

Spatial Grazing Land Management Land Types of Queensland: Review and amendments

(Version 5.4)

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Summary

The Grazing Land Management (GLM) land type spatial layer is the spatial representation of Land types of Queensland as described by the Queensland Department of Agriculture, Fisheries (DAF) (<https://futurebeef.com.au/knowledge-centre/land-types-of-queensland/>). The spatial land type layer is a key input for property mapping and modelling of pasture growth across Queensland by the DAF and the Department of Environment and Science (DES). The spatial layer was first constructed by the ex-Queensland Department of Environment and Resource Management (DERM) as a part of the former Delbessie Agreement (State Rural Leasehold Land Strategy (SRLLS)). Whilst the SRLLS program concluded in 2014, the project legacy has been managed by the Queensland Department of Natural Resources, Mines and Energy (DNRME).

This technical report relates a collaborative multiple departmental approach between (DAF, DES and DNRME) to create the best land type spatial layer for government and public use. This report provides the method, process and outcomes applied to the land type spatial layer as a working account (including Version log) for open reference.

Application of the new approaches and incorporation of new data by DAF and DES scientists into Version 5 (V5) GLM land type mapping has been completed and validated by regional experts in Burdekin, Fitzroy, Mulga and Western Queensland regions. Key regional experts will be used to validate other regions across Queensland (e.g. Southern and Northern Gulf, Inland Burnett, and Mulga). Additionally, the Version 5 land type mapping has been tested as an input for pasture growth modelling for GLM EDGE workshops and in the FORAGE Estimated Safe Carrying Capacity tool with the improved results validated by landholders.

The current GLM land type mapping (Version 3) was released in March 2013 and due to the conclusion of the SRLLS program, no version changes have taken place in the interim. The increased reliance on the land type spatial data for research and extension activities in combination with an increased staff capability attained through recent funding, provided an ideal opportunity to review and update the data. A comprehensive review of Version 3 (V3) revealed easily identifiable errors and deficiencies in the current mapping. New approaches developed to address these mapping errors and deficiencies include the use of current remnant vegetation mapping, new Regional Ecosystems (RE), in combination with all described Land types of Queensland – and ensuring use of regionally appropriate GLM Land Type. Climate zones and the proportion of production by C3 or C4 grasses were also used to improve the interpretation of the new RE data layer. These new approaches were developed in consultation with regional GLM land type experts and government stakeholders.

Continued consultation with: regional experts; ground-based validation; development of Land types of Queensland descriptions and mapping and the capture, processing and inclusion of feedback from users of the GLM land type mapping are essential for further refinement and improvement.

Reviews and timely updates of GLM land type mapping as new information and analyses are made available are key to improving the accuracy of the modelling and condition assessments of Queensland's grazing lands. Whilst validation of V5 mapping will continue, it is recommended that V5 be made available for internal governmental and public use.

As part of the Inside Edge for Graziers to adapt to Queensland's drought prone climate project funded by Reef CBRC and the Drought and Climate Adaptation programs, DES and DAF staff will continue to

validate GLM land type mapping across Queensland in order to provide the best possible land type spatial layer to service both government and public needs.

1 Introduction

Land types of Queensland (henceforth referred to as GLM land types) were developed through consultation with producers, technical specialists and Department of Agriculture and Fisheries (DAF) scientists and extension officers to provide information for native pasture management across Queensland's grazing lands.

The GLM land types of Queensland (State of Queensland 2017) are described in terms of their: landform; woody vegetation; expected pasture composition (including suitable sown pastures and introduced weeds) and broad soil characteristics, limitations to use of the land, and grazing management recommendations are provided. More than 220 land types from 15 grazing land management regions in Queensland have been described.

The GLM land type spatial data has been produced by associating the spatial Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland (Version 10) with the GLM land types of Queensland. The Pre-clearing Vegetation Communities and Regional Ecosystems mapping is predominantly at a scale of 1:100,000, although for part of south-eastern Queensland and map amendments areas mapping is at a scale of 1:50,000. Whilst it is acknowledged that using the Regional Ecosystems (RE) as a basis for the spatial definition of the GLM land types has inherent inaccuracies, there is no better alternative.

The GLM land type spatial data is used in FORAGE (DES, Science Division) grazing decision support tool (Zhang and Carter, 2018) to provide information to assist in grazing and environmental management decision-making. A spatial layer that accurately represents the variability of the Queensland grazing lands is an important input for the simulation of pasture production to assist grazing land management decisions including the calculation of safe carrying capacity information.

The following FORAGE (Zhang and Carter, 2018) reports <https://www.longpaddock.qld.gov.au/forage/> use the GLM land type spatial layer:

- Indicative land type report
- Rainfall and Pasture by land type report
- Foliage Projective Cover (FPC) report
- Estimated Safe Carrying Capacity report (in development)

The GLM land type spatial layer is a publicly available GIS resource from <http://qldspatial.information.qld.gov.au/catalogue/> that is able to be used by mapping consultants (e.g. AgData, Farm Map 4D), however, it is extensively used by DAF: in a suite of extension programs (e.g. GLM EDGE training packages, Stocktake, Grazing BMP); for property mapping; for assessing land condition; for bio-economic modelling; and to communicate with graziers.

2 Methods

2.1 Review of Land Type Mapping Version 3

Since first being published in 2010, feedback from land managers, Queensland government staff, and other users has indicated the need for a regular review of updated new data including source data and on-ground validation that will form the basis of a program of continuous improvement. In June 2017, a review of the land type mapping by DAF and DES officers (in consultation with DNRME officers) revealed a number of deficiencies in the association of REs to GLM land types, including:

- use of an area-dominant regional ecosystem (RE) association to GLM land type;
- non-use of a number of GLM land types; and
- the inability to include changes to the regional ecosystem descriptions due to new mapping and interpretation (particularly in Southern Gulf GLM region).

2.1.1 Area-dominant GLM land type by RE association

GLM land types Version 3 used an area dominant regional ecosystem (RE) approach, where a RE that was spatially spread across multiple GLM regions was allocated to a single GLM land type with the largest area. This created a consistent land type that spanned across GLM regions. In many cases the dominant land type did not represent the full variation of the land types that existed in each different GLM region which are a better reflection of regional management techniques and grazing production across the large spatial extent of Queensland. The misallocation occurred because regional ecosystem mapping is categorised on the Interim Bioregional Regionalisation of Australia (IBRA) regions and subregions <http://environment.gov.au/land/nrs/science/ibra>. However, land types of Queensland descriptions from 16 regions were based on major drainage catchments as well as bioregions. The difference between the classification of catchments and bioregions resulted in a number of regional ecosystems being spatially distributed over multiple GLM regions.

The use of the “area-dominant GLM land types approach” led to the allocation of Border Rivers, Burdekin, Fitzroy and Mulga regional land types to other regions across the state (see Figure 1). Extrapolation of a subset of the described land types to other regions (e.g. the Coastal sand dunes (FT09) and Marine Plains (FT18) to all coastal areas) to form a new spatial layer was undertaken without considering climatic differences and subsequently resulted in some misallocation of land types.

