Department of Agriculture, Fisheries and Forestry

Queensland Agricultural Land Audit Method

Technical Report

Great state. Great opportunity.

Queensland Government

This publication has been compiled by the Agricultural Land Audit Team of Agricultural Resources and Planning Branch, Department of Agriculture, Fisheries and Forestry. Its purpose is to document the data sources, technical tools and methods, and the assumptions that comprise the mapping method used by the Queensland Agricultural Land Audit. It should be read in conjunction with the regional and statewide reports of the Queensland Agricultural Land Audit (available for download at http://www.daff.qld.gov.au).

Contents

Table of figures, images and tables

Summary

The Queensland Agricultural Land Audit (the Audit) was conducted during 2012-13 to identify '*land important to current and future agricultural production across Queensland*'. Outputs from the Audit were required to support the Queensland Government's Agriculture Strategy which aims to *double Queensland's agriculture, fisheries and forestry by 2040*, and it's policy for statutory regional planning which aims to *reduce land use conflicts, coordinate program delivery* and *deliver certainty*.

The Audit was an ambitious project. Its objective was to map the location, extent and character of land that is currently used (or has potential to be used) for agriculture, across the whole of Queensland. While the mapping outputs were not expected to be at a scale suitable for localised planning they were expected to be at a scale suitable for planning at the regional level for each of the 12 regions. Agriculture was defined broadly, to cover a diversity of commodity types and production systems, ranging from intensive livestock, horticulture, broad-acre cropping, grazing and forestry.

A fit for purpose method was developed for the Audit that relied only on using existing resources, data, and knowledge. This method was informed by a review of preceding work in Queensland and elsewhere throughout the world.

The method for the 2012-13 Audit differed however in significant ways from that used in previous studies. This reflects the very substantial changes that have occurred over recent decades in the nature of agriculture, information demands of agricultural land-use policy and planning, and the scientific and technical capacity to conduct an audit. For instance, the Audit utilised standardised mapping of land-use for the whole of the state available for the first time through the Queensland Land Use Mapping Program. Also, for the first time, Agricultural Land Classes were consistently mapped across the state and linked into a single continuous spatial dataset.

The Audit used a desktop based method analysing existing datasets or data developed from existing datasets, and presenting them using existing tools and expert knowledge in a Geographic Information System. The method comprised the following six tasks:

Task 1: Establish regional context
Task 2: Map current agricultural land use
Task 3: Map agricultural land use potential
Task 4: Identify areas important for agriculture
Task 5: Validate
Task 6: Synthesise, interpret and report

Outputs from the Audit include:

- A written report for each regional planning area (individually, or in a couple of instances where two regions are very similar, combined) and a statewide overview. Each report contains a profile of agriculture in the region or state; maps and descriptions of current and potential agricultural land use; and information about the opportunities and constraints for potential agricultural uses and threats to current use.
- Spatial datasets of agricultural land-use, agricultural potential and Important Agricultural Areas. These will be distributed in digital form through existing networks (such as the Queensland Government Information Service portal) for use by the state government departments and local governments.
- A Technical Report (this document) that: describes the methods used; reviews relevant literature; lists data and other inputs; defines key terms; and provides advice on the level of confidence in the outputs and the uses for which they are appropriate.

1. What is an Agricultural Land Audit and why does Queensland need one?

The Oxford Dictionary defines the word audit as "*a systematic review or assessment of something*" (http://oxforddictionaries.com accessed 26th November 2012). An Agricultural Land Audit is therefore a systematic review or assessment of land and its use (or potential use) for agriculture.

Information about land resources is crucial for making good decisions about management and allocation of land. Land is a fundamental input to agricultural production systems. Land with special characteristics such as high fertility and arability is scarce and highly sought after by competing uses. Decisions about land made without good information can result in it being allocated to the wrong use, risking over or under-utilisation and consequent degradation or missed opportunities. Only after taking stock of current land use and land potential is it possible to make sound decisions about the allocation of land for future use. A land audit is consequently an essential precursor to any well informed land use planning decision.

1.1 Current Queensland Government policy in relation to the Audit

The conduct of a *comprehensive audit of agricultural land* was a commitment of the Queensland Government in March 2012. The Agricultural Land Audit was proposed to support the Agriculture Strategy which aims to *double Queensland's agriculture, fisheries and forestry by 2040*, and its policy for statutory regional planning which aims to *reduce land use conflicts, coordinate program delivery* and *deliver certainty*.

The Governments vision for the Audit was to undertake *the most comprehensive audit of agricultural land in Queensland's history*. The Audit would *identify current and future food production areas in Queensland* to enable the proposed statutory regional plans to *better identify and plan for additional future food production land in Queensland*. It would do this by *drawing together key data to identify land that is capable of being further developed to support increased food production*. The Government also identified a gap in current capability to monitor agriculture and cropping land in Queensland.

1.2 Recent changes in Queensland agriculture

It has been more than 30 years since an equivalent study (that of Weston et al 1981) to the Agricultural Land Audit was last conducted in Queensland. Weston et al (1981) used the best data and tools available at that time. They divided the state into 3,283 different units of land using 1:2 million scale mapping of soil associations drawn from Commonwealth Scientific and Industrial Research Organisation (CSIRO) 1968 Atlas of Australian Soils (Northcote et al 1960). For each of these units of land, current (at that time) and potential agricultural use were then estimated by field officers based on their local knowledge, and on descriptions of the soil, climate, and landform characteristics of the units contained in the Atlas. Of the 93% of Queensland (or 160.8m ha) that was considered to be available for agriculture at that time Weston et al found that all had potential for grazing (of which 154.8m ha was being used for that purpose), 23.5% (40.6m ha) had potential for sown pastures (of which 3.9m ha was being used for that purpose) and 8.2% (or 14.2m ha) had potential for cropping (of which 2.1m ha was being used for that purpose) (Weston et al 1981).

Since 1980 agriculture in Queensland has changed in a number of important ways that make it timely that the previous work by Weston et al be revisited. Some of these are discussed in detail below.

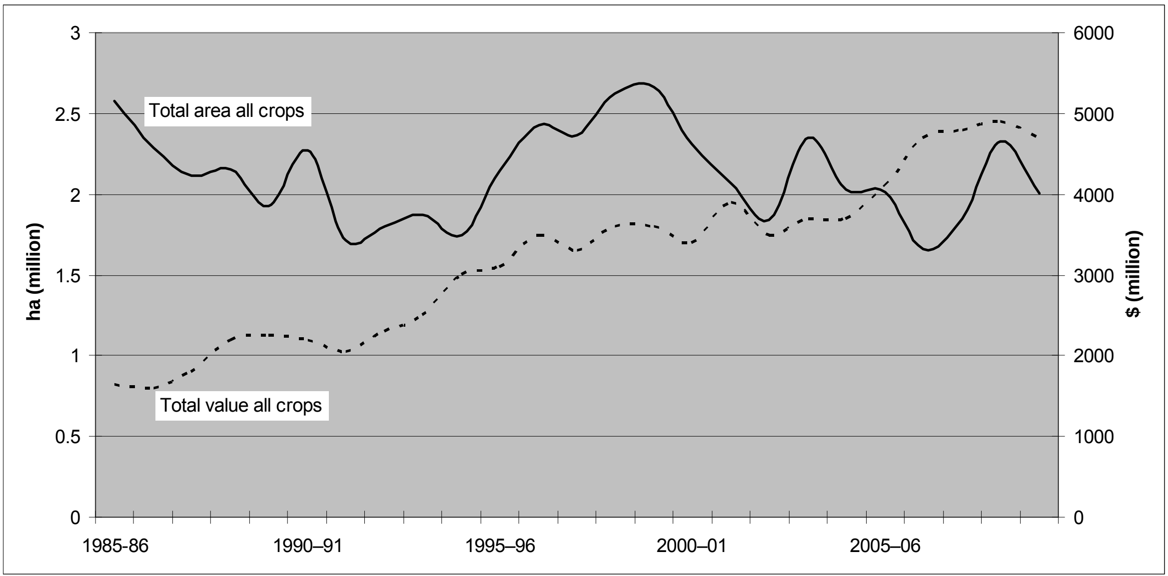
1.2.1 Changes in the nature and extent of agricultural land use

Since 1980, both the proportion of the total land area used for agriculture, and the total number of agricultural holdings, have declined in every state of Australia (Commonwealth of Australia, 2001). In Queensland over this period, the area of the state used for agriculture has fallen by 17% (to 77% of the total land area) and the number of farms occupying that area has fallen by 22% (ABS 1980, ABS 2012). These changes have variously been attributed to growing demands on land for non-agricultural uses such as housing, infrastructure, industry, conservation mining and energy, and to the pressure on farmers to consolidate and innovate in the face of declining terms of trade and increasing mechanisation of farming systems (Commonwealth of Australia, 2001).

The population of Queensland has more than doubled since 1980, and is becoming increasingly urbanised. In 2011 86% of the population resided in urban areas, which are almost exclusively coastal and overwhelmingly concentrated in the southeast of the state (Queensland Government 2012). Consequently coastal areas have experienced ongoing conversion of land from agriculture to other uses, in particular housing and infrastructure to accommodate the rapidly growing population. The broad implications of this are to some extent disguised by the slow pace of land use change across other regions of the state and by the displacement and cascading substitution of one form of agriculture for another. For instance, whilst the total extent of land used for cropping in Queensland has remained relatively stable for the past 30 years – fluctuating between 1.5 and 2.5 million hectares depending on seasonal conditions (see Figure 1) – the footprint of cropping land use has changed as urban and other intensive land uses have excluded cropping from some areas and cropping has in turn displaced grazing from other areas.

The nature of agriculture has also changed. Agriculture is increasingly viewed as a business in the same way as any other commercial enterprise seeking to increase profitability through innovation to increase production and reduce costs, and by expanding market share. In 2005 the Productivity Commission noted that agriculture in Australia had become more diverse and increasingly export oriented over the previous two decades - by 2005 around two-thirds of agricultural production across Australia was being exported - with less reliance on commodities such as wool and more on non-traditional and/or processed products such as seafood, wine and cheese (Productivity Commission 2005). In Queensland the total value of commodities produced from cropping has climbed steadily since 1980 (see Figure 1). This can in part be attributed to an increase in production levels through for example, irrigation - the area of crop grown under irrigation has increased by 2½ times since 1980, to 500,000 hectares (or 21% of the area under cropping) in 2009/10 - and in part by transition to higher value crops. The areas planted to cotton, and sugar, in 2010/11 were 400%, and 60%, greater respectively, than the areas planted to these crops in 1980.

Figure 1: Area and value of agricultural cropping in Queensland 1985 to present



Source: Australian Bureau of Statistics (ABS), Crops and Pastures, Queensland Agricultural Census, cat. no. 7321.3; ABS, Agriculture, Queensland, cat. no. 7113.3; ABS, Agriculture, Australia, cat. no. 7113.0; ABS, unpublished data; Australian Bureau of Statistics, Agricultural Commodities, Australia, cat. no. 7121.0.

Pastoral industries have also changed. With the decline in prices for wool and dairy products the numbers of sheep and dairy cattle have declined rapidly in Queensland since 1980 (by more than 70% and 60% respectively) (ABS 1980, ABS 2012). Meanwhile, the number of beef cattle has increased only slightly (by around 7% on 1980 numbers) (ABS 1980, ABS 2012). This can be attributed to a decline experienced in the total area available for grazing (from over 150 million to less than 130 million hectares) due to expansion of conservation, urban, infrastructure and other non-agricultural uses of land (ABS 1980, ABS 2012) and also the relatively modest productivity gains made over this period by the pastoral industry compared with cropping (Australian Government 2005). Droughts, floods, and fires have also been a contributing factor.

Agriculture has also been affected by changes in land tenure. In Queensland the proportion of freeholded land increased by 5% from 1980 to almost a quarter of the state by 2011 (ABS 1980, ABS 2012). Across the same period rural Queensland experienced a rapid increase in the area of mining tenements (from around 7% to more than 50% of the state) (ABS 1980, https://webgis.dme.qld.gov.au/webgis accessed 1/11/2012) the great majority of which underlie land currently being used for agriculture.

1.2.2 Changes in expectations of agricultural land use policy and planning

The questions being asked of this Agricultural Land Audit differs in important ways from those asked of Weston et al (1981) 30 years ago. The Audit is expected to provide an evidence base for important policy and planning decisions about agriculture not just for the whole of Queensland but also for regions. It will inform decisions not just in the current and near future but also in the long-term as the Government progresses its agenda of *doubling Queensland's agriculture, fisheries and forestry by 2040*. Apart from identifying land that is a priority for protection through planning instruments, information from the Audit is also expected to help guide other strategic investment by governments and the private sector. By documenting and/or mapping constraints to agricultural development the Audit will provide a consistent and comprehensive logic to identifying opportunities that have the potential to deliver benefits to economic development through agriculture and that as such should be a priority for action. Such opportunities could be investment in upgrading strategic infrastructure or they could be actions to address critical knowledge gaps. The quality of such decisions will obviously depend on the accuracy and quality of the base information underpinning the Audit.

Social changes over recent decades also have implications for the conduct of the Audit. Although the population of Australia has become increasingly urbanised with fewer individuals having strong personal connections with mainstream agriculture, concern about environmental issues amongst the population generally has remained high (ABS 2006). With digital communication technology now ubiquitous and participation in social media growing rapidly, the capacity (and expectation) of the community to engage in debates about rural land use planning and to influence policy is increasing. Governments in all jurisdictions have acknowledged the importance of such decisions being evidence based and in response to community demand for access to information, governments are making that evidence increasingly available.

1.2.3 Changes in scientific knowledge, data and tools

Major technological and scientific advances have been made in land resource assessment since 1980. Satellite imagery became widely available from around 1990. When combined with powerful computers and innovative statistical algorithms, satellite imagery enables some land attributes (in particular land use and vegetation structure) to be mapped over large areas relatively quickly with improved levels of detail and accuracy. Geographic information systems (GIS) which came into common use from the late 1990's, enable data from different sources to be combined, analysed, and presented much more efficiently and effectively. The rapid evolution of scientific computing capacity and spatial modelling techniques has spawned digital soil mapping – techniques that combine the point-based field and laboratory observations and measurements that are fundamental to land resource assessment with a range of other information (such as of slope, elevation, and aspect) to predictively map soil attributes (Minasny et al 2008).

The work of Weston at al (1981) was based on mapping at 1:2 million scale originally published in the late 1960's (Northcote 1966, Isbell et al 1967, Isbell et al 1968). At this scale it is only possible to map units of land that comprise a mix, or association, of soils. Each soil within such an association has different characteristics and a single unit mapped at 1:2 million may contain soils ranging from some that are highly suitable for certain types of agriculture to some that are totally unsuitable. If the descriptions of the mapping units are sufficiently detailed it may be possible to describe the variation in suitability of individual soils within a single mapped unit (polygon). However it is not possible to identify the specific location of all such areas with mapping of such a coarse scale. Mapping of this nature is suitable for broad-scale strategic priority setting at national or state-wide levels (e.g. to identify areas that are a priority for more detailed study) but is inadequate for regional or local land use planning.

