National Scan of Vineyards of Australia 2020

Milestone Report Y3.3

Marnie Brice, Meera Deshpande, Adam Gatt, Saisai Ma, Frank Ouyang, Sebastien Wong

Date: 1 March 2021

Version 1.2

GAIA-2020-00003

GAIA agricultural intelligence

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ABN 22 636 813 360
1102/147 Pirie St, Adelaide SA 5000
info@gaia.ag

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info@gaia.ag

Introduction

In this document we first present the headline results for the National Vineyard Scan 2020 (NVS2020) [1] and provide the total area statistics of satellite imagery on which GAIA's machine learning algorithm was run. Following this, for each state, the total area of vineyards within each Geographical Indication (Zones, Regions and Subregions) is provided.

The NVS2020 is the 3rd in a series of maps of Australian vineyards created by GAIA. Information on the previous NVS2018 and NVS2019 can be found in [1-4]. The purpose of the National Vintage Scan is to measure and provide insights on production capacity of the Australian wine industry. With NVS2020 beginning 3 months after the completion of NVS2019, many of the systems and processes used for NVS2019 remain the same for NVS2020. Still, with the continuous improvement efforts, there are small steps that have been changed for NVS2020. A comprehensive explanation of the technical details of the NVS2020 is described in section 2. Completing National Scan 2020.

The report begins with the headline results. Then describes the process for conducting the National Scan. The remainder of the report is devoted to the presentation of the Quality Assurance (QA) results and provides error bounds on the measurements. For states scanned, the QA results are presented as follows:

- Western Australia (Section 4)
- Tasmania (Section 5)
- South Australia (Section 6)
- Victoria (Section 7)
- New South Wales (Section 8)
- Queensland (Section 9)

1. Headline Results

1.1 Scan Summary

GAIA scanned Australia on a state-by-state basis for NVS2020, in line with previous national scans. In total, **11,043** areas of interest (AOIs) within **466** different satellite captures were processed by GAIA's machine learning infrastructure. Using the latest imagery from the 2020 vintage growing season, the total area covered by the AOIs is around **2.3 million hectares**, representing **0.3%** land area of Australia.

After the output review, the total area of vineyards detected was **151,780** hectares. This represents a slight increase from the **146,244** hectares reported for NVS2019 and increases in the total area of vineyards for all states were observed. Enhanced human review of GAIA's machine generated output has been performed in NVS2020 to remove false positives from the data set. False positives are where GAIA has indicated that vineyards exist, but where no vineyards actually exist; for example, an

[1] Also referred to as the National Vintage Scan

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orchard may have been identified as a vineyard. Feedback was also received from the wine industry for missed vineyards, the most significant of these was a section of the Riverina that was not scanned in previous years[2]. Thus, it should be emphasised that the values reported for NVS2020 accurately represents the on-ground reality (within the error bounds discussed in 3.1). Identification of many of these false positives, as well as previously missed vineyards and indeed general improvements to the scan results, are mainly contributed by the feedback from the users of the GAIA NVS2019 vineyard maps. GAIA Innovations thanks everyone that has provided valuable feedback.

Table 1. *Summary statistics of total area scanned and wine-grape vineyard area for each state and Australia.*

State	Total area "scanned" (ha)	Total area of vineyards (ha)
WA	133,110	11,126
TAS	312,163	2,084
SA	691,842	78,321
VIC	586,323	22,445
NSW (incl ACT)	545,834	37,131
QLD	70,125	674
TOTAL	2,339,397	151,780

1.1 Viewing the NVS2020 maps

The complete maps for the NVS2020 are available for viewing by Wine Australia levy payers[3] and Australian regional wine-grape associations without charge. Access is provided through the GAIA web-site. Visit gaia.ag to create an account.

The complete heat map of all vineyards in Australia for the NVS2020 is illustrated in purple in the GAIA web-app, see Figure 1. A large section of the vineyards maps for South Australia is shown in Figure 2. A zoomed-in section of a vineyard, comparing the NVS2019 and the NVS2020 maps, is shown in Figure 3.

[2] This feedback resulted in new search AOIs in the NSW, Riverina GI, which in turn produced 2574ha of mapped vineyards that were not included in previous NVS.

[3] Grape-growers and winemakers that pay the Grape Research Levy or the Wine Grapes Levy.

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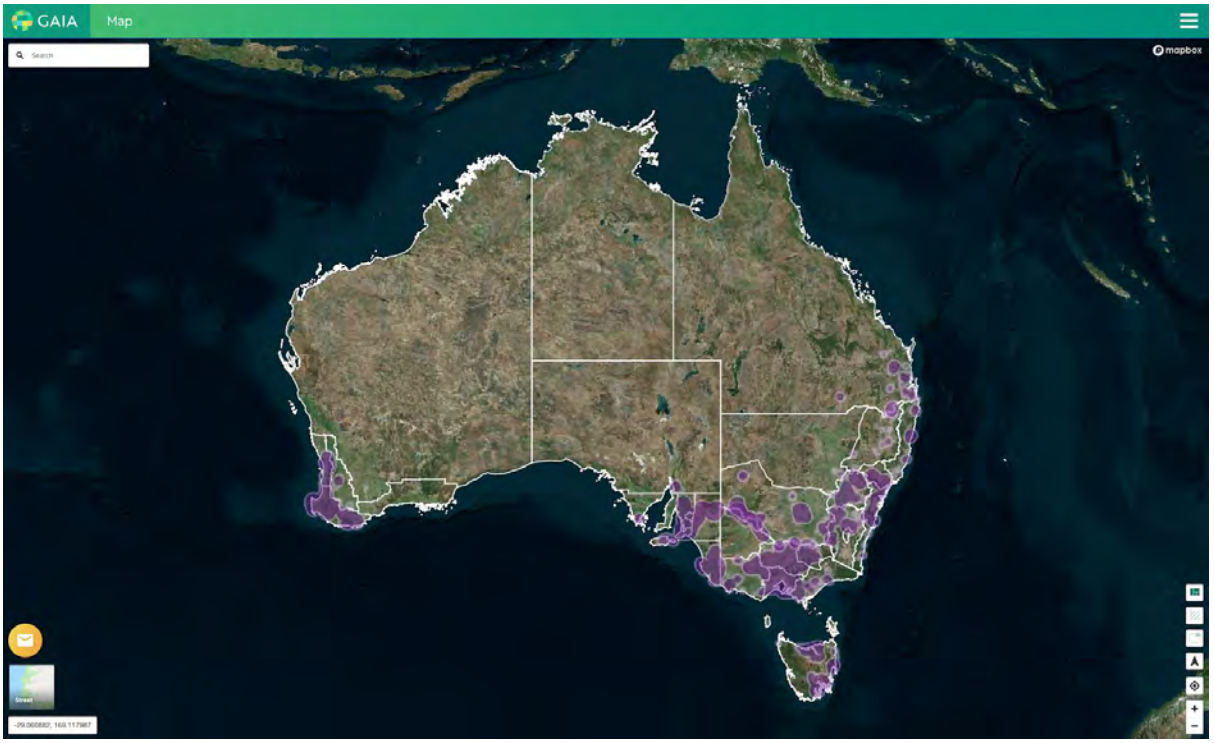


Figure 1. The complete NVS202 map. The location of vineyards in Australia are highlighted as a purple heatmap.

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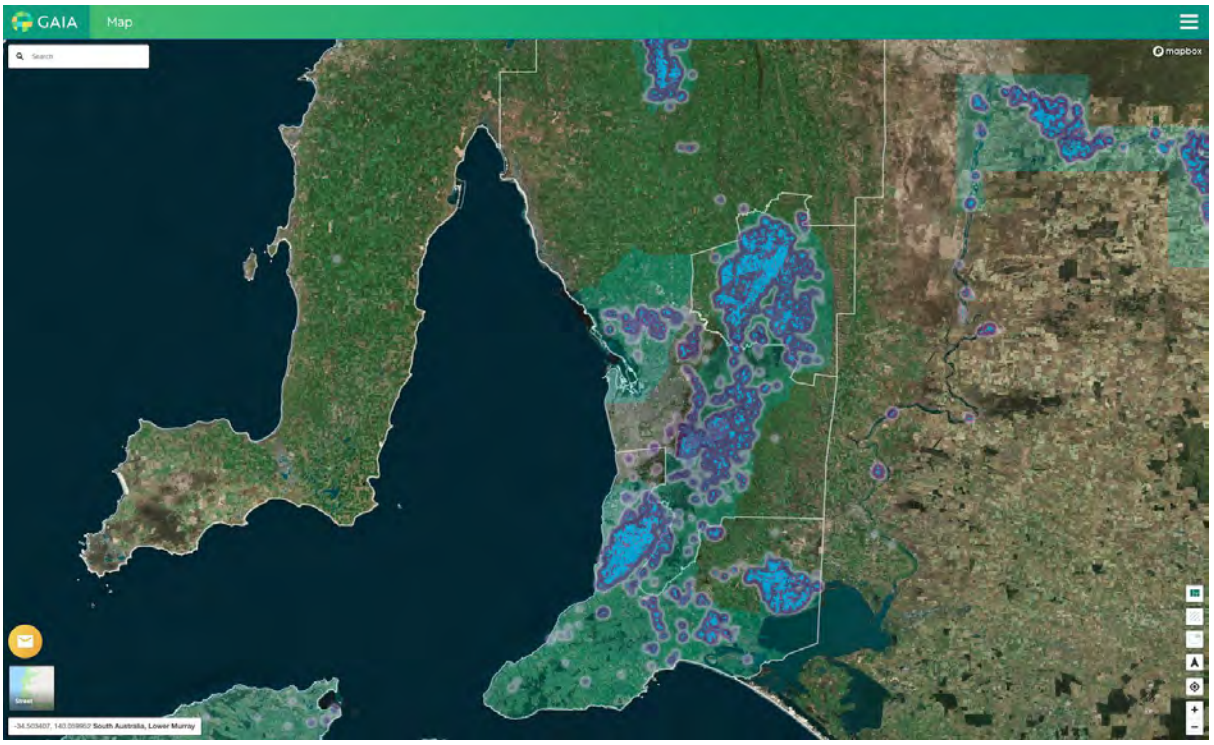


Figure 2. A section of the NVS2020 map of South Australia. The location of vineyards are highlighted as a purple heatmap, while individual vineyards are illustrated as blue polygons.

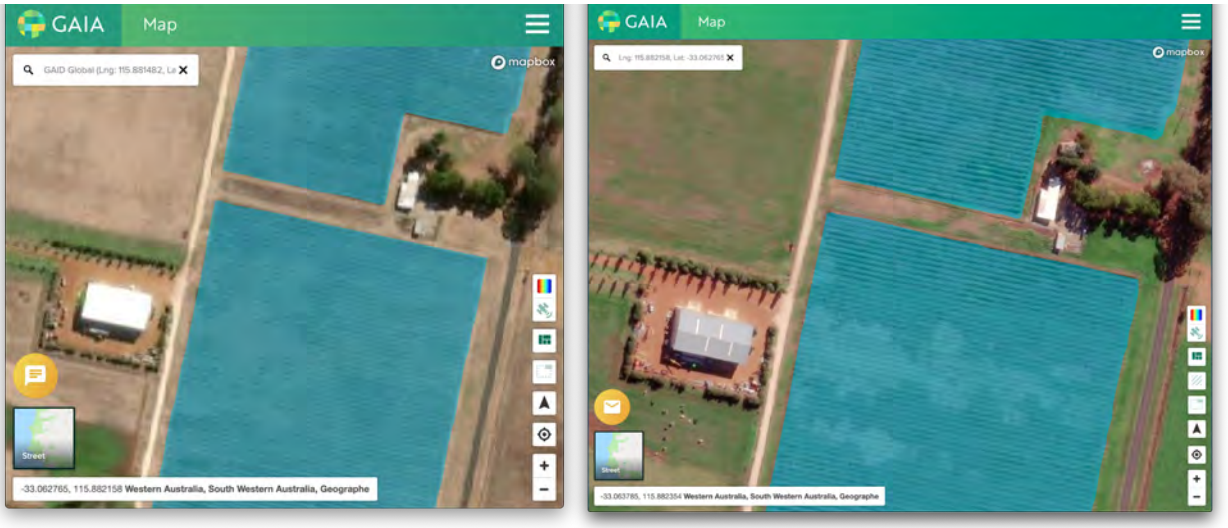


Figure 3. A small section of maps produced for the NVS2019 (left) and the NVS2020 (right).

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1.2 Western Australia

Table 2. *Vineyard area for all Geographical Indications in Western Australia.*

GI name	GI type	Total area of vineyards (ha)
Central Western Australia	Zone	44
Eastern Plains Inland and North	Zone	2
Greater Perth	Zone	1064
South West Australia	Zone	10016
Western Australia South East Coastal	Zone	0
Blackwood Valley	Region	310
Geographe	Region	792
Great Southern	Region	2545
Manjimup	Region	153
Margaret River	Region	5725
Peel	Region	57
Pemberton	Region	468
Perth Hills	Region	142
Swan District	Region	890
Albany	Subregion	85
Denmark	Subregion	90
Frankland River	Subregion	1354
Mount Barker	Subregion	895
Porongurup	Subregion	96
Swan Valley	Subregion	667

1.3 Tasmania

Table 3. *Vineyard area for all Geographical Indications in Tasmania.*

GI name	GI type	Total area of vineyards (ha)
Tasmania	Zone (state)	2084

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1.4 South Australia

Table 4. *Vineyard area for all Geographical Indications in South Australia.*

GI name	GI type	Total area of vineyards (ha)
Barossa	Zone	14040
Far North	Zone	176
Fleurieu	Zone	15554
Limestone Coast	Zone	16160
Lower Murray	Zone	22461
Mount Lofty Ranges	Zone	9855
The Peninsula	Zone	76
Adelaide Hills	Region	3957
Adelaide Plains	Region	567
Barossa Valley	Region	11609
Clare Valley	Region	5093
Coonawarra	Region	5784
Currency Creek	Region	1032
Eden Valley	Region	2169
Kangaroo Island	Region	144
Langhorne Creek	Region	6069
Mclaren Vale	Region	7438
Mount Benson	Region	541
Mount Gambier	Region	327
Padthaway	Region	4160
Riverland	Region	22032
Robe	Region	681
Southern Fleurieu	Region	510
Southern Flinders Ranges	Region	176
Wrattonbully	Region	2727
High Eden	Subregion	408
Lenswood	Subregion	266
Piccadilly Valley	Subregion	228

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1.5 Victoria

Table 5. *Vineyard area for all Geographical Indications in Victoria.*

GI name	GI type	Total area of vineyards (ha)
Central Victoria	Zone	4558
Gippsland	Zone	191
North East Victoria	Zone	2989
North West Victoria	Zone	8245
Port Phillip	Zone	4720
Western Victoria	Zone	1741
Alpine Valleys	Region	260
Beechworth	Region	134
Bendigo	Region	634
Geelong	Region	466
Glenrowan	Region	203
Goulburn Valley	Region	1263
Grampians	Region	651
Heathcote	Region	1836
Henty	Region	145
King Valley	Region	1535
Macedon Ranges	Region	245
Mornington Peninsula	Region	976
Murray Darling Vic	Region	6251
Pyrenees	Region	887
Rutherglen	Region	781
Strathbogie Ranges	Region	534
Sunbury	Region	102
Swan Hill Vic	Region	1994
Upper Goulburn	Region	267
Yarra Valley	Region	2837
Great Western	Subregion	473
Nagambie Lakes	Subregion	511

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1.6 New South Wales and Australian Capital Territory

Table 6. *Vineyard area for all Geographical Indications in New South Wales and Australian Capital Territory.*

GI name	GI type	Total area of vineyards (ha)
Big Rivers	Zone	27492
Central Ranges	Zone	4720
Hunter Valley	Zone	2605
Northern Rivers	Zone	148
Northern Slopes	Zone	115
South Coast	Zone	302
Southern New South Wales	Zone	1743
Western Plains	Zone	6
Canberra District	Region	329
Cowra	Region	999
Gundagai	Region	591
Hastings River	Region	13
Hilltops	Region	591
Hunter	Region	2605
Mudgee	Region	1899
Murray Darling Nsw	Region	6194
New England Australia	Region	77
Orange	Region	1075
Perricoota	Region	388
Riverina	Region	20113
Shoalhaven Coast	Region	38
Southern Highlands	Region	171
Swan Hill Nsw	Region	178
Tumbarumba	Region	214
Broke Fordwich	Subregion	510
Pokolbin	Subregion	1355
Upper Hunter Valley	Subregion	471

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1.7 Queensland

Table 7. *Vineyard area for all Geographical Indications in Queensland.*

GI name	GI type	Total area of vineyards (ha)
Granite Belt	Region	305
South Burnett	Region	204

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2. Producing National Vintage Scan 2020

The production of NVS2020 followed the same process as the NVS2019, which can be summarized as follows. A set of AOIs were selected to be searched for vineyards. The GAIA system searched for the latest and best quality satellite imagery in these AOIs. Search AOIs that did not have new satellite imagery for the current growing season were populated with historical NVS data. The satellite imagery was processed by the machine learning algorithms to automatically generate vineyard boundary polygons. The generated polygons were then collated into complete maps. This collation also included a manual review process to exclude poor quality outputs.

The mechanisms for running the scan at scale were improved to streamline the generation of data and reduce human error. The generation of statistics and metrics was optimised to deal with the growing data repository and allow for faster iteration on data scanning. In addition to automated registration of satellite imagery to the basemap, a manual registration process was used to ensure the location of the detected vineyard boundary polygons aligned with the location of the vineyard shown in the base map. Manual registration was applied to improve the map accuracy and also rectify the misregistration in the vineyard boundaries, due to technical and contractual changes in the satellite imagery service.

The **11,043** search AOIs that were scanned in the pursuit of vineyard geolocation were refined from those used in NVS2019 in consultation with Wine Australia. The scanned AOIs for the NVS2020 totalled an area of **2,339,397** ha. Of these AOIs, 42% overlapped with AOIs from NVS2019[4], while 9% of the AOIs were new search regions for NVS2020.

2.1 Areas of Interest (AOIs) used for NVS2020

In preparing to perform NVS2020, we worked to improve on the AOI creation process and algorithm: expand the search into desirable areas that were not scanned in NVS2019. Feedback from Wine Australia and growers was incorporated into the AOI creation process.

The expansion of the search area for NVS2020 was driven by two factors. The first factor was feedback from users. Some users indicated that a specific location or area should be scanned, so this feedback was incorporated with additional AOIs created. The second factor was adjacency to existing AOI. Adjacent AOIs were created for all AOIs in which a vineyard block was found. Although many adjacent AOIs represented AOIs that were already being scanned, some adjacent AOIs covered areas that had not been scanned in NVS2019 (especially at the boundary of AOI groups). This second factor was the major contributor to the inclusion of previously unscanned AOIs for NVS2020.

The changes made to the AOIs and thus search area between NVS2019 and NVS2020 are best explored through metrics, statistics, and visualisations shown below. When relating to area scanned in the following, unless otherwise indicated, the area values represent unique, non-overlapping areas (in hectares). That is, if some specific AOI was scanned multiple times (overlapping), the area is only

[4] Some AOIs used in the NVS2019 were removed from NVS2020 to improve search configuration and avoid searching over regions that could not contain vineyards, such as water bodies.

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accounted for once. Using unique, non-overlapping area values gives a more accurate indication of scan coverage and allows for a more meaningful comparison between NVS2019 and NVS2020.

The following metrics and statistics provide insight as to how the AOIs used for NVS2020 compare with those used for NVS2019. Each metric or statistic is reported on a per-state and Australia-wide basis (total) basis in Table 8. The reported statistics include:

- ***NVS2019 AOIs scanned:*** the area (ha) of AOIs that were scanned for NVS2019.
- ***NVS2020 AOIs scanned***: the area (ha) of NVS2020 AOIs that were specified and scanned by GAIA.
- ***In both NVS2019 and NVS2020***: the area (ha) of NVS2020 AOIs common to NVS2019 that were scanned.
- ***Not updated in NVS2020 (ha):*** NVS2020 AOIs not scanned: the area (ha) of NVS2020 AOIs that were specified but not scanned, since no imagery was available from either the 2020 vintage growing season or historical data. These AOIs were 'backfilled' with NVS2019 data to form the complete map.
- ***% of NVS2019 area scanned again in NVS2020***: the ratio of AOIs ***In both NVS2019 and NVS2020*** to ***NVS2020 AOIs scanned*** as a percentage.
- ***% of NVS2020 area that is newly scanned***: the ratio of newly scanned in NVS2020 to ***NVS2020 AOIs scanned*** as a percentage.

Table 8. *Details of AOI areas for NVS2020, including comparisons with AOI areas for NV2019.*

NS2020 Stats	WA	TAS	SA	VIC	NSW (& ACT)	QLD	Total
NVS2019 AOIs scanned (ha)	209,901	257,423	948,558	764,693	1,249,170	274,990	3,704,735
NVS2020 AOIs scanned (ha)	133,110	312,163	691,842	586,323	545,834	70,125	2,339,397
In both NVS2019 and NVS2020 (ha)	118,069	153,713	482,041	351,552	390,124	60,284	1,555,783
Not updated in NVS2020 (ha)	91,916	103,899	289,251	315,397	793,907	214,819	1,809,189
% of NVS2019 area scanned again in NVS2020	56%	60%	51%	46%	31%	22%	42%
% of NVS2020 that is newly searched AOIs	2%	27%	0%	8%	14%	0%	9%
Ratio of 2020 area to 2019 area	63%	121%	73%	77%	44%	26%	63%

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In total, 466 satellite images were used to scan for vineyards in 11043 AOIs across Australia (Table 9). New South Wales and Victoria are the two states with the largest number of images scanned and AOI, respectively. This is mainly contributed by the wide distribution of vineyards and wine regions in these two states. South Australia, with some of the largest and most dense growing regions in the country, follows NSW and VIC in the number of images and AOI. Queensland has the fewest scanned AOIs and number of satellite images used due to the small growing regions in the state.

Table 9. *Breakdown of the number of satellite images and AOIs from the 2020 vintage growing season used for NVS2020.*

State	# of satellite images	# of AOIs
WA	67	738
TAS	51	1509
SA	73	2719
VIC	107	3313
NSW (incl ACT)	128	2407
QLD	40	357
Total	466	11043

The AOIs used for vineyard scanning in each state are displayed in the maps below (Figure 3-13). New AOIs added in NVS2020 are also highlighted to show the expansion of the scan coverage, compared with previous scans. For each state, the capture dates of the latest imagery are also shown to demonstrate the distribution of the satellite images throughout the 2020 vintage (Figure 4-14). The legend for the maps is as follows:

- *Red - Existing AOIs from NVS2019 that were updated in NVS2020 with new 2019-20 vintage imagery.*
- *Blue - New AOIs not scanned before and first-time added in the NVS2020. Depending on the availability, imagery used for the scan may be before the 2019-20 vintage*
- *Orange - State/territory Boundaries.*

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Figure 4. Area of Interest (AOIs) used in NVS2020 for Western Australia. Both AOIs from NVS2019 that were updated with new imagery in NVS2020 (red) and newly identified AOIs that were first-time scanned in the NVS2020 (blue) are highlighted. The boundary of the state is also shown (orange).

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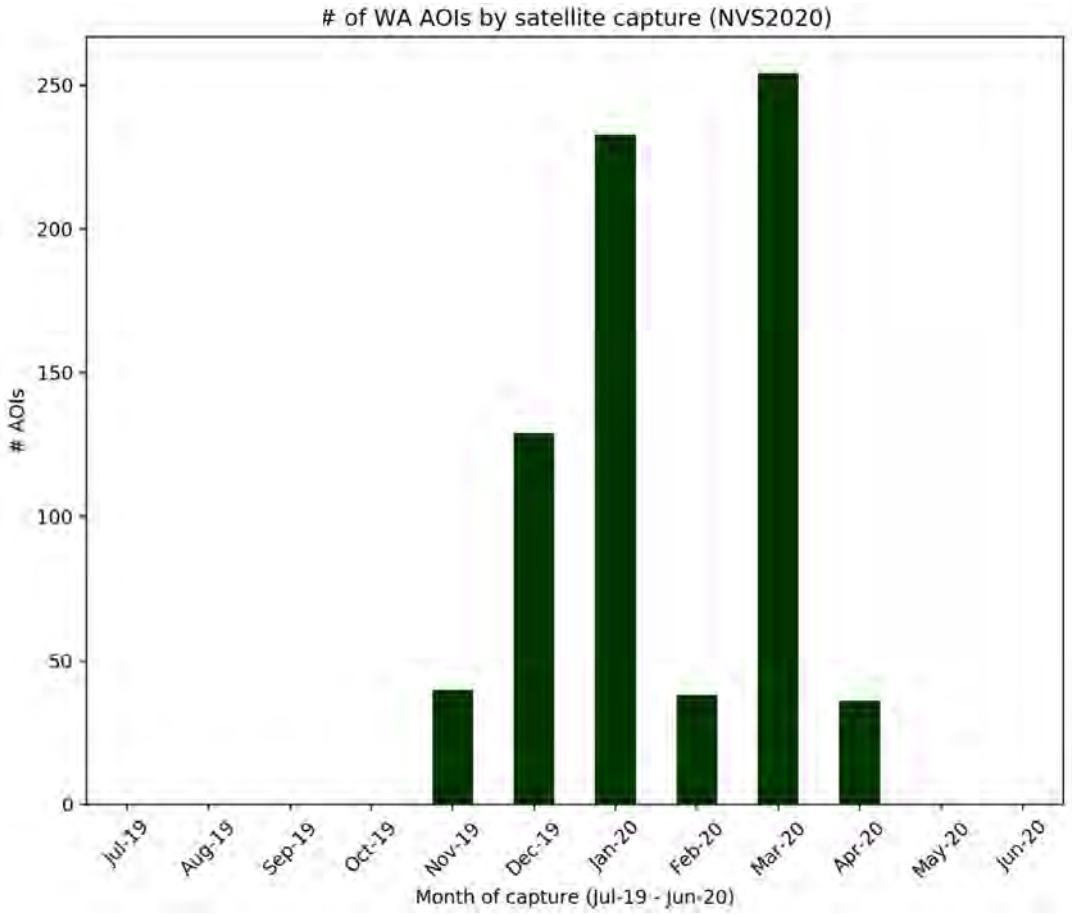


Figure 5. Distribution of Area of Interest (AOIs) by month of corresponding satellite image used for Western Australia (WA), captured during desirable summer months.

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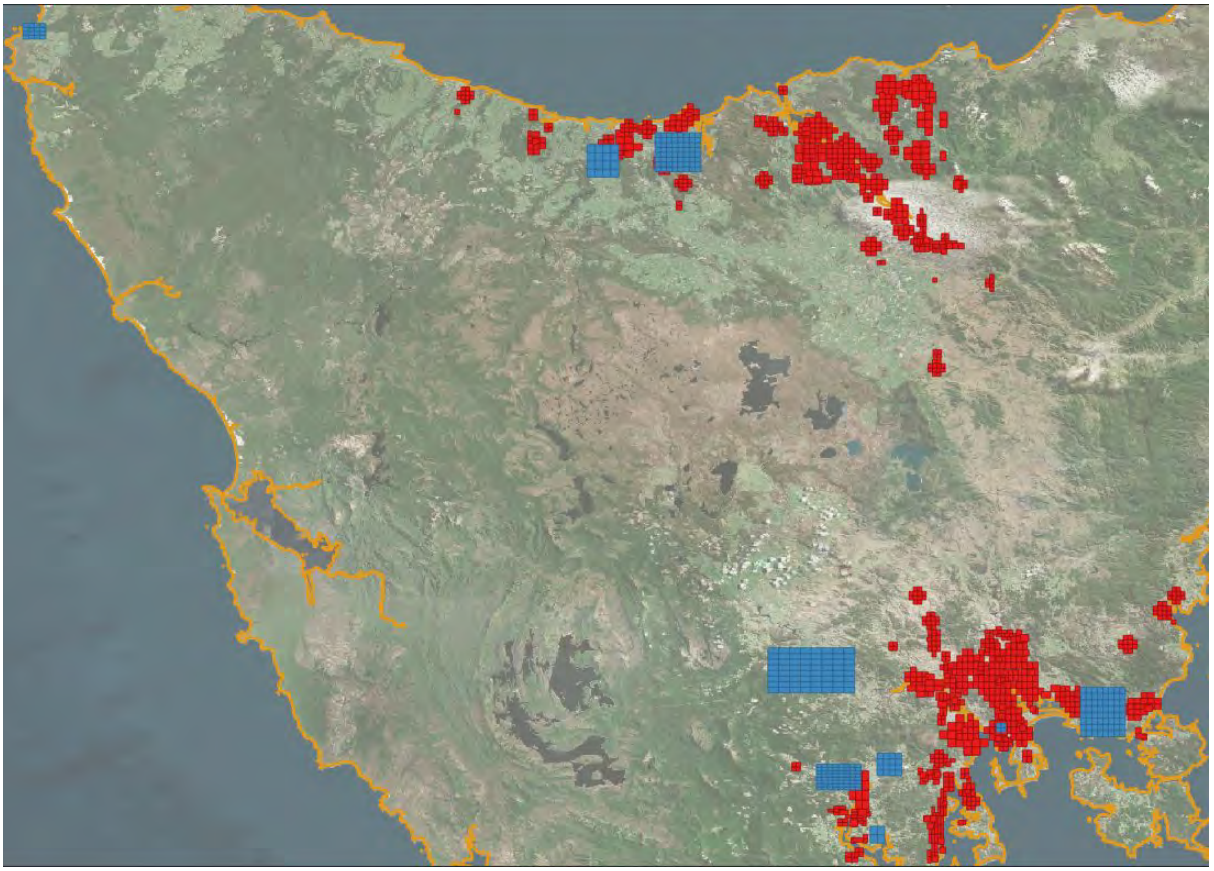


Figure 6. Area of Interest (AOIs) used in NVS2020 for Tasmania.Both AOIs from NVS2019 that were updated with new imagery in NVS2020 (red) and newly identified AOIs that were first-time scanned in NVS2020 (blue) are highlighted. The boundary of the state is also shown (orange).

