



Ministry for the
Environment
Manatū Mo Te Taiao

Land Use and Carbon Analysis System

SATELLITE IMAGERY INTERPRETATION GUIDE FOR LAND-USE CLASSES



LUCAS^{PS}



This report may be cited as:

Ministry for the Environment. 2010. *Land Use and Carbon Analysis System: Satellite Imagery Interpretation Guide for Land-use Classes*. Wellington: Ministry for the Environment.

Cover image by Rob Suisted, Naturespic. Caption: Calm waters of Lake Matheson.

Published in September 2010 by the Ministry for the Environment, Manatū Mō Te Taiao
PO Box 10362, Wellington, New Zealand

ISBN: 978-0-478-37200-7 (print)
978-0-478-37201-4 (electronic)

Publication No: ME 1024

This publication is also available on the Ministry for the Environment's
website www.mfe.govt.nz



Contents

| | |
|--|-----------|
| Purpose | 2 |
| Background | 2 |
| Figure 1: New Zealand’s land-use mapping process | 3 |
| Definitions | 4 |
| Land-use classes | 4 |
| Table 1: Description of land-use classes for 1990 and 2008 | 4 |
| Land-use classification illustrations | 6 |
| Natural forest | 6 |
| Pre-1990 planted forest | 11 |
| Grassland with woody biomass | 16 |
| Post-1989 forest | 18 |
| Cropland – perennial | 22 |
| References | 25 |
| For more information | 26 |

Purpose

This interpretation guide aims to help users understand the LUCAS land-use classifications and how each land-use class is determined/inferred from vegetation cover seen in remotely sensed imagery. In particular it provides transparency and consistency associated with mapping land-use classes important to the LULUCF sector.

Background

The LUCAS (Land Use and Carbon Analysis System) was established to enable New Zealand to meet its reporting and accounting obligations under Article 3.3 of the Kyoto Protocol for Land Use, Land-use Change and Forestry (LULUCF) activities.

Key requirements are to establish land-use maps for the baseline period 1990, and then map land-use changes for the time periods 1990–2008 and 2008–2012. The land-use mapping involves extensive use of satellite imagery and some aerial photography, along with other spatial layers.

The 1990 land-use map is derived from 30-metre spatial resolution Landsat 4 and Landsat 5 satellite imagery taken in, or close to, 1990. The first of the images used were taken in November 1988 and the last in February 1993. In addition to orthorectification and atmospheric correction, the satellite images were standardised for spectral reflectance using the Ecosat algorithms documented in Dymond et al (2001), Shepherd and Dymond (2003) and Dymond and Shepherd (2004). These standardised images were used for automated mapping of woody biomass, and then used to map woody biomass classes into land-use subcategories used for reporting. Land-use subcategories at 1990 included natural forest, pre-1990 planted forest and grassland with woody biomass.

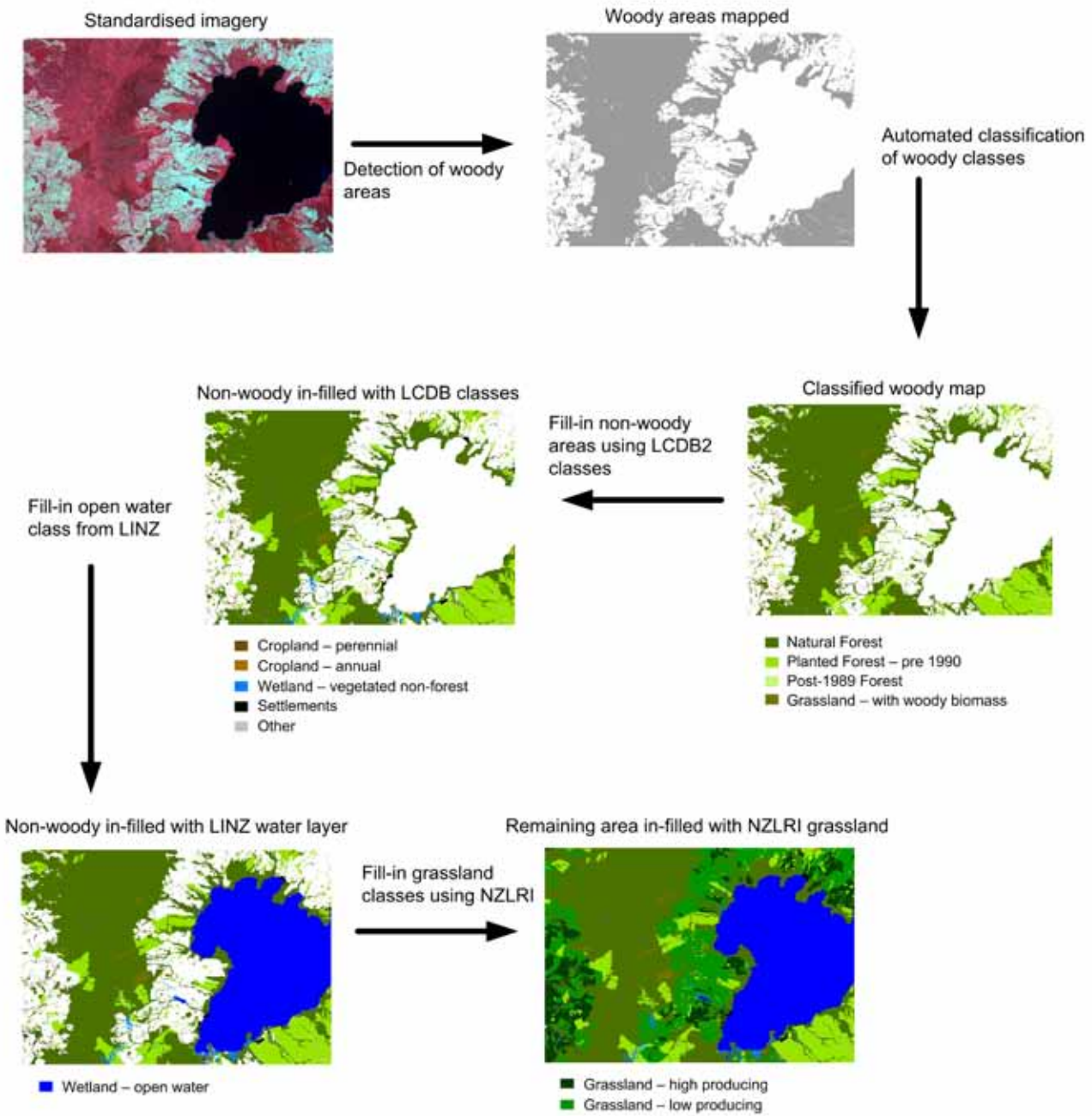
This classification process was validated and improved using 15-metre resolution Landsat 7 ETM+ imagery acquired in 2000–2001, and SPOT 2 and 3 data acquired in 1996–1997. The use of this higher-resolution imagery (coupled with the use of concurrent aerial photography) enabled more certain land-use mapping decisions to be made.

To determine the spatial location of the other land-use categories and subcategories as at 1990 and 2008, information from two land cover databases, LCDB1 (1996) and LCDB2 (2001) (Thompson et al, 2003), the New Zealand Land Resource Inventory (NZLRI) (Eyles, 1977) and hydrological data from Land Information New Zealand have been used (Shepherd and Newsome, 2009a,b).

The NZLRI database was used to better define the area of high- and low-producing grassland. Areas tagged as ‘improved pasture’ in the NZLRI vegetation records were classified as grassland – high producing in the land-use maps. All other areas were classified as grassland – low producing. Figure 1 illustrates this mapping process.

The 2008 land-use map (land-use as at 1 January 2008) is derived from 10-metre spatial resolution SPOT 5 satellite imagery which was processed into standardised reflectance images, using the same approach as for the 1990 imagery. The SPOT 5 imagery was taken over the summers of 2006–07 and 2007–08 (November to April), to establish a national set of cloud-free imagery. Where the SPOT 5 imagery pre-dates 1 January 2008, a combination of aerial photography, Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery and field verification has been used to identify where deforestation has occurred to ensure the 2008 land-use map is as accurate as possible.

Figure 1: New Zealand's land-use mapping process



Definitions

This forest definition applies for mapping of all LULUCF activities (UNFCCC 2001).

“Forest” is the minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 metres at maturity *in situ*. A forest may consist of either closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 metres are included under forest. Forest

also includes areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention, such as harvesting or natural causes, but which are expected to revert to forest.

New Zealand has selected the upper limits of the forest definition parameters, namely:

- 1 ha
- 30 per cent canopy cover
- 5-metre height (or the ability to reach this height under current management (or *in situ*))
- 30-metre width (canopy-edge to canopy-edge).

Land-use classes

A general description of the land-use classes mapped and/or recorded for land-use mapping (LUM) 1990 and 2008 is shown in Table 1. Additional information on the key 1990 and 2008 land-use classes (namely, natural forest, pre-1990 planted forest, post-1989

forest, and grassland – with woody biomass) is provided on pages 6, 11, 16 and 18.

The minimum mapping area specified in these definitions is one hectare and the minimum width mapped is 30 metres.

Table 1: Description of land-use classes for 1990 and 2008

| Land-use class mapped | Land-use/land-cover sub-categories |
|--|--|
| Natural forest* (as at 1990) LUC_ID= 71 | <p>Areas that on 1 January 1990 were:</p> <ul style="list-style-type: none"> • tall forest on public conservation land including self-sown exotic trees such as wilding pines and grey willows • short forest or shrubland (with potential to reach ≥ 5 m at maturity (<i>in situ</i>)) on public conservation land • roads/tracks less than minimum width on public conservation land within the above two categories • tall, non-planted forest (≥ 30 per cent cover) on other (non-public conservation) land • broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland (≥ 30 per cent cover, with potential to reach ≥ 5 m at maturity <i>in situ</i>) on other (non-public conservation) land under current land management |
| Pre-1990 planted forest* LUC_ID= 72 | <ul style="list-style-type: none"> • radiata pine, Douglas-fir, eucalypts, or other planted species (with potential to reach ≥ 5 m height at maturity <i>in situ</i>) planted on land which was forest land as at 31 December 1989. This includes riparian or erosion control plantings that meet the forest definition • harvested areas within forest land (assumes these will be replanted, unless deforestation is later detected) • this includes roads/tracks/skids less than minimum area/width of 30 m within forest areas |
| Post-1989 forest (2008 only) LUC_ID= 73 | <ul style="list-style-type: none"> • includes forests that meet the forest definition and have either been planted or established on or after 1 January 1990 on land that was non-forest land as at 31 December 1989. Generally, these forests are planted with exotic species, but they may arise from natural regeneration of indigenous tree species as a result of management change after 1 January 1990 • for exotic forest, may include radiata pine, Douglas-fir, eucalypts or other planted species (with the potential to reach ≥ 5 m height at maturity <i>in situ</i>) • includes roads/tracks/skids less than a minimum area/width of 30 metres within post-1989 forest areas |