In recognition of these limitations, and of the value to be gained from overcoming them, successive Queensland and Commonwealth Governments have invested in upgrading data about land resources. As a consequence of that investment about 80% of Queensland has been assessed, so that land resource data is of significantly better quality than that available in 1980. This comprises data that is largely based on mapping that existed in 1980 but has been improved with corrections to line-work and mapping unit information (for about 30% of the state) as well as data that has been completely remapped to new land units using improved data and technologies (about 50% of the state). Of the new mapping that has been completed since 1980 about half (or about 25% of the area of the state) is at 1:250,000 or better - a scale upon which broad regional planning decisions can be based with some confidence - and the balance is at scales of between 1:500,000 and 1:1 million – a scale upon which broad regional planning decisions can be based with only low confidence (but still of higher resolution than that used by Weston et al).

Since 1980 major improvements have also been made in land use mapping. The first complete mapping of rural land use for the whole of the state was completed in 1999 under the Queensland Land Use Mapping Program (QLUMP). QLUMP uses satellite imagery and a combination of expert interpretation and analytical tools to provide a comprehensive and consistent mapping of patterns of land use using an Australia-wide standard classification system, Australian Land Use & Management (ALUM). QLUMP maps broad agricultural land use categories and some individual crop types (such as sugarcane). The nominal scale for QLUMP mapping is 1:50,000 in the coastal zone and 1:100,000 in the pastoral zone and in other areas of low intensity land use. Portions of Queensland were remapped by QLUMP in 2006 (parts of the Southern Inland and Southeast), and 2009 (Great Barrier Reef catchments).

2. Precedents

2.1 Previous work in Queensland

Guidelines for agricultural land evaluation in Queensland

The Land Resources Branch of the (then) Department of Primary Industries published guidelines for agricultural land evaluation in Queensland in 1990 (State of Queensland, 1990). The guidelines define land evaluation as *estimating the potential of land for alternative forms of land use*. These guidelines describe eight principles to be applied to agricultural land evaluation in Queensland. The principles are that agricultural land evaluation: relates land use requirements to land resource attributes; considers alternative land uses; interprets land resource information; reflects the quality of the land resource information collected; is based on sustained production; is based on specified management practices and infrastructure relevant to the study area; requires an economic assessment; and, is based on existing conditions of the land.

The guidelines describe three different approaches to land evaluation for use in Queensland: land suitability classification where specific information is required for detailed planning at large scales (1:100 000 or larger) and for individual crops; and land classification for more generalised strategic or regional land use planning. The land suitability approach recommended for detailed planning is consistent with the United Nations Food and Agriculture Organisation (FAO) Framework for Land Evaluation (FAO 1976). This involves defining the requirements of a specified land use and evaluating the degree to which discrete areas of land fulfil these requirements. *Requirements* are expressed as *limitations or* land use requirements for each specified land use stated in a negative sense. Socio-economic factors are considered in general terms only, and in most cases, land suitability classes do not equate to actual costs and benefits, and thus the approach can be considered qualitative. Where soil and land system mapping was only available at coarser scales (1:250,000 or smaller), an established adaptation of the United States Department of Agriculture USDA land capability classification (Rosser et al 1974) focussing on broad-acre cropping, was applied.

The approach recommended for strategic planning is a variation on the United Kingdom Agricultural Land Classification System. In the Queensland Agricultural Land Classification system land is assigned to one of four broad agricultural categories: arable, limited arable, pastoral and non-agricultural, based on its physical characteristics. The classes indicate a decreasing range of land use choice, increasing land use limitations, and increasing land degradation hazard. This classification and mapping is derived largely from information in the land suitability/capability studies described above. Provision is made in the method for these classes to be subdivided by the use of subscripts, so that unique conditions and land uses found in particular regions can be accommodated, however this has been rarely applied. Classes may be assigned directly by interpretation of descriptive information contained within land resource reports or by interpretation of suitability data where it exists for the range of relevant agricultural land uses at a scale appropriate for a strategic plan map. The approach has been widely used across the state to identify good quality agricultural land for input to local government planning schemes under the expired State Planning Policy 1/92: Development and the Conservation of Agricultural Land.

Land and Soil Resources of Northern Australia

In 2009, the CSIRO National Soil Information Centre in collaboration with state government agencies from Queensland, Northern Territory, and Western Australia, conducted a review of land and soil resources in northern Australia (Wilson et al 2009). This study utilised soil and land information which is held within the Australian Soil Resource Information System (ASRIS) and is largely the same as that used by Weston et al in 1981. Much of this data was known to be of poor quality, at coarse reconnaissance scales only (mostly 1:250,000 to 1:1,000,000) and obtained with limited field investigations and limited analytical data. However, it is the only relatively consistent land resource data available that covered the whole study area.

The objective of the Land and Soil Resources of Northern Australia study was to identify land suitable for irrigated agriculture assuming that an adequate supply of water was available. The assessment was based only on the inherent properties or qualities of the soil and land resources themselves. Significant other limitations to agricultural development such as climate, flooding, seasonal waterlogging, water availability and economic social and cultural factors were not taken into account. Potential constraints due to existing or future land tenure or prescribed land use restrictions (such as conservation) were not considered due to the high uncertainty about their possible impact. Similarly, climatic extremes and variability, regular and often extensive and prolonged flooding, and seasonal inaccessibility, and soil nutrient availability were not considered due to limited data.

The approach used was based on the FAO method (FAO 1976). Suitability frameworks were developed for target agricultural land uses (annual crops, perennial crops, rice, forestry and sown pasture). The frameworks comprised soil and land qualities (e.g. erosion hazard, water holding capacity, drainage, soil acidity etc) selected based on their potential to limit agricultural development and their ability to be attributed to mapped soil/land units. Individual soil/land types were assigned to one of five Suitability Classes, ranging from Class 1 (*highly suitable)* to Class 5 (*unsuitable),* depending on the extent to which limitations were present, as indicated by their land qualities. Because of the coarse nature of the mapping most soil/land units contained a mix of suitability classes the specific extent and location of each of which is unknown. To reflect this heterogeneity in the mapped data an overall suitability scale was devised for each land use or crop type as follows:

A1 >70% of the polygon area is suitability class 1 or 2

A2 50-70% of the polygon area is suitability class 1 or 2

B1 >70% of the polygon area is suitability class 1, 2 or 3,

B2 50-70% of the polygon area is suitability class 1,2 or 3

C1 >70% of the polygon area is suitability class 4 or 5

C2 50-70% of the polygon area is suitability class 4 or 5.

2.2 Previous work outside of Queensland

In developing the methodology for the Audit, a number of other jurisdictions with similar socio-economic conditions to Queensland were reviewed.

It was observed that land evaluation systems most commonly use biophysical criteria that are quantified, and most assess land for its utility for agriculture generally across an implied hierarchy of broad land use types (rather than suitability for individual crop types or land uses). A few include socio-economic criteria which in these instances are generally qualitative. In this sense they all appear to be a mix of the USDA and FAO approaches, often taking on various aspects of each approach, and yet while they are similar, they are usually not exactly aligned.

The distinction between the terms suitability and capability is a source of ongoing debate between different groups of land resource scientists. Some argue that the point of difference is one of scale with suitability being specific to individual production systems and crop types while capability is more generalised. Others argue that the difference is about the purpose of the evaluation with capability concerned only with avoiding degradation risks (hence the exclusive consideration of limitations) whilst suitability is about identifying opportunities to increase productivity as well. Thirdly, some argue that the difference is more about scope, with capability exclusively considering biophysical characteristics of the land with suitability including socio-economic criteria as well. In relation to this third point, socio-economic factors are explicitly considered in the FAO framework. However it is acknowledged that in qualitative land evaluation (the most common approach) economic and social analysis may only be addressed in generalised terms by for instance, constraining land use options to those accepted by government and the community.

The importance of good information about land resources to underpin sound agricultural land planning is widely recognised. There is a long history of research and technological development in land resource assessment throughout the world, including in Australia. It is important to learn from this history to ensure that the Audit is conducted in a manner that is as efficient as possible, uses methods that are technically sound, and produces results that are scientifically defensible and repeatable (e.g. for use in monitoring). The examination of previous approaches in Queensland and elsewhere and the comprehensive requirements of the Audit were used to guide the development of the method described in the following section. Table 1 summarises the key differences and similarities between the various approaches used throughout the world. More detail on these approaches is provided in Appendix 1.

Table 1: Summary of various agricultural land evaluation systems in use throughout the world

System	When Introduced	Scale of Application	Number of Classes	Nature of inputs	Scope of Criteria	Class Breadth
US SCS Land Capability	1960's	Regional	8	Quantitative	Biophysical only	Agriculture as broad land use types
US Land Evaluation and Site Assessment	1980's	Regional	Various	Quantitative and qualitative	Biophysical and socio-economic	Agriculture as broad land use types
FAO Land Suitability	1970's	National and regional	5	Quantitative and qualitative	Biophysical and socio-economic	Individual crop
UK Land Capability	1960's	Regional	7	Quantitative	Biophysical only	Agriculture as broad land use types
UK Agricultural Land Classification	1970's	National and regional	5	Quantitative	Biophysical only	Agriculture as broad land use types
New Zealand land capability	1990's	Regional	8	Quantitative	Biophysical only	Agriculture as broad land use types
Victoria land capability	1970's	Regional and local	5	Quantitative	Biophysical only	Individual crop and non agricultural use
New South Wales Department of Land and Water Conservation land capability	1990's	Regional	8	Quantitative	Biophysical only	Agriculture as broad land use types
NSW Department of Agriculture land	2002	Regional	5	Quantitative and	Biophysical and	Agriculture as broad

capability				qualitative	Socio-economic	land use types
Tasmania agricultural land classification	1990's	Regional	7	Quantitative	Biophysical	Agriculture as broad land use types
Western Australia Comparative Agricultural Area Suitability Assessment Method	2000	Regional and local	Various in sliding scale	Quantitative and qualitative	Biophysical and socio-economic	Agriculture as broad land use types
QDPI Agricultural Land Classification	1990's	Statewide and regional	4	Qualitative	Biophysical	Agriculture as broad land use types
Northern Australia Land and Soil study land suitability	2009	Regional	5	Quantitative	Biophysical	Individual crops and land use types

3. Method for the Queensland Agricultural Land Audit

In line with the time and resources available, a fit-for-purpose method was developed for the Queensland Agricultural Land Audit which builds on established approaches and existing datasets for Queensland. The method is described in detail below.

3.1 Objective and scope

The Queensland Agricultural Land Audit (the Audit) aims to identify '*land important to current and future agricultural production across Queensland*'. It seeks to provide information on the location, extent and character of land currently used for agriculture, and to identify areas with potential for future agricultural development. It also aims to provide information on constraints on current (or future) realisation of that potential.

The Audit considers all land in Queensland other than land that is alienated from use for agriculture in the long-term. Land excluded from consideration in the Audit includes land permanently inundated, land gazetted as national parks, defence and other commonwealth purposes, established mines, existing urban areas and other intensive non-agricultural land uses. The Audit considers the land requirements of all activities associated with the production of food or fibre up to the farm gate. For the purposes of the Audit, land use is classified and mapped into the following broad Agricultural Land Use Categories (ALUCs): broadacre cropping (rainfed and irrigated), sugarcane, horticulture (irrigated annual and perennial), grazing (improved and native pastures), forestry (plantation and native), intensive animals (beef, pigs, poultry, and aquaculture). These categories are described in detail in Appendix 2.

The Audit produces maps and information suitable for strategic state-wide and regional planning (see Appendix 3 for region boundaries). It does not map specific locations or provide information at a level suitable for identifying development opportunities at local or fine-scale level (such as for individual local governments or individual properties). However, it does provide an indication of areas where such opportunities are more likely to occur and that therefore should be a priority for detailed further investigation. For the purposes of clarification, Appendix 4 lists matters outside the scope of the Audit.

3.2 Outputs

Queensland Agricultural Land Audit report

The results of the Audit are presented in a report that includes a state-wide overview and a chapter for each region. Each chapter includes:

- a profile of agriculture in the region or state;
- maps and descriptions of current and potential agricultural land use; and
- information about the opportunities and constraints for potential agricultural uses and threats to current use.

The draft final report was required to be provided to Government in early 2013. Interim, summary reports were to be provided to the Government for the Darling Downs and Central Queensland regional planning areas in late 2012.

Technical report

This Technical Report has been prepared to complement the Audit Report. It is intended to provide a permanent record of how the Audit was carried out, allowing the process to be repeated in the future and changes to be monitored.

The Technical Report includes:

- a review of relevant literature
- definitions of Agricultural Land Use Categories (ALUC) and other terms
- a detailed description of the methods used including decision rules
- descriptions of datasets and other inputs including key references and sources of expert advice
- advice on the level of confidence in the outputs and the uses for which they are appropriate

Data

Following approval of the final Agricultural Land Audit report, spatial data produced by the Audit will be distributed in digital form through existing networks (such as the Queensland Government Information Service portal) for use by Queensland Government agencies and local governments in digital form through existing networks.

3.3 Overall approach

Land potential was determined by the Audit through an approach largely based on the established Agricultural Land Classification for strategic planning in Queensland published in *Guidelines for Agricultural Land Evaluation in Queensland* (State of Queensland, 1990). Current land use was identified largely from existing QLUMP datasets (Witte et al 2006). Important agricultural areas were identified by combining the outputs of these two processes in a multi-criteria approach similar to that developed by Western Australia (Kininmonth, 2000). The Audit uses a desktop based method analysing existing datasets or data developed from existing datasets, and presenting them using existing tools and expert knowledge in a Geographic Information System. Appendix 5 lists the datasets used in the Audit.

For efficient validation and delivery of outputs, each region (or aggregation of regions where appropriate) was analysed separately. This involved six tasks for each region as follows:

Task 1: Establish regional context

Task 2: Map current agricultural land use

Task 3: Map agricultural land use potential

Task 4: Identify areas important to agriculture

Task 5: Validate maps and information

Task 6: Synthesize, interpret, and report

3.3 Assumptions

For the purposes of the Audit it is assumed that:

- Current standard industry production systems and land management practices are applied, for example with respect to crop agronomy and animal husbandry;
- Commodity types are limited to those currently produced commercially in Queensland; and
- Land with constraints that have been modified or removed (where appropriate), such as land that has access to water through irrigation infrastructure, land that has been cleared, or land that has been drained, is assessed on its land use potential without these constraints.

The Audit is at '*a point in time'* reflecting current understanding of agricultural systems, infrastructure, markets, and resource conditions. Each of these factors, our understanding of how they influence agriculture and our ability to quantify and map them will change over time. As circumstances change, it is to be expected that the findings of the Audit will become a less accurate reflection of reality and hence less useful basis for decisions. For this reason it would be appropriate for the Audit to be regularly updated. The frequency and comprehensiveness of updating will depend on the particular needs of stakeholders and the resources available. Ideally, this would involve a continuing commitment to revisit all components of the Audit on a rolling program that reflects a logical prioritisation.

