

History of land development in the Lake Taupō catchment

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Note

This technical report comprises two standalone reports, combined into one volume for ease of use.

Report 1:

History of land development in the Lake Taupō catchment: a scoping study

Report 2:

History of land development in the Lake Taupō catchment: phase 2, north-eastern area

HISTORY OF LAND DEVELOPMENT IN THE LAKE TAUPŌ CATCHMENT - A SCOPING STUDY



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HISTORY OF LAND DEVELOPMENT IN THE LAKE TAUPŌ CATCHMENT - A SCOPING STUDY

Contract Report No. 3080

February 2013

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CONTENTS

1.	INTRODUCTION	1
2.	BACKGROUND CONTEXT AND HISTORY	1
2.1	Geology and soils	1
2.2	Historical land use	2
2.3	Nutrient sources for Lake Taupo	3
3.	EXTENT OF HISTORICAL AERIAL PHOTOGRAPHS	4
4.	MAPPING OF PASTURE ON SOUTH-EASTERN SHORES OF LAKE TAUPŌ	6
4.1	Identification of pasture	6
4.2	Extent of pasture	11
4.3	Resources required to identify and digitise pasture areas	11
5.	SCOPE FOR EXPANSION OF STUDY	11

Reviewed and approved for release by:



Sarah Beadel

Director

Wildland Consultants Ltd

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1. INTRODUCTION

Waikato Regional Council (WRC) commissioned Wildland Consultants Ltd to undertake a scoping study of land use in the eastern part of the Lake Taupo Catchment in the 1960s.

WRC would like to improve knowledge around the factors affecting current levels of nitrogen input into Lake Taupo. As part of this, they have been looking at the history of land development in the Taupo Catchment, in particular the location and areas of land on the eastern side of the lake that may have been farmed prior to 1975, but were then converted to plantation forest. Whilst the Council is aware that large areas in the Taupo catchment are currently in indigenous vegetation and plantation forestry, they would like to know what the historical pattern of development was. The Council has already compared the LRI information for 1977-79 with the current land cover (LCDB), and have ascertained that about 50 km², or 8% of the area currently in plantation forest, was covered in pasture at that time.

This initial study is a scoping study to map and report on part of the Taupo Catchment and to assess the usefulness of the resulting information. The initial work will focus on the 1960s (where photographs are available) and the eastern part of the Taupo Catchment.

2. BACKGROUND CONTEXT AND HISTORY

2.1 Geology and soils

The eastern side of Lake Taupo lies within the Taupo Ecological District in the Central Volcanic Plateau Ecological Region. The topography and geology is described by McEwen (1987) as:

“rolling to locally broken landscape centred on L. Taupo, mainly 300-600m a.s.l. formed from eroded upper Pleistocene pumice breccia fan with Holocene pumice alluvium in the NE, E and S, with small areas of rhyolite and dacite (Mt Tauhara

1091m a.s.l.), and more strongly dissected lower Pleistocene Whakamaru ignimbrite in the W and NW; both the Hauhungaroa Range in the W and lower slopes of the NW face of Kaimanawa Range in the S are greywacke and argillite”

Soils are described as:

“coarse textured volcanic ash soils from a moderately to very thick cover of young, coarse textured rhyolitic ash (Taupo) over older brown silty and sandy ashes; in the S soils have thin cover of andesitic Ngaurahoe ash; leaching ranges from moderate in lower rainfall areas to very strong as rainfall increases with podzolised soils and podzols where podocarps extensive; on steep slopes, with thin ash mantle, soils are shallow over ignimbrite, greywacke or Tertiary sedimentary rocks; coarse textured droughty pumice soils from thick deposits of pumice sands and gravels (including flow tephra) in river valleys and on terraces; small areas of peaty and alluvial soils, most extensive around southern shores of Lake Taupo”.

2.2 Historical land use

Ward (1956) provides a summary of land development in the Taupo area (from Rotorua south to Tongariro National Park) for the 1800s through to 1956. Prior to European settlement, Maori settlements occurred along the lake shores, along the Waikato River, and on forest edges. Crops were grown using slash and burn techniques, with areas of cultivation used for two to three years before being abandoned. Whilst this resulted in the replacement of forest by extensive areas of scrub, it later facilitated mechanised operations to establish pasture, as mature forest and large stumps was largely eliminated. The period 1890-1910 saw the peak of large-scale sheep farming in the district, with merinos and cheviots being grazed around the southern lake shores. However sheep farming was short-lived, and most stations were abandoned due to the combined effects of poor feed, loss of stock to dogs and weather, and transport issues. Bush sickness, poor stock health due to a then unknown mineral deficiency, finally put a halt to the expansion of farms into more isolated areas, and pumice soils developed a reputation as being difficult to farm. This paved

the way for the extensive establishment of plantation forests, and by 1925, over 80% of exotic forests in New Zealand were in Taupo Country.

Widespread expansion of agriculture throughout the Lake Taupo catchment did not occur until the 1930s. In this decade, the government began large scale vegetation clearance and pasture establishment to fast track the settlement of the area, and it was discovered that ‘bush sickness’ was caused by deficiencies in cobalt, which could be cured by the application of cobaltised superphosphate. Land development then ceased post 1941 due to World War II, and in some places pasture regenerated into scrub, but began again shortly after the war as land was needed to settle ex-servicemen. Between 1947 and 1954, over 300 dairy farms and 20 sheep farms were established, and the number of sheep in the district increased to 138,600. This included approximately 5000 sheep on the south-eastern shores of Lake Taupo, between Tokaanu and Motutere (interpreted from Ward 1954, Figure 4).

As of 1986, land uses within the lake catchment included indigenous forest and scrub (44.8%), exotic forest (14.3%), other lakes (18.6%), pasture (17.9%), tussock (3.1%), wetlands (1.1%), and urban areas (0.2%) (Livingstone *et al.* 1986)

2.3 Nutrient sources for Lake Taupo

Lake Taupo is the largest lake in New Zealand with a surface area of 622 km². The waters are oligotrophic, with historically very low levels of nitrogen, but nutrient loads are increasing (Hadfield 2007). Large areas of indigenous scrub and shrubland in the lake catchment have been converted to agricultural land uses over the past 50 years, and as discussed above, these areas are dependant on the application of nitrogen-based fertilisers to sustain pasture growth. These nutrients then enter groundwater flows, which are the primary means of transport for nutrients to the lake.

Murphy (2006) demonstrated elevated nitrate concentrations within groundwater from agricultural land, and from residential areas with septic tanks. In contrast, Murphy found low nitrogen concentrations in groundwater from forestry areas, and these low levels were maintained even following the clear-felling of forest plantations (Reeves and Rosen 2002, cited in Murphy 2006).

Groundwater flowing from wetland areas is also very low in nitrogen (Eser and Rosen 1999, cited in Murphy 2006) and presumably most areas of indigenous vegetation, whether wetland or forest and shrubland, contribute little or no nitrogen to the lake.