| Land-use class mapped | Land-use/land-cover sub-categories |
|--|---|
| Grassland – with woody biomass LUC_ID= 74 | <ul style="list-style-type: none"> grassland with tall tree species (< 30 per cent cover), such as golf courses in rural areas (and except where the LCDB has classified these as settlements) grassland with riparian or erosion control plantings (< 30 per cent cover) grassland with matagouri and sweet briar, broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland (< 5 m and any per cent cover) where under current management it is expected that the forest criteria will not be met over a 30–40 year time period above timberline shrubland vegetation and intermixed with montane herbfields (does not have the potential to reach > 5 m height <i>in situ</i>) linear shelterbelts that meet area/width criteria of 30m |
| Grassland – high producing (NZLRI used for LUM 1990 and LUM 2008) LUC_ID= 75 | <ul style="list-style-type: none"> grassland with high quality pasture species mostly in intensive dairying areas with high fertilizer application excludes linear shelterbelts which are larger than the minimum area/width criteria of 30 m (these are mapped separately as grassland – with woody biomass) |
| Grassland – low producing (NZLRI used for LUM 1990 and LUM 2008) LUC_ID= 76 | <ul style="list-style-type: none"> low fertility grassland mostly on hill country tussock grasslands excludes linear shelterbelts which are larger than the minimum area/width criteria (these are mapped separately as grassland – with woody biomass) montane herbfields at either a higher altitude than above timberline vegetation or where the herbfields are not mixed up with woody vegetation other areas of limited vegetation cover and significant bare soil |
| Cropland – perennial (LCDB1.2 used for LUM 1990, LCDB2 used for LUM 2008) LUC_ID= 77 | <ul style="list-style-type: none"> all orchards and vineyards (it is assumed that no crops meet the forest definition) linear shelterbelts associated with cropland |
| Cropland – annual (LCDB1.2 used for LUM 1990, LCDB2 used for LUM 2008) LUC_ID= 78 | <ul style="list-style-type: none"> all annual crops all cultivated bare ground linear shelterbelts associated with cropland |
| Wetland – open water (LINZ Water layer) LUC_ID= 79 | <ul style="list-style-type: none"> lakes, rivers |
| Wetlands – vegetated non forest LUC_ID= 80 | <ul style="list-style-type: none"> herbaceous and/or non-forest woody vegetation periodically flooded. Scattered patches of tall tree-like vegetation to be included as wetlands estuarine/tidal areas including mangroves |
| Settlements LUC_ID= 81 | <ul style="list-style-type: none"> built-up areas and impervious surfaces grassland within ‘settlements’ including recreational areas urban parklands and open spaces which do not meet the forest definition |
| Other LUC_ID= 82 | <ul style="list-style-type: none"> montane rock/scree largely bare ground (if not cropland) any other remaining land |

* Must comprise a minimum of 1 ha contiguous area, of minimum width (outer edge crown-to-crown, or 25 metre stem-to-stem)

Land-use classification illustrations

Natural forest

Natural forests are dominated by indigenous forest tree species, but may include trees arising from natural establishment and regeneration of exotic species. This land-use class includes forests that meet the forest definition, or have the potential to meet the forest criteria under the management regime in place at 31 December 1989 (Pratt, 2007).

Mapping this class requires particular attention. Satellite imagery provides clear evidence for established natural forests, but it provides less clear evidence of the land-use class where scrubland (broadleaved hardwood scrubland, manuka/kanuka scrubland and other woody scrubland) is present. Areas with a pre-dominance of such scrubland vegetation cover with more than 30 per cent canopy cover will require an “*in-situ*” assessment of available evidence, where height, width, surrounding land use, and the perceived land

management practice determine the land-use classification. If an assessment of such areas shows that vegetation is likely to achieve forest height criteria (5 m), even if these are not yet met, then the area is classified as natural forest.

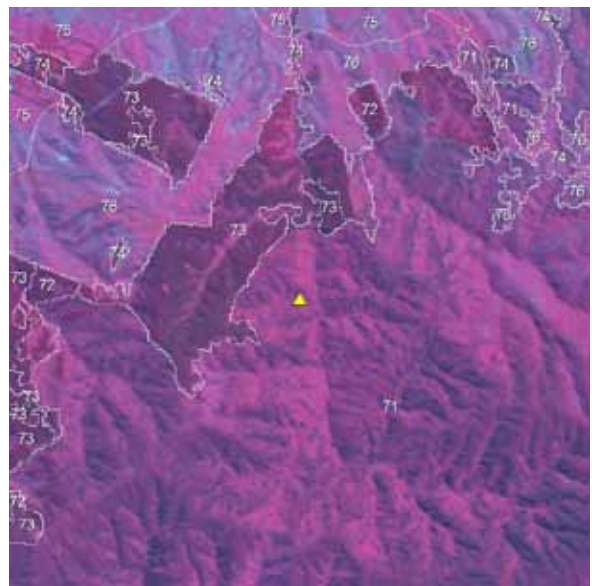
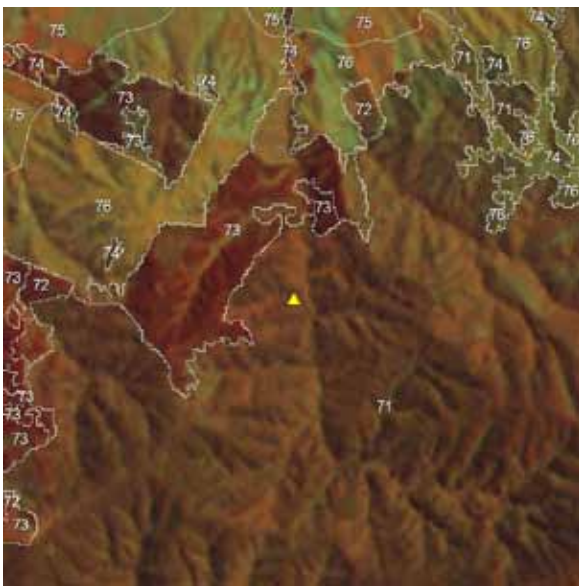
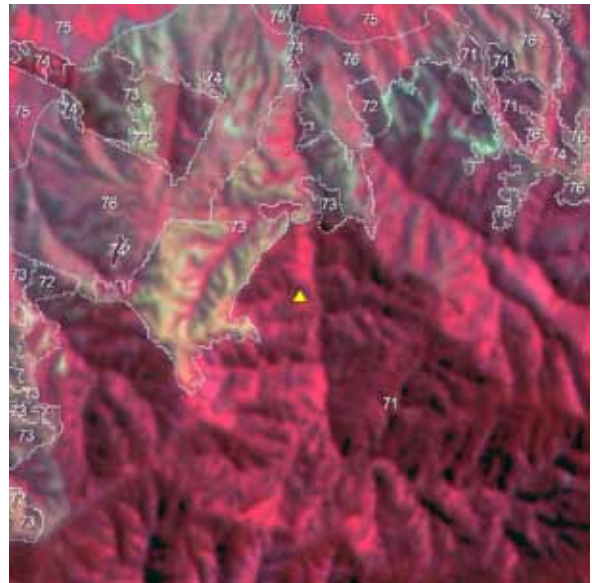
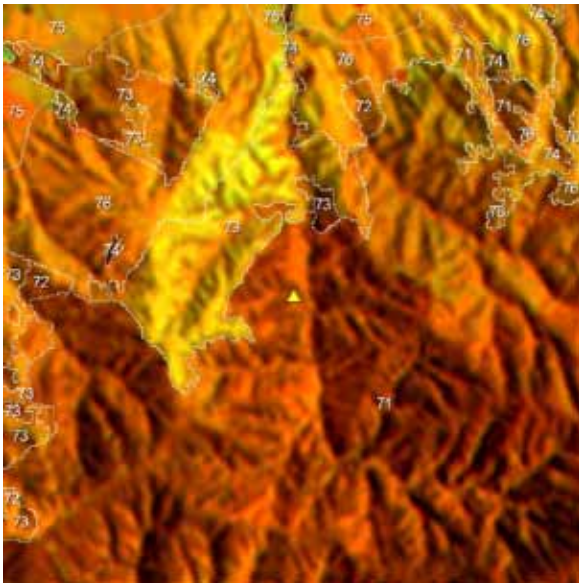
Where land use is 1 to < 5 ha in area and where these areas are totally surrounded by natural forest, these 1 to < 5 ha areas are classified as natural forest. The reason for dissolving these 1 to < 5 ha areas is that the management for the small, completely surrounded areas, will be the same as the larger surrounding area, and these small areas still have the potential to meet the forest definition.

If the 1 to < 5 ha areas are planted forest they will retain their land-use classification, ie, planted forest.



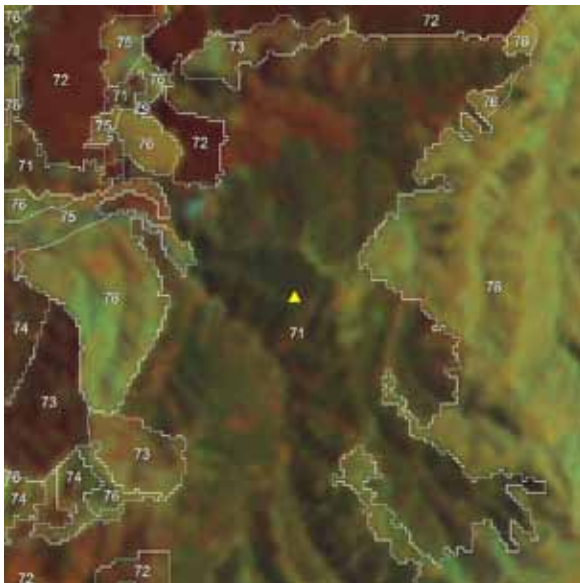
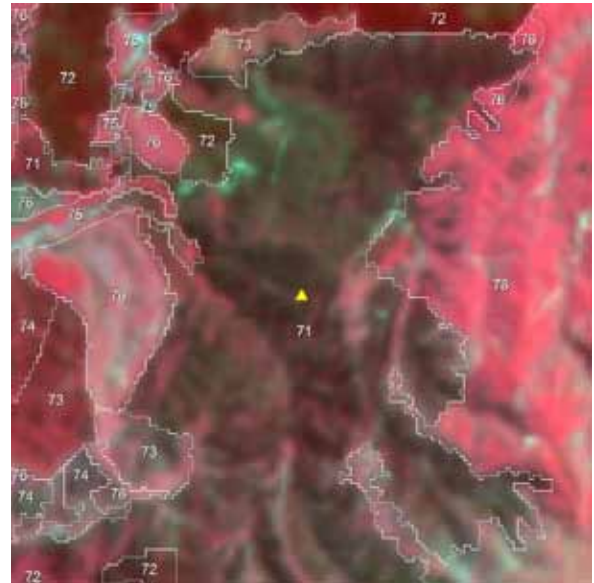
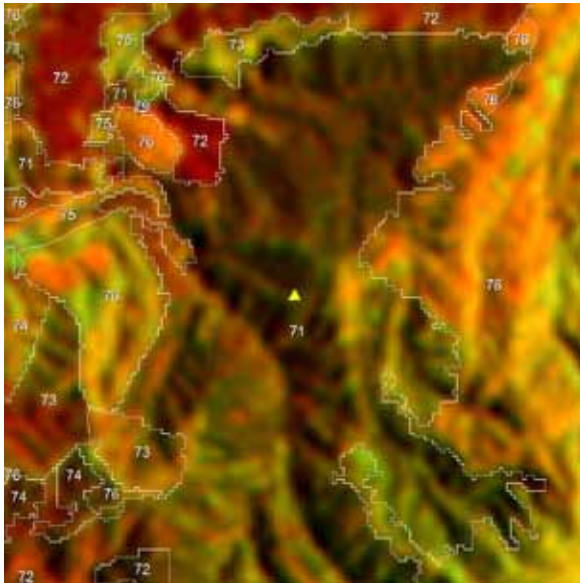
Caption: Southern Rata trees flowering on the Heaphy Track, Kahurangi National Park. Photo by Rob Suisted, Naturespic.