3.4 Tasks

Task 1: Establish regional context

Regional boundaries

The Audit has been conducted across the whole of Queensland at a regional level. Regional boundaries follow those used in statutory regional plans by the Department of State Development, Infrastructure and Planning (DSDIP). A map of these regional boundaries is available on the DSDIP website (refer to http://dlgp.qld.gov.au/resources/map/regional-plan-areas.pdf for map) and shown in Appendix 3. Appendix 6 lists the local governments within each of these regions.

Exclusion areas

The Audit does not consider land that is permanently inundated, land gazetted as national parks, for defence or other commonwealth purposes, and land used for mines, urban areas and other intensive non-agricultural purposes that are permanent. GIS masks were prepared at the outset to exclude such land from further consideration in the analysis. Masks differed depending on the ALUC being considered. For instance, whilst it is appropriate that state forests be excluded from consideration in identifying cropping potential it is important that they not be excluded when considering potential for native forestry or for grazing. The masks were prepared from existing tenure data and from statewide land use mapping (see Task 2 for an explanation of sources for this data).

Regional agriculture profile

A description of the general agricultural character of the region was compiled as a starting point for the analysis. This *regional agriculture profile* sets the context, explains the role of agriculture in the region, and assists in identifying current and future development opportunities. The profile includes information about the importance of the region to

Queensland agriculture; the importance of agriculture to the region; important towns for sourcing inputs and services; labour availability; weather and exceptional circumstances; and any other factors that influence agricultural activity in the region. It was developed through a literature review and statistical data interrogation as well as through consultation with regional experts.

Strengths, weaknesses, opportunities and threats (SWOT) analysis

A range of socio-economic, biophysical and environmental factors shape the agricultural activities and opportunities in each region. To help understand these factors the Audit undertook a SWOT analysis, documenting the strengths (existing factors that favour agricultural production), weaknesses (unfavourable conditions which reduce the profitability of agricultural production), opportunities (actions that could be taken to enhance future agricultural production) and threats (issues which could negatively impact on agricultural production), to agriculture in the region. The SWOT analysis was based on a review of published and unpublished literature as well as consultation with staff from Queensland government agencies with technical expertise in areas relevant to the Audit.

The SWOT and the *region agricultural profile* were confirmed with regionally-based expert staff during the validation (see Task 5), informed later decisions in the method, and formed a part of the report for each region.

Task 2: Map current agricultural land use

Due to the diverse nature of Queensland agriculture and the limited time and resources available to conduct the Audit, it was necessary to group agriculture into categories of activities that can be consistently assessed at a regional scale across all of Queensland. The Audit assessed current land use and importance of land for agriculture based on the following Agricultural Land Use Categories:

- Broadacre cropping (rainfed/irrigated)
- Annual horticulture (irrigated)
- Perennial horticulture (assumed to be irrigated)
- Intensive animal industries (i.e. cattle feedlots and piggeries state-wide, and poultry in South East Queensland only, eggs and aquaculture)
- Grazing – sown pasture
- Grazing – native pasture
- Plantation forestry
- Native forestry
- Sugarcane

These categories are based on generally accepted commodity and farming system groupings and reflect those currently used in statutory planning processes. Appendix 2 describes each of the Agricultural Land Use Categories in detail. Dairy was not specifically included due to unavailability of data.

The current spatial extent of each of these categories across the state and within each region was mapped using best available statewide data. Table 2 outlines the data sources used in the Audit to map current land use for each ALUC.

Table 2: Data sources used to map current land use

Agricultural land use class	Data source	Data source class description
Broadacre cropping	QLUMP	Production from dryland agriculture and plantations: *cropping* and production from irrigated agriculture and plantations: *irrigated cropping*
Annual horticulture	QLUMP	Production from dryland agriculture and plantations: *seasonal horticulture* and production from irrigated agriculture and plantations: *irrigated seasonal horticulture* and intensive uses: *Intensive horticulture*.
Perennial horticulture	QLUMP	Production from dryland agriculture and plantations: *perennial horticulture* and production from irrigated agriculture and plantations: *irrigated perennial horticulture*
Intensive animals	Department of Agriculture Fisheries and Forestry (DAFF) Intensive livestock environmental regulation unit (ILERU) database (for cattle and pigs) DAFF data (for poultry).	Cattle – enterprises with capacity >150 head of cattle. Pigs – DAFFs Intensive livestock environmental regulation unit (ILERU) database. Poultry – DAFF data Egg producers – Safe Food Qld register
Aquaculture	QLUMP	Intensive Uses: Intensive Animal Husbandry: *aquaculture*
Grazing – native pasture	QLUMP	Excludes only non-agricultural land uses as described in the note at the base of this table.
Grazing – sown pasture	GLM land-type and SLATS FPC	Extracted from *Grazing – native pasture* by modelling (using method described in Peck et al. 2010). Areas mapped as currently cropped by QLUMP as described above for: *broadacre cropping*, *annual horticulture* and *perennial horticulture* are mapped as potential for sown pastures.

Native forestry	DAFF Forestry plus VMA	MUIDS (areas of state timber interest), forest practice notifications
Plantation forestry	Forest Plantations Queensland (FPQ), Australian Bureau of Agricultural Research Economics and Sciences (ABARES), Forest Enterprises Australia Holdings (FEA)	Hardwood or softwood (or mixed or fallow).
Cane	QLUMP	Production from dryland agriculture and plantations: cropping: sugar and production from irrigated agriculture and plantations: irrigated cropping: irrigated sugar.

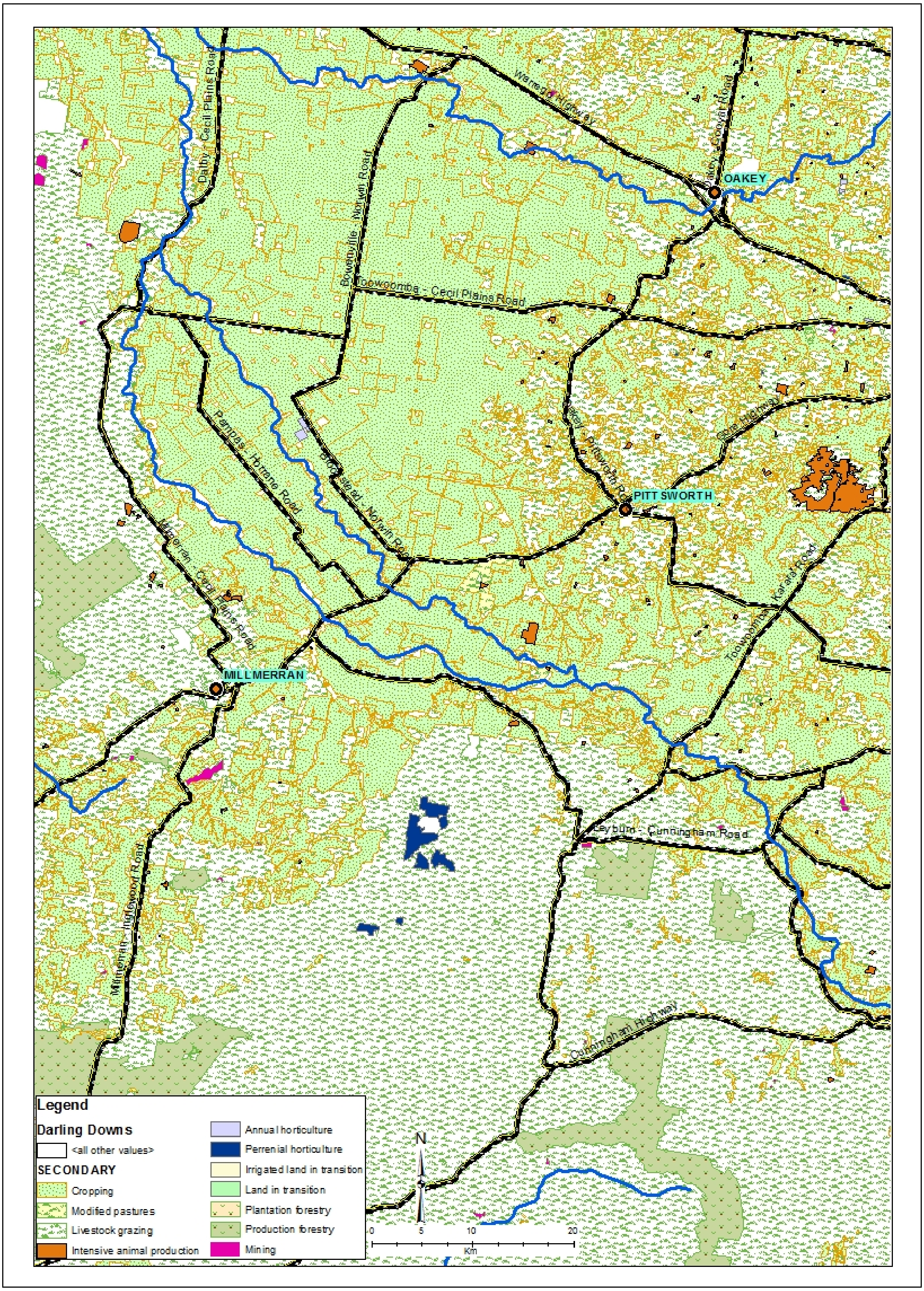
Note: areas used for urban, intensive use (such as mining), national park, managed by the Department of Defence or areas permanently under water as mapped by QLUMP are excluded in every case. State forests are also excluded except for grazing unsown pastures and forestry.

For most land uses the best available statewide data of current land use is the Queensland Land Use Mapping Project (QLUMP). QLUMP provides comprehensive and consistent mapping of patterns of land use using the Australian Land Use and Management (ALUM) classification. ALUM uses a three-level hierarchical structure that reflects the range in intensity of intervention in each land use. There are six classes at the primary level – five of which represent progressively increasing levels of intervention or potential impact on the natural landscape and the sixth is areas under water. Classes at the secondary levels also relate to land use whilst at the tertiary level classes relate to commodities or vegetation types.

QLUMP mapping is available for the whole of Queensland to at least the secondary level and to the tertiary level for some specific crop types (such as sugarcane). For much of the state the only mapping available is from a baseline dataset of land use in 1999. While mapping of such comparative age is still usable for much of rural Queensland - land use changes quite slowly (around 1% a year on average) across the rural landscape generally – for some areas (e.g. along the coast and near urban areas where change is much more rapidly) – it is a concern. QLUMP has an ongoing program of updating the data. Portions of the state have been remapped in 2006 (parts of the Southern Inland and Southeast), and 2009 (Great Barrier Reef catchments). The nominal scale of QLUMP mapping is 1:50,000 in the coastal zone and 1:100,000 in the pastoral zone and areas of low intensity land use. Figure 2 shows an example of QLUMP mapping to the secondary level.

Intensive animal industries were mapped using data from the Intensive Livestock Environmental Regulation Unit (ILERU) database held by DAFF. Compared with other ALUCs, individual intensive animal enterprises are small in area and most such enterprises would not be visible when represented to scale on Audit maps. Because of this, intensive animal enterprises were mapped using a symbol centred on point located at the centre of each property rather than the spatial extent of each enterprise. Aquaculture was mapped in a similar way to other intensive animal industries using data from QLUMP. Forest plantations were mapped using data obtained from Forest Plantations Queensland (FPQ), Australian Bureau of Agricultural Research Economics and Sciences (ABARES), Forest Enterprises Australia Holdings (FEA), and DAFF.

Figure 2: Agricultural land use mapping 2006 in the vicinity of Pittsworth, Darling Downs region



Task 3: Map agricultural land use potential

Agricultural potential was mapped using a rule-based approach that combined biophysical and socio-economic spatial data. Rules were developed to identify land with characteristics that best match the requirements of each ALUC determined from expert advice and by reviewing relevant literature. The rules were exclusively based on inherent biophysical characteristics of the land, such as the soil, climate, and landform as well as native vegetation. Socio-economic factors which are relatively permanent and related to the location of the land, such as proximity to labour resources, were also shown on the maps but these were for information only.

Land/soil resource criteria

The characteristics of land/soil resources are a fundamental determinant of potential for most agricultural land uses. Data about land/soil resources has been collected in Queensland by a large number of separate projects (in excess of 250) over many decades. Each of these projects covers different parts of the state. These projects vary in the attributes they report and the quality with which that information has been collected (and hence the confidence with which it can be used) as well as in the scale and accuracy of the mapping. Hence, for the purposes of the Audit it was necessary to first collate these diverse datasets into a single map layer and to establish a consistent scheme for classifying land according to inherent soil characteristics that reflect its fitness for agricultural use.

For Audit purposes land/soils have been classified using the Queensland Agricultural Land Class approach as detailed in Chapter 5 of the Guidelines for Agricultural Land Evaluation in Queensland (State of Queensland 1990). This approach has been developed to interpret land resource information for use in strategic land use planning in Queensland building on a wealth of experience in land evaluation from within the state and internationally. It is based on a four-tier hierarchy ranging from Class A (arable land) through to Class D (land that is unsuitable for agriculture). The standard definitions published in the Guidelines have been amended slightly as described in Table 3 (below) to better match the requirements of the Audit.

Table 3: Definition of agricultural land classes

Code	Description
A – Crop land Land that is suitable for a wide range[a] of current and potential crops with nil to moderate limitations to production.	
A1	Land that is suitable for a wide range of current and potential broadacre and horticulture crops with limitations to production that range from none to moderate levels.
A2	Land that is suitable for a wide range of current and potential horticultural crops only, with limitations to production that range from none to moderate levels.
B – Limited crop land Land that is suitable for a narrow range[b] of current and potential crops. Land that is marginal for current and potential crops due to severe limitations but is highly suitable for pastures. Land may be suitable for cropping with engineering and/or agronomic improvements.	

C – Pasture land Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment	
C1	Suitable for grazing sown pastures (with ground disturbance for establishment) or has native pastures on higher fertility soils
C2	Suitable for grazing native pastures with or without the introduction of pasture species - not suitable for ground disturbance to establish pastures
C3	Suitable for light grazing of native pastures in accessible areas, and includes steep land more suited to forestry or catchment protection
D – Non-agricultural land Land not suitable for agricultural uses due to extreme limitations. This may be: undisturbed land with significant conservation and/or catchment values; land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop, poor drainage, salinity, acidic drainage; or is an urbanised area.	

Notes:
[a] A wide range of crops is defined as four or more existing crops of local commercial significance. In areas where specialised infrastructure to support an agricultural industry is present, the land may only be currently suitable for two or more crops, providing at least one is regionally significant.
[b] A narrow range of crops is defined as three or less crops of local commercial significance (or less than two where specialised infrastructure is present).

