Department of Science, Information Technology, Innovation and the Arts

The land-resource base to the Strategic Cropping Land Trigger map

Data and processes used to update the trigger map

Soil and Land Resources

Version 1.0

Great state. Great opportunity.

Queensland Government

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Disclaimer

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Overview

Following a request from the Department of Natural Resources and Mines (DNRM) to review and update the Strategic Cropping Land (SCL) Trigger Map, the Soil and Land Resources group in DSITIA undertook a comprehensive process to compile the latest data and undertake refinements to the trigger map. The updated land-resource based trigger map is used by DNRM to rebuild the final SCL trigger map with other data such as validation decisions, vegetation, land use and small lots1.

The land-resource trigger map was produced using a combination of soil and elevation data to produce a refined land-resource based trigger that will define with more accuracy the area likely to contain strategic cropping land. The soil based data employed had undergone a rigorous Quality Assurance / Quality Control (QA/QC) review during 2012/3 for the Agricultural Land Audit, this review made alterations to the way in which land is classified, and to provide a more accurate description of the land resource. In addition, the reclassification allowed a more consistent approach to be delivered by government o the resource and agricultural sectors. The inclusion of a terrain based limitation on the land resource data was made available through the release in 2011 of a consistent and accurate elevation model and subsequent slope assessment.

The combination of improved description of soil data and the ability to use terrain data to further enhance the accuracy of the land-resource based trigger map will lead to a more reliable SCL trigger map that uses the most appropriate and consistent data to identify areas likely to contain SCL. The updated and improved land-resource based trigger data was delivered to DNRM in February 2014.

This report provides a detailed description of the methods used to update the SCL trigger map for Queensland.

[1] Refer to DNRM Land and Mines Policy for details on the non-land resource based components of the trigger map.

Data used

Soil and land resource data

The soil and land resource data used as a base to the SCL trigger is the foundational dataset for a number of regulations, policies and programs. The soil data is from a series of individual projects which were collected over the last 60 years. During 2012 the spatial soil and land resource data underwent significant QA/QC processes. These processes identified some errors within individual datasets and highlighted inconsistencies between projects in the definition of key attributes. Within the Queensland Government, the point of truth for soil and land resource data is the Soil and Land Information (SALI) system.

Agricultural Land Class

Agricultural land classification uses a simple hierarchical scheme that is applicable across the state. It allows the presentation of interpreted land evaluation information to indicate the location and extend of agricultural land that can be used sustainably for a wide range of land uses with minimal degradation. A full description of the agricultural land classification for land planning can be found in (Land Resources Branch 1992).

The major inconsistencies between projects discovered by the QA/QC process were variations in the description of agricultural land class over the previous 20-25 years. A decision was therefore made to revisit the agricultural land classification for all significant soil and land resource projects across the state. The review process coincided with the Agricultural Land Audit (Department of Agriculture, Fisheries and Forestry 2013) which provided a strict timeline for completion of the re-interpretation of the existing agricultural land class data.

To assist the review of the agricultural land classes, the land resource scientists within DSITIA and DNRM took the opportunity to refine the definitions of Agricultural Land Class in the Guidelines for Agricultural Land Evaluation (Queensland Government *in prep*). The previous definitions were not necessarily clear and concise when applied in the context of SCL. The need to refine and make the definition explicit had become a priority since the scheme is now used to underpin regulations rather than as a decision support tool for land planning. Table 1 lists a comparison of the definitions from the 1992 (Land Resources Branch 1992) and 2013 (Queensland Government *in prep*) versions of Queensland's land evaluation guidelines.

The terms 'wide range' and 'narrow range' were introduced to the definitions to remove vague statements such as 'most' and 'some'. The definitions of wide and narrow are also defined to remove any ambiguity. The updated definitions are:

> *A 'wide range' of crops is defined as four or more existing crops of local commercial significance. In areas where there is an infrastructure requirement to support an industry, the land may only be suitable for three or fewer crops, providing the crop is considered to be a regionally significant crop.*
>
> *A 'narrow range' of crops is defined as three or fewer existing crops of local commercial significance, with the exception of areas where there is an infrastructure requirement to support an industry.*

The updated definitions of Agricultural Land Class also included an important new addition with the allowance to record complex codes, i.e. A/C, C/A. This enabled the description of areas with a sub-dominant land class to be identified. During the QA/QC process it was identified that several studies had used Class B land to identify mixed units of A and/or B lands with Class C land. The addition to allow complex codes clearly identifies these areas of mixed units with dominant and sub-dominant land classes.

