.3)	155 (1.9)	4 (<1)	<1 (<1)
BD13 - Loamy alluvials	7240	3198 (44.2)	2185 (30.2)	737 (10.2)	565 (7.8)	556 (7.7)	<1 (<1)
BD04 - Box and napunyah	793	430 (54.2)	350 (44.1)	13 (1.6)	<1 (<1)	<1 (<1)	<1 (<1)
BD20 - Yellowjacket with other eucalypts	790	34 (4.3)	737 (93.3)	19 (2.4)	<1 (<1)	<1 (<1)	<1 (<1)
BD16 - Ranges	375	74 (19.7)	298 (79.4)	3 (<1)	<1 (<1)	<1 (<1)	<1 (<1)
BD11 - Goldfields country - red soils	198	26 (13.1)	89 (44.9)	69 (34.7)	15 (7.3)	<1 (<1)	<1 (<1)
AL10 - Wetland	81	<1 (<1)	3 (3.2)	27 (33.7)	22 (27.4)	29 (35.8)	<1 (<1)
AL09 - Water	4	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)
BD05 - Box country BD	2	<1 (<1)	<1 (<1)	2 (100.0)	<1 (<1)	<1 (<1)	<1 (<1)
Total	36182	18746 (51.8)	13901 (38.4)	2003 (5.5)	925 (2.6)	604 (1.7)	0 (0)

Data sources

The Soil P map is based on data from products (2022) SLR_QLD_COLWELL_P_Stage3_05.tif, SLR_QLD_COLWELL_P_Stage3_EV.tif, SLR_QLD_COLWELL_P_Stage3_95.tif and SLR_QLD_COLWELL_P_Stage3_rel_uncert.tif of Queensland Spatial Catalogue (*https://qldspatial.information.qld.gov.au/catalogue*). The map has a spatial resolution of 100m, and the map accuracy depends on soil uniformity and density of soil sampling in any region. The GLM land type information is based on "SIRQRY.DAF_GLM_LAND_TYPES_V6" dataset. The categories of soil P concentration are adopted from Ahern C.R. *et al.* (1994). Some of the content in the 'Introduction' section of this report is referenced from McCosker and Winks (1994).

Note: This version of FORAGE Soil P reports currently does not cover the Gulf and Cape York regions. The spatial prediction of plant-available soil phosphorus is constantly evolving. The current map will be superseded when new analyses are completed and reviewed and will include all of Queensland.

We acknowledge the work of numerous soil scientists, chemists, researchers and field staff who collected and analysed soil samples - and we also thank the many landholders for on-property access to collect samples since collections commenced.

You can now measure soil P on your property by registering for the national 'Pilot Soil Monitoring and Incentives Program' (*https://www.awe.gov.au/agriculture-land/farm-food-drought/natural-resources/soils/soil-monitoring-and-incentives*). Any data collected through this program will eventually contribute to a better P map for this report in the future.

Figure 39. An example of the Indicative Soil Phosphorus report – page 2.

Page 3 - Map of Soil P Data Relative Uncertainty (see Figure 40).

The indicative soil P map on page one is generated using complex digital mapping techniques. This uncertainty map indicates the 'relative' uncertainty (i.e. relative to the median pixel value) of soil P data in the Soil P Map (page 1). There are 3 categories - low, moderate and high uncertainty.

High uncertainty of soil P data can be due to a number of factors including: high spatial variability of soil P determined by the model, and/or low quantity of soil P measurements taken in the local area.

Red dots on the map show the locations where soil samples have been analysed (if any).

Page 3 - Reference list (see Figure 40 and below).

The reference list lists the publications in which the detailed phosphorus information on soils, plants and animal nutrition and well-being can be found.

Note: The accuracy of the mapping will vary, particularly in relation to how many samples were present in an area. In general, the density of sites used to predict the map is low. Further on-site sampling is recommended to determine actual P values more accurately.

If there are:

- major discrepancies with the Soil P mapping in the report for your property;
- sites where there have been samples taken historically on your property, but they are not showing up on the map;
- no Soil P sample points (red dots) for your property in the report and you would like to have some samples taken,

you can contact: longpaddock@qld.gov.au and relate the details. A member of our team will then contact you to discuss the mapping issue.