Queensland is geographically very large - extending across 20 degrees of latitude and 7 degrees of longitude respectively, and agroecologically diverse, with climates ranging from cool temperate in the south to dry monsoonal in the north. It supports a wide range of crop types and farming systems. Because of this diversity, and the wide-range of crops and farming systems represented by each of the individual Land Use Classes used by the Audit, it was not possible to develop simple quantitative criteria to define Agriculture Land Class (ALC) classes as have for instance been developed in the UK (Natural England 2009). Instead classes within the Queensland Agricultural Land Class System (QALC) have been assigned based on expert knowledge by regional land resource officers from the Queensland Department of Natural Resources familiar with the soils in the region and their suitability for agriculture and using available published and unpublished land resource information. This took a form similar to that adopted in New South Wales (NSW Agriculture 2002). Figure 3 shows representative examples of each ALC and Figure 4 shows an example of ALC mapping.

In some instances the land units mapped by the various land resource projects have already been assessed for their suitability for individual crops or broad land use categories and assigned land capability or similar classes. Where such information exists and is suitable for conversion to ALC for use in the Audit, it has been directly applied. Where such information doesn’t exist, the relevant regional expert made an assessment based on the soil and landscape descriptions contained within the respective project report and their own knowledge.

Figure 3: **Representative examples of each ALC [a) Class A1 – land being used for broadacre cropping on the Darling Downs, b) Class A2 – land being used to grow lettuce in the Granite Belt, c) Class B – land being used for wine grape production near Stanthorpe, d) Class C1 – land supporting sown pasture in Central Queensland, e) Class C2 – land supporting partially sown pasture in South Central Queensland, f) Class C3 – rough grazing land in South West Queensland, g) Class D – land being used for conservation at the Glasshouse Mountains, South East Queensland]**

a)

b)

c)

d)

e)

f)

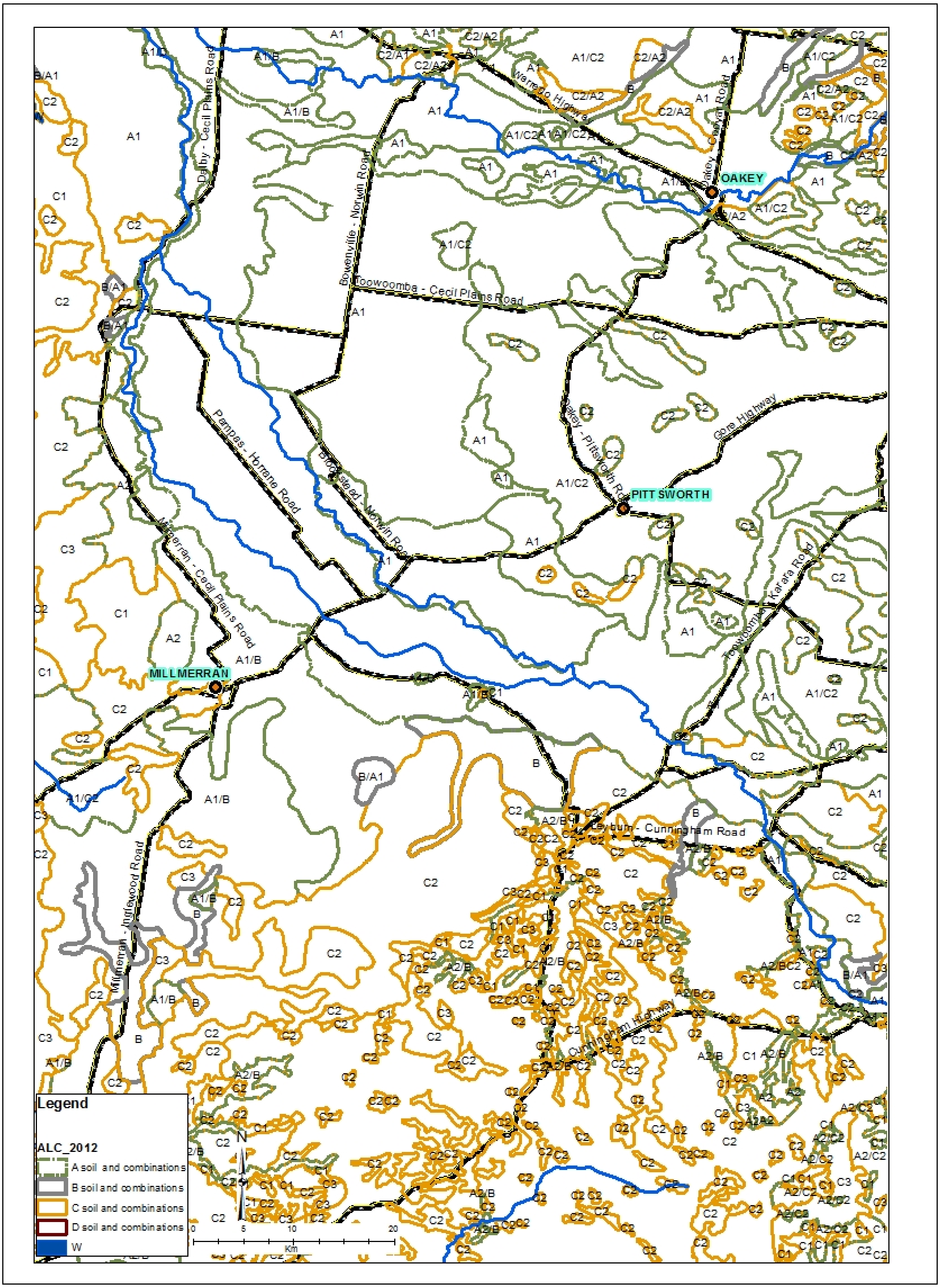
g)

It was not possible to map ALC for all parts of the state. Soil/land unit mapping needs to be at a resolution better than 1:2 million to be suitable for regional level planning purposes. This means that for the portions of the state where Atlas of Australian Soils (which is at a resolution of 1:2 million) is the best available mapping, ALC was not assigned. These areas have been left blank in the mapping of land potential. While this represents a relatively small proportion of the state, it does include some areas significant to agriculture, such as parts of south east Queensland.

At the scale at which most land units have been mapped they generally contain a mix of soils with varying characteristics and hence a range of ALCs. Where one ALC accounts for more than 70% of the area, the land unit was assigned a single ALC. Where no single ALC accounts for more than 70% of the area, the unit was assigned a combination of two ALCs, the first representing the most abundant (dominant) and the second the next most abundant (subdominant). This allows the ALC to reflect that there is variable potential across that part of the landscape even if it is not possible to map the exact location of the different classes. However, because of time and resource limitations, it was necessary to simplify this information for use in the Audit. For Audit purposes mixed units where either the dominant or subdominant class was A, were treated the same as pure units of class A. While this simplification resulted in an over-estimation of potential, it was considered a reasonable course of action under the circumstances to ensure that potentially important opportunities for agriculture were not overlooked.

Other specific characteristics of soils which are important determinants of potential for particularly ALUCs were also included as criteria where relevant. For example, for tree crops such as plantation forestry and perennial horticulture the presence of cracking clay soils is a major limitation as the seasonal physical movement that occurs in these soils damages and destroys the root systems of trees inhibiting their growth and potentially killing them. Conversely, aquaculture requires soils with a high content of particular clays to seal ponds to prevent leakage and ensure that potential contamination of surrounding water bodies and groundwater systems is minimised. Where specific soil attributes such as these were identified as important for particular ALUCs and it was feasible to include them in the criteria they were mapped by interpreting existing land resource project spatial units or other spatial datasets (such as those generated from the Australian Soil Resource Information System) with assistance of relevant experts.

Figure 4: Agricultural Land Classes mapping in the vicinity of Pittsworth, Darling Downs region



Slope is also an important determinant of land potential for most forms of agriculture. All other things being equal, land with greater slope has a greater risk of erosion. This is particularly an issue where management under a particular ALUC requires cultivation and/or extensive soil surface disturbance (for example in broadacre cropping or annual horticulture). Also, as slope increases, so does the difficulty of access and on steep slopes farm machinery such as tractors become unstable and are at risk of toppling. Furthermore, slope adds additional costs (through the need for additional earthworks) for ALUCs such as aquaculture or intensive animal industries that routinely require construction of structures, or for other ALUCs such as broadacre cropping slope requires additional expense to mitigate against erosion hazard such as through construction of contour banks.

Maximum slope thresholds were developed for ALUCs where slope was considered an important determinant of potential. These included annual and perennial horticulture, broadacre cropping, sugarcane, intensive animal industries and plantation forestry. Different thresholds were developed for different ALUCs depending on their specific requirements. The slope thresholds were developed in consultation with regional experts taking into account the average character of land used for these purposes with respect to other relevant factors e.g. erosivity and rainfall, and the nature of the activity. The slope thresholds developed for these ALUCs were mapped using a state-wide digital elevation model. Because of the relatively coarse resolution of the Digital Elevation Model (DEM) which is 1 second or approximately 30 meters, the slope measured through this process is an approximation of the true slope on the ground.

Aquaculture has some specific requirements in relation to land/soil resources which warranted the inclusion of additional criteria specific to that ALUC. Because marine aquaculture, the main form of aquaculture practiced in Queensland, is dependant on access to seawater, maximum thresholds for elevation and distance from the coast were included as criteria. However, tidal inundation is also a constraint for land-based aquaculture, due to the risk of contamination and stock loss, so it was specified that land identified as having potential for aquaculture also be above the high tide level.

Climate criteria

Precipitation and temperature are the only climate criteria included in the Audit to identify land potential. Precipitation and temperature were considered to be the most important climate criteria to consider and to be the only ones that are feasible to map with the resources and time available. Attempts were made to include other criteria such as flood frequency and potential cyclone impact however no suitable spatial datasets were found or able to be created in the time and with the resources available to the Audit. This is likely to be a significant omission given the extent, frequency and severity of flood and cyclone impacts on agriculture within Queensland over recent years.

Precipitation has a major influence on potential for cropping. Insufficient precipitation places crops under moisture stress leading to low yields or death. For Audit purposes it is assumed that all horticulture, both annual and perennial, are irrigated and hence not limited by insufficient precipitation. Broadacre cropping and plantation forestry are both assumed to be not irrigated and consequently a minimum precipitation threshold was included as part of the criteria for determining potential for each of these ALUCs. Minimum precipitation thresholds were set at seven years in 10 (rather than the more commonly used Mean Annual) to better represent what is considered to be the frequency of crop failure at which cropping becomes marginal. Also, in the case of plantation forestry it was also considered to better reflect the likelihood that trees would survive a single year of drought but are much less likely to survive two consecutive years of drought.

A criterion of maximum winter (Oct-April) precipitation was used for horticulture (both annual and perennial) for most of the state. This was in recognition that winter is the main production season and excessive precipitation over this period inhibits the ability to access the site with machinery to harvest the current crop and to prepare the site for the next crop. It also leads to reduced productivity, crop losses and increased disease through excess soil and atmospheric moisture and through a lack of sunlight. While summer precipitation has similar effect for summer harvested perennial crops (e.g. mangoes, table grapes, stonefruit and lychees) it was unable to be included in this initial iteration of the Audit due to time and resource constraints. Maximum mean annual rainfall was used however for western regions.

A specific temperature criterion was also included for sugarcane. This was set at a maximum frequency of days with less than a specified minimum temperature. Sugarcane is particularly sensitive to cool temperatures. Cool temperatures reduce plant growth and sugar accumulation whilst frost can severely damage and kill plants. A minimum temperature threshold was not included for other cropping ALUCs even though many individual crop types are also known to be sensitive to this. This is because those ALUCs represent a wide diversity of species and varieties of plant types with widely varying requirements and it is assumed that growers would select those best suited to local conditions.

Socio-economic criteria

Spatial surrogates for relatively permanent, or ‘hard’ constraints or business requirements were also included in the analysis to further refine the identification of areas of land with potential for particular ALUCs. Initial consultation with experts indicated that availability of built infrastructure and human resource requirements are key factors in determining the potential of an area for a particular land use. Where relevant and possible these were represented by mapping the location of key processing facilities and transport infrastructure as well as: distance from labour and services; and availability of water for irrigation.

Data to map socio-economic limitations was accessed from a range of existing sources. Information about built infrastructure is widely available throughout government, including from the Queensland Geographic Information Service (QGIS) data library. Information about transport infrastructure was obtained from the original source where possible (e.g. the Department of Transport and Main Roads or Department of State Development, Infrastructure and Planning). Information about irrigation schemes and water availability was sourced from the Department of Natural Resources and Mines.

Mapping of population centres was derived from existing national census and agricultural surveys conducted by Australian Bureau of Statistics and the Australian Bureau of Agricultural and Resource Economics and Sciences.

Other socio-economic data was obtained online either directly from Australian Government agencies or through the Queensland Office of Economic and Statistical Research. Due to privacy concerns Australian Bureau of Statistics data is generally made available only at a restricted level of resolution. For rural areas where populations are sparse this requires that statistics be aggregated across very large areas of land. In some instances it was possible to complement the maps with a more detailed written explanation in the relevant report using additional information available to the project team.

Mapping land potential

The rules used by the Audit to combine these spatial datasets to identify and map agricultural land use potential are summarised in Table 4. The rules have been developed from existing published and unpublished information and in consultation with relevant experts. For some agricultural industries e.g. grazing, studies have already been undertaken to identify land potential. Where such studies exist, in particular where they are recent, at the equivalent (or finer) scale and scope as the Audit and the requirements of that sector are highly specialised, the Audit has incorporated the outputs of such studies. For example, grazing potential has been mapped using existing state-wide predictions of pasture biomass production developed using the Grass Production Model (GRASP) through the method described below.

Where studies do not exist and new rules were required to be developed, for efficiency they are as consistent as possible across the state. However, in some instances it was necessary to customise rules to account for particular circumstances that are unique to an individual region (or subset of regions). For example, different maximum rainfall thresholds were used for horticulture in the south and north to reflect the different types of crops grown and their different rainfall tolerances. Such regional variations have been developed in consultation with relevant experts and are documented in the report for the region to which they relate.

Table 4: Rules used to map land use potential

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Broadacre cropping	A	≤ 8%	annual rainfall ≥ 450mm in 7 out of 10 years	nil		Location of cotton gins

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Annual horticulture	A and B	≤ 8%	None specified	1000mm mean annual (Darling Downs, South West, Central West, North West and Gulf regions) 500mm winter mean (April – October) (Cape, Far North Queensland, Charters Towers, Mackay Isaac Whitsunday, Central Queensland and Wide Bay Burnett regions) 600mm mean winter rainfall (April-October) South East Queensland region.		Areas that are within 50 kilometres from a population centre of 2,000 people.

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Perennial horticulture	A and B	≤15%	None specified	1000mm mean annual (Darling Downs, South West, Central West, North West and Gulf regions) 500mm winter mean (April – October) (Cape, Far North Queensland, Charters Towers, Mackay Isaac Whitsunday, Central Queensland and Wide Bay Burnett regions) 600mm mean winter rainfall (April-October) South East Queensland region.	Land with cracking clay soils excluded [c].	Areas that are within 50 kilometres from a population centre of 2,000 people.

