Carbon Forest Services

POST QUAKE FARMING

Milestone B

Mapping Exotic and Native Forest Potential in the Post-Quake Farming Project Area

Prepared For

The Post-Quake Farming Project

By

Carbon Forest Services Limited

May 2020

DISCLAIMER

Projections contained herein are estimates only and should not be considered a promise as to future actual results which may be different. Carbon Forest Services Limited, its employees and contractors shall not be liable for any loss, damage or liability incurred as a direct or indirect result of any reliance upon the information contained within this report.

PROJECT LEAD

Ollie Belton

Carbon Forest Services Limited
14 Lombard Street, Wellington
obelton@carbonforestservices.co.nz

Contents

EXECUTIVE SUMMARY

The Post-Quake Farming Project (PQF) Area includes 285,900 hectares of privately held hill and high-country land between the East coast of the South Island and Main Divide.

PQF stakeholders require an improved understanding of the potential of both native and exotic forest resources on hill and high-country farms in the Project Area. There is particular interest in the potential of native forest or scrublands with little productive value, but potentially significant opportunities to establish or enhance native forest.

A desktop land classification and mapping exercise (the PQF Classification) estimates that of this land:

- 79,400 hectares is unlikely to be suitable for forestry because the environment is inhospitable to trees or because the land is suitable for high value use
- 9,650 hectares is in exotic forestry
- 110,200 hectares is clear land (predominantly hill country land) which may be afforested in future, and which is likely to be eligible for the NZ ETS and One Billion Trees Program
- 86,650 hectares is in native forest or shrubland, some of which is eligible for the NZ ETS

The PQF Classification was validated against and compared with information from past field assessments undertaken by Carbon Forest Services across 22,800 hectares of land in the Project Area. This work indicated that the area of post-1989 native forest is likely to be significantly larger than identified in the PQF Classification (26,350 hectares of post-89 native forest across the whole study area compared to 2,800 hectares originally identified). This indicates that the situation on the ground for indigenous vegetation may be quite different to that estimated in national datasets such as LUCAS.

The work did not formally examine the carbon and restoration potential of land confirmed as pre-1990 native forest, nor did it build an overall picture of forest composition in this area. Observations of other experts have determined that large amounts this land consists of scrubland, young forest, and degraded mature forest, which is regenerating very slowly. The process of native forest restoration is likely to benefit from active interventions such as herbivore control and re-introduction of locally extinct tree species (through enrichment planting), knowledge and resources are required to support these activities.

1 Introduction and Purpose

This report was commissioned by PQF to meet requirements of project stakeholders for a better understanding of existing and potential forestry resources on hill and high-country farms in the Project Area, particularly native forest resources.

The PQF Area totals 442,000 hectares extending from Gore Bay in the South to the Ward area in the North and extending inland approximately 40 kilometers to the Inland Kaikoura Range and Amuri Range. Of this area, 285,900 hectares is on privately held properties larger than 100 hectares (i.e. hill and high-country farms).

Many hill and high-country farms in the Project Area include large areas of un-grazed native forest and scrubland. Of 50 farmers interviewed during Project development, approximately 80% saw this area as a significant missed opportunity in terms of:

- A potential carbon sink and source of income or offset - but often ineligible for the NZ ETS;
- Native forest restoration or establishment - hindered or stalled by herbivory and local extinction of canopy tree species.

Community interest in this issue extends to hill and high-country farming communities around New Zealand. There is approximately 2.8 M hectares of woody native vegetation on sheep and beef farms across New Zealand[1], areas with similar challenges and opportunities to those evident in the PQF Area.

There is also interest in the potential of less productive hill and high-country grazing land (Generally LUC class 6 and 7 land) which may generate better returns under forestry in the context of a sustained high carbon price, afforestation incentives (e.g. the One Billion Trees Program), and increasing regulatory challenges for pastoral farming. This information assists better understanding of the likely long term pattern of change (and how the community may need to adapt), and provides useful context to extension work on integrating exotic forest enterprises into grazing operations to create more resilient farming businesses.

[1] Norton DA, Pannell J (2018) Desk-top assessment of native vegetation on New Zealand sheep and beef farms. [Online] https://beeflambnz.com/sites/default/files/FINAL%20Norton%20Vegetation%20occurence%20sheep%20beef%20farms.pdf