Natural forest: Example 1



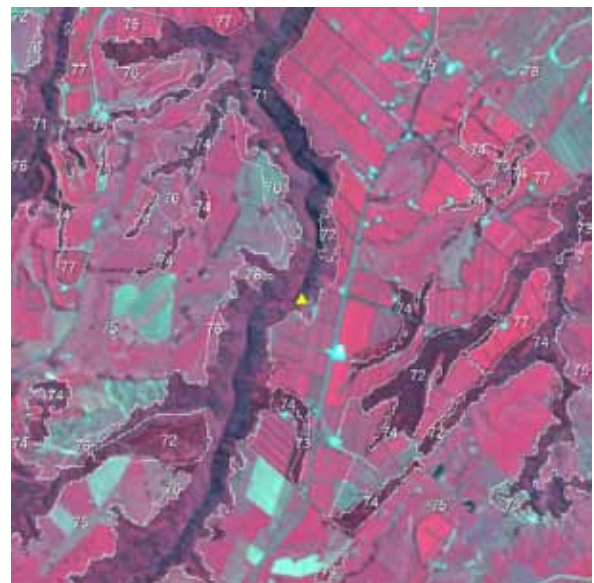
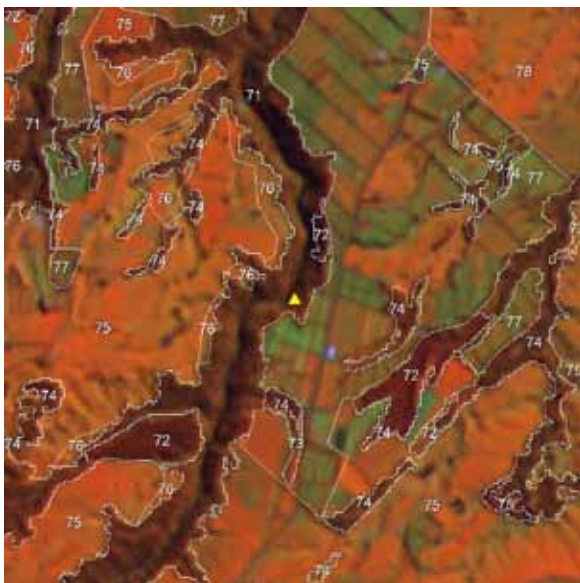
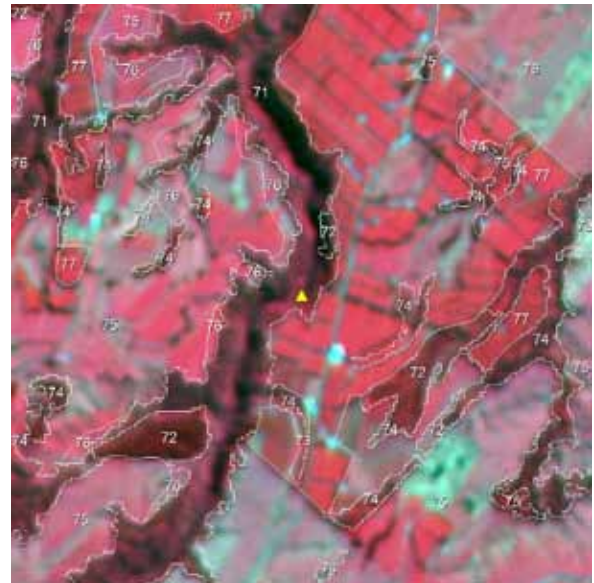
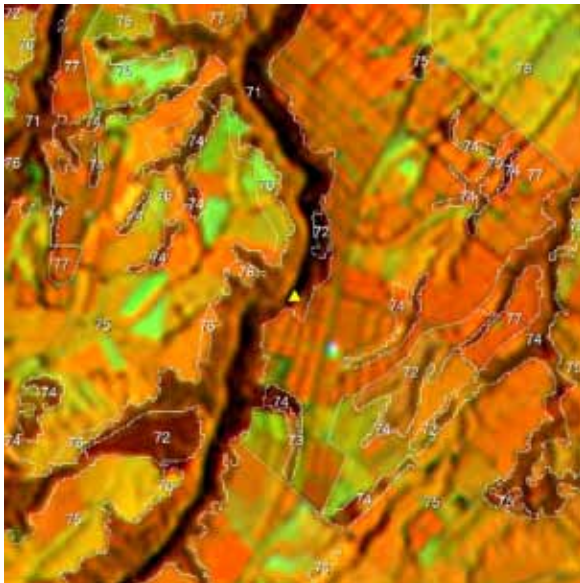
| | |
|-----------------------|--|
| Images | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | East of Manakau, Grid reference 2703462, 6052893 (NZMG), 1793446, 5491179 (NZTM) |
| 1990 land use: | Natural forest |
| 2008 land use: | Natural forest |
| Explanation: | The lower half of these images comprises mature natural forest. Areas of such natural forest are relatively easy to identify in Landsat 4, SPOT 2 and Landsat 7 satellite imagery. These forests have reasonably unique spectral signatures; however, there are some subtle variations depending on the predominant tree species. The trees in this area of natural forest are over 5 m in height with more than 30 per cent canopy cover. |

Natural forest: Example 2



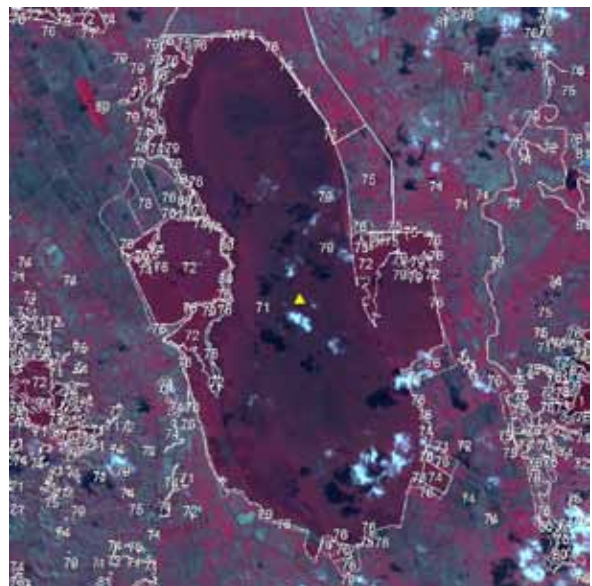
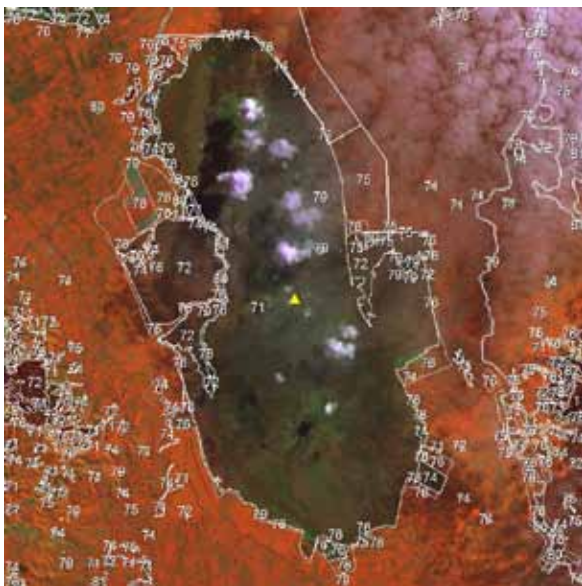
| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Northwest of Wellington, Grid Reference 2655222, 5994769 (NZMG), 1745201, 5433057 (NZTM) |
| 1990 land use: | Natural forest |
| 2008 land use: | Natural forest |
| Explanation: | In the 1990 imagery the steep-sloped areas inside the polygon boundary are inferred to be either manuka or kanuka shrubland. This is confirmed in the SPOT 2, Landsat 7 and SPOT 5 imagery. In the 1990 imagery there is a sharp delineation between the shrubland and grazed grassland (in an orangey colour). The sharp delineation persists and is evident in later years. Accordingly, it is inferred that the shrubland areas were not grazed and as they had more than 30 per cent canopy cover, are larger than 1 ha, and have the potential to reach 5 m at maturity under the 1990 non-grazing land management practice. |

Natural forest: Example 3



| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 1999 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | South of Te Puke, Grid reference 2800589, 6364981 (NZMG), 1890409, 5803484 (NZTM) |
| 1990 land use: | Natural forest (in the gullies) |
| 2008 land use: | Natural forest (in the gullies) |
| Explanation: | At 1990, and through to 2008, the incised gullies are fenced off and managed differently to the flat terraces where the land use is either cropland (kiwifruit) or grassland – high producing. Given the gully areas are wider than 30 m, greater than 1 ha in size, have nearly 100 per cent canopy cover, and are composed of tree species that have not been planted, they are classified as natural forest. |

Natural forest: Example 4



| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 1999 Landsat 7ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Waikato Region, Grid Reference 2736908, 6417407 (NZMG), 1826605, 5855833 (NZTM) |
| 1990 land use: | Natural forest |
| 2008 land use: | Natural forest |
| Explanation: | In this example, for the four dates of imagery, there is vegetation that either already meets the forest definition, or for the most part, will meet the forest definition under the current management regime. The area is mapped as natural forest. The area is a wet site, but does not meet the definition of the wetlands land category (wetland – non-forest), a land category lower in the hierarchy than forest land. The area was mapped as manuka/kanuka on a wet site in LCDB. |

Pre-1990 planted forest

All forest that has been planted with exotic tree species onto land which was forest land as at 31 December 1989 is referred to as pre-1990 planted forest. The most common tree species in these forests is radiata pine, with Douglas-fir the next most common species. This land use includes exotic planting occurring on land which had a natural forest land use at 31 December 1989.

This land use also includes exotic species that have been planted for erosion and river control purposes such as willows and poplars. These forests are likely to be harvested between 1990 and 2012, the end of the first commitment period of the Kyoto Protocol. At 1990 (when deforestation was an extremely rare form of land-use change), it is assumed harvested areas were re-planted, so these temporarily un-stocked areas will be classified as pre-1990 planted forest.