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Intensive animals	For cattle and pigs: A and B (and C1 within 10km of current cropping)	≤8%.	None specified	None specified		Major beef, pork, and poultry abattoirs.
Aquaculture	none specified	≤5%.	None specified	None specified	Within 2km of an "estuarine" water source Above high astronomical tide <10m elevation Not in protected areas, nature refuges, high ecological significance areas, or Fish Habitat Areas and >20% clay content (or data missing in soil maps) Excludes acid sulphate soils.	Occurrence of vulnerable groundwater systems

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Grazing – sown pasture (criteria as per Peck, 2010)	None specified	None specified	>500mm mean annual	None specified	GLM Land Type suitable for establishing sown pastures (http://futurebeef.com.au/topics/grazing-land-management/) cleared land (as mapped by SLATS FPC), Excludes areas that are currently cropped (as mapped by QLUMP).	
Grazing – unsown pasture current	None specified	None specified	None specified		Pasture biomass potential modelled using GRASP (http://www.longpaddock.qld.gov.au/grasp/index.html) according to GLM land type (http://futurebeef.com.au/topics/grazing-land-management/) modified by: tree basal area (as currently mapped by SLATS FPC) land condition assumed to be 'B' (http://futurebeef.com.au/topics/grazing-land-management/land-condition/)	

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Grazing – unsown pasture future potential	None specified	None specified	None specified	None specified	Pasture biomass potential modelled using GRASP (http://www.longpaddock.qld.gov.au/grasp/index.html) according to GLM land type (http://futurebeef.com.au/topics/grazing-land-management/) modified by: by tree basal area (as currently mapped by SLATS FPC) land condition assumed to be 'A' (http://futurebeef.com.au/topics/grazing-land-management/land-condition/)	

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Native forestry	None specified	None specified	None specified	None specified	For sawlogs and other timber products (high or medium native forestry potential) FPC > 15% AND preclearing RE contains commercial sawlog species (as described in REDD) AND (High) NOT (Low) canopy top height (as derived by Scarth et al 2010) > threshold determined by the Audit for that type. for non-sawlog timber products only (low native forestry potential) FPC >15% FPC and commercial sawlog species not present. Areas with FPC not native forest i.e. perennial horticulture and plantation forest, excluded.	Location of native timber sawmills

Agricultural Land Use Class	Agricultural Land Class	Slope	Precipitation		Other	
			Minimum	*Maximum*	*Included in decision rules*[a]	*Displayed for information only*[b]
Plantation forestry	A, B, or C1 (also C2 and C3 for softwoods)	≤25%	For hardwoods ≥ 700mm 7 in 10 years For softwoods ≥ 800mm 7 in 10 years	None specified	Areas with cracking clay soils excluded	Location of sawmills processing predominately plantation timber
Sugarcane	A and B	≤ 5%			minimum temperature is 9 degrees or less for fewer than 55 days per year	Locations of cane mills and cane rail.

Notes:

[a] Existing urban, intensive use (such as mining), national park, area managed by the Department of Defence or areas permanently under water masked on each map. State forests also masked on each map other than grazing and native forestry.

[b] Major towns, rivers, highways and regional boundary shown on each map.

[c] This is true as a general rule, however, some individual tree and vine crops such as mangoes and grapes are known to be tolerant of cracking clay soils

Generally the maps of agricultural potential show some land that has potential to be suitable for an individual ALUC but which is not currently used for that purpose. It should not be assumed from this that all (or any particular portion) of land so identified will be converted to that use. The Audit identifies the potential of land for a particular use based on a limited number of criteria for which mapping is readily available. A range of other factors such as markets, pre-existing land uses or other competing potential land-uses are important influences on business decisions and management practices of producers. However, the range of these factors that are relevant, and the extent to which they are significant to a particular business, vary with location, time, and the businesses unique circumstances. Because of this variation, business factors such as these have not been included in the decision rules.

Some information is included on the maps for information only. For instance, availability of labour, especially during harvest season, is an important consideration in selecting suitable land for some forms of use such as perennial horticulture. To reflect this, areas that are within defined distances from a sizeable population centre are highlighted on maps of horticulture potential. However labour is not always a critical factor (e.g. for crops that are mechanically harvested) and the size of the nearest population centre is not always the best surrogate for labour force availability (e.g. many horticultural businesses make extensive use of itinerant seasonal workers or backpackers). Hence, this is presented for information only and not incorporated into the decision rules. Explanatory notes to this effect are included in the reports and attached to the maps to which they are relevant.

Some datasets related to land potential, such as water and vegetation, are mapped separately. This is because they are complex and difficult to integrate with the other Audit data sets in a meaningful way. By including them in the report as separate maps readers can make their own assessment of how they relate to their particular interests.

Mapping grazing potential

The Audit defines productive potential for grazing as the ability of the land to grow pasture including grass, legumes and other herbaceous plants. This is calculated as the average annual pasture growth in kilograms of dry matter per hectare (kg/ha/yr). To map the productive potential of grazing lands it is necessary to address both the spatial distribution of land with different inherent characteristics that affect its potential; and the temporal patterns of pasture growth through time.

For Audit purposes the spatial dimension was addressed through the use of Grazing Land Management (GLM) land types. GLM land types are defined by unique combinations of soil and vegetation. They have been specifically developed for use within the grazing industry. The GLM program has identified and mapped all of the common land types across the state and has published biophysical descriptions and assessments of the productive potential of each land type.

The temporal dimension was addressed through the use of the GRASP model (Rickert et al 2000). GRASP is a daily water balance model that simulates daily pasture growth using climate inputs to simulate the water balance (runoff, infiltration, soil evaporation, transpiration, and drainage), pasture growth (green growth, death, and detachment) and animal intake (diet selection, utilisation and live weight gain). It is a mechanistic model in that the overall structure of the model has a biophysical basis but individual algorithms within GRASP are mainly empirical. The GRASP model was run over a 100 year time cycle to develop a long term average pasture production for each GLM land type.

GRASP is a model that is analytically demanding due to the high number of input parameters and complexity of the system that is being modelled. To simplify the analysis GRASP models have been developed for each GLM land type individually. The GRASP models of each GLM land type have been paramaterised for that specific land type's region e.g. Red Basalt land type in the Burdekin. The high specificity in each individual land type's model means that the accuracy of these models diminishes rapidly as one region's land types spread into different region, for instance if a Fitzroy land type Alluvial Brigalow is mapped in the Burdekin region. To maximize the accuracy of the modelling used in the Audit, those land types that are mapped outside of their geographically correct area were converted into a land type that is correct for that region (for example, Alluvial Brigalow was converted to Clayey Alluvials when modelled in the Burdekin).

Models have been built for the majority of land types in Queensland. However there are some gaps, most notably in the Southern Gulf area where models for each individual land type have not yet been developed. These are currently under development and testing and they will be included in the Audit as they become available. Until that time the most appropriate models from other geographically close regions have been substituted. The GRASP model also does not predict pasture growth well in areas where most of the input water is due to flooding or overland flow. Hence some flooded land type systems in the Channel Country of south western Queensland may have modelled average pasture growth below what is actually produced.

For the Audit, potential pasture productivity was modelled for each land unit using the GRASP model appropriate to the particular GLM land type and incorporating the climate specific to that area. Both current and future potential productivity were modelled. To model current productivity, tree basal area was set at the current level as determined from the latest State Land and Tree Study (SLATS) Foliage Projected Cover (FPC) layer, and land condition was assumed to be B. To determine the future potential productivity, which is land in optimum land condition, condition was set to A. In each instance modelled pasture production was expressed as 3 classes of grazing potential (kg DM/ha/yr): high: >3500, medium: 1500-3500, and low: <1500. No attempt was made to derive a long term carrying capacity of the land, as this requires a much higher level of complexity than permitted within the time and resource constraints available to the project. Specific studies of soil fertility for pasture production exist for a number of parts of Queensland (e.g. Ahern et al 1994, Shields & Anderson 1989). Due to time and resource constraints it was not possible to include the results of these studies in this first phase of the Audit.

Mapping potential for native forestry

Native forestry is defined by the Audit as production of sawlog and non-sawlog timber products from naturally occurring tree species. The density of trees (represented as % foliage projected cover) has been mapped across Queensland by SLATS. For the purposes of the Audit any area with greater than 15% foliage projected cover was classified as having potential for native forestry. Land identified as having potential for native forestry was then further subdivided according to its potential to produce sawlogs and other high value timber products (such as poles and girders).

Not all native forest tree species that occur in Queensland have timber characteristics that make them suitable for production of sawlogs. A short-list of species that have been proven to have such characteristics was developed through consultation with experts. The spatial distribution of these species was determined through their association as components of native vegetation communities (or Regional Ecosystems). The occurrence of Regional Ecosystems (REs) has been mapped across the state by the Queensland Herbarium (Neldner et al 2012). Descriptions of these REs, listing their dominant overstorey species, are contained within the Regional Ecosystem Description Database (REDD). The REDD is publicly accessible on the website of the Queensland Herbarium (http://www.ehp.qld.gov.au/ecosystems/biodiversity/regional-ecosystems/index.php). An RE where the description contained in the REDD lists one or more species known to produce commercial sawlogs was classified as having potential for sawlog production.

To be viable for harvesting sawlogs, a forest needs to contain not only trees of suitable species but a sufficient abundance of suitably large trees of these species must be present – or at least the potential must exist for this to occur. The most readily available surrogate of the actual (or potential) size and abundance of trees is the height of the upper canopy of the vegetation. A dataset of vegetation height for each RE has been developed for Queensland (Scarth et al 2010). Vegetation height was determined by measuring the distance to and intensity of backscatter generated by a laser beam emitted from a satellite based instrument – or LIDAR. Average top height was defined as the height above ground level below which 95% of the laser beam was reflected or absorbed. For Audit purposes this was assumed to approximate the general top of the upper canopy or potential sawlog trees.

The relationship between upper canopy height and sawlog production potential depends on the growth rates and other characteristics of the particular species of trees concerned. The minimum height for a forest to be viable for sawlog production is generally lower in inland areas because a higher proportion of the volume of slower grown trees is recoverable as sawn timber. Based on expert advice the following minimum height thresholds were determined for use in the Audit: 20m for REs containing rainforest or scrub commercial species; 20 m for REs containing 'coastal hardwoods'; 15 m for REs containing 'inland hardwoods'; 15 m for REs containing cypress pine. REs for which the average top height as determined by Scarth et al (2010) exceeded this height threshold were classified as having high potential for sawlog production.

Task 4: Identify areas important for agriculture

Maps and accompanying written material, identifying and describing areas that are important for Queensland agriculture are a key output from the Audit. For Audit purposes an Important Agricultural Area is defined as: *an area that has all of the requirements for agriculture to be successful and sustainable, is part of a critical mass of land with similar characteristics and, is strategically significant to the region or the state.*

Important Agricultural Areas were mapped by the Audit through the following six steps:

Step1: **Identify candidate Important Agricultural Areas** through consultation with regional experts and through review of the main products from Audit steps 2 and 3. Regional experts were initially asked to indicate on a satellite image of the region the areas they thought were most important for the commodity groupings they were most familiar with.

Step 2: **Identify critical masses of agricultural land that have *all of the requirements for agriculture to be successful and sustainable*.** Land was considered part of a critical mass where it adjoined (or was in sufficiently close proximity to sufficient other agricultural land) that it would be self-sustaining with respect to long term investment in critical inputs such as essential infrastructure, labour or market access. Critical masses were identified by reviewing the characteristics, spatial extent and distribution of the areas identified in the previous step. This review was undertaken in consultation with relevant experts and took into account the requirements of different commodity groups. A critical mass could include land with different characteristics and it could be important for a range of different agricultural uses. This is particularly the case when such uses are complementary such as intensive animal industries and cropping.

Step 3: **Assess the strategic significance of the identified critical masses of land to agriculture.** This included consideration of a range of criteria that reflect the current (or potential) contribution that the land can make to the region and the state economically and socially. These criteria include:

- Current or potential contribution of agricultural development of the area to economic activity, employment (and other social factors) in the locality, region or state
- Strategic importance of the area for continuity and consistency of supply of particular products or particular markets locally, nationally or internationally
- Extent of investment to develop the land for agriculture (e.g. through construction of irrigation schemes, grain storage facilities, sale yards).

Step 5: **Review and finalise candidate Important Agricultural Areas**. Experts were then asked to review the outputs from Steps 2 and 3 of the Audit for each of the ALUCs. Steps 2 and 3 identify areas for each ALUC that are currently used for agriculture and areas that have potential to be used for agriculture. Such areas are initially assumed to meet the first component of the definition of an Important Agricultural Area, i.e. that it has: *all of the requirements for agriculture to be successful and sustainable*. Areas mapped by the Audit Step 3 as having potential to be used for agriculture but identified by the experts as being marginal for agriculture or having constraints that are severe and permanent were removed from further consideration. Similarly, areas that had not been mapped by the Audit Step 3 as having potential to be used for agriculture but which were identified by the experts as candidates for inclusion in Important Agricultural Areas, were added for further consideration.