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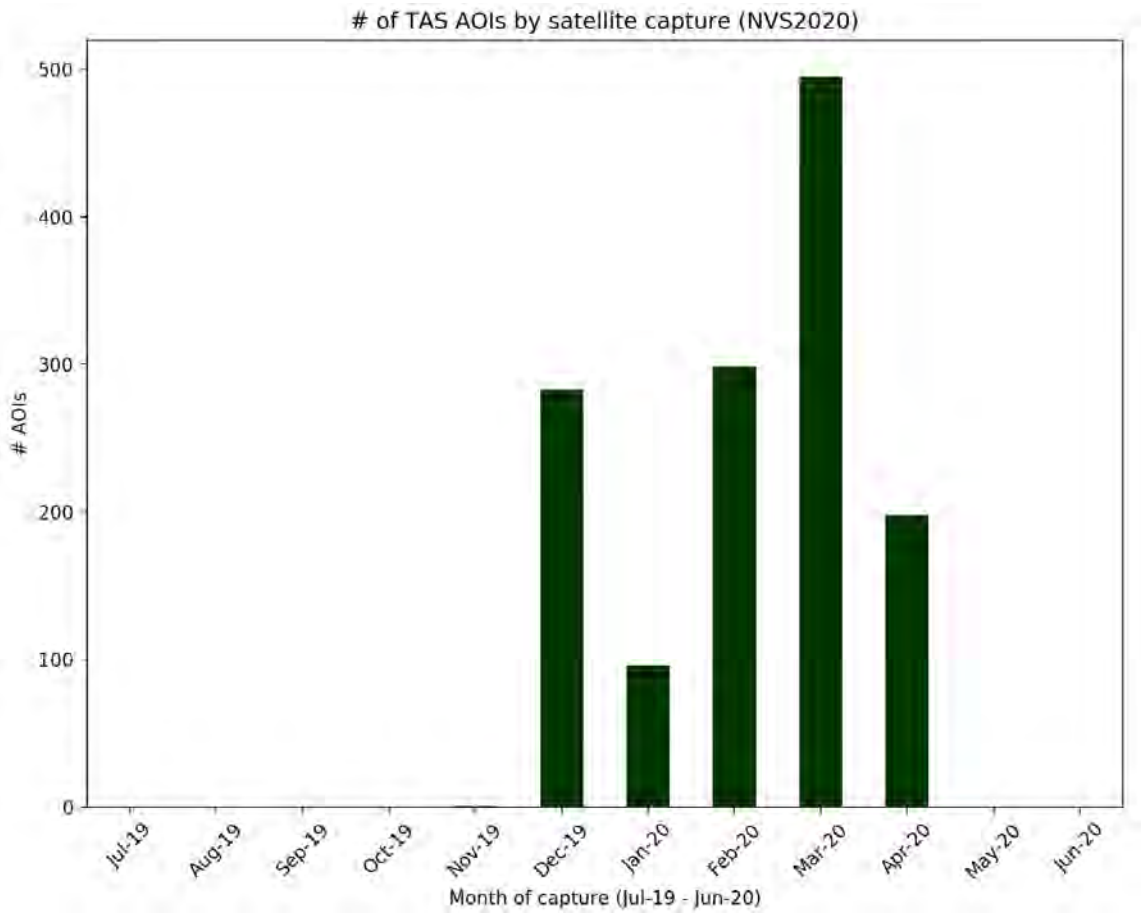


Figure 7. Distribution of Area of Interest (AOIs) by month of corresponding satellite image used for Tasmania (TAS), captured during 2020 vintage months.

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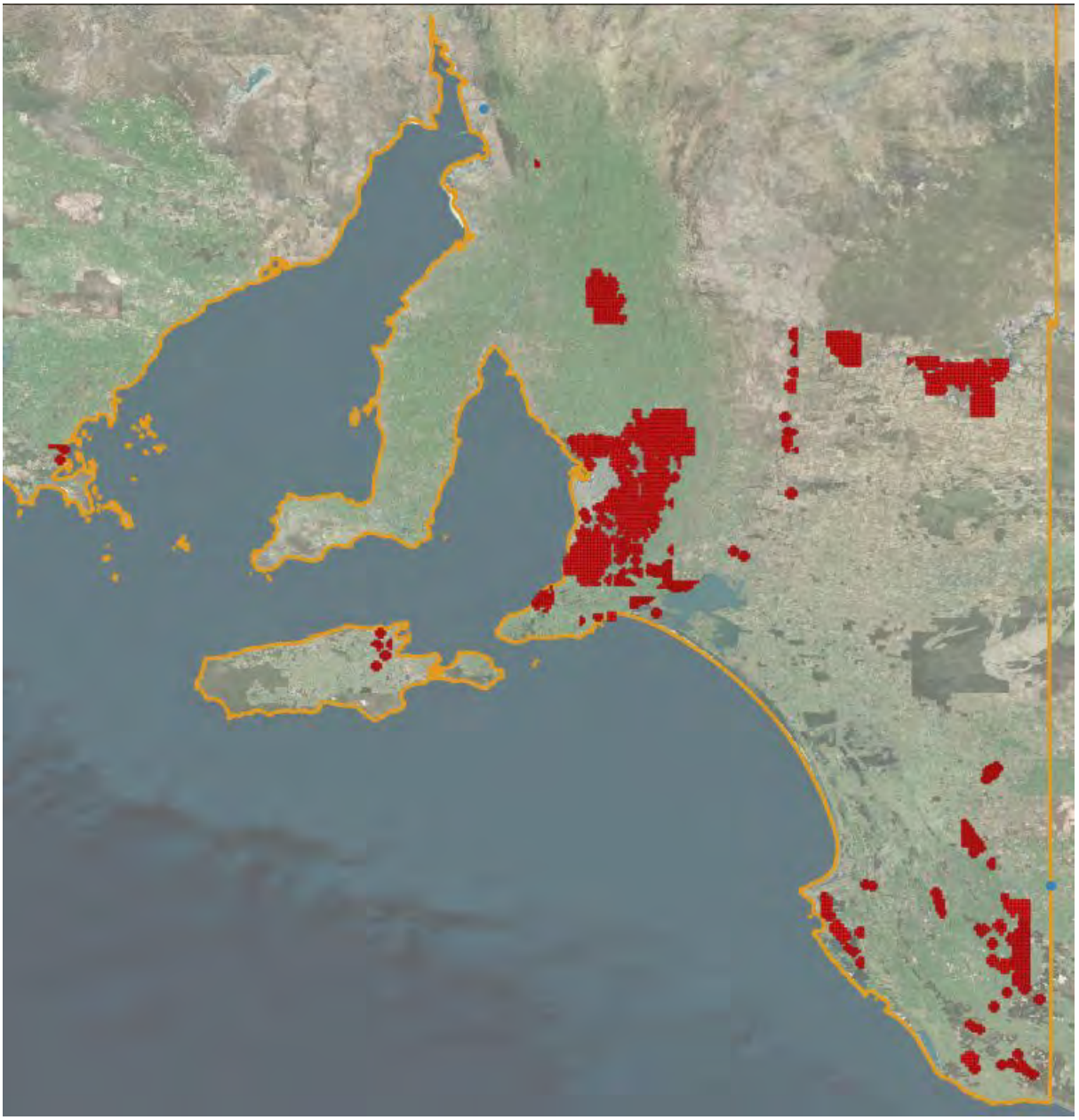


Figure 8. Area of Interest (AOIs) used in NVS2020 for South Australia. Both AOIs from NVS2019 that were updated with new imagery in NVS2020 (red) and newly identified AOIs that were first-time scanned in NVS2020 (blue) are highlighted. The boundary of the state is also shown (orange).

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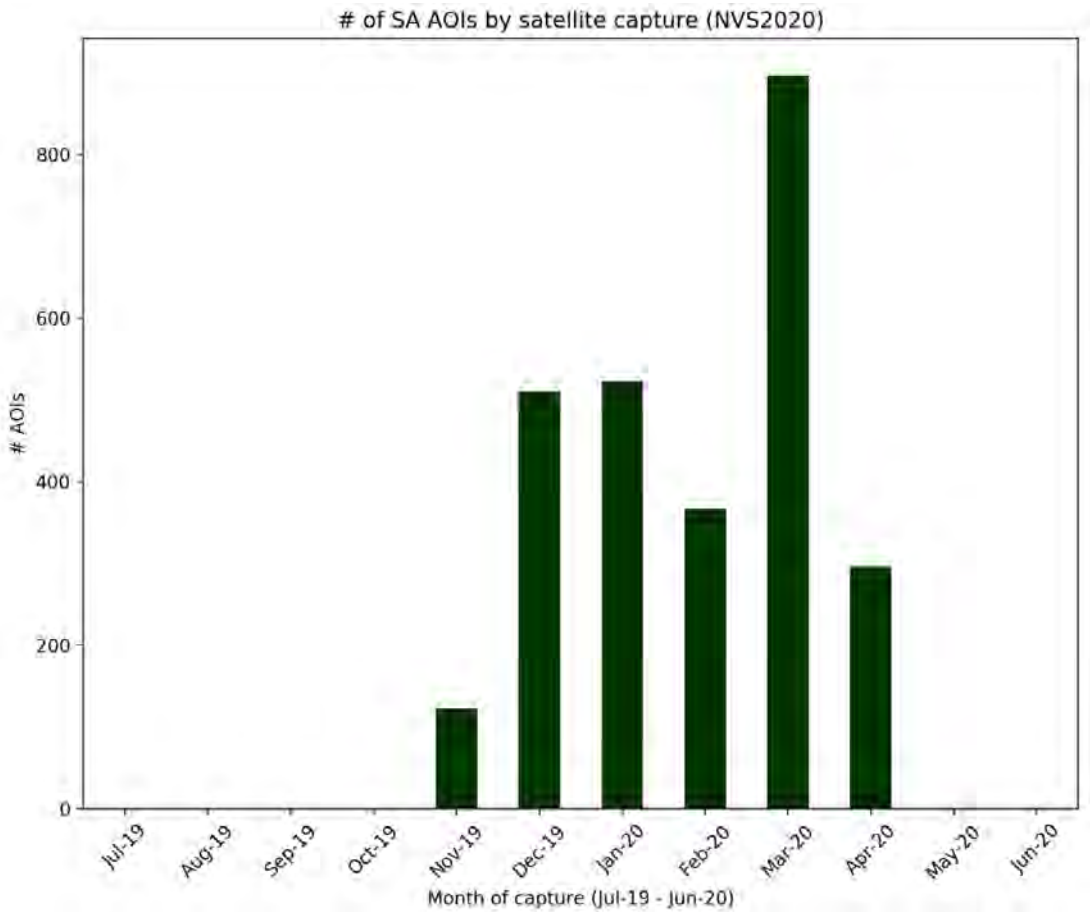


Figure 9. Distribution of Area of Interest (AOIs) by month of corresponding satellite image used for South Australia (SA), captured during 2020 vintage months.

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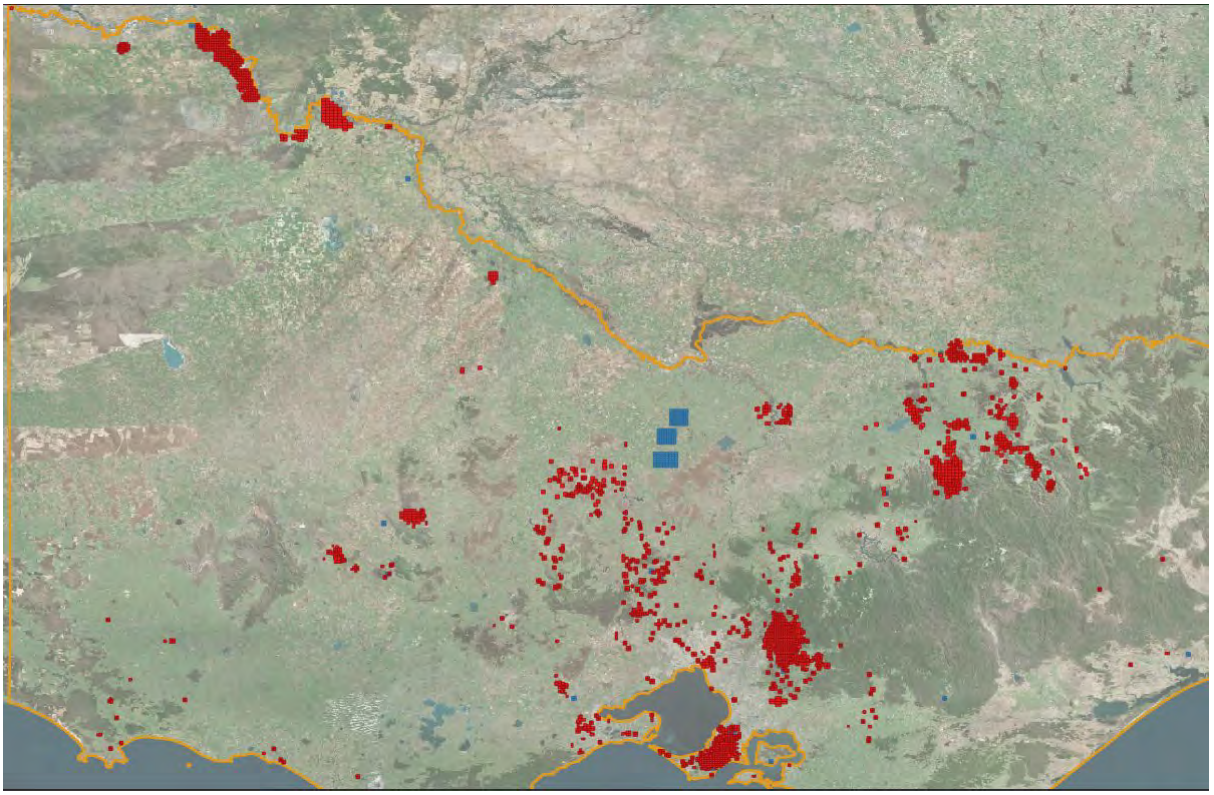


Figure 10. Area of Interest (AOIs) used in NVS2020 for Victoria. Both AOIs from NVS2019 that were updated with new imagery in NVS2020 (red) and newly identified AOIs that were first-time scanned in NVS2020 (blue) are highlighted. The boundary of the state is also shown (orange).

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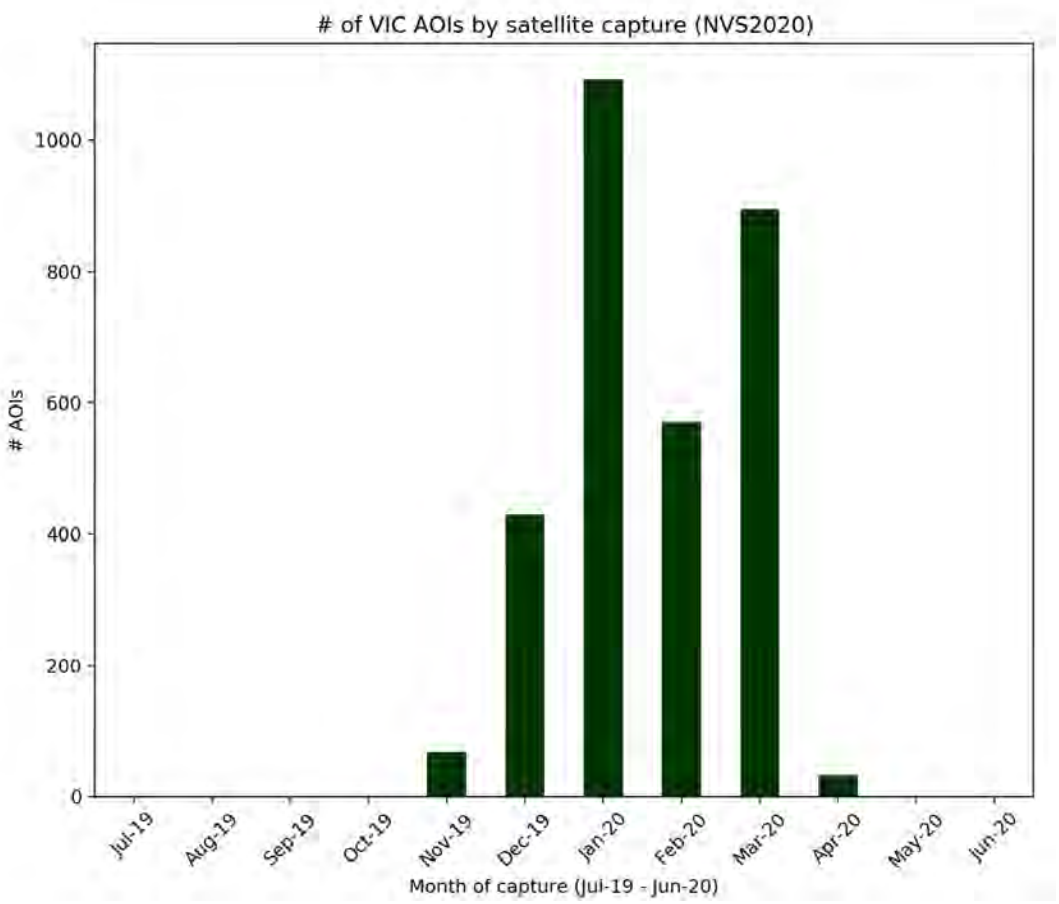


Figure 11. Distribution of Area of Interest (AOIs) by month of corresponding satellite image used for Victoria (VIC), captured during 2020 vintage months.

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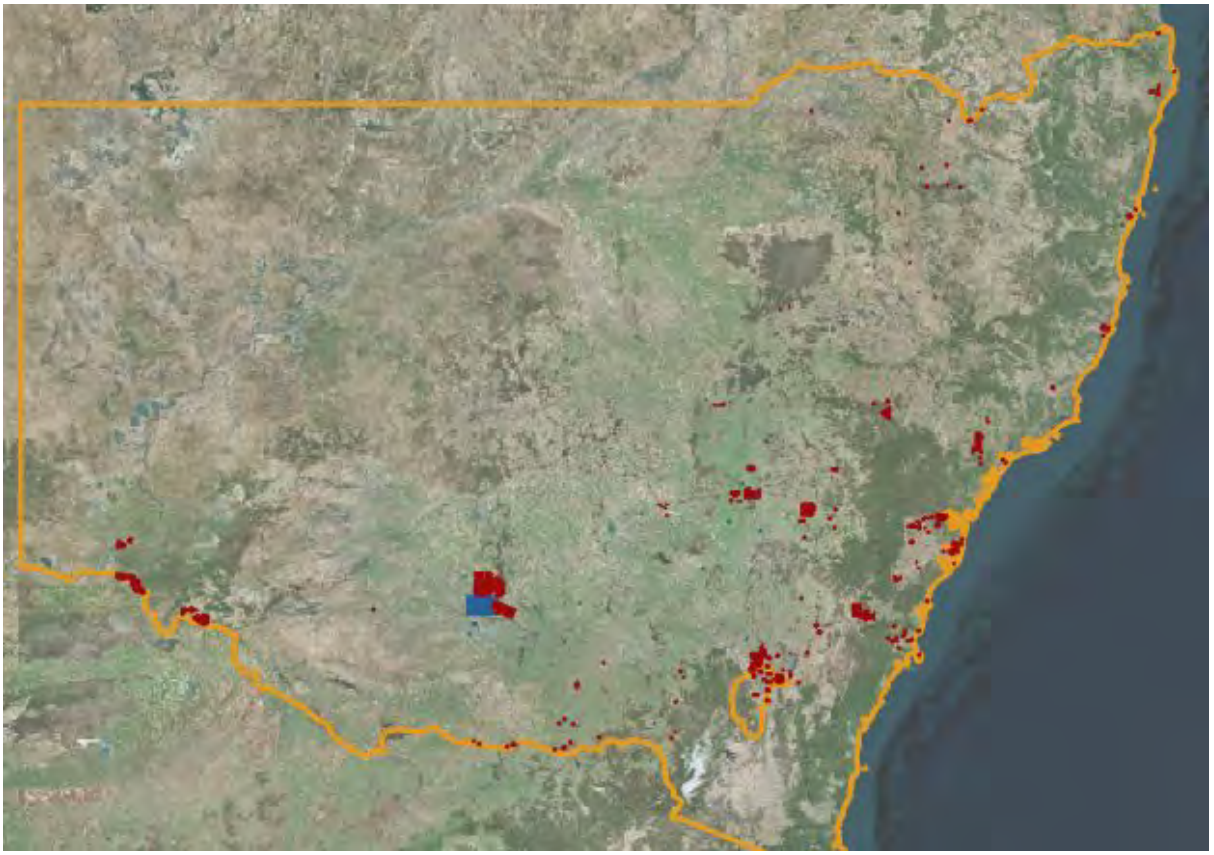


Figure 12. Area of Interest (AOIs) used in NVS2020 for New South Wales. Both AOIs from NVS2019 that were updated with new imagery in NVS2020 (red) and newly identified AOIs that were first-time scanned in NVS2020 (blue) are highlighted. The boundary of the state is also shown (orange).

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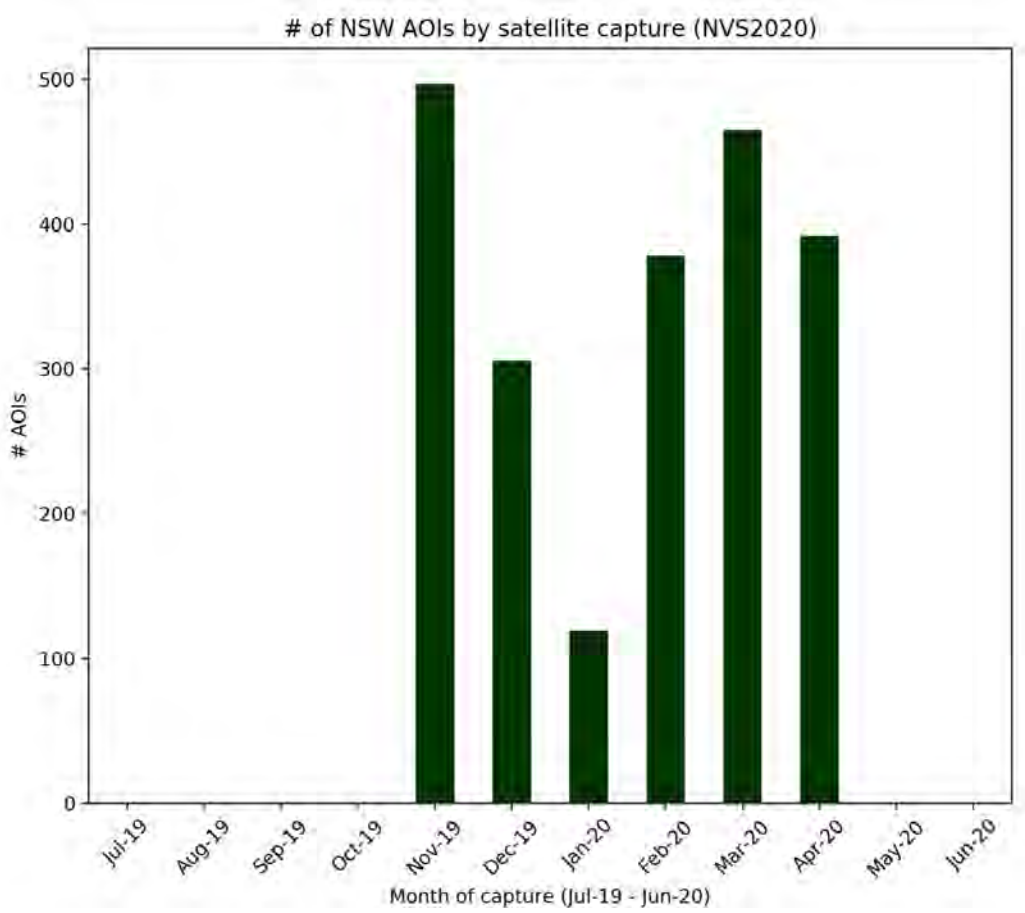


Figure 13. Distribution of Area of Interest (AOIs) by month of corresponding satellite image used for New South Wales (NSW), captured during 2020 vintage months.

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Figure 14. Area of Interest (AOIs) used in NVS2020 for Queensland. Both AOIs from NVS2019 that were updated with new imagery in NVS2020 (red) and newly identified AOIs that were first-time scanned in NVS2020 (blue) are highlighted. The boundary of the state is also shown (orange).

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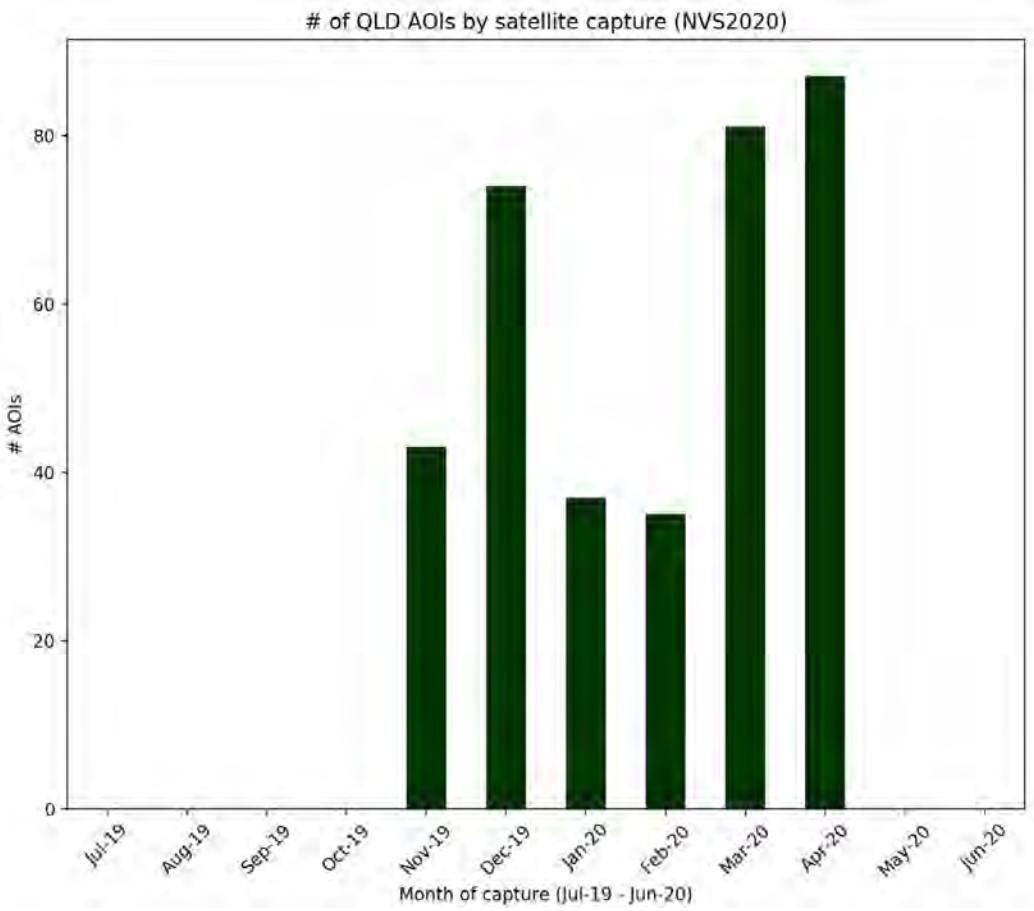


Figure 15. Distribution of AOIs by month of corresponding satellite image used for Queensland (QLD), captured during 2020 vintage months.

2.2 Imagery availability for NVS2020

The ML models used by GAIA give the best results when run on imagery from the summer growing months. The GAIA imagery search algorithm preferentially sought to use imagery from the summer months from the 2020 vintage. If there was no imagery for a given desired search location for the current vintage, the algorithm proceeded to search the back catalog for the most recent summer imagery. If summer imagery could not be found, then the most recent winter imagery was used. Additional search criteria, such as the amount of cloud cover and off-nadir angle was also used to exclude unsuitable satellite imagery. With the satellite imagery searching criteria defined, the AOIs were then used to scan the imagery for vineyards.