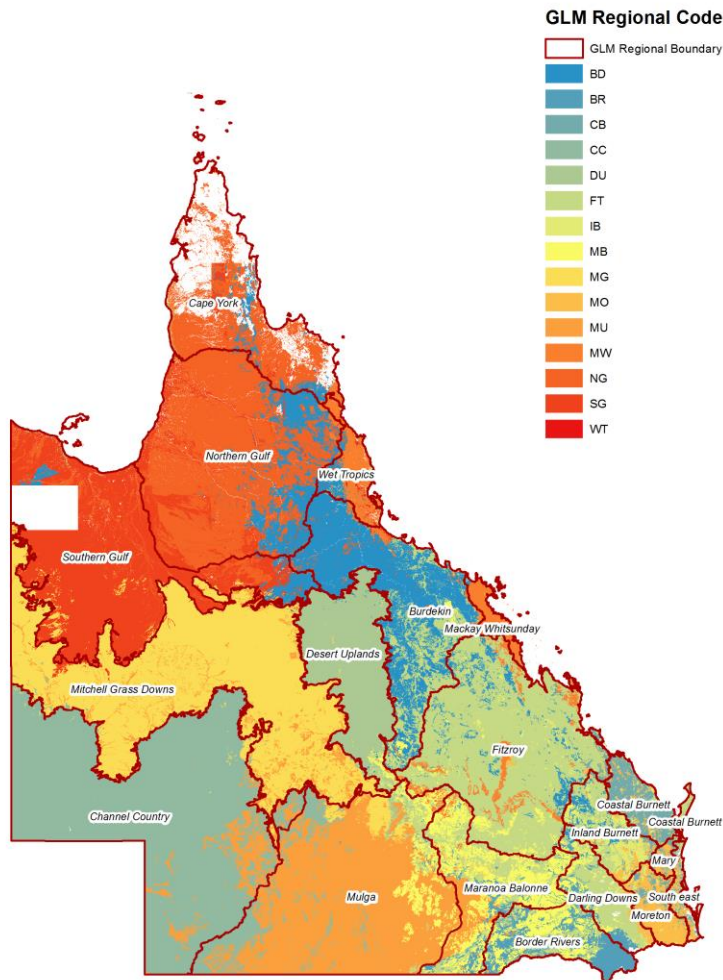


Figure 1. The GLM land types of Queensland regional code used in the Version 3 mapping shows that a number of GLM land types, particularly Fitzroy and Mulga land types, have been mapped outside of regional boundaries.

2.1.2 Non-use of a number of GLM Land types

The “area-dominant GLM land type” methodology used in Version 3 also excluded some regional GLM land types with important local characteristics. This approach resulted in 19 GLM land types that were not mapped (Table 1). However, it is acknowledged that a number of the GLM land types in this group are of limited extent and/or have not been adequately aligned to regional ecosystem mapping.

Table 1. Grazing Land Management Land types of Queensland not shown in the Version 3 mapping.

| Land Type Name | GLM Region | Code |
|--|----------------------|-------|
| Brigalow belah +/- melonholes | Border Rivers | BR02 |
| Ironbark and bloodwood on non-cracking clays (CB) | Coastal Burnett | CB07 |
| Ironbark and blue gum on basalt ridges | Coastal Burnett | CB08 |
| Open downs (CC) | Channel Country | CC08 |
| Coolibah flats | Desert Uplands | DU03 |
| Poplar box with ironbark | Fitzroy | FT25 |
| Blue gums on cracking clays | Inland Burnett | IB02 |
| Blue gums on granite | Inland Burnett | IB03 |
| Blue gums on loams and duplexes | Inland Burnett | IB04 |
| Box on erosive soils | Inland Burnett | IB06 |
| Brigalow melonholes (IB) | Inland Burnett | IB08 |
| Ironbark on basalt upper slopes and benches | Inland Burnett | IB12 |
| Silver-leaved ironbark on granite | Inland Burnett | IB17 |
| Brigalow belah scrub | Maranoa Balonne | MB03 |
| Hard mulga | Maranoa Balonne | MB08 |
| Poplar box on duplex soils | Maranoa Balonne | MB12 |
| Poplar box with sandalwood understorey | Maranoa Balonne | MB15 |
| Ashy downs (MGD) | Mitchell Grass Downs | MGD02 |

2.2 Changes to the regional ecosystem descriptions due to new mapping and interpretation

The Version 3 mapping used a previous version of the remnant Regional Ecosystems (RE) mapping (Version 6b 2010). The RE mapping has been updated to Version 10 (2018) to include the following:

- new RE mapping in Southern Gulf GLM region;
- new RE descriptions across Queensland; and
- adjustments to the remnant and non-remnant vegetation area.

The use of pre-European vegetation layer in previous version of the GLM land type mappings also added a higher level of interpreted data as opposed to observed data to the information, causing some mismatches of current vegetation areas and their GLM land type interpretation.

2.3 Progression from Version 3 to Version 4

To address the deficiencies of the GLM land type mapping the project team of Chris Holloway (DAF) and Scott Irvine (DES) formed a steering group of John Carter (DES), Ramona Dalla Pozza (DES), Shawn Darr (DNRME), Rob Hassett, (DNRME), Grant Stone (DES) and Giselle Whish (DAF). The steering group met on three occasions and agreed to:

- Document background and methodology used for previous versions of the GLM land type mapping.
- Document the methodology to be used to improve mapping.
- Identify widely distributed REs and the designation of a GLM land type.
- Engage and consult with regional experts that could assist in the interpretation of the information.

Updating of Version 3 GLM land type mapping to a non-published version (i.e. Version 4, completed January 2018) was undertaken to include:

- both pre-clear and remnant vegetation (Version 10);
- regional input on the widely distributed REs; and
- provision of documentation for changed or revised RE interpretation for GLM Land types.

The GIS methodology to update Version 3 to Version 4 was developed by Chris Holloway, Scott Irvine and Shawn Darr. The majority of the GIS work was performed by Chris Holloway, with Scott Irvine providing some assistance to GIS work, interpreting data and undertaking the subsequent overview.

The two vector spatial layers that represent vegetation mapping (based on regional ecosystems) in Queensland, used were:

1. HERB.QLD_REG_ECO_PRECLEAR (Version 10) – likely regional ecosystems before European clearing; and
2. HERB.QLD_REG_ECO_REMNANT (Version 10) – current areas not considered to be affected by European clearing.

The remnant regional ecosystem mapping described cleared areas as “cleared” or “disturbed” and included no RE information. The pre-clear layer contains interpretative RE data for these areas. To create a consistent layer, the polygons from the RE pre-clear layer were inserted into the cleared areas thus allowing for a RE description to be identified. A table documenting the alignment of regional ecosystem to GLM Land types was constructed from the GLM land type mapping-Version 3 and applied to the new land type mapping-Version 4. As the GLM land type mapping-Version 3 was based on an earlier regional ecosystem mapping, association of a number of newly described regional ecosystems to GLM land types was required. The RE to GLM land type associations for all mapping versions are available on request.

In Version 3 of the land type mapping the use of area dominant GLM land types by RE associations resulted in a number of easily identifiable errors. These were identified by the project team and following assessment of RE data were converted to the most appropriate GLM land type.

Regional experts were consulted on the changes to the RE-land type associations, mapping and on-ground interpretation of GLM land types. The regional experts included George Bourne DNRME – Fitzroy, Burdekin and Desert Uplands GLM Regions, David Phelps DAF – Mitchell Grass Downs and Channel Country GLM Regions, Bob Shepherd DAF Burdekin and Desert Uplands GLM regions and Giselle Whish – DAF Maranoa Balonne and Mulga GLM regions. The regional experts were presented with lists of RE (V10) with a wide distribution and invited to provide comment on the GLM land type classification for their respective regions. The new Version 4 RE-land type association was documented.

2.4 Progression of Version 4 to Version 5

2.4.1 Widely distributed regional ecosystems and the use of climate zones

During the review process of Version 4, we identified the RE's that were widely distributed over two to four GLM regions. This occurred as some IBRA regions that cover large geographic areas over two or more climatic zones. In order to maintain a sole land type associated with a single RE or RE combination we needed to split the RE that were identified as distributed across large geographic zones. GLM regions on their own were not considered an appropriate data layer to split a RE into sub-groups, so it was proposed that climate zones and the photosynthetic pathway of different grasses (hereafter grass type) could be used to overcome this problem. This led to the development of Version 5, where climate classes and grass type classifications were used to improve the RE to GLM land type associations. To date, the feedback regarding this approach to improve the mapping has been positive.

In Version 5, climate classes were used to split the widely distributed RE into multiple parts without having to change any RE boundaries (Figure 2). Climate classes were an agro-climate classification developed by Hutchinson *et al.* (2005) based on the Köppen climatic zones associated to IBRA subregions. The use of agro-climate classes permitted the allocation of individual REs to a regionally specific land type without any spatial division (Figure 3). As an example, the agro-climate classes were used to divide the widely distributed regional ecosystem 11.9.3 (Brigalow Belt IBRA) that was assigned as only FT29 in the Version 3 mapping (Figure 2). This RE had the largest occurrence within the Fitzroy GLM Region. However, 11.9.3 also occurred within the Burdekin and Maranoa Balonne GLM regions as BD09 and MB13 respectively. Each of these regional GLM land types has differing characteristics that were related to each region's climate. The agro-climate classes were used to divide 11.9.3 into one of the three regional GLM land types: the northern areas as Burdekin BD19; the central as Fitzroy FT29; and the southern areas as Maranoa-Balonne MB13. As not all GLM Regions were defined by biogeographic areas (Figure 3), it was necessary to allocate the GLM regions based on drainage catchments to appropriate agro-climate classes (Table 2).