Groundwater has a mean residence time of 20-75 years in the lake catchment (Hadfield *et al.* 2001 cited in Murphy 2006), and high nitrate and nitrogen concentrations have been found in groundwaters with recent recharge (Hadfield 2007). This suggests that even without further nutrient inputs into groundwater, the trend towards higher nitrogen loads in the lake will continue for the short to medium term, and that further measures are required to protect water quality. Environment Waikato policy variation proposes to reduce nitrogen loading to the lake by 20% by the conversion of pasture to alternative land uses such as forestry, that require low inputs of nitrogen, the use of new farming practices and crops, and upgrades to wastewater treatment facilities.

3. EXTENT OF HISTORICAL AERIAL PHOTOGRAPHS

Historical aerial photographs taken between 1958 and 1979, and held by WRC, cover most of the Lake Taupo catchment (Figure 1 and Table 1). No aerials for this period are available for some of the upper stream catchments, which lie within the forests of the Hauhungaroa Range, the lower south-eastern slopes of Tongariro, and the Kaimainawa Range, or for the upper catchment of the Waihora Stream, that flows through pasture in the north-west of the lake catchment. Urban areas have the greatest coverage, with the towns of Taupo and Turangi covered by two or more different aerials during this time period.

The decade during this period with the greatest coverage of the lake catchment is the 1960s. Aerials for this period cover 125,967 ha, or 44.7% of the lake catchment. Aerials for the 1970s cover 93,484 ha, or 33.2%, and the 1950s cover 28,722 ha or 10.2% (Livingstone *et al.* 1986).

The aerials for the 12-year period from 1958-1969 (inclusive) cover 137,794 ha, or 48.9% of the lake catchment. As for most of the aerials, the coverage for this period is greatest for the lower stream and river catchments where most of the pasture occurs.

If all of the aerials are used, the extent of pasture could be mapped for 210,895 ha, or 74.8% of the catchment. However this would require the use of aerials spanning a period of 22 years (1958-1979) so would not be a “snapshot” of pasture use at a particular time.

Table 1: Dates, coverage, and location for historical aerials of the Lake Taupo catchment 1958-1979.

Aerial Date	Geographical Coverage	Location
1958	Southern lake catchment from Tokaanu in west to Mission Bay in east, and south to SH46 and Rangipo.	Hard copy and digital held by WRC
1959	Single aerial for north-western catchment centred on Waihaha Stream.	Hard copy in WRC Taupo office
1962	Two series covering all of eastern shoreline from Taupo to Tokaanu, and from Mission Bay south to the Waipakihi River.	Digital copy held by WRC
1965	Series covering north-eastern catchment from airport south to the headwaters of the Tauranga Taupo River.	Digital copy held by WRC
1969	Single aerial for south-western catchment centred on Lake Kuratau.	Hard copy in WRC Taupo office
1969	Single aerial centred for north-eastern catchment centred on the upper Mangamutu Stream.	Hard copy in WRC Taupo office
1971	Single aerial for northern catchment centred on SH5.	Hard copy in WRC Taupo office
1971	Single aerial for northern catchment centred on Nukuhau.	Hard copy in WRC Taupo office
1977	Series covering most of south-western catchment from Omori and Tokaanu upstream to western boundary of catchment.	Hard copy in WRC Taupo office
1979	Series covering most of north-western catchment from Omori to Waihora Bay upstream to western boundary of catchment.	Hard copy in WRC Taupo office
1979	Series covering northern catchment from Kawakawa Bay to Acacia Bay, excluding the headwaters of Whangamata Stream and Otaketake Stream.	Hard copy in WRC Taupo office

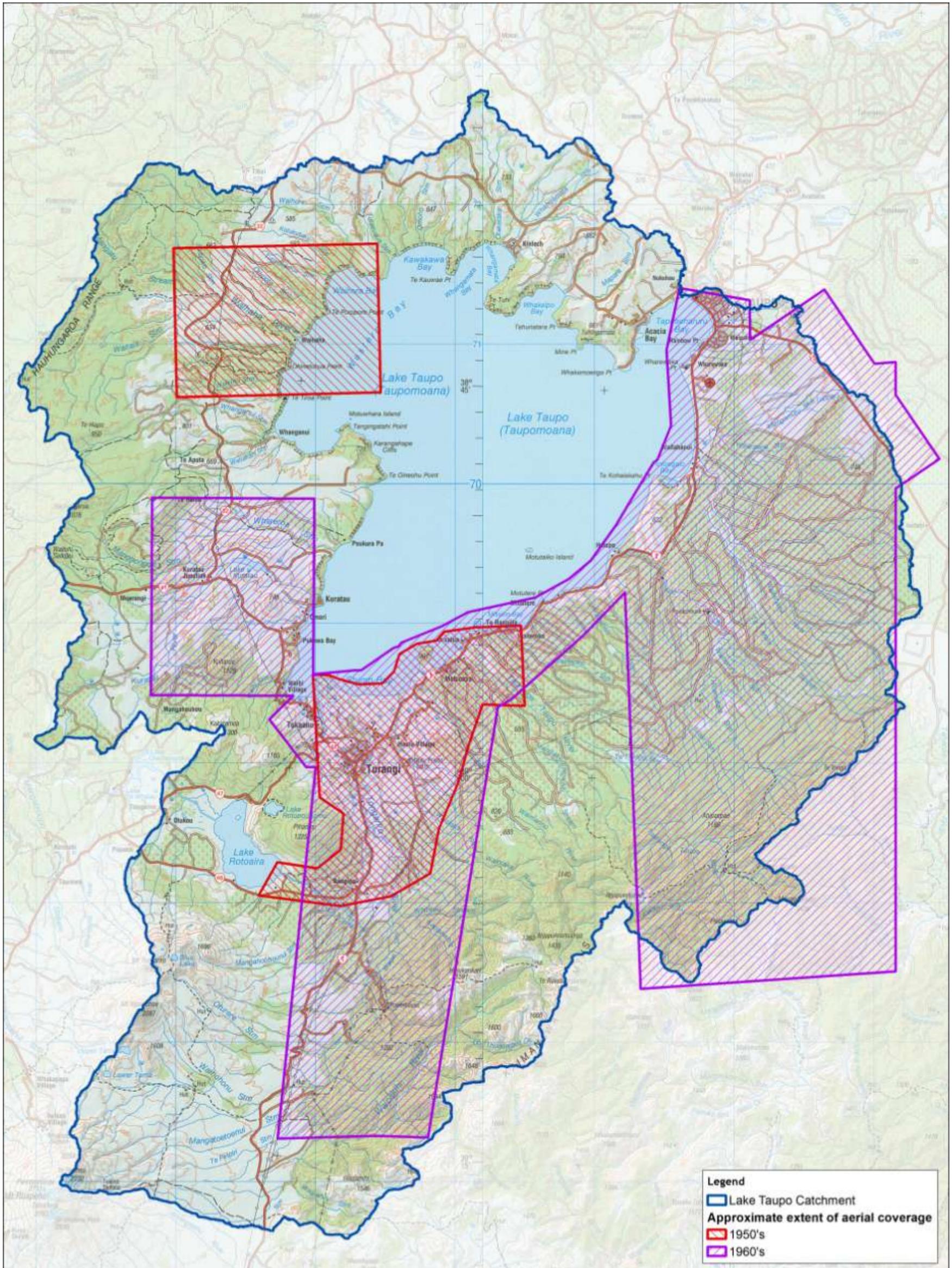
4. MAPPING OF PASTURE ON SOUTH-EASTERN SHORES OF LAKE TAUPŌ

4.1 Identification of pasture

Pasture on the black and white aerials usually shows as a fairly uniform grey. Pasture areas can also be identified in some areas by their patchwork nature, with different shades