Majority of imagery scanned in NVS2020 was recent, where 90.8% of the total imagery scanned area in NVS2020 was from the 2020 vintage growing season while 4.1% from 2019 and 5.1% from earlier years before 2019. Existing AOIs scanned in previous years' national scan without any new imagery

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was backfilled by the NVS2019 dataset. Effectively none of the imagery scanned for the NVS2020 was sourced from winter months.

3. National Scan Quality Assurance

The National Scan Quality Assurance process was described in detail in 'GAIA - National Scan Quality Assurance' (CT-TR-2018-00018) [5]. In brief, Quality Assurance for the National Vintage Scan 2020 is achieved by computing a suite of metrics on a number of regions, the National Scan Quality Assurance Regions (NSQARs). The assessments of the 31 NSQARs[5], selected from Geographical Indications (GIs) across Australia, are documented in Table 10. The "Updated" column in Table 10 indicates in which year's national scan the labels of the region have been updated.

Table 10. *National Scan Quality Assurance Regions (NSQAR), with name, date of image capture and the national scan year that the NSQAR was last updated.*

#	State	NSQAR name	Imagery date	Updated
1	WA	Margaret River	January 2017	NVS2018
2		Swan Valley #1	January 2020	NVS2019
3		Swan Valley #2	February 2018	NVS2018
4		Mount Barker	January 2018	NVS2018
5		Geographe	March 2016	NVS2018
6	TAS	Tasmania North #1	February 2020	NVS2020
7		Tasmania North #2	February 2020	NVS2020
8		Tasmania South #1	December 2019	NVS2020
9		Tasmania South #2	March 2020	NVS2020
10	SA	Riverland	December 2019	NVS2020
11		Clare Valley	February 2020	NVS2020
12		Wrattonbully	April 2020	NVS2020
13		Barossa Valley	February 2017	NVS2018
14		Adelaide Hills	February 2017	NVS2018
15		Coonawarra	April 2020	NVS2020
16		McLaren Vale	February 2020	NVS2020
17	VIC	Murray Darling VIC #1	January 2017	NVS2018
18		King Valley	February 2020	NVS2020

[5] Tasmania North #1 and Tasmania North #2 are treated as a single NSQAR, similarly for Tasmania South #1 and South #2. This reduces the number of NSQAR samples to 31 compared to the 33 items listed in Table 10.

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19		Goulburn Valley	April 2018	NVS2018
20		Yarra Valley	March 2017	NVS2018
21		Strathbogie Ranges	January 2020	NVS2020
22		The Grampians	December 2019	NVS2020
23		Gippsland	January 2019	NVS2020
24		Murray Darling VIC #2	March 2020	NVS2020
25		Mornington Peninsula	December 2019	NVS2020
26	NSW	Riverina	February 2018	NVS2018
27		Canberra District	March 2016	NVS2018
28		Hunter	February 2018	NVS2018
29		Orange	March 2018	NVS2018
30		Shoalhaven	March 2018	NVS2018
31		Swan Hill NSW	December 2018	NVS2018
32	QLD	South Burnett	November 2019	NVS2020
33		Granite Belt	November 2016	NVS2018

Each NSQAR is represented by a satellite image and corresponding labels generated by a human labeller. The labels generated by the human labeller are considered to be the ground-truth and are compared against predictions generated by GAIA machine learning algorithms. Each NSQAR is at least 300 hectares as specified in *'GAIA - National Scan Quality Assurance'*, with the exception of Swan Hill NSW, which comes in at 281 hectares. Details relating to the satellite imagery/labels, such as imagery date, total area of imagery and total area of vineyards are included in the results table for each NSQAR.

For NVS2020, 16 of the NSQARs were selected to be updated. As described in *'GAIA - National Scan Quality Assurance'*, periodic updates are made to NSQARs to ensure that ground truth labels accurately reflect the actual on-ground conditions during the scan period. Specifically, more recent satellite imagery corresponding to the exact area defined by an existing NSQAR is acquired, and the existing ground truth labels are updated such that they reflect what is in the more recent imagery. As part of the overall process improvement the Tasmanian North and Tasmania South NSQARs were each split into two smaller regions, making it easier for human labellers to manually update the ground truth maps. However, for consistency with previous national scans, they are still considered as one NSQAR each.

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The update of the NSQARs by human labellers was performed from March to June 2020. The process includes selecting new satellite imagery that best overlaps the previous NSQAR region and updating the ground-truth labels. When the NSQARs were used for error analysis of the NVS2020 maps in December 2020, a number of issues were discovered that resulted in low apparent performance for a few NSQARs. These issues include:

- Changes in the boundaries due to the new satellite image not providing a 100% overlap of the old NSQAR, resulting in vineyards labelled outside of the NSQAR region, or missing vineyards for a portion of the NSQAR.
- Human error in the storage of files, names and versions of NSQARs.
- Spatial mis-alignment (registration error) between the NSQAR and the GAIA maps.
- The introduction of cloudy NSQARs, which is useful for training GAIA models to be robust to clouds, is not indicative of the cloud-free maps generated by GAIA.

In addition to above issues there is also the limitation of human generated ground-truth maps always including an element of human error. The accuracy of human labellers decreases as the complexity of the labelled scenes increases.

The NSQARs define the current understanding of the accuracy of the National Scan result, not the result itself. An investigation into NSQARs with the above issues is described in annex [6]. This investigation explains the performance and guides the inclusion of NSQARs into the overall summary statistics.

3.1 Quality Assurance Summary Statistics

For each NSQAR, a suite of metrics and properties is computed and reported. The performance of the NVS2020 is shown in Table 11, where 4 regions impacted by ground-truth generation issues (mentioned in Section 3) were excluded[6]. After investigation the NSQARs that were excluded include[7]:

- Wrattonbully
- Yarra Valley
- Murray Darling #1 and
- Murray Darling #2

These performance parameters include truth, prediction, misses and mistakes, measured as area per hectare scanned. For example, ***Truth(/ha)*** of 0.16556 indicates there is on average 0.16556 hectares of actual vineyard, per hectare satellite imagery scanned. Other parameters include recall, precision, category accuracy, area accuracy and jaccard are also presented which are unitless and represent prediction accuracy assessment results. The detailed explanations for each parameter can be found below:

[6] An annex [6] has been provided to explain these impacted regions.

[7] Part of the South Burnett NSQAR was also excluded, see Annex [6] for more details.

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- ***Truth (/ha):*** area per hectare scanned identified as vineyards by manual labelling (involving a human methodologically parsing the satellite imagery, drawing polygon classifications for vineyards and other features present).
- ***Prediction (/ha):*** area per hectare scanned predicted as vineyards by GAIA.
- ***Misses (/ha):*** area per hectare scanned of true vineyards missed by GAIA.
- ***Mistakes (/ha):*** area per hectare scanned of false positives (GAIA indicated vineyards exist but where no vineyards actually exist), also known as false positive rate.
- ***Recall (%):*** the proportion of truth predicted correctly.
- ***Precision (%)***: the proportion of prediction was correct.
- ***Category accuracy (%)***: the fraction of correctly labelled pixels for every pixel in the satellite image, also known as class accuracy .
- ***Area accuracy (%)***: the ratio of the smaller area between truth and prediction to the larger.
- ***Jaccard (%)***: the size of the intersection divided by the size of the union, also known as Intersection over Union.

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Table 11. Summary statistics of QA metrics/properties.

Metrics	Mean	StdDev	Min	Max
Truth (/ha)	0.15572	0.17917	0.00379	0.80700
Prediction (/ha)	0.15569	0.18252	0.00359	0.80687
Misses (/ha)	0.01039	0.00819	0.00048	0.03468
Mistakes (/ha)	0.01008	0.01155	0.00028	0.04543
Recall (%)	89.3504	8.0669	69.5600	97.8700
Precision (%)	92.0594	5.2328	78.8100	99.4200
Category accuracy (%)	98.2776	1.3022	95.6200	99.9200
Area accuracy (%)	93.5422	7.1862	72.2000	99.9800
Jaccard (%)	82.8863	9.5203	62.7900	95.9000

3.2 Vineyard Area Error Analysis

A conservative estimate of total area in Australia can be computed using a lower bound estimate of area accuracy (**90.83%**). This gives a range of **137,864** to **165,696** hectares, based on the observed measurement of **151,780** hectares for the total area of vineyards identified in the national scan search regions.

The above range was computed as follows. First the standard error (1.3830) was calculated from standard deviation and the number of samples. Area accuracy bounds were estimated by using standard error and the 95% confidence interval. This provides both an upper and lower estimate of the true area accuracy. The assumptions include that the area accuracy is normally distributed and that the 27 samples (with Murray Darling #1, Murray Darling #2, Wrattonbully and Yarra Valley excluded from 31 regions) used are representative of the entire search region used for the national scan. This gives a lower bound estimate of area accuracy of **90.83%** and an upper bound of area accuracy of **96.25%**.

3.3 Wine Grapes and Other Grapes

The GAIA system uses a semantic segmentation approach to generate vineyard polygon boundaries. The algorithm was trained on data to produce polygons that exclude other grapes (table grapes and dried grapes). This semantic segmentation approach works for excluding some, but not all table grapes. We found that in regions of mixed plantings the algorithm performance can drop to 60%-70% area accuracy, while performance is reasonable in other mixed planting regions.

When trying to discriminate between wine grape and table grape in NVS2020, the investigations into the predictions and classification labels revealed challenges for the GAIA algorithm and human ground truth labels. This is caused by the similarity between table grapes and wine grapes when performing segmentation. In addition, changes in the table grape vineyard's ongoing management, such as reworking, replanting and the amount of irrigation applied, will impact the canopy size of the vine and its spectral signatures. For example, a replanted table grape vineyard will look very similar to

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a wine grape vineyard in the first a few years. Another factor affecting the scan result was the timing of the imagery capture relative to harvest, which can see the netting applications in some vineyards. This also increased the complexities in differentiating wine grape and table grape.

Due to the changes in plantings of wine grapes and expansion of table grapes in the Murray Darling region, the preliminary results of the NVS2020 showed a growth in total plantings in the Murray Darling Region. To try to improve the scan estimates, third party data was used to select and remove table grape vineyards from the national scan results. After the removal, vineyard area reduction occurred in several regions, most notably Murray Darling VIC and Murray Darling NSW. This removal of polygons resulted in a staggering loss of measured accuracy (as low as 30%), compared to the initial results (of around 70%). That is, errors in the third party data may have caused a substantive number of actual wine grape polygons to be removed. However, it is likely that NSQARs also have incorrect labels due to human errors in mixed wine grape table grape planting regions. Nevertheless, we propose that Murray Darling VIC and Murray Darling NSW are now biased to underestimate the number of winegrape plantings in the region.

A future research area for improvement of the National Scan would be to

1. perform segmentation on all grapes,
2. and then perform varietal classification on each polygon to estimate the type of grape.

This varietal classification research may lead to new approaches to categorising the number and volume of each variety of grape in a region.

For other regions the performance of the underlying GAIA model is sound, unless there are land use changes and label errors that impact the measurement of performance using the NSQARs. Detailed investigation and explanations on these NSQARs can be found in the Annex of this report [6].

3.4 Visualizing National Scan Quality Assurance Regions (NSQARs)

For the quality assurance conducted in NVS2020, the NSQARs can be visualized in the following sections (Sections 4-9 and Figures 15-81). There are multiple quality assurance regions in each state to ensure the satisfactory performance of the GAIA system under different climatic regions, growing conditions and vineyard management practices. For each quality assurance region, the performance metrics are also computed and presented (Tables 12-42) to demonstrate the accuracy of the GAIA system in comparisons with ground-truth labels marked by humans.

The following colour scheme is used in figures in Sections 4-9 to represent the classification of ground-truth labels:

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4. Quality Assurance in Western Australia

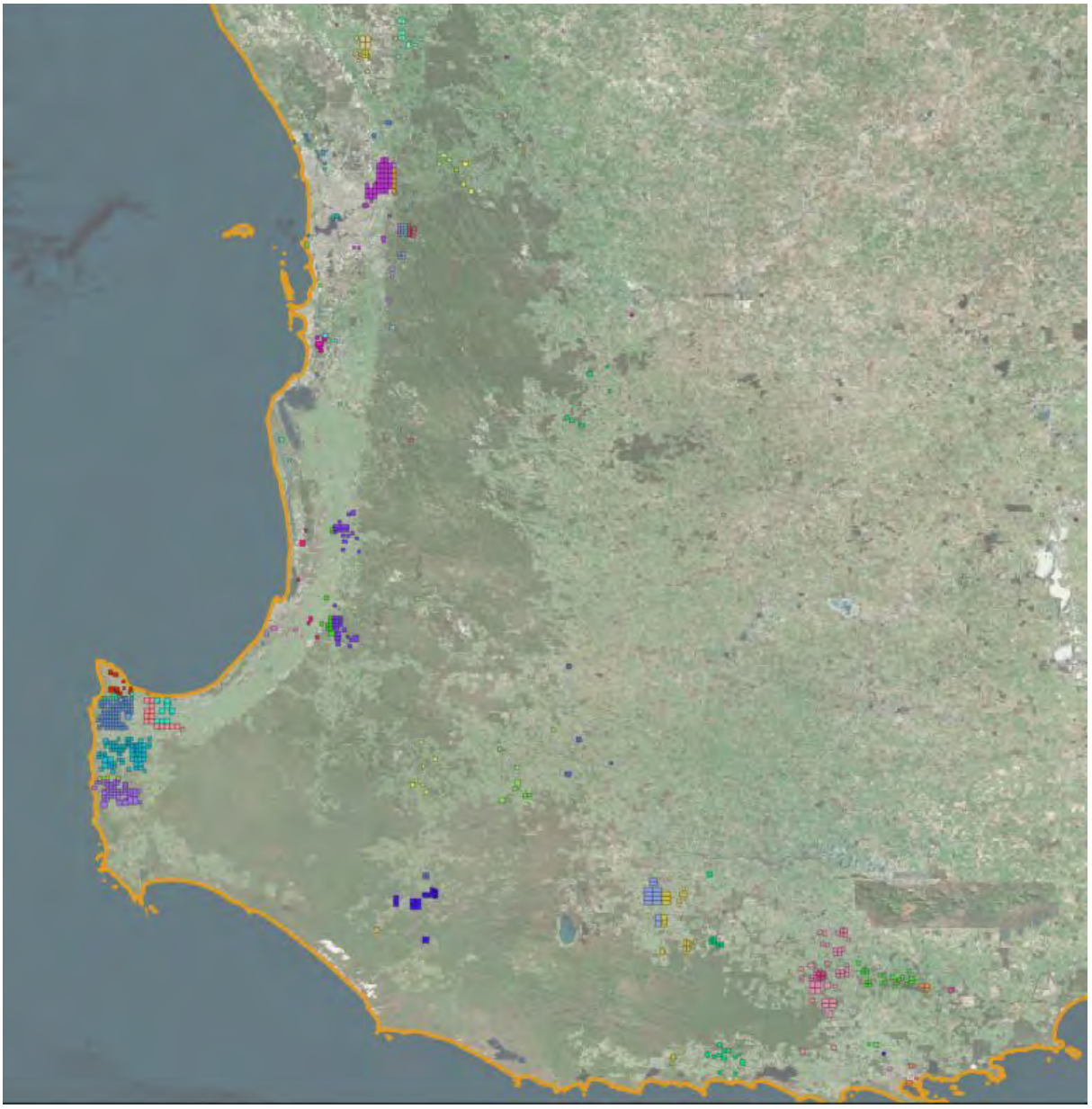


Figure 16: A visualisation of the AOIs in Western Australia that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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4.1 Margaret River



Figure 17. The Margaret River NSQAR in the context of the Margaret River GI. The entire labelled region (greyscale rectangle) is used for Quality Assurance to maintain consistency with earlier reporting.

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Figure 18. The Margaret River labels overlaid on the Panchromatic satellite imagery.

Table 12. QA metrics/properties for Margaret River

Date of imagery used for ground truth	2017-01-15T02:50:50.846Z
Total area (ha)	25961.62
Truth area (ha)	1570.09
Prediction area (ha)	1564.59
Misses area (ha)	109.33
Mistakes area (ha)	102.77
Union area (ha)	1672.63
Intersection area (ha)	1462.15
Recall	93.04
Precision	93.43
Category accuracy	99.23
Area accuracy	99.65
Jaccard	87.33
False positive rate (/m2)	0.0000

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4.2 Swan Valley #1

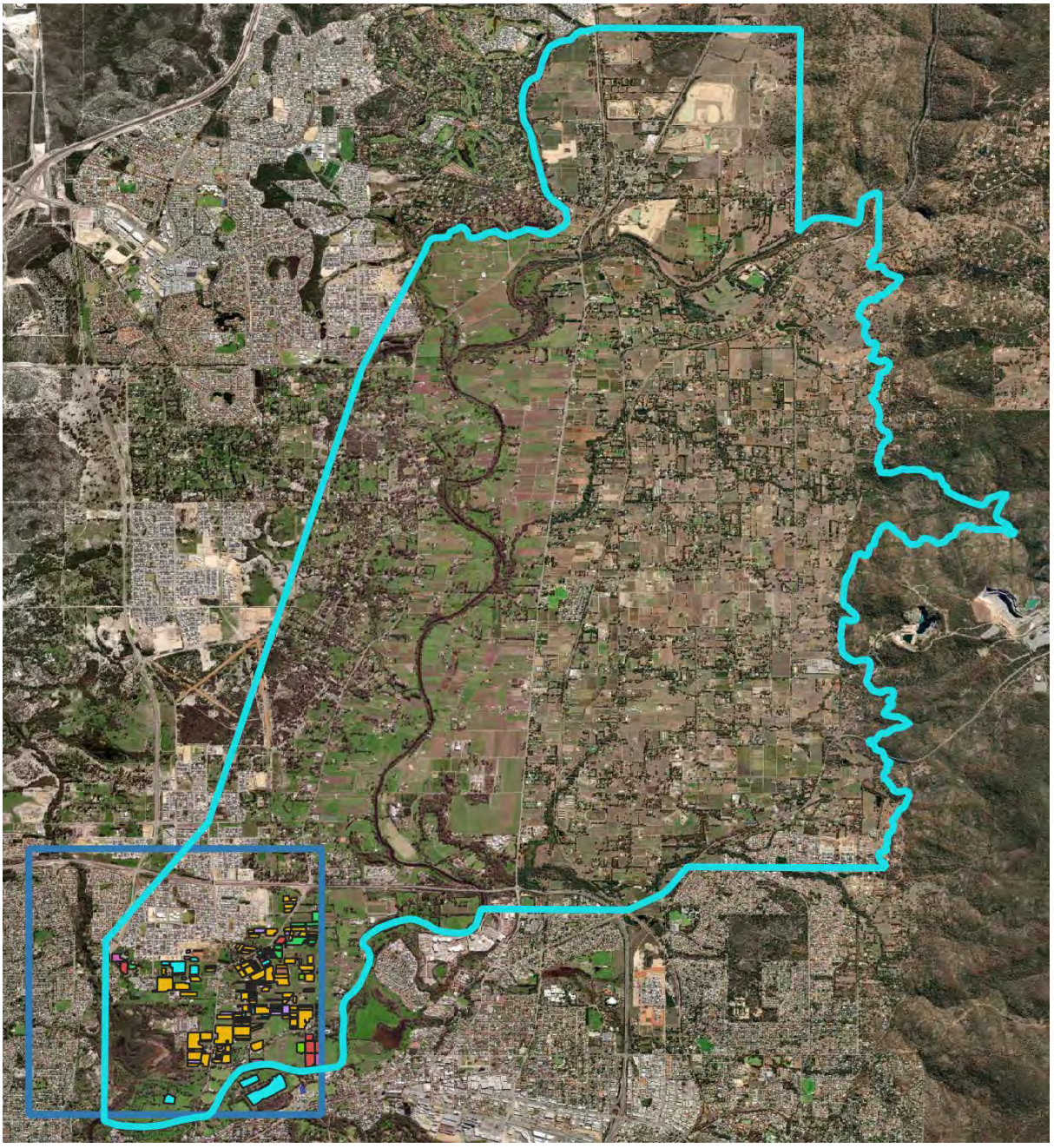


Figure 19. The Swan Valley #1 NSQAR in the context of the Swan Valley GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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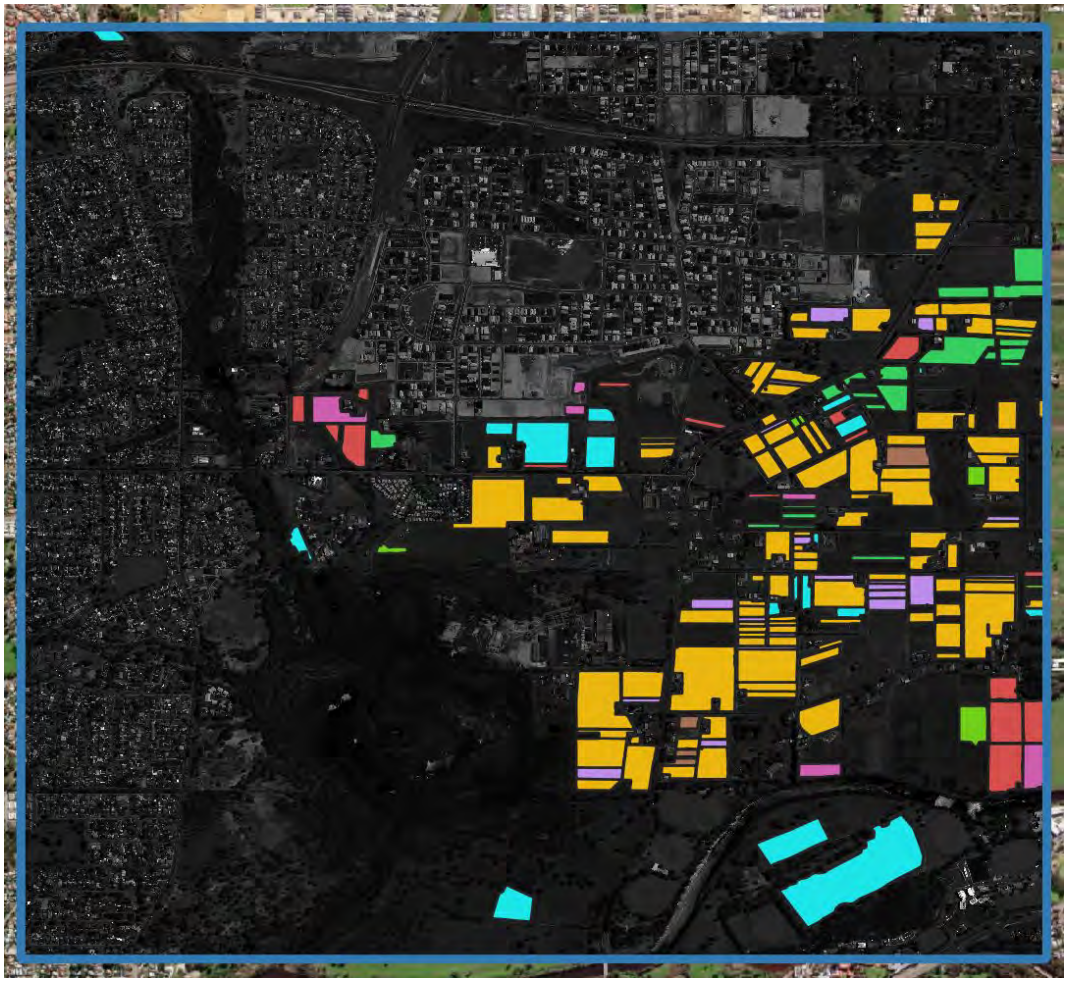


Figure 20. The Swan Valley #1 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the DPIRD dataset.

Table 13. QA metrics/properties for Swan Valley #1

Date of imagery used for ground truth	2020-01-06T02:33:05.000Z
Total area (ha)	354.59
Truth area (ha)	5.52
Prediction area (ha)	5.68
Misses area (ha)	0.69
Mistakes area (ha)	0.85
Union area (ha)	6.38
Intersection area (ha)	4.83
Recall	87.53
Precision	85.05
Category accuracy	99.57
Area accuracy	97.17
Jaccard	75.86

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False positive rate (/m2)	0.00000

4.3 Mount Barker

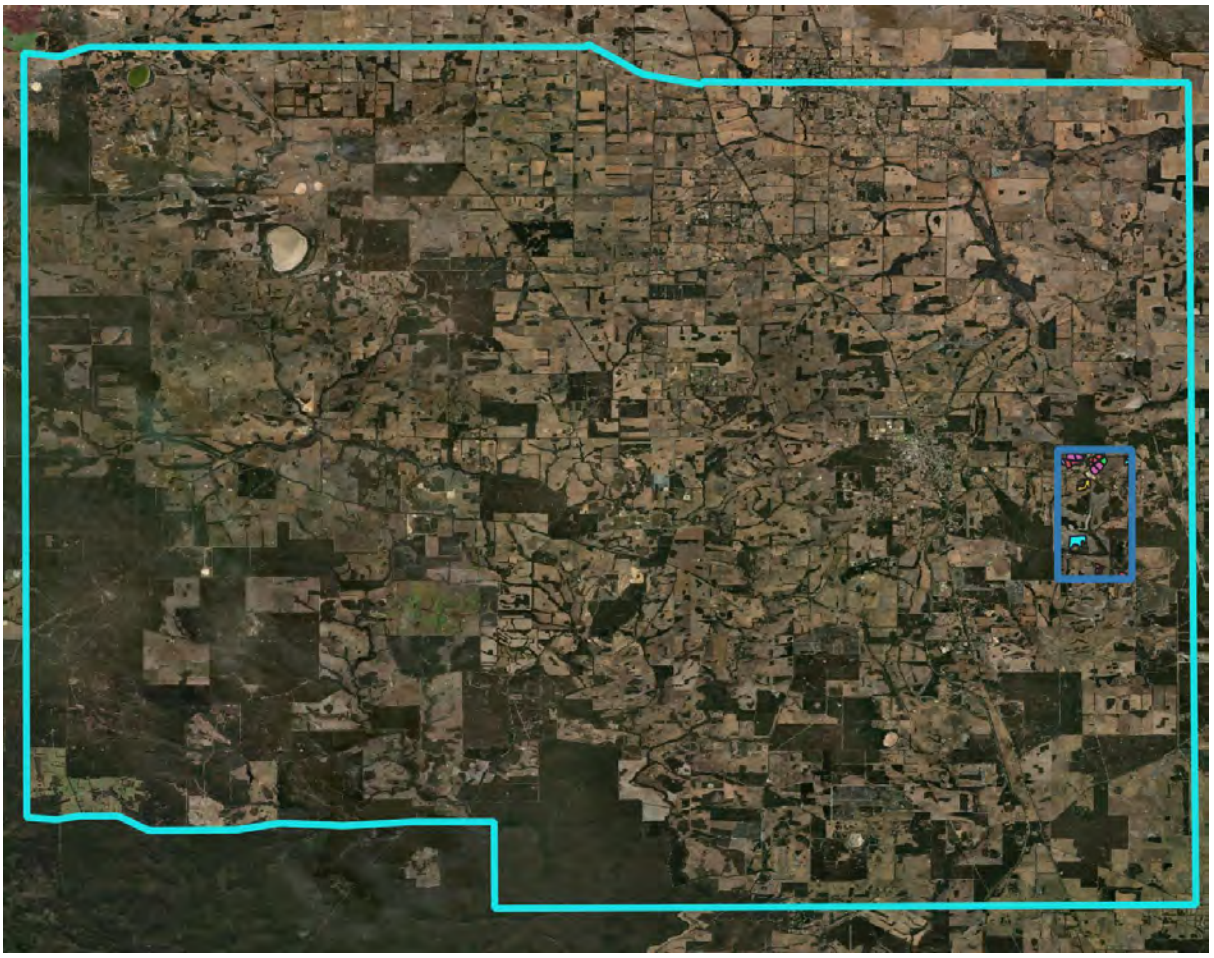


Figure 21. The Mount Barker NSQAR in the context of the Mount Barker GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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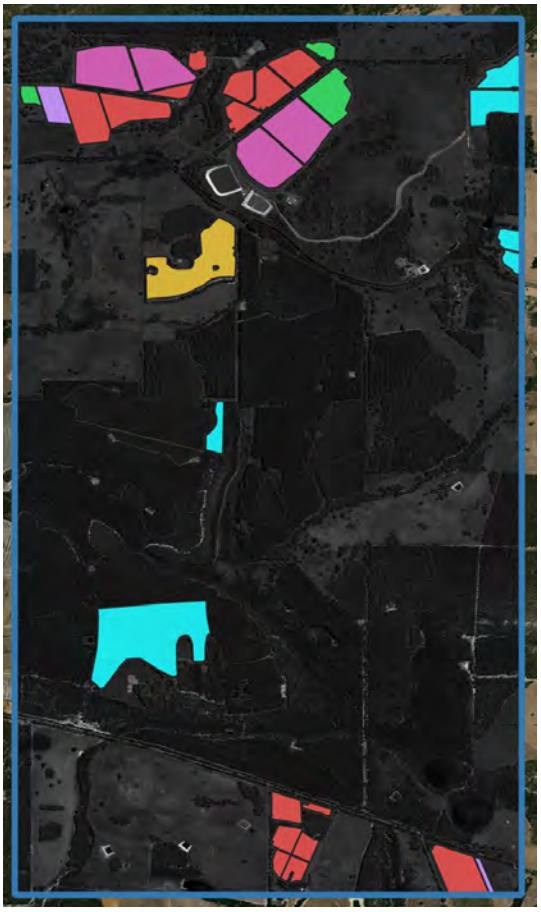


Figure 22. The Mount Barker labels overlaid on the Panchromatic satellite imagery.