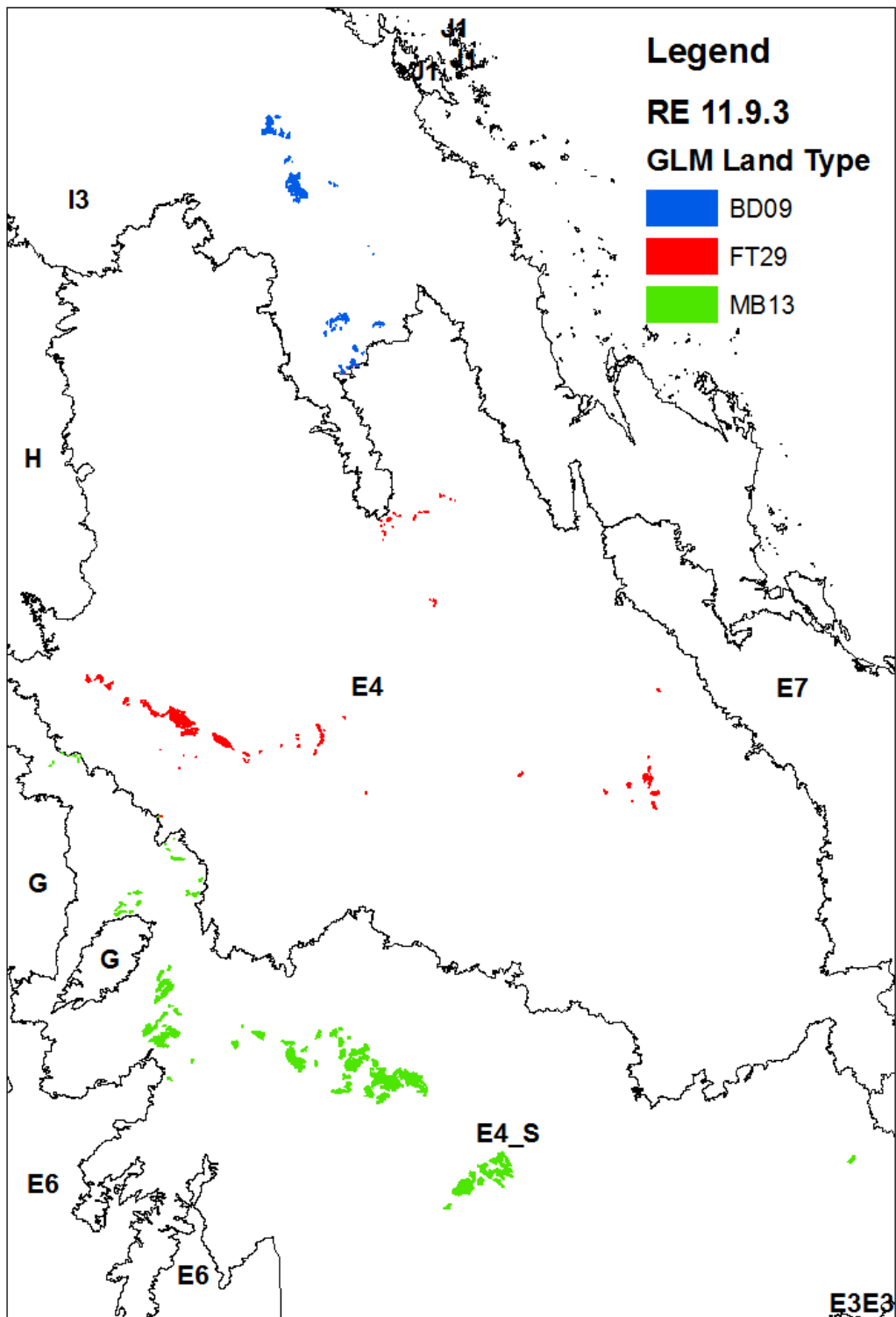


Figure 2. Map showing the wide distribution of Regional Ecosystem (RE) 11.9.3 and the final determination of a regional Grazing Land Management (GLM) land type code based on agro-climate classes. In this example, RE 11.9.3 has been divided into Burdekin (BD09), Fitzroy (FT29) and Maranoa-Balonne (MB13) GLM Land types depending on the location of the RE in relation to the agro-climate class.

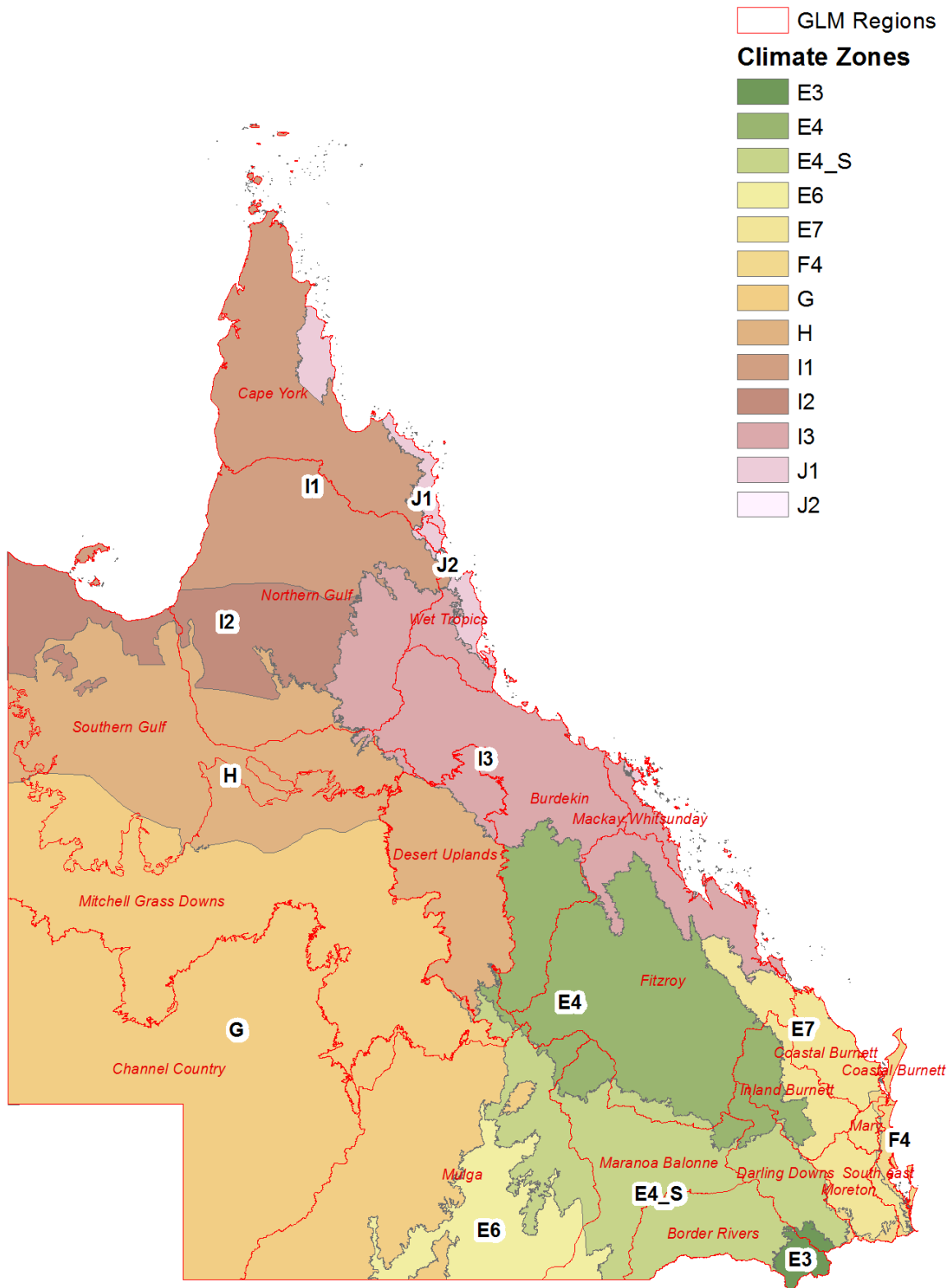


Figure 3. Map showing the location of the GLM Regions in relation to the agro-climate classes adapted from Hutchinson et al. (2005). The map shows some general relationship between the GLM regions and the climate zones. This relationship is described in more detail in Table 2