All of the applicable soil and land resource data within the state was re-evaluated in light of the revised definitions and the changes recorded in SALI. Prior to updating the land class information, a copy of the historical data was captured and stored for future reference within appropriate record-keeping systems.

Versatile Cropping Lands

The versatile cropping lands methodology assesses the number of crops that the soil can suitably support. Where the area is suitable for four or more crops, it is classed as 'versatile'. Under this methodology, these areas are comparable to Class A agricultural land.

The regions that have been assessed with the versatile cropping lands methodology are along the coast, principally between Sarina to Cairns. There has been no change to versatile cropping land methodology since its development in 2008/9.

Exemption areas for use of land use mapping

In certain areas of the trigger map, where there is high quality soil and land resource information, a land use overlay should not be used to assist in the identification of potential strategic cropping land. The areas with data that met this condition have soil and land resource mapping with a scale of 1:100,000 or better, and have a land suitability assessment scheme applied. In these areas it is considered that soil and land resource mapping is at a scale appropriate for the adequate identification of the land resources.

In the absence of data with this level of accuracy, it is considered that a land use overlay will be beneficial to identify areas of potential strategic cropping land.

The new version of the trigger map has been updated to accommodate this revised rule. A mask of the areas to have the land use rules applied was produced based on project boundaries and the data requirements. This mask was delivered to DNRM for use in the final version of the SCL trigger map when QLUMP data was included.

Table 1. Comparison of Agricultural Land Class definitions from 1992 to 2013.

Class	2013 Definition	1992 Definition
A	Land that is suitable for a wide range of current and potential crops with nil to moderate limitations to production.	Land suitable for most agricultural land uses in a particular area. Limitations to production range from none up to moderate levels. Conservation tillage and structural soil conservation works are required for cultivation on sloping lands.
B	Land that is suitable for a narrow range of current and potential crops but unsuitable for a wide range of current and potential crops due to severe limitations. The land is suitable for pastures and may be suitable for cropping with changes to knowledge, economics or technology.	Land suitable for pastures and/or some crops with specialised requirements. Land with severe limitations for most agricultural land uses, and would require further economic, engineering or agronomic studies before the land would be considered suitable (Suitability class 4 land for most crops). and/or Land with severe limitations to most crops but which may be suitable for crops that have different requirements. For example, land too steep for continuous cultivation may be suitable for tree crops or perennial forage crops, as such crops do not require continuous cultivation. Poorly drained land may be only suitable for rice production.
C	Land that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.	Land suitable for native and improved pastures only. Limitations preclude continuous cultivation for crop production but some areas may tolerate a short period of ground disturbance for pasture improvement.
D	Land not suitable for agricultural uses due to extreme limitations, including land alienated from agricultural uses.	Land not suitable for agricultural land uses
Complexes (e.g. A/C)	Land that is a complex of Class A, B, C or D land where it is not possible to delineate the land class at the map scale. The dominant class is the first code in the sequence and is assumed to be >50% in area, but <70%.	No provision

Digital Elevation Model

A Digital Elevation Model (DEM) is an electronic representation of the earth's surface and for the purposes of the land-resource trigger map was used to model the slope of the land surface. There are several methods of creating DEMs and numerous DEMs are available for parts of Queensland.

The most detailed and state-wide consistent DEM dataset that is available for Queensland is from the Shuttle Radar Topography Mission, known as the SRTM DEM. This dataset is available at two different scales, with the higher resolution 1 arc second version used as an input to the trigger map. The resolution of 1 arc second is comparable to about 30 m on a global level. Although the SRTM product is based on a geographic product with a resolution of 1 arc second, the actual resolution will vary. Across Queensland, this variation is approximately 3 m between Cape York and the border with New South Wales.

