National Vineyard Scan 2018

Summary Report

Date: 7 June 2019

Report Number: CT-TR-2019-00029

Document Version 1.0

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National Scan 2018

Foundation Data relating to wine production capability is of strategic importance to the Australian wine sector. Vineyard planting data was last made available by the Australia Bureau of Statistics (ABS) in 2015. Consilium Technology was engaged by Wine Australia in August 2018 to deliver a technical capability to resume the measurement of the production capacity of the Australian wine industry. The capability Consilium Technology developed[1] is offered as a product known as GAIA (http://projectgaia.ai). This document outlines the methodology of how GAIA was used to deliver the National Scan 2018 and summarises the per-state, per-GI values for vineyard area and vine row length reported for the National Scan 2018.

GAIA allows Wine Australia to obtain Foundation Data about the Australian wine industry on an ongoing basis by virtue of the radically different approach used, compared to previous methods. Previously, the ABS was tasked with producing a ***Vineyards Census***. The ABS surveyed industry participants by sending the census to establishments identified as undertaking viticulture activity, with involvement in the survey being voluntary (there was an 87% response rate in 2015).

GAIA represents a departure from manual surveying techniques, instead leveraging the analysis of satellite imagery using state-of-the-art machine learning techniques. The advantage of such an approach is that it can be highly automated, does not require any participation from industry (who suffer from "survey fatigue"), can provide updated information on a continual basis and can offer richer data. GAIA uses partner Maxar Technologies' GBDX platform to access 100's of Petabytes of satellite imagery and cloud computing infrastructure. Through integration with GBDX, GAIA is able to perform analysis on satellite imagery at scale, such as the geolocation of each vineyard block and every individual vine row in Australia. GAIA performed such an analysis for the 2018 growing season, culminating in the National Scan 2018.

Results of the National Scan 2018

An incremental approach was adopted for the National Scan 2018. On a state-by-state basis, GAIA was used to perform an initial ***scan*** of Australia. This initial scan was performed on satellite imagery representing **~4.91 million** hectares. This initial scan successfully geolocated a significant portion of all vineyards in Australia, but a second scan was initiated to expand the search, fill gaps and rescan problem areas. This rescan was performed on satellite imagery representing **~145,000** hectares, so **~5.054 million** hectares were scanned in total.

After the outputs from the multiple scans were reviewed by a human, the total area of vineyard blocks was found to be **146,128** hectares. With a mean area accuracy of **95.22%**, the error was calculated to be **± 8,669** hectares, so the total area of vineyards as detected by GAIA is thus between **137,459** and **154,797** hectares (95% confidence). A breakdown of total area scanned and total area of vineyards found by state is outlined in Table 1, with a detailed breakdown of vineyard areas within each state, for each GI, provided in Tables 2-7. The GI boundary files used for this per-GI analysis consist of the

[1] Additional research partners are the University of South Australia and Maxar Technologies.

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South Australia GI boundaries updated in mid-2018, and the updated boundaries for GIs in other states from early 2019. Consilium Technology thanks Wine Australia and their partners for providing these updated GI boundaries.

Aside from measuring area, the geolocation of vineyard blocks was also the basis for an even more impressive feat: vine row detection and length calculation for each and every vine row, in each and every block. To achieve this, a vine row detection algorithm was run on the small patches of satellite imagery corresponding to each vineyard block. The total length of vine rows in Australia as found by GAIA for National Scan 2018 was **463,718** km.

National Results

Table 1. *Summary statistics of wine vineyard block area of wine vine row length in each state and Australia.*

State	Total area "scanned" (ha)	Total area of vineyards (ha)	Total length of vine rows (km)
WA	294269	11371	34992
TAS	358346	1941	6981
SA	1322969	74521	240395
VIC	832154	23633	76524
NSW (incl ACT)	1844899	34031	102929
QLD	448143	630	1897
Total	**5,100,780**	**146,128 ± 8,669**	**463,718**