Table 2. Earlier Grazing Land Management (GLM) Region agro-climate class allocations used for Regional Ecosystems that are distributed across multiple GLM Regions.

| GLM Region and Code | Agro-climate Class | Notes |
|-----------------------------------|--------------------|------------------------------|
| Border Rivers (BR) | E4_S, E3 | |
| Burdekin (BD) | I3 | |
| Channel County (CC) | G | |
| Cape York (CY) | I1, J1 | Interim GLM Land types |
| Coastal Burnett (CB) | E7 | |
| Darling Downs (DD) | E4_S, E3 | GLM Land types not developed |
| Desert Uplands (DU) | I3 | |
| Fitzroy (FZ) | E4 | |
| Inland Burnett (IB) | E7, E4_S | |
| Mackay Whitsunday (MW) | I3 | |
| Maranoa Balonne (MB) | E4_S | |
| Mary | F4 | GLM Land types not developed |
| Mitchell Grass Downs (MGD) | G | |
| Moreton (MO) | E7 | |
| Northern Gulf (NG) | I2 | |
| South-East | F3, F4 | GLM Land types not developed |
| Southern Gulf (SG) | H | |
| Wet Tropics (WT) | J2 | |

2.4.2 Use of a C₄ and C₃ grass division

In southern areas of Queensland, the proportion of C₃ and C₄ grasses change over a gradient from south to north and leads to differing pasture production depending on the amount of rainfall received over the summer and winter months (Hattersley, 1983). A spatial layer was developed to separate the north/south spread of regional ecosystems within the Brigalow Belt bioregion to more accurately reflect the potential pasture production differences of GLM land types within southern Queensland due to varying C₃ and C₄ grass proportions. By using median winter rainfall and AussieGRASS (Carter *et al.*, 2000) modelled native pasture growth that was based on C₄ and C₃ grasses, a separation of the bioregion was possible. Separation was achieved when median value of C₄ average pasture growth of 77% was applied across the IBRA sub-regions (via ArcGIS Zonal Statistics). The allocation of Brigalow Belt sub-regions based on the agro-climate classes of Hutchinson *et al.* (2005) and AussieGRASS median proportion of C₄ average pasture growth is shown in Table 3.

Table 3. Summary of Brigalow Belt GLM land type agro-climate class and C₄ pasture growth divisions.

| GLM land type Region | Agro-climate classes* | C ₄ median growth % [#] | Brigalow Belt IBRA Sub Region |
|---|-----------------------|---|--|
| Burdekin Catchment GLM Land Types | I3 | 98 | BBN1 Townsville Plains |
| | | 97 | BBN2 Bogie River Hills |
| | | 95 | BBN3 Cape River Hills |
| | | 94 | BBN4 Beucazon Hills |
| | | 93 | BBN5 Wyarra Hills |
| | | 93 | BBN6 Northern Bowen Basis |
| | | 95 | BBN12 Nebo-Connors Ranges |
| | | 96 | BBN14 Marlborough Plains |
| Inland Burnett GLM Land Types | E7 | 93 | BBS4 Mount Morgan Ranges |
| Fitzroy Catchment GLM Land Types | E4 | >80 | All BBS Sub-regions not listed in this table |
| Maranoa and Balonne or Border Rivers GLM Land Types | E4 | 76 | BBS12 Southern Downs |
| | | 72 | BBS14 Dulacca Downs |
| | | 75 | BBS15 Weribone High |
| | | 70 | BBS16 Tara Downs |
| | | 73 | BBS17 Eastern Downs |
| | | 75 | BBS18 Inglewood Sandstone |
| | | 69 | BBS19 Moonie-Commoron Floodout |
| | | 71 | BBS20 Moonie-Barwon |
| | E3 [^] | 70 | BBS21 Northern Basalts |
| | | 70 | BSB28 Narrandool |

* Hutchinson *et al.* (2005) [#] Carter *et al.* (2000)

[^] **Minor occurrence in Queensland**

I3 – Cooler winters with a growing season lasting at least six months

E7 – Moisture is the main limit on crop growth. Growth index is lowest in Spring

E4 – Growth is limited by moisture rather than temperature and the winters are mild. Growth is relatively even through the year

E3 – Most plant growth in summer, although summers are moisture limiting. Temperature limits growth in winter

2.4.3 Absence of some GLM land types in the mapping

In GLM land type mapping version 3 and version 4, some land types were not present at all. This anomaly was as a result of some land type descriptions having no REs listed or the regional ecosystems that were listed had changed or been removed in subsequent releases. Additionally, some land types were removed as a result of the area dominate RE association to GLM land type used in Version 3 mapping. A key example of this occurred within the Wet Tropics GLM region, where

Mackay Whitsunday GLM land types were used despite both GLM regions being from different bioregions (see Wet Tropics GLM land types in Table 4).

These anomalies was corrected by using the GLM land type descriptions, GLM land type mapping-Version 2 regional ecosystem associations and the new information associated with Version 10 of Regional Ecosystem mapping (Table 4).

Table 4. The Regional Ecosystem allocation for the missing GLM land types from Version 3 mapping and currently described GLM land types that were not allocated.

| GLM Land type | Regional Ecosystems as listed on GLM land type description (Version 1.2) | Additional Regional Ecosystems as used in the GLM Mapping (Version 2) | Notes | Final RE/Agro-Climate class allocation (Version 5) |
|----------------------|---|--|---|---|
| BR02 | 11.4.3 | - | Common regional ecosystem | 11.4.3a_E4_S |
| CB07 | 12.11.8, 12.9-10.8 | 12.12.8, 12.12.27 | IB10 12.9-10.8, MO4 12.11.8, IB16 0 12.12.8. | 12.12.27_E7 |
| CB08 | 12.8.16, 12.8.17 | 12.8.16 removed | | 12.8.16_E7 |
| CC08 | 4.9.1, 4.9.2, 4.9.4, 4.9.4x1, 4.9.20 | 4.9.5, 5.9.3x1, 4.9.4x1 removed, 4.9.20 removed | 4.9.1, 4.9.2, 4.9.4, 4.9.4x1, 4.9.5 not located in Channel Country bioregion. | 5.9.3_G, 5.9.3a_G, 5.9.3b_G |
| DU03 | 10.3.15h 10.3.15i, 11.3.3 | - | 11.3.3. not located in Desert Uplands bioregion | 10.3.15h_H, 10.3.15i_H |
| FT25 | 11.5.5, 11.5.9a, 11.10.7a | 11.5.3 , 11.10.11 | | 11.5.3_E4, 11.5.3_E4_S |
| IB02 | 11.3.4, 11.3.25, 11.3.27b, 12.3.3, 12.3.7, 12.3.7b, 12.3.8 | - | | 11.3.4_E4_S, 11.3.27b_E4, |
| IB03 | 12.11.9, 12.12.12, | 12.12.23 | | 12.12.12_E7, 12.12.23_E7 |
| IB04 | 11.5.17, 12.3.10 | 12.3.11, 12.3.10 removed | | 11.5.17_E7 |
| IB06 | 11.5.13, 11.9.7, 11.11.9, 11.12.17 | 11.3.2, 11.3.18 | | 11.5.13_E4, 11.9.7_E7, 11.11.9_E7 |
| IB08 | 11.9.10, 11.11.13 | Not included in Version 2 | | 11.9.5_E7 |
| IB12 | 11.8.4, 11.8.8, 12.8.16, 12.8.17 | - | | 12.8.17_E7 |
| IB17 | 11.9.2 | Not included in Version 2 | | 11.9.2_E7 |
| MB03 | 11.3.1, 11.9.5, 11.9.5a | 6.6.4, 11.3.18, 11.9.1, 11.9.11, 11.9.13 | | 11.3.1_E4_S, 11.9.5_E4_S, 11.9.5a_E4_S |
| MB08 | 6.5.1 (in part) | Not included in Version 2 | | 6.7.2_E4_S |