DEM-S and accuracy assessment

The version of the DEM used for the slope products was the smoothed DEM (DEM-S). The smoothed DEM had features removed such as vegetation, man-made structures and also removed noise from the raw digital surface model (Gallant *et al* 2011). The DEM-S supports calculation of local terrain shape attributes such as slope.

Gallant *et al* (2011) state the elevation accuracy of the base SRTM DEM as having 90% of tested heights with 9.8 m for Australia. They go on to say that the relative elevation accuracy of the DEM-S has not been assessed but it is improved by the noise reduction procedures imposed on the dataset. The noise reduction procedures typically altered the elevation by 2-3 m but in some cases by up to 10 m. The smoothing process should have improved the elevation accuracy of the DEM-S to approximately 5 m.

In flatter areas (e.g. floodplains) the smoothing algorithms should have improved the data set significantly by the removal of noise. In areas with high slopes the de-noising will be reduced. In low relief areas is may be possible to resolve very low slopes. These low relief areas would include the significant floodplains of Queensland, e.g. the Condamine.

As the focus areas for improvement to the SCL Trigger map are those more gently undulating landscapes it could be expected that the improvements to the DEM-S accuracy are of a higher order. Using the error estimates and commentary provided by Gallant *et al* (2011), the elevation errors in the DEM for the purposes of this project have been set at 2 m. Using a 2 m elevation error in the DEM-S will allow improvements to be made to the Land Resource base for the SCL Trigger map but still allow for unknown variation.

SRTM Slope

A slope product developed by CSIRO and Geoscience Australia was used to minimise the time required to re-calculate a slope product. The slope product used is ‘Percent slope derived from 1 second DEM-S version 0.1’ (Gallant *pers comm*). The percent slope product was developed from the Smoothed 1 arc second DEM.

Percent slope was calculated from DEM-S using the finite difference method (Gallant and Wilson, 2000). The different spacing in the E-W and N-S directions due to the geographic projection of the data was accounted for by using the actual spacing in metres of the grid points calculated from the latitude.

Gallant *et al* (2011) did not quantify the potential errors in the DEM-S after smoothing, but as discussed above they are likely to be less than 5 m. Based on assumed improvements to the relative elevation by the smoothing an assumption was made that the actual elevation error may be reduced to 2 m for the majority of the areas of concern. This 2 m elevation difference would equate to a potential for an error in slope of approximately 3%, i.e. 2 m elevation change over 60 m is 3.33%.

Therefore the SCL slope limits for the on-ground assessment were buffered by an increase of 3% slope. The slope limits for the land-resource trigger map in the Wester Cropping Zone for SCL were 6% (increased from 3% in the regulations), while 8% (increased from 5% in the regulations) was used in the remainder of the SCL zones. By allowing for the uncertainty in the DEM-S slope derived product, the more accurate on-ground assessments, required by the *Regional Planning Interests Act 2014* (Queensland Government 2014), will be used.

Process

The following section describes the process used to derive the land-resource trigger product in ArcGIS 10.1 (ESRI 2014). The process was complete in four main sections, build the soil and land component, build the slope component, combine the soil and slope data and perform an interpretation to smooth the final product.

A raster data processing environment was used to create and manipulate the data for the trigger map. The raster pixel size, datum, extent and cell locations were based on the 1 arc second SRTM slope product. A mask was used to identify areas outside of the scope of the SCL mapping and this was based on the SCL zone boundaries obtained from the Spatial Information Resource (SIR) environment.

DEM data

The SRTM slope data was obtained in 1 degree tiles. In order to simplify processing, the tiles were mosaicked into a single raster dataset for Queensland. This single dataset became the base raster that all subsequent raster processing operations were based on.