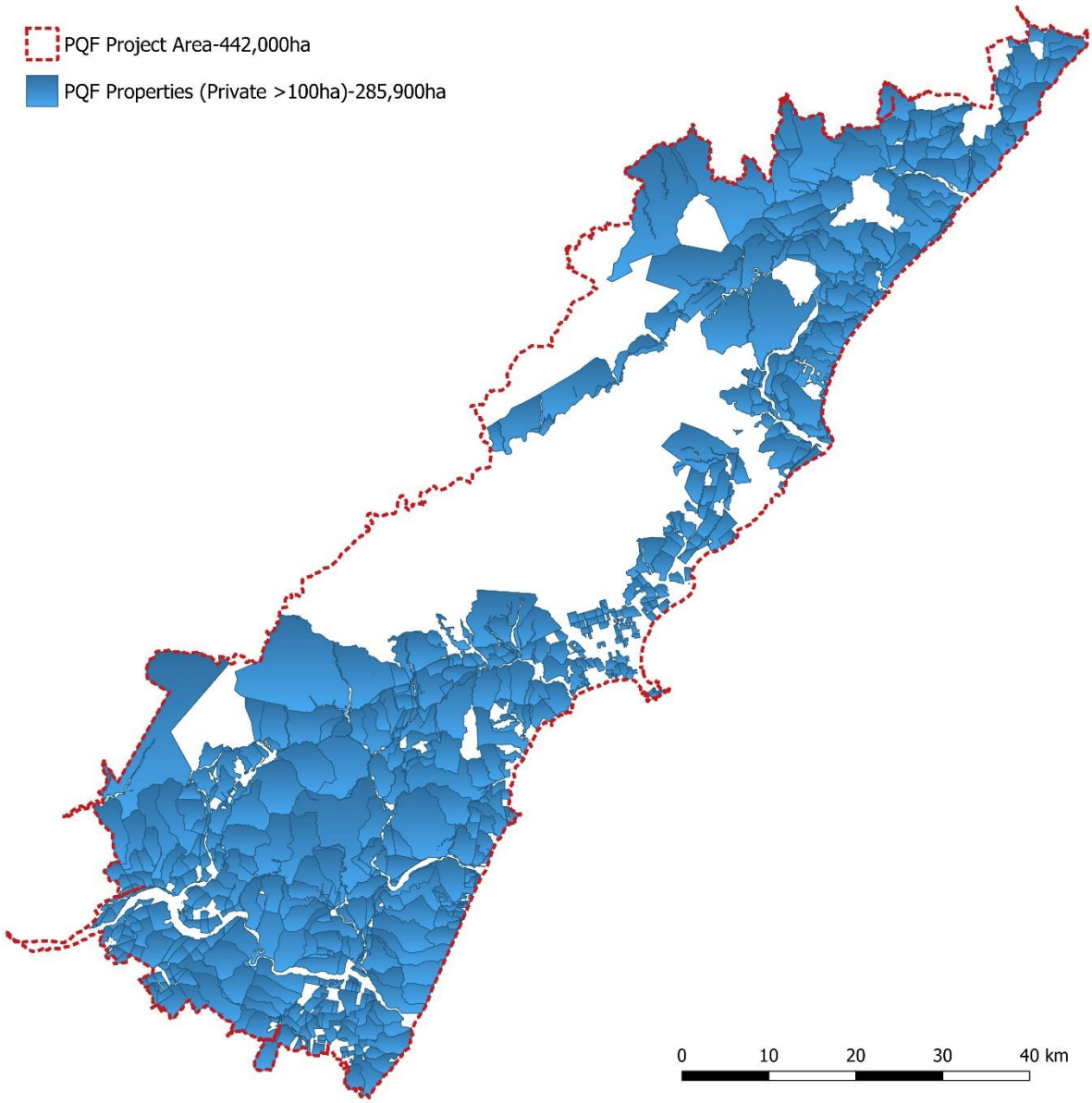
2 Description of Resource – Developing the PQF Classification

2.1 PQF Area

The PQF Area includes privately held hill and high-country farmland between Gore Bay and Lake Grassmere, and between the East Coast and Inland Kaikoura and Amuri Ranges (approximately 40 kilometers inland). It includes:

- **442,000** hectares = total PQF Area
- **335** properties = number of properties in private ownership over 100 hectares
- **285,900** hectares = total area of properties in private ownership over 100 hectares

Map 1: PQF Project Area and Properties in Private Ownership larger than 100 hectares



**Only properties over 100 hectares have been selected because those smaller than this are unlikely to be hill and high-country farming units.*

2.2 Developing the PQF Classification

Existing data was used to map vegetation cover and potential NZ ETS eligibility (primarily LUCAS[2] data). The resulting dataset and associated maps are referred to as the 'PQF Classification[3]'. The PQF Classification includes:

- Land considered unsuitable for forestry (either high value or very poor land);
- Clear land and shrub land with forestry potential[4]; and
- Land currently covered by forest (along with its classification as native/exotic and post-1989 or pre-1990).

Table 1 describes the PQF Classification categories and areas on hill and high-country farms within the PQF Area. Map 2 depicts the PQF Classification across the entire PQF Area, including crown land.