Table 14. QA metrics/properties for Mount Barker

Date of imagery used for ground truth	2018-01-24T02:27:00.000Z
Total area (ha)	344.05
Truth area (ha)	38.60
Prediction area (ha)	31.76
Misses area (ha)	11.93
Mistakes area (ha)	4.33
Union area (ha)	42.92
Intersection area (ha)	27.43
Recall	69.70
Precision	86.37
Category accuracy	95.68
Area accuracy	82.28
Jaccard	62.79
False positive rate (/m2)	0.0100

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4.4 Geographe

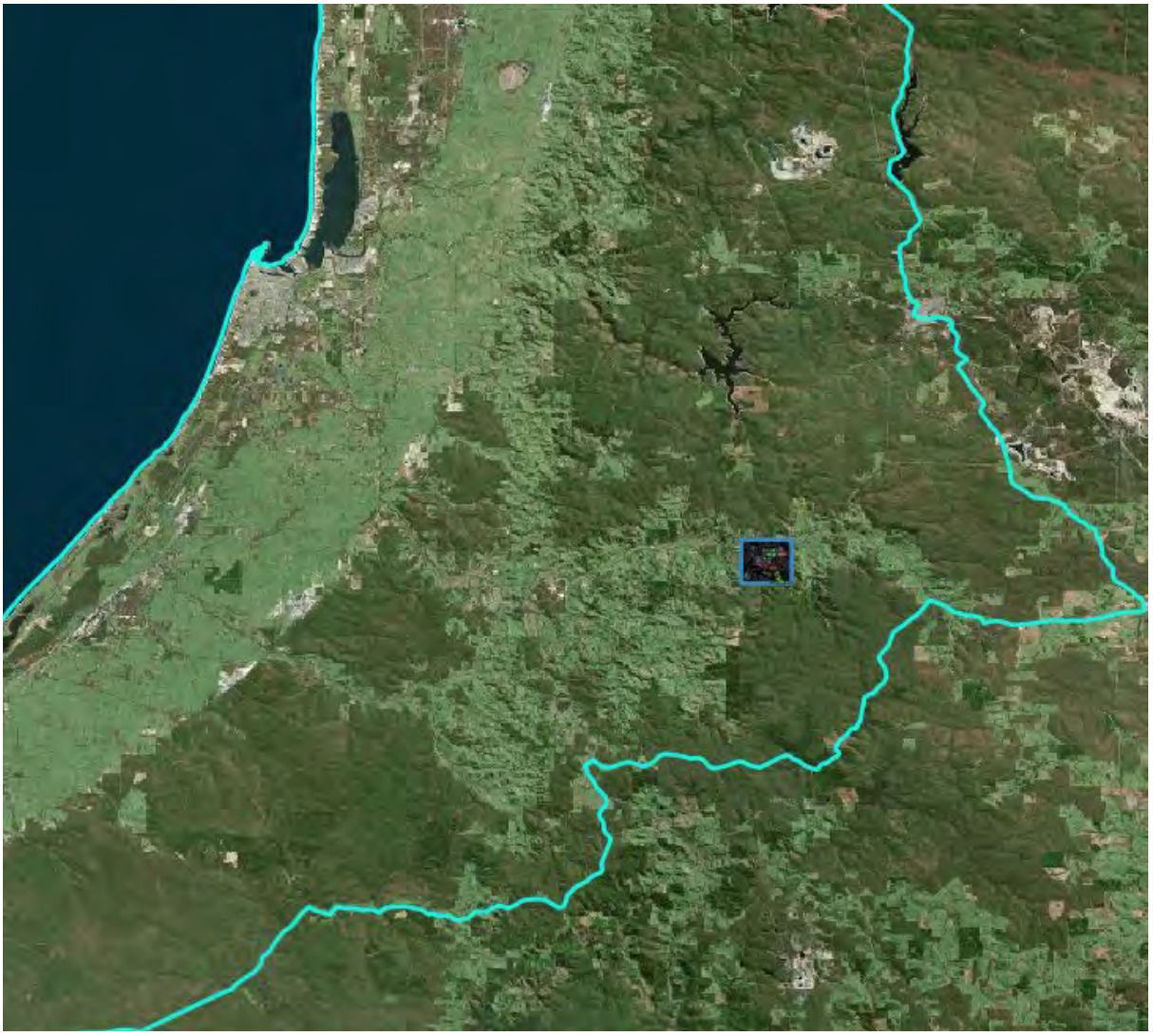


Figure 23. The Geographe NSQAR in the context of the Geographe GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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Figure 24. The Geographe labels overlaid on the Panchromatic satellite imagery.

Table 15. QA metrics/properties for Geographe

Date of imagery used for ground truth	2016-03-09T02:22:14.000Z
Total area (ha)	340.19
Truth area (ha)	40.88
Prediction area (ha)	39.98
Misses area (ha)	1.92
Mistakes area (ha)	1.00
Union area (ha)	41.87
Intersection area (ha)	38.99
Recall	95.32
Precision	97.50
Category accuracy	99.18
Area accuracy	97.81
Jaccard	93.04
False positive rate (/m2)	0.0000

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4.5 Swan Valley #2

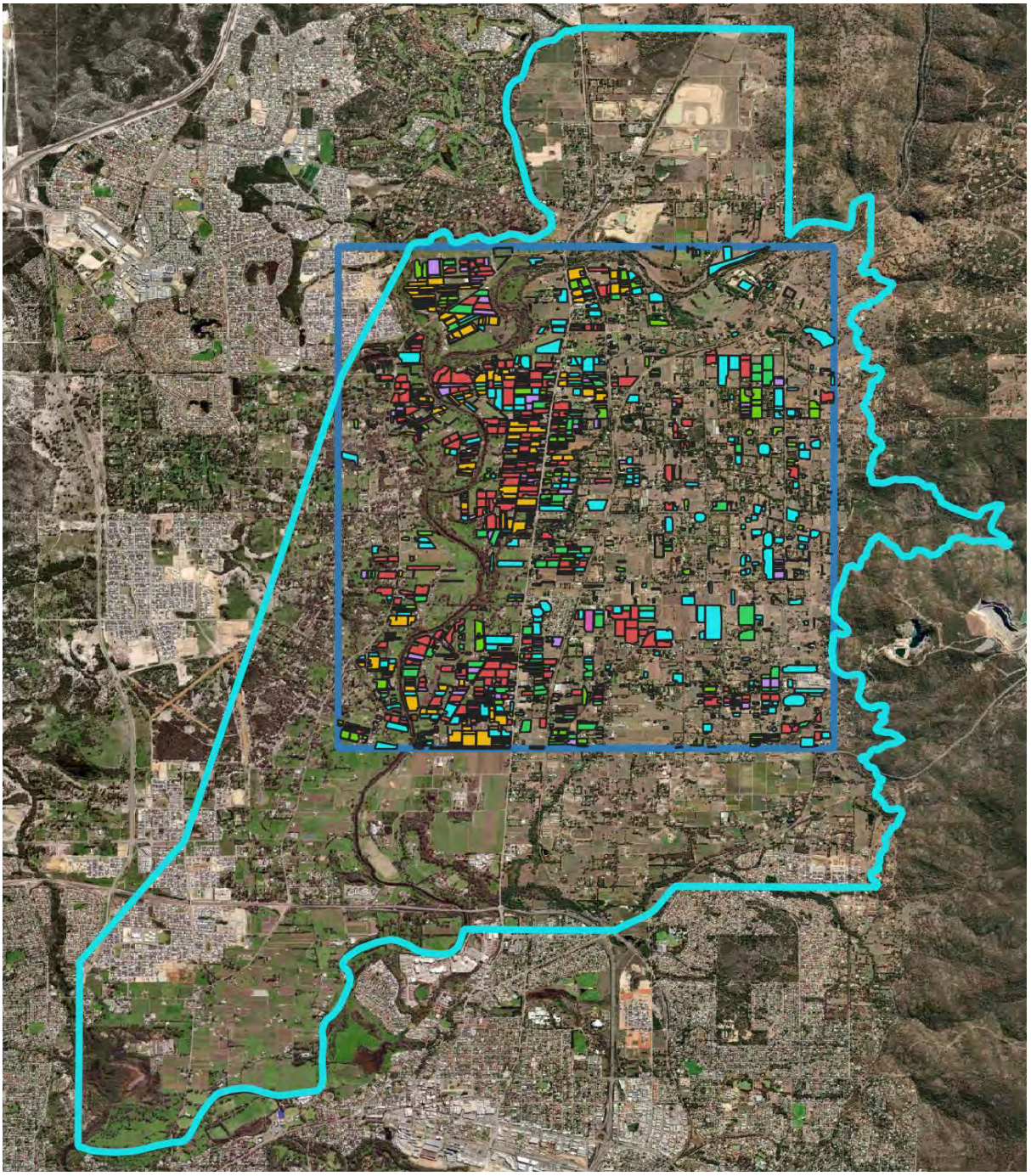


Figure 25. The Swan Valley #2 NSQAR in the context of the Swan Valley GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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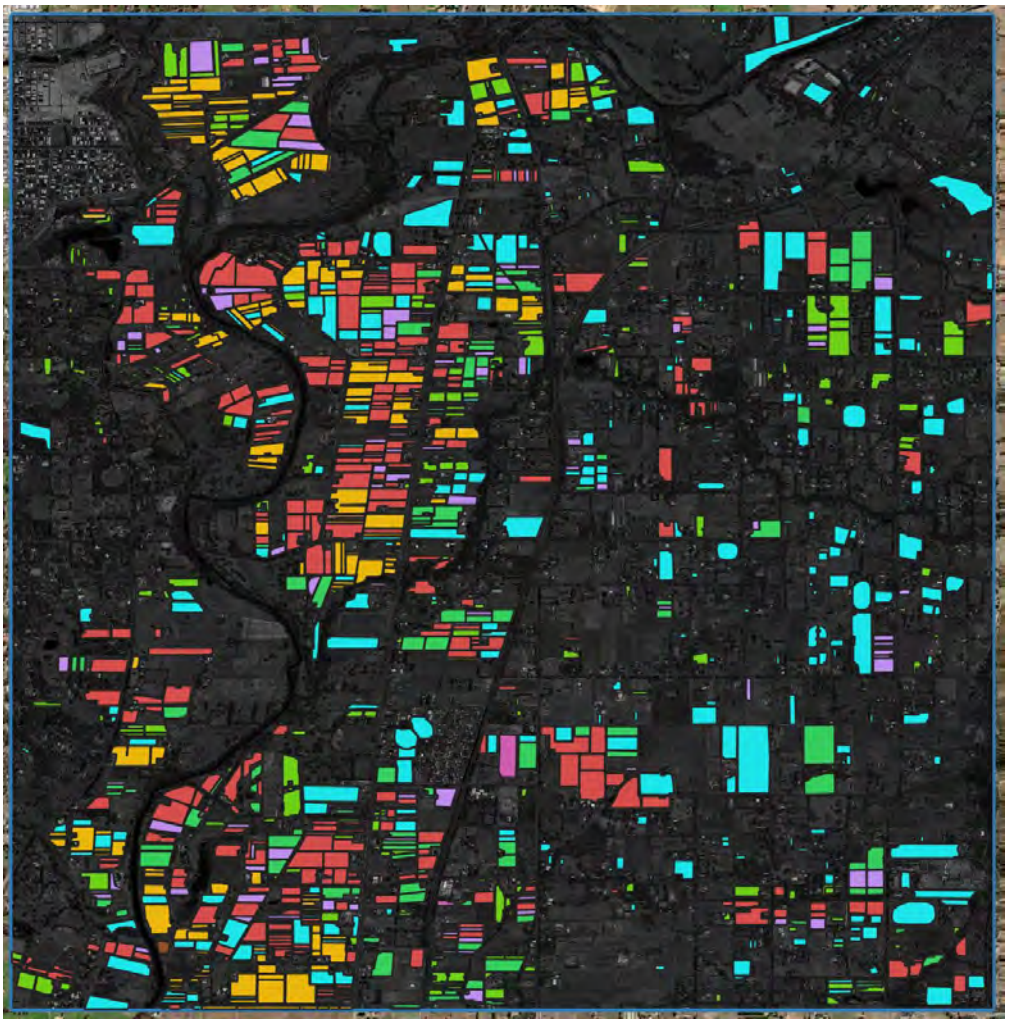


Figure 26. The Swan Valley #2 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the DPIRD dataset.

Table 16. QA metrics/properties for Swan Valley #2

Date of imagery used for ground truth	2018-02-06T02:48:14.000Z
Total area (ha)	1082.27
Truth area (ha)	55.50
Prediction area (ha)	40.07
Misses area (ha)	16.91
Mistakes area (ha)	1.43
Union area (ha)	56.94
Intersection area (ha)	38.64
Recall	69.56
Precision	96.42
Category accuracy	98.39
Area accuracy	72.20

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Jaccard	67.81
False positive rate (/m2)	0.00132

5. Quality Assurance in Tasmania

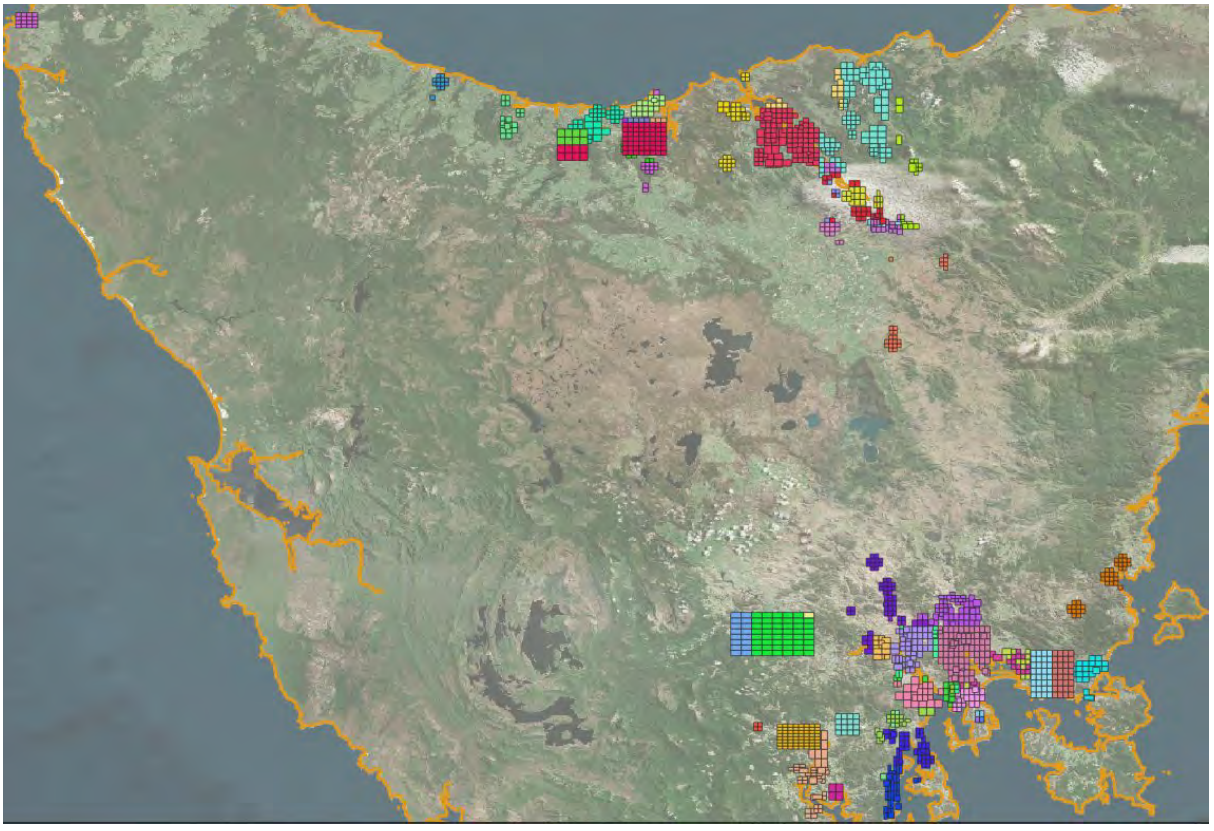


Figure 27: A visualisation of the AOIs in Tasmania that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI. Note that Tasmania had no new AOIs for 2020 and thus it looks the same as the figure from NVS2019.

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Figure 28. The Tasmania North (top) and Tasmania South (bottom) NSQARs in the context of Tasmania. The entire areas within the coloured rectangles has been labelled (details shown in Figures 28 and 29), and the entire areas are used for Quality Assurance to maintain consistency with earlier reporting.

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5.1 Tasmania North

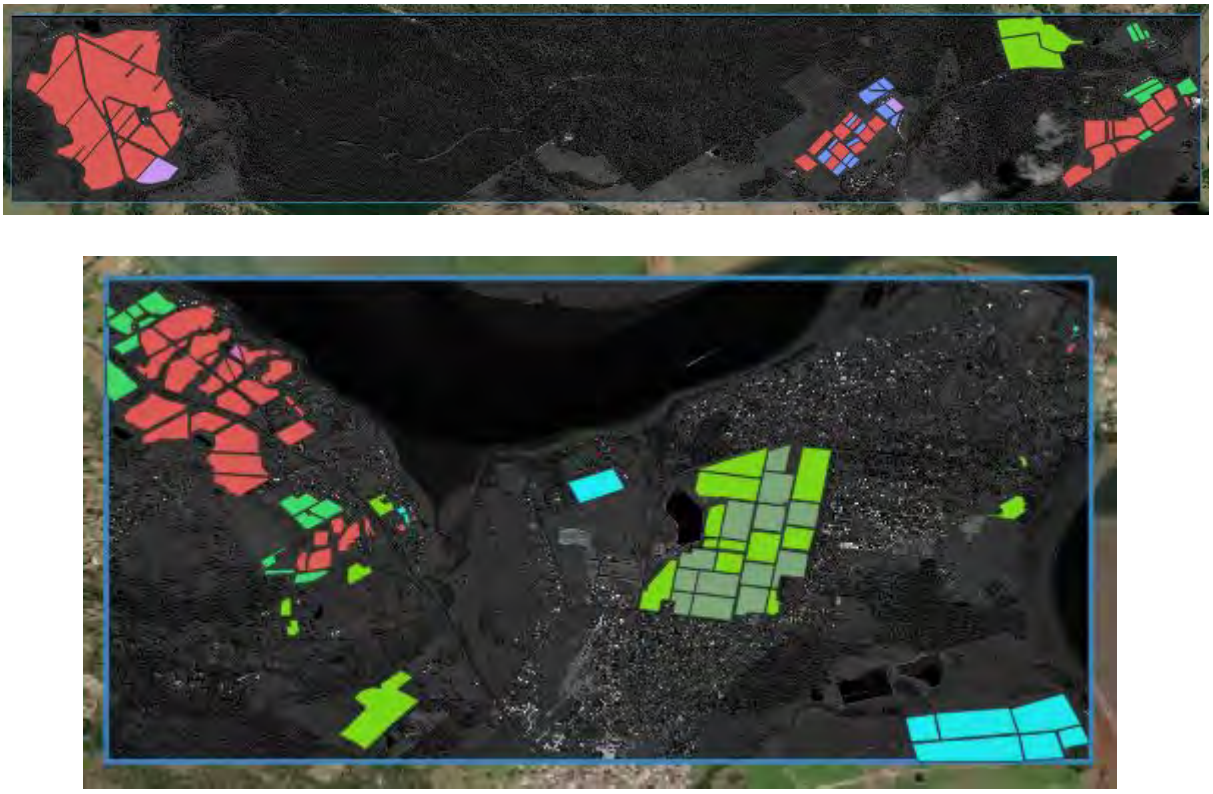


Figure 29. Tasmania North labels overlaid on the Panchromatic satellite imagery. Tasmania North labels are split into two areas (top and bottom) for a better visualization.

Table 17. QA metrics/properties for Tasmania North

Date of imagery used for ground truth	2020-02-11T23:53:08.000Z
Total area (ha)	638.86
Truth area (ha)	94.62
Prediction area (ha)	90.84
Misses area (ha)	8.07
Mistakes area (ha)	4.29
Union area (ha)	98.90
Intersection area (ha)	86.55
Recall	92.25
Precision	95.29
Category accuracy	98.36
Area accuracy	95.65
Jaccard	88.22
False positive rate (/m2)	0.00672

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5.2 Tasmania South

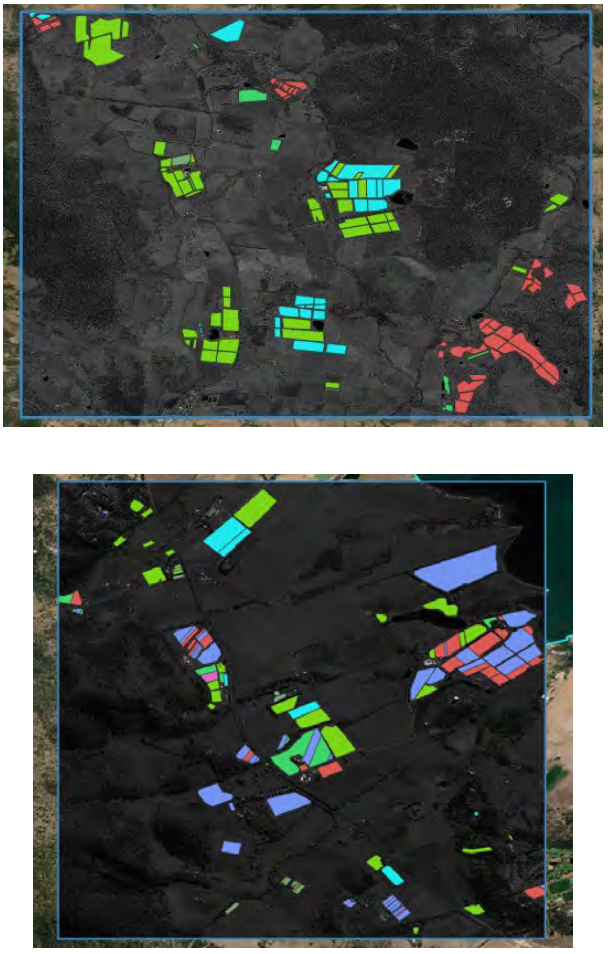


Figure 30. Tasmania South labels overlaid on the Panchromatic satellite imagery.Tasmania South labels are split into two areas (top and bottom) for a better visualization.

Table 18. QA metrics/properties for Tasmania South

Date of imagery used for ground truth	2020-03-28T00:15:26.000Z
Total area (ha)	1371.47
Truth area (ha)	27.02
Prediction area (ha)	23.60
Misses area (ha)	7.90
Mistakes area (ha)	4.29
Union area (ha)	31.31
Intersection area (ha)	19.31
Recall	76.62
Precision	81.32
Category accuracy	99.12
Area accuracy	78.59

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Jaccard	64.01
False positive rate (/m2)	0.00313

6. Quality Assurance in South Australia

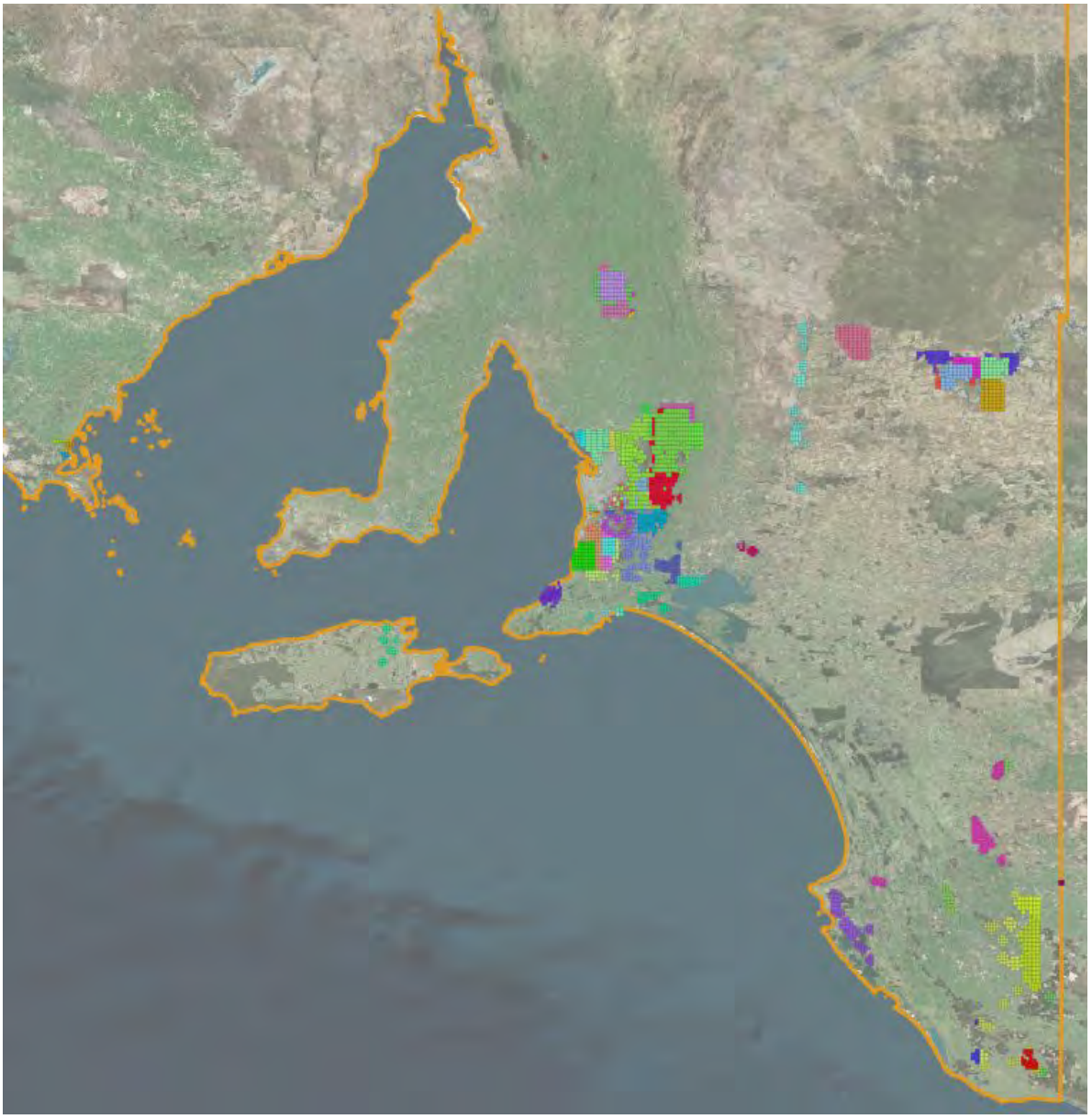


Figure 31: A visualisation of the AOIs in South Australia that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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6.1 Riverland



Figure 32. The Riverland NSQAR in the context of the Riverland GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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Figure 33. Riverland labels overlaid on the Panchromatic satellite imagery.

Table 19. QA metrics/properties for Riverland

Date of imagery used for ground truth	2019-12-18T00:53:38.000Z
Total area (ha)	729.33
Truth area (ha)	254.01
Prediction area (ha)	269.83
Misses area (ha)	9.79
Mistakes area (ha)	25.46
Union area (ha)	279.48
Intersection area (ha)	244.34
Recall	96.15
Precision	90.56
Category accuracy	96.23
Area accuracy	94.14
Jaccard	87.39
False positive rate (/m2)	0.030

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6.2 Clare Valley



Figure 34. The Clare Valley NSQAR in the context of the Clare Valley GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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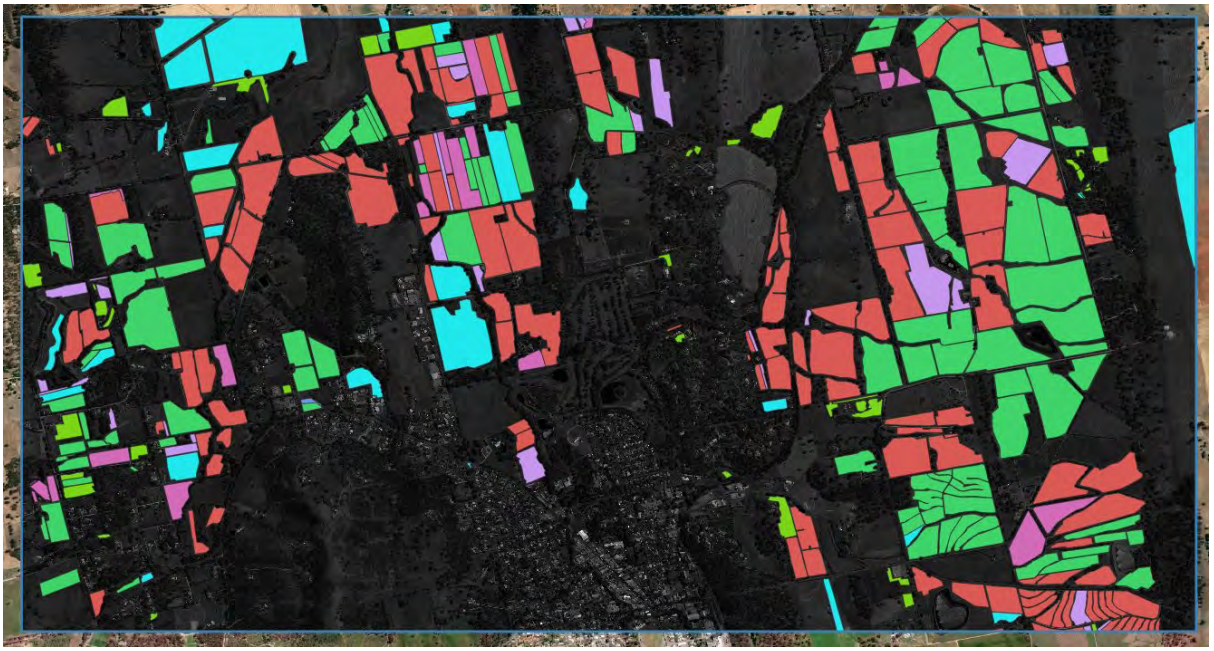


Figure 35. Clare Valley labels overlaid on the Panchromatic satellite imagery.

