A Ngāti Whare Evaluation of Natural Regeneration and Weed Cover on Returned Lands Following Harvesting of Exotic Plantations: To Plant or Not to Plant Native Seedlings for Restoration

Commissioned by Te Pua o Whirinaki Regeneration Trust

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Cover photograph:
Aerial view of Forest Compartment 130, located within the Ngati Whare Forest Return Area, and positioned on the flat valley-floor landform, and adjacent to the Whirinaki River (November 2017).

1.0 INTRODUCTION

Te Pua o Whirinaki Regeneration Trust (the Trust) has engaged Forbes Ecology to evaluate the regeneration potential of ex-plantation forest (harvested land) returned to Ngati Whare (the Ngati Whare Forest Return Area; FRA). In a broad sense, the Trust wishes to restore indigenous forest cover, with a particular interest in restoring podocarp dominant forest, across the FRA. Revegetation would take the form of both restorative plantings of nursery-raised indigenous seedlings and natural regeneration. To inform the decision making regarding restoration management, the Trust requires data on both the regeneration potential, and the nature and distribution of weed issues, across the FRA.

1.1 Project Objectives and Deliverables

The specific objectives of the project are as follows:

1. The primary goal is to determine which exotic conifer plantation compartments, and parts of compartments, will require the planting of indigenous tree seedlings and which will not.
2. A secondary goal is to determine the types of weed control that will be required in each compartment, and parts of compartments.

The Trust requires the following deliverables:

1. Maps/GIS layers of the 480-ha area showing modelled predictions of (1) total seeding density, (2) podocarp seedling density, (3) angiosperm seedling density, (4) exotic conifer seedling density, and (5) weed species cover.
2. Estimates of (1) the proportion of the 480-ha area that will regenerate naturally, (2) the proportion of the area requiring exotic conifer control, and (3) the proportion of the area requiring weed control.

1.2 Approach

The approach is to survey sufficient land area representing conditions following exotic plantation clear-fell, in order to establish statistical relationships between forest regeneration attributes (e.g., indigenous seedling densities, cover by weed species; these are the response variables) and predictor variables, such as landform attributes (e.g., slope, slope aspect[1], elevation), and landscape parameters such as distance to indigenous forest seed sources.

[1] The predictor variable slope aspect is interchangeably referred to as direction in subsequent analyses.

At its largest extent, the project relates to the 582.5 ha land area encompassed within forest compartments collectively making up the FRA (Figs. 1 & 2). This area contains some areas of reserve and cutover, with an area of approximately 480 ha having been planted in exotic conifers. As there was insufficient land already harvested within the FRA to support the survey, the project also utilised nearby ex-plantation clear-felled land owned by the Crown (administered by the Department of Conservation).

Data was sampled from six independent clear-felled forestry compartments totalling 205.9 ha (Figs. 1 & 2; Table 1). The relationships between response and predictor variables were modelled using a statistical technique termed Boosted Regression Tree (BRT) analysis. Once BRT models were developed for each response variable, those predictions were applied to the FRA. This was achieved by producing a predictor variable set (i.e., slope, slope aspect, elevation) for the FRA, with each predictor variable being derived from a Digital Elevation Model of the FRA lands. The DEM-derived predictor variables were then incorporated into the BRT models and predictions for each response variable were thereby applied to the FRA lands. The specific methods for the study are detailed below.

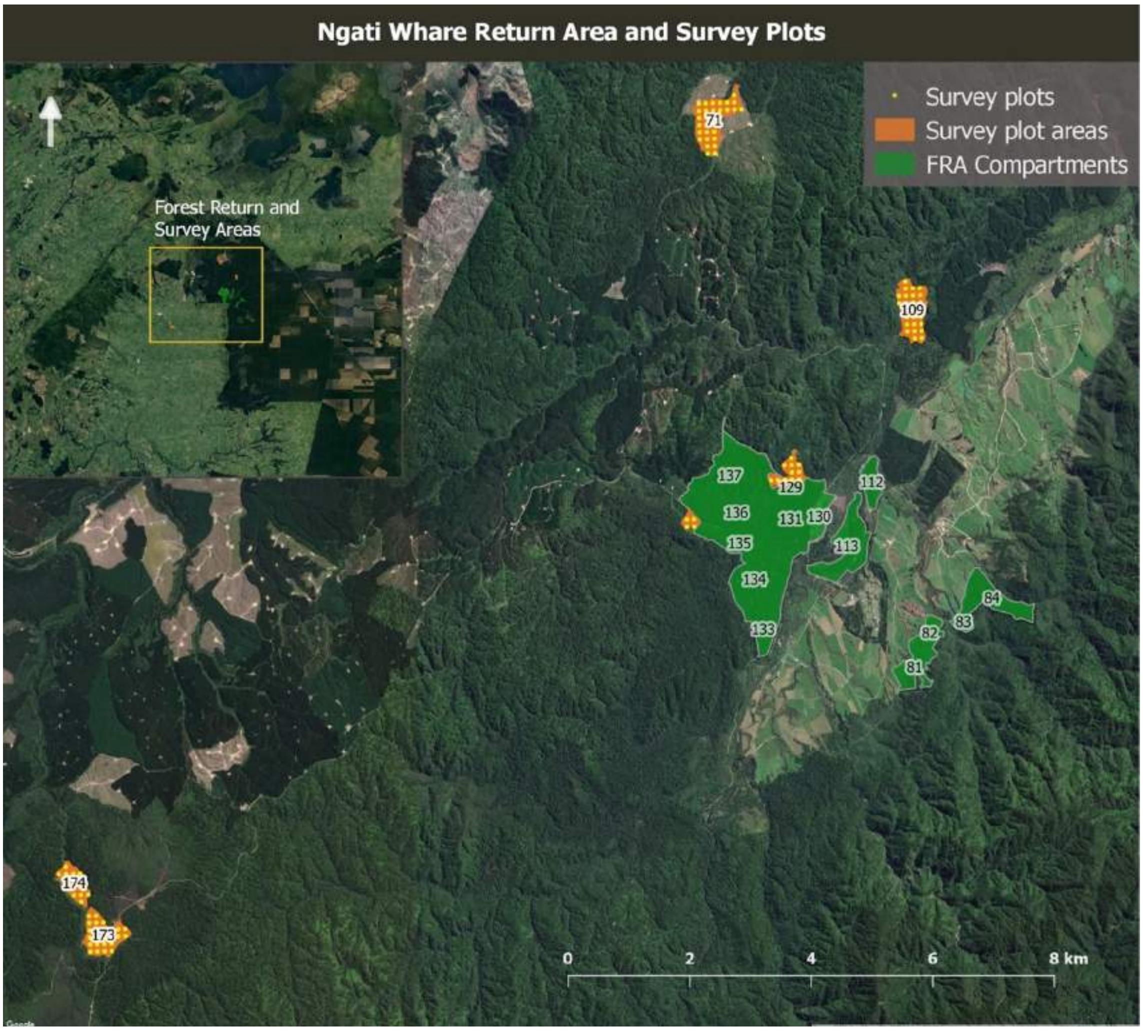

Figure 1. Overview satellite image of the Department of Conservation/Ngati Whare Forest Return Area (FRA) compartments surveyed (orange), and the extent of the FRA (green), located near Minginui in the central North Island. Forestry compartment numbers are given.

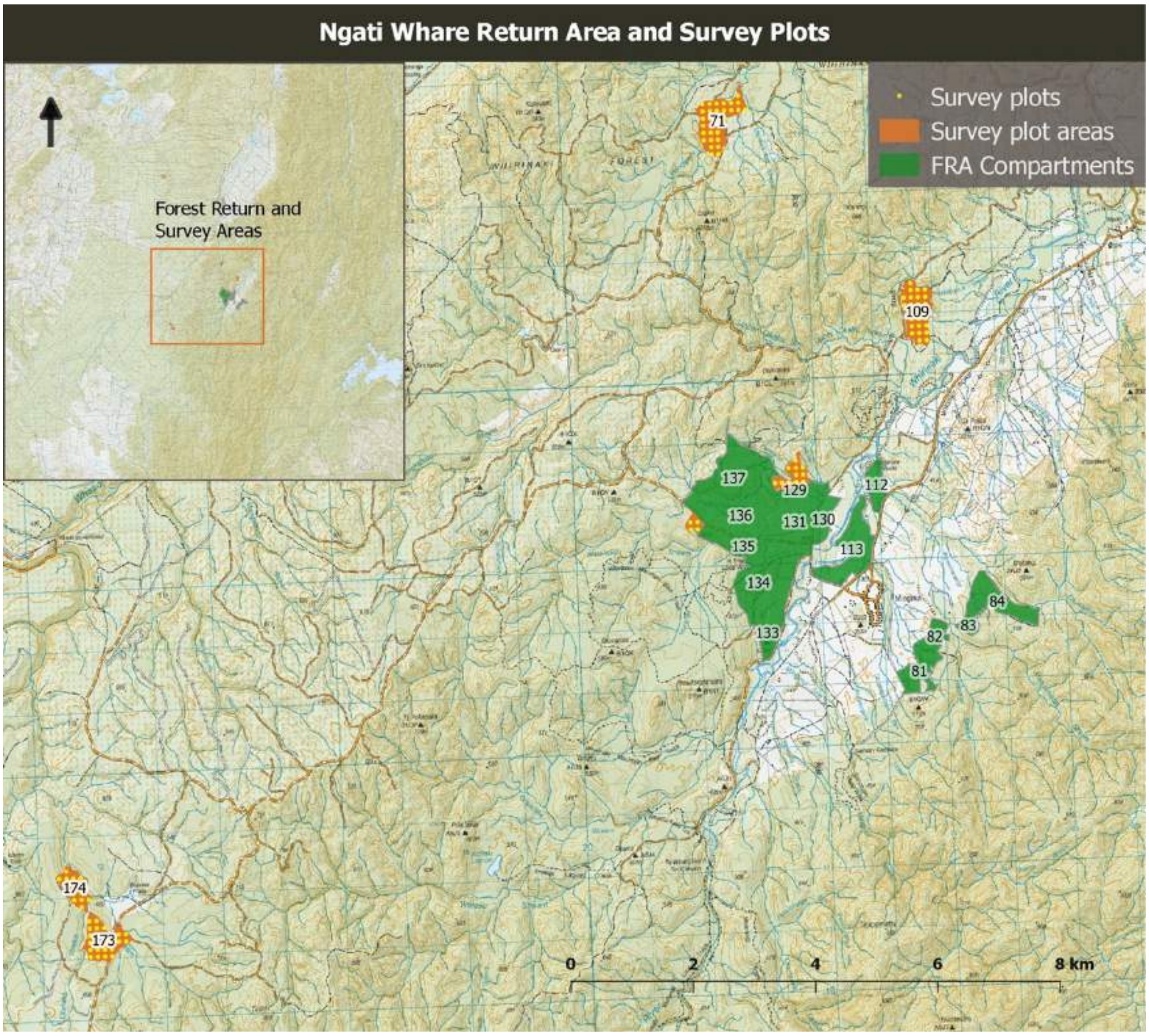

Figure 2. Overview topographical map of the Department of Conservation/Ngati Whare Forest Return Area (FRA) compartments surveyed (orange), and the extent of the FRA (green), located near Minginui in the central North Island. Forestry compartment numbers are given.