Reference list

Ahern C.R. et al. (1994). The soil fertility of central and north-east Queensland grazing lands, ISBN 0724259201, Queensland Department of Primary Industries, Q194065.

Jackson D. *et al.* (2012). Phosphorus management of beef cattle in northern Australia. Meat & Livestock Australia. http://publications.mla.com.au/login/GetDocViewer/11-10699.pdf

McCosker T.H. and Winks L. (1994). Phosphorus nutrition of beef cattle in northern Australia, ISSN 0727-6273, Queensland Department of Primary Industries, GPO Box 46, Brisbane, Qld 4001.

Meat & Livestock Australia. FutureBeef: Phosphorus supplementation of cattle in northern Australia. https://futurebeef.com.au/knowledgecentre/ phosphorus-supplementation-of-cattle-in-northern-australia/.

Meat & Livestock Australia. Phosphorus. https://www.mla.com.au/research-and-development/livestock-production/livestocknutrition/phosphorus/.

Queensland Government. Phosphorus map Of Queensland. https://www.publications.qld.gov.au/dataset/phosphorus-map-of-queensland-pmap.

Zund P., Walton J., Antoni M., Harms B., and Thomas E. (2022). Soil bicarbonate-extractable P (Colwell-P) map of Queensland main grazing lands. Published by Meat and Livestock Australia Limited. https://www.publications.qld.gov.au/dataset/phosphorus-map-of-queensland-pmap/resource/e32542a2-be95-4d53-a5de-ecbe6252cb10

FORAGE REPORT: INDICATIVE SOIL PHOSPHORUS (PROTOTYPE)