Table 20. QA metrics/properties for Clare Valley

Date of imagery used for ground truth	2020-02-10T01:05:08.000Z
Total area (ha)	725.30
Truth area (ha)	173.31
Prediction area (ha)	175.10
Misses area (ha)	11.21
Mistakes area (ha)	12.72
Union area (ha)	186.31
Intersection area (ha)	162.31
Recall	93.54
Precision	92.73
Category accuracy	97.32
Area accuracy	98.98
Jaccard	87.15
False positive rate (/m2)	0.020

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6.3 Wrattonbully

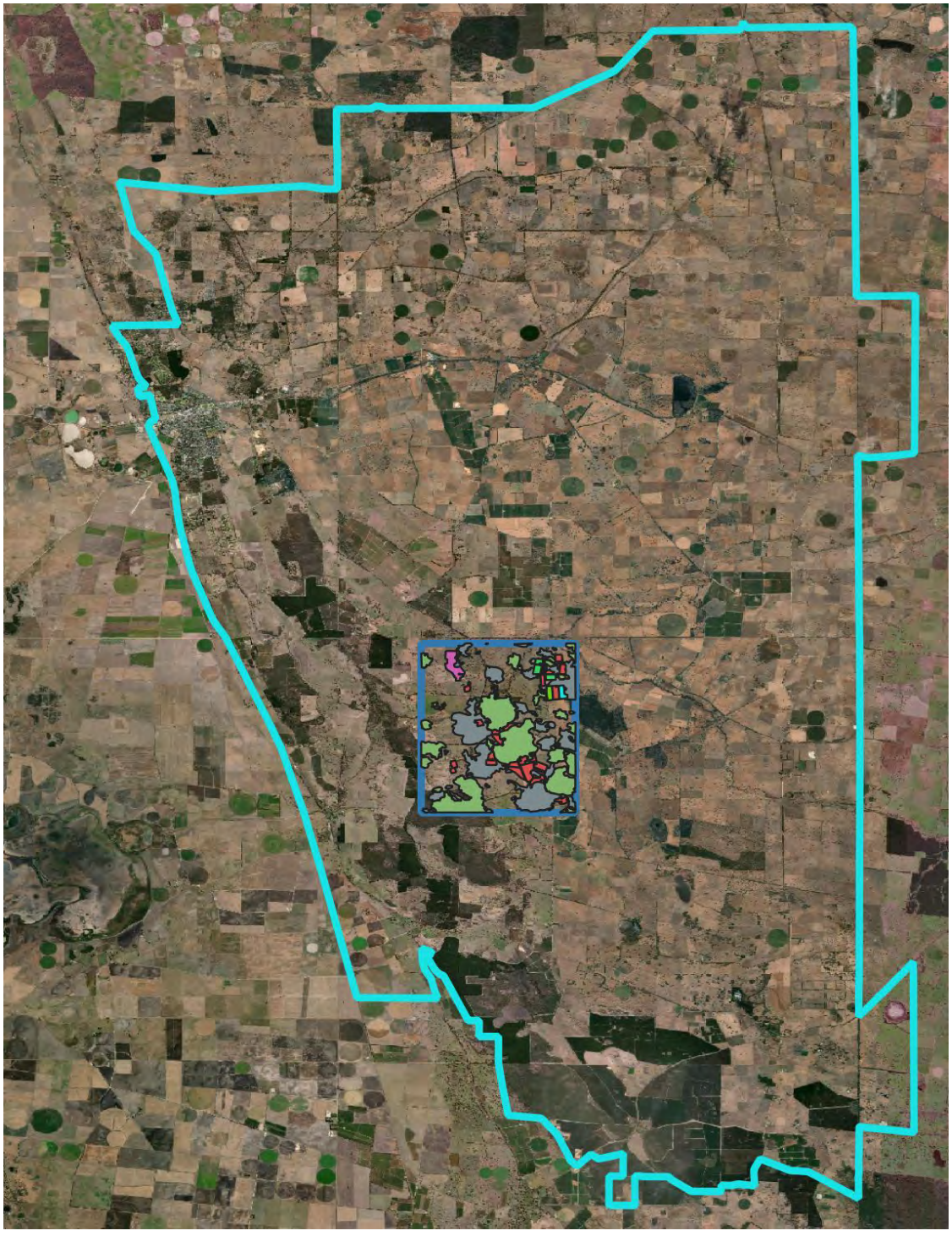


Figure 36. The Wrattonbully NSQAR in the context of the Wrattonbully GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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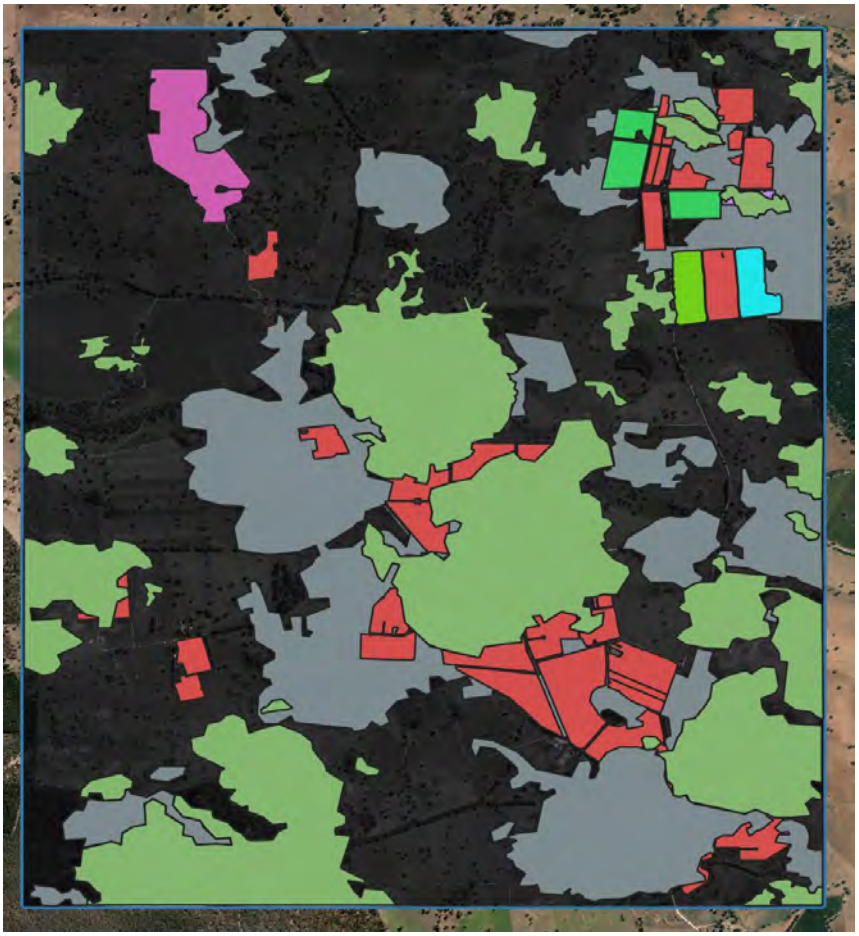


Figure 37. Wrattonbully labels overlaid on the Panchromatic satellite imagery. The skewed bounds (dark blue) shows the bounds of the entire capture that was taken by the satellite WorldView 2: most other NSQARs are small extractions, with the exception of Margaret River, Tasmania North and South, Barossa Valley and Adelaide Hills.

Table 21. QA metrics/properties for Wrattonbully

Date of imagery used for ground truth	2020-04-02T00:50:17.000Z
Total area (ha)	754.27
Truth area (ha)	46.20
Prediction area (ha)	62.94
Misses area (ha)	1.89
Mistakes area (ha)	17.47
Union area (ha)	63.68
Intersection area (ha)	45.44
Recall	96.00
Precision	72.23
Category accuracy	97.60

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Area accuracy	73.40
Jaccard	70.12
False positive rate (/m2)	0.0200

6.4 Barossa Valley

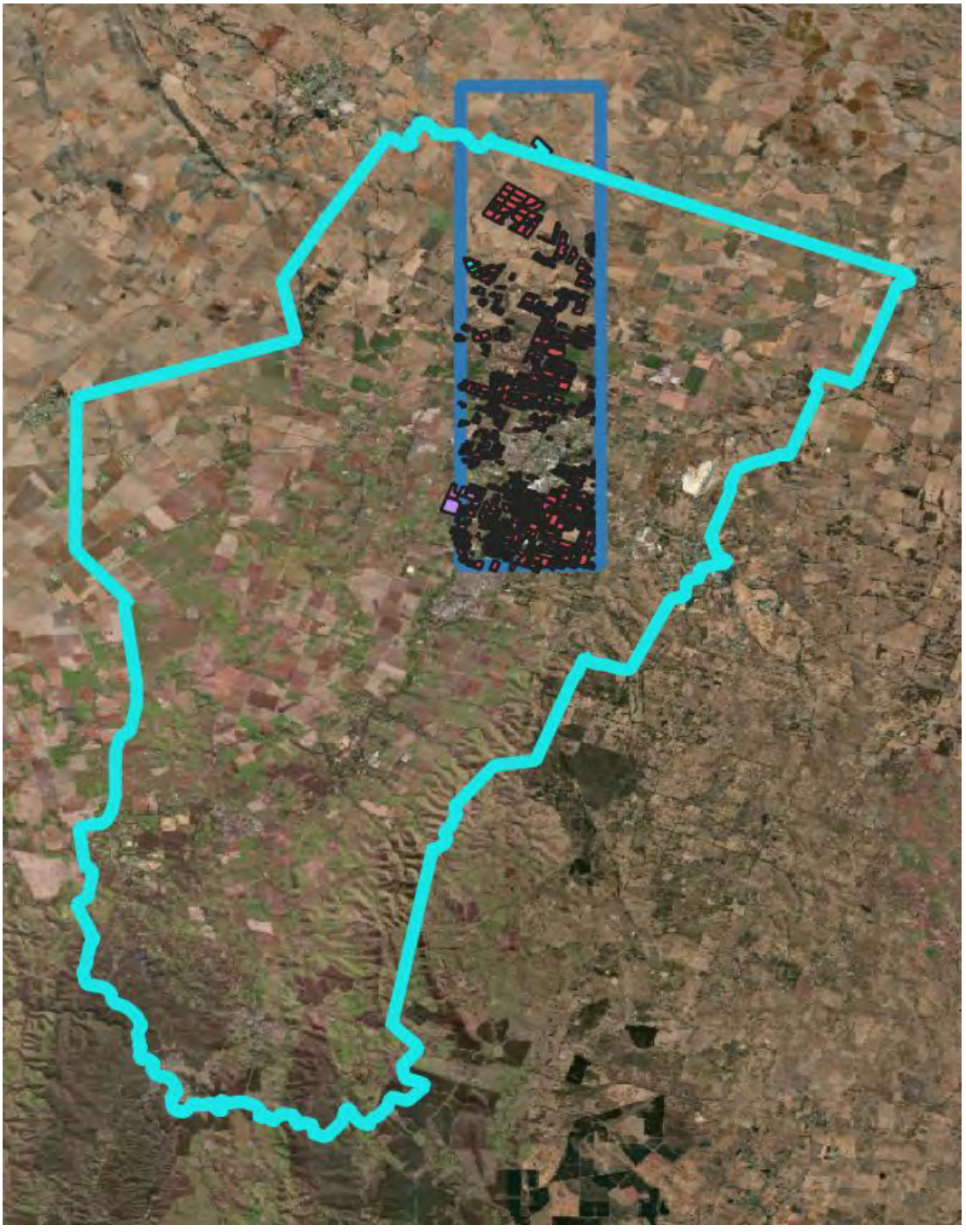


Figure 38. The Barossa Valley NSQAR in the context of the Barossa Valley GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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Figure 39. Barossa Valley labels overlaid on the Panchromatic satellite imagery.

Table 22. QA metrics/properties for Barossa Valley

Date of imagery used for ground truth	2017-02-10T01:08:22.132Z
Total area (ha)	2188.70
Truth area (ha)	254.81
Prediction area (ha)	221.62
Misses area (ha)	52.25
Mistakes area (ha)	16.86
Union area (ha)	271.68
Intersection area (ha)	204.72
Recall	79.67
Precision	92.39
Category accuracy	97.15
Area accuracy	86.97
Jaccard	74.76
False positive rate (/m2)	0.0100

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6.5 Adelaide Hills

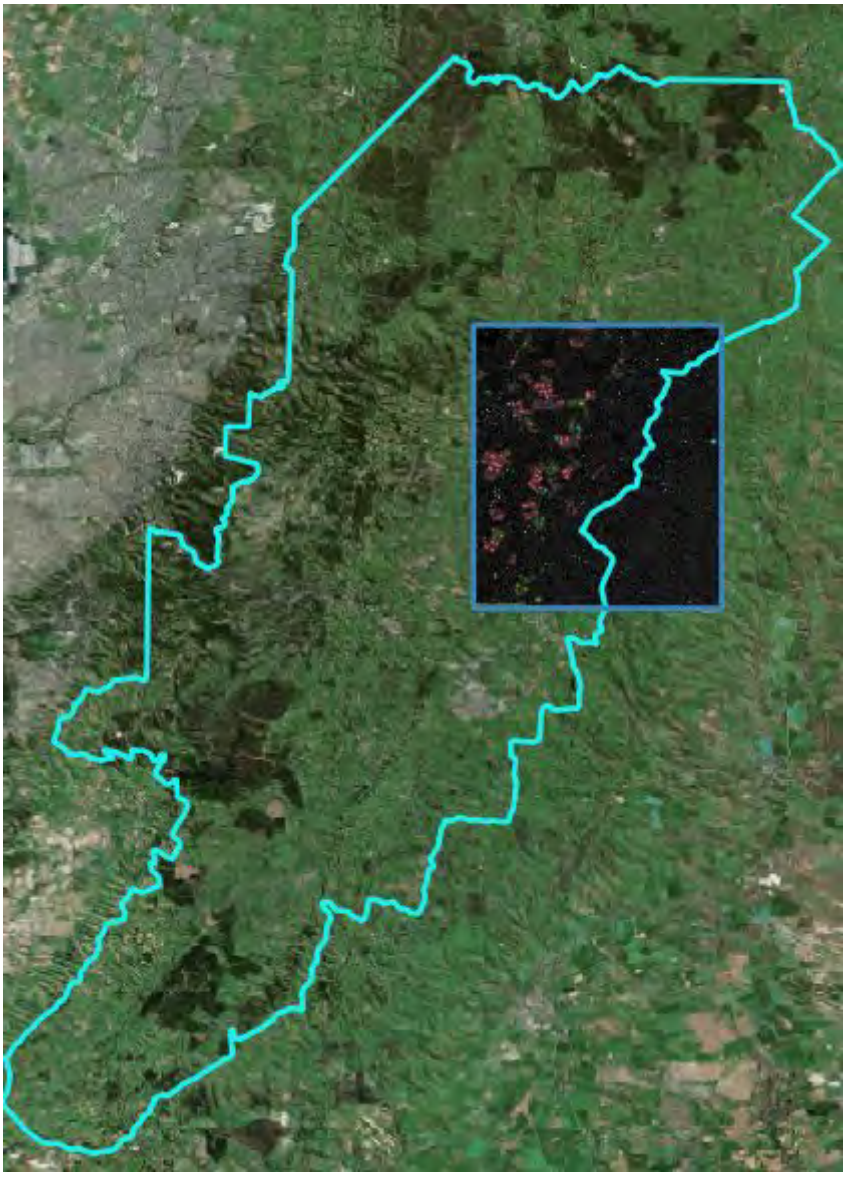


Figure 40. The Adelaide Hills NSQAR in the context of the Adelaide Hills GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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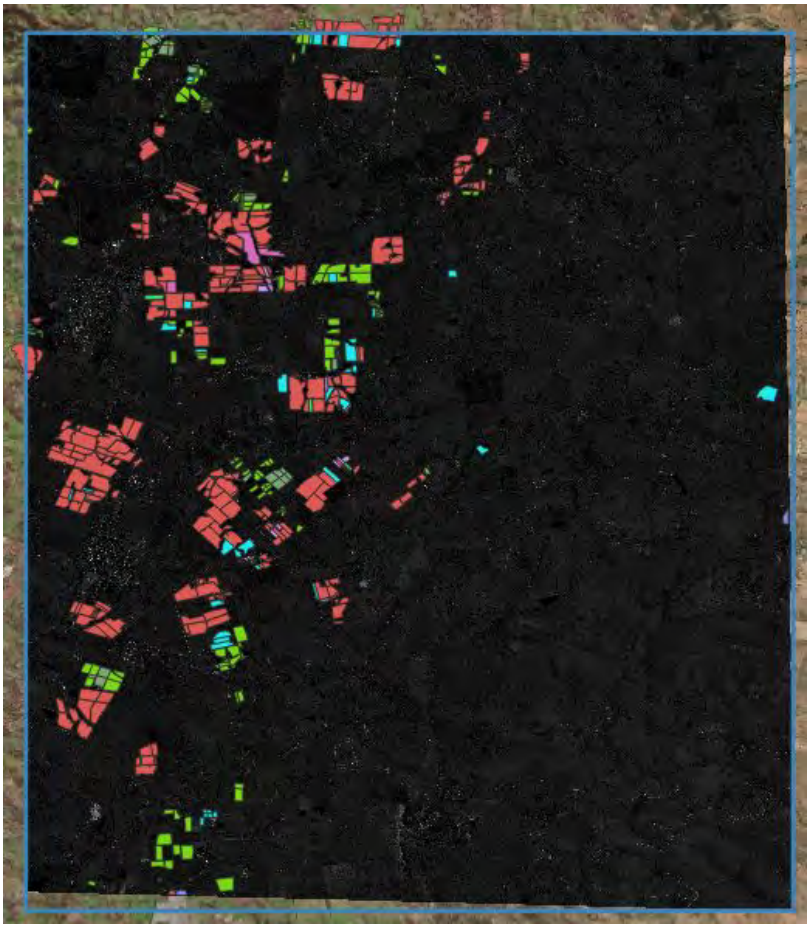


Figure 41. Adelaide Hills labels overlaid on the Panchromatic satellite imagery.

Table 23. QA metrics/properties for Adelaide Hills

Date of imagery used for ground truth	2017-02-10T01:08:22.132Z
Total area (ha)	6507.00
Truth area (ha)	579.72
Prediction area (ha)	607.81
Misses area (ha)	28.32
Mistakes area (ha)	52.93
Union area (ha)	632.94
Intersection area (ha)	554.48
Recall	95.14
Precision	91.29
Category accuracy	98.86
Area accuracy	95.38
Jaccard	87.22

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False positive rate (/m2)	0.0100

6.6 Coonawarra

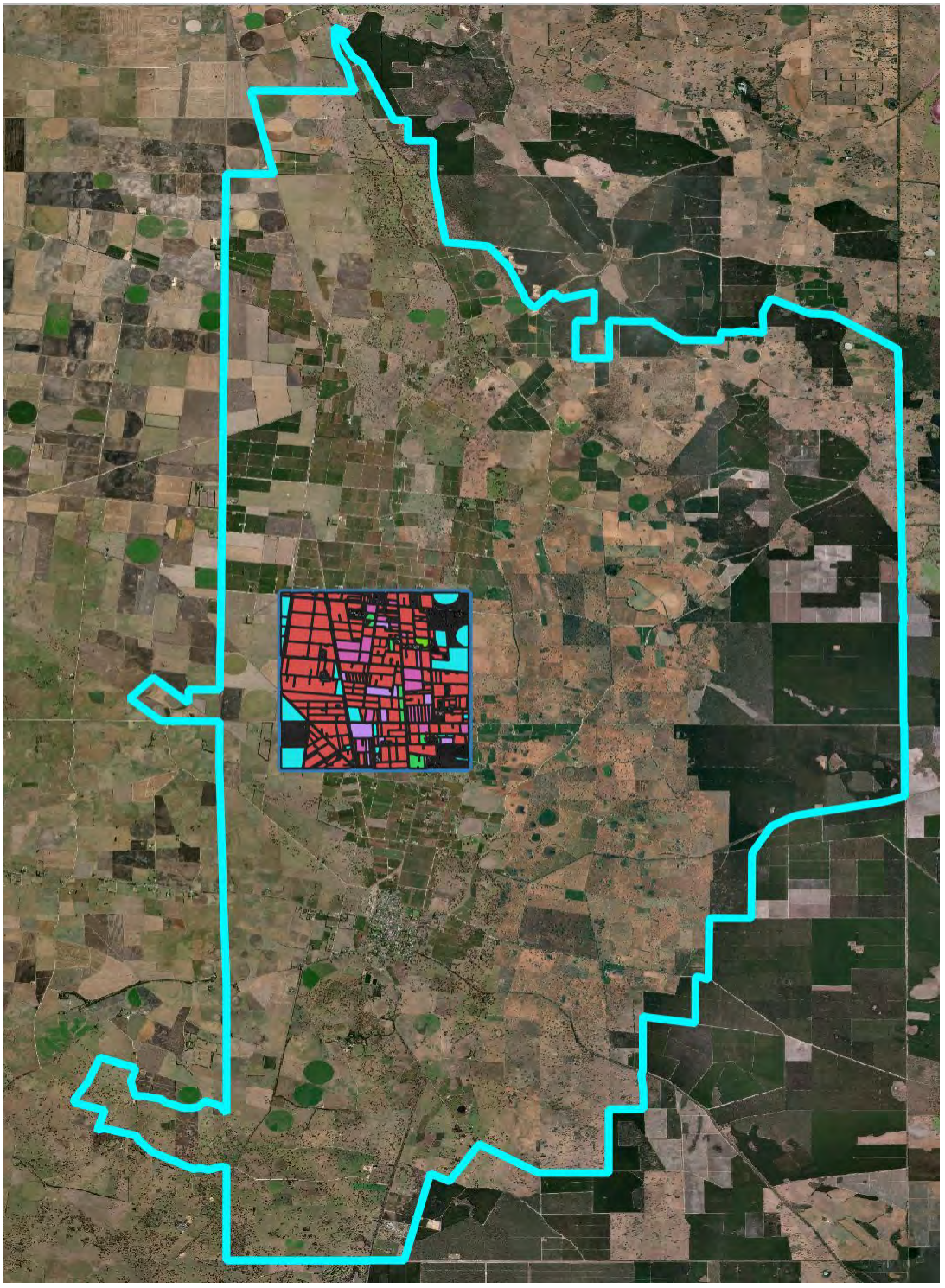


Figure 42. The Coonawarra NSQAR in the context of the Coonawarra GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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Figure 43. Coonawarra labels overlaid on the Panchromatic satellite imagery.

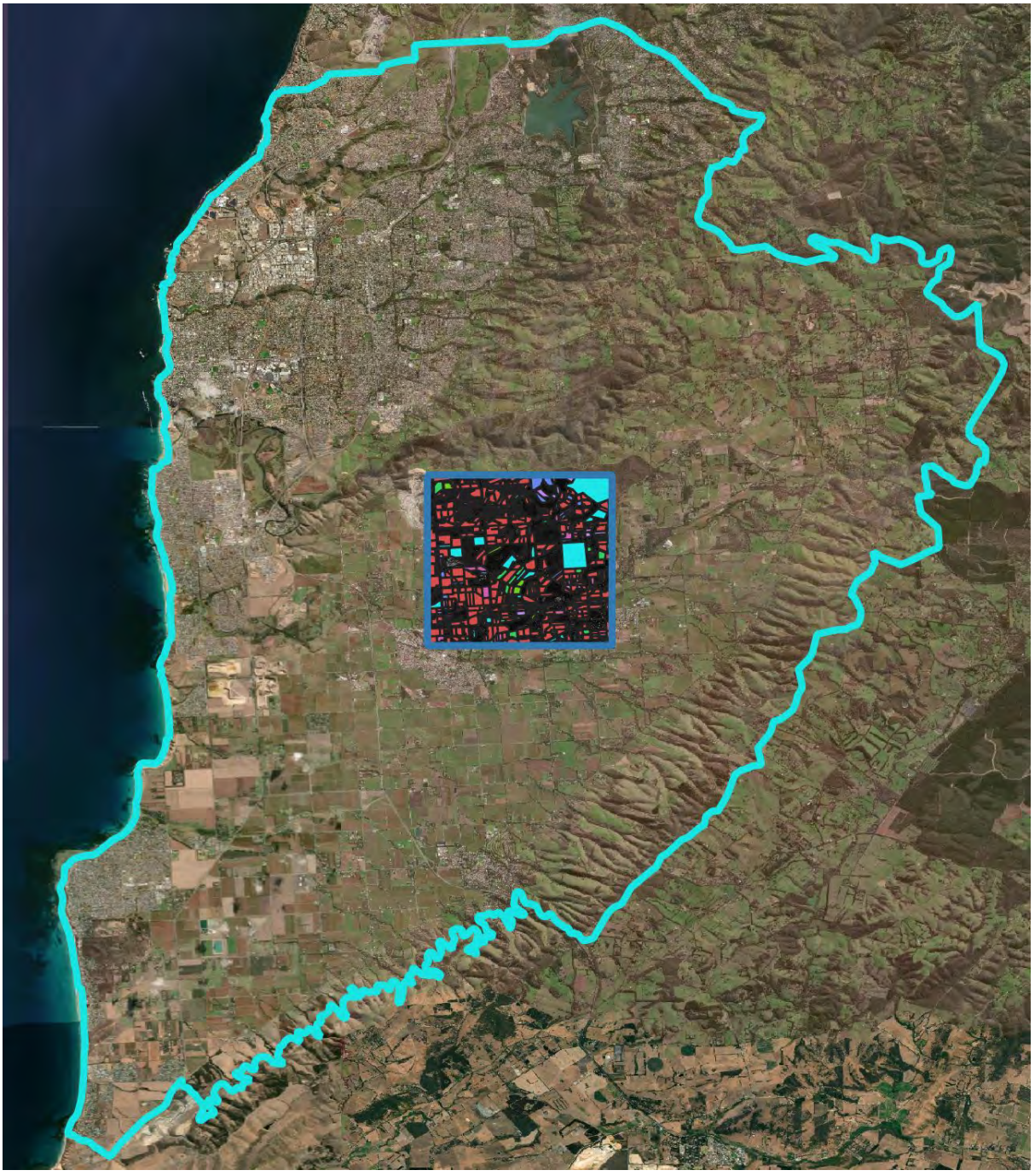
Table 24. QA metrics/properties for Coonawarra

Date of imagery used for ground truth	2016-03-17T00:47:50.808Z
Total area (ha)	571.39
Truth area (ha)	461.11
Prediction area (ha)	461.04
Misses area (ha)	9.82
Mistakes area (ha)	9.49
Union area (ha)	470.89
Intersection area (ha)	451.44
Recall	97.87
Precision	97.94
Category accuracy	97.82

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Area accuracy	99.98
Jaccard	95.90
False positive rate (/m2)	0.020

6.7 McLaren Vale



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Figure 44. The McLaren Vale NSQAR in the context of the McLaren Vale GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

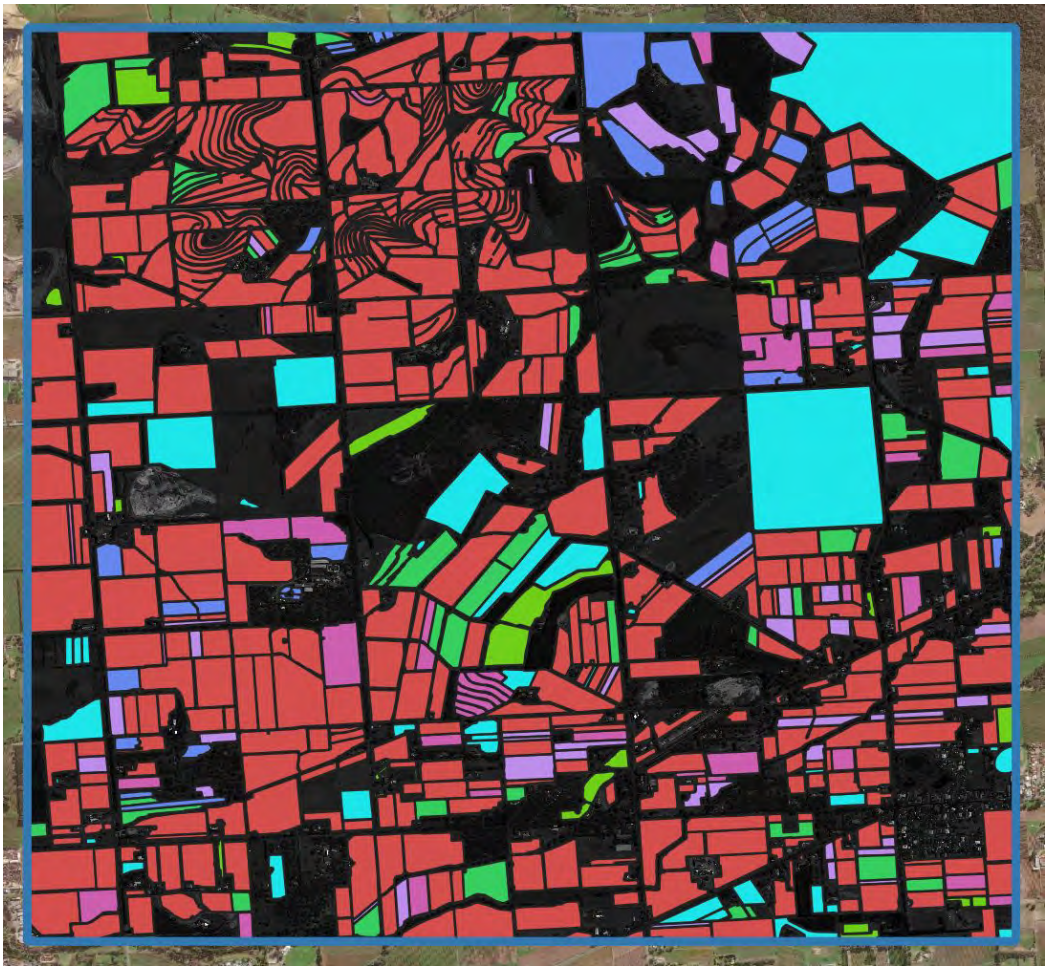


Figure 45. McLaren Vale labels overlaid on the Panchromatic satellite imagery.