2.0 METHODS

2.1 Survey Design

Six forestry compartments were assessed as being suitable for inclusion in the survey. Criteria for compartment selection included the respective management histories, the degree to which each compartment added variability to the predictor variables, and representativeness of conditions as they relate to the FRA. Details of the compartments surveyed are presented in Table 1 and a map and photograph of each compartment is presented in Appendix A.

A total of 112 survey plot locations were predetermined in GIS using a systematic grid of 117.5 m spacing between plot centres. A 50-m exclusion buffer was applied to the compartment boundaries to separate plots from adjacent forest and to ensure that plot locations fell within compartment areas representing cutover forest. A copy of the grid-plot survey arrangement is contained in Appendix A.

Table 1. Details of the forestry compartments surveyed

Compartment	Compartment owner	Previous plantation species	Harvest year	Compartment area (ha)	Number of survey plots
71	DoC	Douglas fir	2015	46.3	31
109	DoC	Radiata pine	2003	38.6	26
129	FRA	Radiata pine	2011	26.3	11
135	FRA	Unknown	2011	43.2	4
173	DoC	Radiata pine	2004	35.7	15
174	DoC	Radiata pine	2004	15.8	25
Totals				205.9	112

The response variables selected for the survey needed to relate to patterns in indigenous forest regeneration and to the distribution of weed species. The density (stems ha^{-1}) of indigenous woody species (>15 cm tall; i.e., seedlings having attained a stature sufficient to be considered part of the future vegetation composition) was therefore a key response variable of interest. Additional response variables were the total number of angiosperm stems (>15 cm tall), and the total number of podocarp stems (>15 cm tall). Weed cover response variables represented both the total combined cover (including exotic conifer cover), and the cover of each species (those for which sufficient data were available; and excluding exotic conifer cover). Exotic conifer density (>15 cm tall) was also a response variable explored relating to potential weed issues within the FRA.

Predictor variables needed to be readily applicable across the entire FRA. Slope, slope aspect, elevation, landform topographic index (McNab 1993), physiography and distance to indigenous forest were applied as predictor variables. All variables used in the analysis are described in Table 2, along with their mean and range statistics.

2.2 Field Survey

The field survey was undertaken between April and November 2017. Each plot was located within the predetermined plot grid using a handheld GPS (Garmin GPSmap 62s). Plot measurements were undertaken within 10 × 10 m plots, following the Recce (Hurst & Allen, 2007) method in part. Topographic exposure (McNab, 1993) was measured at each plot centre, which required measurement of eight equidistant slope to horizon measurements. Also measured at each plot were slope aspect, slope, physiography, drainage, shape, the nature of ground cover and the percentage of canopy cover (both above and below 1.35 m above ground level). Plot elevation was determined using the handheld GPS.

All indigenous woody species and all exotic conifer species were identified to species level. Individuals >15 cm tall were assigned to the seedling height classes <15, 16–45, 46–75, 76–105, 106–135 cm. Individuals >135 cm tall were counted. The cover-abundance of weed species was estimated using the scale 1 = <1%, 2 = 1–5%, 3 = 6–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%. Weed species were recorded when they had live foliage present within the height tiers <0.3, >0.3–2, 2–5, 5–12, 12–25, >25 m.

In total, 101 of the 112 plots were surveyed. Plots were not able to be surveyed where their location fell in locations within advanced regeneration or mature bush near compartment margins, thus not representing regeneration following clear-fell, or in inaccessible steep-sided ravines, or on compacted roads or tracks were flora were not regenerating (and thus, again, the plot survey would not represent regeneration following plantation clear-fell). Photographs and notes were kept for each eventuality were a plot could not be surveyed.

Table 2. Variables used to model the regeneration potential of the Ngati Whare Forest Return Area. Mean and range values are from the 101 vegetation plots measured

Variable	Description	Mean and range
	Response variables	
Total Indigenous Woody Stem Density	Density of all indigenous woody species (>15 cm tall; stems ha^{-1})	3 855, 0–16 300
Total Indigenous Angiosperm Stem Density (Individuals >15 cm Tall)	Density of all indigenous angiosperm woody species (>15 cm tall; stems ha^{-1})	3 750, 0–16 200
Total Podocarp Stem Density (Individuals >15 cm Tall)	Density of all podocarp species (>15 cm tall; stems ha^{-1})	106, 0–4 400
Total Weed Cover	Importance Value (IV) derived from the summed cover class midpoint values of weed species cover-abundance in tiers <0.3, >0.3–2, 2–5, 5–12, 12–25, >25 m, applying weightings to percent cover classes: 1 = <1%, 2 = 1–5%, 3 = 6–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%	9.8, 0–28
Total Blackberry Cover	IV derived from the sum of blackberry cover-abundance in tiers <0.3, >0.3–2, 2–5, 5–12, 12–25, >25 m, applying weightings to percent cover classes: 1 = <1%, 2 = 1–5%, 3 = 6–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%	5.4, 0–17
Total Buddleia Cover	IV derived from the sum of buddleia cover-abundance in tiers <0.3, >0.3–2, 2–5, 5–12, 12–25, >25 m, applying weightings to percent cover classes: 1 = <1%, 2 = 1–5%, 3 = 6–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%	1.5, 0–9
Total Spanish Heath Cover	IV derived from the sum of Spanish heath cover-abundance in tiers <0.3, >0.3–2, 2–5, 5–12, 12–25, >25 m, applying weightings to percent cover classes: 1 = <1%, 2 = 1–5%, 3 = 6–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%	0.8, 0–10
	Predictor variables	
Slope	Average slope of the survey plot along the predominant aspect (degrees)	14.6, 0–52
Slope Aspect	Predominant aspect (degrees), translated to cardinal direction: flat = <5˚, N = 337.5–22.5, NE = 22.5–67.5, E = 67.5–112.5, SE = 112.5–157.5, S = 157.5–202.5, SW = 202.5–247.5, W = 247.5–292.5, NW = 292.5–337.5	NA
Elevation	Elevation at plot centre (m above mean sea level; a.s.l)	478, 341–658
Distance to Mature Indigenous Forest	Linear distance from plot centre to edge of nearest mature indigenous forest (m)	125.9, 20–302

2.3 Data Analysis and Mapping

The cover-abundance data for each of the weed species were transformed to Importance Values (IV) for analysis (Allen et al. 1995). The IV was calculated from the weighted sum of a weed species cover-abundance in tiers <0.3, >0.3–2, 2–5, 5–12, 12–25, >25 m. The weighting applied to the percent cover classes were: 1 = <1%, 2 = 1–5%, 3 = 6–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%. Importance Values therefore integrated both horizontal and vertical dimensions of vegetation structure with the weighting applied to express the varying degrees of cover occurring for each weed species in height tiers. For example, blackberry with 6–25% live foliage cover occurring in height tier 4 (2–5 m); and 76–100% cover in both tiers 5 (0.3–2 m) and 6 (<0.3 m) would score an IV of 15 (i.e., 3 + 6 + 6 = 15 IV). This resulted in species IVs ranging from 0–17. The total weed cover IV was calculated by summing the percent cover class mid-point value for all species within a tier, and then summing this total cover across all tiers. This resulted in total weed cover IVs of 0–28. Total weed cover included exotic conifers, but exotic conifer stem density was used as the variable for the potential prediction of conifer distribution within the FRA. The predictor variable: distance to mature indigenous forest, was a desktop measure from each plot centre-point, using satellite imagery in Google Earth Pro.

All statistical analyses were undertaken in R (R Core Team, 2017). Potential relationships, Pearson correlation coefficients, and the presence of outliers were assessed using a combined graphical scatterplot matrix and correlation coefficient output. Only weak associations occurred for exotic conifer density, gorse IV, wild broom IV (gorse and wild broom occurred only infrequently in plots) and the predictor variables, and for this reason, subsequent modelling of total conifer density, gorse cover, or wild broom cover was not possible. Modelling the cover of grey willow, tree lupin, cotoneaster, and Eucalyptus were not attempted due to the low frequency of occurrence by these species in survey plots. See Appendix B for the IV for all woody exotic weed species surveyed.

Statistical modelling was undertaken using BRT analysis. BRT analysis is an advanced from of regression analysis. Rather than the traditional regression approach of seeking to fit a single best model, BRT modelling combines a large number of relatively simple trees to optimise predictive performance (Elith et al. 2008). BRTs do not require prior data transformations and are not sensitive to outliers; and interactions are automatically identified and modelled (Elith et al. 2008). The BRT output provided (1) relative measures of strength of association (% contribution/relative influence; RI) between the response and predictor variables in the model, (2) a non-linear response curve (in the form of partial dependence plots[2]), and (3) a

[2] Partial dependence plots show how a response variable changes in relation to changes in a given predictor variable accounting for the average effects of all other variables in the model (Elith et al. 2008). Note that the partial dependence plot y-axes are not in the units of the response variable.

measure of performance from the prediction to withheld sites, calculated using k-fold cross validation (CV)[3], using the gbm.step function of the gbm package (Ridgeway, 2017). Model optimisation involved systematically tuning the number of trees (*nt*), learning rate (*lr*), and tree complexity (*tc*) (Elith et al. 2008). Given the relatively small dataset, the data were best modelled with simple trees (*tc* 2 & 4), and this still allowed for the modelling of least two-way interactions. Optimal model selection (Appendix C) resulted from a combination of *tc* and *lr*, which provided >1 000 *nt*, and returned the lowest predictive deviance from the CV (mean and SE; Elith et al. 2008).

