Indufor ...forest intelligence

Deforestation Mapping 2015 & 2016
Final Report

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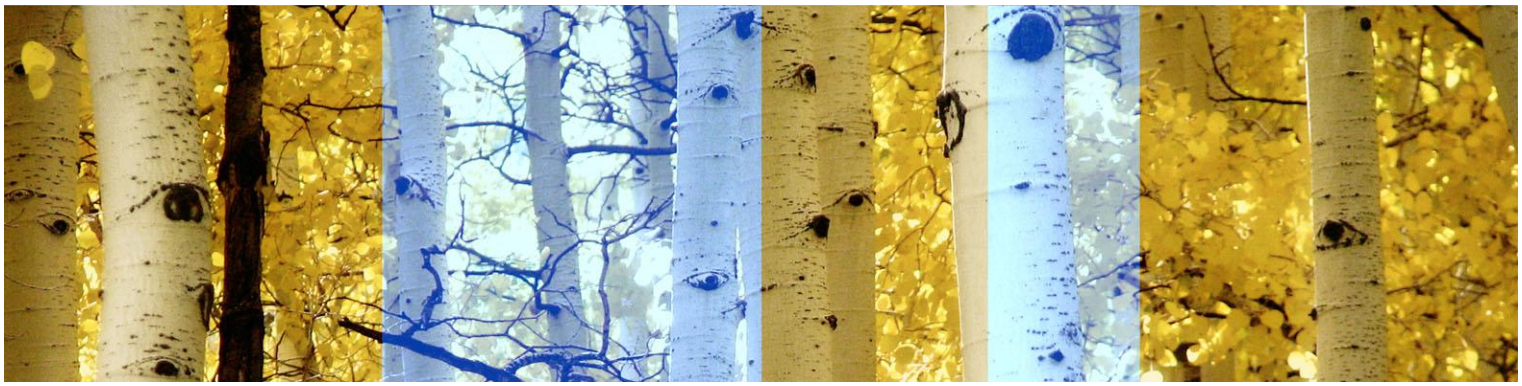

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Submitted by Indufor Asia Pacific for the Ministry for the Environment

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
CP1	Commitment Period 1 (2008 – 2012)
CP2	Commitment Period 2 (2013 – 2020)
(A)	Awaiting Land Use Decision
(D)	Deforestation
HDA	**H**arvesting, **D**eforestation, Land **A**waiting Land Use Decision
(H)	Harvesting
IPCC	Intergovernmental Panel on Climate Change
GPG	Good Practice Guidance
GPS	Global Positioning System
LCR	Landcare Research
LUCAS	Land Use and Carbon Analysis System
LUCID	Land Use Class Identifier
LULUCF	Land Use Land Use Change and Forestry
LUM	Land Use Map
MfE	Ministry for the Environment
MPI	Ministry of Primary Industries (formerly MAF)
NAC	Non-anthropogenic Change
NC	No Change
QAQC	Quality Assurance, Quality Control
UNFCCC	United Nations Framework Convention on Climate Change

SUMMARY

The LUCAS (Land Use and Carbon Analysis System) project was established to enable New Zealand to meet its obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The carbon accounting and reporting system is designed to meet the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance (GPG).

Indufor Asia Pacific (IAP) was engaged by the Ministry for Environment (MfE) to review and estimate the total area of deforested, awaiting, and harvested land occurring across New Zealand.

The purpose of this report is to document forest change for 2015 and 2016, across three forest classes: Natural forest, Pre-1990 planted forest and Post-1989 forest. The analysis includes all forest loss over this time period except areas which are confirmed as deforestation by the Ministry for Primary Industries, via submission of Emissions Trading Scheme Deforestation Emissions Returns.

Deforestation is an important land-use change in terms of greenhouse gas emissions. Nationally, every year a significant area of forest is harvested, but only a small proportion area is deforested and converted to an alternative non-forest land use.

Using a national coverage of satellite imagery, MfE identified 10 218 targets where forest was lost during 2015 and 2016. A small number of targets from 2013 and 2014 were also re-assessed. Each area is assessed to determine if the forest loss represents a harvesting activity (has since been replanted, or shows evidence of an ongoing commercial, or forest conservation land-use), or alternatively been deforested. Areas of forest loss may also be classified as non-anthropogenic change (e.g. erosion or wind damage); no change (i.e. still forest); never forest (false identification of forested areas); or “awaiting determination” (where future land use is uncertain).