Table 25. QA metrics/properties for McLaren Vale

Date of imagery used for ground truth	2020-02-13T00:55:19.000Z
Total area (ha)	558.00
Truth area (ha)	289.20
Prediction area (ha)	294.34
Misses area (ha)	14.07
Mistakes area (ha)	18.23
Union area (ha)	308.28
Intersection area (ha)	275.27

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Recall	95.14
Precision	93.79
Category accuracy	95.90
Area accuracy	98.25
Jaccard	89.50
False positive rate (/m2)	0.030

7. Quality Assurance in Victoria

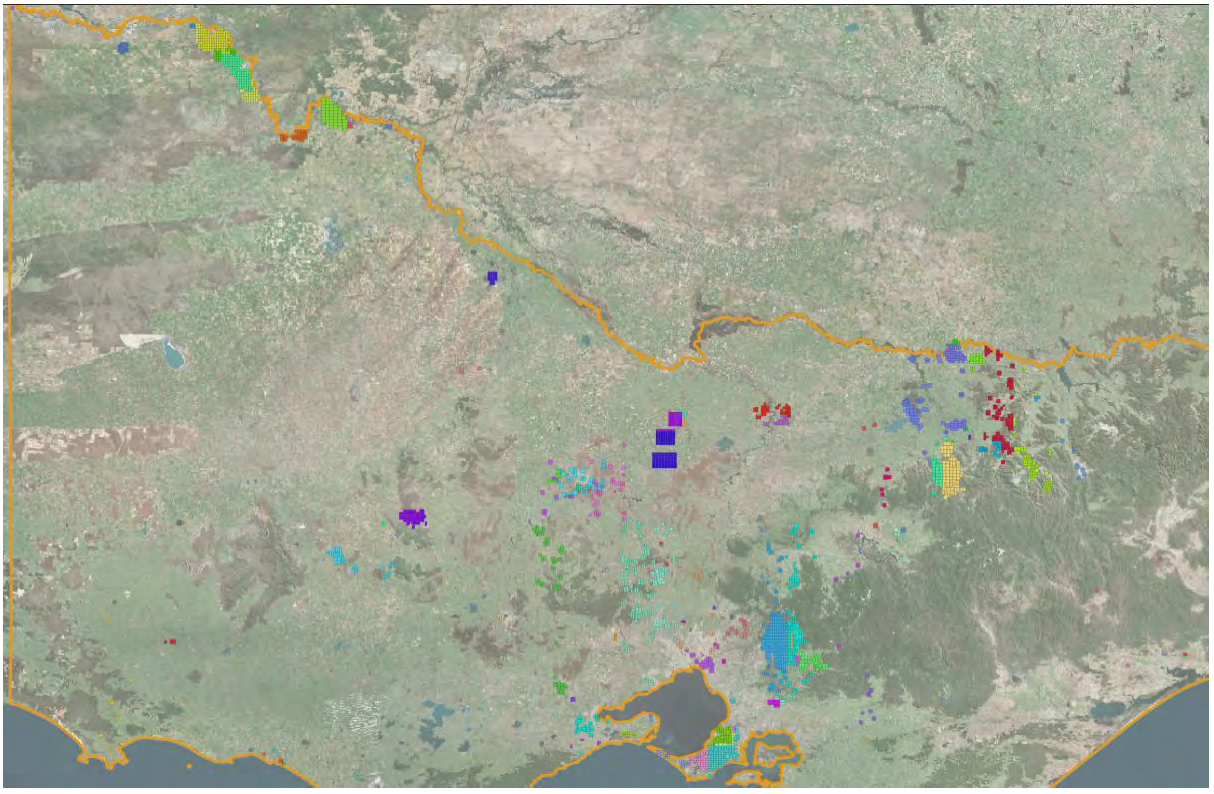


Figure 46: A visualisation of the AOIs in Victoria that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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7.1 Murray Darling VIC #1

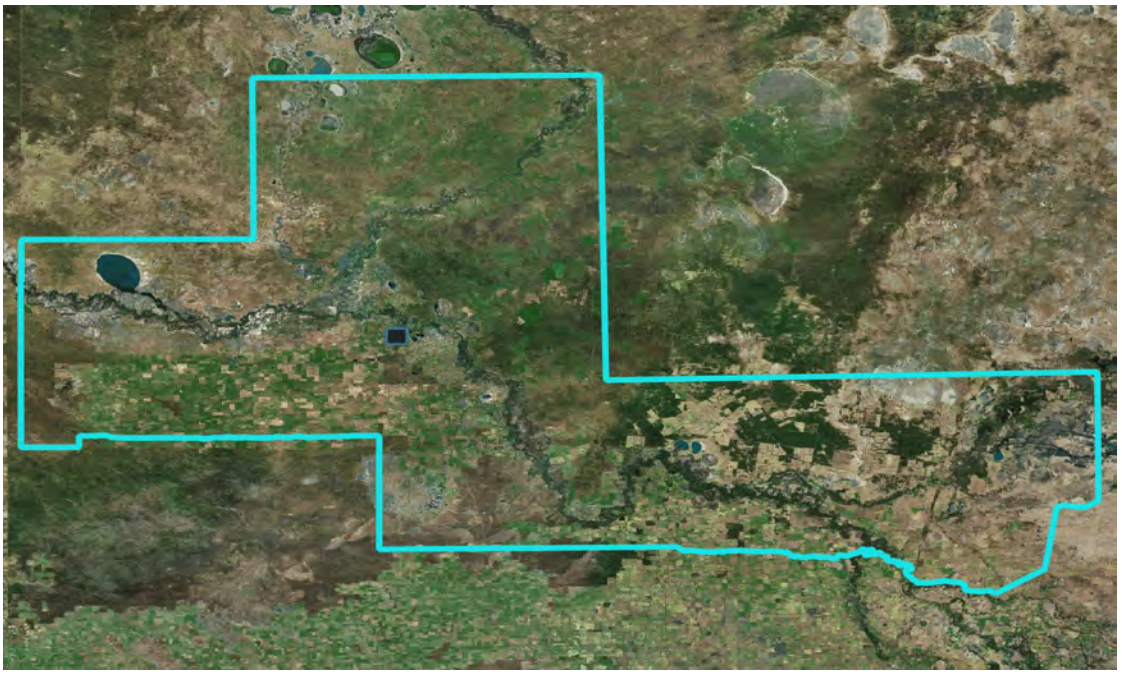


Figure 47. The Murray Darling #1 NSQAR in the context of the Murray Darling GI . The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).



Figure 48. Murray Darling #1 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as determined by a human using the best data available.

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Table 26. QA metrics/properties for Murray Darling #1

Date of imagery used for ground truth	2017-01-28T00:49:05.000Z
Total area (ha)	413.44
Truth area (ha)	81.64
Prediction area (ha)	23.55
Misses area (ha)	59.13
Mistakes area (ha)	1.05
Union area (ha)	82.68
Intersection area (ha)	22.50
Recall	27.56
Precision	95.55
Category accuracy	87.46
Area accuracy	28.85
Jaccard	27.22
False positive rate (/m2)	0.0000

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7.2 King Valley



Figure 49. The King Valley NSQAR in the context of the King Valley GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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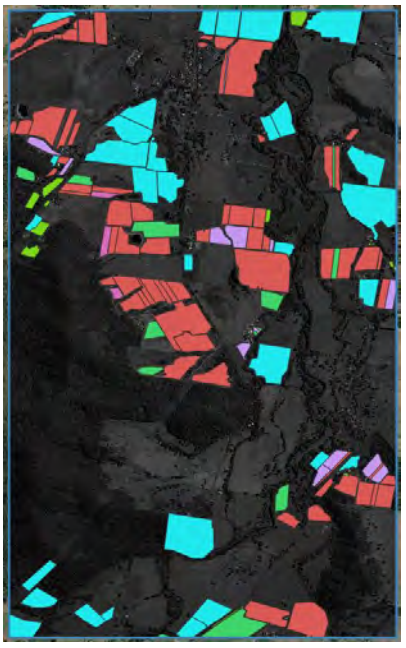


Figure 50. King Valley labels overlaid on the Panchromatic satellite imagery.

Table 27. QA metrics/properties for King Valley

Date of imagery used for ground truth	2020-02-22T00:23:56.000Z
Total area (ha)	630.85
Truth area (ha)	101.53
Prediction area (ha)	99.32
Misses area (ha)	4.61
Mistakes area (ha)	2.40
Union area (ha)	103.93
Intersection area (ha)	96.91
Recall	95.46
Precision	97.58
Category accuracy	99.03
Area accuracy	97.82
Jaccard	93.25
False positive rate (/m2)	0.000

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7.3 Goulburn Valley

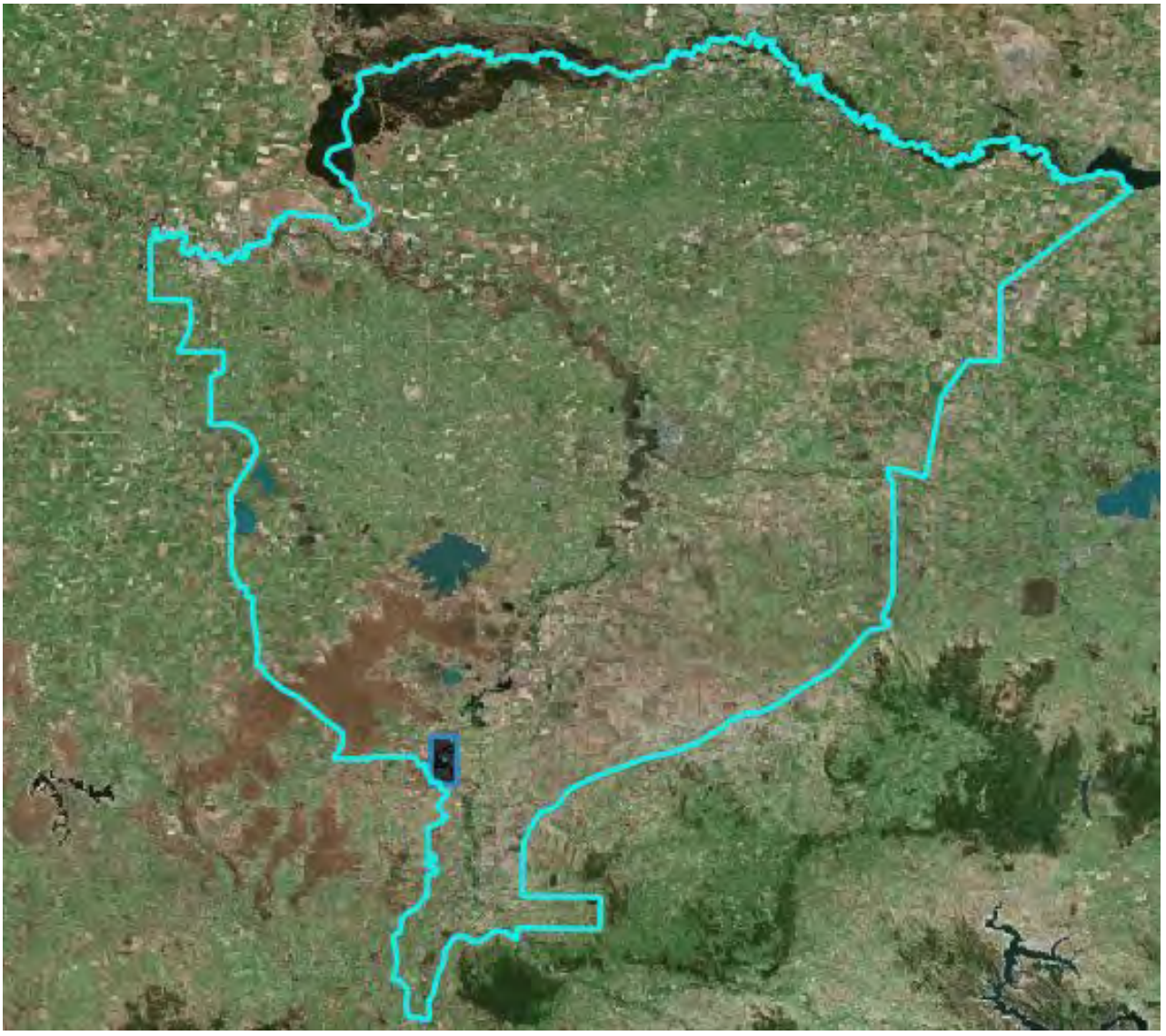


Figure 51. The Goulburn Valley NSQAR in the context of the Goulburn Valley GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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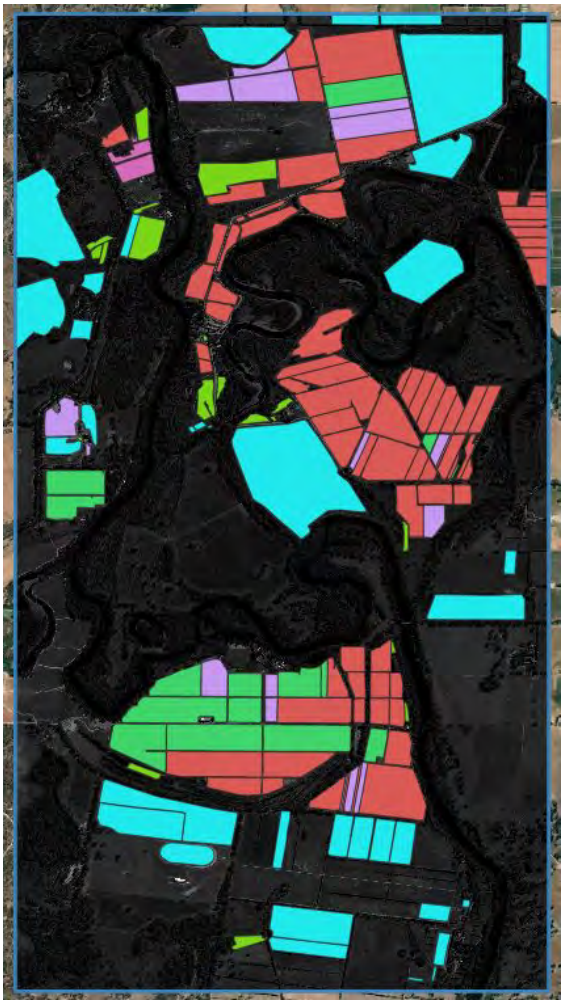


Figure 52. Goulburn Valley labels overlaid on the Panchromatic satellite imagery.

Table 28. QA metrics/properties for Goulburn Valley

Date of imagery used for ground truth	2018-04-02T00:48:09.000Z
Total area (ha)	634.80
Truth area (ha)	37.10
Prediction area (ha)	38.22
Misses area (ha)	4.47
Mistakes area (ha)	5.56
Union area (ha)	42.66
Intersection area (ha)	32.66
Recall	87.96
Precision	85.45
Category accuracy	98.50
Area accuracy	97.05
Jaccard	76.50

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False positive rate (/m2)	0.010

7.4 Yarra Valley



Figure 53. The Yarra Valley NSQAR in the context of the Yarra Valley GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

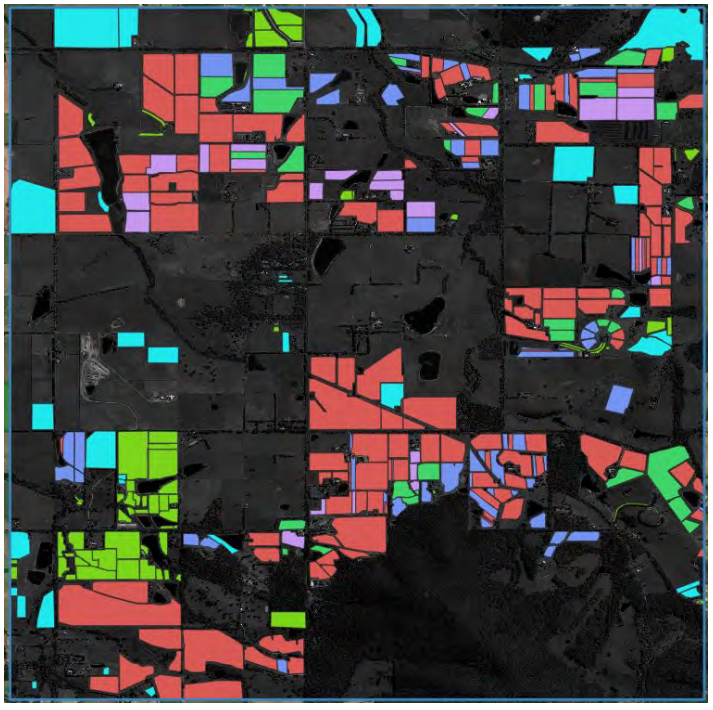


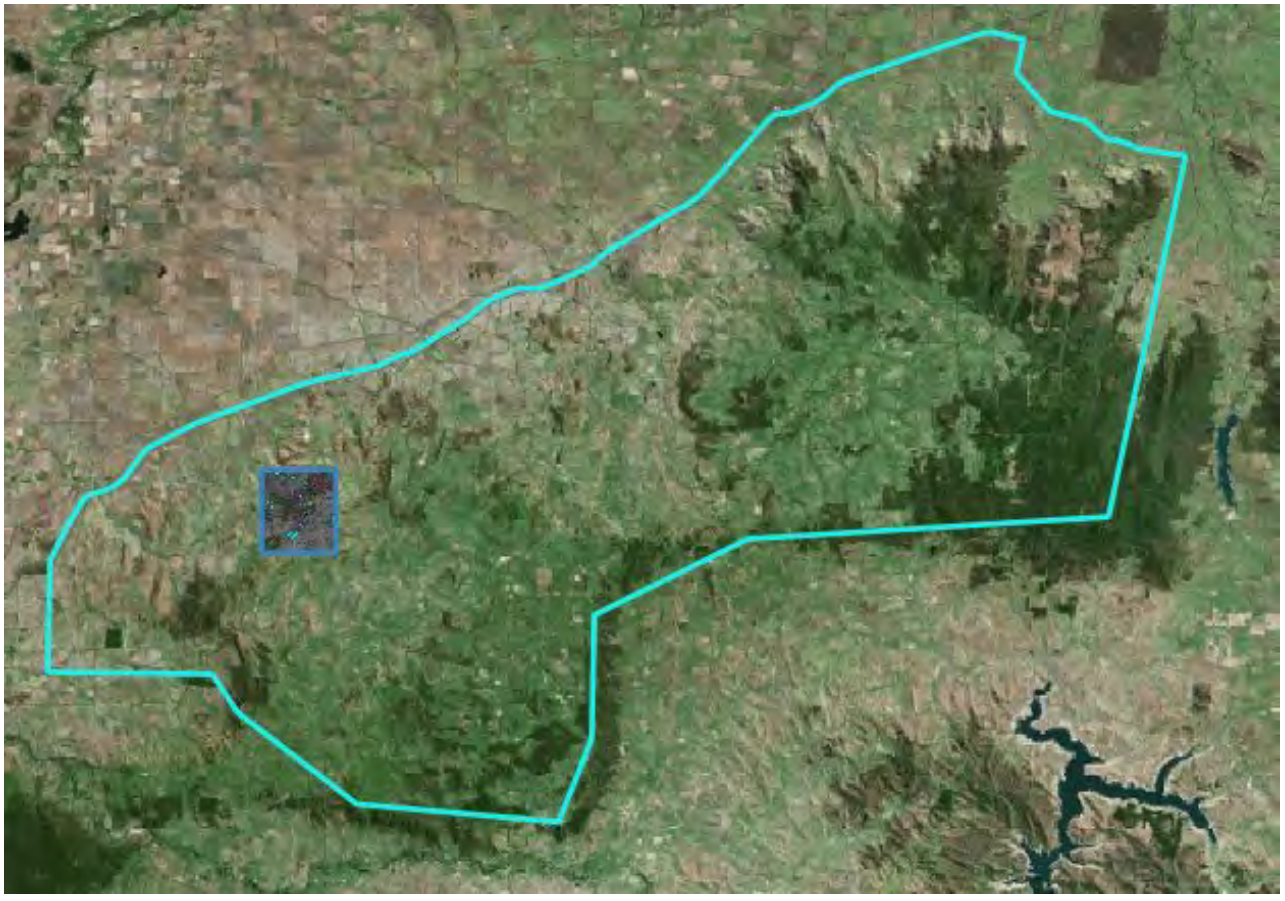
Figure 54. Yarra Valley labels overlaid on the Panchromatic satellite imagery.

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Table 29. QA metrics/properties for Yarra Valley

Date of imagery used for ground truth	2017-03-02T00:31:05.911Z
Total area (ha)	637.39
Truth area (ha)	110.47
Prediction area (ha)	124.95
Misses area (ha)	3.23
Mistakes area (ha)	17.67
Union area (ha)	128.13
Intersection area (ha)	107.29
Recall	97.08
Precision	85.86
Category accuracy	97.27
Area accuracy	88.41
Jaccard	83.70
False positive rate (/m2)	0.030

7.5 Strathbogie Ranges



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Figure 55. The Strathbogie Ranges NSQAR in the context of the Strathbogie Ranges GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

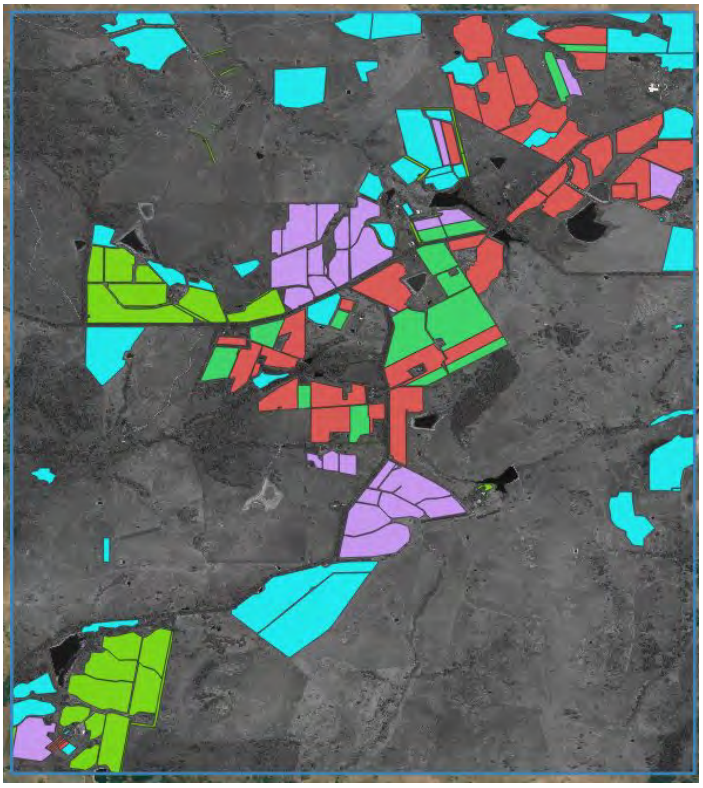


Figure 56. Strathbogie Ranges labels overlaid on the Panchromatic satellite imagery.

Table 30. QA metrics/properties for Strathbogie Ranges

Date of imagery used for ground truth	2020-01-07T00:17:38.000Z
Total area (ha)	706.07
Truth area (ha)	160.97
Prediction area (ha)	167.66
Misses area (ha)	7.31
Mistakes area (ha)	13.74
Union area (ha)	174.71
Intersection area (ha)	153.92
Recall	95.46
Precision	91.80
Category accuracy	97.54
Area accuracy	96.01
Jaccard	87.97
False positive rate (/m2)	0.020

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7.6 Grampians

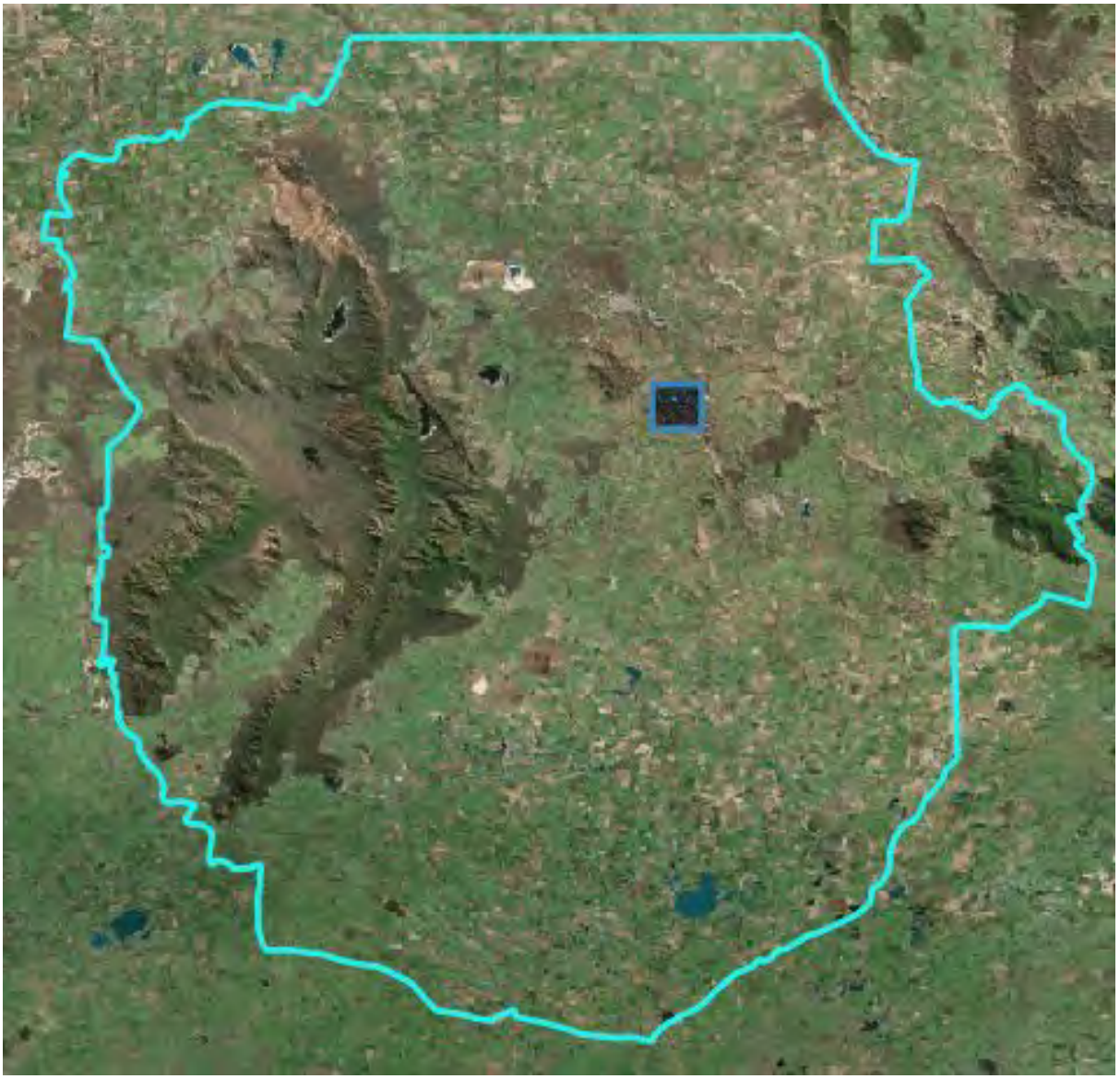


Figure 57. The Grampians NSQAR in the context of the Grampians GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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Figure 58. Grampians labels overlaid on the Panchromatic satellite imagery.