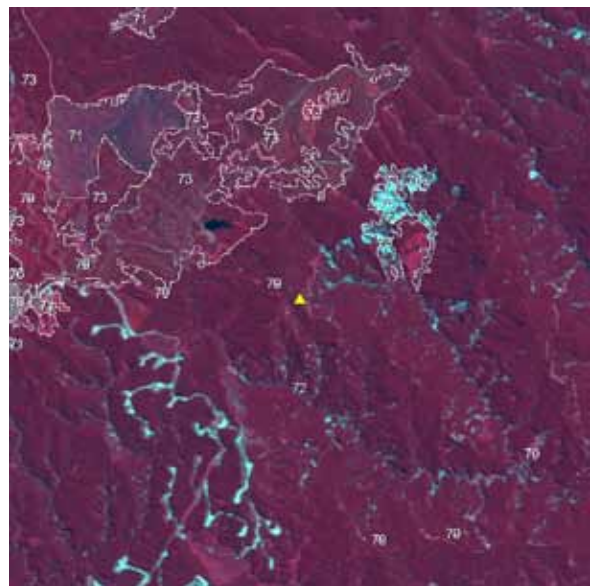
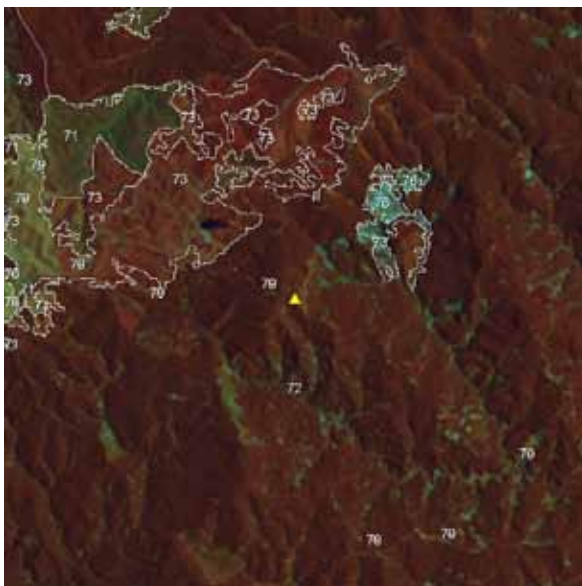
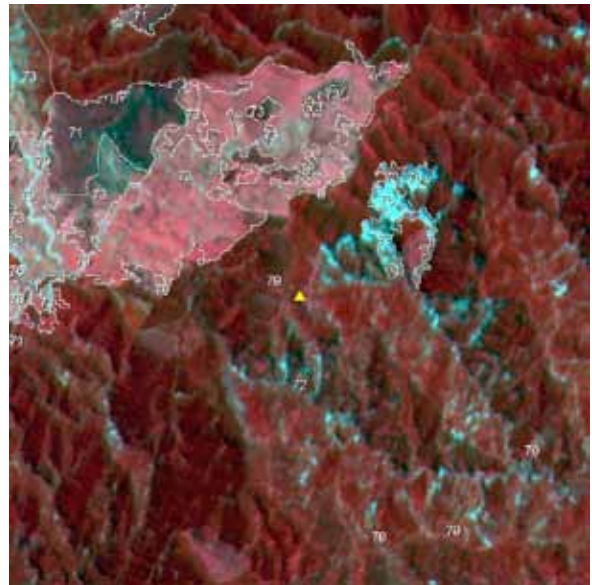
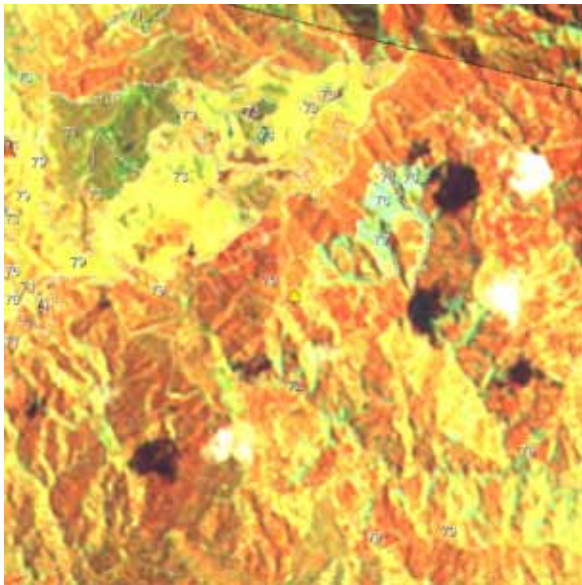
Where land use is 1 to < 5 ha in area, and where these areas are totally surrounded by planted forest, these 1 to < 5 ha areas are classified as planted forest. The reason for dissolving these 1 to < 5 ha areas is that the management for the small, completely surrounded areas, will be the same as the larger surrounding area, and these small areas still have the potential to meet the forest definition.

If the 1 to < 5 ha areas are natural forest they will retain their land-use classification, ie, natural forest.



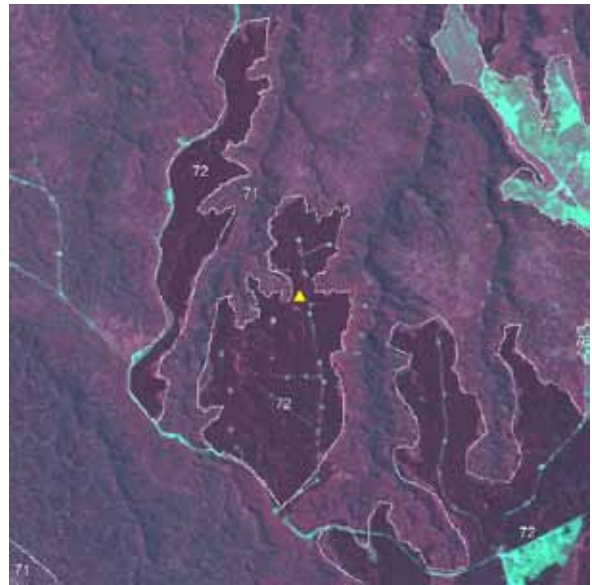
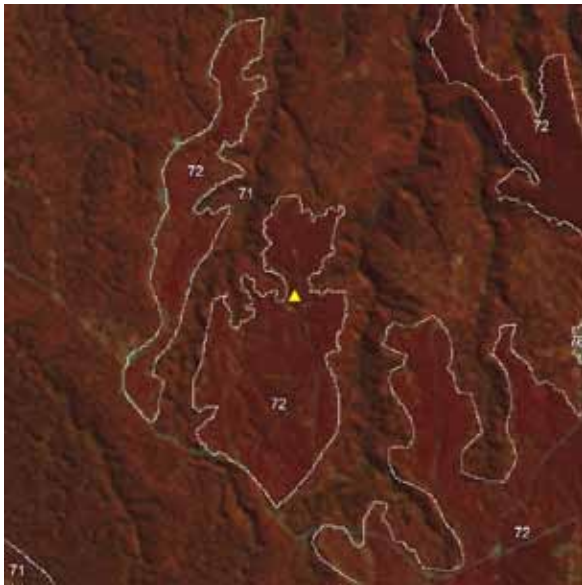
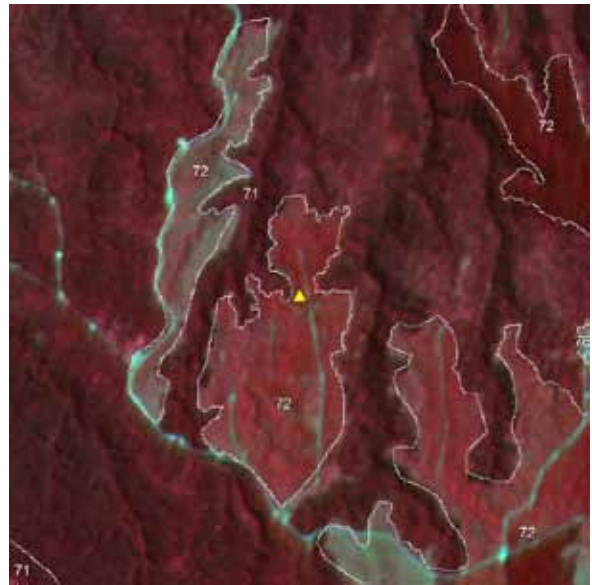
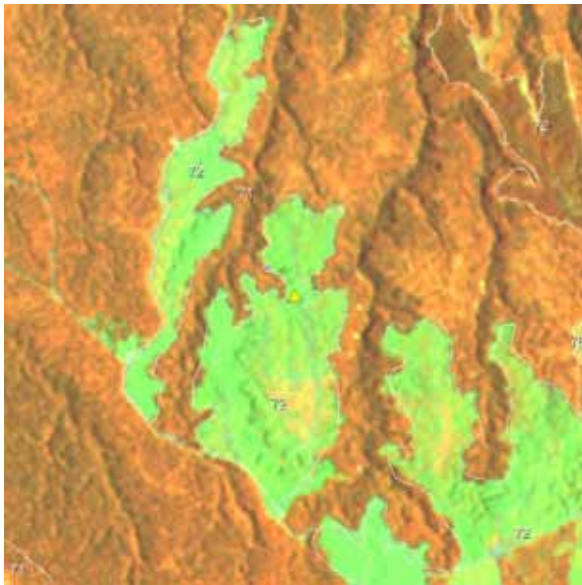
Caption: Pine tree plantation forest, Taupo.