Indufor’s approach was to classify each target using either existing or newly captured vertical aerial photography.

In total, 129 578 hectares were reviewed and attributed with a destock classification. Of this total, 10 968 hectares was classified as deforestation. The regions with the greatest contribution to deforestation are Waikato (32%), Canterbury (12%) and Manawatu-Wanganui (11%). The main driver for deforestation is observed as conversion from forestry to pastoral activities.

1. BACKGROUND

The LUCAS (Land Use and Carbon Analysis System) project has been established to enable New Zealand to meet its reporting obligations under the Kyoto Protocol and United Nations Framework Convention on Climate Change. A key requirement is that the carbon accounting and reporting system must meet the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance (GPG). LUCAS has been developed to fulfil the following functions:

a. Be appropriate for the United Nations Framework Convention on Climate Change (UNFCCC) Land Use, Land-Use Change and Forestry (LULUCF) sector reporting.

b. Enable reporting under Article 3.3 of the Kyoto Protocol in the first (and subsequent) commitment periods.

c. Ensure New Zealand's eligibility to participate in international carbon trading.

d. Support and underpin New Zealand climate change policy development through to 2014 and beyond.

A key requirement of LUCAS was to map and report deforestation by target or polygon annually during CP1 (2008 to 2012). Three further land-use change assessments have been conducted since the creation of the 2008 land use map (LUM).

The first national assessment 2008 to 2010 used a combination of DMC 22 m resolution satellite data and Landsat ETM+ 30 m imagery. The second identified land cover changes between 2010 and 2011 in the four most active change regions, Northland, Waikato, Marlborough and Southland. The final assessment of CP1, covering the entire period from 2008 to 2012, assessed all regions using data from the previous assessments and satellite images acquired by the SPOT 5 satellite. An assessment of deforestation occurring during 2013 and 2014 was completed in 2016 based on a combination of SPOT 5 and Landsat 8 imagery.

As stated in the New Zealand GHG Inventory Report 1990-2016, it is important to highlight that New Zealand uses the IPCC (2003) definition of deforestation. Deforestation is the direct human-induced conversion of forested land to non-forested land. There is an explicit distinction between deforestation and harvesting, in that harvesting is part of usual forest management practice and involves the removal of biomass from a site followed by reforestation (replanting or regeneration, i.e. there is no change in land use).

In New Zealand, change resulting from forest harvesting is given a temporarily unstocked status, as these areas remain as forest land unless converted. When land is destocked, and the forest is removed and not replanted for a period of four years, it is considered "deforested" for the purposes of Kyoto Protocol reporting. The four-year period is appropriate as it is common for the land and forests to be owned by different parties, commonly under a lease or forest right arrangement. Forest land can remain temporarily unstocked for several years while land owners decide what to do with land after harvesting.

Deforestation can also be confirmed earlier if there is evidence of land use change such as farm infrastructure (fences, troughs, buildings or irrigation settings), grazing stock or other developments (i.e. non-harvest related roading or mining activities). Lastly, deforestation events are attributed to the year in which forest is destocked, not to the year in which deforestation is confirmed by the evidence of land-use change.

2. SCOPE & APPROACH

The purpose of the 2015 and 2016 deforestation project is to classify the destocked area as provided by MfE into three classes; deforested, harvested and awaiting (land awaiting land-use decision). The definitions for each classification is shown below in section 2.1. This area includes all detected forest loss occurring during this period except deforested areas reported to the Ministry for Primary Industries under the Emissions Trading Scheme (ETS). The analysis primarily tracks annual change occurring during 2015 and 2016 across three forest classes; Pre-1990 natural forest, Pre-1990 planted forest, and Post-1989 forest. A small number of destock targets that had occurred prior to 2015 were also reassessed.

The methodology applied is a 100% review of the targets supplied by MfE. This is in line with the approach used for the final CP1 deforestation mapping project. The status of each destock target was determined using vertical aerial photograph.