according to grazing intensity and fertiliser use, and drains, small streams and fencelines are also often visible.

In contrast, scrub and forest shows up as dark tones (dark grey to black) and on topographic maps also tends to coincide with steeper land (especially steep hillslopes and gullies). Tussock is intermediate between pasture and scrub but usually shows up as a more stippled texture. The inclusion of areas of native grassland within 'pasture' areas cannot be ruled out, but tussock would be uncommon at the altitude of the study area. Greater care would need to be taken if the project site included land at 800-1000 m altitude where tussock is more prevalent. . Areas of scrub and forest recently cleared for pasture, and some wetland types (e.g. marshes) may also have been included within "pasture" due to their similarity in appearance.



Data Acknowledgment
 Map contains data sourced from LINZ
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 REC and Catchment boundaries sourced from NIWA
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Figure 1. Coverage of historical aerial photographs for the Lake Taupo catchment held by WRC for the 1950's-1960's



Wildlands
 www.wildlands.co.nz, 0168 WILDNZ
 Scale: 1:250,000
 Date: 20/02/13
 Cartographer: RPB
 Format: A3

4.2 Extent of pasture

Pasture was mapped using black and white aerial photographs taken in the eastern catchment in 1958, 1962, and 1965 (Figure 2). These photographs covered *c.*28,926 ha, of which *c.*12,896 ha was mapped as pasture, and *c.*16,030 ha as “not pasture”. This equates to 45% pasture coverage for this time period. A simplified map of historical pasture areas (1958-1965) is presented in Figure 3, and an overlay of historical pasture on recent land use (aerial photographs taken in 2007) is shown in Figure 4.

4.3 Resources required to identify and digitise pasture areas

Collation of the maps, and the identification, mapping, and digitising the areas of pasture for 28,926 ha of the eastern catchment, as shown in Figure 2, required 20 hours of GIS time. To estimate the cost of extending this study, GIS mapping time can be estimated at approximately seven hours per 10,000 ha.

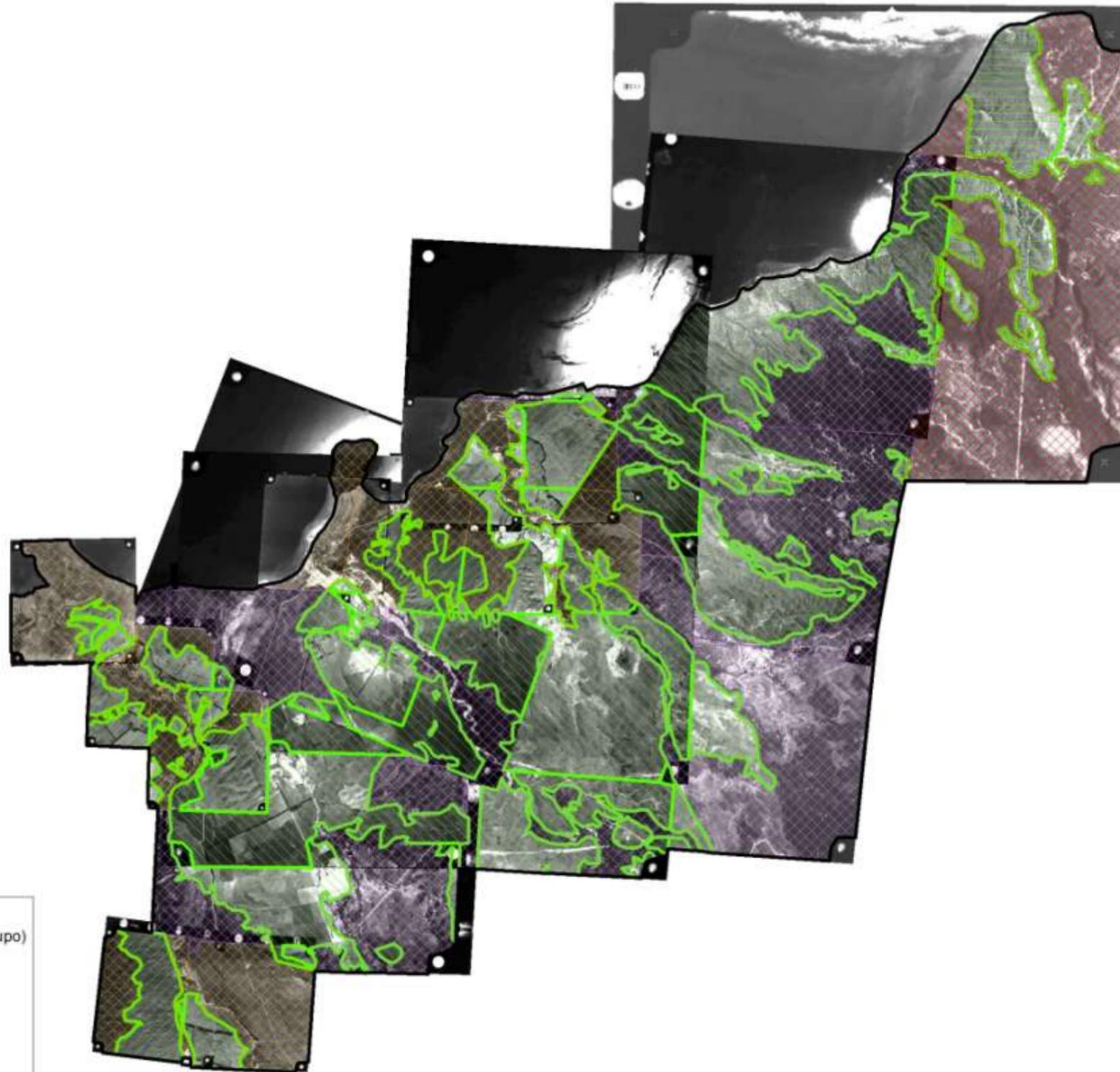
5. SCOPE FOR EXPANSION OF STUDY

The aerials held by WRC for the 12-year period from 1958-1969 (inclusive) cover 137,794 ha (Figure 5). Given that the mapping of 28,926 ha required *c.*20 hours of GIS time, the estimate for GIS time to extend coverage to include all of the aerials for this time period (a further 108,868 ha) is 77 hours. This would also require set up, oversight, interpretation, and reporting.