Table 1. PQF Classification on Hill and High-Country Land

Category	Description	Mapped Area (ha)
N/A_ Unsuitable_ Other	Unsuitable, no potential for afforestation due to site conditions or existing use	79,400
Pre90_Existing Forest_Exotic	Exotic forest pre-1990, no potential for ETS credits but potential for ETS deforestation obligations	4,050
Post89_Existing Forest_Exotic	Exotic forest post-1989, potential for ETS credits	5,600
Post89_Perm or plantation_Clean	Clean land, potential for permanent or production afforestation	75,050
Post89_Permanent_Clean	Clean land, potential for permanent afforestation	35,150
Post89_Perm. or plantation_Shrub)	Shrub land, potential for permanent or production afforestation	15,600
Post89_Permanent _Shrub	Shrub land, potential for permanent afforestation	7,300
Pre90_Existing Forest_Native	Native forest pre-1990, no potential for ETS credits or obligations	60,950
Post89_Existing Forest_Native	Native forest post-1989, potential for ETS credits	2,800
	Total:	**285,900 ha**

Of the 285,900 hectares hill and high-country farmland assessed:

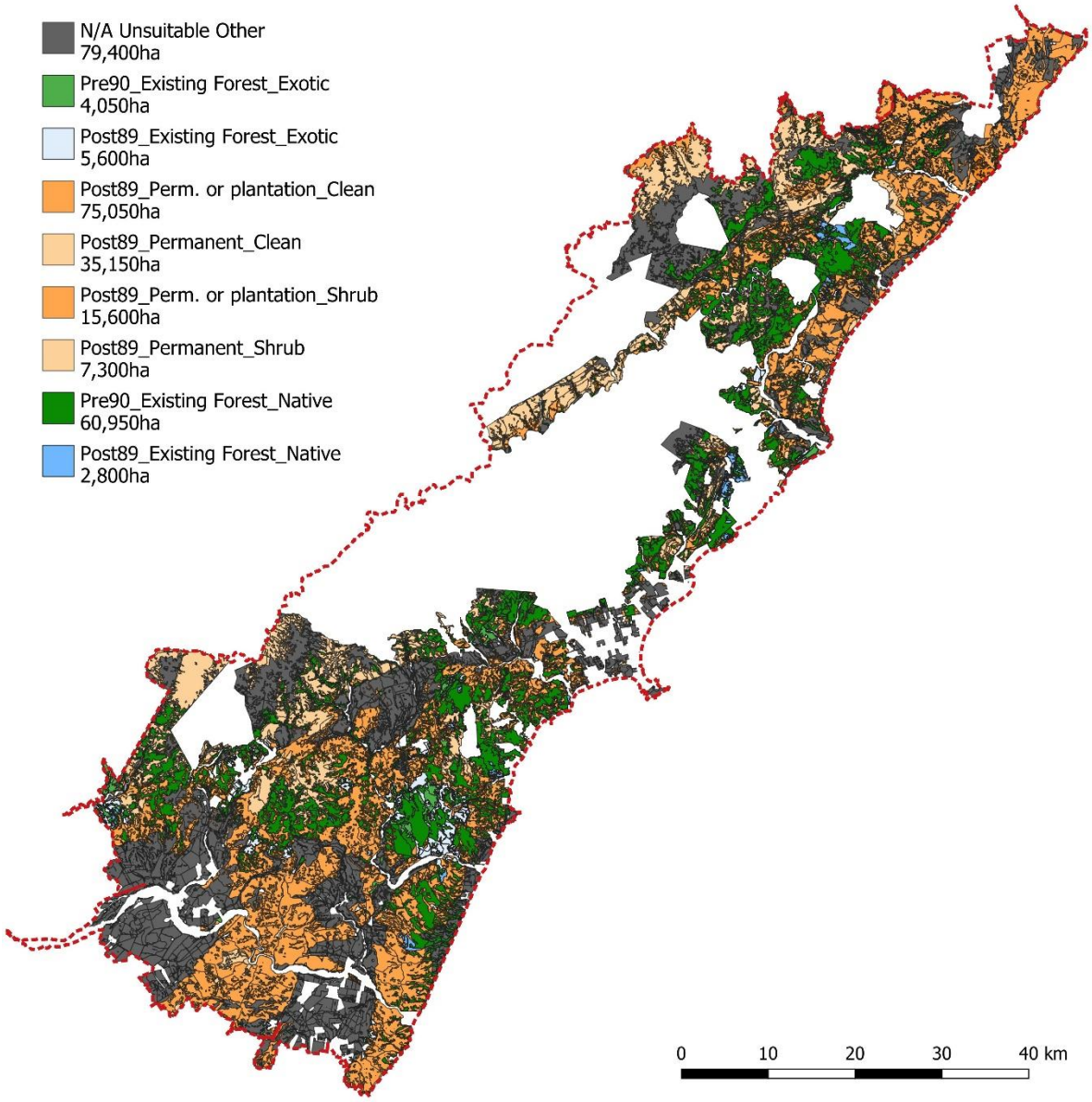
- 79,400 hectares is unlikely to be suitable for forestry because the environment is inhospitable to trees or because the land is suitable for high value use.
- 9,650 hectares is in exotic forestry.
- 110,200 hectares is clear land (predominantly hill country land) which may be afforested in future, and which is likely to be eligible for the NZ ETS and One Billion Trees Program.
- 86,650 is in native forest or shrubland, including 2,800 hectares classified as Post89_Existing Forest_Native.