In determining if a land change has occurred, the photographic evidence, in addition to definitions that describe destock event, were used, along with contextual information. Relevant definitions and contextual descriptions are as follow;

2.1 Definitions

As part of the on-going implementation of LUCAS, several definitions and classification guidelines relevant to prevailing anthropogenic land use practices in New Zealand have been established. There are six land-use change options that can be used to describe the destock event. They are as follows:

- **Deforestation (D)**: is the direct human-induced conversion of forested land to non-forested land, e.g. from forest to pasture. Typically, deforestation should only be confirmed when there is sufficient evidence of land use change such as farm infrastructure (fences, troughs, buildings or irrigation systems), livestock or other development of non-harvest related activities such as road construction or mining activity.
- **Harvesting (H)**: is part of usual forest management practice and involves the temporary removal of biomass from a site followed by reforestation (replanting). Harvesting implies the target has not undergone a land use change.
- **Land awaiting land-use decision (A)**: is an area that has been destocked but with insufficient evidence to confirm deforestation or harvesting. The land can remain in such a state for up to 4 years, after which the four-year rule becomes applicable.
- **Non-anthropogenic change (NAC)**: is an area that has been destocked through natural events such as windthrow or erosion in steep terrain i.e. non-human induced change.
- **No Change (NC)**: is a false change where an area of existing forest is incorrectly classified as change.
- **Never Forest (NF):** changes detected in non-forest areas that have been incorrectly included in the forest mask. These areas are confirmed by Indufor using either the current capture of aerial photography, or historical satellite imagery which identifies the vegetation as a non-forest type.

There are three main considerations when determining the type of change. These are: (a) the location (b), the intensity and scale of the change, and (c) the time elapsed since the change was first detected. All of these factors provide context for the change. Context becomes quite important, especially in situations where the change is recent, small, or isolated. In making a final decision, the photographic evidence in conjunction with surrounding land use, trends observed from nearby change and other contextual clues such as infrastructure are also considered. If uncertainty remains, then the change area is recorded as (A).

Understanding the context within which the change occurs is key. The primary drivers and specific characteristics of deforestation include, but are not limited to:

Dairy/cropping: Evidence of land use change in intensively farmed areas. Typically characterized by de-stumping and heaping of residual harvesting waste into regularly spaced windrows. Depending on time since clearance, pasture may be visible as will infrastructure developments associated with dairy conversion. Generally, the conversion area will be located on flat to undulating terrain near existing intensively farmed areas.

Farm: Evidence of land use change in hill country or more remote areas. Typically, deforestation is characterized by expansion of existing pastoral areas. This can include clearance and conversion of natural forest or plantations. The clearance method may include heaping, burning or spraying, but in the case of natural forest is more likely to be smaller in scale, fragmented and near areas identified as Grassland with Woody Biomass (GWB) in the LUM.

Development: Evidence of land use change in areas near existing or new infrastructure and the proximity relative to existing settlements. Typically, the development areas are a result of road construction (>15 m width), transmission lines, wind farm developments, quarries, subdivision or lifestyle block development. These changes are smaller scale and characterised as linear features (i.e. roads) or represent localized change.

In identifying deforestation, the evidence and context have been used to assist with the classification of destocking events.

3. DATASETS

3.1 Supporting Datasets

The following list of datasets were used to assist in determining the final destock classification. These include a combination of data provided by MfE and sourced by Indufor.

- **LUCAS Destocking Tracking 2017:** attributed polygons representing previously identified destock areas.
- **MPI Forestry Schemes:** Provides approximate spatial location of forest areas and common forestry metadata such as species, planting year and forestry scheme. This includes information on deforestation activities notified to MPI.
- **NZ Forest Ownership Maps:** Maps that identify the location of plantations larger than 50 ha.
- **MfE National Mosaic:** National-scale mosaic to assist with identifying the context of the destock target. In some cases, the mosaic was also sufficient to confirm a destock classification.

3.2 Primary Datasets

To assist with the identification of destocking events, MfE provided Indufor GIS layers that identify forest loss along with an image capture metadata layer template.

- The forest loss layer identifies all destock targets for the project. The layer also includes basic information for each target such as the destock year. Indufor has reviewed this layer and, for each target, applied a destock classification and noted the supporting evidence used to make the classification.
- The image capture metadata layer template defines the schema for recording image footprints and information where a vertical photograph is captured and used as evidence. The information recorded covers attributes such as the image name, date of capture, format and (if any) usage limitations.

4. METHODOLOGY

There are three main aspects to the methodology; pre-flight planning, aerial photography capture and post-processing. For this project two capture options were considered, either the acquisition of new aerial photography, or the use of existing aerial photography. Both sources were used to provide definitive evidence of land use change.