Pre-1990 planted forest: Example 1



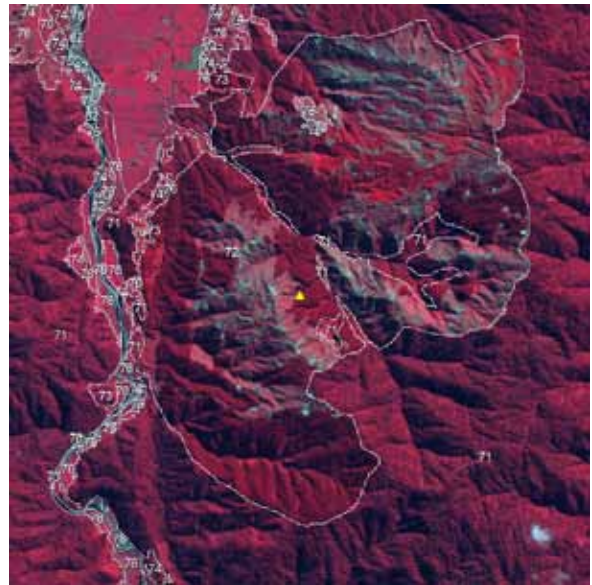
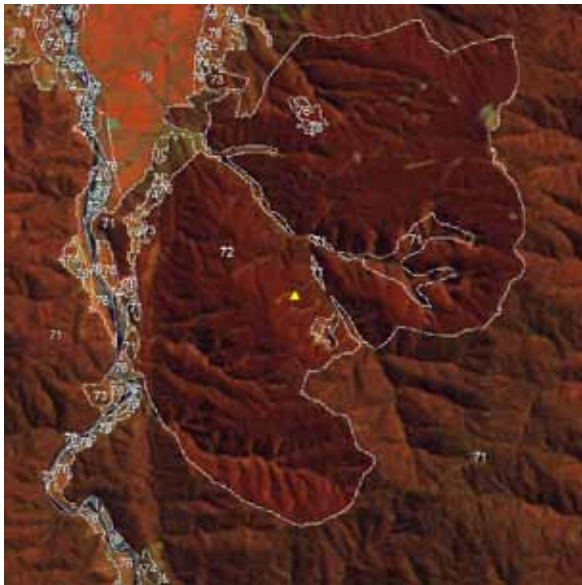
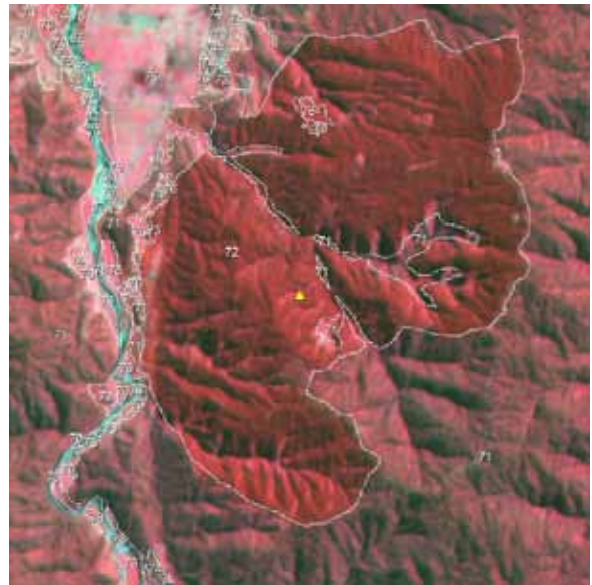
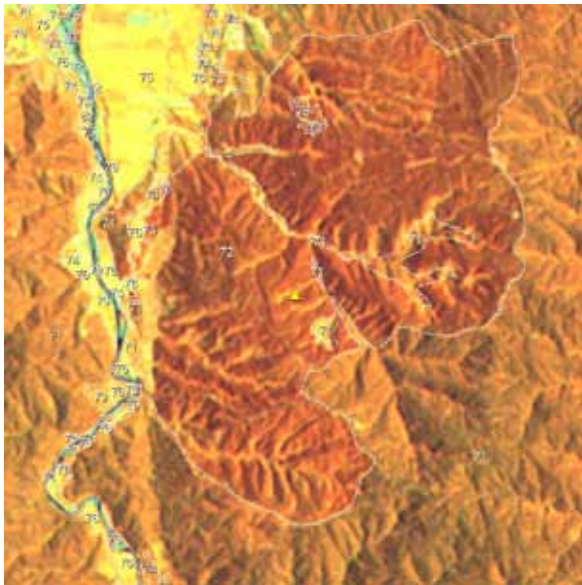
| | |
|-----------------------|--|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2003 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Northwest of Tolaga Bay, Grid reference 2961515, 6314672 (NZMG), 2051625, 5753336 (NZTM) |
| 1990 land use: | Pre-1990 planted forest |
| 2008 land use: | Pre-1990 planted forest |
| Explanation: | The central portion of the 1990 image (with a few clouds and cloud shadows) is planted forest, with some grassland areas in the margins of the image. These planted forests have a bright red colour and persist through to 2008, with new plantings evident in both the 1996 SPOT 2 imagery and in the 2000 Landsat 7 imagery. There is also some evidence of harvesting in the 2008 SPOT 5 imagery. The large cyan-coloured landslide/gullied area in the northwest portion of the 1996–2008 imagery would be classified as ‘other’ as it is large enough to be easily identified. |

+ Pre-1990 planted forest: Example 2 +



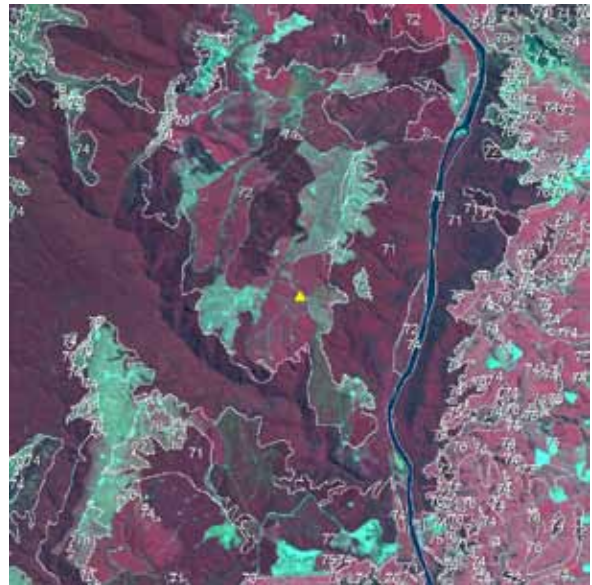
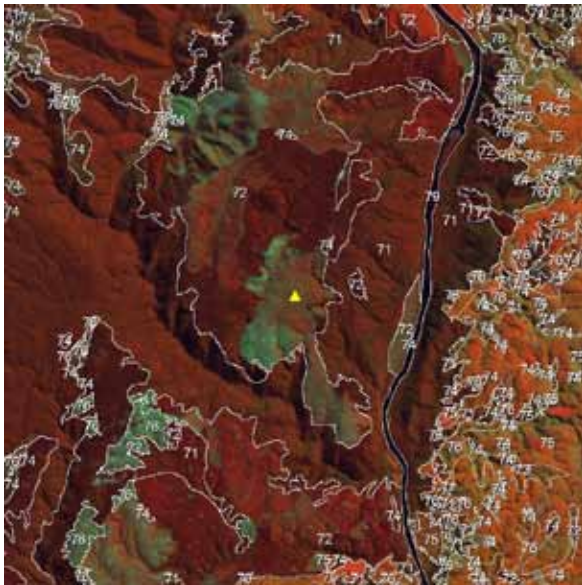
| | |
|-----------------------|--|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left), 2008 SPOT 5 (bottom right) |
| Location: | Northwest of Rotorua, Grid reference 2778004, 6354239 (NZMG), 1867824, 5792700 (NZTM) |
| 1990 land use: | Pre-1990 planted forest |
| 2008 land use: | Pre-1990 planted forest |
| Explanation: | In this example there is evidence of clearing at 1990 which is either harvesting or preparation for planting of exotic forest. Planted forest is evident in the 1996, 2000 and 2008 imagery. Irrespective of whether there are young trees planted at 1990, it is clear the land is being managed as a forestry land use at that date, and it should therefore be mapped as pre-1990 planted forest. |

Pre-1990 planted forest: Example 3



| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 1999 Landsat 7ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | South of Whakatane, Grid reference 2871350, 6324612 (NZMG), 1961300, 5763175 (NZTM) |
| 1990 land use: | Pre-1990 planted forest |
| 2008 land use: | Pre-1990 planted forest |
| Explanation: | The land use in these four images has not changed over the period 1990 to 2008. The centre of each image shows a large area of planted forest, which is surrounding smaller areas of natural forest. Where there are areas of natural forest > 1 ha within such planted forest blocks, they will be mapped separately, for example the polygon labelled 71 within the planted forest polygon is an area of natural forest (riparian). Where there are small pockets (1 to < 5 hectares) of other (non-forest) land uses present they will be mapped as the surrounding land use, in this example pre-1990 planted forest. |

+ Pre-1990 planted forest: Example 4 +



| | |
|-----------------------|--|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Blue Mountains, Otago Region. Grid reference 2235636, 5468040 (NZMG), 1325841, 4906260 (NZTM) |
| 1990 land use: | Pre-1990 planted forest |
| 2008 land use: | Pre-1990 planted forest |
| Explanation: | This is a depiction of land that has been harvested and then replanted over the period 1990–2008. The land use for this area has not changed and therefore remains pre-1990 planted forest. The bright green areas in the SPOT 2 1996 image are recently harvested blocks. The Landsat 7 ETM+ image shows the harvested areas have been replanted, and that some additional areas of planted forest have been harvested. This trend continues and is shown in the 2008 SPOT 5 imagery. |

Grassland with woody biomass

This land-use class comprises managed grasslands containing woody vegetation that does not meet the forest definition (area, height and canopy cover). The woody vegetation may include scattered tall trees, riparian vegetation, linear shelterbelts, and/or erosion control plantings. The land-use class also contains scattered areas of shrubland (broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland less than 5 m in height and any percentage cover).

Where there are well-separated and isolated small clumps of woody vegetation, these can be ignored in assigning a land-use sub-category, so the overwhelming dominance of the surrounding land-use type is used to determine the mapped class. In the grassland context, the use of either low- or high-producing is preferred instead of woody biomass.

It has been demonstrated, using temporal trends in land use (over the period 1964–2001, or a 30–40 year timeframe), and knowledge of farmer’s land-use intentions and land management practices, that under business-as-usual pastoral farming, scattered manuka/kanuka shrubland and indigenous broadleaved shrubland do not exceed the crown cover and minimum area thresholds for Kyoto forest, and that where this does occur it is through human intervention that favours shrubland establishment (Trotter and Mackay, 2005). Further, these researchers established, by relating farmer intentions to changes in land-use/cover, the basis for interpreting changes in land cover as changes in land use in those instances where land-use information is not directly obtainable. Accordingly, where evidence of grazing/grassland management exists and the vegetation present does not currently meet the forest definition as at 1990, the area is classified as grassland with woody biomass. Evidence of grassland management includes: pasture in immediate locality, fence lines, cattle troughs, farm tracks, and accessibility to farm grazing stock.