| | | | | |
|-------|--|---------------------------------------|---|---|
| MB12 | 11.9.7, 11.9.7a | 11.3.26, 11.4.12, 11.5.1a and 11.5.20 | | 11.9.7_E4_S, 11.9.7a_E4_S |
| MB15 | 11.4.12 | 11.5.13, 11.9.7 and 11.9.7a | | 11.4.12_E4_S, 11.4.12a_E4_S |
| MGD02 | 4.9.3 | Not included in Version 2 | New Regional Ecosystem | 4.9.20_G, 4.9.20_H |
| MGD09 | 6.7.9, 6.7.10, 6.7.11 | Not included in Version 2 | | 4.5.2_G, 4.5.3_x70_G |
| MGD10 | 11.5.1 | - | Regional Ecosystem mapping removed (Version 10) | 4.5.3a_G, 4.5.3x1a_G, 4.5.3x1b_G, 4.5.3x2_G |
| MU07 | 4.9.1, 4.9.20 | Not included in Version 2 | | 4.9.1_E4_S, 4.9.20_E4_S |
| NG01 | 9.3.10a-b, 9.3.11, 9.3.11a, 9.8.9, 9.8.13 | Not included in Version 2 | | 9.3.10a_H, 9.3.10b_H, 9.3.11a_I2, 9.3.11a_I3 |
| NG09 | 2.8.28x11, 7.8.7a, 7.8.19, 9.8.1a, 9.8.1c, 9.8.4a-b, 9.8.4d | Not included in Version 2 | | 7.8.7a_J1, 7.8.7c_J1, 7.8.19_I1 7.8.19_J1, 9.8.1a_I2 |
| NG10 | 9.5.6a, 9.5.11a and 9.7.3x5 | Not included in Version 2 | | 9.5.6a_I3 |
| NG15 | 3.3.61b, 3.5.22x1. | Not included in Version 2 | | 3.3.61b_I1 |
| WT02 | 7.8.7b, 9.8.1b, 9.8.2a-b, 9.8.4c, 9.8.9, 9.8.10a, 9.8.11a, 9.8.13 | Not included in Version 2 | | 7.8.7b_I3, 7.8.7b_J1, 9.8.2a_I1, 9.8.2a_I3, 9.8.2a_J1, 9.8.2a_J2, 9.8.2b_I1, 9.8.13_I1 |
| WT04 | 7.8.7c, 7.8.8a-b, 7.8.10a, 7.8.15a-b, 7.8.16a-c, 7.8.17a-b, 7.8.18b, 7.8.18d, 7.8.19, 9.8.1, 9.8.2 | Not included in Version 2 | | 7.8.7c_J1, 7.8.8b_J1, 7.8.18b_J1, 7.8.19_I1, 7.8.19_J1 |
| WT05 | 7.11.37a, 7.11.41a-b, 7.12.63, 7.12.69a-b, 9.11.3b, 9.12.31a | Not included in Version 2 | | 7.11.37a_J2, 7.11.41a_J2, 7.11.41b_J2, 7.12.69a_I1, 7.12.69a_J1, 9.11.3b_I1, 9.11.3b_J1, 9.12.31a_I1, 9.12.31a_J1 |
| WT06 | 7.5.1b, 7.5.1d, 7.5.2a, 7.5.2c-d, 7.5.4a-e, 9.5.5a-b, 9.5.6a, 9.5.8, 9.11.7a-b, 9.12.3 | Not included in Version 2 | | 9.5.8_I1, 9.11.7a_I1, 9.11.7a_J2, 9.11.7b_I1, 9.12.3_I1 |
| WT07 | 9.5.6a, 9.5.6b | Not included in Version 2 | | 7.11.34_J1, 7.11.34a-d_J1, 7.3.8a-c_I3 7.3.8a-d_J1, 7.3.8a-c_J2 |

2.5 Additional GLM land types

The Version 5 mapping includes interim Cape York GLM land types and a separate classification for natural environments across Queensland. To date there are no land type descriptions for the Cape York GLM region. These are shown in Table 5 and Table 6. The natural environment category defines polygons that are not described with a RE, or described as non-grazing ecosystem. These natural environments are miscellaneous units that are not considered suitable for GLM land type designation.

Table 5. Interim Cape York GLM Land Types.

| Code | Description | Code | Description |
|-------|--|-------|---|
| CYP01 | Coastal country | CYP08 | Tea tree plains |
| CYP02 | Marine couch plains | CYP09 | Box (Molloy red box and shiny-leaved box) |
| CYP03 | Bloodwoods on frontage and alluvium | CYP10 | Stringybark |
| CYP04 | Heaths | CYP11 | Bloodwoods on uplands |
| CYP05 | Tussock grasslands | CYP12 | Ironbark |
| CYP06 | Wiregrass-wanderrie (Aristida-Eriachne) plains | CYP13 | Shallow stony land |
| CYP07 | Vegetated swamps | CYP14 | Scrubs-vine forest and rainforest |

Table 6. Interim Natural Environment GLM Land Types.

| Code | Description | Code | Description |
|------|-------------|------|-----------------|
| AL01 | Estuary | AL08 | BLANK |
| AL02 | Island | AL09 | Water |
| AL03 | BLANK | AL10 | Wetland |
| AL04 | Mangroves | AL11 | Beach |
| AL05 | Ocean | AL12 | Coastal swamp |
| AL06 | Other | AL13 | Coastal wetland |
| AL07 | Sand | | |

2.6 Progression within Version 5

2.6.1 Use of Hard Mulga and Soft Mulga Decision Criteria

During the field inspection with regional experts of the Mulga GLM region, two REs (6.7.10 and 6.7.12) previously described as Hard mulga (MU04) showed significant Soft mulga components, particularly in the northeast of the Mulga GLM region. After reviewing the associated land resource documentation (Dawson, 1974) and the floristics of the two REs these areas are likely to have poplar box (*Eucalyptus populnea*) present which is a general indicator of Soft mulga country (Dawson, 1974).

Additionally the soils in these associated land system mapping are formed in situ from deposition of Tertiary material in the vicinity, in these cases, the areas are not strictly RE land zone 7 (in-situ Tertiary residuals) but more likely land unit 5 (post Tertiary sandy/loamy deposits). However, the scale of the RE mapping was unable to separate the Poplar box component.

As there are 704 individual polygons of RE 6.7.10 and 6.7.12, it was necessary to create a decision raster to designate individual RE polygons as Soft mulga (MU09). To facilitate the mapping three decision rules were incorporated in Version 5.3 in order to divide the 6.7.10 and 6.7.12 into either Hard or Soft Mulga GLM land types.

The DSMART modelling of Queensland Land Systems (Irvine *in preparation*) allowed a number of land units with Mulga incorporating Poplar box land units to be mapped (see Table 7). Soil potassium is generally an indicator of the age of the soil. Hence, it would be expected that soil potassium would be lower in RE land zone 5 compared to land zone 7, due to the increased time of weathering or exposure that transported material would have in regards to soil development. In-situ soils formed by solid Tertiary materials would have a higher potassium content compared to soils formed by transported material.

Minty et al. (2009) has provided a modelled filtered radiometric potassium radiometric coverage of Australia. This spatial product is able to designate areas of recent soil development due to the amount of potassium within the soil profile. Areas that are recently exposed within the 6.7.10 and 6.7.12

polygons were shown to have higher levels of radiometric potassium compared to areas that contain deposition of debris or relict materials. By calculating a mean value for the DSMART modelled land units that are contained within all Mulga RE's with land zone 7, a value was found to potentially separate Hard and Soft mulga (0.43 mean radiometric potassium %) . Table 7 shows the results of these calculations.