[2] Land-use and Carbon Analysis System (LUCAS)- www.mfe.govt.nz/publications/rma/measuring-carbon-emissions-land-use-change-and-forestry-new-zealand-land-use-and

[3] The methodology used and derivation of land use categories to develop the PQF Classification is described in detail in Appendix 1. The PQF Classification is intended as a guide for medium scale interpretation and therefore should be treated as a high-level assessment only and not a substitute for property specific assessments.

[4] Land may have afforestation potential based on physical or economic factors. There will be regulatory requirements (notably Regional and District Plans) which must also be considered. While the NES-PF Standard was used it was not practical to consider all regulatory requirements because applicable policies vary substantively from one situation to the next, and over time, and there is often a case-by-case decision making process involved.

Map 2: PQF Classification across land in Private Ownership larger than 100 hectares[5]



Map 2 shows a diverse pattern of vegetation types and potential across the study area. Many farms in the area include areas of native forest or areas of less productive grazing land which may represent opportunities to establish forest, depending on the specific opportunities and outcomes desired in each situation.

[5] Map 2 breaks the area down by forest type or afforestation potential , with areas of clean land or shrub land with production (i.e. harvest) potential in darker orange and areas with permanent forest potential in lighter orange. Shrubland can be differentiated as it appears as patches within areas of clear land.

3 Validating the PQF Classification

The PQF Classification was validated against information from field assessments previously undertaken by Carbon Forest Services Limited (CFS). These assessments covered 11 properties totaling 22,790 hectares. We believe these sites are reasonably representative of the privately owned properties (>100ha) within the PQF Project Area.

This work indicates desktop information may differ significantly from actual assessments, with a high degree of uncertainty around status of native forest and scrubland. For instance, the LUCAS – derived PQF Classification predicted 1,082 hectares of post-1989 Native Forest within the assessment area, while actual assessment work found 2,896 hectares (as depicted in Table 2).

The CFS assessments consisted of a detailed desktop assessment using historic and recent aerial imagery. Additionally, most of the desktop assessments were followed by onsite ground validation to determine vegetation type and age for ETS eligibility.

Table 2: CFS assessed 'Post89_Exisiting Forest_Native' compared with PQF Layer Classification within 11 properties totaling 22,790 *hectares*

PQF Classification	PQF Classification (ha)	CFS Assessed Post89 _Existing Forest_Native (ha)	CFS Assessed Post89 _Existing Forest_Native (%)
N/A_Unsuitable_Other	3,003	33	1.1%
Pre90_Existing Forest_Exotic	108	0	0.1%
Post89_Existing Forest_Exotic	227	1	0.2%
Post89_Perm. or plantation_Clean	3,251	482	14.8%
Post89_Permanent_Clean	2,025	155	7.6%
Post89_Perm. or plantation_Shrub	1,561	244	15.6%
Post89_Permanent_Shrub	1,418	136	9.6%
Pre90_Existing Forest_Native	10,115	1,124	11.1%
Post89_Existing Forest_Native	1,082	721	66.7%
Total:	**22,790**	**2,896**	

These results show actual assessments may differ significantly from LUCAS or other desktop GIS information, with a high degree of uncertainty around the status of native forest and scrubland.

4 Extrapolating CFS Assessments

Following validation, the CFS assessment areas were extrapolated across the 285,900 hectares of hill and high-country farmland within the Project Area and compared alongside the PQF Classification. The results are shown in Table 3.

Table 3: CFS assessed 'Post89_Exisiting Forest_Native' extrapolated across PQF Project Area within Properties in Private Ownership larger than 100 hectares

	PQF Classification Private Properties >100ha (ha)	CFS Assessed Post89 _Existing Forest_Native (%)	Extrapolated Post89 _Existing Forest_Native (ha)
N/A_Unsuitable_Other	79,400	1.1%	850
Pre90_Existing Forest_Exotic	4,050	0.10%	0
Post89_Existing Forest_Exotic	5,600	0.20%	0
Post89_Perm. or plantation_Clean	75,050	14.80%	11,100
Post89_Permanent_Clean	35,150	7.60%	2,650
Post89_Perm. or plantation_Shrub	15,600	15.60%	2,450
Post89_Permanent_Shrub	7,300	9.60%	700
Pre90_Existing Forest_Native	60,950	11.10%	6,750
Post89_Existing Forest_Native	2,800	66.70%	1,850
Total:	**285,900 ha**		**26,350 ha**

This exercise was an extrapolation. Despite this limitation it is reasonable to infer the following:

- The area of post-1989 native forest is likely to be significantly larger than might be supposed from LUCAS or other desktop GIS data; extrapolated data indicates this may be up to 26,350 hectares compared to the 2,800 hectares originally indicated in LUCAS.
- Up to 6,750 hectares of the PQF Classification of pre-1990 native forest may in fact be post-1989 native forest.
- Up to 16,950 hectares of the grassland and shrubland categories could be post-1989 indigenous forest. Many of these areas are relatively small polygons feathering out from existing native forest and encroaching into grassland and shrubland as the native forest regenerates.