The optimal BRT models were predicted (gbm.predict.grids function; Elith et al. 2008) to 10 × 10 m ascii grids of predictor variables derived from a 2.5 × 2.5 m Digital Elevation Model of the FRA. Predictions were then mapped from the resulting ascii grids using ArcGIS. The maps generated from the BRT predictions were therefore at the same 10 × 10 m scale as the plot grid survey.

In relation to the first project objective, adequate indigenous woody regeneration was defined as >2 500 indigenous woody stems ha^{-1} (>15 cm tall) on the basis that this stem density would equate to approximately 2 × 2 m spacing (or denser groupings) from which canopy closure of indigenous species could be reasonably expected. A mask was applied to the prediction map in GIS to indicate the spatial extent of adequate regeneration, and conversely, the area of the FRA for which restorative planting is recommended.

Blackberry was the most prevalent weed regarding species cover, and under some circumstances formed dense stands inhibiting forest regeneration. Thus, blackberry cover provided a useful descriptor of the extent of the FRA requiring weed control (putting aside exotic conifers, which are discussed later). A total blackberry IV of >4 (i.e., allowing up to a total of 50% (but no more than 50%) cover summed across all tiers) was defined as providing a threshold above which blackberry control should be undertaken within the FRA. A mask was applied in GIS to the total blackberry prediction map to define the extent of the FRA requiring blackberry control.

[3] In BRT modelling, cross validation (CV) is a diagnostic technique used for model development and/or evaluation, which provides a means of testing the model on withheld portions of data (Elith et al. 2008). For a given model, the model CV (and SE) expresses the mean change in predictive deviance calculated over all stages in the stepwise model building process (Elith et al. 2008).

3.0 RESULTS

3.1 Boosted Regression Tree Analyses

Mapped BRT predictions for each response variable are contained in Appendix D. Percentage contribution of predictor variables in each BRT are contained in Table 3. In all models, CV deviance and SE results showed no benefit in dropping predictor variables (Appendix C), thus all models retained the predictor variables: elevation, slope, distance and direction.

Total indigenous woody stem density was strongly predicted (71.9% RI) by, and positively associated with, elevation (Fig. 3A). Slope contributed 10.5% RI, with an increasing positive association with total stem density evident on slopes between approximately 8–28˚ slope. Distance to mature indigenous forest contributed 8.9% RI, with stem density negatively associated with distance, and stem density most affected by distance within 100 m of mature indigenous forest edges.

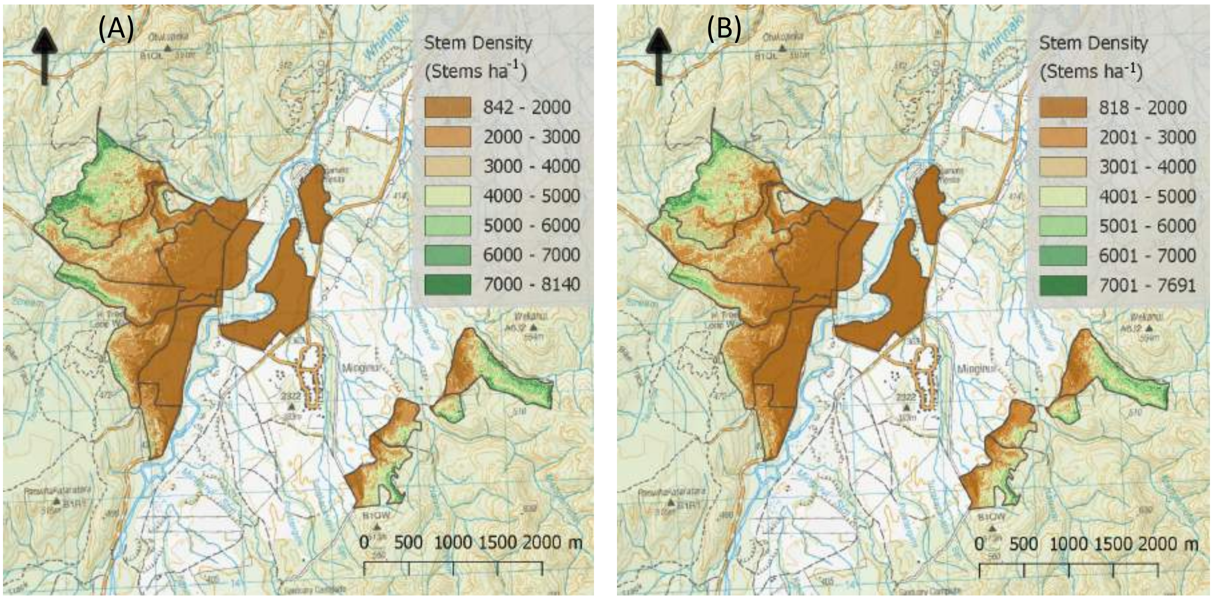

Figure 3: Mapped predictions of (A) total indigenous woody stem density (>15 cm tall) and (B) total indigenous woody angiosperm stem density (>15 cm tall) for the Ngati Whare Forest Return Area.

Angiosperm stem density was influenced by predictors in a similar manner as described above for total indigenous woody stem density—elevation had the greatest RI on angiosperm stem density, with lesser RIs relating to direction (10.9% RI), slope (9.7% RI) and distance from mature indigenous forest (7.8% RI; Fig. 3B).

In marked contrast to angiosperm stem density, total podocarp stem density was only weakly influenced by elevation (2.8% RI; Fig. 4A). Direction (56.7% RI) and distance (28.3%

RI) were the predictors with greatest influence over podocarp density. Slope explained 11.2% RI for podocarp stem density. These results suggest that podocarps occur in even density across the 341–658 m a.s.l elevation range of the survey area, with greater podocarp stem densities occurring in SW–NW and E–SE aspects. Podocarp stem densities were lowest on flat (<5˚ slopes) sites, and on sites with southern aspects. Sixty-two percent of podocarp individuals occurred on ridge physiography, 36% on faces, and 2% on terraces. These results are consistent with the light-demanding life-history traits of the main podocarp species observed (totara, kahikatea, rimu & matai), which are relatively light-demanding (to differing degrees), yet very long-lived, species (Ebbett & Ogden, 1998).

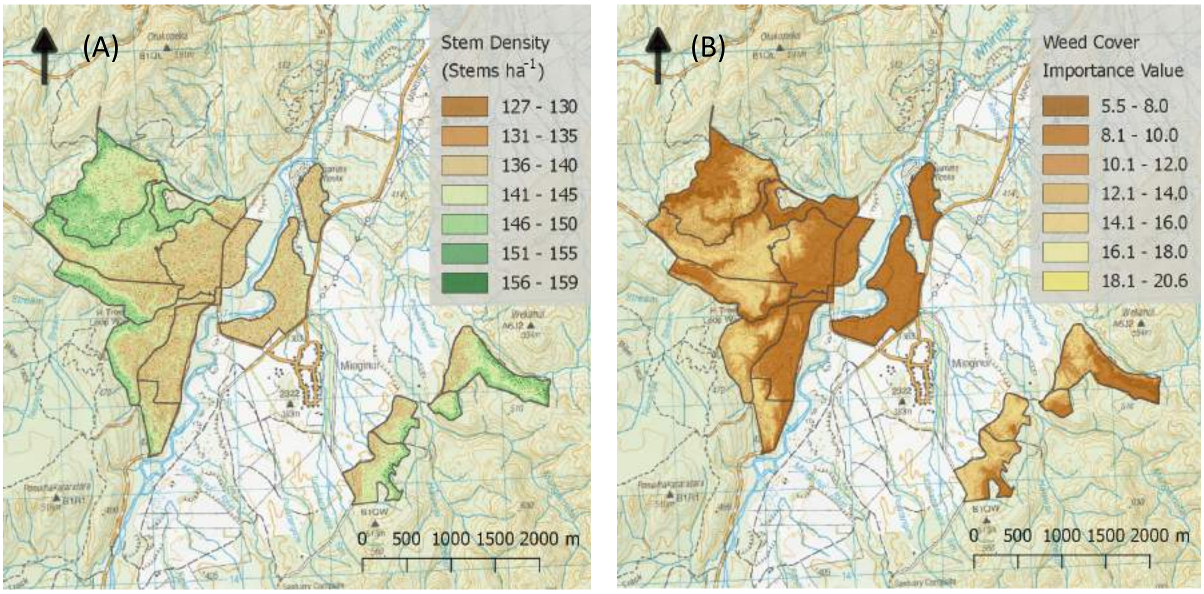

Figure 4: Mapped predictions of (A) total podocarp stem density (>15 cm tall) and (B) total weed cover Importance Value (IV) for the Ngati Whare Forest Return Area.

Total weed cover was most influenced by the predictor variables elevation (62.7% RI) and direction (20.1% RI; Fig. 4B). Total weed cover increased initially with increasing elevation, then sharply declined, followed by a more gradual decline (negative association) with increasing elevation. The initial spike in total weed cover may be influenced by the inclusion of exotic conifer cover, as a low elevation compartment (109) featured substantial exotic conifer regeneration. As conifer distribution was not explained by the predictor variables used in this study, remodelling total weed cover excluding exotic conifer cover would likely provide clearer relationships between total (non-exotic conifer) weed cover and the predictor variables. Nevertheless, there was an overall negative association between total weed cover and elevation. Total weed cover had a negative association with slope. These predictions suggest that total weed cover would reduce with increasing elevation and slope.

Total blackberry cover was influenced by elevation (42.1% RI), slope (26.3% RI), and direction (24.4% RI), with clear negative associations between blackberry cover and both elevation and slope (Fig. 5A). Total blackberry cover was greatest on flat sites (<5˚ slope).

Total buddleia cover was influenced most strongly by slope (44.9% RI) and distance to indigenous forest. The association with slope was positive, and the association with distance negative (Fig. 5B). The ecological reason for an association between buddleia cover and distance from indigenous forest is unclear and may be a result of small sample size for this species. There may be unmeasured predictors which are of more importance to explaining buddleia cover.