4.1 Overflights – Vertical Aerial Photography

The vertical photographs were captured from overflights using light aircraft. The destock targets were divided into manageable groups, considering aircraft range and accessibility. Within each group, an optimal flight path was calculated.

For each group, the relevant destock targets were loaded into a customised flight management system which was developed specifically for this project to meet the capture requirements. The system is linked to a full frame digital camera system and uses GPS live tracking linked to a target guidance system.

The capture process is automated; the aircraft flies over the predetermined path and as it approaches a destock target, a proximity alert triggers the camera to capture an image. The photos are geotagged on capture to assist with post-processing.

On completion of the overflights, the vertical aerial photographs are post-processed into a georeferenced product, such that when displayed on a GIS platform the image is spatially registered. The spatial resolution of the images is between 10 to 30 cm depending on the altitude of the aircraft and ground elevation.

4.2 Existing Aerial Photography

Aerial photography captured from 2016 to present was made available through multiple sources:

- Collected directly from Indufor's contractor.
- Land Information New Zealand (LINZ) Data Service.
- MfE's national mosaic of New Zealand

In general, most of the destock targets confirmed with existing aerial photography were those with earlier destock years. The data was ideally suited for confirming remnant destock targets from CP1 (2011 – 2012) and the first two years of CP2 (2013 – 2014).

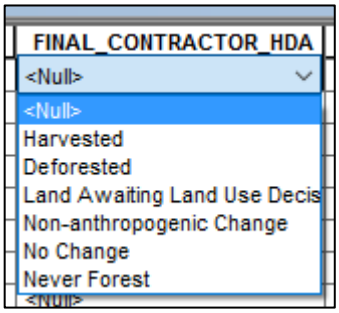
However, in certain situations current destock targets (2015 – 2016) were also confirmed using existing aerial photography. These targets tended to be:

- Corporate plantation estates with short rotations where replanting evidence is typically seen within one to two years.
- Land conversion/development blocks. These changes tend to present clear evidence of deforestation and typically over a short period of time. For example, property developments will show roading and infrastructure shortly after a destock event.

4.3 Deliverables

The destock layer was then updated with the relevant destock attributes. The destock layer, as provided by MfE uses coded domains to maintain consistency, as opposed to the operator manually entering the classification. This discourages input errors when attributing the destock layer. The example below in Figure 4-1 shows the domains available for the destock classification.

Figure 4-1: Domains for Classifying a Destock Target



The core requirements for attributing a destock target involves:

- A final destock classification
- Confirming the destock year
- Contractor comment (where applicable) to support the classification
- Contractor evidence – the image name used to confirm the classification

All images used to confirm the destock classification were supplied to MfE. To meet project requirements, all data was converted to a format and compression type suitable for integration into MfE's system. For this project, several hundred Gigabytes (over 8 000 individual images) were formatted and supplied to MfE.

The image capture metadata layer, as provided by MfE was updated by Indufor. This layer holds the metadata for each image used as evidence, including an image frame, image properties (e.g. capture date, format and compression applied).

In cases where no datasets provided sufficient evidence of the destocking type, the destock polygon was attributed as "land awaiting land use decision". These targets require future monitoring to determine if they have been deforested.

5. SUMMARY OF NATIONAL RESULTS

It is important to note that as new information is made available, classifications may be updated which means that reported figures and trends may change. The figures reported and discussions surrounding these findings are accurate at the time of writing.

5.1 Regional Summary

The total estimated area of deforestation is approximately 11 000 ha or 8% of the total destocked area (Table 5-1). The regions with the greatest contribution to deforestation are Waikato (32%), Canterbury (12%) and Manawatu-Wanganui (11%). The remaining regions each contribute less than 10% towards the national estimate.

The majority of the 10 218 destock targets have been harvested and replanted, in area terms this represents some 94 000 ha or 73% of the total destock area. Bay of Plenty has the highest proportion of the harvesting activity, accounting for 18% of the national area harvested. This is followed by Northland (16%) and Waikato (15%). These trends are consistent with previous assessments and aligns with the knowledge that these regions contain some the largest forest plantations in New Zealand.