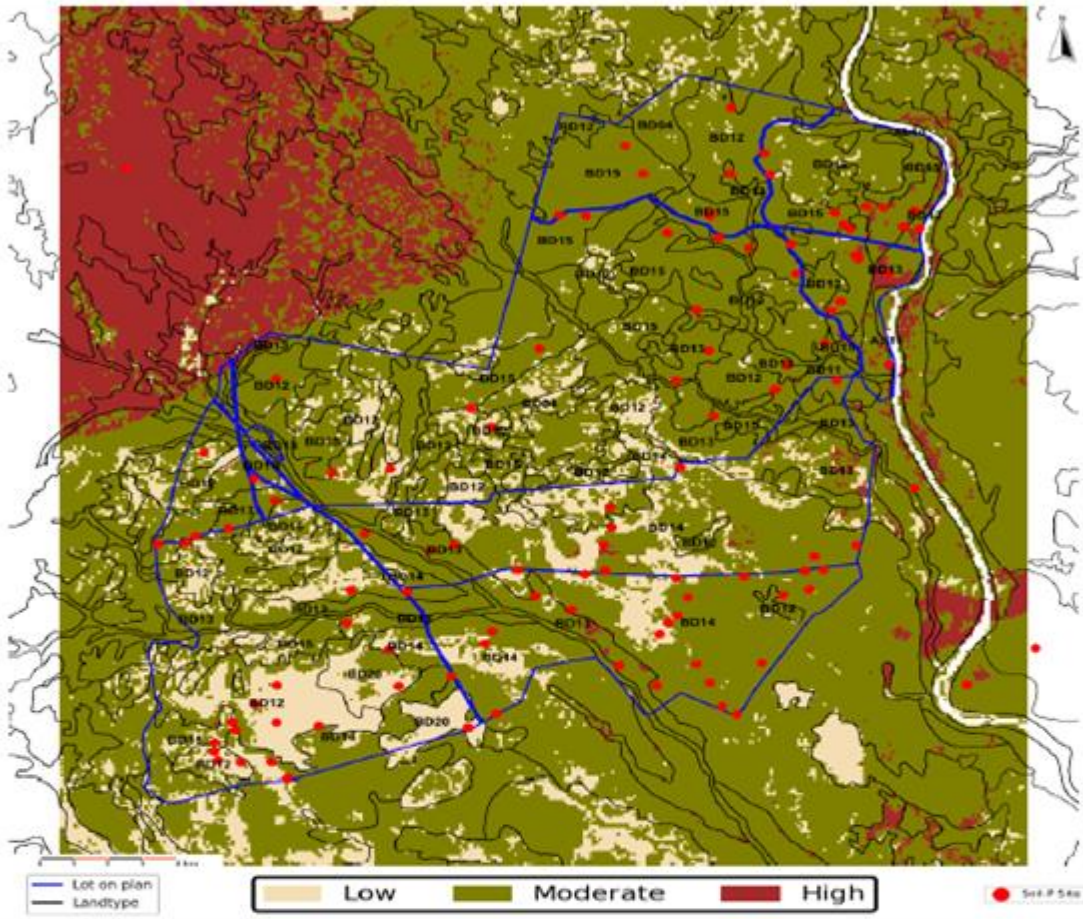
Queensland Government

https://www.longpaddock.qld.gov.au/forage 10/10/2022 Lot on plan: 1OC57,4835CP858256,3RP941848,4SP233424 Label: spyglass

Relative Uncertainty of Soil P Data

The indicative soil P map on page one is generated using complex digital mapping techniques. The map below indicates the 'relative' uncertainty of the soil P data used in the Soil P Map, expressed as low, moderate and high relative uncertainty.

Map of Relative Soil P Data Uncertainty



References

Ahern C.R. *et al.* (1994). The soil fertility of central and north-east Queensland grazing lands, ISBN 0724259201, Queensland Department of Primary Industries, Q194065.

Jackson D. *et al.* (2012). Phosphorus management of beef cattle in northern Australia. Meat & Livestock Australia. *http://publications.mla.com.au/login/GetDocViewer/11-10699.pdf*

McCosker T.H. and Winks L. (1994). Phosphorus nutrition of beef cattle in northern Australia, ISSN 0727-6273, Queensland Department of Primary Industries, GPO Box 46, Brisbane, Qld 4001.

Meat & Livestock Australia. FutureBeef: Phosphorus supplementation of cattle in northern Australia. *https://futurebeef.com.au/knowledge-centre/phosphorus-supplementation-of-cattle-in-northern-australia/*

Meat & Livestock Australia. Phosphorus. *https://www.mla.com.au/research-and-development/livestock-production/livestock-nutrition/phosphorus/*

Queensland Government. Phosphorus map Of Queensland. *https://www.publications.qld.gov.au/dataset/phosphorus-map-of-queensland-pmap*

Zund P., Walton J., Antoni M., Harms B., and Thomas E. (2022). Soil bicarbonate-extractable P (Colwell-P) map of Queensland main grazing lands. Published by Meat and Livestock Australia Limited. *https://www.publications.qld.gov.au/dataset/phosphorus-map-of-queensland-pmap/resource/e32542a2-be95-4d53-ecbe6252cb10*

Disclaimer

Figure 40. An example of the Indicative Soil Phosphorus report – page 3.

5 Common access problems

5.1 Time

The time taken, from ordering to receipt of a FORAGE time report, can vary from as little as a few minutes to a few hours, depending on system processing. A problem may have occurred if you do not receive your report after six hours. However, if a report is not received within three hours, this is likely to be due to a system fault (e.g. computer servers being offline or a computer database outage). FORAGE administrators are available to resolve problems during office hours (longpaddock@qld.gov.au).

5.2 Saving a report

Occasionally a FORAGE report will not save when the report is open and you attempt to save through the 'File' tab and 'save as' option. If this occurs, close the report and try either:

- saving the unopened report directly from the email attachment by right clicking the mouse on the attachment, then select the 'save as' option in the drop down menu to save the document to a selected folder
- left click and hold the mouse on the email attachment, and 'drag' the attachment to a folder or computer desktop.

5.3 No Report

From time to time, when you request a report from FORAGE, you may receive either no response or a message stating that there is no image available for the requested location (for Ground Cover reports or SLATS satellite imagery).

If there is no response, first check that you have submitted the correct Lot on Plan for the location. It may be that your selection is correct, but one of our computer servers is busy or off-line. In this case, try re-submitting your request or contact the FORAGE administrator (longpaddock@qld.gov.au.) during office hours.