Additional aerials are held by New Zealand Aerial Mapping (NZAM). These aerials could be purchased to allow for pasture extent for the period 1969-1971 to be mapped for most if not all of the catchment. However, taking into consideration the cost of aerial purchase, time to travel to and from the WRC photograph archives in Taupo, and GIS time to combine the aerials held by NZAM with those by WRC, the most cost-effective method to digitise pasture areas for all of the Lake Taupo catchment is to purchase all of the required aerials from NZAM. Given the size of the Lake Taupo

catchment is 281,851 ha, this would require the mapping of a further 252,925 ha. This would require approximately 177 additional hours of GIS time.





Legend

- Extent of aerals (excluding Lake Taupo)
- Landcover - Photo Year**
- Pasture - 1958
- Pasture - 1962
- Pasture - 1965
- Not pasture - 1958
- Not pasture - 1962
- Not pasture - 1965

Data Acknowledgment
 Map contains data sourced from LINZ
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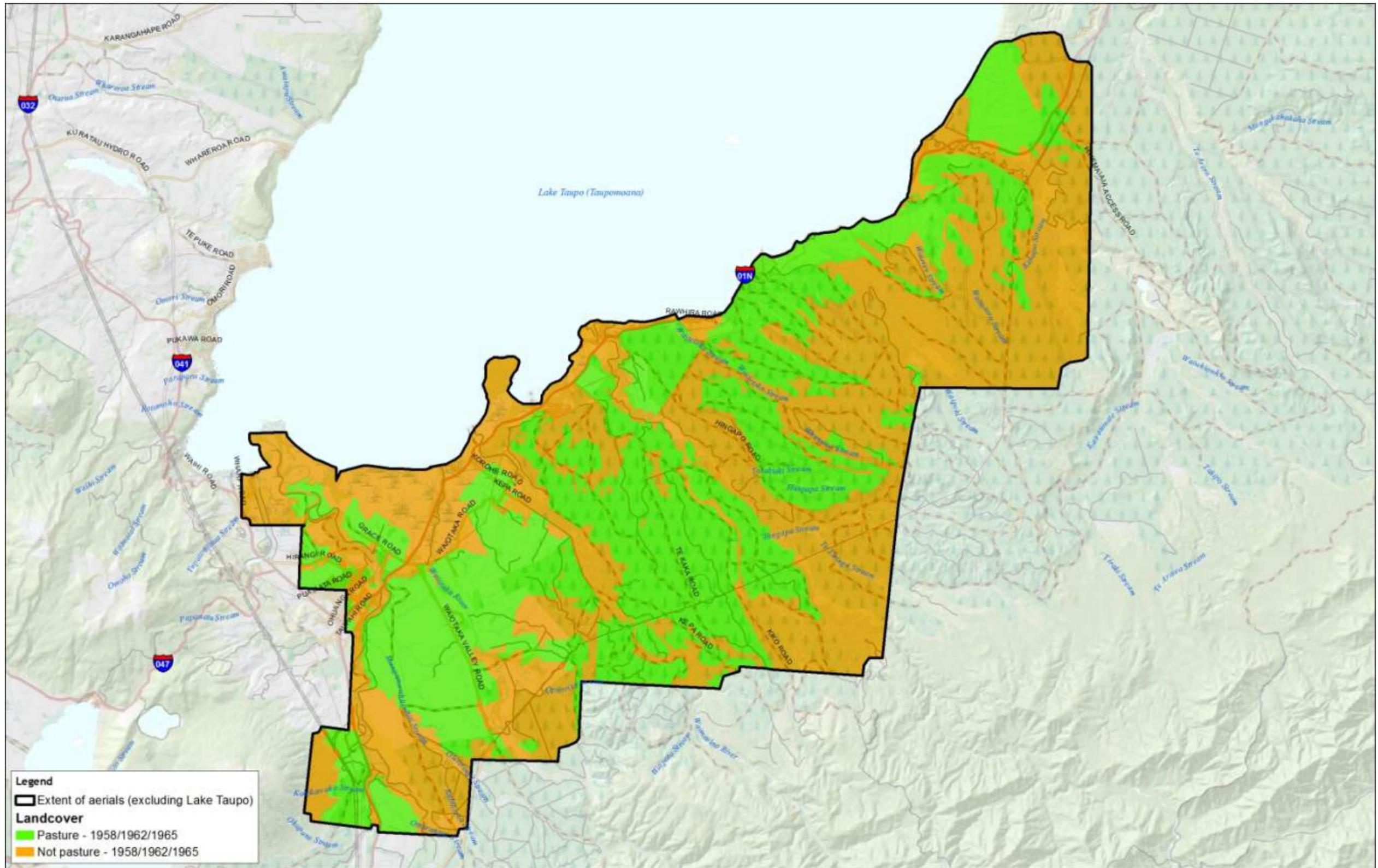
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 Ref: 01 1349
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Figure 2. Pasture Overlaid on Historical Aerial Photographs for Lake Taupo catchment - eastern side, 1958-1965



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 www.wildlands.co.nz 0800 WILDND

Scale: 1:110,000
 Date: 21/02/2013
 Cartographer: RPB
 Format: A3R



Legend

- Extent of aerials (excluding Lake Taupo)
- Landcover**
- Pasture - 1958/1962/1965
- Not pasture - 1958/1962/1965