The national figure for land awaiting land use decision is some 21 000 ha (16% of the total destock area). Waikato and Manawatu-Wanganui each contribute 13% towards the total, followed by Canterbury at 11%. At this point there is insufficient evidence to confirm if these areas have been harvested or converted to another land use.

The three classes, non-anthropogenic change, no change and never forest account for 3% of the total destock area. No change and never forest are randomly distributed across the regions and tend to be misclassifications by the detection routine. Non-anthropogenic changes tend to be more common in the South Island.

Table 5-1: 2015-16 National Destocking Summary by Region

Region	H	D	A	NAC	NC	NF	Total by Region
	(ha)						
Northland	14 804	355	1 158		87	77	16 482
Auckland	1 867	184	191		9	31	2 282
Waikato	13 756	3 463	2 742	10	781	88	20 840
Bay of Plenty	16 910	847	1 492	1	523	64	19 837
Gisborne	9 196	213	1 008		15	17	10 449
Hawke's Bay	5 493	876	1 620		97	117	8 202
Taranaki	529	352	1 128		17	65	2 092
Manawatu-Wanganui	4 254	1 182	2 632	3	143	24	8 239
Wellington	3 151	404	908	3	87	71	4 625
West Coast	2 354	346	380	4	97	40	3 223
Canterbury	3 660	1 281	2 307	16	42	63	7 369
Otago	5 461	543	1 154		131	63	7 352
Southland	3 763	599	1 593		105	298	6 358
Tasman	3 638	184	1 248	3	56	55	5 184
Nelson	370		3		2	1	377
Marlborough	5 125	138	1 145	59	44	158	6 668
Total by Class	94 331	10 968	20 711	99	2 236	1 233	129 578

Legend

D – Deforested

H – Harvested

A – Land Awaiting Land Use Decision

NF – Never Forest

NC – No Change

NAC – Non-anthropogenic Chance

5.2 Annual Summary

The destock year is defined as the year in which the destock event occurred. A summary of findings by destock year is shown below in Table 5-2. The majority of the area (116 000 ha or 89%) falls within the current mapping project (2015 – 2016). Harvesting and deforestation rates are consistent between the two years, considering that the area currently classified as land awaiting land use decision (**A**) will be reclassified as new evidence is acquired. Aerial images acquired over areas destocked in 2015 tended to provide more evidence to confirm a destock classification. For this reason, we see a lower proportion of **A** in 2015 (some 8 000 ha compared to some 12 500 ha in 2016).

In both 2015 and 2016, a reasonable area has been classified as no change (2 000 ha) or never forest (1 000 ha). These are largely attributed to misclassifications in the routine used to generate the destock targets provided to Indufor. However, proportionally these classes only represent some 3% of the total area.

Some 14 000 ha are remnants from CP1 (2011 – 2012) and the first two years of CP2 (2013 – 2014). These are destock targets which have previously been unconfirmed (**A**), the majority have now been attributed with destock classifications. For these reasons, the area classification by destock year are not directly comparable, as some the classifications have since been reviewed and updated. For a complete picture to date, these numbers will need to be appended to MfE's current destock summaries.