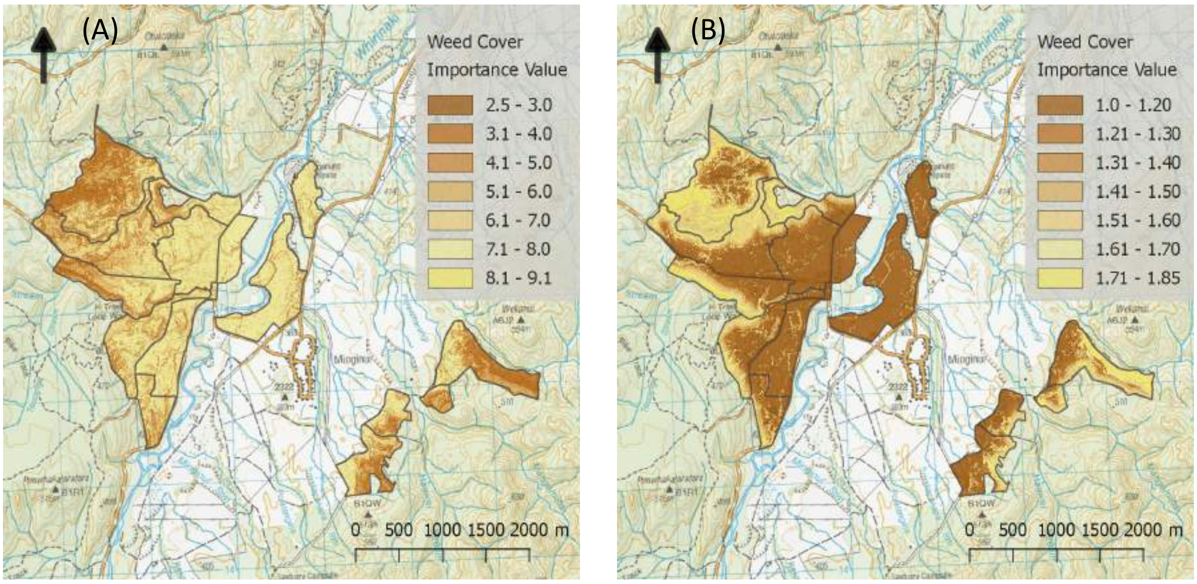

Figure 5: Mapped predictions of (A) total blackberry cover Importance Value (IV) and (B) total buddleia cover IV for the Ngati Whare Forest Return Area.

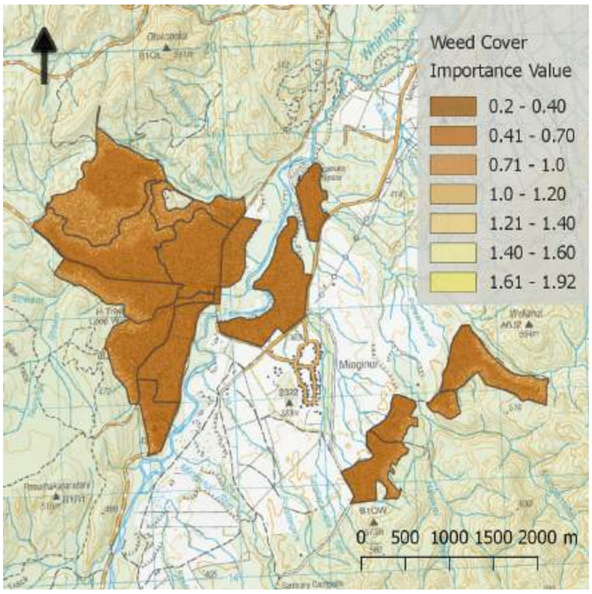

Figure 6: Mapped prediction of total Spanish heath cover IV for the Ngati Whare Forest Return Area.

Total Spanish heath cover was most strongly influenced by direction (54% RI), and distance (41.1% RI), although the ecological basis for these results is difficult to interpret and this is possibly the result of Spanish heath sample size being relatively small (Fig. 6). There may be unmeasured predictors which are of more importance to explaining Spanish heath cover.

Partial dependence plots for predictor variables in each BRT are presented in Figures. 7–10.

Table 3. Summary of the relative contributions (%) of predictor variables for boosted regression tree models fitted to data from 101 sites within exotic conifer plantation forest compartments following plantation clear-fell

Model	Predictor	Relative influence (%)	Model (SE) CV
Total indigenous woody stem density	Elevation	71.9	21.11 (2.0)
	Slope	10.5	
	Distance	8.9	
	Direction	8.7	
Total indigenous angiosperm stem density	Elevation	71.6	20.04 (2.9)
	Direction	10.9	
	Slope	9.7	
	Distance	7.8	
Total podocarp stem density	Direction	56.7	5.56 (2.42)
	Distance	28.3	
	Slope	11.2	
	Elevation	3.8	
Total weed cover	Elevation	62.7	3.89 (0.43)
	Direction	20.1	
	Slope	9.3	
	Distance	7.9	
Total blackberry cover	Elevation	42.1	4.52 (0.48)
	Slope	26.3	
	Direction	24.4	
	Distance	7.3	
Total buddleia cover	Slope	44.9	3.19 (0.33)
	Distance	38.5	
	Direction	12.3	
	Elevation	4.3	
Total Spanish heath cover	Direction	54.4	2.60 (0.38)
	Distance	41.1	
	Slope	3.3	
	Elevation	1.2	

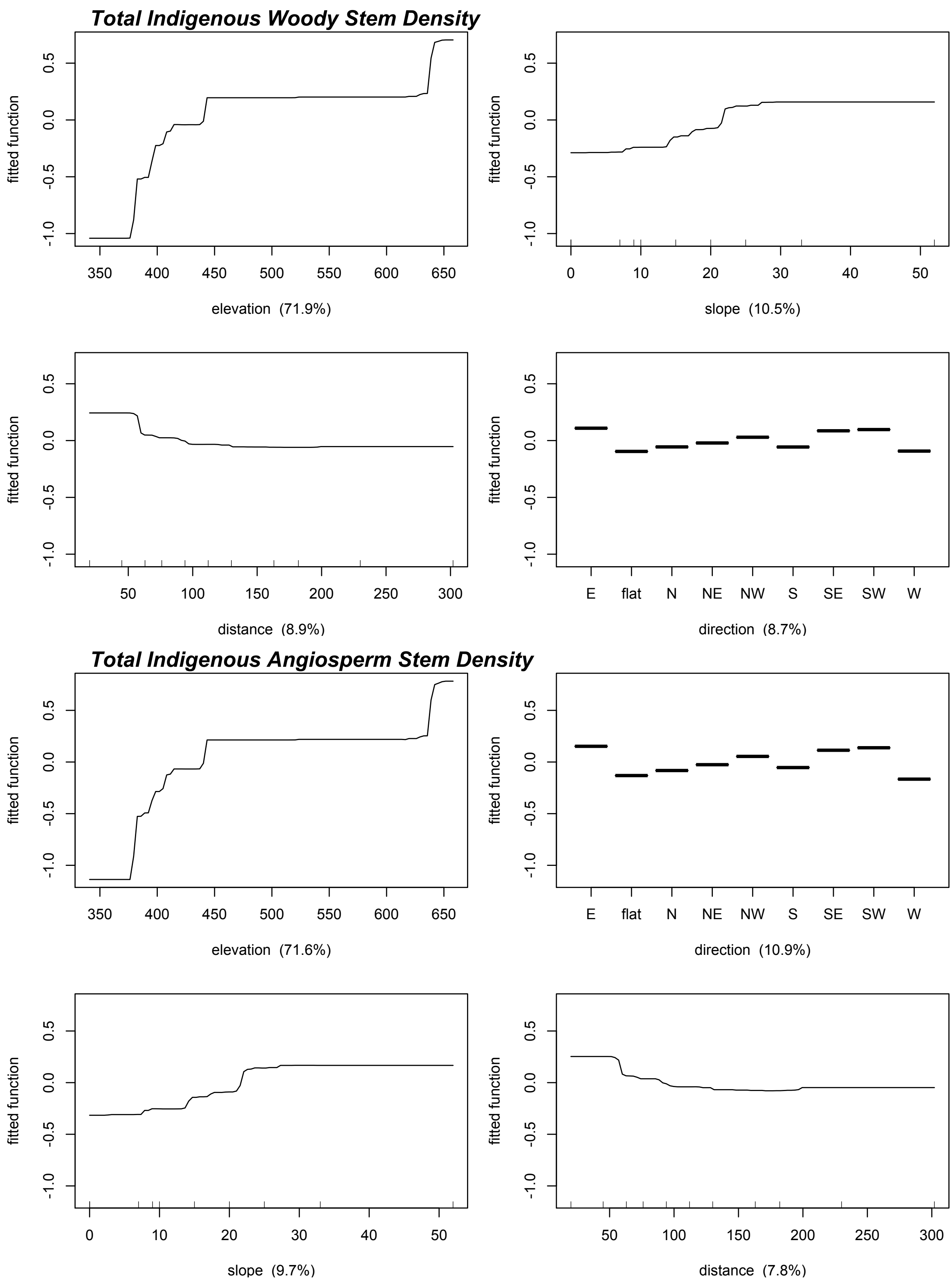

Figure 7: Partial dependence plots of the response curves for each of four predictor variables in the models for total indigenous woody stem density and angiosperm stem density. The units of the predictors are elevation = metres above sea level, slope = degrees, direction = intercardinal direction and flat (<5˚ slope), distance = metres from nearest mature indigenous forest.