Data Acknowledgment
 Map contains data sourced from LINZ
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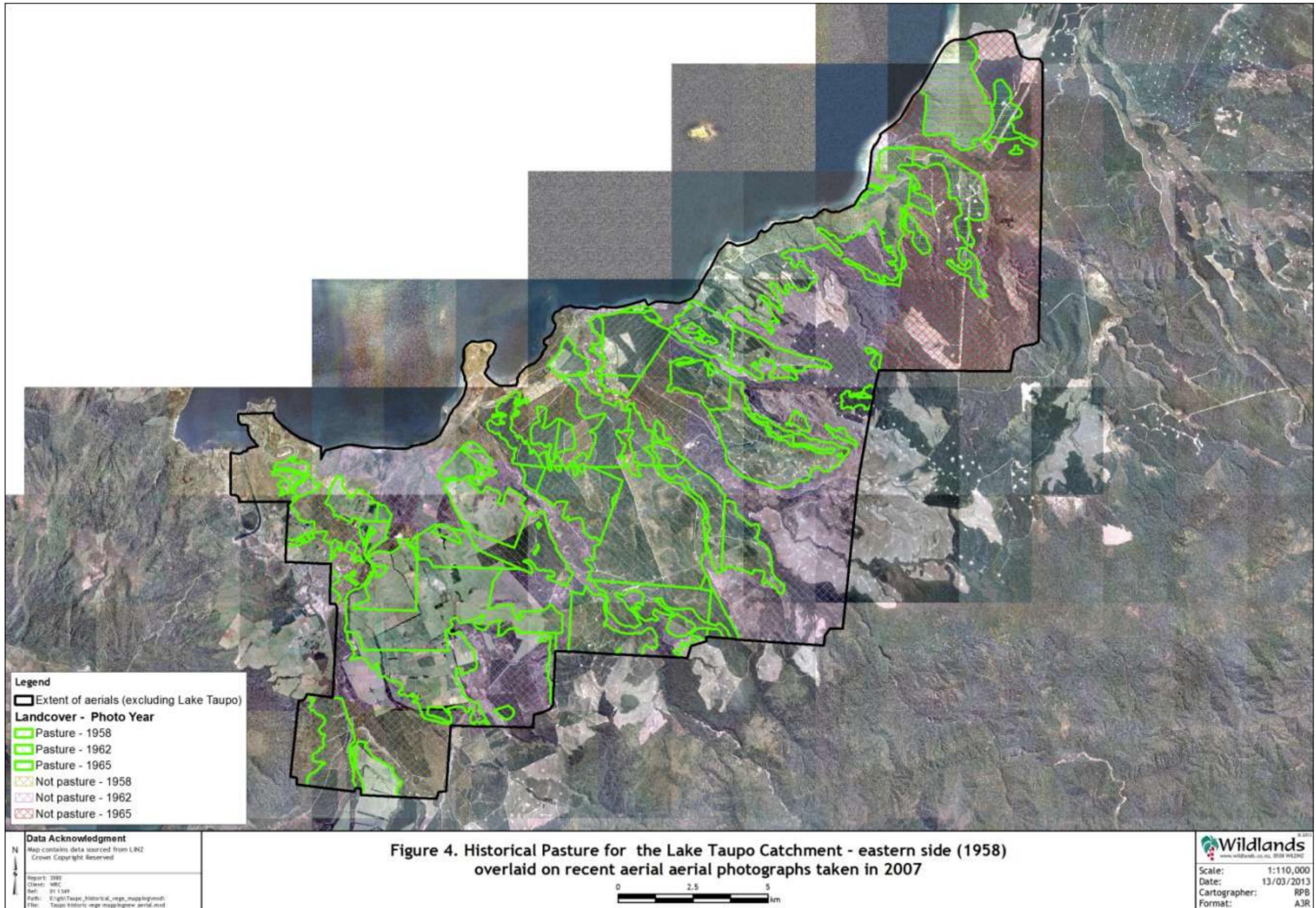
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 Client: MRC
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Figure 3. Pasture coverage within the Lake Taupo catchment - eastern side, 1958-1965



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 Date: 12/03/2013
 Cartographer: FM
 Format: A3R



HISTORY OF LAND DEVELOPMENT IN THE LAKE TAUPŌ CATCHMENT PHASE 2 - NORTH-EASTERN AREA

Contract Report No. 3190a

September 2013

Project Team:

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Federico Mazzieri - Mapping and GIS analysis

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CONTENTS

1.	INTRODUCTION	1
2.	BACKGROUND CONTEXT AND HISTORY	1
2.1	Geology and soils	1
2.2	Historical land use	2
2.3	Nutrient sources for Lake Taupo	2
3.	MAPPING OF PASTURE ON IN THE NORTH-EASTERN LAKE TAUPŌ CATCHMENT	3
3.1	Identification of pasture	3
3.2	Extent of pasture in north-eastern catchment in 1965	3
3.3	Extent of pasture - a comparison of north-eastern and south-eastern areas of the lake catchment	3
3.4	Extent of pasture - combined mapping for the early 1960s to date	4
4.	SCOPE FOR EXPANSION OF STUDY	4
	ACKNOWLEDGMENTS	5
	REFERENCES	5

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6. INTRODUCTION

Waikato Regional Council (WRC) commissioned Wildland Consultants Ltd to map the extent of pasture in the north-eastern part of the Lake Taupo Catchment in the 1960s.

The Waikato Regional Council would like to improve knowledge around the factors affecting current levels of nitrogen input into Lake Taupo. As part of this, they have been looking at the history of land development in the Taupo Catchment, in particular the location and areas of land that may have been farmed prior to 1975, but were then converted to plantation forest.

In 2012-2013, Wildland Consultants undertook a scoping study on a selected part of the Taupō catchment and reported on the availability of historical aerial photographs for the Taupo Catchment that are suitable for mapping pasture extent (Wildland Consultants 2013). As part of this scoping study, the extent of pasture was mapped for 28,926 ha within the eastern catchment, using aerial photographs taken in 1958-1965.

This report includes the mapping for 83,282 ha (part of which was also mapped in the earlier scoping study) within the north-eastern lake catchment, which is covered by aerials that were taken in 1965 (from the airport south to the headwaters of the Tauranga-Taupo River). The aerial photography for this area is held in digital format by WRC.

7. BACKGROUND CONTEXT AND HISTORY

7.1 Geology and soils

The eastern side of Lake Taupo lies within the Taupo Ecological District in the Central Volcanic Plateau Ecological Region. The topography and geology is described by McEwen (1987) as:

“rolling to locally broken landscape centred on L. Taupo, mainly 300-600 m a.s.l. formed from eroded upper Pleistocene pumice breccia fan with Holocene pumice alluvium in the NE, E and S, with small areas of rhyolite and dacite (Mt Tauhara 1,091 m a.s.l.), and more strongly dissected lower Pleistocene Whakamaru ignimbrite in the W and NW; both the Hauhungaroa Range in the W and lower slopes of the NW face of Kaimanawa Range in the S are greywacke and argillite”.

Soils are described as:

“coarse textured volcanic ash soils from a moderately to very thick cover of young, coarse textured rhyolitic ash (Taupo) over older brown silty and sandy ashes; in the S soils have thin cover of andesitic Ngaurahoe ash; leaching ranges from moderate in lower rainfall areas to very strong as rainfall increases with podzolised soils and podzols where podocarps extensive; on steep slopes, with thin ash mantle, soils are shallow over ignimbrite, greywacke or Tertiary

sedimentary rocks; coarse textured droughty pumice soils from thick deposits of pumice sands and gravels (including flow tephra) in river valleys and on terraces; small areas of peaty and alluvial soils, most extensive around southern shores of Lake Taupo”.