5 Limitations of the work – What was not included

The work did not formally examine the carbon and restoration potential of pre-1990 native forest, nor did it build an overall picture of forest composition in this area. The 'health' of a forest cannot be determined from the datasets used in the PQF Classification, and the CFS extrapolation was based on property assessments that were carried out prior to this project where forest health was not recorded.

Observations of experts[6] have determined that even though much of the PQF Area is classified as pre-1990 forest, most of it consists of scrubland or young forest, which is regenerating very slowly. This situation is unlikely to improve without large-scale active interventions to control browsing pests and increase rates of indigenous forest regeneration/succession, and resources to support this activity at the required scale. This situation is likely applicable across many parts of hill and high country in New Zealand where native vegetation is a component of the environment.

Currently the NZ ETS is not the appropriate mechanism to deliver the required economic incentives for improving the health and carbon storage potential of older indigenous forest. This is because the NZ ETS does not allocate carbon credits to pre-1990 native forest. A further issue is a lack of commercially viable methods to assess these benefits, though it is hoped this will change with rapid advances in remote sensing technology.

[6] As part of PQF work, Dr Adam Forbes has visited over 30 properties in the Project Area, including botanical assessments at four sites. Ollie Belton (Carbon Forest Services) has undertaken work on a further 11. There is also substantial anecdotal evidence of herbivore pest infestation and associated impacts.

Appendix 1 – PQF Classification Methodology

Examples of target forest land include:

- Scrubland (non-forest land) suitable for afforestation which can be registered under the emissions trading scheme as post-1989 forest land
- Exotic Forest (forest land) which already qualifies to be registered under the emissions trading scheme as post-1989 forest land

Examples of non-target land include:

- Grassland (non-forest land) that is unsuitable for afforestation due to being;
    - Too poor for forestry (e.g. high altitude)
    - Too good for sensible or economic forestry (e.g. prime pastoral land)
- Natural Forest (forest land) which is pre-1990 forest land under the emissions trading scheme and will not benefit from additional forestry interventions
- Incompatible existing use (e.g. towns, roads, hydro areas)

1. Target Classifications

Initial target classifications along with corresponding field attributes were identified as follows:

Table 1: Initial draft classifications and expected fields

Classification	Classification Detail	Exclusion Reason	LCDB Summary	LUCAS Summary	PVNZ Summary
N/A_ Unsuitable_ Other	Other areas unsuitable for afforestation due to site conditions and/or existing use.	Concat Field	Concat Field	Concat Field	Concat Field
Post89_ ExistingForest_ Exotic	Existing post-1989 exotic forest with potential ETS entitlements.	Concat Field	Concat Field	Concat Field	Concat Field
Post89_ ExistingForest_ Native	Established post-1989 native forest with potential ETS entitlements.	Concat Field	Concat Field	Concat Field	Concat Field
Post89_Perm. or plantation_ Clean	Clean land suitable for post-1989 permanent or plantation afforestation. Potential for ETS entitlements if afforested.	Concat Field	Concat Field	Concat Field	Concat Field
Post89_Perm. Or plantation_ Shrub	Scrub land suitable for post-1989 permanent or plantation afforestation. Potential for ETS entitlements if afforested.	Concat Field	Concat Field	Concat Field	Concat Field
Post89_ Permanent_ Clean	Clean land suitable for post-1989 permanent afforestation - unsuitable for plantation (timber) afforestation due to regulatory and or physical limitations. Potential for ETS entitlements if afforested.	Concat Field	Concat Field	Concat Field	Concat Field
Post89_ Permanent_ Shrub	Scrub land suitable for post-1989 permanent afforestation - unsuitable for plantation (timber) afforestation due to regulatory and or physical limitations. Potential for ETS entitlements if afforested.	Concat Field	Concat Field	Concat Field	Concat Field
Pre90_ ExistingForest_ Exotic	Pre-1990 exotic forest. No ETS entitlements but potential deforestation obligations if converted.	Concat Field	Concat Field	Concat Field	Concat Field

Pre90_ ExistingForest_ Native	Pre-1990 native forest. No ETS entitlements.	Concat Field	Concat Field	Concat Field	Concat Field
Pre90_ IFM_Native	Pre-1990 native forest that may benefit from Improved Forest Management (IFM) to increase carbon stocks. Potential ETS entitlements if CCRA amended.	Concat Field	Concat Field	Concat Field	Concat Field
Pre90_ Review_Native	LUCAS classified pre-1990 native forest that may in fact be post-1989 native forest. Potential for ETS entitlements if reviewed.	Concat Field	Concat Field	Concat Field	Concat Field
Pre90_ Review_Shrub	LUCAS classified pre-1990 native forest that may not meet 'forest' definition under CCRA. Potential for ETS entitlements if afforested.	Concat Field	Concat Field	Concat Field	Concat Field

**Exclusions= Regulatory, Physical, economic, etc... LCDB4.1- Land cover database 2012. LUCAS= Land-use and Carbon Analysis System. PVNZ = Potential Vegetation of New Zealand*

2. Datasets & Assumptions

Key datasets were identified and assumptions for obtaining classifications were tested and validated with a NZ Institute of Forestry (NZIF) registered forest consultant.