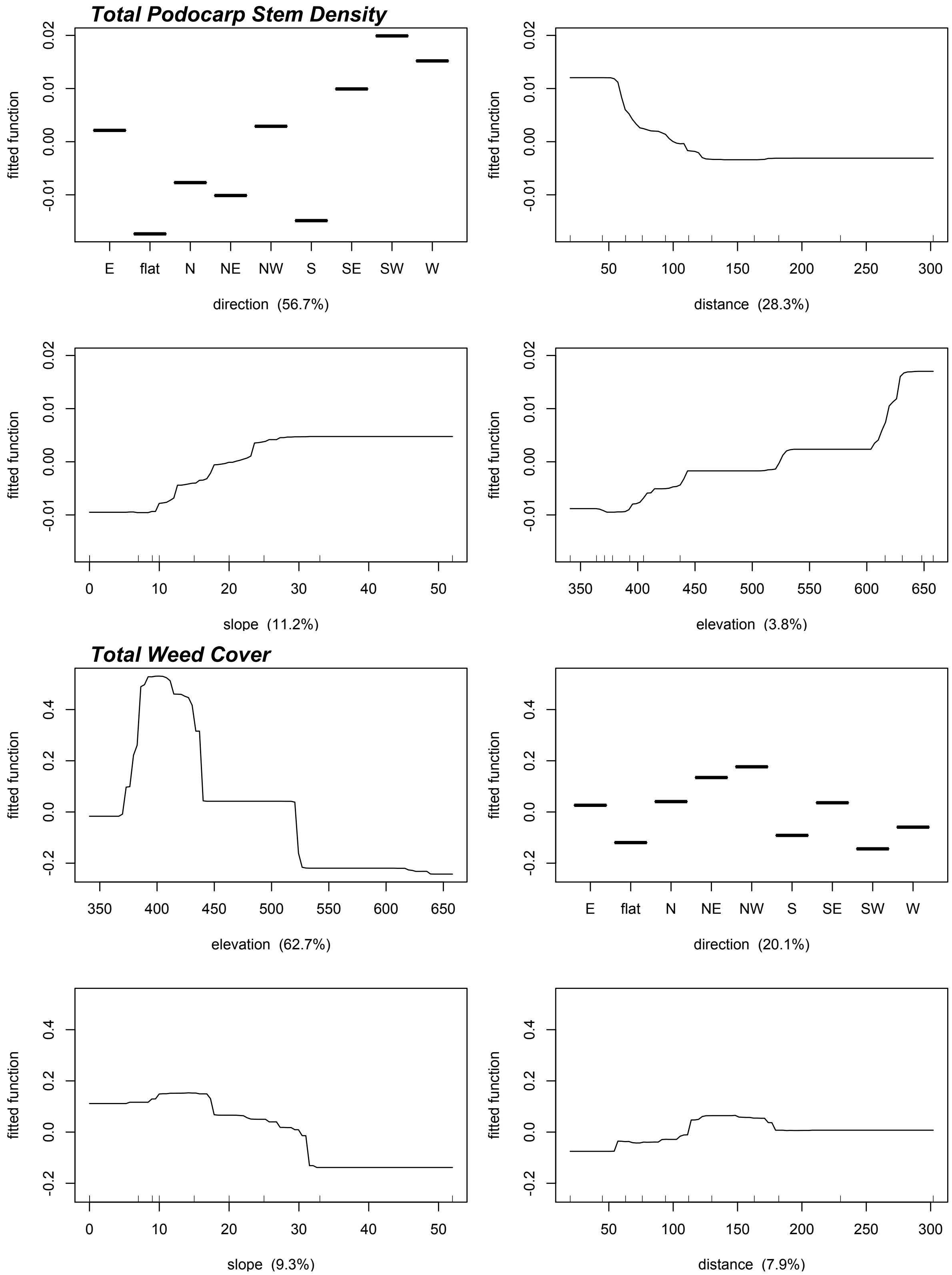

Figure 8: Partial dependence plots of the response curves for each of four predictor variables in the models for total podocarp stem density and total weed cover. The units of the predictors are elevation = metres above sea level, slope = degrees, direction = intercardinal direction and flat (<5˚ slope), distance = metres from nearest mature indigenous forest.

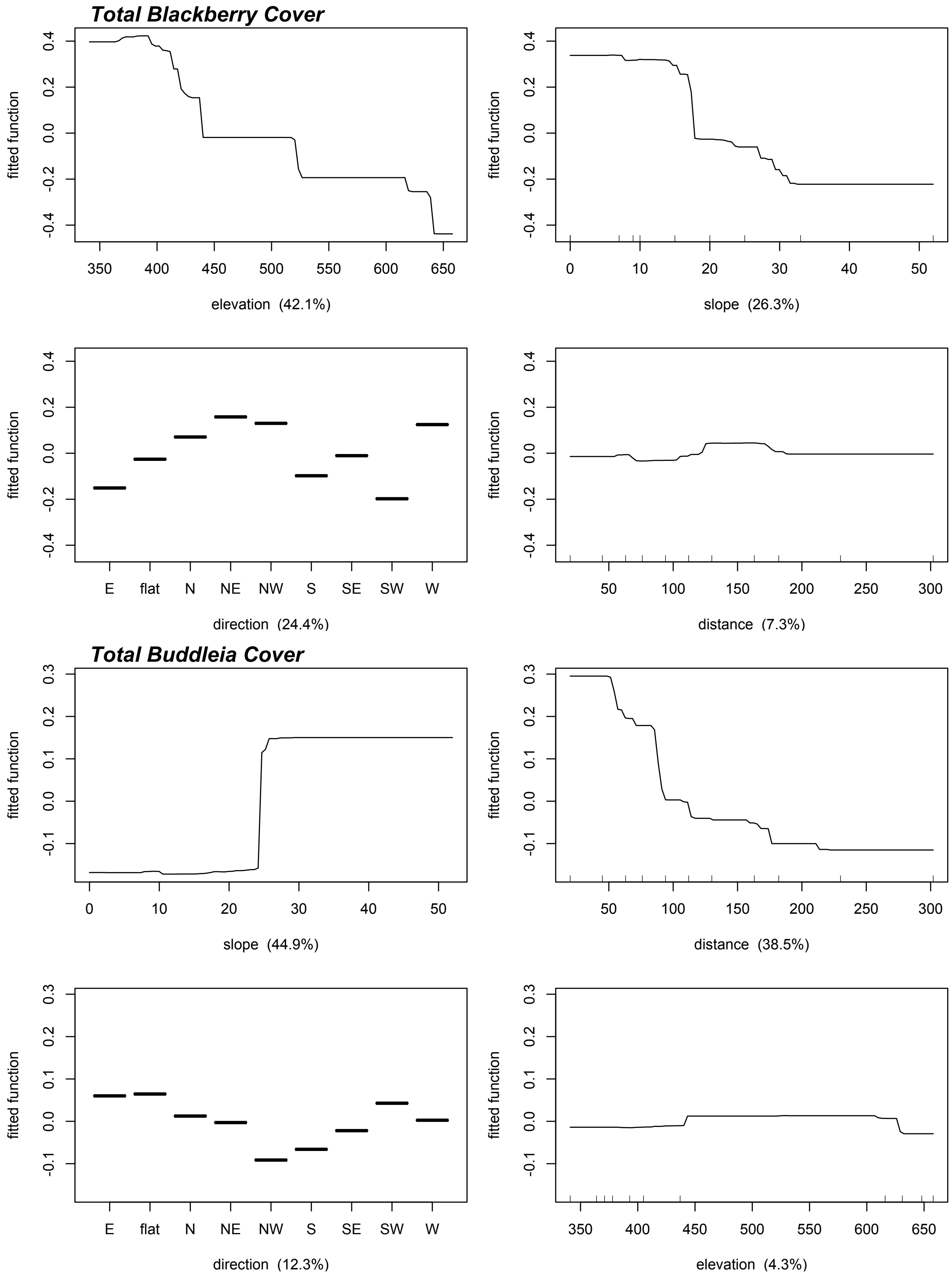

Figure 9: Partial dependence plots of the response curves for each of four predictor variables in the models for total blackberry cover and total buddleia cover. The units of the predictors are elevation = metres above sea level, slope = degrees, direction = intercardinal direction and flat (<5˚ slope), distance = metres from nearest mature indigenous forest.

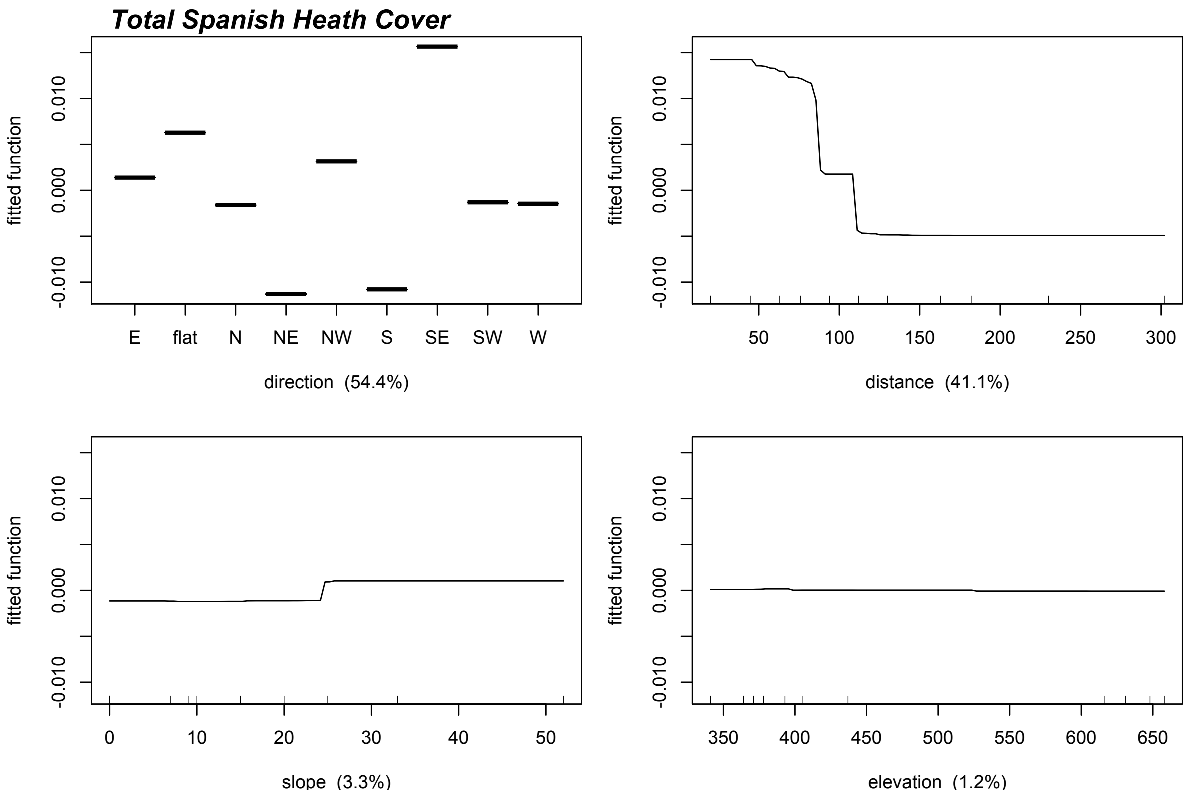

Figure 10: Partial dependence plots of the response curves for each of four predictor variables in the model for Spanish heath cover. The units of the predictors are elevation = metres above sea level, slope = degrees, direction = intercardinal direction and flat (<5˚ slope), distance = metres from nearest mature indigenous forest.

3.2 Exotic Conifer Summary Statistics Within the FRA

Three species of exotic conifers were recorded as occurring as wilding conifers (>15 cm tall) in survey plots. In order of abundance, stem densities for exotic confer species were: Douglas fir 126.9±37.3 stems ha^{-1}, radiata pine 114.8±23.3 stems ha^{-1}, and lucitanica 42.6±30.1 stems ha^{-1}. Total exotic conifer stem density across all survey plots was 284.3±51.3 stems ha^{-1}.