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Western Australia Results

Table 2. *Vineyard area and vine row length of all Geographical Indications in WA.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Central Western Australia	Zone	47	145
Eastern Plains Inland and North	Zone	2	5
Greater Perth	Zone	990	2850
South West Australia	Zone	10333	31993
Western Australia South East Coastal	Zone	0	0
Blackwood Valley	Region	360	1107
Geographe	Region	868	2692
Great Southern	Region	2370	7056
Manjimup	Region	224	720
Margaret River	Region	5840	18397
Peel	Region	55	179
Pemberton	Region	645	1953
Perth Hills	Region	166	485
Swan District	Region	756	2159
Albany	Subregion	84	227
Denmark	Subregion	93	279
Frankland River	Subregion	1137	3330
Mount Barker	Subregion	934	2845
Porongurup	Subregion	96	297
Swan Valley	Subregion	508	1476

Tasmania Results

Table 3. *Vineyard area and vine row length of all Geographical Indications in Tasmania.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Tasmania	Zone (state)	1941	6981

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South Australia Results

Table 4. *Vineyard area and vine row length of all Geographical Indications in SA.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Barossa	Zone	13103	40276
Far North	Zone	176	522
Fleurieu	Zone	14919	49648
Limestone Coast	Zone	15126	51804
Lower Murray	Zone	21492	65651
Mount Lofty Ranges	Zone	9648	32305
The Peninsula	Zone	57	188
Adelaide Hills	Region	3854	13906
Adelaide Plains	Region	600	1733
Barossa Valley	Region	10871	33272
Clare Valley	Region	5009	16101
Coonawarra	Region	5170	17737
Currency Creek	Region	1022	3502
Eden Valley	Region	1984	6233
Kangaroo Island	Region	136	427
Langhorne Creek	Region	5930	20556
Mclaren Vale	Region	6999	22273
Mount Benson	Region	478	1563
Mount Gambier	Region	271	849
Padthaway	Region	4022	13885
Riverland	Region	21058	64427
Robe	Region	681	2428
Southern Fleurieu	Region	476	1584
Southern Flinders Ranges	Region	176	522
Wrattonbully	Region	2647	8868
High Eden	Subregion	404	1237
Lenswood	Subregion	271	987
Piccadilly Valley	Subregion	213	866

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Victoria Results

Table 5. *Vineyard area and vine row length of all Geographical Indications in Victoria.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Central Victoria	Zone	4272	14001
Gippsland	Zone	175	613
North East Victoria	Zone	2886	9527
North West Victoria	Zone	10502	32062
Port Phillip	Zone	4238	15149
Western Victoria	Zone	1561	5171
Alpine Valleys	Region	295	941
Beechworth	Region	130	465
Bendigo	Region	622	1974
Geelong	Region	423	1560
Glenrowan	Region	176	570
Goulburn Valley	Region	1211	4004
Grampians	Region	595	1916
Heathcote	Region	1636	5287
Henty	Region	136	501
King Valley	Region	1468	5050
Macedon Ranges	Region	192	593
Mornington Peninsula	Region	891	3108
Murray Darling Vic	Region	8358	25641
Pyrenees	Region	781	2590
Rutherglen	Region	765	2352
Strathbogie Ranges	Region	529	1804
Sunbury	Region	99	330
Swan Hill Vic	Region	2140	6411
Upper Goulburn	Region	252	873
Yarra Valley	Region	2533	9201
Great Western	Subregion	454	1440
Nagambie Lakes	Subregion	494	1569

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New South Wales Results

Table 6. *Vineyard area and vine row length of all Geographical Indications in NSW.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Big Rivers	Zone	24875	74042
Central Ranges	Zone	4402	13864
Hunter Valley	Zone	2499	7790
Northern Rivers	Zone	82	240
Northern Slopes	Zone	106	327
South Coast	Zone	306	959
Southern New South Wales	Zone	1750	5673
Western Plains	Zone	11	34
Canberra District	Region	316	1040
Cowra	Region	907	2871
Gundagai	Region	631	2113
Hastings River	Region	13	40
Hilltops	Region	607	1939
Hunter	Region	2499	7790
Mudgee	Region	1919	5806
Murray Darling Nsw	Region	7043	24117
New England Australia	Region	82	253
Orange	Region	1078	3909
Perricoota	Region	395	1226
Riverina	Region	16653	46168
Shoalhaven Coast	Region	41	120
Southern Highlands	Region	143	472
Swan Hill Nsw	Region	227	646
Tumbarumba	Region	176	551
Broke Fordwich	Subregion	481	1617
Pokolbin	Subregion	1328	4009
Upper Hunter Valley	Subregion	447	1402

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Queensland Results

Table 7. *Vineyard area and vine row length of all Geographical Indications in QLD.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Granite Belt	Region	319	975
South Burnett	Region	191	574

How GAIA Works

There are two components to GAIA related to undertaking and displaying the National Scan 2018: 1) the user-facing web-app (https://app.projectgaia.ai/) which displays the output of 2) the machine learning system. The machine learning system itself can be thought of as machine learning software and ***models***, and data to train the models. The models are responsible for finding vineyard blocks and vine rows in satellite imagery; they are ***trained*** to achieve this by repeatedly being shown what is, and what is not, a vineyard.