Key assumptions independently validated by NZIF registered consultant include:

- Location of ports and domestic wood processors
- Distance from port and domestic wood processors for economic viability of plantation forestry
- Altitude limitations forest growth
- Geographical constraints such as slope for harvesting feasibility
- Physical limitations for forestry such as soils, geology, moisture

Table 2: Datasets and Derived Data

Source	What	Dataset	Description
NZ School of Surveying	Elevation	NZSoSDEM	NZSoSDEM v1.0 is a free Digital Elevation Model (DEM) covering the whole of New Zealand at a spatial resolution of 15m, created by the School of Surveying by interpolating LINZ topographic vector data.
MFE	Land Cover	LUCAS	Land-use and Carbon Analysis System Land Use Map (LUCAS). The Land Use Map is composed of New Zealand-wide land use classifications (12) nominally at 1 January 1990, 1 January 2008, 31 December 2012 and 31 December 2016 (known as "1990", "2008", "2012" and "2016"). These date boundaries were dictated by the First and Second Commitment Periods of the Kyoto Protocol. The layer can be used to create either a 1990, 2008, 2012 or 2016 land use map.
LINZ	Transport	Topo50	Determine distance from mills and ports for haulage feasibility for plantation forestry.
LINZ	Property	CRS Parcels	Legal boundaries and property ownership information.
LINZ	Coastal proximity	Topo50	Coastline
Landcare	Soil	NLRI-Fundamental Soil Layers (FSL)	The soil fundamental data layers (FDLs) contain spatial information for 16 key attributes, each of which is measurable (i.e. is given a numeric value rather than being assigned to a descriptive class or category) and is recorded in appropriate units of measure. Since attributes have measurable values, FDLs are particularly useful in computer modelling and have enabled

Source	What	Dataset	Description
			researchers and resource management decision-makers to make the most of rapid developments in GIS technology. Key soil attributes were selected through a consultation process with stakeholders, and generally fall into three groups: soil fertility/toxicity, soil physical properties (particularly those related to soil moisture), and topography/climate (T). Parameters include slope, potential rooting depth, topsoil gravel content, proportion of rock outcrop, pH, salinity, cation exchange capacity, total carbon, phosphorus retention, flood interval, soil temperature, total profile available water, profile readily available water, drainage, and macropores (shallow and deep).
Landcare	Capability	NZLRI - Land use capability	Polygon layer delineating land areas classified according to their capability to sustain continuous production. Land Use Capability (LUC) is a hierarchical classification identifying: the land's general versatility for productive use; the factor most limiting to production; and a general association of characteristics relevant to productive use (e.g., landform, soil, erosion potential, etc.). LUC classifications have been constructed for each NZLRI survey region. These individual classifications have been correlated to North and South Island classifications to permit wide-area analyses.
Landcare	Land Cover	LCDB4.1	The New Zealand Land Cover Database (LCDB) is a classification of New Zealand's land cover. It contains 33 mainland classes at each of four nominal time steps: summer 1996/97, summer 2001/02, summer 2008/09, and summer 2012/13.
Landcare	Land Cover	Potential Vegetation of New Zealand	New Zealand's potential forest composition was predicted from regressions relating the distributions of major canopy tree species to environment. Environmental variables, chosen for their correspondence to major tree physiological processes, included annual and seasonal temperature and solar radiation, soil and atmospheric water deficit, soil leaching, slope, and soil parent material and drainage. Environmental values were estimated both for a large set of irregularly distributed plots describing forest composition, and points on a 1-km grid across New Zealand. Regressions were fitted to the ploy data species by species, with those for the four Nothofagus species also including terms to correct for the effects of their geographic disjunctions. Predictions of species abundance were then made for the grid data set, and the resulting matrix was classified to derive groups of similar composition. This data is expected to provide a context for both the assessment of the biodiversity value of surviving forest remnants and for the subsequent management and/or restoration of these sites.
Landcare	Erosion	NES-PF - Erosion Susceptibility	The Erosion Susceptibility Classification (ESC) is used to identify the susceptibility of land to erosion and then to set regulatory thresholds for various plantation forestry activities. The ESC is based on the analysis of potential and present erosion data associated with the NZ Land Resource Inventory and classification of Land Use Capability (LUC) units. This revision extends the ESC to cover all New Zealand, revises the ESC class of some LUC units, allows identification of ESC units dominated by gully, tunnel gully and earthflow erosion, and identifies all polygons containing class 8e land. This dataset has been prepared to support the National Environmental Standard for