3.3 Correlations Amongst Response Variables

The strongest correlations amongst response variables relevant to regeneration and weed management of the FRA were:

1. Negative relationships between blackberry cover and both total indigenous woody stem density (>15 cm tall; *r* = -0.46) and total angiosperm density (>15 cm tall; *r* = -0.46).
2. Negative relationships between total weed cover and both total indigenous woody stem density (>15 cm tall; *r* = -0.21) and total angiosperm density (>15 cm tall; *r* = -0.21).

These results (Fig. 11) indicate that increasing levels of blackberry cover, and total weed cover, have a clear negative influence on the density of woody indigenous forest regeneration. All correlations amongst response variables are contained in Appendix E.

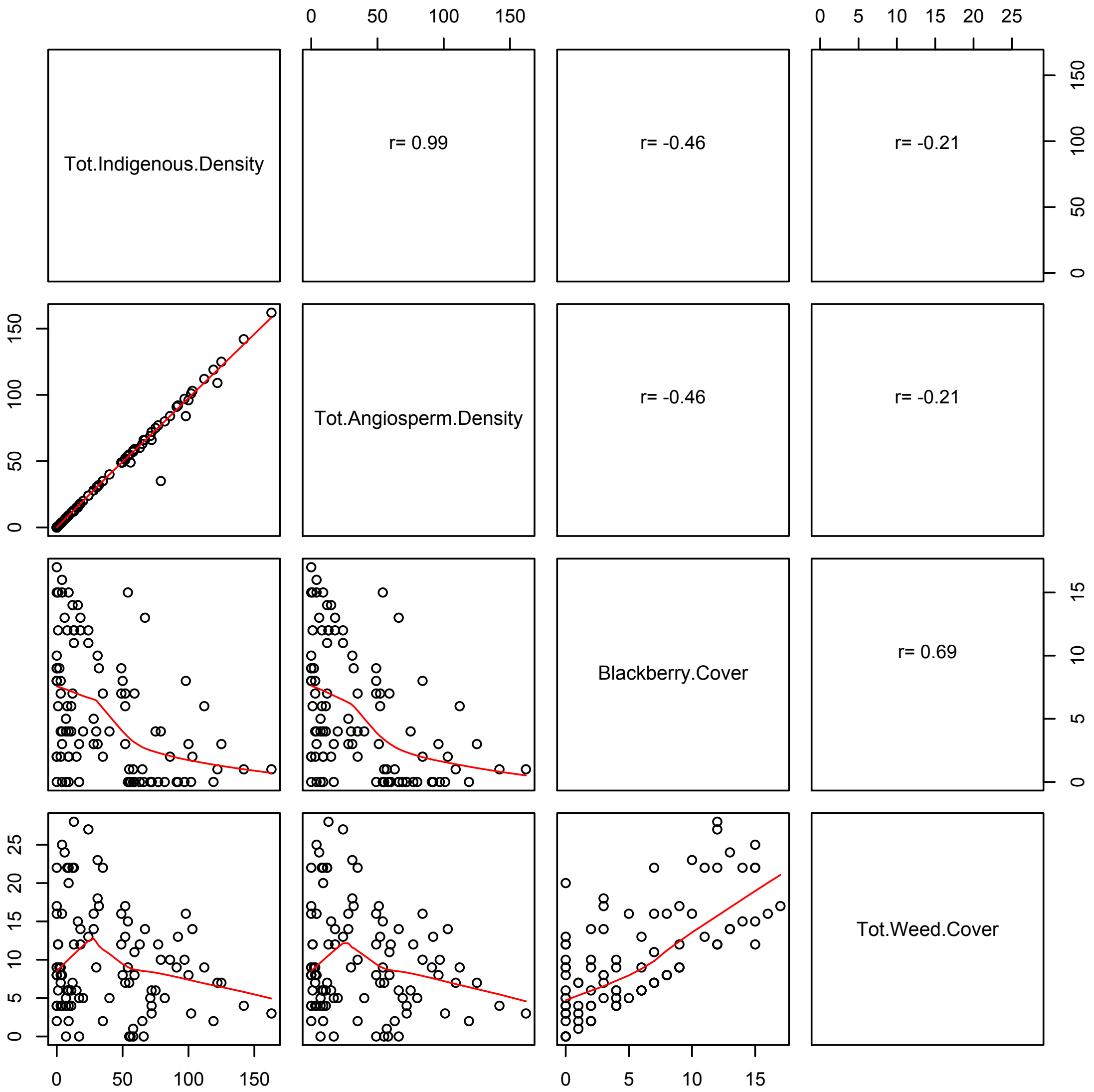

Figure 11: Orthogonal scatterplots with corresponding Pearson correlation coefficients for the response variables total indigenous woody stem density (>15 cm tall; stems ha^{-1}), total angiosperm wood stem density (>15 cm tall; stems ha^{-1}), and blackberry cover and total weed cover (inc. exotic conifers) importance values.

4.0 RECOMMENDATIONS

Based on the results of the study, the following recommendations are made in relation to the extent of indigenous planting and the types of weed control that will be required in each compartment, and parts of compartments.

4.1 Density Threshold for Planting ("Indigenous Planting Area")

The density threshold for planting is the predicted total indigenous woody stem density of <2 500 stems ha^{-1} (Appendix F). This is based on a potential seedling spacing at this density of 2 x 2 m (such as commonly used in restoration plantings of indigenous nursery-raised seedlings) to achieve indigenous canopy closure, acknowledging that natural establishment might not result in even spacing of stems, but that this stem density is overall likely to lead to canopy closure by indigenous forest species. A breakdown of each forestry compartment recommended for indigenous planting is presented in Table 4. A total of 323.6 ha is recommended for planting. This is 55.6% of the FRA. Leave the remainder of the FRA to naturally regenerate in indigenous angiosperms.

Table 4. Areas (ha) and percentages of Ngati Whare Forest Return Area Forestry Compartments Recommended for Revegetation and Blackberry Control

FRA Compartment	Compartment area (ha)	Area requiring revegetation (ha, %)	Area requiring blackberry control (ha, %)
81	30.41	8.83, 29.0	23.55, 77.4
82	16.20	7.31, 45.2	14.80, 91.4
83	8.03	0.75, 9.4	5.90, 73.6
84	43.75	11.71, 26.8	28.30, 64.7
112	19.42	19.39, 99.8	19.10, 98.3
113	57.25	57.23, 100.0	56.58, 98.8
129	26.30	22.49, 85.5	25.61, 97.4
130	19.80	19.67, 99.3	19.65, 99.2
131	53.20	52.08, 97.9	53.20, 100.0
132	40.66	40.29, 99.1	40.39, 99.3
133	21.39	12.56, 58.7	20.87, 97.6
134	44.03	26.73, 60.7	43.01, 97.7
135	43.19	17.74, 41.1	36.74, 85.1
136	71.74	17.66, 24.6	67.21, 93.7
137	87.13	9.16, 10.5	56.15, 64.5
Totals	582.5	323.6, 55.6	511.1, 87.8

4.2 Cover Threshold for Blackberry Control ("Blackberry Control Area")

The IV threshold for blackberry control is the predicted total blackberry cover of IV >4.0 (equivalent of Recce Cover Class 4; 26–50% blackberry cover summed across all tiers; Appendix F). Control blackberry and other woody weeds occurring in the Blackberry Control Area. A breakdown of each forestry compartment recommended for blackberry control is presented in Table 4. A total of 511.1 ha is recommended for blackberry control. This is 87.8% of the FRA. Leave the remainder of the FRA for natural succession to outcompete (through shading by angiosperm regeneration) the remaining blackberry.

4.3 Wilding Exotic Conifer Control

Periodically control all wilding exotic conifers across the entire FRA. The timing and frequency of this management measure needs to be determined.

4.4 Indigenous Conifer Enrichment Planting

Low-density enrichment planting of podocarp species in either (1) areas of higher predicted naturally occurring densities (Fig. 4A)—to establish podocarps into optimal site conditions for these species, or (2) outside of the higher predicted areas of naturally occurring podocarp regeneration—to increase the representativeness of podocarps across the FRA (e.g., on flat sites where natural regeneration is weak), or both 1 and 2—blanket podocarp planting across the entire FRA to achieve both of the podocarp enrichment planting objectives.

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Appendices

Appendix A: Map and Photographs of the Forestry Compartments Surveyed

Appendix B: Weed Cover Importance Values (IV)

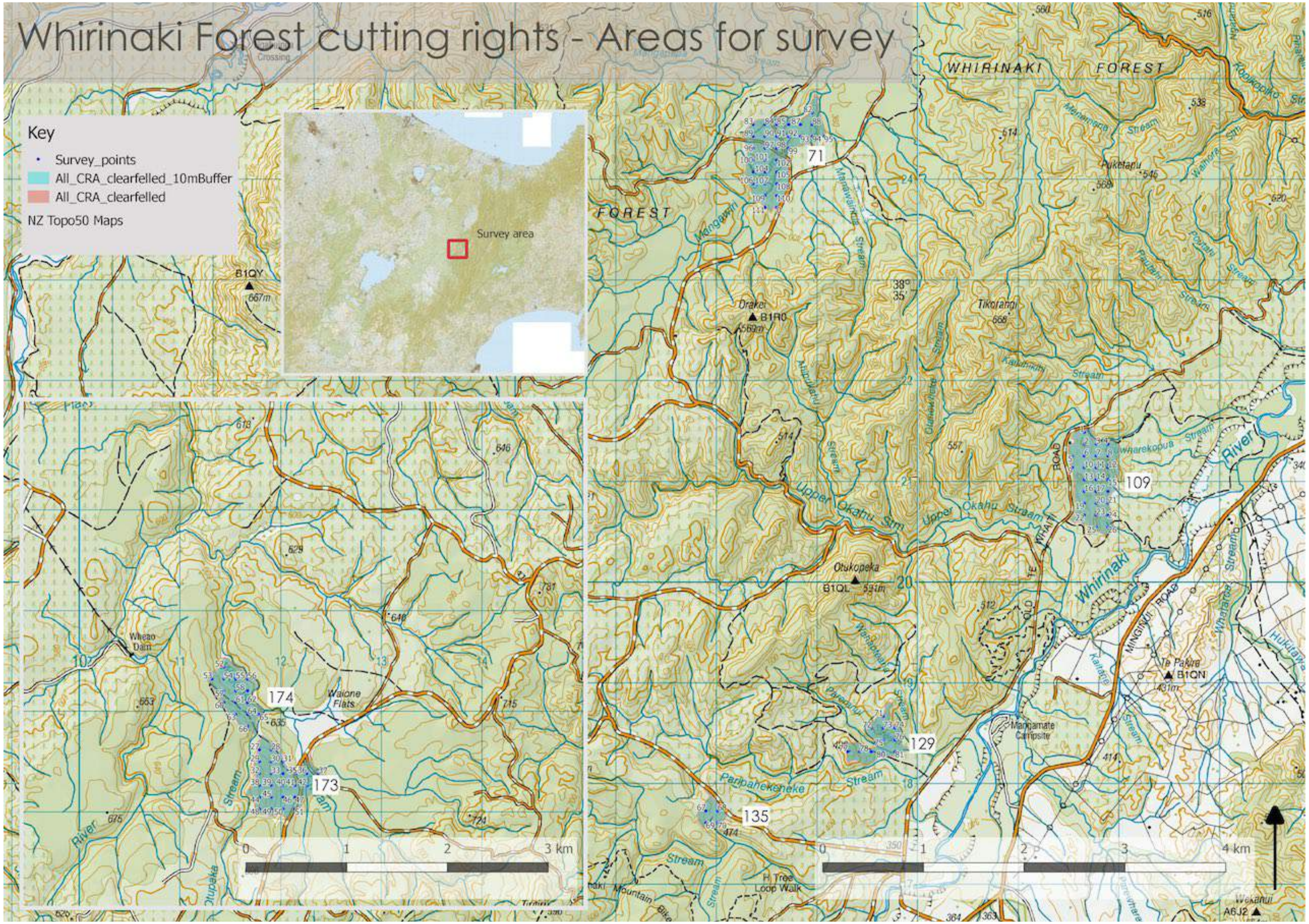
Appendix C: Boosted Regression Tree K-Fold Cross Validation Model Selection Outputs