The SRTM slope data was reclassified into three classes based on the SCL criteria for each zone using the 'Reclass tool' in ArcGIS (Table 2). As previously discussed, the SCL slope criteria were buffered by 3% slope to allow for variations and errors in the base DEM. The slope reclassification resulted in three categories as listed in Table 3:

These categories relate to lands that are below the slope limits for the Western Cropping Zone and the remainder of the SCL area. The >8% slope category is for lands that are above the slope limit in all SCL areas. The slope reclassification grid was used with a zonal slope criteria product to allow slope categories within the SCL zones to be determined (Table 4).

Table 2. Parameters for slope reclassification using reclass tool.

Name	Direction	Type	Data Type	Value
Input raster	Input	Required	Composite Geodataset	slope_qld.tif
Reclass field	Input	Required	Field	Value
Reclassification	Input	Required	Remap	0 6.5 6;6.5 8.5 8;8.5 1000 15
Output raster	Output	Required	Raster Dataset	slope_group.tif
Change missing values to NoData	Input	Optional	Boolean	true

Table 3. Slope reclassification values.

Output reclassification value	Minimum slope %	Maximum slope %
6	0	6.5
8	6.5	8.5
15	8.5	1000

Table 4. Parameters for feature to raster conversion for SCL zonal slope criteria.

Name	Direction	Type	Data Type	Value
Input features	Input	Required	Composite Geodataset	scl_zones
Field	Input	Required	Field	scl_slope_criteria
Output raster	Output	Required	Raster Dataset	scl_slope_criteria.tif
Output cell size	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Soil and Land Resource data

The majority of the soil and land resource data to re-build the SCL trigger map was sourced from the SALI database to use both the agricultural land class and versatile cropping lands information. All of the data had its agricultural land class converted to a numeric system (Table 5) to enable more efficient data processing. For all complex agricultural land class codes, the higher classification was used, e.g. complex units of both A/C and C/A were categorised as A and B/C was categorised as B. This method matched that used in the Agricultural Land Audit (H Taylor *pers comm*).

The data from SALI with an agricultural land class was converted from polygons to raster by using the Polygon to Raster tool in ArcGIS (Table 6). The polygons across the state were assigned a priority order for the overlay process based on scale and mapping type. This enabled the best data to be used to create the initial agricultural land class grid. A similar process was used for the versatile cropping land information extracted from SALI (Table 7).

Several regions had relevant data that was not included in SALI and was used in addition to the process. For the Wide Bay – Burnett region, several digital soil assessments had been completed over the past 15 years. These led to key areas having information that was not in SALI for ready access. These key areas included sections along the Burnett River and the former Cooloola Shire. The single Wide Bay / Burnett product developed by DNRM officers in Bundaberg was used to ensure these important areas had high quality data included in the land-resource trigger map (Table 8).

South-East Queensland has numerous areas of poor quality soil and land resource mapping. Within the SEQ region a renewed effort to identify and refine the location of Class A lands is underway. This data is scheduled for loading into SALI but given the timing constraints for the SCL Trigger map re-build, a subset of the QA/QC data was used (Table 9 and Table 10). This led to significant improvements in key areas. A similar process was undertaken for recent mapping around Crows Nest that was not available into SALI.

The South-West Region Agricultural Land Class data was obtained from a single regional dataset from the SIR database. This combined dataset was developed from data in SALI but had an additional interpretation applied to ensure cross-project consistency of mapping (Table 12). This data is also in the process of being loaded into SALI.

All of the datasets with agricultural land class or versatile cropping land were merged into a single state-wide map (Table 13) with value ranging from 1-4 as per Table 5

Table 5. Numeric representation of soil and land data.

Numeric Value	Agricultural Land Class	Versatile Cropping Land
1	A	Yes
2	B	
3	C	No
4	D	

Table 6. Parameters for polygon to raster conversion for agricultural land class from SALI.

Name	Direction	Type	Data Type	Value
Input Features	Input	Required	Feature Layer	SALI data\sali_qgis_view
Value field	Input	Required	Field	alc_num
Output Raster Dataset	Output	Required	Raster Dataset or Raster Catalog	alc_poly2raster.tif
Cell assignment type	Input	Optional	String	CELL_CENTER
Priority field	Input	Optional	Field	overlay_order
Cellsize	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Table 7. Parameters for polygon to raster conversion for versatile cropping land class from SALI.