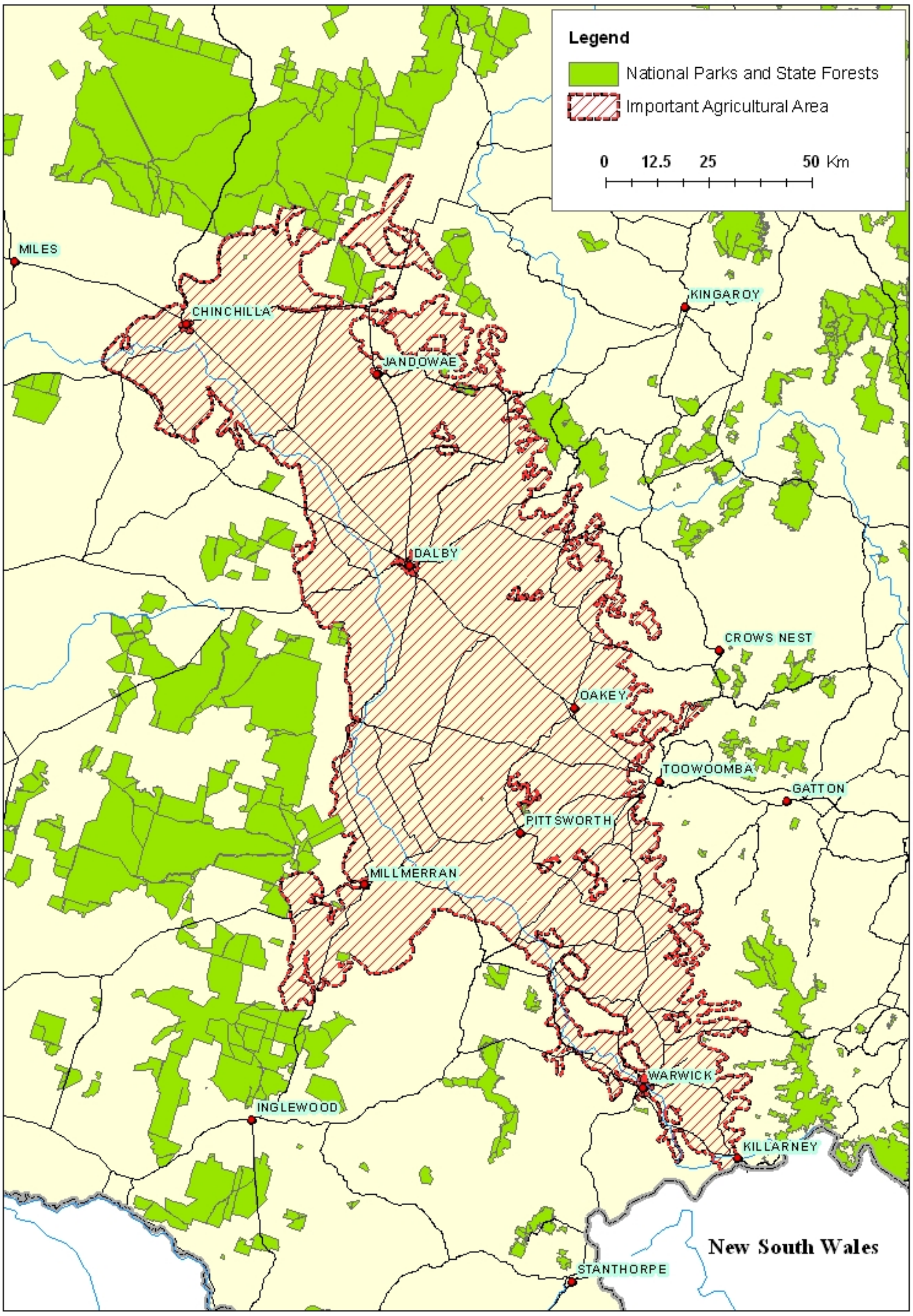
Step 6: **Map the extent of Important Agricultural Areas**. Important Agricultural Areas were initially identified as generalised polygons by freehand drawing on a satellite image of each region. The boundaries were then further refined as follows:

- Select from the outputs of Step 2 and 3 areas mapped as potential and key current production areas for each ALUC for which the area is considered important and that lie inside or immediately adjoin the generalised polygon. Where grazing and native forestry were included, i.e. where potential is mapped by the Audit as high medium and low, only areas identified as having the high production potential were used in this step.
- Refine the boundary to remove areas that have been identified by technical experts as being incorrectly mapped or as not meeting the criteria for identification as part of an important agricultural area. This may include for instance areas where the land resource mapping indicates that soils are highly heterogeneous and there is unlikely to be sufficiently large and contiguous areas to support a viable cropping industry. In this process areas were also removed if information that was unable to be included in the initial analysis (e.g. localised or regional information about labour availability) indicates they did not meet the requirements for agriculture to be successful and sustainable.
- Create a single more detailed boundary by overlaying and merging the outputs for each individual ALUC that lie within the outer generalised polygon. This boundary was then buffered and smoothed to reflect the uncertainty in the input data.

Step 7: **Prepare a detailed description of the agricultural values that make the area important and of their associated input requirements.** This description is included in the report relevant to each area.

An example of the final output of this process is shown in Figure 5 (below).

Figure 5: Eastern Darling Downs Important Agricultural Area



Identifying opportunities

Opportunities for agriculture were identified from both the mapping and the SWOT outputs for each region. Areas that lack coincidence between land use potential and existing land use may be indicative of unutilised potential (or opportunity) or they may also reflect inaccuracies resulting from limitations in the mapping. Where aggregations of such land are identified, the mapping was checked by experts and against published information to confirm whether it is correctly mapped and represents a real opportunity.

Where an opportunity was identified, the Audit attempted to determine what factors are constraining its realisation. Opportunities may be considered as current or future potential depending on social or economic conditions. Current potential exists where current biophysical and business requirements permit land use change and the constraints are relatively 'soft'. Future potential exists where land use change is constrained by relatively 'hard' biophysical, social or economic factors. Appendix 8 contains a list of possible constraints. The Audit considered, but was not limited to, this list.

Constraints were identified by reviewing the inputs to identifying land potential (Step 4). 'Hard" biophysical constraints were identified by reviewing soil/land limitations. Soil/Land limitations are already noted in many land resource projects and in many instances are already recorded against mapped units in the Soil and Land Information System (SALI) to allow the occurrence of these constraints to be mapped and their spatial extent to be calculated. Socio-economic and regulatory constraints were also identified through discussions with relevant experts and interrogation of spatial data where appropriate. This was also informed and reviewed during the validation process (see below) and literature review.

Constraints may also be related to individual business management decisions on specific properties or by specific companies, personal choices of producers and social issues for which data have not been collected. These issues occur largely outside the mandate of government influence. They are therefore considered to be outside the scope of the Queensland Agricultural Land Audit (See Appendix 4).

Task 5: Validate

It is important for users to know what confidence they can have in the Audit products. Users need to be confident that consistency has been maintained between the input data and the final maps and the process needs to be transparent and repeatable. Given the time and resource constraints on the Audit, it was not possible to thoroughly ground-truth the outputs and to thus quantitatively evaluate their accuracy. Instead, a process of expert validation was used to help to ensure the products are as practical and accurate to inform regional scale planning decisions as possible, given the limitations of the project.

A range of Queensland Government staff with expertise in agricultural science, land resources, and regional services were consulted in developing the methods and in selecting datasets for use in the Audit. Outputs of the Audit were also be reviewed by these experts. This process included staff from various Queensland Government departments with technical and scientific expertise and knowledge in the different land use categories and in each region.

A series of structured validation meetings were held in the second half of 2012 at a range of locations throughout the state as listed in Table 5 below.

Table 5: Validation meetings

Date	Location	Regions covered	Number of participants	Departments represented
28th June	Toowoomba	Darling Downs	18	DAFF, DNRM, DoSITIA, DLGP
19th September	Rockhampton	Central Queensland	19	DAFF, DNRM, DSDIP, DLGP, DTMR
10th October	Webinar	Darling Downs	22	DNRM, DoSITIA, DTMR, DAFF
16th October	Gympie	Wide Bay Burnett	26	DNRM, DSDIP, DTMR, DAFF
18th October	Mackay	Mackay, Isaac, Whitsunday	18	DNRM, DAFF, DTMR, DSDIP
30th October	Cairns	Far North Queensland, Cape York, Gulf	21	DNRM, DSDIP, DTMR, DAFF
1st November	Townsville	Charters Towers, North West	23	DNRM, DSDIP, DTMR, DAFF
7th November	Nambour	South East Queensland	28	DNRM, DLGP. DTMR, DAFF, DTMESB + CG
7th November	Webinar	South West, Central West	15	DNRM, DTMR, DAFF

These validation meetings were a key component of the process by which opportunities, constraints and threats were described and Important Agricultural Areas identified.

Data confidence

As part of the validation process data confidence maps were developed. These maps reflected the variation across the state (from area to area and from project to project) in the relative precision and accuracy in the data used in the Audit. Confidence in land resource data is broadly related to the scale of original mapping. Mapping at better than 1:100,000 is considered highly adequate for regional planning. Mapping at between 1:100,000 and 1:250,000 is considered to be adequate but still requiring some caution in its use. Mapping at greater than 1:250,000 is considered to be marginally adequate for regional planning and should be used for this purpose only with a high degree of caution (e.g. decisions should not be based on this information alone without cross-validation with other sources). Data mapped at scales of 1:2 million or greater (i.e. CSIRO's Atlas of Australian Soils) is considered inadequate for Audit purposes.

Table 6 below summarises the data confidence of land resources data available for use in the Audit.

Table 6: Quality of available land resources data in audit regions

Audit region	Land resource data confidence			
	High	***Medium***	***Low***	***No data***
Cape York	0%	96%	4%	<1%
Central	0%	16%	82%	2%
Central West	0%	0%	100%	0%
Charters Towers	0%	4%	96%	0%
Darling Downs	0%	0%	99%	<1%
Far North	13%	4%	78%	5%
Gulf	0%	0%	99%	<1%
Mackay, Isaac, Whitsunday	18%	14%	68%	0%
North West	0%	9%	91%	0%
South East	16%	2%	68%	14%
South West	0%	0%	100%	0%
Wide Bay Burnett	11%	35%	38%	16%
Whole of state	**2%**	**11%**	**86%**	**1%**

Task 6: Synthesize, interpret, and report

Information and maps developed through the preceding five tasks have been brought together in individual reports for each region and in an overall synthesis report for the whole state. This required interpretation of a diverse range of different sources of information into summary maps and commentary.

The Audit has produced maps for each ALUC for each region of existing land use and land use potential with contextual information describing the nature of existing land use, land use potential, and factors that may be impacting on realising land use potential. It has also summarised this information to identify land with overall importance to agriculture in each region (initially mapped for use in the development of regional statutory plans, as broad areas with smoothed boundaries and with detailed supporting information available on request). Table 7 lists the maps be produced in the Audit reports. The content and presentation of the report has been refined to improve its usefulness in response to feedback on the draft chapters.

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Table 7: List of maps to be produced by the Audit

Map Number	Extent	Title	Description
Maps to be produced once only			
A	Whole of state	*None* (used on front page of each regional chapter with region highlighted for orientation)	Coastline, state boundary, region boundaries
B	Whole of state	Land audit regions and LGAs	Coastline, state boundary, region boundaries, LGA boundaries
C1	Whole of state	Gross value of production by LGA – broadacre cropping	Production in millions of dollars based on ABS data aggregated by LGA for broadacre cropping.
C2	Whole of state	Gross value of production by LGA –sugar cane	As above for sugar cane.
C3	Whole of state	Gross value of production by LGA – annual horticulture	As above for annual horticulture.
C4	Whole of state	Gross value of production by LGA – perennial horticulture	As above for perennial horticulture.
C5	Whole of state	Gross value of production by LGA – cattle	As above for cattle.
C6	Whole of state	Gross value of production by LGA – pigs	As above for pigs.
C7	Whole of state	Gross value of production by LGA -poultry	As above for poultry.

Map Number	Extent	Title	Description
D	Whole of state	Stock movement	General movement of cattle around the state.
E	Whole of state	Queensland climate	Climate zones and rainfall isohyts.
Maps to be produced for each Region			
1	Each region	Water management and existing infrastructure	Overview of current water resources and water infrastructure
2	Each region	Transport and infrastructure	Key infrastructure components, major agricultural processing plants, and natural features relevant to current and future agricultural development within the region.
3	Each region	Land affected by Vegetation Management Regulation and Policy.	Land where, based on currently available information, agricultural use is potentially impacted by the provisions of the Vegetation Management Act or associated Regulations protecting native vegetation.
4	Each region and whole of state	Current land use	Extent and distribution of land used for each Agricultural Land Use Class mapped from QLUMP and other sources described in Table 2
5	Each region and whole of state	Important Agricultural Areas	Areas identified by the Audit as containing important agricultural land.
6	Each region and whole of state	Broadacre cropping – current and potential.	Land identified by the Audit as currently being used for broadacre cropping (rainfed or irrigated) and land having potential to be used for broadacre cropping.
7	Each region (where sugarcane is grown) and whole of state	Sugarcane – current and potential	Land identified by the Audit as currently being used for sugarcane cultivation and also land identified by the Audit as having potential to produce sugarcane.

Map Number	Extent	Title	Description
8	Each region and whole of state	Annual horticulture – current and potential	Land identified by the Audit as currently being used for annual horticulture and also land identified by the Audit as having potential to be used for annual horticulture.
9	Each region and whole of state	Perennial horticulture – current and potential	Land identified by the Audit as currently being used for perennial horticulture and also land identified by the Audit as having potential for use for perennial horticulture.
10a	Each region and whole of state	Intensive animal industries – current and potential	Locations identified by the Audit of current intensive animal industries (feedlot cattle, pigs or poultry) and also land identified by the Audit as having potential for use for intensive animal industries
10b	Each region and whole of state	Aquaculture – current and potential (shown on intensive livestock map)	Locations identified by the Audit of current aquaculture enterprises and also the extent of land identified by the Audit as having potential for use for aquaculture
11	Each region and whole of state	Sown pastures, current extent and potential.	Land identified by the Audit as currently supporting sown pastures, land identified as having potential to be sown but which is not currently supporting sown pastures, and land which has no potential for establishment of sown pasture.
12a	Each region and whole of state	Unimproved pasture land, current potential annual biomass production	Land by relative amount of pasture biomass that it has current potential to produce annually as identified by the Audit
12b	Each region and whole of state	Unimproved pasture land, future potential annual biomass production	Land by relative amounts of pasture biomass that it has potential to produce annually in the future as identified by the Audit

Map Number	Extent	Title	Description
13	Each region and whole of state	Native forestry – current and potential	Land identified by the Audit as currently being used for production of sawlogs and/or other timber products from native forestry or which has potential to be used for production of sawlogs and/or other timber products from native forestry.
14	Each region (where plantation timber is grown) and whole of state	Plantation forestry – current and potential	Land identified by the Audit as currently being used for plantation forestry (softwood/hardwood) and also the extent of land identified by the Audit as having potential for use for plantation forestry (softwood/hardwood)
15	Each region	Data confidence – land use potential	Variation across the region (from area to area and from project to project) in the relative precision and accuracy in the mapping of land resources used by the Audit to derive land use potential

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Appendices

Appendix 1: Review of agricultural land evaluation approaches used by other jurisdictions

1. International

United States of America: Systematic classification and mapping of land potential was pioneered in the 1960's by the US Soil Conservation Service (US SCS) (Klingebiel & Montgomery 1961). The US SCS system of land capability assessment uses soil, landform and climate characteristics to assign soil units mapped by aerial photo interpretation to a Capability Class. Capability is scored from 1 to 8 according to the degree to which the characteristics of the land limit potential, or create hazards, from long-term use to produce common cultivated crops and pasture plants. The approach is essentially negative, with land graded according to mixed qualitative and quantitative measures that represent the extent of limitations to land use. Four types of limitations or hazards are recognized: erosion hazard, wetness, rooting zone limitations (such as a deficiency of essential nutrients), and climate. The higher the Capability Class number the greater the limitations. Class 1 land has few limitations and consequently the potential to be used for a wide range of purposes with few inputs. Class 8 land has many limitations and its use for any purpose other than conservation is considered to be unsustainable and to create extreme environmental risk. Land is assessed according to current circumstances and current standards of good management are assumed. This means that the capability classification may change when engineering works that permanently affect the limitations or reduce the hazards, such as drainage, are installed. It also means that when new standards of land management become widely adopted, as for instance with the uptake of conservation tillage practices over recent decades, some land may require reclassification.