Source	What	Dataset	Description
			Plantation Forestry. The ESC is used to identify the susceptibility of land to erosion which is used as the basis for setting resource consent requirements for various plantation forestry activities on different types of land. The ESC is based on the New Zealand Land Resource Inventory (NZLRI).
GNS	Erosion	Kaikoura Landslide Inventory	A landslide inventory compiled to capture the spatial distribution of landslides triggered by the Kaikoura earthquake, to provide information for recovery activities and to provide a high-quality dataset for future research. The inventory captures information on: landslide type (material type and style of movement), landslide magnitude (areal size, and volume where possible), runout (distance the debris travels down slope), activity (whether pre-existing), connection and/or interaction with rivers (e.g. occlusions, blockages, buffered), and method of mapping and source of the data, along with the person who digitised and attributed the landslide.
Derived	Distance	from roads and tracks	Derived from buffers from LINZ Topo50 road & track layers.
Derived	Distance	from port via road	Derived from road network created from LINZ Topo50 road & track layers.
Derived	Elevation	< 800m	Polygon layer less than 800m elevation derived from NZSoSDEM. This is our cut-off for plantation forestry.
Derived	Elevation	800m-1000	Polygon layer less than 1,000m. This is our cut-off for permanent forestry. Derived from NZSoSDEM.
Derived	Slope	< x degrees	Feasible slope for plantation forestry. Derived from NZSoSDEM.
Derived	Slope	x-y degrees	Feasible slope for permanent forestry. Derived from NZSoSDEM.
Derived	Distance	from coast > 1km	Derived from LINZ Topo50 hydro layers.
Created	Distance	Local Mills	Local mills as a potential destination for timber.

3. Method

i. Property Definition

Council rating data supplied was deemed to be out of date and a less reliable source than LINZ CRS Title -owner information.

LINZ parcels were used with the parcels being merged into a *'PQF Property'* if they had the same owner details and were within 2km of each other. This enabled grouping of separate legal titles into properties/farms based on common ownership.

ii. Existing Landcover Definition

At the start of the project the *LCDB 4.1* and *LUCAS* layers were both intended to be used to define existing landcover. As the project neared completion, the new *LUCAS NZ Land Use Map 2016* was released. This caused a change in methodology because the latest LUCAS layer is much more current than both the other initial sources and results in more simplified dataset (having a fewer number of small features). This latest LUCAS layer was used as the core dataset to identify what current landcover.

iii. Forestry Exclusion Layers

A process was then implemented to identify areas of land that would be deemed to be not feasible for forestry based on physical and climatic conditions.

The exclusions were identified by overlaying;

- Town/residential areas
    - *LINZ* Topo 50 Residential Area Polygons
    - *LUCAS* where "LUCNA_2016" IN ('Settlements')
    - *FSL* where "NZSC" = 'town'
- Hydro Areas
    - *FSL* where "NZSC" IN ('river','lake')
    - *LCDB* where "Name_2012" IN ('Estuarine Open Water','Lake or Pond','River','Herbaceous Freshwater Vegetation','Herbaceous Saline Vegetation'
    - *LUCAS* where "LUCNA_2016" IN ('Wetland - Open water','Wetland - Vegetated non forest')
    - *LINZ* Topo50
        - Coastline where within 50m
        - lagoon_polygons
        - lake_polygons
        - pond_polygons
        - reservoir_polygons
        - river_polygons
        - swamp_polygons
- Areas too good for forestry
    - *NZLRI* LUC 1–4
- Road and Rail Areas
    - *LINZ* CRS Road and Rail Parcels
- Shallow soils
    - *FSL* where "PRD_CLASS" = '6' (very shallow rooting depth)
- Steep Slope or High Altitude derived from *NZSoS* DEM
    - Slope > 45 degrees
    - Elevation > 1,000

This step removed some areas that LUCAS had identified as having a current forest cover, so these areas were then added back in (i.e. no longer excluded) where appropriate. For example, road parcels were left excluded as these cannot be a part of a property or eligible for the emissions trading scheme.

Exclusion layers were overlaid, intersected, and their basic attribute concatenated onto the base master layer.

iv. Plantation Forestry Exclusion Layers

Polygons that were deemed to be not feasible for plantation (timber) forestry were treated as only suitable for permanent afforestation. These were identified by overlaying;

- LINZ Topo50
    - Coastline where within 200m (minus the <50m already excluded)
- Areas too poor for plantation forestry
    - *NZLRI* LUC 8
    - *FSL* where "NZSC" IN ('GOE', 'GOT', 'PPJX', 'WO', 'WX')
- Derived from *NZSoS* DEM, Elevation > 600
- Areas too erosion prone poor for plantation forestry
    - NES-FP where "ESC2018" in ('High', 'V. high')

    - Kaikoura earthquake landslides as defined and supplied by GNS Science
- Proximity to timber industry infrastructure
    - A navigable road network was created using the LINZ Topo 50 road centerlines and drive distances from the nearest port or wood processing facility where identified. If greater than 150km would be excluded.

These layers were overlaid, intersected, and their basic attribute concatenated onto the base master layer.

v. Enrichment of With Additional Landcover Layers

It was requested by ecologist Doctor Adam Forbes that the *Land Cover Database version 4.1* and *Potential Vegetation of New Zealand* layers were included. Intersecting these layers within the base master layer would lead to millions of small polygons. Therefore, it was decided a better approach was to summarise these datasets onto the analysis.