7.2 Historical land use

Ward (1956) provides a summary of land development in the Taupo area (from Rotorua south to Tongariro National Park) for the 1800s through to 1956. Prior to European settlement, Maori settlements occurred along the lake shores, along the Waikato River, and on forest edges. Crops were grown using slash and burn techniques, with areas of cultivation used for two to three years before being abandoned. Whilst this resulted in the replacement of forest by extensive areas of scrub, it later facilitated mechanised operations to establish pasture, as mature forest and large stumps was largely eliminated. The period 1890-1910 saw the peak of large-scale sheep farming in the district, with merinos and cheviots being grazed around the southern lake shores. However sheep farming was short-lived, and most stations were abandoned due to the combined effects of poor feed, loss of stock to dogs and weather, and transport issues. Bush sickness, poor stock health due to a then unknown mineral deficiency, finally put a halt to the expansion of farms into more isolated areas, and pumice soils developed a reputation as being difficult to farm. This paved the way for the extensive establishment of plantation forests, and by 1925, over 80% of exotic forests in New Zealand were in Taupo County.

Widespread expansion of agriculture throughout the Lake Taupo catchment did not occur until the 1930s. In this decade, the government began large scale vegetation clearance and pasture establishment to fast track the settlement of the area, and it was discovered that ‘bush sickness’ was caused by deficiencies in cobalt, which could be cured by the application of cobaltised superphosphate. Land development then ceased post 1941 due to World War II, and in some places pasture regenerated into scrub, but began again shortly after the war as land was needed to settle ex-servicemen. Between 1947 and 1954, over 300 dairy farms and 20 sheep farms were established, and the number of sheep in the district increased to 138,600. This included c.5,000 sheep on the south-eastern shores of Lake Taupo, between Tokaanu and Motutere (interpreted from Ward 1954, Figure 4).

As of 1986, land uses within the lake catchment included indigenous forest and scrub (44.8%), exotic forest (14.3%), other lakes (18.6%), pasture (17.9%), tussock (3.1%), wetlands (1.1%), and urban areas (0.2%) (Livingstone *et al.* 1986).

7.3 Nutrient sources for Lake Taupo

Lake Taupo is the largest lake in New Zealand with a surface area of 622 km². The waters are oligotrophic, with historically very low levels of nitrogen, but nutrient loads are increasing (Hadfield 2007). Large areas of indigenous scrub and shrubland in the lake catchment have been converted to agricultural land uses over the past 50 years, and as discussed above, these areas are dependent on the application of nitrogen-based fertilisers to sustain pasture growth. These nutrients then enter groundwater flows, which are the primary means of transport for nutrients to the lake.

Murphy (2006) demonstrated elevated nitrate concentrations within groundwater from agricultural land, and from residential areas with septic tanks. In contrast, Murphy found low nitrogen concentrations in groundwater from forestry areas, and these low levels were maintained even following the clear-felling of forest plantations (Reeves and Rosen 2002, cited in Murphy 2006).

Groundwater flowing from wetland areas is also very low in nitrogen (Eser and Rosen 1999, cited in Murphy 2006) and presumably most areas of indigenous vegetation, whether wetland or forest and shrubland, contribute little nitrogen to the lake.

Groundwater has a mean residence time of 20-75 years in the lake catchment (Hadfield *et al.* 2001 cited in Murphy 2006), and high nitrate and nitrogen concentrations have been found in ground waters with recent recharge (Hadfield 2007). This suggests that even without further nutrient inputs into groundwater, the trend towards higher nitrogen loads in the lake will continue for the short to medium term, and that further measures are required to protect water quality. Waikato Regional Council policy variation proposes to reduce nitrogen loading to the lake by 20% by the conversion of pasture to alternative land uses such as forestry, that require low inputs of nitrogen, the use of new farming practices and crops, and upgrades to wastewater treatment facilities.

8. MAPPING OF PASTURE ON IN THE NORTH-EASTERN LAKE TAUPŌ CATCHMENT

8.1 Identification of pasture

Pasture on the black and white aerials usually shows as a fairly uniform grey. Pasture areas can also be identified in some areas by their patchwork nature, with different shades according to grazing intensity and fertiliser use, and drains, small streams and fence lines are also often visible.

In contrast, scrub and forest shows up as dark tones (dark grey to black) and on topographic maps also tends to coincide with steeper land (especially steep hillslopes and gullies). Tussock is intermediate between pasture and scrub but usually shows up as a more stippled texture. The inclusion of areas of native grassland within 'pasture' areas cannot be ruled out, but tussock would be uncommon at the altitude of the study area. Greater care would need to be taken if the project site included land at 800-1,000 m altitude where tussock is more prevalent. Areas of scrub and forest recently cleared for pasture, and some wetland types (e.g. marshes) may also have been included within "pasture" due to their similarity in appearance.

8.2 Extent of pasture in north-eastern catchment in 1965

Pasture was mapped using black and white aerial photographs taken in the north-eastern catchment in 1965 (Figure 1). These photographs covered *c.*83,282 ha, of which *c.*12,155 ha was mapped as pasture, and *c.*66,284 ha as "not pasture", and 4,844 ha as "not mapped" due to obscuring of the land surface by cloud. This equates to 15% pasture coverage for this time period (Table 1). A simplified map showing the

extent of historical pasture area is presented in Figure 2, and an overlay of historical pasture on recent land use (aerial photographs taken in 2007) is shown in Figure 3.

Most of the pasture in the north-eastern catchment in 1965 occurred in the Hinemaia, Waipehi, Waitetoko, and Tauranga-Taupo catchments, south of a line between Te Kohaiakahu Point and the Te Ininga highpoint in the Kaimanawa Range. Pasture is also likely to have occurred between Te Kohaiakahu Point and Taupo, but this area is either excluded from the photograph series, or obscured by cloud. Along the north-eastern boundary of the catchment, to the south of SH5, large tracts of scrub and shrubland have been cleared to establish the extensive areas of pasture present today. The upper catchments of streams draining eastwards to Lake Taupo, from Te Araro Stream in the north to the Waiotaka River in the south, are in the foothills of the Kaimanawa Range. These upper catchments have largely retained their cover of indigenous forest from 1965 to the present.

Since 1965, most of the pasture areas (as mapped in Figure 1) have been converted to exotic forestry plantations. This is particularly evident in the Tauranga-Taupo and Hinemaia catchments, where the shape of pasture areas in 1965 closely follows the shape of areas currently in forestry (refer to Figure 1 and 2).

Table 1: Pasture extent for north-eastern Lake Taupo catchment, early 1960s.

Catchment Area	Date of Aerial Photographs	Coverage (ha)	Pasture (ha)	Pasture (%)	Not Pasture (ha)	Not Pasture (%)	Unknown (ha)	Unknown (%)
North-east	1965	83,282	12,155	15	66,284	79	4,844	6

8.3 Extent of pasture - combined mapping for the early 1960s to date

The mapping in Phase 1 and Phase 2 have been combined to give a total extent of pasture within these study areas. Where the mapping of pasture in the south-east catchment (28,926 ha, 1958-1965) and north-east catchment (83,282 ha, 1965) overlapped, the mapping for the south-east was used as this was derived from aerial photographs of higher resolution.