The US SCS Land Capability System is based only on the inherent biophysical characteristics of land. Socio-economic factors such as distance to market, availability of water for irrigation, kinds of roads, size and shape of the soil areas, locations within fields, skill or resources of individual operators, and other characteristics of land-ownership patterns are specifically excluded as criteria in assigning land to a Capability Class. In the USA, growing contention over rural land use has given rise to measures at both federal and state levels to conserve agricultural land both for its inherent biophysical characteristics and for its economic contribution and social value. Land Evaluation and Site Assessment (LESA) (Pease & Coughlan undated) was developed to address this need. LESA provides a systematic and repeatable method of combining biophysical and socio-economic characteristics of land.

LESA comprises two components. The Land Evaluation component which is based on scoring of soil and landscape characteristics using the land capability approach, and the Site Assessment component which is based on expert assessment of social and economic limitations and values. The Site Assessment includes the following: non-soil related limitations on agriculture such as the size and shape of a property; development pressure for land conversion out of agriculture such as access to services and land-use zoning; and, other public values supporting retention of land in agriculture such as landscape aesthetics. These factor scores are combined using weightings developed through consultation with experts and interest groups. LESA has been widely used throughout the USA at all levels of Government to identify areas requiring protection as agricultural land (e.g. USDA 2011).

United Nations Food and Agriculture Organisation (FAO): The FAO published a Framework in the mid 1970's describing a generalised approach to evaluate land for a wide range of uses (FAO 1976). FAO define land evaluation as *assessment of land performance when used for specified purposes*. Land is assessed in the FAO approach based on *land qualities* which are complex attributes of land that affect its potential for a specified kind of use. Land qualities may be either *limitations* (defined as in the US SCS approach) or *requirements* (defined by FAO as qualities that determine the production and management conditions of a kind of land use). Land qualities may be relatively abstract concepts such as erosion hazard or soil fertility and are represented in scoring suitability with objectively measurable surrogates or *diagnostic criteria*, such as degree of slope or soil erosivity values.

FAO propose six general principles as the basis for conducting land evaluation projects:

- Land suitability is assessed and classified with respect to specified kinds of use
- Evaluation requires a comparison of the benefits obtained and the inputs needed on different types of land
- A multidisciplinary approach is required
- Evaluation is made in terms relevant to the physical, economic, and social context of the area concerned
- Suitability refers to use on a sustained basis
- Evaluation involves comparison of more than a single kind of land use

United Kingdom: The British Land Capability Classification system (Bibby & Mackney 1969) has much in common with the USCS Land Capability System US (described above). Land is assigned to one of seven Capability Classes based on the extent to which its agricultural use potential is constrained by the presence of limitations. Class 1 has potential for a wide range of uses with few (if any) limitations, while the remaining six classes suffer from increasingly severe limitations and are progressively less flexible in the range of their potential land uses. Limitations considered include: wetness; soil characteristics; gradient and soil pattern; liability to erosion; and climate. Limitations that can be removed or reduced at acceptable cost or under reasonable practices are ignored. Land assigned to Classes 1 to 3 is considered capable of being cropped although increasing limitations in classes 2 and 3 require specialised management and input of additional resources. Class 4 is considered marginal arable land with limitations that preclude cropping in all but exceptional circumstances. Class 5 and 6 are considered non-arable land but are suitable for pastoral use and Class 7 is considered unsuitable for agriculture. Land is assessed on its capability under a moderately high level of management and according to its potential for a wide range of general agricultural purposes. It is not assessed for specific crops nor is it necessarily assessed under its present use. Socio-economic factors such as access to markets, road access and farm structure are not part of the criteria used in assigning land to a Capability Class.

The Agricultural Land Classification System for England and Wales (UK ALC) (MAFF 1988) incorporates some features of the Land Capability System that preceded it (described above). Land is assigned to one of five grades depending on the presence of limitations and their affect on the range of commodities which can be grown, the estimated yields, the consistency of yields, and/or the cost of production. Grade 1 land is considered excellent quality land that has no or very minor limitations and is suitable for a very wide range of crops for which it would be expected to produce consistently high yields. Grade 5 land is considered very poor quality agricultural land with very severe limitations that restrict use to permanent pasture or rough grazing.

The UK ALC system uses objective criteria based on bio-physical limitations i.e. climate, site, and soil, to determine the Class of a piece of land. The main climatic factors are temperature and rainfall although account is taken of exposure, aspect and frost risk. The site factors used in the classification system are gradient, microrelief and flood risk. Soil characteristics of particular importance are texture, structure, depth and stoniness. To determine the Class of a parcel of land each of these factors are measured and these values assessed against quantitative thresholds for each class level. For soil depth for instance, the threshold values are 60cm, 45 cm, 20cm, 15cm, and <15cm for classes 1 to 5 respectively.

ALC has been mapped for the whole of England and Wales between 1966 and 1974 at 1:250,000 (Natural England 2009). Selected areas have subsequently been remapped in greater detail and with an updated classification system. The UK ALC is considered to be well established and understood in the UK planning system and is used to provide an appropriate framework for determining the physical quality of land at national, regional and local levels (MAFF 1988).

New Zealand: The New Zealand Handbook for the Classification of Land (Llyn et al 2009) uses a capability system similar to that of the USA and UK. Capability is defined in terms of those properties of land that determine its long-term sustained production and versatility and is based on interpretation of biophysical attributes contained in the Land Resource Inventory (NZ LRI) national database. Five factors from the NZ LRI are considered in assigning land to a capability class: rock type; soil; slope; vegetation cover; erosion (present and potential); and, climate. Land is assigned to one of 8 capability classes where: classes 1 to 4 are considered arable land suitable for cropping; classes 1 to 7 are considered suitable for pastoral grazing, tree crops, and forestry; and, class 8 is considered unsuitable for agriculture. Land considered suitable for cropping must be capable under good management, of growing at least one common annual field crop 4 years in 5 without permanent adverse impacts to soil or environment.

2. Other states within Australia

Victoria: The Land Capability Assessment system developed by the Soil Conservation Authority of Victoria in the late 1970's assesses potential of land for specific individual land utilisation types. Land utilisation types are defined as combinations of the kind of production and the principal management requirements of a land use (Rowe et al 1981). Land is assigned to one of five capability classes according to the severity of limitations present that impact on the degree of production (or level of success) in the use specified by the land utilisation type for which it is being scored. Land in Class 1 is considered highly suitable for the use being assessed, Classes 2 to 3 are considered suitable but with limitations, Class 4 is considered marginally suitable, and Class 5 is considered unsuitable for that use. Capability rating systems have been developed for: engineering uses; septic waste disposal; extractive industries; land-based recreation; grazing; cropping; and forestry. Land features used in the assessment include: soil structure; flooding return period; soil drainage; rooting depth; texture of A horizon; aggregate stability of A horizon; gravels and stones; and boulders and rock outcrop.

Rowe et al also discuss mapping requirements. They point out that land capability rating systems are designed for application to areas of land which are uniform with respect to the relevant diagnostic criteria. Such areas they term *land components.* They argue that mapping at scales of 1:50,000 to 1:25,000 is required to consistently distinguish between land components and note that land resources projects are much more commonly mapped at scales of 1:250,000 to 1:100,000. They point out that at these scales the mapped units are usually *land systems*, or areas of land where land components occur in consistent patterns. They suggest that the needs of regional planning can be satisfied with mapping of *land systems* together with more detailed and specific information about the components that they comprise.

New South Wales: Two systems of land evaluation exist in New South Wales (NSW Agriculture 2002). The (former) Department of Land and Water Conservation (now Department of Primary Industries) developed an eight class land capability system. This system is analogous to that developed in the US (described above). It assesses land according to its inherent physical characteristics, or physical constraints, and classifies it according to the measures required to protect the land from soil erosion and other forms of land degradation.

NSW Agriculture has developed a system that classifies land in terms of its suitability for general agricultural use. This system takes into account social and economic factors as well as biophysical ones in assigning land to one of a hierarchy of five classes ranging from arable land with few constraints and high productive potential (Class 1) through to land that is unsuitable for agriculture (Class 5). Intensive animal industries are excluded from the system because it is argued their requirements are largely independent of land suitability. A Specialist Class is also included to identify land which, because of a combination of soil, climate and other features, is suited to intensive production of a notable specialised crop or a narrow range of crops (such as bananas). This system was developed specifically to meet the objectives of the *NSW Environmental Planning and Assessment Act 1979*, '*to encourage the proper management, development and conservation of natural and man-made resources, including agricultural land...for the purpose of promoting social and economic welfare of the community and a better environment'*, by identifying land requiring land use planning protection because of its agricultural value. This system is the basis for the agricultural land use planning approach currently being implemented by the NSW Government (State of New South Wales 2012).

Tasmania: The *Guidelines for the Classification of Agricultural Land in Tasmania 2nd Edition* (State of Tasmania 1999), define *land capability* as a ranking of the ability of land to sustain a range of agricultural land uses without degradation of the land resource. Tasmania applies a system based on that used in the USA to assess land potential for generalised agricultural land uses (defined as broadscale grazing and cropping, but not forestry). The stated intention is to assess the versatility of the land to produce a range of agricultural goods that are considered typical for Tasmania, and not just those that are specific or suited to localised areas. Only permanent biophysical characteristics of the land, such as geology, soils, slope, climate and their implications for long-term sustainable use under current land management practices, are taken into account in assigning capability. Economics of agricultural production, distance from markets, and social or political factors are specifically excluded from consideration. However it is assumed that the land is being managed at a better than average level and that appropriate soil conservation measures are being applied. Also, where physical limitations (e.g. high water tables, stoniness, or low fertility) are present that are considered reasonable and feasible for an individual farmer to remove or modify, the land is assessed assuming the improvements have been made.

The Tasmanian system uses seven classes ranging from: Class 1, which is defined as *land capable of being cropped eight to nine years out of ten in a rotation with pasture or equivalent without risk of damage to the soil resource or loss of production, during periods of average climatic conditions*; to Class 7, which is defined as *land unsuitable for agricultural use*. Classes 2 to 6 represent increasing incidence and severity of limitations with sustainable cropping frequency declining for instance from five to eight years out of ten for Class 2; three to five years out of ten for Class 3; one to two years out of ten for Class 4; to not at all for Classes 5, 6, and 7 (State of Tasmania 1999). Where mapping of land resources is available it is at 1:100,000 scale. This means that units are generally only mapped at the land system level.

Western Australia: In March 2002 the Western Australian Government implemented the Statement of Planning Policy No. 11 Agricultural and Rural Land Use Planning (Government of Western Australia 2002). This policy aims to: protect agricultural land resources; plan and provide for rural settlement; minimise the potential for land use conflict; and carefully manage natural resources. It does this in part by requiring that land identified as an *agricultural area of state or regional significance* be zoned as 'Priority Agriculture' within a town planning scheme. Land uses other than agriculture are only permitted in areas zoned as 'Priority Agriculture' where they have minor impact. Before land zoned as 'Priority Agriculture' can be rezoned, subdivided or developed for non-agricultural use an Agricultural Impact assessment is required.

Agricultural areas of state or regional significance are defined as: *areas that contain productive agricultural land that is suitable for the sustainable development of key or specialised agricultural uses that are of significant economic or social value to the state or a particular region*. To form the focus of further detailed investigations to identify agricultural areas of state or regional significance, the Department of Agriculture identified a set of Agricultural Priority Management Areas. Agricultural Priority Management Areas were identified by regional soil experts broadly delineating areas which contained or potentially contained combinations of water, land and climatic resources suitable for the key agricultural uses (Government of Western Australia 2002). Maps of Agricultural Priority Management Areas are contained as attachments to the Statement of Planning Policy.

A method for evaluating and refining Agricultural Priority Management Areas for classification as agricultural areas of state or regional significance has been developed by the Department of Agriculture Western Australia. This method uses a multi-criteria evaluation tool, the Comparative Agricultural Area Suitability Assessment Methodology (CAASAM) (Kininmonth, 2000). CAASAM has been specifically designed to overcome many of the limitations associated with previous over-reliance in WA exclusively on land capability assessment for strategic land use planning. Features of the method include: consideration of a wider range of factors relevant to an area's development; inclusion of both quantitative and qualitative attributes; and, encouraging planners to focus on agro-ecological areas. CAASAM involves assessment of 15 physical and non-physical criteria considered important for the use and development of an area by the key agricultural uses. These criteria are grouped into three areas: productivity (such as soil limitations to plant growth); conservation (such as land degradation hazards); and, development (such as transport infrastructure). A score is assigned to each criterion for each area and then weighted to recognise that some criteria were more important than others. The weighted scores are then summed to calculate an overall score to provide a consistent basis for comparison between all areas.

Appendix 2: Agricultural land use categories used in the Audit

The following are sourced from definitions used by the Australian Land Use Mapping program (http://adl.brs.gov.au/landuse/) and from the relevant Queensland Planning Provisions (http://www.dlgp.qld.gov.au/resources/policy/state-planning/qpp-3.pdf.)

Annual horticulture (intensive seasonal cropping): land used for growing plants and/or production of plant materials for commercial purposes where plants live for less than one year, are dependant on intensive cultivation of the soil, and usually require a relatively high degree of nutrient, weed and moisture control. Rainfall is almost exclusively supplemented by irrigation to promote high yields and productivity. Cropping usually takes place on a small scale (paddocks generally <100ha). Includes harvesting and the storage and packing of produce and plants grown on the site and the ancillary repair and servicing of machinery used on the site.

Aquaculture: use of land for the cultivation of aquatic animals or plants in a confined area that may require the provision of food either mechanically or by hand. Examples include pond farms, tank systems, hatcheries, raceway system, rack and line systems.

Broadacre cropping: land used for growing plants and/or production of bulk plant materials (such as cereal grains, oil seeds or pulses) for commercial purposes where plants live for less than two years, are dependant on cultivation of the soil, and usually require some nutrient, weed and moisture control. Production relies entirely on rainfall or is normally supplemented to promote productivity over dry periods, depending on the season, water availability and commodity prices. Cropping usually takes place on a large scale (paddocks generally >100 ha). Land may be managed in a rotation system, so that from time to time the same area may be, for example, under pasture. Land in a rotation system is classified according to the land use it is expected to be in for the majority of time between the present and 2040.

Grazing – native pasture: use of land for production of animals or animal products on native pastures or vegetation. Native pastures are defined as vegetation where there has been limited or no deliberate attempt at pasture modification. Some change in species composition may have occurred due to invasion but the vegetation groundcover is more than 50% native species. Land may be managed in a rotation system, so that from time to time the same area may be, for example, under crop. Land in a rotation system is classified according to the land use it is expected to be in for the majority of time between the present and 2040. Includes land used for ancillary yards, stables and temporary holding facilities and the repair and servicing of machinery.