These results were presented as;

- LCDB_Dom: the dominant LCDB class on the polygon.
- LCDB_Concat: An ordered concatenation with percentages of LCDB classes on the polygon.
- PVNZ_Dom: the dominant PVNZ class on the polygon.
- PVNZ_Concat: An ordered concatenation with percentages of PVNZ classes on the polygon.

4. Limitations

Target classifications were largely derived from existing datasets. It became apparent through the application of the methodology that three Classification groups could not be identified through the process and would require manual assessment of historic and recent aerial imagery to determine, with further on the ground validation. Table three shows the removed target classifications.

Table 3: Removed Classifications

Classification	Classification_Detail
Pre90_IFM_Native	Pre-1990 native forest that may benefit from Improved Forest Management (IFM) to increase carbon stocks. Potential ETS entitlements if CCRA amended.
Pre90_Review_Native	LUCAS classified pre-1990 native forest that may in fact be post-1989 native forest. Potential for ETS entitlements if reviewed.
Pre90_Review_Shrub	LUCAS classified pre-1990 native forest that may not meet 'forest' definition under CCRA. Potential for ETS entitlements if afforested.

Some validation was carried out based on our knowledge of the PQF Project Area and previous assessment of properties within the region. These results are discussed further in section 3.

It should also be noted that classification was derived from the source datasets which are designed for medium scale interpretation and therefore should be treated as high-level and not a substitute for property specific assessments. Polygons may not always accurately reflect the characteristics at a precise location.

5. Final Classifications

Two PQF GIS layers have been created. The *PQF_Master* layer preserves the original draft target classifications and fields. However, given the volume of polygons generated from multiple splits another simplified layer called *PQF_Simplified* has been created. In the *PQF_Simplified* layer the

Exclusion_Reason field is removed, and the LCDB and PVNZ concatenated fields are replaced with the dominant attribute. For example, an LCDB_Concat field with "81% Low Producing Grassland, 16% High Producing Exotic Grassland" is replaced with "Low Producing Grassland" under the LCDB_Dom field. The simplified fields were then merged based on shared attributes to further reduce the number of unique polygons. The final simplified layer classifications and field attributes are listed in table 4 and an example is given in table 5. A short guide to interpretation is provided in table 6.

Table 4: Final Classification and simplified fields

Classification	LUCAS	SUBLUCAS	LCDB_Dom	PVNZ_Dom
N/A_Unsuitable _Other	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Post89_Existing Forest_Exotic	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Post89_Existing Forest_Native	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Post89_Perm. or plantation_Clean	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Post89_Perm. or plantation_Shrub	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Post89_Permanent _Clean	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Post89_Permanent _Shrub	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Pre90_Existing Forest_Exotic	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField
Pre90_Existing Forest_Native	LUCAS Class	LUCAS Sub Class	Dominant LCDB type from ConcatField	Dominant PVNZ type from ConcatField

** LCDB_Dom= Dominant Landcover Data Base classification. LUCAS= Land-use and Carbon Analysis System classification. SUBLUCAS= further LUCAS information. PVNZ_Dom = Dominant (future) Potential Vegetation of New Zealand classification.*

Table 5: Example Classification and example simplified fields

Classification	LUCAS	SUBLUCAS	LCDB_Dom	PVNZ_Dom
N/A_Unsuitable _Other	Cropland – Annual	Unknown	Short-rotation Cropland	Kahikatea-pukatea-tawa forest
Post89_Existing Forest_Native	Post 1989 Forest	Regenerated natural species	Manuka and/or Kanuka	Matai-totara/black/mountain beech forest

Table 6: Interpretation Guide

Classification	Classification Detail
N/A_ Unsuitable_ Other	Other areas unsuitable for afforestation due to site conditions and/or existing use.
Post89_ExistingForest_Exotic	Existing post-1989 exotic forest with potential ETS entitlements.

Classification	Classification Detail
Post89_ExistingForest_Native	Established post-1989 native forest with potential ETS entitlements.
Post89_Perm.or plantation_Clean	Clean land suitable for post-1989 permanent or plantation afforestation. Potential for ETS entitlements if afforested.
Post89_Perm.or plantation_Shrub	Scrub land suitable for post-1989 permanent or plantation afforestation. Potential for ETS entitlements if afforested.
Post89_Permanent_Clean	Clean land suitable for post-1989 permanent afforestation - unsuitable for plantation (timber) afforestation due to regulatory and or physical limitations. Potential for ETS entitlements if afforested.
Post89_Permanent_Shrub	Scrub land suitable for post-1989 permanent afforestation - unsuitable for plantation (timber) afforestation due to regulatory and or physical limitations. Potential for ETS entitlements if afforested.
Pre90_ExistingForest_Exotic	Pre-1990 exotic forest. No ETS entitlements but potential deforestation obligations if converted.
Pre90_ExistingForest_Native	Pre-1990 native forest. No ETS entitlements.