The total area in the study was c. 98,703 ha, of which pasture covered 18,237 ha (19%), in the eastern lake catchment in the early 1960s. The area studied was c. 34% of the total lake catchment.

9. SCOPE FOR EXPANSION OF STUDY

Additional aerials are held by New Zealand Aerial Mapping (NZAM). These aerials could be purchased to allow for pasture extent for the period 1969-1971 to be mapped for most if not all of the catchment. Given the size of the Lake Taupo catchment is 281,851 ha, and that to date 98,763 ha has been mapped, this would require the

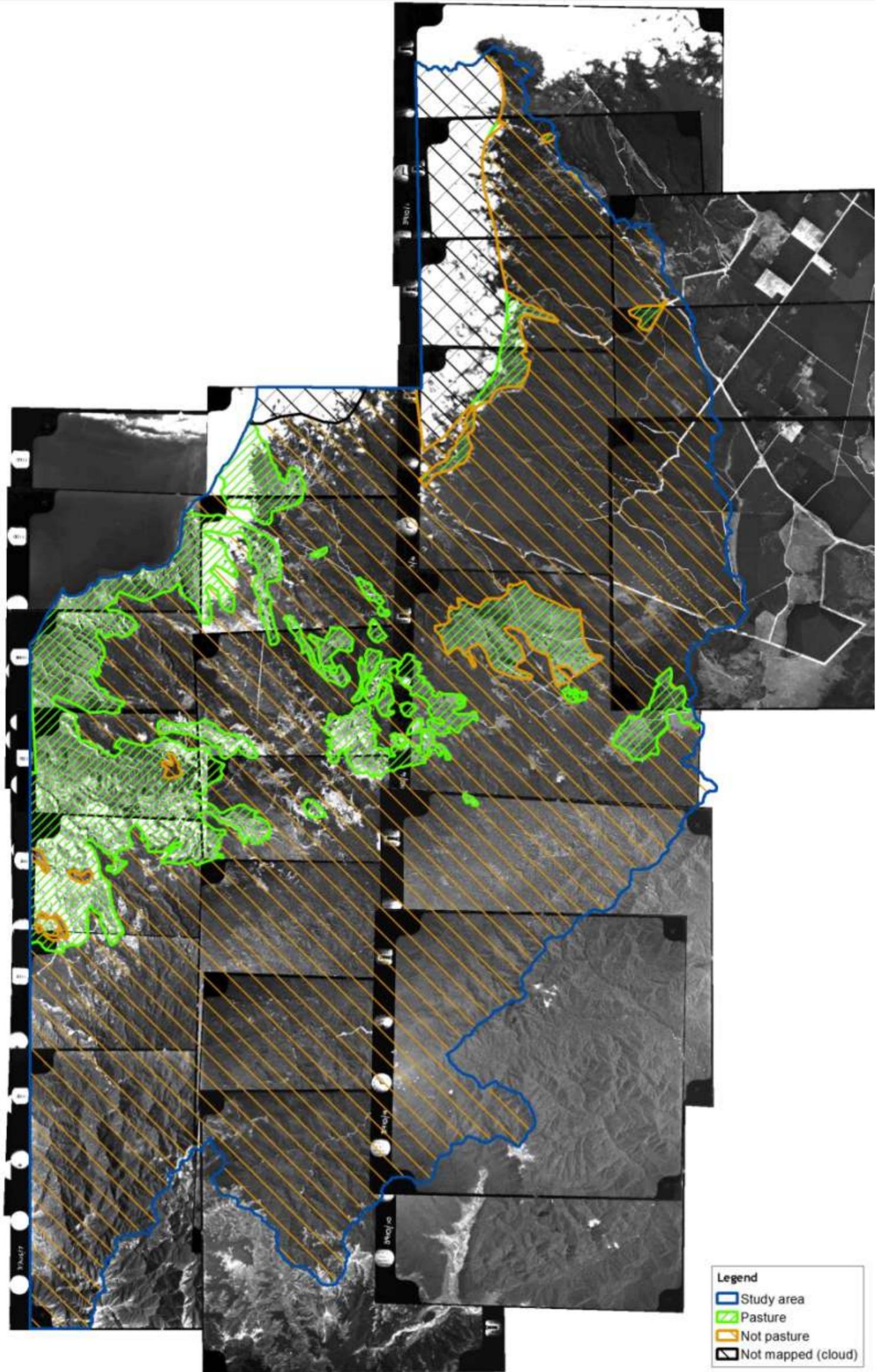
mapping of a further 183,088 ha. This would require approximately 128 additional hours of GIS time, at an estimated seven hours per 10,000 ha.

ACKNOWLEDGMENTS

Bill Vant (Waikato Regional Council) initiated this project and provided logistical report. Other staff at Waikato Regional Council, including JoAnne Evelyn, Aimee Rossi, Ed Brown, Dan Borman, Laurie Donal, and Sue Taylor assisted with the provision of historical aerial photographs and reports held by the Waikato Regional Council in Taupo and Hamilton.

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Legend

- Study area
- Pasture
- Not pasture
- Not mapped (cloud)

Data Acknowledgment
 Imagery sourced from Waikato Regional Council

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Figure 1. Extent of pasture identified from study of 1965 aerial photographs, north-eastern Lake Taupo catchment



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 Date: 13/09/2013
 Cartographer: RPB
 Format: A3