6 Glossary

AussieGRASS – Australian Grassland and Rangeland Assessment by Spatial Simulation (Carter *et al.* 2000). An Australian climate and biological modelling system run by Grazing Land Systems – Science Delivery, Department of Environment and Science, using advanced spatial simulation techniques and high performance computing facilities. http://www.longpaddock.qld.gov.au/about/researchprojects/aussiegrass/

Bare ground – Bare ground refers to the proportion of ground which is either bare soil or covered by rock.

Consistent Climate Change Scenarios (CCCS) projections data – Projected climate information for 2030 and 2050, prepared by the former Department of Science, Information Technology and Innovation now Department of Environment and Science (DES) in collaboration with CSIRO and based on IPCC AR5 global climate models deemed most suitable for Australia Long Paddock website http://www.longpaddock.qld.gov.au/climateprojections/, using the SILO climate dataset.

Digital Cadastral Data Base (DCDB) – This is the spatial representation of the property boundaries and the related property descriptions of Queensland. The DCDB (https://data.qld.gov.au/en/dataset/cadastral-data-queensland-series) provides the map base for systems dealing with land and land related information and provides data for generating of hard copy map products.

Foliage Projective Cover – Foliage Projective Cover (FPC) is a widely adopted metric of vegetation cover that is used in vegetation classification frameworks in Australia. FPC is defined as the vertically projected percentage cover of photosynthetic foliage from tree and shrubs greater than two metres in height. This is the definition of woody vegetation cover adopted by the Department of Environment and Science (DES) in the Statewide Landcover and Tree Study (SLATS).

GRASP – A computer model of variable climate and animal impacts upon grasses and soils, principally in northern Australia (McKeon *et al.* 1990).

Ground cover – Ground cover refers to the proportion of ground covered by green and dead foliage, cryptogram and detached plant litter.

Percentile – The percentile of a number indicates where the number lies in an ordered list of numbers. For example, if last year's rainfall was ranked at the 30th percentile of the long-term annual rainfall record, then the rainfall in 30% of the years in the record are less than (or equal to) last year's rainfall and the rainfall in the remaining 70% of years in the record are greater than last year’s rainfall. Percentiles that are multiples of 25 are called quartiles. The 25th percentile is the first quartile, the 50th percentile is the second quartile and so on.

SILO – A climate database, accessible through the internet, hosted by Science Information Delivery – Science Delivery, Department of Environment and Science (DES), containing Australian climate data from 1889 to current, in a number of ready-to-use formats, suitable for research and climate applications. https://silo.longpaddock.qld.gov.au/.

SLATS – The Statewide Landcover and Trees Study (SLATS) is a Department of Environment and Science (DES) research project, monitoring Queensland's forests and woodlands to assess woody vegetation extent and change, supporting the Vegetation Management Act 1999 and regional planning initiatives. The project provides satellite images and detailed spatial data and reports to help landholders, scientists, industry and government improve land management practices.
http://www.qld.gov.au/environment/land/vegetation/mapping/slats/

Stocktake – Stocktake © is a paddock-scale land condition monitoring and management software package, developed by the Queensland Department of Agriculture and Fisheries to provide grazing land managers with a practical, systematic way to assess land condition and long-term carrying capacity, and to calculate short-term forage budget.

TSDM – Total standing dry matter, refers to the above-ground total standing green and dead plant material, reported on a dry weight basis. TSDM does not include plant litter.

7 References

Armston, J., Denham, R., Danaher, T., Scarth, P. and Moffiet, T. (2009) Prediction and validation of foliage projective cover from Landsat-5 TM and Landsat-7 ETM+ imagery for Queensland, Australia. Journal of Applied Remote Sensing, 3: 033540.

Carter, J.O., Hall, W.B., Brook, K.D., McKeon, G.M., Day, K.A. and Paull, C.J. (2000). AussieGRASS: Australian Grassland and Rangeland Assessment by Spatial Simulation. In Applications of seasonal climate forecasting in agricultural and natural ecosystems—the Australian experience. (Eds G. Hammer, N. Nicholls and C. Mitchell) pp. 329–349. Kluwer. Academic Press, Netherlands.