Table 31. QA metrics/properties for Grampians

Date of imagery used for ground truth	2019-12-20T00:46:15.000Z
Total area (ha)	689.68
Truth area (ha)	121.84
Prediction area (ha)	147.83
Misses area (ha)	5.56
Mistakes area (ha)	31.33
Union area (ha)	153.17
Intersection area (ha)	116.51
Recall	95.45
Precision	78.81
Category accuracy	95.62
Area accuracy	82.42
Jaccard	75.95
False positive rate (/m2)	0.0500

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7.7 Gippsland



Figure 59. The Gippsland NSQAR in the context of the Gippsland GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

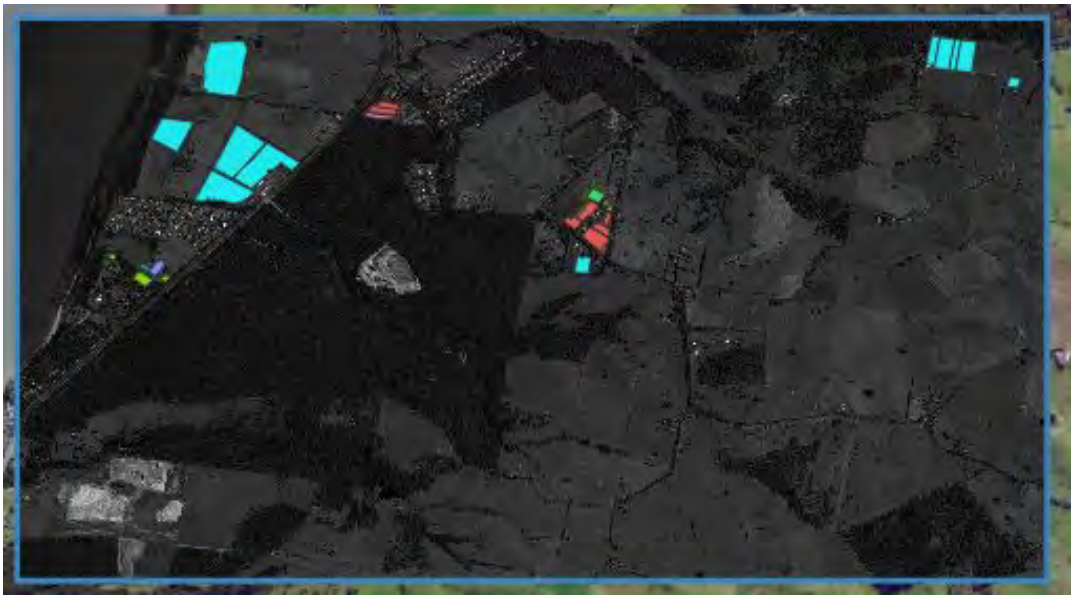


Figure 60. Gippsland labels overlaid on the Panchromatic satellite imagery.

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Table 32. QA metrics/properties for Gippsland

Date of imagery used for ground truth	2019-01-13T00:33:10.000Z
Total area (ha)	2426.53
Truth area (ha)	9.20
Prediction area (ha)	8.71
Misses area (ha)	1.17
Mistakes area (ha)	0.68
Union area (ha)	9.88
Intersection area (ha)	8.03
Recall	87.29
Precision	92.16
Category accuracy	99.92
Area accuracy	94.72
Jaccard	81.25
False positive rate (/m2)	0.00000

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7.8 Mornington Peninsula



Figure 61. The Mornington Peninsula NSQAR in the context of the Mornington Peninsula GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).



Figure 62. Mornington Peninsula labels overlaid on the Panchromatic satellite imagery.

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Table 33. QA metrics/properties for Mornington Peninsula

Date of imagery used for ground truth	2019-12-24T00:34:02.000Z
Total area (ha)	649.78
Truth area (ha)	32.60
Prediction area (ha)	30.81
Misses area (ha)	2.57
Mistakes area (ha)	0.79
Union area (ha)	33.39
Intersection area (ha)	30.03
Recall	92.11
Precision	97.45
Category accuracy	99.51
Area accuracy	94.52
Jaccard	89.94
False positive rate (/m2)	0.0000

7.9 Murray Darling VIC #2

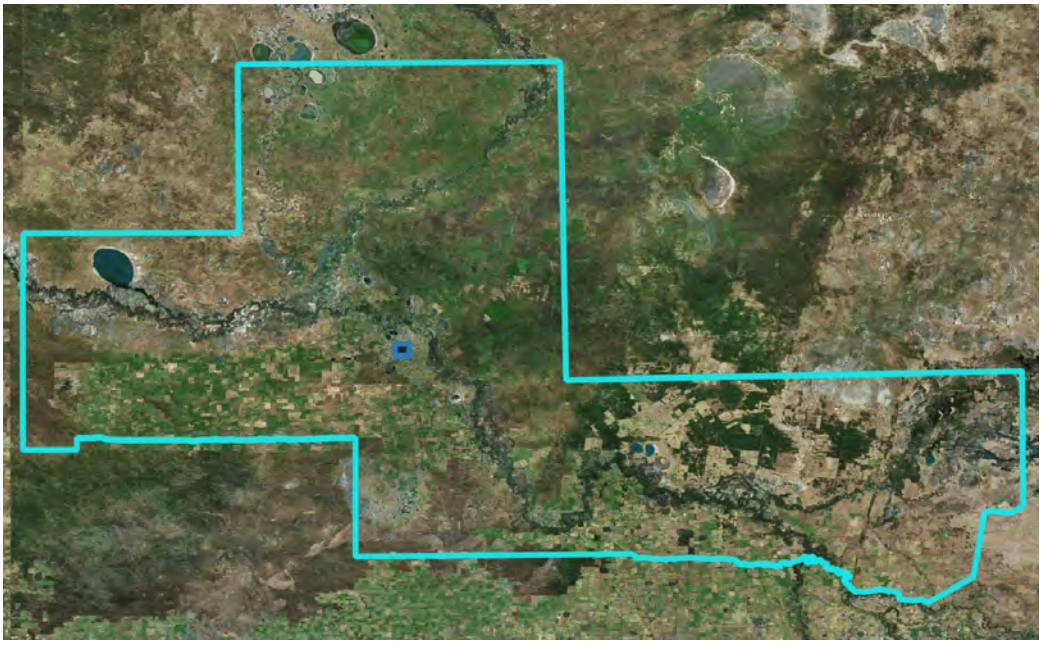


Figure 63. The Murray Darling #2 NSQAR in the context of the Murray Darling GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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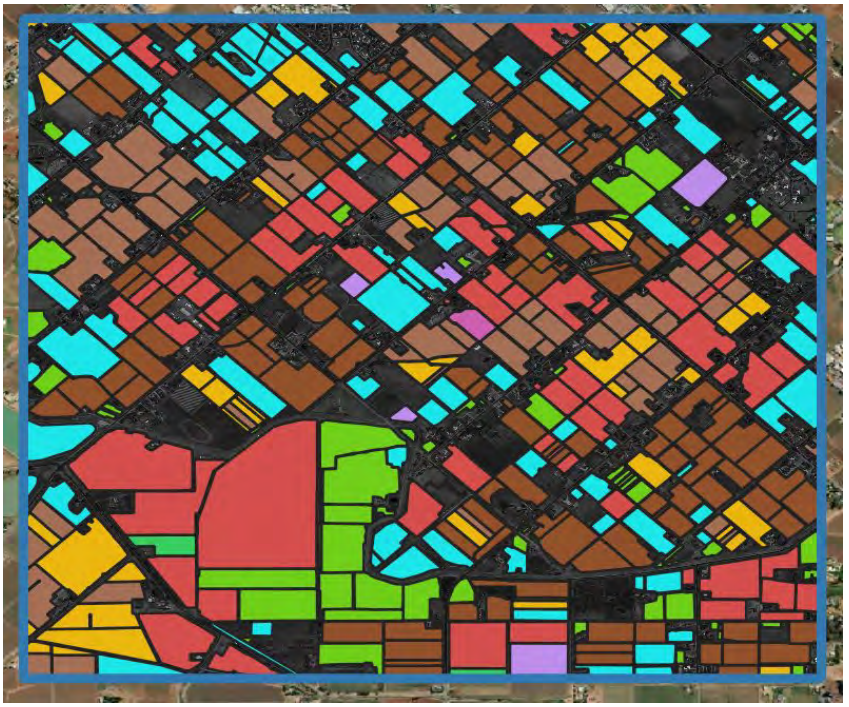


Figure 64. Murray Darling #2 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as determined by a human using the best data available.

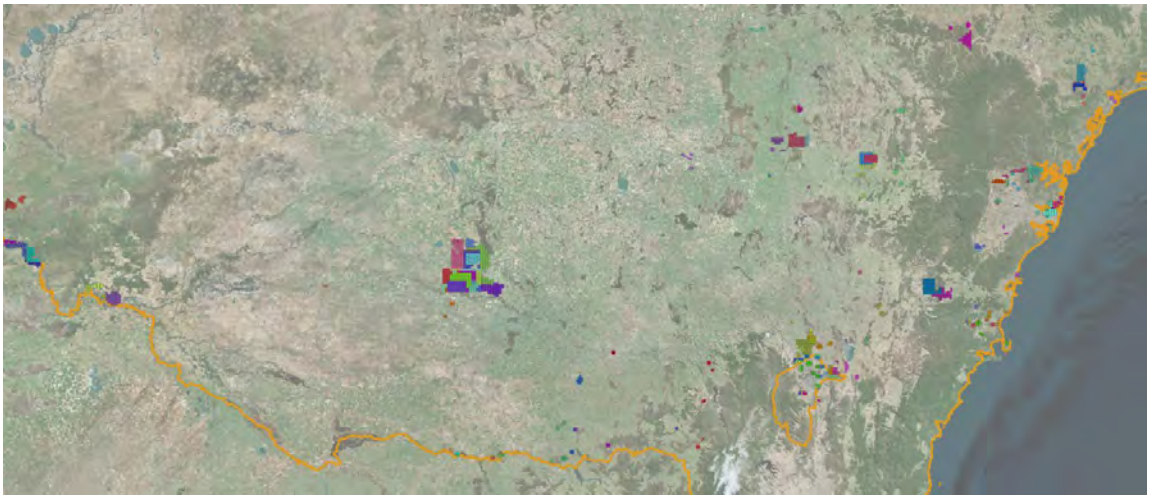
Table 34. QA metrics/properties for Murray Darling #2

Date of imagery used for ground truth	2020-03-09T00:33:10.000Z
Total area (ha)	413.21
Truth area (ha)	79.32
Prediction area (ha)	35.36
Misses area (ha)	45.61
Mistakes area (ha)	1.65
Union area (ha)	80.96
Intersection area (ha)	33.71
Recall	42.50
Precision	95.34
Category accuracy	90.22
Area accuracy	44.58
Jaccard	41.64
False positive rate (/m2)	0.0000

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ABN 22 636 813 360
1102/147 Pirie St, Adelaide SA 5000
info@gaia.ag

8. Quality Assurance in New South Wales





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ABN 22 636 813 360
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Figure 65 A visualisation of the AOIs in New South Wales that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI. Two screenshots are taken for AOIs in New SOuth Wales for a better visualisation.

8.1 Riverina

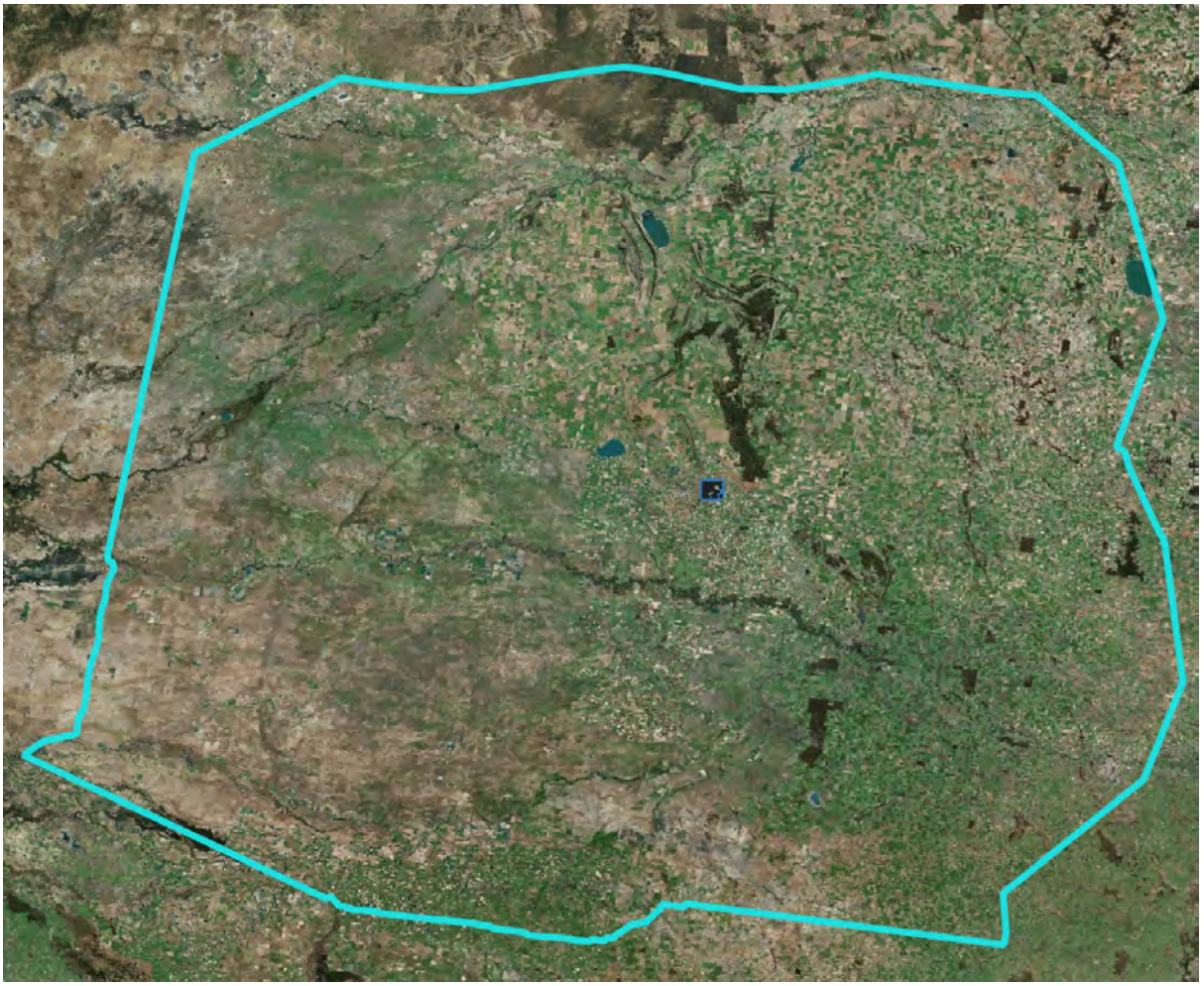


Figure 66. The Riverina NSQAR in the context of the Riverina GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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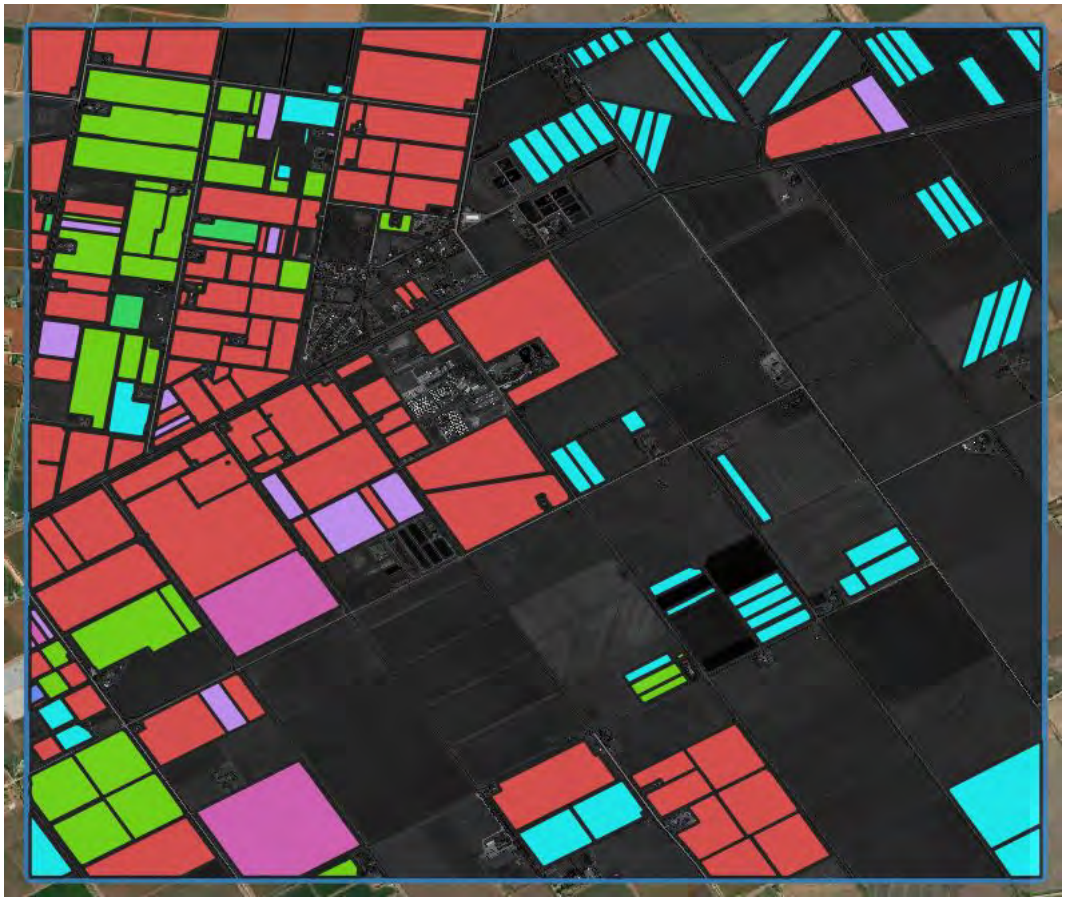


Figure 67. Riverina labels overlaid on the Panchromatic satellite imagery.

Table 35. QA metrics/properties for Riverina

Date of imagery used for ground truth	2018-02-07T00:31:20.000Z
Total area (ha)	680.39
Truth area (ha)	263.04
Prediction area (ha)	263.84
Misses area (ha)	9.83
Mistakes area (ha)	10.62
Union area (ha)	273.67
Intersection area (ha)	253.22
Recall	96.26
Precision	95.98
Category accuracy	97.59
Area accuracy	99.70
Jaccard	92.53
False positive rate (/m2)	0.020

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8.2 Canberra District

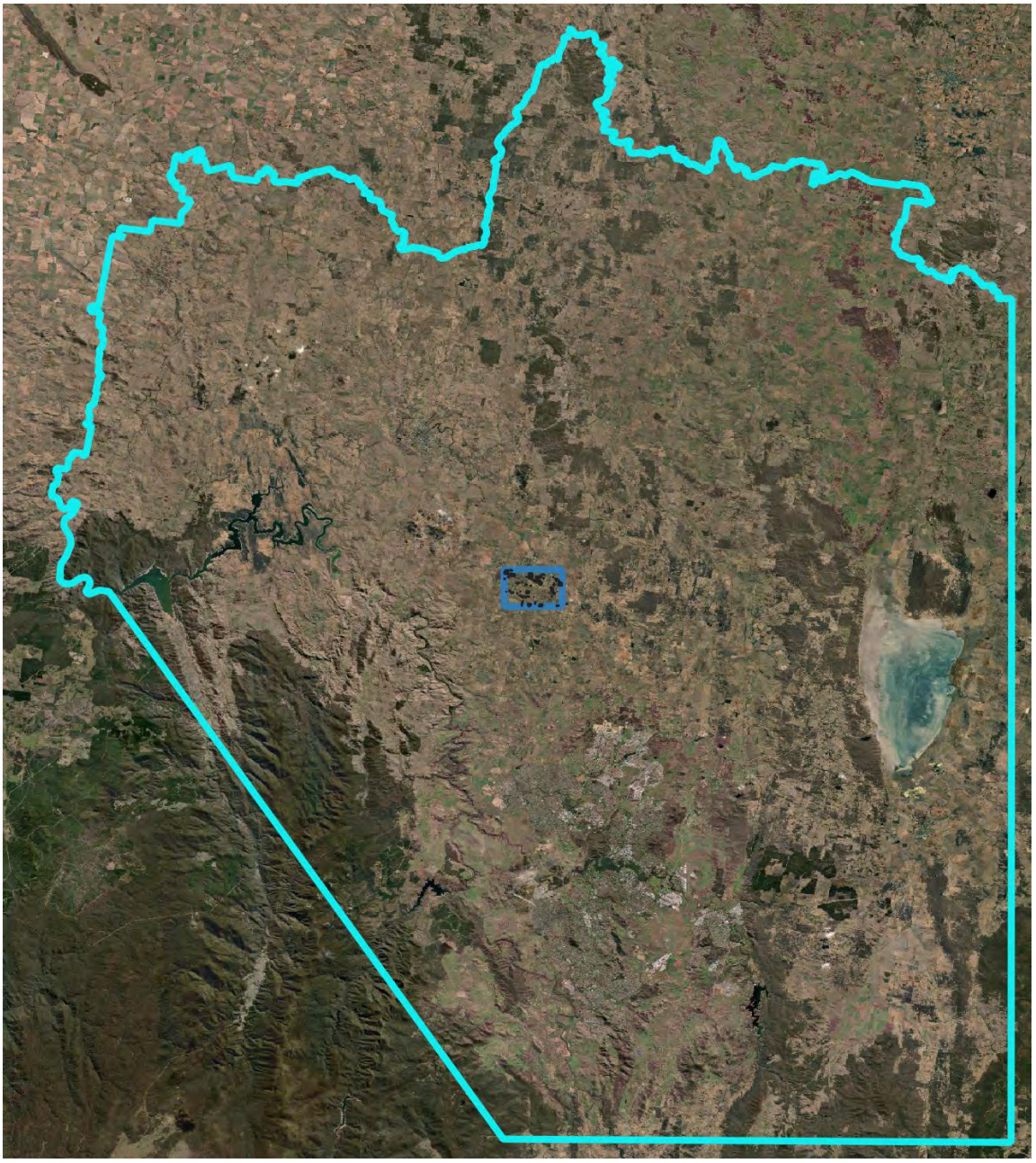


Figure 68. The Canberra District NSQAR in the context of the Canberra District GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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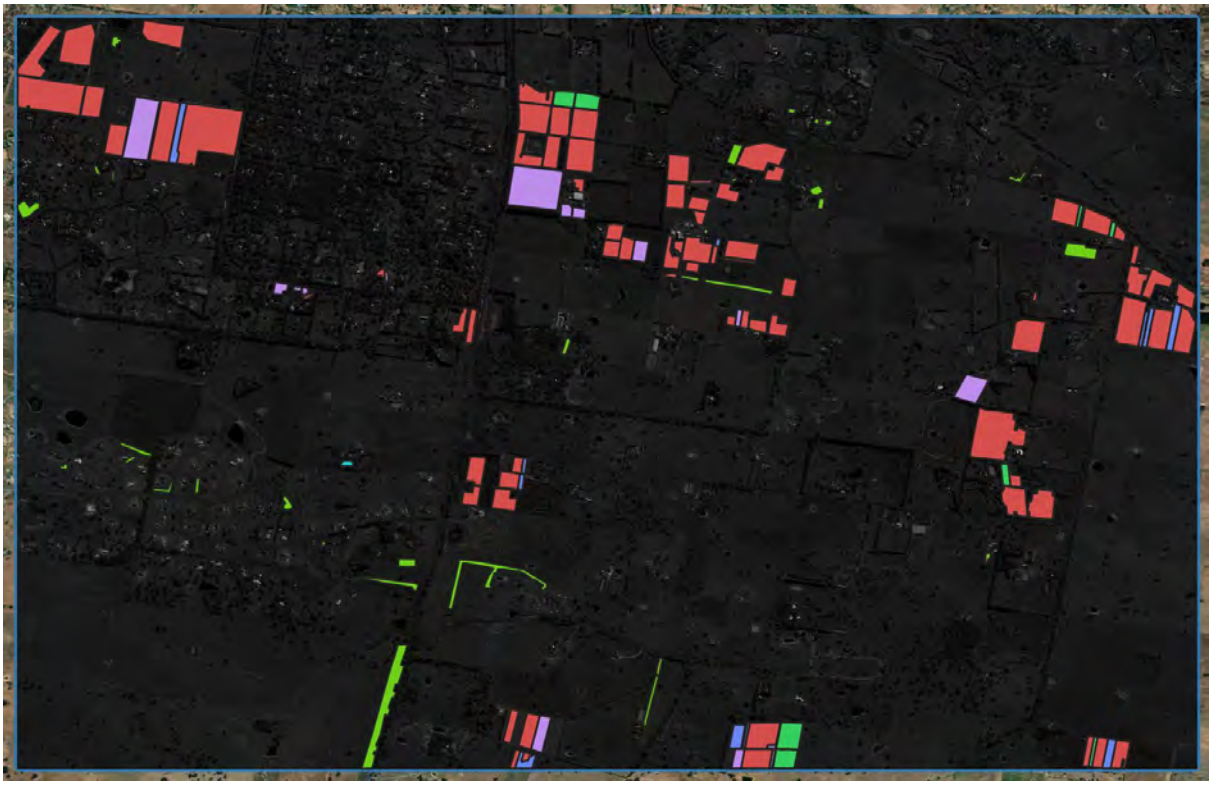


Figure 69. Canberra District labels overlaid on the Panchromatic satellite imagery.

Table 36. QA metrics/properties for Canberra District

Date of imagery used for ground truth	2016-03-31T23:53:59.781Z
Total area (ha)	605.30
Truth area (ha)	45.15
Prediction area (ha)	42.38
Misses area (ha)	4.06
Mistakes area (ha)	1.27
Union area (ha)	46.41
Intersection area (ha)	41.11
Recall	91.02
Precision	97.01
Category accuracy	99.17
Area accuracy	93.88
Jaccard	88.54
False positive rate (/m2)	0.0000

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8.3 Hunter

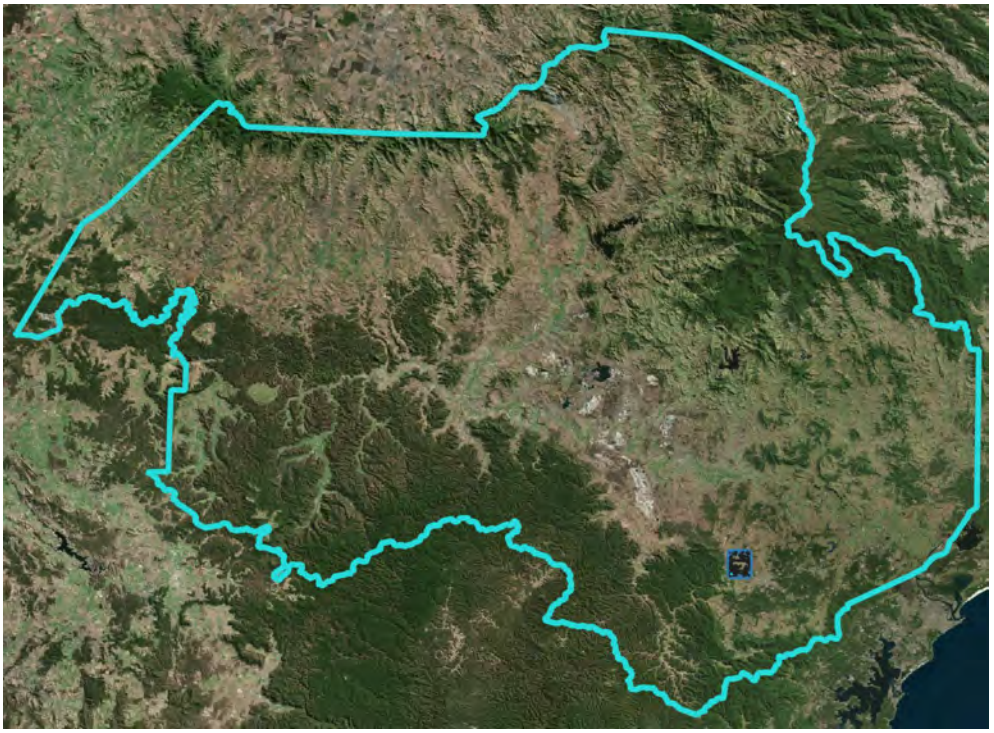


Figure 70. The Hunter NSQAR in the context of the Hunter (Region) GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

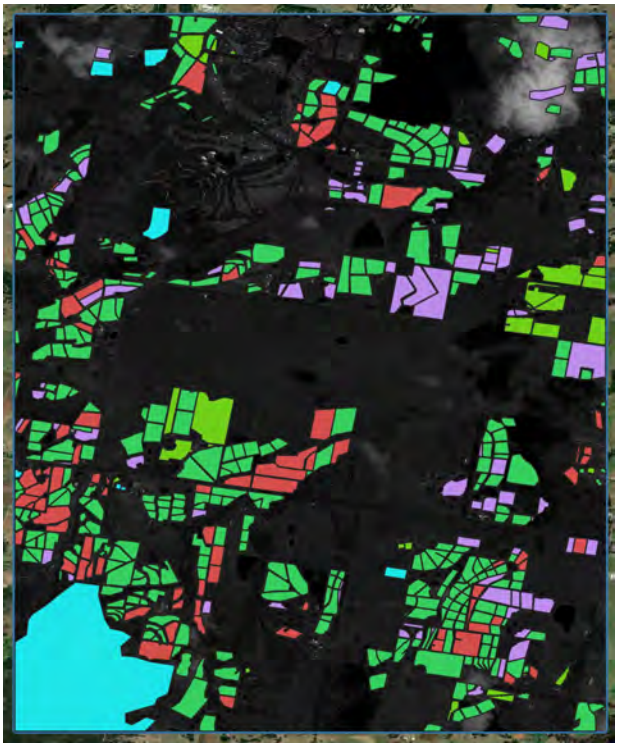


Figure 71. Hunter labels overlaid on the Panchromatic satellite imagery.