Name	Direction	Type	Data Type	Value
Input Features	Input	Required	Feature Layer	SALI data\sali_vcl_polygons
Value field	Input	Required	Field	vcl_alc_num
Output Raster Dataset	Output	Required	Raster Dataset or Raster Catalog	alc_vcl_poly2raster.tif
Cell assignment type	Input	Optional	String	CELL_CENTER
Priority field	Input	Optional	Field	project_order
Cellsize	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Table 8. Parameters for feature to raster conversion for Wide-Bay/Burnett agricultural land class.

Name	Direction	Type	Data Type	Value
Input features	Input	Required	Composite Geodataset	SALI data\WBB_AGRICULT_LAND_CLASS_CUR
Field	Input	Required	Field	alc_num
Output raster	Output	Required	Raster Dataset	alc_wbb_poly2raster.tif
Output cell size	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Table 9. Parameters for feature to raster conversion for South-East Queensland agricultural land class.

Name	Direction	Type	Data Type	Value
Input features	Input	Required	Composite Geodataset	SALI data\alc_AB_SEQ_Nov2013
Field	Input	Required	Field	alc_num
Output raster	Output	Required	Raster Dataset	tmp_alc_poly2raster_SEQ.tif
Output cell size	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Table 10. Parameters to mosaic South-East Queensland agricultural land class data into a unified dataset.

Name	Direction	Type	Data Type	Value
Input Rasters	Input	Required	Multiple Value	tmp_alc_poly2raster_SEQ.tif; tmp_alc_seq_backgnd.tif
Output Location	Input	Required	Workspace or Raster Catalog	D:\ag_land\SCL_2014
Raster Dataset Name with Extension	Input	Required	String	alc_seq_poly2raster.tif
Spatial Reference for Raster	Input	Optional	Coordinate System	GCS_WGS_1984
Pixel Type	Input	Optional	String	8_BIT_UNSIGNED
Cellsize	Input	Optional	Double	
Number of Bands	Input	Required	Long	1
Mosaic Operator	Input	Optional	String	MINIMUM
Mosaic Colormap Mode	Input	Optional	String	FIRST
Output Raster Dataset	Output	Derived	Raster Dataset	alc_seq_poly2raster.tif

Table 11. Parameters for feature to raster conversion for Crows Nest agricultural land class

Name	Direction	Type	Data Type	Value
Input features	Input	Required	Composite Geodataset	SALI data\CN_Agland_A_Class
Field	Input	Required	Field	ALC_NUM
Output raster	Output	Required	Raster Dataset	alc_cn_poly2raster.tif
Output cell size	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Table 12. Parameters for feature to raster conversion for South-West region agricultural land class.

Name	Direction	Type	Data Type	Value
Input features	Input	Required	Composite Geodataset	SALI data\SWR_alc_2012_v3
Field	Input	Required	Field	alc_num
Output raster	Output	Required	Raster Dataset	alc_swr_poly2raster.tif
Output cell size	Input	Optional	Analysis Cell Size	2.77777777782262E-04

Table 13. Parameters to mosaic all agricultural land class data into a unified dataset.

Name	Direction	Type	Data Type	Value
Input Rasters	Input	Required	Multiple Value	alc_vcl_poly2raster.tif; alc_cn_poly2raster.tif; alc_swr_poly2raster.tif; alc_wbb_poly2raster.tif; alc_seq_poly2raster.tif; alc_poly2raster.tif
Output Location	Input	Required	Workspace or Raster Catalog	D:\ag_land\SCL_2014
Raster Dataset Name with Extension	Input	Required	String	alc_qld.tif
Spatial Reference for Raster	Input	Optional	Coordinate System	GCS_WGS_1984
Pixel Type	Input	Optional	String	8_BIT_UNSIGNED
Cellsize	Input	Optional	Double	
Number of Bands	Input	Required	Long	1
Mosaic Operator	Input	Optional	String	FIRST
Mosaic Colormap Mode	Input	Optional	String	FIRST
Output Raster Dataset	Output	Derived	Raster Dataset	alc_qld.tif

Combination of soil and DEM data

Following the preparation of the soil and land resource data and the slope derived classification the datasets were combined with the SCL zones to produce a single raster of land class, slope and zone. This single dataset allowed the selection of areas that met the relevant criteria.