Jeffrey, S.J. Carter, J.O. Moodie, K.B. Beswick, A.R. (2001) Using spatial interpolation to construct a comprehensive archive of Australian climate data. Environmental Modelling & Software 16(04), 309-330

Kitchen J., Armston J. Clark, A., Danaher T. and Scarth P. 2010. Operational use of annual Landsat-5 TM and Landsat-7 ETM+ image time-series for mapping wooded extent and foliage projective cover in north-eastern Australia. In Proceedings of the 15th Australasian Remote Sensing and Photogrammetry Conference, Alice Springs, Australia, 13 -17 September 2010.

McKeon, G., Day, K., Howden, S., Mott, J., Orr, W., Scattini, W. and Weston, E. (1990). Northern Australia savannahs: Management for pastoral production. Journal of Biogeography, 17, 355-372.

McKeon, G, Hall, W, Henry, B, Stone, G & Watson, I (eds) (2004) 'Pasture Degradation and Recovery in Australia's Rangelands: Learning from History' Department of Natural Resources Mines & Industry, Queensland Government

McKeon G., Stone G., Ahrens D., Carter J., Cobon D., Irvine S. and Syktus J. (2021). Queensland's multi-year Wet and Dry periods: implications for grazing enterprises and pasture resources . The Rangeland Journal 43(3) 121-142

Pringle, M., Schmidt, M., and Tindall, D. (revised): Multi-decade, multi-sensor time-series modelling based on geostatistical concepts to predict broad groups of crops. Remote Sensing of Environment.

Schmidt, M., Pringle, M. Devadas, R. Denham, R. and Tindall, D. (2016): A Framework for Large-Area Mapping of Past and Present Cropping Activity Using Seasonal Landsat Images and Time Series Metrics. Remote Sensing, 8, 312; DOI:10.3390/rs8040312.

Smith, I. and Chiew, F. (2009). Document and assess methods for generating inputs to hydrological models *and extend delivery of projections across Victoria. Final report for SEACI Phase 1 Project 2.2.5P.* http://www.seaci.org/publications/documents/SEACI-1%20Reports/S1_FR225P.pdf.

Stone, R.C., Hammer, G. L., and Marcussen, T. (1996). Prediction of global rainfall probabilities using phases of the Southern Oscillation Index. Nature 384, 252-255. doi: 10.1038/384252a0.

Stone, G., Dalla Pozza, R., Carter J., & McKeon, G. (2019). Long Paddock: climate risk and grazing information for Australian rangelands and grazing communities . The Rangeland Journal, 41, 225–232.

Stone G., Zhang B., Carter J., Fraser G., Whish G., Paton C., McKeon G. (2021) An online system for calculating and delivering long-term carrying capacity information for Queensland grazing properties. Part 1: background and development . The Rangeland Journal 43, 143-157.

Suppiah, R., Hennessy, K.J., Whetton, P.H., McInnes, K., Macadam, I., Bathols, J., Ricketts, J., & Page, C.M. (2007). Australian climate change projections derived from simulations performed for the IPCC 4th Assessment Report. Aust. Met. Mag. 56 (2007) 131-152. CSIRO Marine & Atmospheric Research, Australia. http://www.bom.gov.au/amm/docs/2007/suppiah.pdf

Zhang, B. and Carter, J (2018). FORAGE – An online system for generating and delivering property-scale decision support information for grazing land and environmental management. Computers and Electronics in Agriculture, 150, 302-311.

Zhang B., Fraser G., Carter J., Stone G., Irvine S., Whish G., Willcocks J., McKeon G. (2021) An online system for calculating and delivering long-term carrying capacity information for Queensland grazing properties. Part 2: modelling and outputs . The Rangeland Journal 43, 159-172.

Zund P. *et al.* (2022). Soil bicarbonate-extractable P (Colwell-P) map of Queensland main grazing lands (GBP.0043). Queensland Department of Environment and Science. Published 11 March 2022, Meat and Livestock Australia Limited, North Sydney NSW.