Grazing – sown pasture: use of land for production of animals or animal products on non-native pastures or plants, both annual and perennial. Pasture improvement requires significant active modification or replacement of the initial vegetation such that more than 50% of vegetation groundcover is exotic species. Land may be managed in a rotation system, so that from time to time the same area may be, for example, under crop. Land in a rotation system is classified according to the land use it is expected to be in for the majority of time between the present and 2040. Includes land used for ancillary yards, stables and temporary holding facilities, as well as facilities for the repair and servicing of machinery.

Intensive animal industries: use of land for the intensive production of animals or animal products in an enclosure that requires the provision of food and water either mechanically or by hand. The use includes the ancillary storage and packing of feed and produce.

Perennial horticulture (tree and vine cropping): use of land for production of nuts and fruits from woody and semi-herbaceous plants (trees or perennial vines) that are cropped over a period longer than one year. Production may be dependant on intensive cultivation of the soil at intervals during that period, and usually requires a relatively high degree of nutrient, weed and moisture control. Rainfall is normally supplemented to promote high yields and productivity, and survival over dry periods, depending on the season and water availability.

Plantation forestry: use of land to establish and manage plantations of trees (native or exotic species) for commercial production of timber. Trees are generally relatively long-lived (>20 years) and there is normally a period of relatively intensive cultivation of the soil, nutrient addition and weed control during the early establishment years as well as periodic disturbance associated with harvesting at intervals throughout the rotation.

Native forestry: use of land for commercial production of timber from *existing* native forests. Also includes related activities to encourage regeneration and increase production such as burning and thinning.

Appendix 3: Audit regions

Appendix 4: Issues that are outside the scope of the Audit

The Queensland Agricultural Land Audit (the Audit) will not cover:

- use of land for off-farm processing of agricultural products;
- Non-agricultural land uses such as industrial uses, mining, built-up or developed areas and conservation areas. Farm-based tourism will also not be considered;
- Wild harvest of native and feral species. This is not included within the scope as such animals are transient and therefore are difficult to assign to a particular site and harvest of such animals is opportunistic, varying considerably with season, markets and prices of other agricultural commodities; and
- Potential use of land on off-shore islands. While it is recognized that these areas are significant for local communities in terms of food production, due to the limits on the capacity of such land/communities, this is considered to be outside the objective of the Audit.

The Audit will not:

- analyse implications for industry development. Such work will occur as part of policy development and other decision-making processes by government and industry that will follow completion of the Audit;
- replace existing legislation or state planning policies regarding use of agricultural land;
- make recommendations regarding research and development priorities for agriculture (although it is expected that the Audit will provide key factual information to underpin such recommendations);
- retrospectively analyse agricultural land lost to urban expansion, industry and other development;
- suggest or recommend management practices for land important to current and future agricultural production;
- produce on-line decision and information presentation tools. Once the Audit project is completed, the information developed under the Audit could be developed further (in accordance with client needs) into online based tools however time and resource constraints will prevent this being done as part of the Audit; or
- monitor changes in land use. The Queensland Land Use Monitoring program (QLUMP) currently monitors changes in land use on an irregular basis. With additional resourcing such monitoring could occur on a regular basis (i.e. every 2-3 years).

Constraints outside the scope of the Audit:

- business management decisions on specific properties or by specific companies, personal choices of producers and social issues for which either no, or only anecdotal data is available. These issues occur largely outside the mandate of government influence, and therefore are considered to be outside the scope of the Audit. These include:
    - Business factors that influence the existing and potential agricultural land use of an area such as:
        - Business management preferences of individual land managers
        - Pre-existing infrastructure such as fences and water points that can 'lock in' the use of land
        - land management practice choices made by a manager for business reasons which have lasting influence on the potential a land to be used for other purposes e.g. the choice of conventional approaches precludes a shift to organic farming in the short-term

  - Investment capability of individual farmers. Although there are a number of indicators of industry financial performance such information is very changeable between sectors and individuals.

- External market forces
  - Critical mass of land within an individual property suitable for a particular land use that creates a viable enterprise of that type (e.g. the area of land with cropping potential across a farm).
  - Profitability of an agricultural activity. This is a complex indicator based on a range of business management decisions, market forces and land management practices (including the history of land management and ownership).
  - Existing knowledge/experience of a producer and access to external technical advice. This can impact on the type of agricultural activity conducted by an agribusiness.
  - Financial capacity of an agribusiness. This impacts on the ability of a farmer to invest in improvements and to adapt in accordance with markets and other changes. Off-farm income, access to finance, property size and productivity, and the condition of existing capital assets can all influence financial decisions which in turn influences the viability of different agricultural activities.

- Personal or lifestyle decisions
  - Individual choices relating to family, 'culture', and lifestyle e.g. regarding retention rates of families and skills in agricultural communities. Such choices will also be influenced by access to social infrastructure to community services (schools, etc) and in turn to proximity to urban centres.

- Community level influences
  - Communities exert persuasive power over individuals to behave in a particular way. This can influence the willingness of landholders to change practices and adopt innovative ideas.

Appendix 5: Spatial datasets used in the Audit

Topic	Name	Attributes or unit of measure	Custodian or source and currency	Use in the Audit
Current land use	QLUMP	Land use classes	DoSITIA (various, mainly 1999 and 2009)	Show current land use. Also used to exclude urban areas, infrastructure, and mines from potential agricultural land.
Intensive livestock producers	Feedlots, piggeries, poultry meat, egg, and aquaculture producers	Property	DAFF (2013)	Show current locations of producers for intensive animal production.
Agricultural commodity marketers and processors	Sawmills, sugar mills, cotton gins, fruit and vegetable processors and markets, poultry meat and egg processors, livestock saleyards and abattoirs	Location	DAFF (2013)	Show current locations of processors with specified minimum capacity..
Soil and land resources	ALC	ALC Class	DoSITIA (various, ALC classification updated to 2013)	Map potential landuse. Constraints applied to this depending on land use type.
Relief	DEM	1 sec DEM	DoSITIA (2013)	Calculate slope and remove unsuitable areas from potential
Precipitation	SILO	Mean annual rainfall and rainfall probability	DoSITIA (2012)	Identify and exclude areas where rainfall is too low or too high from potential agricultural land depending on land use.

Topic	Name	Attributes or unit of measure	Custodian or source and currency	Use in the Audit
Tenure	DCDB	Tenure and location	DNRM (2013)	Background context regarding constraints and potential. Remove protected areas from potential agricultural land - include all NPs, state forest, nature refuges (estate layer and nature refuges layer)
	Stock routes	Location of stock routes	DNRM (2013)	Identify transport corridors for droving livestock
	Forest practices notifications	Land parcels where a FPN has been issued	DNRM (2012)	Identify freehold land currently used for native forestry production
Administration	State boundary	Location	DAFF (2013)	Define geographic scope of statewide study
	Planning region boundaries	Location and name of region	DSDIP (2012)	Define geographic scope of regional studies
	LGA boundaries	Location and name of LGA	DNRM (2012)	Landscape context and orientation.
Temperature	Minimum temp	Annual average number of days with minimum temperatures below threshold.	BoM (2011)	Remove areas unsuitable due to frost incidence from potential agricultural land depending on land use.
Water	Irrigation areas	Qld irrigation systems DCDB	DEWS (2013)	Background context regarding constraints and potential for irrigated agriculture.

Topic	Name	Attributes or unit of measure	Custodian or source and currency	Use in the Audit
	Water Manag't Areas	Boundaries and names of water allocation areas/districts	DEWS (2013)	Background context regarding constraints and potential for irrigated agriculture
	Rivers	Location and name	ANZLIC the Spatial Information Council (2008)	Landscape context and orientation
	Dams and Lakes	Location	Geo Science Australia (2008)	Landscape context and orientation
	Coastline	Location	Geo Science Australia (2008)	Landscape context and orientation
Vegetation	VMA	VMA status	DNRM (2012)	Identify areas where land clearing is restricted under VMA.
	RE	Regional ecosystem	DoSITIA (2012)	Identify native forestry production potential
	RE height	Mean canopy top height	DoSITIA (2012)	Identify native forestry production potential
	Forest Plantations	Hardwood, softwood, or fallow plantations	DAFF (2013)	Identify current forestry plantation land use.
	FPC	Foliage projected cover %	DoSITIA (2012)	Use for potential native forestry map and grazing models.
	MUIDS	Land parcels where state has a forestry interest.	DAFF (2013)	Identify areas of current native forestry activity

Topic	Name	Attributes or unit of measure	Custodian or source and currency	Use in the Audit
	GLM land types	Extent and location of identified different land types	DAFF (2013)	Input to modelling of pasture production to assess grazing actual and potential.
Biosecurity	APDS	Distribution of pest plants and animals	DAFF (2012)	Check presence of weeds and feral animals as possible reason for not using potential land. Info only.
Transport	Public road and rail network		DAFF (2012)	Identify areas where access to markets is constrained by transport.
	Cane rail network		Australian Sugar Milling Council (2013)	Identify areas of potential sugar land with rail access to mills.
	Airports and harbours	Location	DAFF (2013)	Identify potential transport routes for agricultural produce
Population	Population centres	Townships by number or residents at last census	DAFF (2013)	Identify areas with access to workforce

Appendix 6: Local governments in each of the planning regions

Darling Downs

- Balonne Shire
- Goondiwindi Regional Council
- Maranoa Regional Council
- Southern Downs Regional Council
- Toowoomba Regional Council
- Western Downs Regional Council

Central Queensland

- Banana Shire
- Central Highlands Regional Council
- Gladstone Regional Council
- Rockhampton Regional Council
- Woorabinda Shire

Mackay, Issac, Whitsunday

- Mackay Regional Council
- Issac Regional Council
- Whitsunday Regional Council

Charters Towers

- Burdekin Shire
- Charters Towers Regional Council
- Hinchinbrook Shire
- Palm Island Shire
- Townsville City

Gulf

- Burke Shire
- Carpentaria Shire
- Croydon Shire
- Doomadgee Shire
- Etheridge Shire
- Kowanyama Shire
- Mornington Shire

Cape

- Aurukun Shire
- Cook Shire
- Hope Vale Shire
- Lockhart River Shire
- Mapoon Shire
- Napranum Shire
- Northern Peninsula Area Regional Council
- Pormpuraaw Shire
- Torres Shire
- Torres Strait Island Regional Council
- Weipa Town

Far North Queensland

- Cairns Regional Council
- Cassowary Coast Regional Council
- Tablelands Regional Council
- Wujal Wujal Shire
- Yarrabah Shire

South West Queensland

- Bulloo Shire
- Murweh Shire
- Paroo Shire
- Quilpie Shire

Central West Queensland

- Barcaldine Regional Council
- Barcoo Shire
- Blackall Tambo Regional Council
- Boulia Shire
- Diamantina Shire
- Longreach Regional Council
- Winton Shire

North West Queensland

- Cloncurry Shire
- Flinders Shire
- McKinlay Shire
- Mount Isa City
- Richmond Shire

South East Queensland

- Brisbane City
- Gold Coast City
- Ipswich City
- Lockyer Valley Regional Council
- Logan City
- Moreton Bay Regional Council
- Redland City
- Scenic Rim Regional Council
- Somerset Regional Council
- Sunshine Coast Regional Council.

Wide Bay Burnett

- Bundaberg Regional Council
- Cherbourg Shire
- Fraser Coast Regional Council
- Gympie Regional Council
- North Burnett Regional Council
- South Burnett Regional Council

Appendix 7: Glossary of terms

Agricultural Land: land that is currently used, or has the potential to be used in the future, for any of the Agricultural Land Use Categories listed in Appendix 1.

Agricultural Land Evaluation: the process of estimating the potential of land for alternative kinds of land use so that the consequences of change can be predicted.

Agricultural Land Class: A hierarchical system of classifying land for the purposes of strategic planning. The classes indicate a decreasing range of land use choice, an increasing range of land use limitations, and an increasing land degradation hazard.

Agricultural Land Use Category: broad sectors or commodity groupings of agriculture for the purposes of the Audit as defined in Appendix 1.

Built infrastructure: civil engineering works such as roads, bridges, railways, channels, communications towers etc. that have been constructed.

Constraint: a physical, social, economic or policy condition that currently prevents land use change.

Geographic Information System: a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data.

GRASP: a one dimensional daily timestep model of the climate-soil-plant-animal-management of perennial grasses of northern Australia. Inputs include daily rainfall, temperature, evaporation, radiation and vapour pressure, soil data (e.g. field capacities and wilting points), plant growth, cover, temperature responses, nitrogen, senescence, litter breakdown and management decisions like stocking rate and burning. Outputs include simulated pasture production and degradation risk.

Important Agricultural Land: land that has the potential (currently or in the future) to supply the natural, built and human resource requirements to practice one or more agricultural land use category(s) (as defined in Appendix 1) successfully and sustainably, is part of a critical mass of land with similar characteristics that is sufficiently large to support an aggregation of agricultural businesses of that type that is viable in the long-term, and is strategically significant to the region or the state.

Land Unit: An area of common landform, geology and soils occurring repeatedly at similar points in the landscape over a defined region.

Land Use Potential: the fitness (in terms of ability to supply either natural, built, and human resource requirements) of a given area for a particular category of agricultural land use.

Limitation: a characteristic of land that, in certain quantities (called limitation subclasses), restricts the potential use of that land for a particular category of agricultural land use.

Multi-criteria Analysis: a decision-making approach used for problems with many alternative solutions and many different types of consequences. Alternative solutions may include variations in space and/or time. Multi-criteria analyses may include qualitative and/or quantitative aspects of the problem in the decision-making process and usually include a component of ‘trading off’ and/or prioritising different consequences.

Natural Requirements: components of the natural environment such as soils, terrain and climate which determine the ability for agriculture to fully utilise land potential.

Opportunity: a location where current land use does not reflect potential land use.

Processing facilities: abattoirs, fruit packing sheds and other factories or plants used to process agricultural produce from raw form.

QLUMP: the Queensland Land Use Mapping Program maps and monitors land use and land use change across Queensland using remote sensing and ground survey. Land use is mapped using a standard classification system, the Australian Land Use Mapping (ALUM) system.

Regional Planning Area: boundaries for existing or proposed Statutory Regional Plans determined by the Department of State Development, Infrastructure and Planning.

Threat: a trend in activities that restrict, or have the potential to restrict, current agricultural activity.

Appendix 8: Constraints considered in the Audit

- Biosecurity (including quarantine zones, weeds, feral animals, diseases)
- Land degradation
- Vegetation (Clearing controls)
- Wild Rivers (Dams/weirs; new crops or orchards in high preservation zones)
- State leasehold land requirements (requirements/conditions placed on leases)
- Planning controls (state, regional and locally set zoning and planning provisions)
- Water access (i.e. entitlements and access to new/unallocated water)
- Critical mass required for agricultural activities to be viable
- Capacity of processing facilities
- Land valuation (cost and return)
- Land ownership, availability, competition with other sectors (e.g. urban growth, mining, CSG)
- Power supply availability (Access, viability of on-grid and off-grid arrangements)
- Access to fast reliable digital networks
- Aging workforce (skills and labour)
- Maintenance of research, development and extension capacity.

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