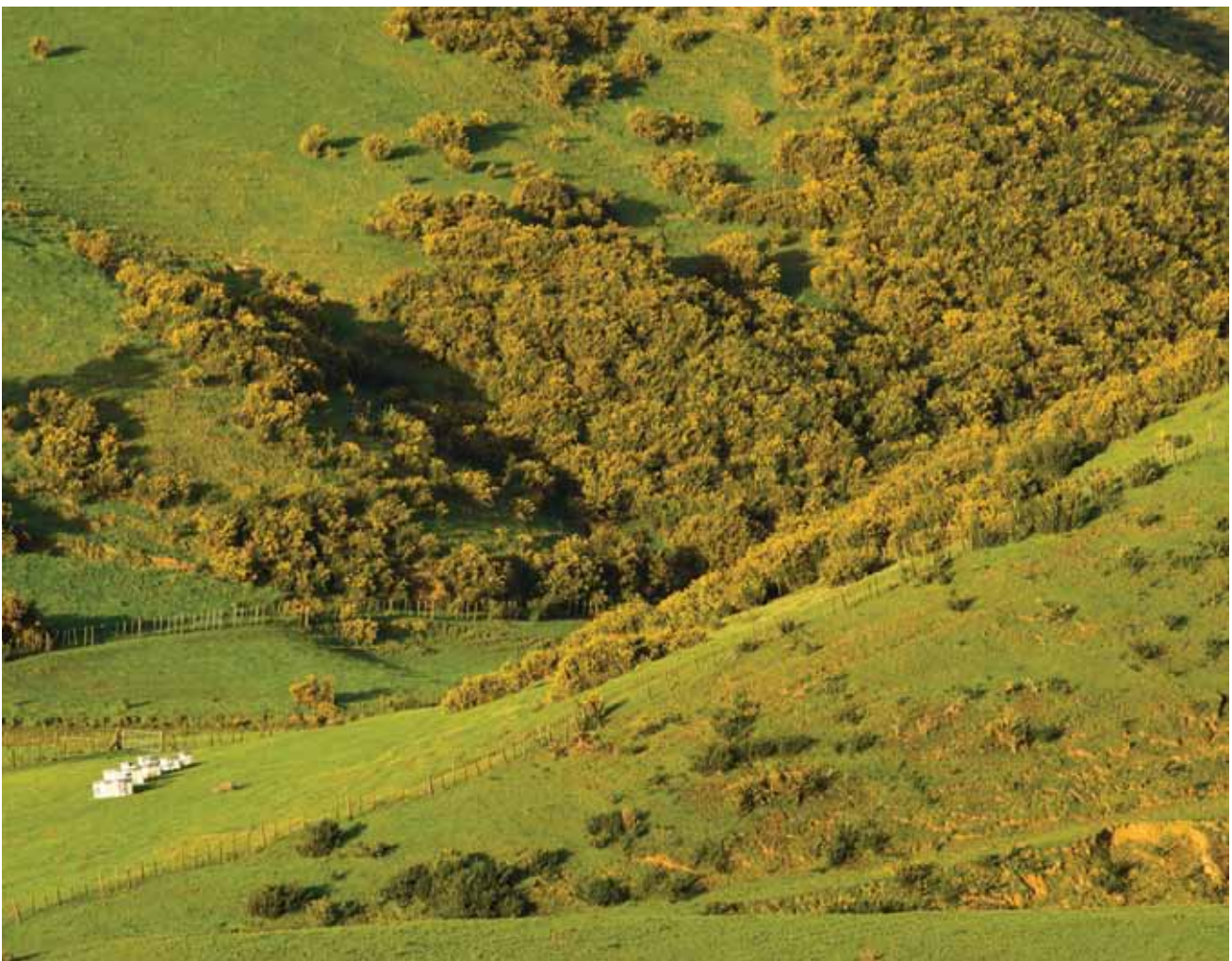
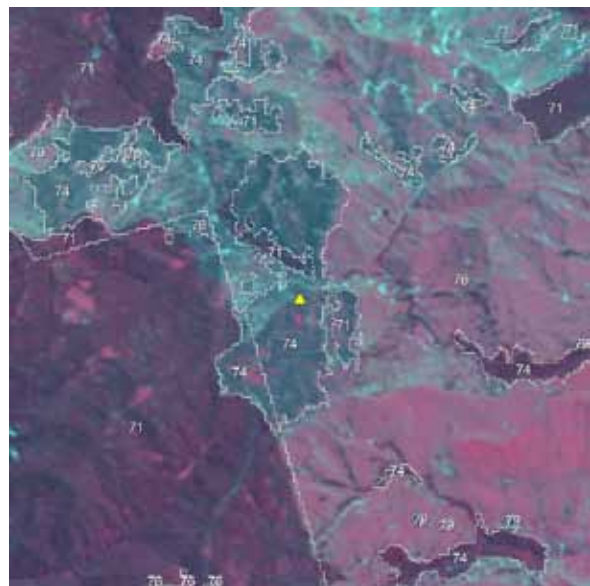
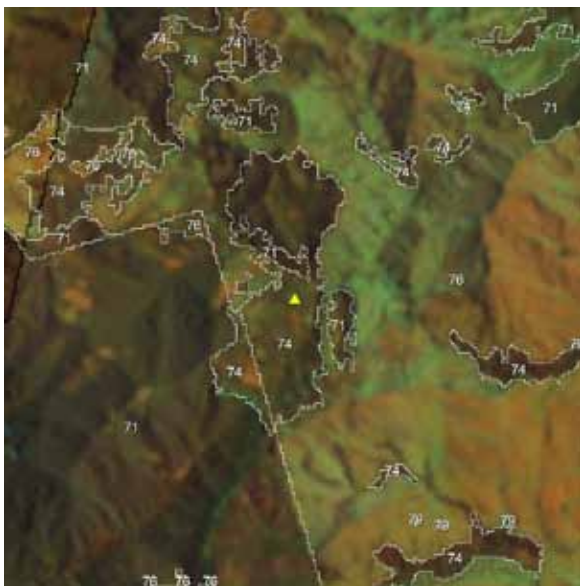
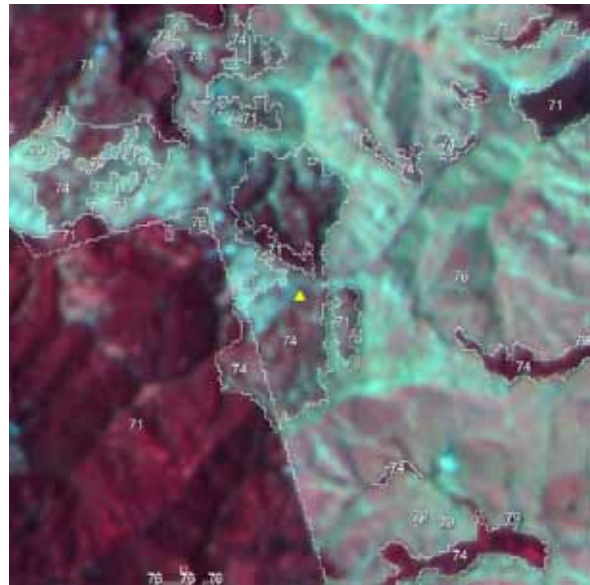
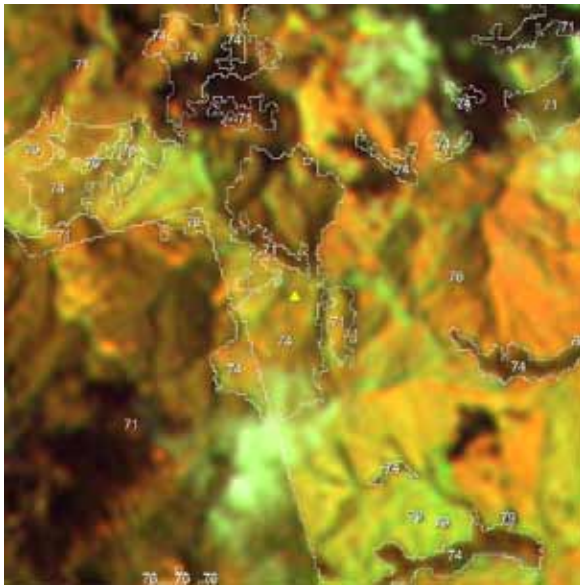


Photo credit: “Woody” by Garry Woodroffe from www.mychillybin.co.nz

Grassland with woody biomass: Example 1



| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Inland, West of Gisborne. Grid reference 2900029, 6262028 (NZMG), 1990087, 5700537 (NZTM) |
| 1990 land use: | Grassland – with woody biomass |
| 2008 land use: | Grassland – with woody biomass |
| Explanation: | In 1990, the majority of the right side of the image (labelled 76) is low-producing pasture with evidence of scattered woody shrubland species in the central area (labelled 74). These areas are more evident in the 1996 and 2000 imagery. Accordingly, these areas are classified as grassland – with woody biomass. The bottom left part of this image in 1990 (labelled 71) would be classified as natural forest, being closed canopy cover comprising woody shrubland species that would either be 5 m in height or have the potential to reach 5 m in 30–40 years time under the 1990 land management regime. |

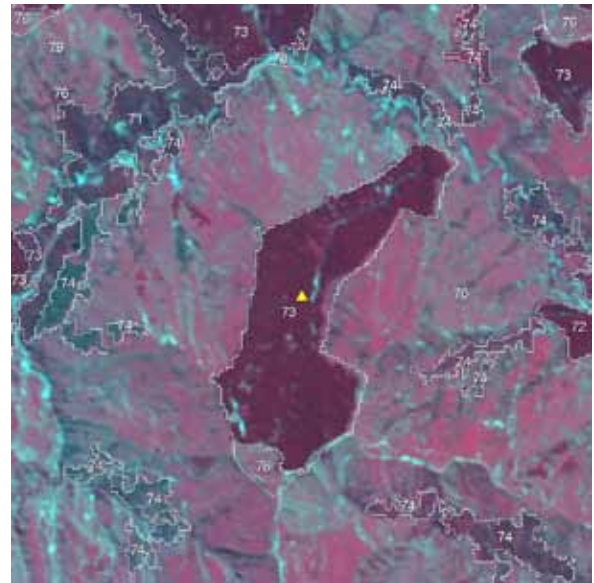
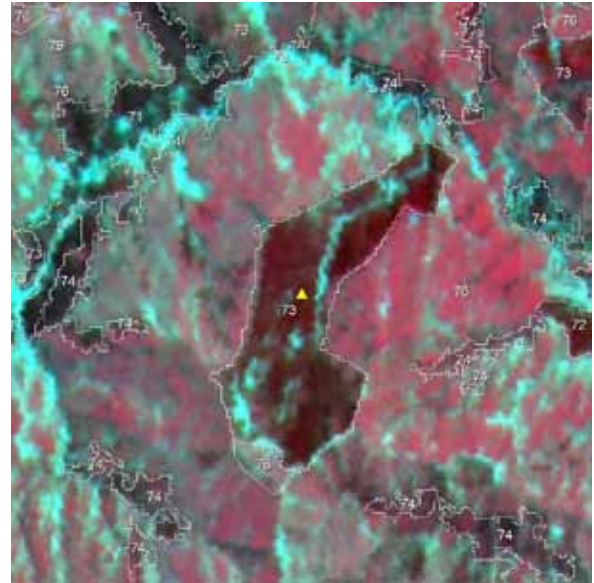
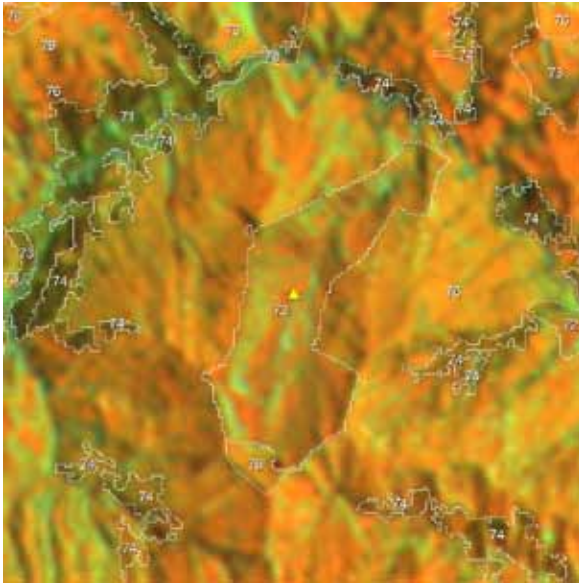
Post-1989 forest

These include forests which meet the forest parameters adopted by New Zealand for the Kyoto Protocol reporting and have either been planted or established after 1 January 1990, on land which was non-forest land as at 31 December 1989. Generally, these forests are planted with exotic species, but they may arise from natural regeneration of indigenous tree species as a result of management change after 1 January 1990. For exotic forest they include radiata pine, Douglas-fir, eucalypts, or other planted species (with potential to reach ≥ 5 m height at maturity *in situ*) and roads/tracks/skids less than minimum area/width within forested areas. This class also includes riparian or erosion control plantings (≥ 30 per cent cover, potentially ≥ 5 m height *in situ*).