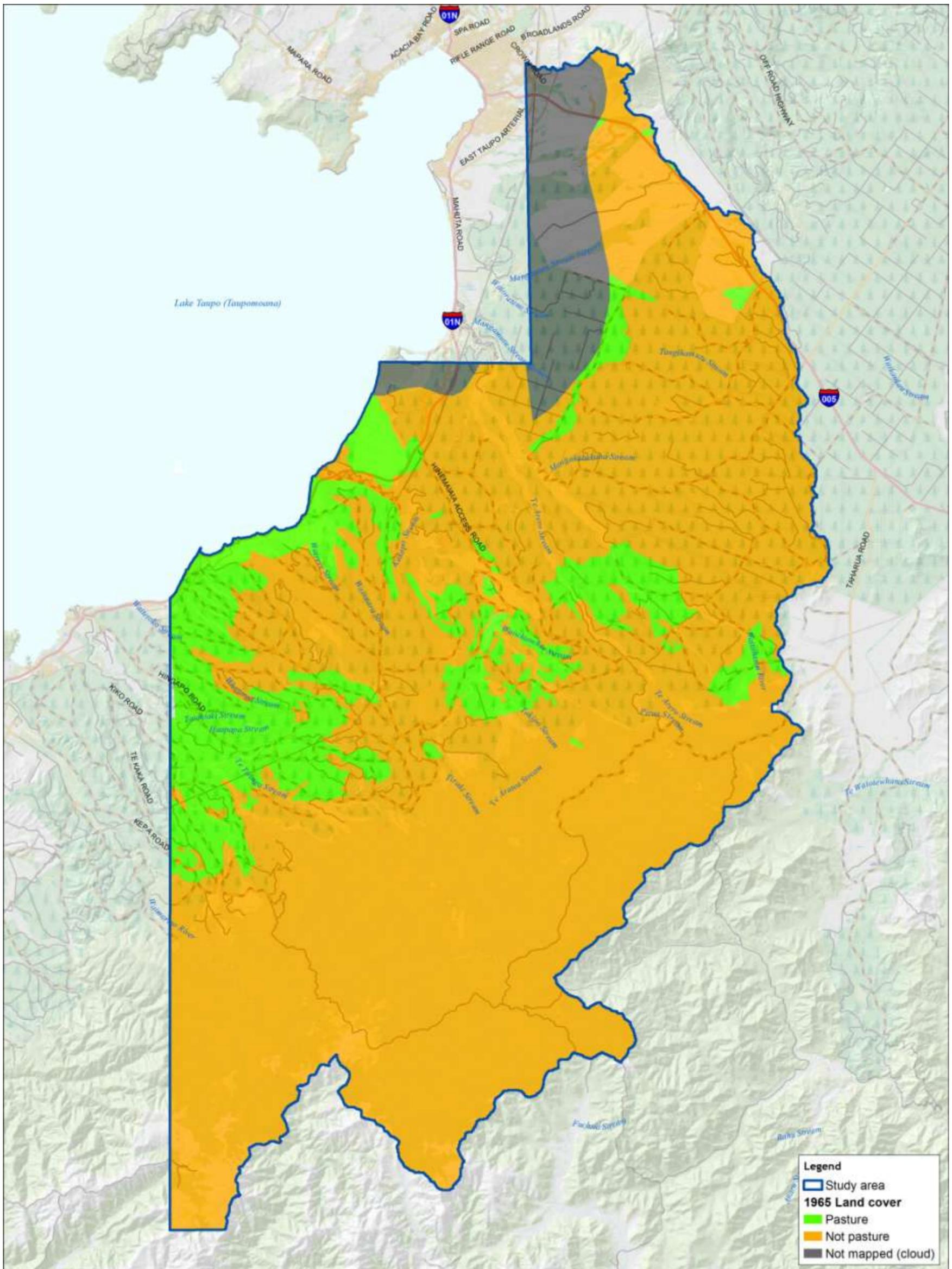


Figure 2. Extent of pasture present in 1965, north-eastern Lake Taupo catchment

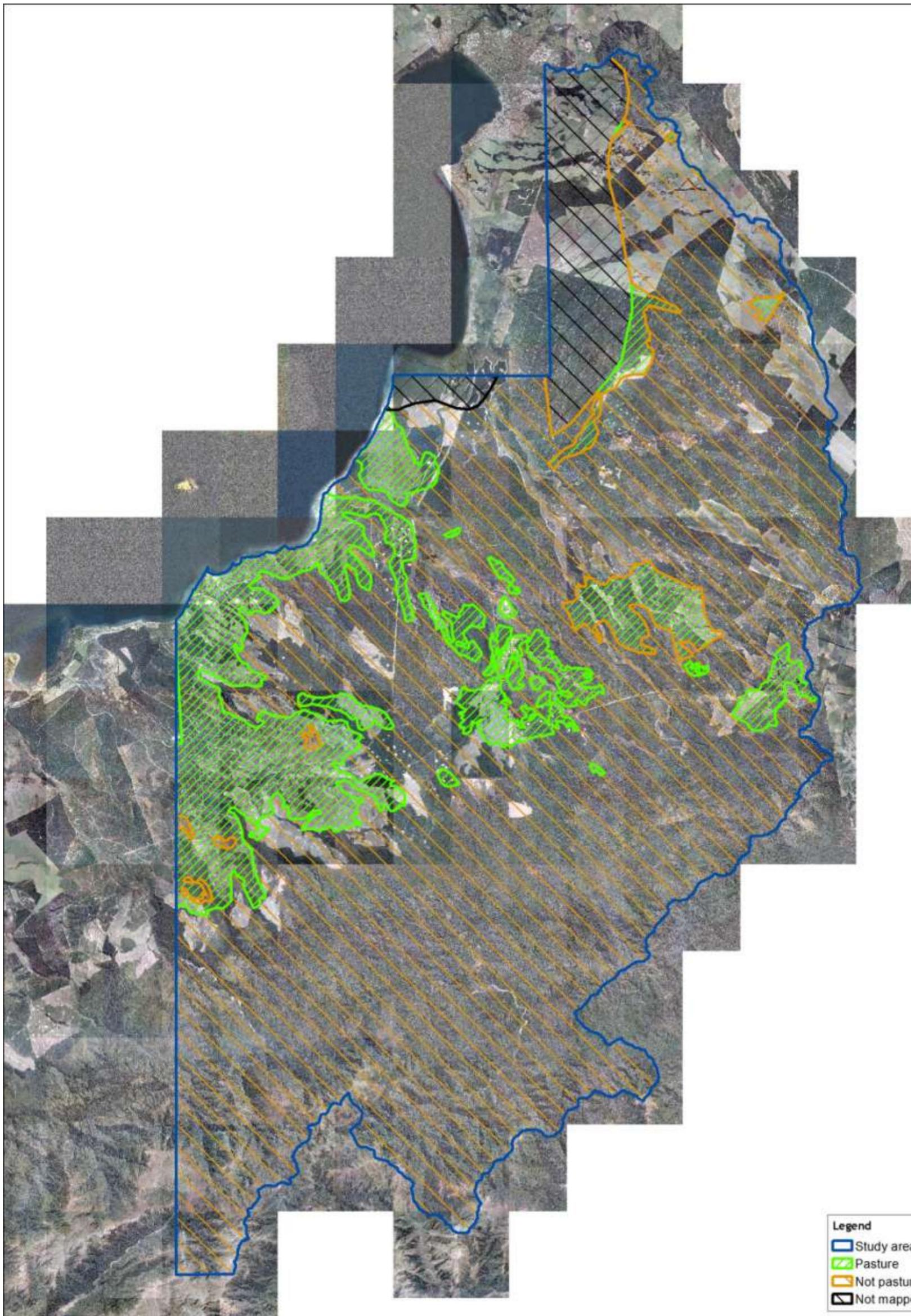


Legend

- Study area
- 1965 Land cover**
- Pasture
- Not pasture
- Not mapped (cloud)

Data Acknowledgment
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 Cartographer: RPB
 Format: A3



Legend

- Study area
- Pasture
- Not pasture
- Not mapped (cloud)

Figure 3. Extent of pasture in 1965 overlaid on 2007 aerial photographs, north-eastern Lake Taupo catchment



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