Table 7. Decision criteria of mean radiometric potassium percentage in common* WARLUS land units within Mulga Land Zone 7 Regional Ecosystems showing units with Poplar box having a lower mean.

| Contains Poplar Box | DSMART Areas | Land Unit | Approximate Area of RE 6.7x (%) | Mean Radiometric Potassium % | |
|---------------------|--|-----------|---------------------------------|------------------------------|------------------|
| Yes | WARLUS Part 1 | 49 | 5.8 | 0.40 | |
| | WARLUS Part 3 | 38 | 6.0 | 0.40 | |
| | | 42 | 2.5 | 0.40 | |
| | | | Total 14.3 | Mean 0.40 | |
| No | WARLUS Part 1 | 26 | 1.2 | 0.49 | |
| | | 42 | 1.3 | 0.49 | |
| | | 50 | 9.3 | 0.45 | |
| | | 51 | 8.0 | 0.44 | |
| | | 52 | 3.4 | 0.44 | |
| | | 56 | 3.6 | 0.49 | |
| | | 58 | 9.6 | 0.48 | |
| | | 64 | 1.2 | 0.48 | |
| | | 88 | 1.2 | 0.48 | |
| | | 89 | 1.3 | 0.46 | |
| | 90 | 10.9 | 0.44 | | |
| | WARLUS Part 2 | 17 | 3.8 | 0.50 | |
| | | 19 | 1.0 | 0.43 | |
| | | 24 | 1.6 | 0.42 | |
| | | 26 | 2.3 | 0.42 | |
| | | 31 | 8.9 | 0.43 | |
| | WARLUS Part 3 | 38 | 6.0 | 0.40 | |
| | | 57 | 1.5 | 0.50 | |
| | | 59 | 1.4 | 0.40 | |
| | WARLUS Part 4 | 58 | 1.3 | 0.43 | |
| | | | | Total 72.9 | Mean 0.46 |
| | * Common refers to areas greater than 1%. In total there are 186 land units, most are less than 1% in area within REs 6.7x | | | | |

The mean for each individual RE polygon (6.7.10 and 6.7.12) was then calculated from DSMART and radiometric potassium masks. Any polygon mean of ≥ 1.5 was selected (184 polygons) and each was examined with the SPOT 2012 imagery to determine if any Mulga clearing has occurred and landscape location. If Mulga clearing within the RE polygon was observed or located in lower landscape positions, the polygon was assigned as Soft Mulga (MU09). As a result of this process, a total of 102 polygons (14%) were assigned as Soft Mulga (MU09).

2.7 Revision of I3 Climate Zone (Shoalwater Bay Area)

Feedback from the Ametdale Northern Gulf demonstration project showed some inconsistency in the allocation of the GLM land types. The area has been described with the Brigalow Belt Bioregion, however proximately to the exposed coast generates a higher rainfall. The increased rainfall suggests a closer correlation towards Mackay Whitsunday GLM grazing land types which are based on the Central Queensland Coast Bioregion regional ecosystems.

As the I3 climate zone incorporates parts of the Burdekin, Fitzroy, Mackay Whitsunday and Wet Tropics GLM regions, a review was required.

Regional Ecosystems within the I3 climate area bioregion were assigned an average Prescott Index number as calculated by ArcGIS Zone Statistics. The Prescott Index is a simple index of water accumulation, where rainfall exceeds evaporation and shown to be useful in determining bioregional differences. Areas with a high Prescott Index were assigned GLM Land Types from the Mackay Whitsunday catchment. It is note that smaller RE will tend to have a higher mean due to the limited distribution of the Prescott Index.

Table 8. The Regional Ecosystem allocation changes for the Shoalwater Bay area

| Regional Ecosystem (Version 10) | Prescott Index Zonal Mean | GLM Land Type (Version 5.3) | GLM Land Type (Version 5.4) |
|---------------------------------|---------------------------|-----------------------------|--|
| 11.12.6b | 1.39 | FT12 | MW06 no |
| 11.12.19 | 1.24 | BD16 | MW06 no |
| 11.12.18a | 1.03 | FT17 | MW06 no |
| 11.11.4b | 0.99 | MW06 | MW02 ok |
| 11.11.4d | 0.95 | FT22 | MW02 ok |
| 11.11.4 | 0.94 | FT22 | MW02 |
| 11.11.4c | 0.93 | FT16 | MW02 no south of shoal water bay |
| 11.12.12 | 0.93 | FT29 | AL02 yes |
| 11.11.4a | 0.89 | FT30 | MW02 ok |
| 11.11.20 | 0.88 | FT08 | MW08 ok |
| 11.11.5a | 0.87 | IB09 | MW02 no south of shoal water bay |
| 11.12.13 | 0.85 | FT20 | MW02 ok |
| 11.3.25g | 0.85 | FT02 | MW01 yes |
| 11.12.3 | 0.83 | FT22 | MW02 no BD11 north end climate I3 |
| 11.5.8a | 0.83 | FT08 | MW02 yes |
| 11.12.6a | 0.82 | FT30 | MW02 yes (Ametdale) |
| 11.3.13 | 0.82 | BD08 | MW01 yes |
| 11.3.27x1b | 0.82 | FT02 | MW01 yes |
| 11.3.12 | 0.80 | FT10 | MW02 yes |
| 11.3.9a | 0.80 | FT10 | BD13 yes |
| 11.2.1a | 0.80 | FT20 | MW02 yes |
| 11.3.27e | 0.79 | FT02 | BD13 no AL10 |
| 11.12.7 | 0.79 | BD16 | MW02 no change |
| 11.3.27x1a | 0.79 | FT02 | MW05 yes |
| 11.5.8 | 0.79 | FT10 | MW04 yes Ametdale |
| 11.3.29a | 0.78 | FT08 | MW01 yes Ametdale |
| 11.11.3 | 0.78 | FT30 | MW02 no south of shoal water bay |
| 11.11.15a | 0.77 | FT22 | MW02 yes I3 climate only |
| 11.11.15b | 0.77 | BD15 | BD14 yes |
| 11.3.12a | 0.77 | FT10 | MW04 yes |
| 11.3.30d | 0.75 | BD14 | BD13 yes |
| 11.5.8b | 0.75 | FT08 | MW02 yes |
| 11.3.26 | 0.72 | FT02 | MW02 no south of shoal water bay |
| 11.3.35 | 0.72 | FT08 | BD13 11.3.35_E4 is FT03 box flats, 11.3.35_I3 is MW08 Poplar gum woodlands |

3 Review of the RE to GLM Land type associations

We initiated a process to review the RE to GLM Land type associations created in the above methodology. The associations were reviewed by regional experts for each GLM region (see Table 9).

Validation of the methodology used to improve mapping has involved comprehensive consultation with regional experts. To date, David Phelps (DAF), Jenny Milson (DAF), Jed Sommerfield (DAF), Bob Shephard (DAF) and George Bourne (NRME) have provided positive feedback on specific RE by climate allocations to GLM land types. The consultation also included field trips to Emerald, Charters Towers, Charleville and Longreach during 2017-2018 as well as meetings in Brisbane.

Approximately 48% of Regional Ecosystem associations were changed due to:

- The revision of the Channel County, Mitchell Grass Downs, Northern and Southern Gulf GLM land types;
- implementing agro-climate classes and grass type divisions for the Brigalow Belt IBRA (Border Rivers, Burdekin, Darling Downs, Fitzroy, Maranoa Balonne GLM regions); and,
- matching new Regional Ecosystems created in Version 10 to GLM land types; and
- matching unmapped GLM land types to regional ecosystems.

The majority of changes of individual RE associations occurred in Southern Gulf and Northern Gulf GLM regions (Figure 5). The distribution of GLM Land types based on the GLM regional code (Figures 4 and 5) illustrate the changes that have occurred from the Version 3 to Version 5 mapping.