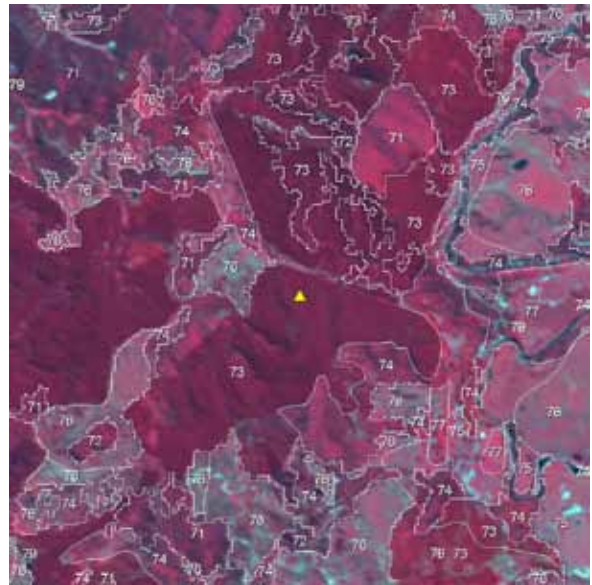
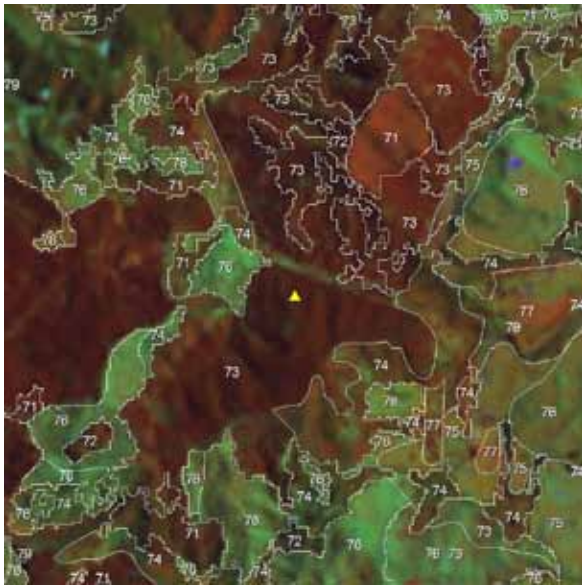
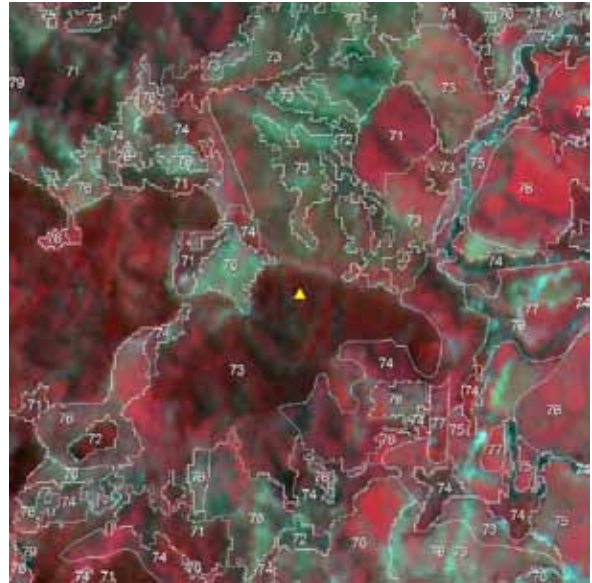
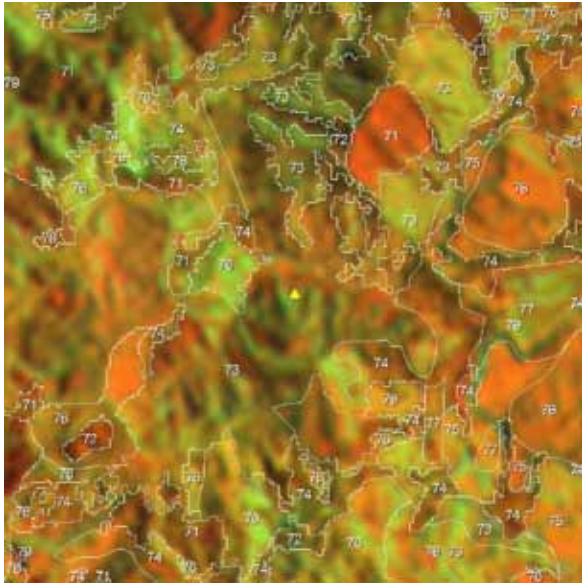
Caption: Young pine trees in post-1989 forest.

+ Post-1989 forest: Example 1 +



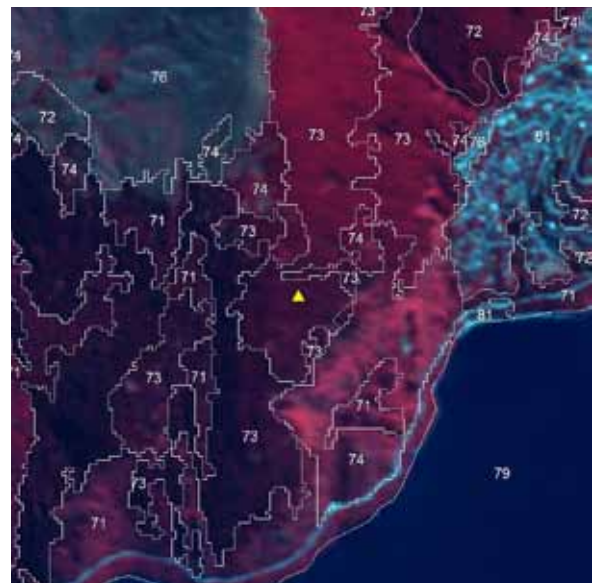
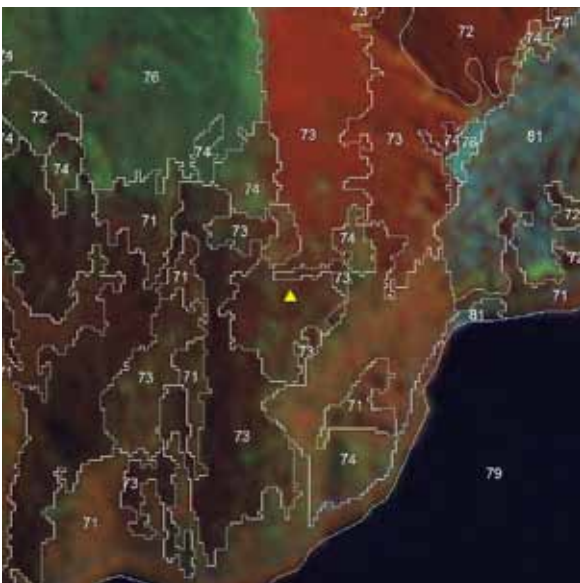
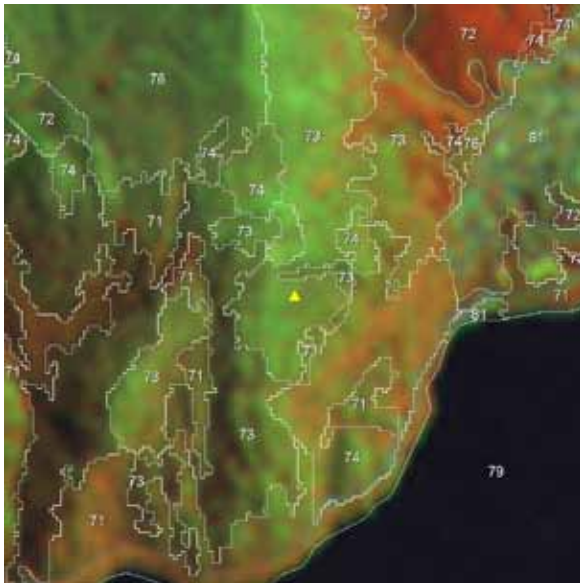
| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | West of Gisborne, Grid reference 2922572, 6263985 (NZMG), 2012663, 5702516 (NZTM) |
| 1990 land use: | Grassland – low producing |
| 2008 land use: | Post-1989 forest |
| Explanation: | In this example, the 1996 SPOT 2 imagery provides key information for making a 1990 land-use decision. The central polygon is classified as grassland – low producing in the 1990 land-use map (LUM) data. From the 1996, 2000 and 2008 imagery, we can determine the forest in the central polygon was planted after 1 January 1990 and should therefore be classified as post-1989 forest in the 2008 LUM data. |

Post-1989 forest: Example 2



| | |
|-----------------------|--|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Northeast of Gisborne, Grid reference 2948803, 6274378 (NZMG), 2038931, 5712950 (NZTM) |
| 1990 land use: | Grassland – low producing |
| 2008 land use: | Post-1989 forest |
| Explanation: | In the 1990 imagery, the central area is slightly darker than neighbouring steep hill country slopes, however the orange colour in the gullies indicates small pockets of natural forest. Planted forest is present in the 1996 and 2000 imagery. It is inferred that the area was planted soon after 1990 and is therefore classified as post-1989 forest. The small polygon to the north of the reference point (labelled 73) is also classified as post-1989 forest; however it is not planted until much later. The 1996 imagery does not indicate planted forest but forest is present in the 2000 Landsat 7 and 2008 SPOT 5 imagery. |

+ Post-1989 forest: Example 3 +



| | |
|-----------------------|---|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Near Bob's Peak, Queenstown. Grid reference 2164642, 5564431 (NZMG), 1254655, 5002642 (NZTM) |
| 1990 land use: | Grassland – low producing |
| 2008 land use: | Post-1989 forest |
| Explanation: | In this area on the western edge of Queenstown, the vegetation in the 1990 image has the typical spectral signature of tussock grassland. Between 1990 and 1996 there has been a dramatic change in spectral response due to tree growth. As the edge of the forest is not depicted as a series of clean and straight lines, it is assumed the forest is wilding pines (Douglas-fir). Accordingly, this series of satellite imagery shows an area at 1990 as being grassland – low producing which changed to post-1989 forest by 1996 and through to 2008. |