Appendix D: Mapped Predictions for Response Variables

Appendix E: Scatterplot Matrix Showing Associations and Pearson Correlation Coefficients Among Response Variables

Appendix F: Recommended Indigenous Planting and Blackberry Control Areas

Appendix A: Map and Photographs of the Forestry Compartments Surveyed


Whirinaki Forest cutting rights - Areas for survey
Key
Survey_points
All_CRA_clearfelled_10mBuffer
All_CRA_clearfelled
NZ Topo50 Maps
Survey area
71
109
129
135
173
174
WHIRINAKI FOREST
Upper Okahu Stream
Whirinaki River
Otukopeka
Drakei
Tikorangi
Waione Flats
Mangamate Campsite
Te Pakire
0 1 2 3 km
0 1 2 3 4 km

Compartment 71

Compartment 109

Compartment 129

Compartment 135


Compartments 173 (foreground/middle) and 174 (middle-distant right)

Appendix B: Weed Cover Importance Values (IV)

Plot reference	CYTSCO	ULEEUR	BUDDAV	PSEMEN	RUBFRU	ERILUS	LEYFOR	PINRAD	CUPLUS	SALCIN	LUPARB	COTGAL	Eucalyptus sp	Tot. Ex. Conifer
112	9	2	1	1	2	1								1
110			2	2	4									2
109					2									
108					9	2								
107			4		3		2							
106			4	2	2		4			1				2
105	2			1	9									1
104			2	2	4									2
103			4	2	4					2				2
102	5		1	2	8									2
101				2	8									2
100					6									
99					4									
98				2	7									2
97		4	4	2	6					2				2
96					12									
95					2									
94			1		4									
93			4	2	2		2							2
91					15	2				3				
90		1		2	12		4							2
89		2	2		8									
88			5							2				
87					6									
86	2										2			

Plot reference	CYTSCO	ULEEUR	BUDDAV	PSEMEN	RUBFRU	ERILUS	LEYFOR	PINRAD	CUPLUS	SALCIN	LUPARB	COTGAL	Eucalyptus sp	Tot. Ex. Conifer
85			2	1	9									1
84				2	8									2
83				1	5	2		2						2
82			2		2									
81				3	14	6								3
79	7		2		13	5				6				
78			9		9	3								
77			3		15									
76	5				16	3						2		
75	5		4	5		5								5
74			7	6	4	7				2				6
73			9	7	3	10	4							7
72			7	5	3	5								5
71			9	4	7	6								4
69			6		4				9	3				9
68	15				10									
67	14			4	8	5			7					7
66		2	4		4	4		2		2				2
65			2					7		3				7
64		6	2		3	2				5				
63						2				3				
62			4				2							
60			2		1	2								
59														
58														
57			2					8		3				8
55			2			1								

Plot reference	CYTSCO	ULEEUR	BUDDAV	PSEMEN	RUBFRU	ERILUS	LEYFOR	PINRAD	CUPLUS	SALCIN	LUPARB	COTGAL	Eucalyptus sp	Tot. Ex. Conifer
54			5					4					3	4
53														
52			5											
50		5						8						8
49			5		2			7						7
48			2											
47					13			2						2
46								12						12
45								13						13
44		5			4									
43					1									
42					7									
41					12			1		1				1
40					9		7	8						8
39					6			9		3				9
38					3			4						4
37	2				8									
36					1			1						1
35		6	4		11	4								
34		2			4	2		2		2				2
33			5		6			4		3				4
32														
30					1			2						2
29								3						3
28														
27					2									
26					17					4				

Plot reference	CYTSCO	ULEEUR	BUDDAV	PSEMEN	RUBFRU	ERILUS	LEYFOR	PINRAD	CUPLUS	SALCIN	LUPARB	COTGAL	Eucalyptus sp	Tot. Ex. Conifer
25			2		3	2		14		2				14
24			3		5			13						13
23					7			13						13
22					15			9						9
20					7			17						17
19					10	2		16						16
18		4			7									
17					1			6						6
16					14			11						11
15					1			6						6
14					3			15						15
13					13			14						14
12								9						9
11														
10					15			8						8
8					12			12						12
7					11			13						13
6	8		4		2	2		9		2				9
5								20						20
4					12			18						18
2					12			19						19
1					15			12						12
# of plots occurring	11	11	39	22	78	24	7	39	2	20	1	1	1	61
Mean IV per plot	6.7	3.5	3.8	2.7	7.0	3.5	3.6	9.1	8.0	2.7	2.0	2.0	3.0	7.0
SUM of IV all plots	74	39	147	60	549	85	25	353	16	54	2	2	3	424

Appendix C: Boosted Regression Tree K-Fold Cross Validation Model Selection Outputs

Total indigenous woody stem density	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	2700	21.114	1.957
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	2100	21.066	3.114
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	1650	21.92	4.164
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	1450	23.51	3.11
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	1150	21.04	2.3
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	950	22.014	4.288
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	800	22.278	2.918
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	800	22.951	5.532
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	550	22.36	3.176
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	450	21.896	4.2
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	400	22.832	4.218
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	350	23.005	4.181
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	300	23.824	6.086
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	200	21.931	3.372
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	200	22.292	4.652
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	200	22.395	4.263

Explanatory variables dropped from model:	CV deviance	CV SE
Slope and distance.	21.584	3.597
Model not simplified as no benefit in CV statistics.		

Total indigenous angiosperm stem density	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	2600	20.283	2.904
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	2300	20.7	3.113
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	1900	21.376	3.892
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	1500	21.352	3.656
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	1150	20.485	2.624
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	900	21.703	4.635
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	850	19.687	3.098
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	800	20.632	3.879
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	550	20.066	3.103
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	450	19.487	2.412
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	450	20.303	3.907
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	400	19.518	4.588
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	300	20.983	3.778
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	250	20.502	4.355
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	200	19.953	2.646
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	200	20.625	3.182

Explanatory variables dropped from model:	CV deviance	CV SE
Distance, slope.	22.108	3.094
Model not simplified as no benefit in CV statistics.		

Total podocarp stem density	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc2.Lr0.000003.bag.frac0.5	2	0.000003	0.5	2350	5.456	2.42
tc2.Lr0.000005.bag.frac0.5	2	0.000005	0.5	2050	5.734	2.702
tc2.Lr0.000002.bag.frac0.5	2	0.000002	0.5	1000	5.521	2.388
tc2.Lr0.000005.bag.frac0.75	2	0.000005	0.75	1000	5.862	2.768
tc2.Lr0.000004.bag.frac0.75	2	0.000004	0.75	950	5.801	2.674
tc2.Lr0.000004.bag.frac0.5	2	0.000004	0.5	900	6.265	3.583
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	No model		
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	No model		
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	No model		
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	No model		
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	No model		
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	No model		
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	No model		
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	No model		
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	No model		
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	No model		
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	No model		
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	No model		
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	No model		
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	No model		
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	No model		
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	No model		
tc2.Lr0.000002.bag.frac0.75	2	0.000002	0.75	No model		
tc2.Lr0.000003.bag.frac0.75	2	0.000003	0.75	No model		

Explanatory variables dropped from model:	CV deviance	CV SE
Elevation, slope.	6.128	3.224
Model not simplified as no benefit in CV statistics.		

Total weed cover	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	no model		
tc2.Lr0.001.bag.frac0.75	2	0.001	0.75	2550	4.182	0.472
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	2500	3.894	0.43
tc2.Lr0.002.bag.frac0.75	2	0.002	0.75	2050	4.069	0.408
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	1800	4.094	0.373
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	1600	4.098	0.314
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	1300	4.08	0.646
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	800	4.12	0.496
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	800	4.174	0.52
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	750	4.154	0.411
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	650	4.063	0.555
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	550	3.897	0.593
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	550	4.102	0.518
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	500	4.283	0.577
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	450	4.085	0.535
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	250	4.119	0.404
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	200	3.965	0.554
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	200	4.184	0.377

Explanatory variables dropped from model:	CV deviance	CV SE
Distance, slope.	4.009	0.43
Model not simplified as no benefit in CV statistics.		

Total blackberry cover	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	No model		
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	No model		
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	No model		
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	1350	4.484	0.348
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	1050	4.605	0.371
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	900	4.646	0.374
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	750	4.486	0.558
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	700	4.46	0.495
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	650	4.51	0.308
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	500	4.457	0.353
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	400	4.456	0.373
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	400	4.466	0.374
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	350	4.571	0.46
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	200	4.388	0.511
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	200	4.412	0.486
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	100	4.464	0.36

Explanatory variables dropped from model:	CV deviance	CV SE
Distance, slope.	4.834	0.494
Model not simplified as no benefit in CV statistics.		