GAIA uses a form of fully convolutional neural network architecture, a unet, as the machine learning model. Unets have been shown to excel at semantic segmentation-style classification problems such as vineyard block boundary demarcation. This architecture allows patches of imagery to be fed in, and ***patches of predictions*** to be produced, where a patch of prediction is essentially an array of numbers indicating the probability that corresponding pixels in the input imagery belong to a vineyard.

To train a model requires both input data (multi-channel satellite imagery) and correct labels (Geographical Information System files that demarcate vineyard block boundaries). Input data is easy to come by, being raw satellite imagery, but correct and accurate labels are difficult to acquire. For the purpose of this project, they had to be manually and painstaking created by a human labeller. In total, **260,882** hectares of satellite imagery was examined by human labeller, resulting in **5,921** hectares of vineyard being labelled. The imagery which was labelled was from **31** locations around Australia: WA (5), TAS (2), SA (7), VIC (9), NSW (6), QLD (2).

Similarly, a small number of vine rows in the imagery labelled for vineyards were also manually labelled, that is, a line was drawn along the middle of each row. In total, **9,613** vine rows measuring **1,820** km in length were also manually and painstakingly traced. These labelled vineyard blocks and labelled vine rows were simultaneously fed into a unet machine learning model with corresponding satellite imagery to train GAIA's machine learning models.

Using GAIA's machine learning models to find vineyards across Australia was the next task. Because wine grapes are known to typically be grown in certain areas of Australia, to reduce the search space required to find every vineyard block in the country, information on where vineyards might be grown was acquired. A variety of both open and private data sets were used for this purpose. Using such data sets, Areas of Interest (AOIs) representing the areas to search for vineyards within were defined.

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AOIs are rectangular shapes, the corners of which are defined by coordinates of latitude and longitude that is, World Geodetic System 1984 (WGS84) coordinates.

To search within each AOI with GAIA's machine learning models first required each AOI to be associated to an appropriate satellite image or images. Appropriate satellite images are recent images from the growing months of the years prior to the 2018 vintage. It was not always possible to find a recent and/or growing month match, and for these cases the search would be broadened to include older imagery and non-growing months. 85% of the total area of the AOIs was matched to imagery from the last four years.

The satellite images covering the AOIs were scanned as described above. More specifically, GAIA's machine learning models were executed on the extraction from each satellite image corresponding to each AOI. This process yielded vineyard block shapes represented by vector polygons with hard boundaries. Hard boundaries for vineyard blocks means definite areas are computed for each vineyard block. However, because there is obviously some inherent error or uncertainty in the predictions and thus areas computed by GAIA, this error had to be quantified. The error was calculated to be **± 8,669** hectares with better than **95%** confidence, using the mean area accuracy of **95.22%** and a standard error in area accuracy of **0.5893**. Area calculation of vineyard blocks is performed after a reprojection from WGS84 coordinates to Universal Transverse Mercator (UTM) coordinates within the appropriate UTM zone.

Future Use of GAIA

The results generated by GAIA unquestionably validate the approach of using state-of-the-art machine learning on satellite imagery for the purpose of acquiring Foundation Data and performing National Scans for Wine Australia. The methodology used by GAIA may not yet be perfect (as is sometimes evident in the web-app when the boundaries of a vineyard block are "messy") but the adoption of a technology-centric approach can offer much deeper insights than could ever be achieved via survey response. The geolocation of vineyard blocks and individual vine rows will allow for much more detailed analyses to be developed, and the methodology and outputs will be incrementally improved and updated as capability matures and new imagery and data is ingested. As GAIA continues to evolve in this manner, Wine Australia will gain unparalleled insights into the state of the Australian wine industry in the months and years to come.