Table 5-2: National Destocking Summary by Year

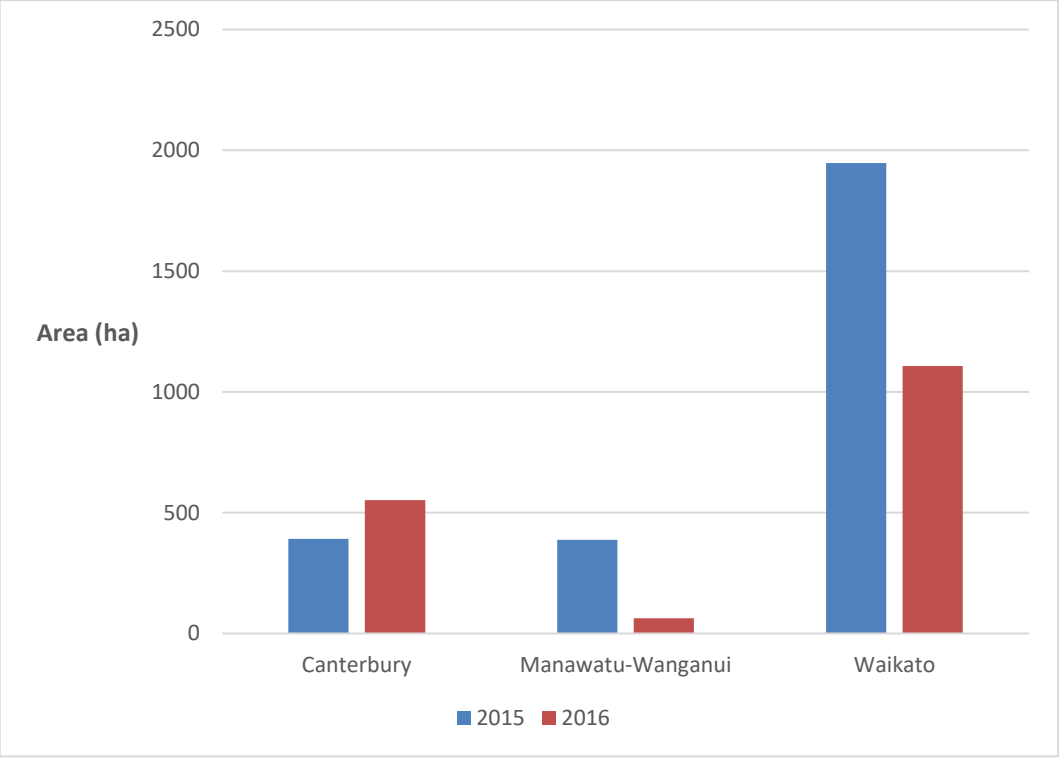
Destock Year	H	D	A	NAC	NC	NF	Total by Year
	(ha)						
2011		6					6
2012	2 603	1 832	36		45	70	4 586
2013	5 262	2 950	191	60	93	123	8 679
2014	704	3	1				709
2015	46 633	3 710	7 948	31	458	574	59 353
2016	39 129	2 467	12 535	8	1 641	466	56 246

5.3 Deforestation

The three regions with the largest areas of deforestation are Canterbury (392 ha in 2015 and 553 ha in 2016), Manawatu-Wanganui (388 ha in 2015 and 63 ha in 2016) and Waikato (1 948 ha in 2015 and 1 108 ha in 2016).

It should be noted that Manawatu-Wanganui's contribution is largely based on 417 ha destocked in 2012, now classified as deforestation. Data captured in this project provided sufficient evidence to confirm these areas.

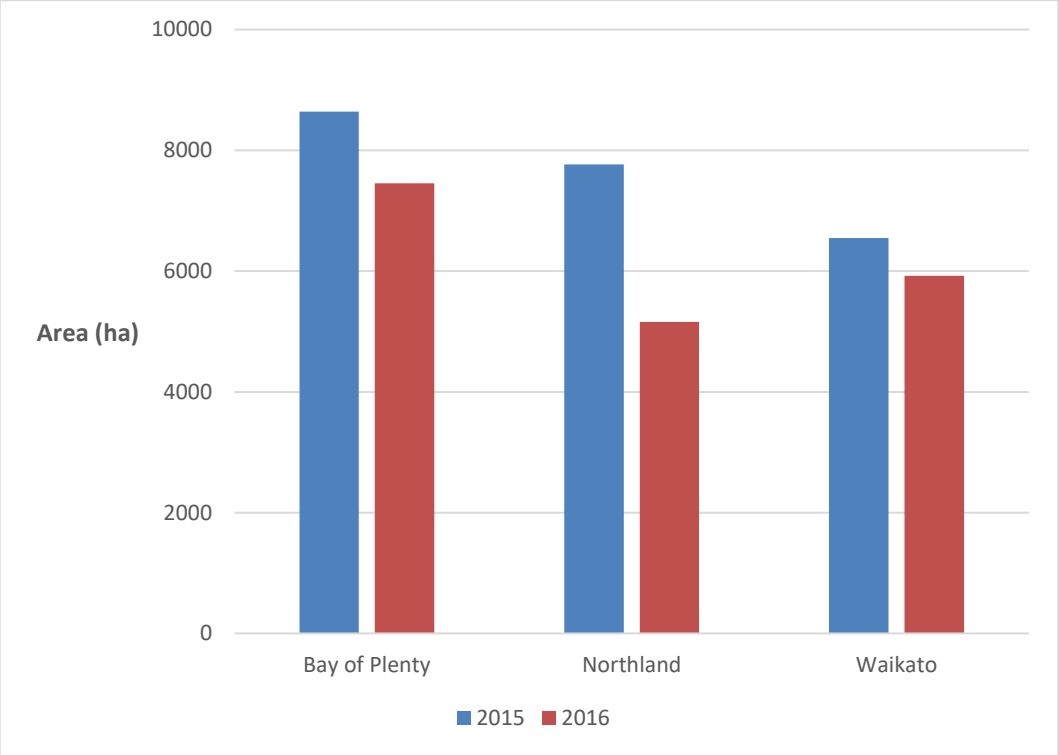
Figure 5-1: Waikato, Manawatu-Wanganui & Canterbury Deforestation 2015-16