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Table 37. QA metrics/properties for Hunter

Date of imagery used for ground truth	2018-02-10T00:20:19.000Z
Total area (ha)	645.76
Truth area (ha)	64.33
Prediction area (ha)	63.09
Misses area (ha)	7.31
Mistakes area (ha)	6.04
Union area (ha)	70.40
Intersection area (ha)	57.03
Recall	88.64
Precision	90.42
Category accuracy	98.12
Area accuracy	98.07
Jaccard	81.03
False positive rate (/m2)	0.0100

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8.4 Orange

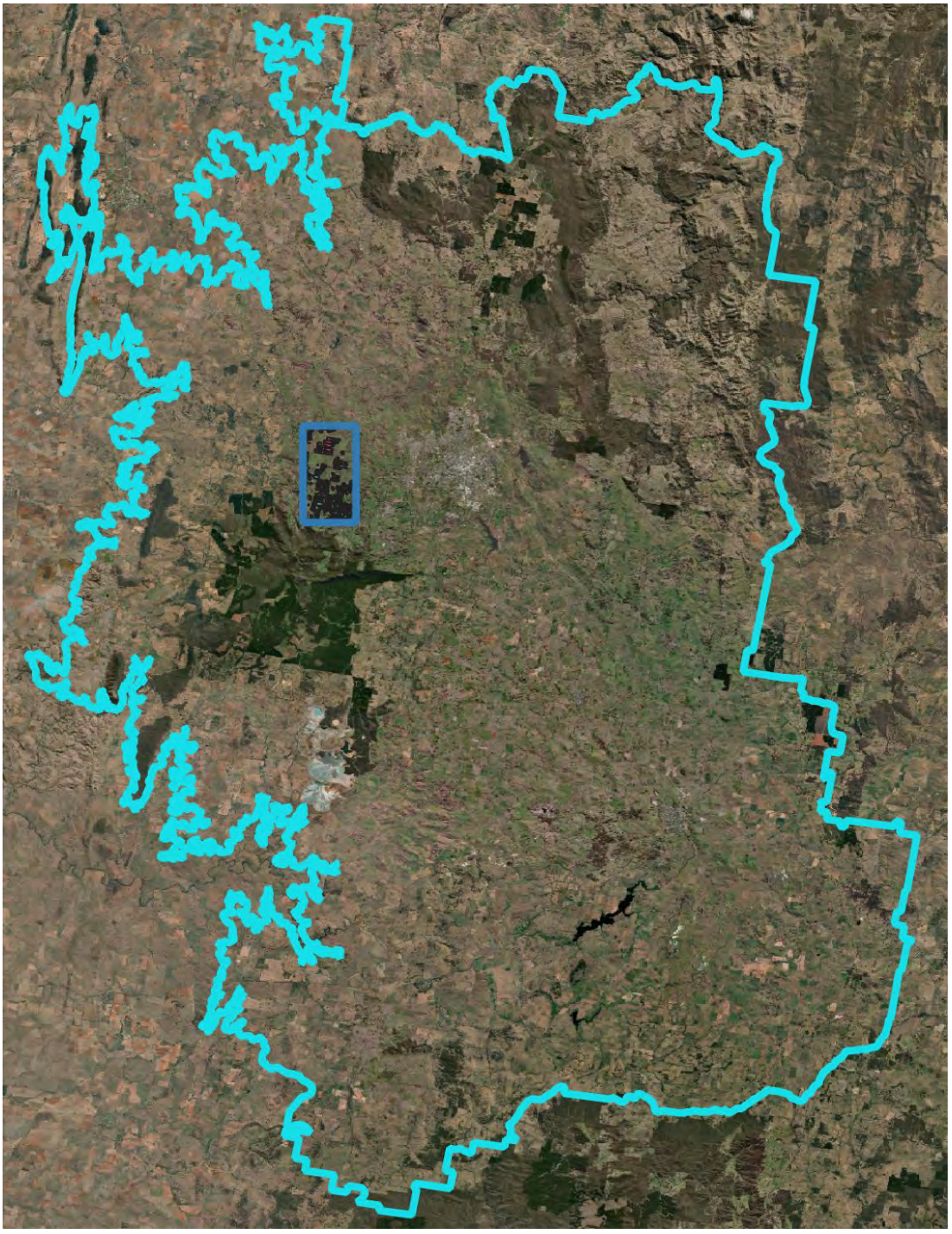


Figure 72. The Orange NSQAR in the context of the Orange GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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Figure 73. Orange labels overlaid on the Panchromatic satellite imagery.

Table 38. QA metrics/properties for Orange

Date of imagery used for ground truth	2018-03-09T00:27:50.000Z
Total area (ha)	666.99
Truth area (ha)	90.52
Prediction area (ha)	90.22
Misses area (ha)	4.16
Mistakes area (ha)	3.86
Union area (ha)	94.39
Intersection area (ha)	86.36
Recall	95.40
Precision	95.72
Category accuracy	98.87
Area accuracy	99.67
Jaccard	91.50
False positive rate (/m2)	0.0100

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8.5 Shoalhaven Coast

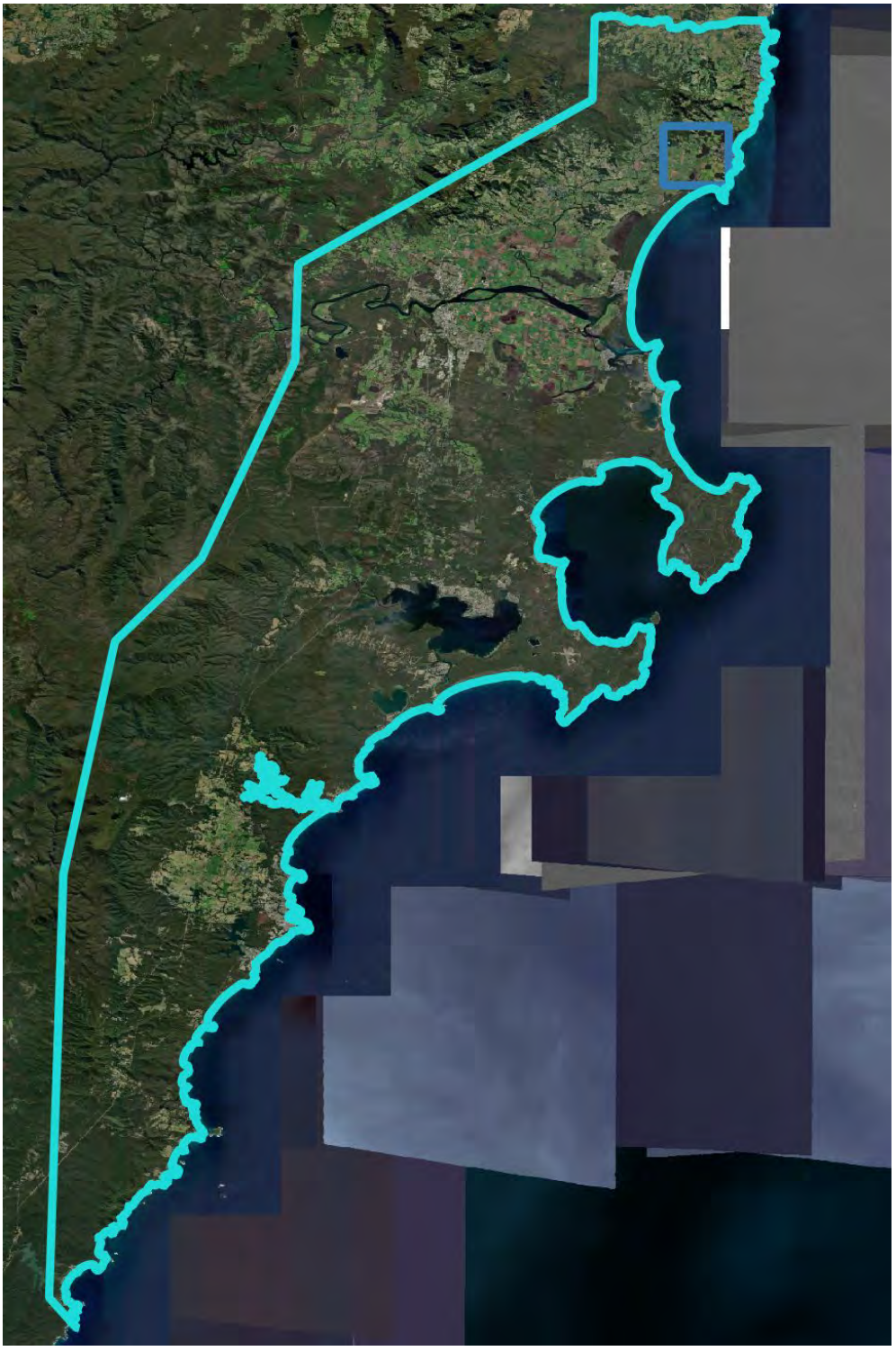


Figure 74. The Shoalhaven Coast NSQAR in the context of the Shoalhaven Coast GI. The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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Figure 75. Shoalhaven Coast labels overlaid on the Panchromatic satellite imagery.

Table 39. QA metrics/properties for Shoalhaven Coast

Date of imagery used for ground truth	2018-03-15T00:09:21.000Z
Total area (ha)	2527.55
Truth area (ha)	14.67
Prediction area (ha)	13.59
Misses area (ha)	2.21
Mistakes area (ha)	1.11
Union area (ha)	15.78
Intersection area (ha)	12.48
Recall	84.98
Precision	91.85
Category accuracy	99.87
Area accuracy	92.65
Jaccard	79.02
False positive rate (/m2)	0.00000

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8.6 Swan Hill (NSW)

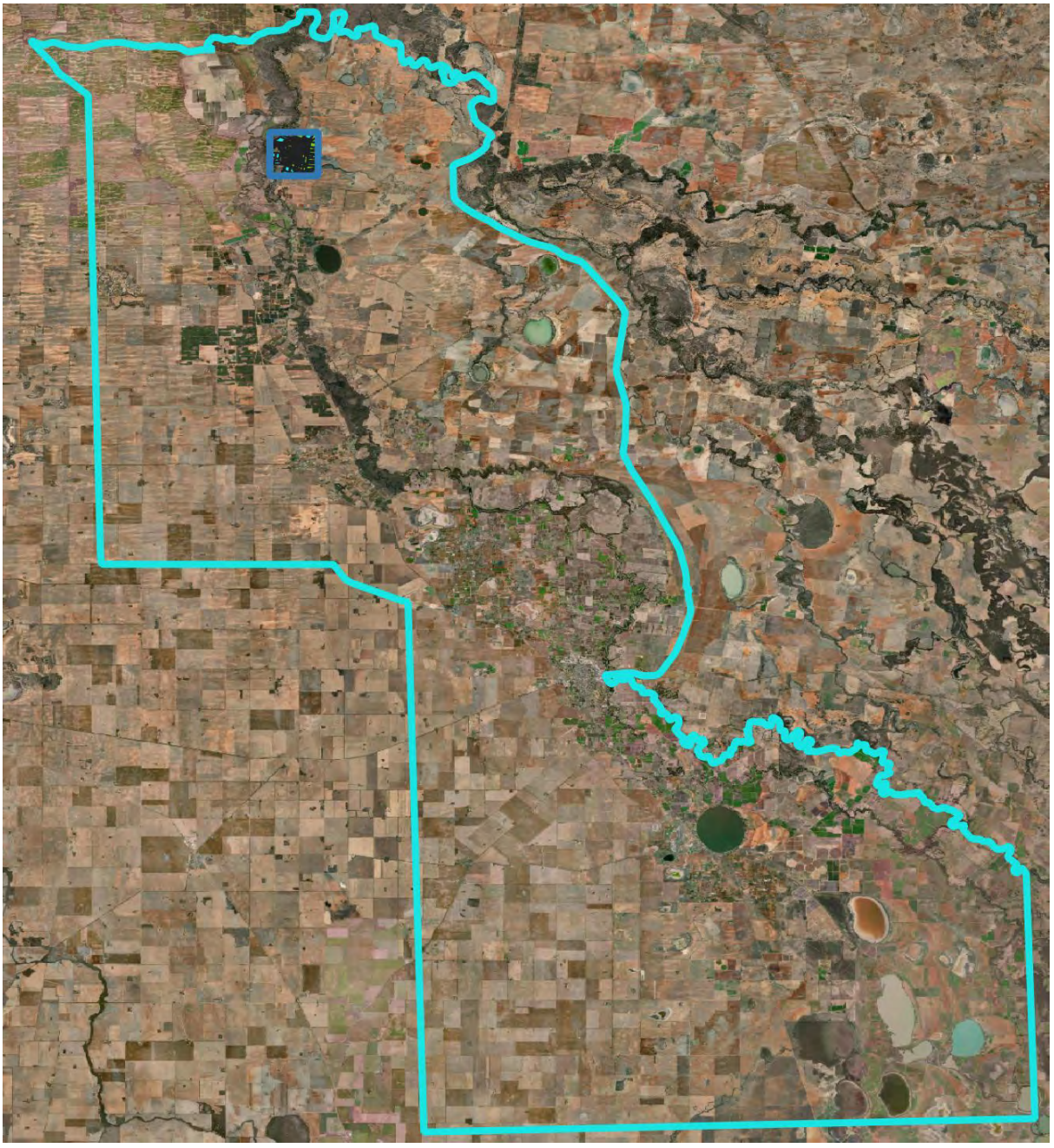


Figure 76. The Swan Hill (NSW) NSQAR in the context of the Swan Hill GI (NSW). The entire area within the dark blue square has been labelled (labels shown as multi-coloured shapes).

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Figure 77. Swan Hill (NSW) labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the SunRISE Mapping dataset.

Table 40. QA metrics/properties for Swan Hill (NSW)

Date of imagery used for ground truth	2018-12-19T00:51:08.000Z
Total area (ha)	281.40
Truth area (ha)	28.10
Prediction area (ha)	26.39
Misses area (ha)	1.86
Mistakes area (ha)	0.15
Union area (ha)	28.25
Intersection area (ha)	26.23
Recall	93.37
Precision	99.42
Category accuracy	99.35
Area accuracy	93.92
Jaccard	92.87
False positive rate (/m2)	0.00000

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9. Quality Assurance in Queensland



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Figure 78: A visualisation of the AOIs in Queensland that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.Two screenshots are taken for AOIs in Queensland for a better visualisation.

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9.1 South Burnett

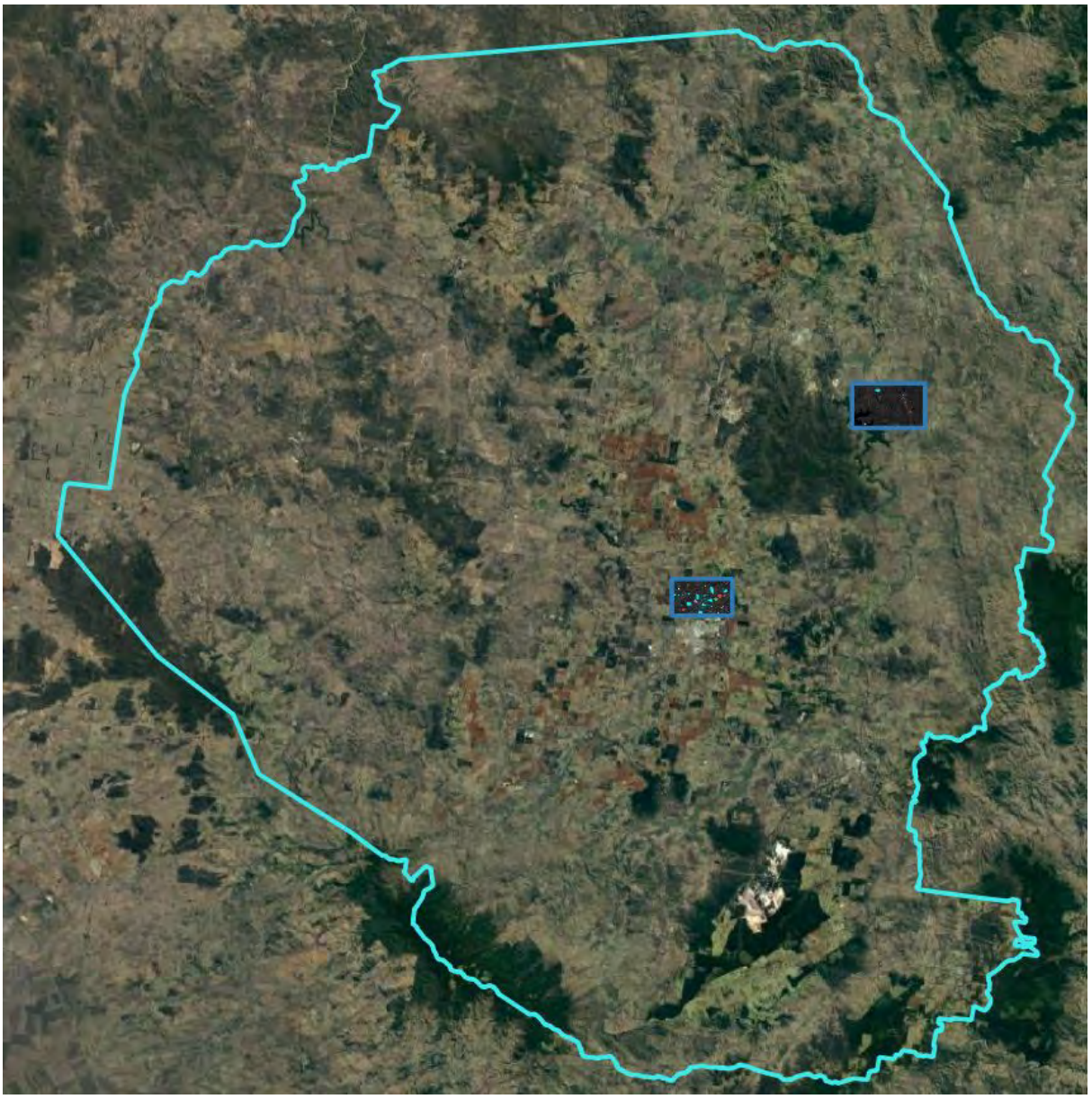


Figure 79. The South Burnett NSQAR (consist of South Burnett #1 and #2) in the context of the South Burnett GI. The entire area within the dark blue rectangles has been labelled (labels shown as multi-coloured shapes).

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Figure 80. South Burnett labels overlaid on the Panchromatic satellite imagery for South Burnett #1(top) and #2 (bottom).

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Table 41. QA metrics/properties for South Burnett[8].

Date of imagery used for ground truth	2016-11-17T00:05:17.787Z
Total area (ha)	926.84
Truth area (ha)	67.15
Prediction area (ha)	59.41
Misses area (ha)	15.23
Mistakes area (ha)	7.49
Union area (ha)	74.64
Intersection area (ha)	51.92
Recall	77.32
Precision	87.40
Category accuracy	97.72
Area accuracy	88.47
Jaccard	69.56
False positive rate (/m2)	0.0100

[8] South Burnett 1 was excluded from the metrics presented, due to human labelling errors.

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9.2 Granite Belt

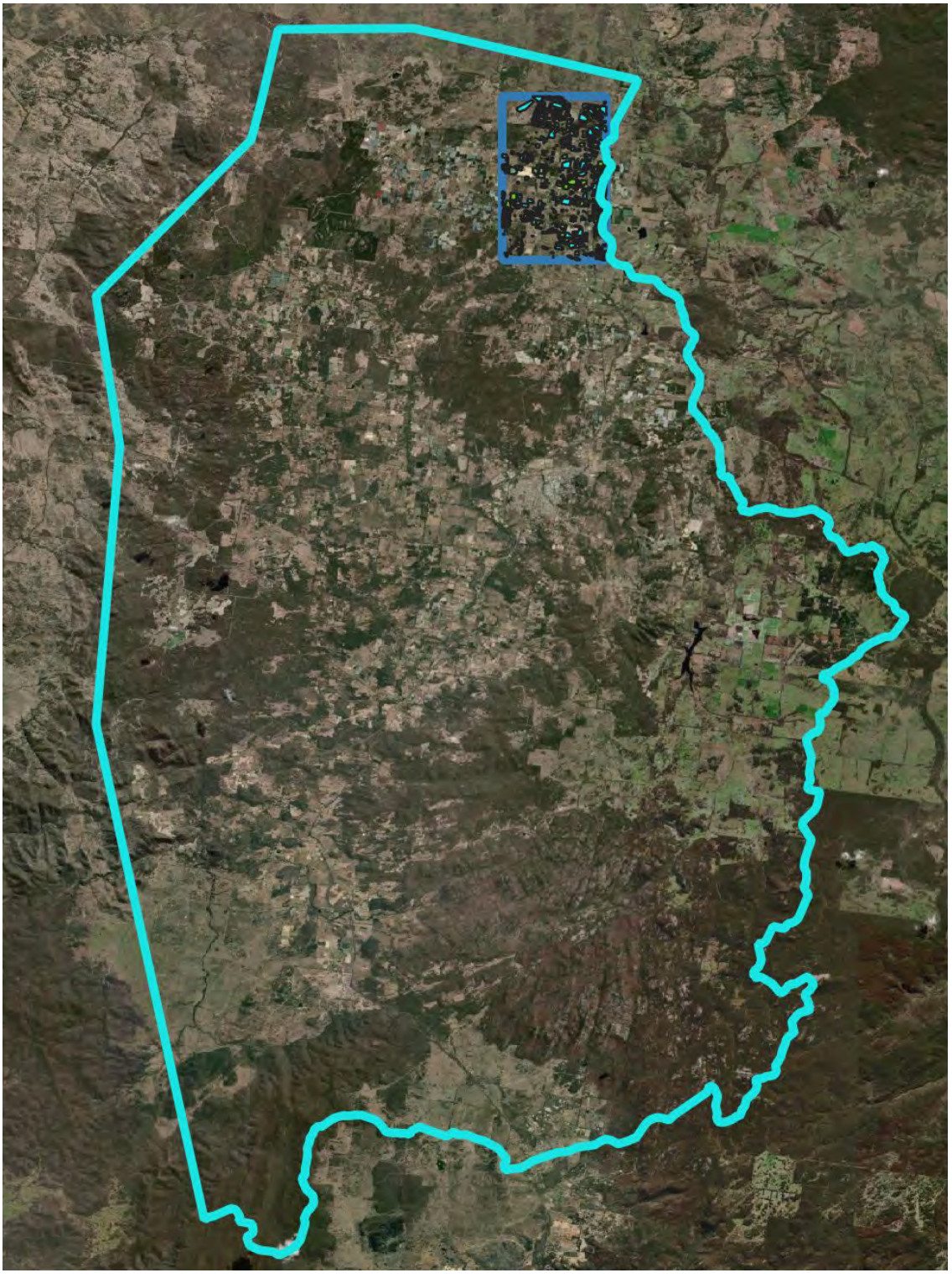


Figure 81. The Granite Belt NSQAR in the context of the Granite Belt GI. The entire area within the dark blue rectangle has been labelled (labels shown as multi-coloured shapes).

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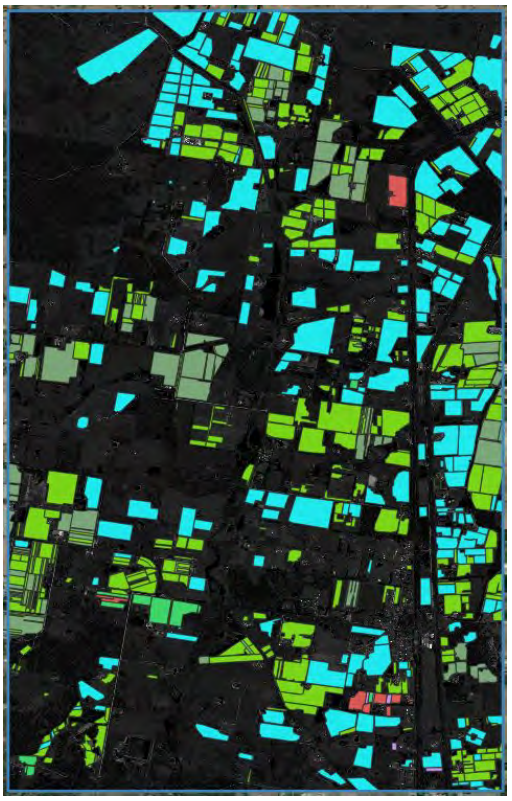


Figure 82. Granite Belt labels overlaid on the Panchromatic satellite imagery.

Table 42. QA metrics/properties for Granite Belt

Date of imagery used for ground truth	2016-11-17T00:05:17.787Z
Total area (ha)	741.72
Truth area (ha)	4.62
Prediction area (ha)	4.61
Misses area (ha)	0.45
Mistakes area (ha)	0.44
Union area (ha)	5.06
Intersection area (ha)	4.17
Recall	90.21
Precision	90.48
Category accuracy	99.88
Area accuracy	99.70
Jaccard	82.38
False positive rate (/m2)	0.00000

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10. References

[1] Anthony Milton, Sebastien Wong & Sarah Hibbard (2019) "National Vineyard Scan 2018 Summary Report" v1.0, 7th June 2019, CT-TR-2019-00029. Download from Wine Australia

[2] Anthony Milton, Joseph Sclauzero, Lucas Sargent, Adam Gatt & Sebastien Wong (2019) "National Scan of Vineyards, Milestone Report Y1.8: National Scan 2018" v1.1, 23rd May 2019, CT-TR-2019-00027. Download from Wine Australia

[3] Anthony Milton, Sebastien Wong, Adam Gatt (2019) "National Vineyard Scan 2020 Summary Report" v1.1, 18th December 2019. CT-TR-2019-00037. Download from Wine Australia

[4] Anthony Miltion, Adam Gatt, Sebastien Wong, Travis Muirhead (2020) "National Scan of Vineyards of Australia 2019 - Milestone Report Y2.3" v1.0, 28 January 2020, CT-TR-2019-00041.

[5] Anthony Milton, Joseph Sclauzero, Mark McDonnell, Hayden Hohns, Sebastien Wong (2018) "GAIA - National Scan Quality Assurance", 23 Spetember 2018, CT-TR-2018-00018.

[6] Marnie Brice, Meera Deshpande, Saisai Ma, Frank Ouyang, Sebastien Wong (2021) "National Scan of Vineyards of Australia 2020 - Milestone Report Annex", 29 Janunary 2021, GAIA-2020-00003-A.

Acknowledgements

The authors would like to thank the following individuals for their contributions to the National Vintage Scan 2020. GAIA CEO Andy Clarke for his leadership and guidance. Former GAIA team members Travis Muirhead and Anthony Milton for their support. Sandy Hathaway and Wine Australia for their sponsorship, support and insight into the Wine Industry. Brian Simpson from the Riverina Winegrape Growers for contributions to improving the maps. Hans Loder for assisting with the curation of the Coonawarra region. Melissa Burton from Agriculture Victoria for providing feedback on the Mornington Peninsula.

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Appendix 1 - Document Revision History

Version 1.0 - 18 December 2020

- **Initial document version.**

Version 1.1 - 19 February 2021

- **Reviewed NSQARs and provided more information in an annex report.**
- **Removal of table grapes from Murray Darling maps**

Version 1.2 - 1 March 2021

- **Minor corrections and errata**