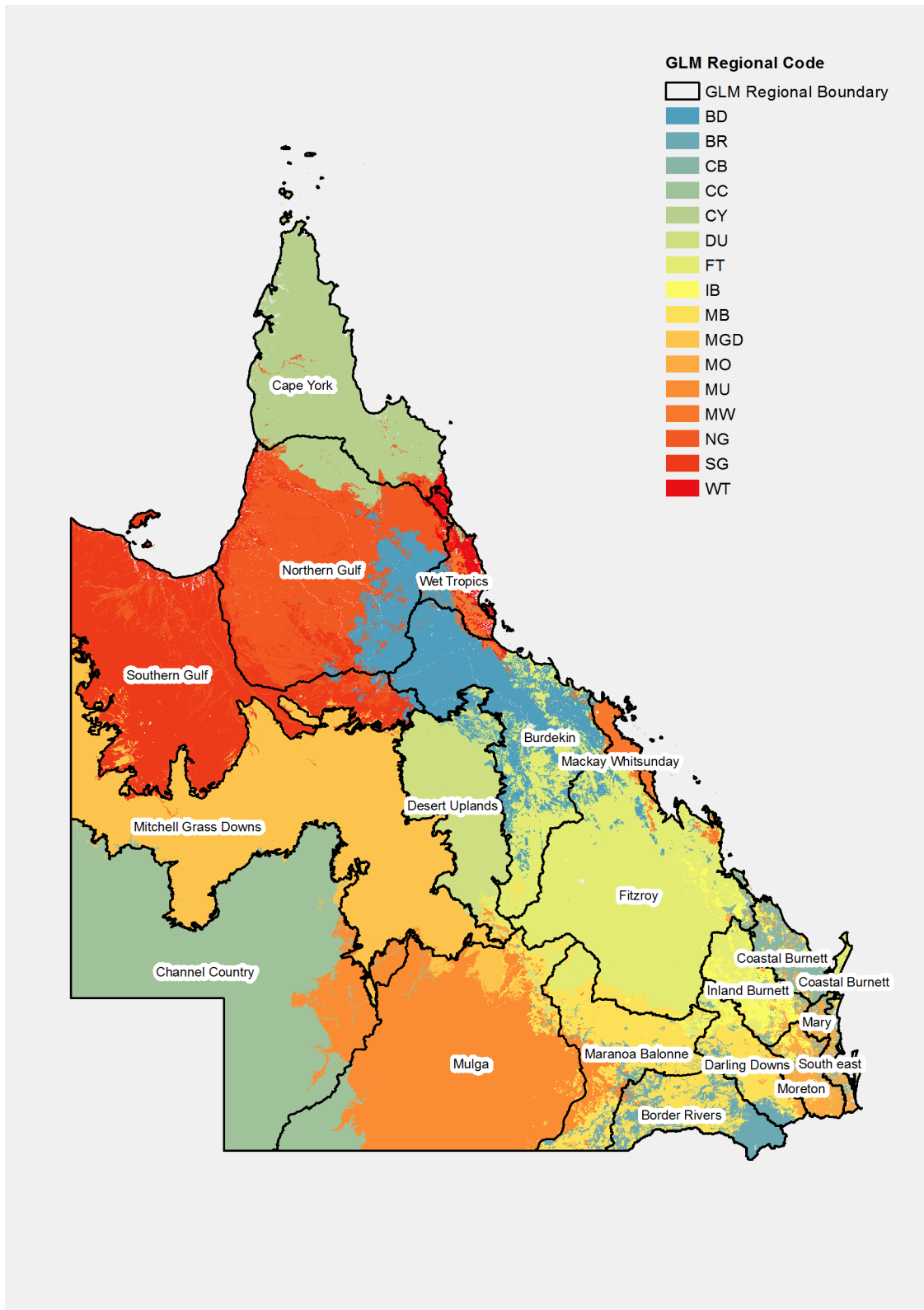


Figure 4. The distribution of GLM Land types based on GLM Regional code used in the Version 5 mapping.

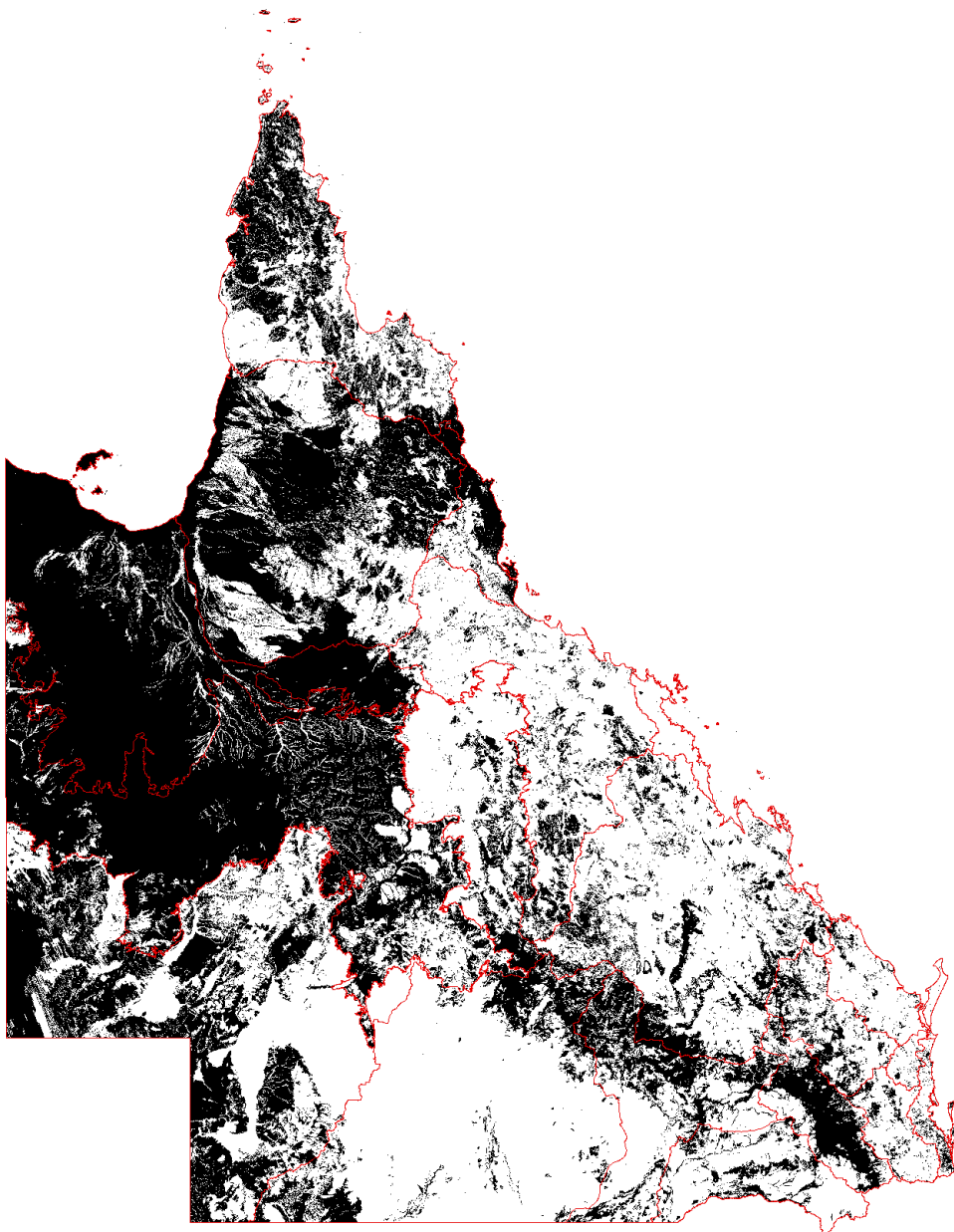


Figure 5. Overall changes in the individual GLM land types from Version 3 to Version 5.4 mapping as shown by dark areas.

3.1 Property Examples

A selection of properties was used to demonstrate the differences in the GLM land type mapping from Version 3 to Version 5 (Table 10).

Table 9. Selected properties to demonstrate the GLM land type changes from Version 3 to 5 mapping and possible land management differences due to these mapping changes.

| Property | GLM region | Changes | Effects |
|---------------------------|------------|--|---|
| Alice Downs | Mulga | No changes | Nil |
| Maryvale | Mulga | | |
| Wyoming | Mulga | | |
| Kilmore | Mulga | | |
| Wambiana | Burdekin | | |
| Woodland | Mulga | | Landholder feedback suggested changes to individual polygons (see <i>Conversion to Single Part Polygons</i>) |
| Victoria Downs (Figure 6) | Mulga | Southern boundary – MU01 replaced DU11 (Version 3). | Within the changed land type: estimated pasture utilisation drops from 30% to 20%, more emphasis on Brigalow as opposed to Gidgee. Description matches the proximately to the alluvial areas. |
| | | Northern boundary – MB09 replaced MGD06 (Version 3) | Tree species match Mulga bioregion |
| | | Northern boundary – MB12 replaced FT24 Version 3) | Utilisation increases to 25% from 20%, difference in preferred grass species. |
| Spyglass (Figure 7). | Burdekin | Throughout - BD16 replaced NG08. Polygon changes from RE version 10. | Utilisation decreases to 10%, difference in preferred grass species. |



Figure 6. Map of Victoria Downs showing the GLM land type changes (shaded) from Version 3 to Version 5. Table 7 provides a description of the changes.