5.4 Harvesting

The three regions with the greatest contribution to harvesting are Bay of Plenty (8 640 ha in 2015 and 7 452 ha in 2016), Northland (7 764 ha in 2015 and 5 161 ha in 2016) and Waikato (6 546 ha in 2015 and 5 923 ha in 2016).

Figure 5-2: Bay of Plenty, Northland & Waikato Harvesting 2015-16



6. KEY OBSERVATIONS

6.1 Oblique Aerial Photography (Previous Approach)

In previous assessments, oblique photographs were used as the primary mode of capture. In the 2015 – 2016 assessment, these were replaced with vertical photographs. The overall conclusion was that the switch provided a more conclusive product, at the cost of greater logistical requirements and processing effort.

6.2 Vertical Aerial Photography

The logistical steps to prepare overflights for vertical capture require significant planning and preparation, especially when compared to the oblique approach. For example, the aircraft must be level at the time of capture, thus traditional least-cost flight path models were incompatible. Each destock target must also have an associated image due to the limited swath of the verticals. In certain situations, the oblique method was able to capture multiple targets in a single image, thus reducing flight time and cost.

The time of capture is also limited, as the vertical approach requires minimal shadow, especially over mountainous terrain. The capture period spanned the winter months which further limited flying hours.

Handling of the data, especially the post-processing steps also require additional effort and is a time-consuming exercise. Sound knowledge of remote sensing data is required along with the ability to handle large volumes of data.

However, the final product is more robust than the obliques. Furthermore, there is little ambiguity as to where the target lies, relative to the image. In a spatial context the image is more easily integrated into the GIS and so is better suited for performing calculations and edits to the destock layer. Overall, the benefits of the vertical approach justify the additional effort required.

6.3 Existing Aerial Photography

Aerial photography from existing captures were the easiest data format to handle. They were provided as an off-the-shelf product, meaning they are already georeferenced and in a GIS friendly format.

Existing aerial photography also has a wider swath than the other modes of data. In certain situations, this was useful to determine the context surrounding the destock target in question. The context provides additional information which helps in determining the final destock classification. The larger swath also removed the risk of mis-capture, a possible outcome of the vertical option should the GPS signal be weak.

7. CONCLUSION

The results presented provide an overview of the temporal land use trends by region over 2015 and 2016. Remnant targets belonging to CP1 and earlier in CP2 (2013 and 2014) were also reassessed and classified.

The evidence provided to classify destock targets uses two primary sources:

- Vertical aerial photography captured for this project
- Existing aerial photography

A combination of newly captured and existing vertical photographs provided current and high-resolution assessment of the destock targets. The advancement of using verticals (over obliques) has proven to be highly effective.

Improvements in the methodology and hardware for capture of vertical aerial photography allowed for higher quality photographs. This enabled more confident decisions to be made when assigning the destock classification.

Appendix 1

Destock Classification Illustrations

Destock Classification – Harvesting

Region: Hawke's Bay

Destock Year: 2013

Destock Image (Evidence Type/Capture Year): Vertical aerial photography/2014

Evidence Image (Evidence Type/Capture Year): Vertical aerial photography/2018

Destock Classification – Deforestation

Region: Otago

Destock Year: 2016

Forest Image (Evidence Type/Capture Year): Vertical aerial photography/2014

Evidence Image (Evidence Type/Capture Year): Vertical aerial photography/2018

Destock Classification – Land Awaiting Land Use Decision

Region: Canterbury

Destock Year: 2016

Forest Image (Evidence Type/Capture Year): Vertical aerial photography/2015

Evidence Image (Evidence Type/Capture Year): Vertical aerial photography/2018

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