Cropland – perennial

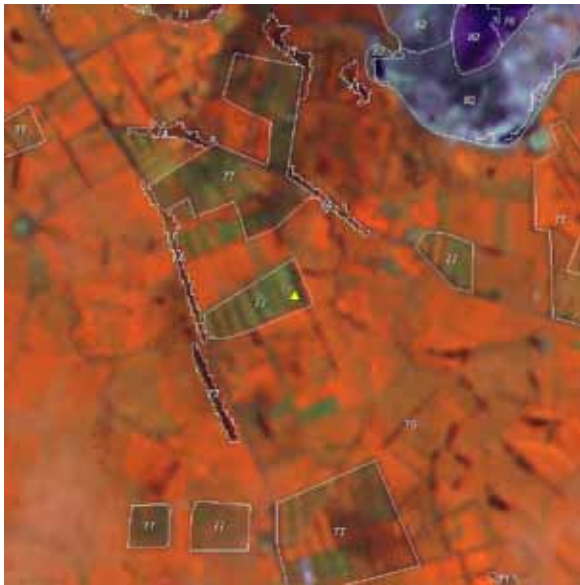
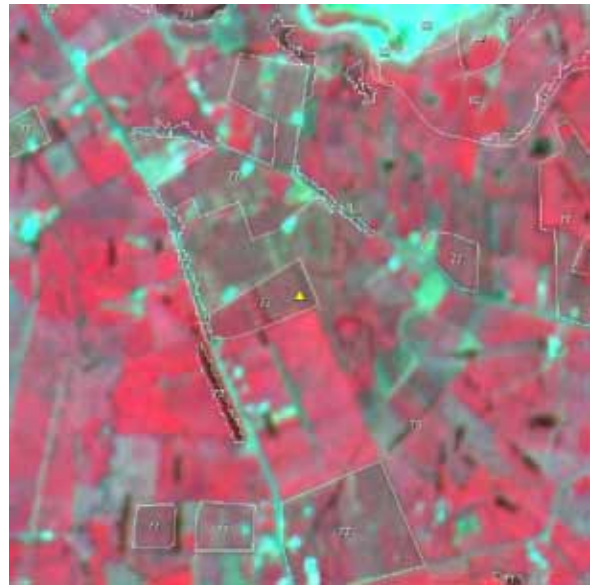
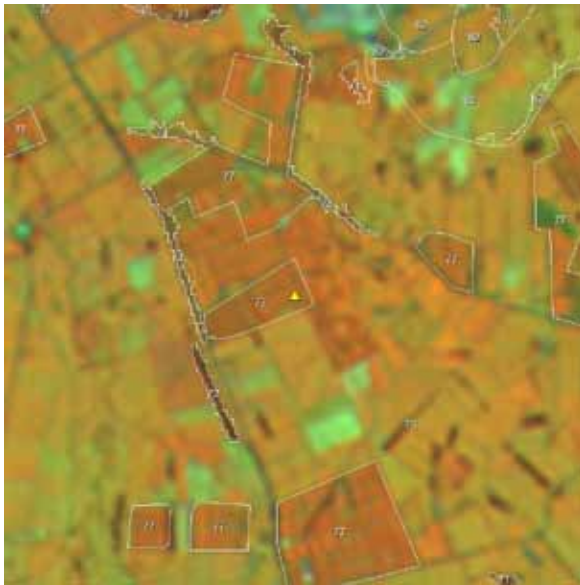
All orchards and vineyards (it is assumed that no crops meet the forest definition) and linear shelterbelts associated with cropland.

Initially LCDB2 was used to account for perennial cropland. During the 2008 land-use mapping it was found that the Agribase layer was better suited for mapping areas of perennial cropland. The 2008 cropland mapping was subsequently improved using the Agribase layer as a guide to mapping new areas of perennial cropland.



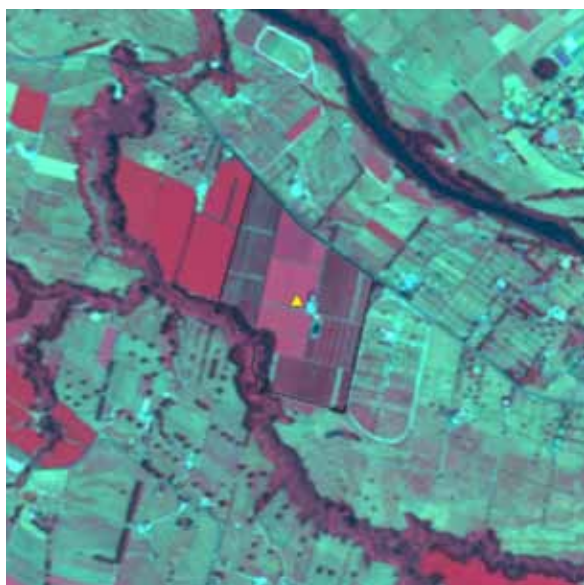
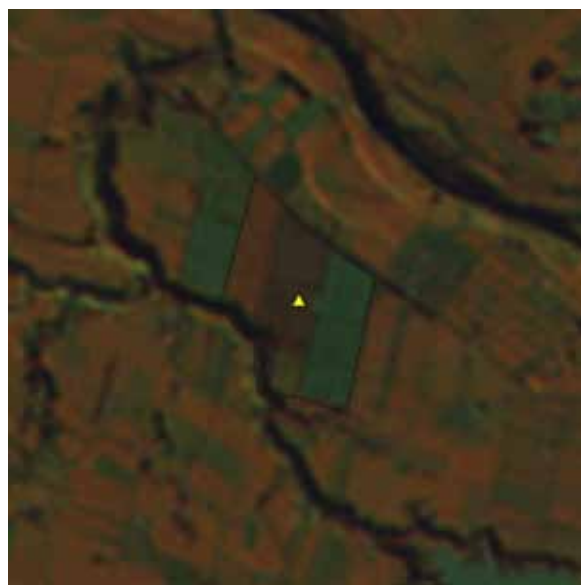
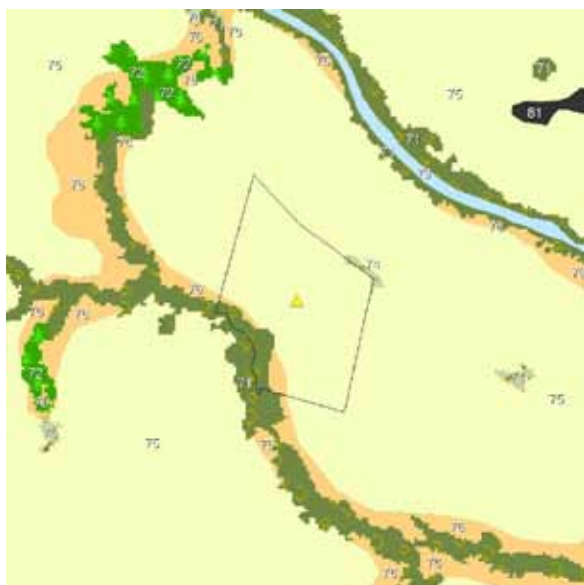
Caption: Ascension Wine Estate, Auckland.

+ Cropland – perennial: Example 1 +



| | |
|-----------------------|--|
| Images: | 1990 Landsat 4 (top left), 1996 SPOT 2 (top right) Landsat 7 ETM+ (bottom left) and 2008 SPOT 5 (bottom right) |
| Location: | Waikato region. Grid reference 2764773, 6416585 (NZMG), 1854483, 5855061 (NZTM) |
| 1990 land use: | Cropland – perennial |
| 2008 land use: | Cropland – perennial |
| Explanation: | In this area of Waikato the polygons labelled 77 are cropland – perennial. Perennial cropland mapping is based on LCDB1 and LCDB2 for the 1990 and 2008 (respectively) land-use maps. Additional perennial cropland areas have been identified using Agribase. |

Cropland – perennial: Example 2 (using Agribase to update cropland)



| | |
|----------------------|--|
| Images: | Agribase layer on top of 1990 land-use map (top left), Agribase layer on top of 1990 Landsat 4 (bottom left), Agribase layer on top of 2008 SPOT 5 (bottom left) and 2008 land-use map layer updated with improved classification (bottom right) |
| Location: | Waikato region. Grid reference 2722441, 6364054 (NZMG), 1812220, 5802439 (NZTM) |
| Top left: | The black box shows an Agribase polygon of perennial cropland. This polygon will be added to the LUM layer by clipping in the polygon and attributing the appropriate fields. |
| Top right: | The Landsat imagery shows there was cropland here in 1990. This area was not collected in LCDB1, therefore this is an improvement to the 1990 and 2008 land-use map. |
| Bottom left: | 2008 SPOT 5 imagery is used to clip proper boundary into LUM layer. |
| Bottom right: | Land-use map for 2008 showing the area is cropland – perennial. |

References

- Dymond JR, Shepherd JD, Qi J. 2001. A Simple Physical Model of Vegetation Reflectance for Standardising Optical Satellite Imagery. *Remote Sensing of Environment*. 37: 230–239.
- Dymond JR, Shepherd JD. 2004. The spatial distribution of indigenous forest and its composition in the Wellington region, New Zealand, from ETM+ satellite imagery. *Remote Sensing of Environment* 90: 116–125.
- Eyles GO. 1977. NZLRI worksheets and their applications to rural planning. *Town Planning Quarterly* 47: 38–44.
- IPCC, 2003. Penman, J, Gytarsky M, Hiraishi T, Krug T, Kruger D, Pipatti R, Buendia L, Miwa K, Ngara T, Tanabe K, and Wagner F (Eds.). Good Practice Guidance for Land Use, Land-use Change and Forestry. IPCC National Greenhouse Gas Inventories Programme. Published for the IPCC by the Institute for Global Environmental Strategies: Tokyo, Japan.
- Ministry for the Environment, 2006. New Zealand’s Initial Report under the Kyoto Protocol.
- Pratt J. 2007. LUCAS Project Glossary.
- Shepherd JD, Dymond JR. 2003. Correcting satellite imagery for the variance of reflectance and illumination with topography. *International Journal of Remote Sensing* 24: 3503–3514.
- Shepherd JD, Newsome P. 2009a. *Establishing New Zealand’s Kyoto Land Use and Land-use Change and Forestry 1990 Map*. Contract report prepared for Ministry for the Environment. Wellington: Ministry for the Environment.
- Shepherd JD, Newsome P. 2009b. *Establishing New Zealand’s Kyoto Land Use and Land-use Change and Forestry 2008 Map*. Contract report prepared for Ministry for the Environment. Wellington: Ministry for the Environment.
- Thompson S, Grüner I, and Gapare N. 2003. New Zealand Land Cover Database Version 2 Illustrated Guide to Target Classes. Ministry for the Environment, Wellington.
- Trotter C and Mackay A. 2005. Contract 04/05-0410-L: Potential Forest Land, an Interim Report. Contract report for Ministry for the Environment.
- Trotter C, Shepherd J, Belliss S, Berben P, Newsome P, Sutherland A, Willoughby J, and Lynn, I. 2008. Determining the area of change in Kyoto-related land cover between 1990 and 2000. Landcare Research contract report LC0708/162.

For more information

See the LUCAS website:

www.mfe.govt.nz/issues/climate/lucas/

View the latest LUCAS newsletter:

www.mfe.govt.nz/publications/climate/looking-at-lucas/index.html

See the latest New Zealand Greenhouse Gas Inventory report:

www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2010/index.html

Contact the LUCAS team:

lucas@mfe.govt.nz