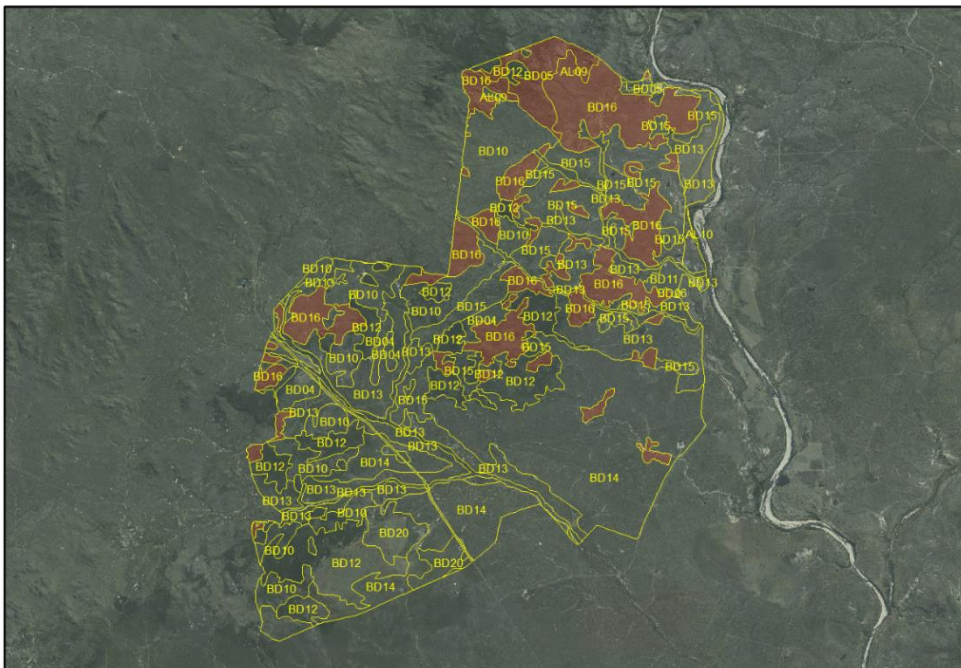


Figure 7. Map of Spyglass showing the GLM land type changes (shaded) from Version 3 to Version 5. Table 7 provides a description of the changes.

Table 11. Validation summary relating persons involved, planned future validation, the area (ha) and number of regional ecosystem associations that changed from land type Version 3 to Version 5 mapping for each GLM region.

| Grazing Land Management Region | Validated by regional expert | Future Validation | Area changed (ha) | Number of RE by Climate combinations changed |
|--------------------------------|--|---|-------------------------------------|--|
| South east | No | | Included in Moreton region | |
| Moreton | No | | 177788 8% | 49 23% |
| Darling Downs | In progress | November 2018 | Currently included in Border Rivers | |
| Border Rivers | Giselle Whish ¹ | Completed | 234979 8% | 17 23% |
| Mary | No | | Included in Coastal Burnett region | |
| Coastal Burnett | No | Damien O'Sullivan Steven Bray 2019 | 206624 9% | 27 24% |
| Inland Burnett | No | Damien O'Sullivan Steven Bray 2019 | 1141494 45% | 41 38% |
| Maranoa Balonne | Giselle Whish ¹ | Completed | 4718728 51% | 59 58% |
| Mulga | Giselle Whish ¹ Jed Somerville ¹ | Completed | 3301236 17% | 21 11% |
| Fitzroy | George Bourne ² | Completed | 4827282 24% | 90 19% |
| Mackay Whitsunday | No | 2019 | 9537 < 1% | 10 3% |
| Burdekin | Bob Shepherd ¹ , Chris Holloway ¹ | Completed | 2249991 19% | 60 17% |
| Desert Uplands | Bob Shepherd ¹ | Completed | 1287232 19% | 14 4% |
| Mitchell Grass Downs | David Phelps ¹ , Jenny Milson ¹ | Completed | 19217154 79% | 190 78% |
| Channel Country | David Phelps ¹ , Jenny Milson ¹ | Completed | 12354192 53% | 40 37% |
| Wet Tropics | No | Joe Rolfe ¹ 2019 | 579370 85% | 408 86% |
| Southern Gulf | Bob Shepherd ¹ , Jenny Milson ¹ , Rebecca Gunther ¹ | Completed | 17758781 98% | 422 99% |
| Northern Gulf | No | Joe Rolfe ¹ 2019 | 9116250 64% | 309 65% |
| Cape York | In progress | Joe Rolfe ¹ , Giselle Whish ¹ , Chris Holloway ¹ . | 5425312 63% | 242 51% |

1 DAF, 2 DNRME

4 Future Work

At the time of writing, the project team were unable to get regional experts to provide feedback on the Northern Gulf GLM regions. However, as part of the continued improvement program, regional experts will be consulted during planned visits in 2019 (Table 2). In addition, planned visits for the Cape York regions are expected to be in 2020 (Table 2). Validation will also be required for the South-East, Moreton, Mary, Coastal and Inland Burnett GLM regions.

As part of the *Inside Edge for Graziers to adapt to Queensland's drought prone climate* project funded by Reef CBRC and the Drought and Climate Adaptation programs, DES and DAF staff will continue to validate GLM land type mapping across Queensland in order to provide the best possible land type spatial layer to service both government and public needs.

4.1 New GLM Land types

The Darling Downs GLM region will have land type descriptions developed in November 2018 (Table 2). These new land types will require RE interpretation before being incorporated into the mapping. Additional checks with the interpretation of bordering regions will also be carried out at this time. As this work is not expected to have any structural changes to the methodology, the update will be incorporated into future Versions.

4.2 RE Polygon Co-dominance

Within the RE spatial layers, each polygon may have up to 5 individual RE described and a percentage expressed that estimates the proportion of the polygon that the 5 different REs occupy. In the majority of cases, there is a dominant RE occupying more than 70% of the area of individual polygon. Where a polygon has multiple REs it is called RE polygon co-dominance.

Within Version 5, polygon co-dominance was not reviewed. The first dominant RE (RE1) code for each polygon was used to identify the most appropriate land type. Version 6 will convert all co-dominant RE to a land type, and combine the percentage proportions of the land types into a codominant land type list. This will produce a percentage of area of the land types present in each polygon.

5 Recommendations

It is proposed that the dataset is fully published as an internal spatial layer to Spatial Information Repository (SIR) and external to QSpatial and other spatial engines. The GLM spatial layer Version 5 has been tested for GIS topology and metadata approved by all contributors. This document has been made available to DNRME, DAF and DES staff for feedback.

6 References

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7 Appendices

7.1 Version 5.1 December 2017

Minor topology errors corrected, boundary slithers corrected Burdekin and Northern Gulf

7.2 Version 5.2 March 2018

Review of the Regional Ecosystems and Mitchell Grass Downs GLM Land Types incorporated.

5.2a June 2018 - Minor textural errors corrected – Southern and Northern Gulf GLM Catchments

5.2b July 2018 - Minor textural errors corrected – Southern and Northern Gulf Catchments

7.3 Version 5.3 October 2018

Review of the Regional Ecosystems and Mulga GLM Land Types incorporated. New decision rule to determine the boundary between Hard (MU04) and Soft Mulga (MU09) for RE 6.7.10 and 6.7.12.

Minor topology errors corrected, boundary slithers within Mulga GLM catchment.

Review of the Regional Ecosystems and Channel Country GLM land types incorporated.

7.4 Version 5.4 December 2018

Review of Shoalwater Bay area incorporated.

Review of the Regional Ecosystems and Southern Gulf and part Northern Gulf GLM land types incorporated.