The single dataset was developed using the 'combine' function in ArcGIS (Table 14). This allowed all the combinations of land class, slope and SCL zone to be readily identified. The combinations that are potentially SCL and would appear on the land-resource based trigger map were then able to be selected using the rules in Table 15 and used as a subset for later processing.

Table 14. Parameters to combine the soil and land resource agricultural land dataset and the slope datasets into the single combined coverage.

Name	Direction	Type	Data Type	Value
Input rasters	Input	Required	Multiple Value	slope_group.tif; alc_qld.tif; scl_slope_criteria.tif
Output raster	Output	Required	Raster Dataset	comb_zone_criteria_alcA.tif

Table 15. Combinations of soil and land resource and DEM data used.

Land-resource based trigger	Soil and land resource data	DEM data	SCL Zone
Included on map	Class A agricultural land or Versatile Cropping Land	SRTM slope < 6%	Western Cropping Zone
Included on map	Class A agricultural land or Versatile Cropping Land	SRTM slope < 8%	All other SCL zones
Excluded from map	All other categories	SRTM slope > 6 %	Western Cropping Zone
Excluded from map	All other categories	SRTM slope > 8 %	All other SCL zones

Following the delineation of areas to be included on the land-resource based component of the trigger map from the single dataset a smoothing routine was used to simplify and remove small areas from the final product. The smoothing process was undertaken by calculating the size of the regions or groups of pixels in the single soil and DEM dataset (Table 16). The calculation of patch size allowed small areas that are less than the minimum size criteria from the SCL regulations to be removed from the dataset. This meant that areas in the single combined dataset of less than 100 ha in the Western Cropping Zone and the Eastern Darling Downs were deleted from the dataset.

After the removal of the small areas (Table 17) the 'Nibble' function was used in ArcGIS to expand the surrounding patches of either included or excluded sections of the single dataset into areas that failed to meet the size criteria (Table 18). The nibbling typically removed small areas of higher slope land or small areas of relatively flat land within larger patches of the landscape.

The effect of removing small areas, some as tiny as 0.009 ha, was to remove noise from the dataset and smooth the final product to a map that ignored minor landscape variations.

Table 16. Parameters to group raster patches to regions.

Name	Direction	Type	Data Type	Value
Input raster	Input	Required	Composite Geodataset	comb_size_scl_reclass.tif
Output raster	Output	Required	Raster Dataset	comb_size_scl_reclass_g.tif
Number of neighbors to use	Input	Optional	String	FOUR
Zone grouping method	Input	Optional	String	WITHIN
Add link field to output	Input	Optional	Boolean	true
Excluded value	Input	Optional	Long	

Table 17. Parameters to set as null small regions of included and excluded areas.

Name	Direction	Type	Data Type	Value
Input conditional raster	Input	Required	Composite Geodataset	comb_size_scl_reclass_g.tif
Input false raster or constant value	Input	Required	Composite Geodataset	comb_size_scl_reclass_g.tif
Output raster	Output	Required	Raster Dataset	comb_size_scl_reclass_g_m.tif
Expression	Input	Optional	SQL Expression	("Count" <= 22 and "scl_zone_s" = 5) or ("Count" <= 111 and "scl_zone_s" = 100)

Table 18. Parameters to nibble the small regions of included and excluded areas to produce the final land-resource based trigger product.

Name	Direction	Type	Data Type	Value
Input raster	Input	Required	Composite Geodataset	Building SCL Input Layer\scl_A_slope_reclass.tif
Input raster mask	Input	Required	Composite Geodataset	comb_size_scl_reclass_g_m.tif
Output raster	Output	Required	Raster Dataset	SCL_Land_Trigger.tif
Use NoData values if they are the nearest neighbor	Input	Optional	Boolean	false

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