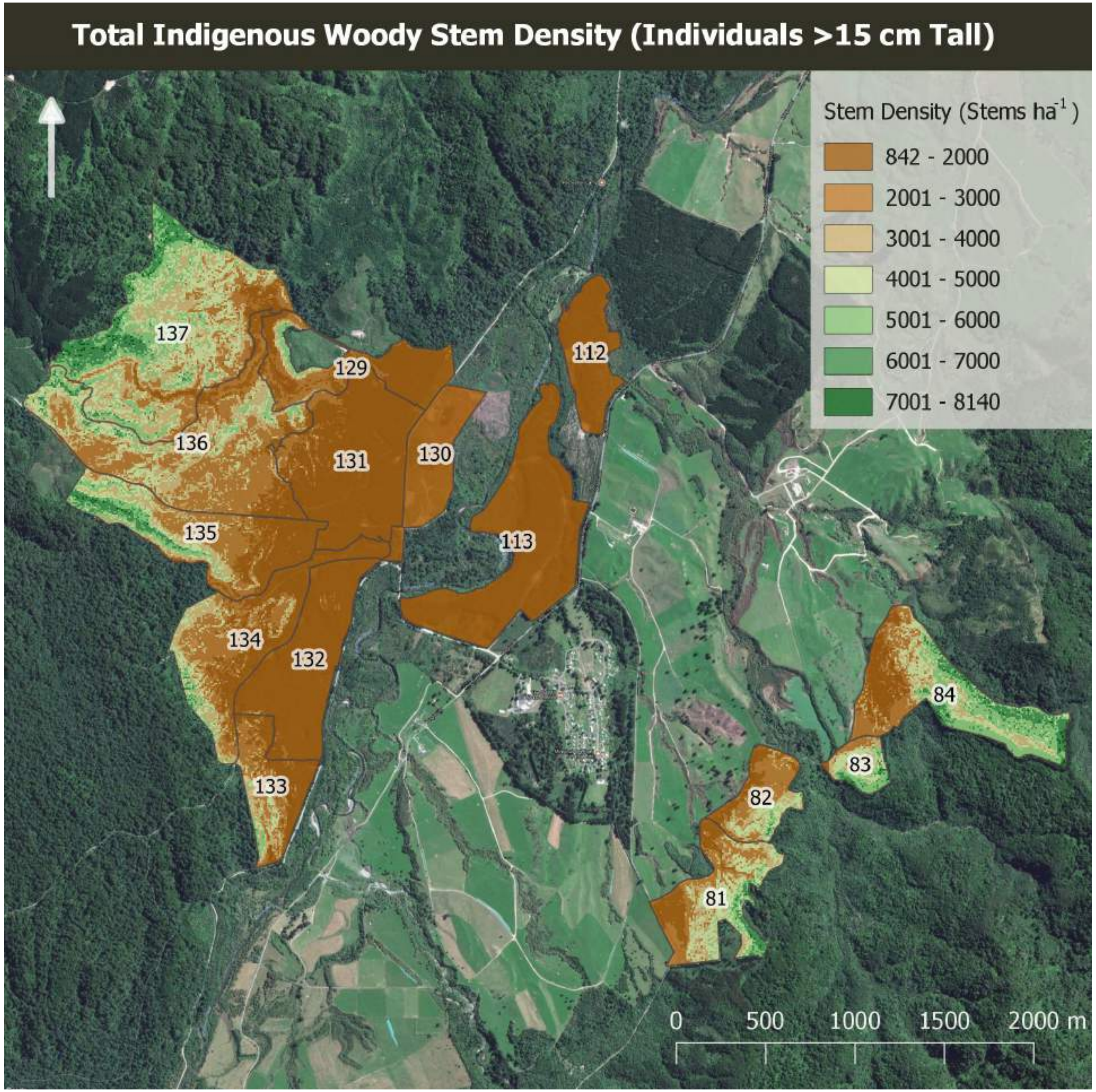
Total buddleia cover	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc5.Lr0.00003.bag.frac0.75	5	0.00003	0.75	1850	3.237	0.254
tc3.Lr0.0001.bag.frac0.75	3	0.0001	0.75	1650	3.248	0.34
tc2.Lr0.0003.bag.frac0.75	2	0.0003	0.75	1600	3.192	0.332
tc4.Lr0.00004.bag.frac0.75	4	0.00004	0.75	1300	3.273	0.249
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	No model		
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	No model		
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	No model		
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	No model		
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	No model		
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	No model		
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	No model		
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	No model		
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	No model		
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	No model		
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	No model		
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	No model		
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	No model		
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	No model		
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	No model		
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	No model		

Explanatory variables dropped from model:	CV deviance	CV SE
Elevation, direction.	4.996	0.552
Model not simplified as no benefit in CV statistics.		

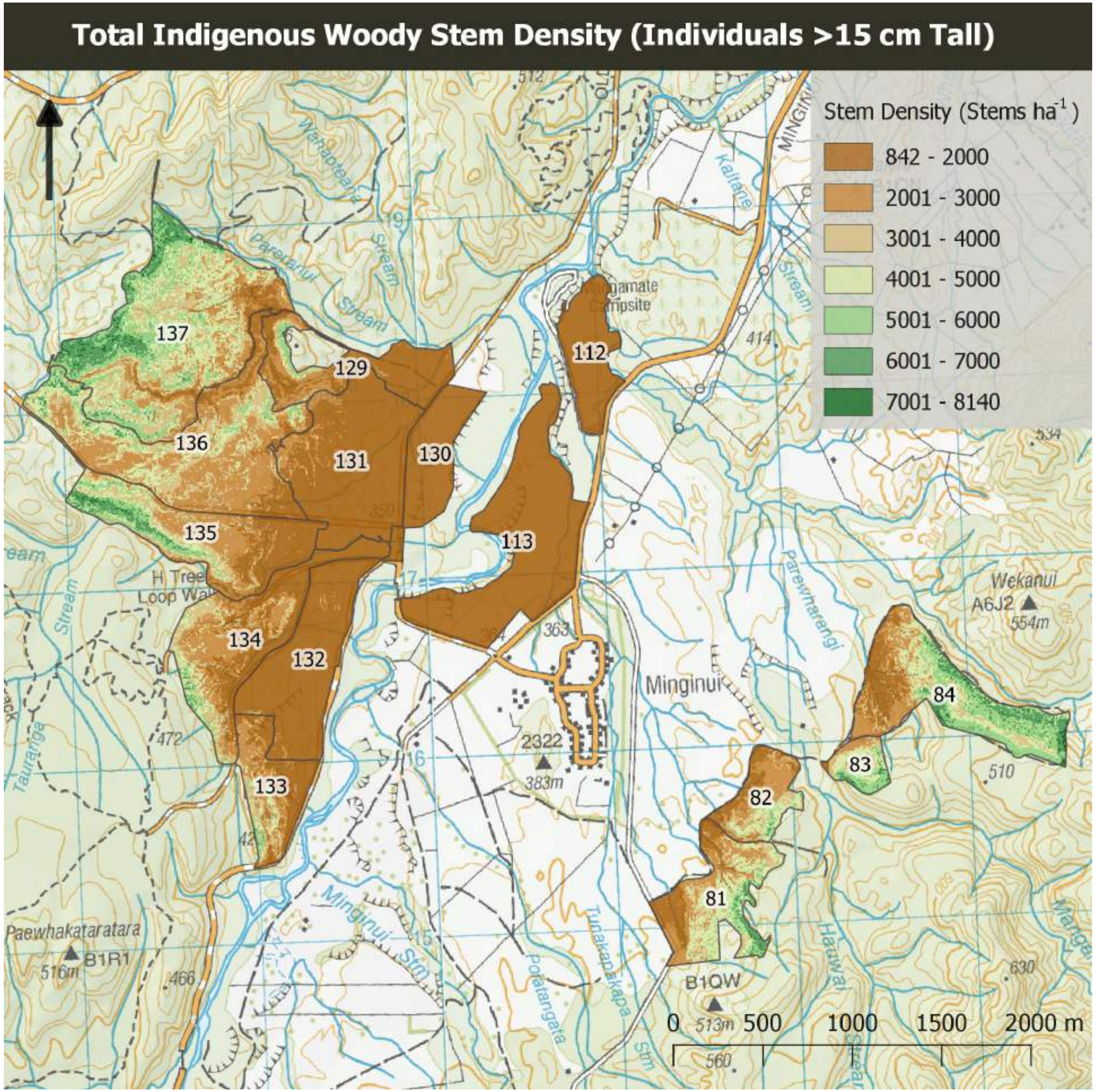
Total Spanish heath cover	Tree complexity	Learning rate	Bag fraction	Number of trees	CV deviance	CV SE
tc2.Lr0.000625.bag.frac0.75	2	0.000625	0.75	1100	2.598	0.375
tc2.Lr0.00001.bag.frac0.75	2	0.00001	0.75	1000	2.773	0.302
tc2.Lr0.00125.bag.frac0.75	2	0.00125	0.75	300	2.774	0.608
tc2.Lr0.01.bag.frac0.75	2	0.01	0.75	No model		
tc2.Lr0.005.bag.frac0.75	2	0.005	0.75	No model		
tc2.Lr0.0025.bag.frac0.75	2	0.0025	0.75	No model		
tc2.Lr0.000001.bag.frac0.75	2	0.000001	0.75	No model		
tc3.Lr0.01.bag.frac0.75	3	0.01	0.75	No model		
tc3.Lr0.005.bag.frac0.75	3	0.005	0.75	No model		
tc3.Lr0.0025.bag.frac0.75	3	0.0025	0.75	No model		
tc3.Lr0.00125.bag.frac0.75	3	0.00125	0.75	No model		
tc4.Lr0.01.bag.frac0.75	4	0.01	0.75	No model		
tc4.Lr0.005.bag.frac0.75	4	0.005	0.75	No model		
tc4.Lr0.0025.bag.frac0.75	4	0.0025	0.75	No model		
tc4.Lr0.00125.bag.frac0.75	4	0.00125	0.75	No model		
tc5.Lr0.01.bag.frac0.75	5	0.01	0.75	No model		
tc5.Lr0.005.bag.frac0.75	5	0.005	0.75	No model		
tc5.Lr0.0025.bag.frac0.75	5	0.0025	0.75	No model		
tc5.Lr0.00125.bag.frac0.75	5	0.00125	0.75	No model		
tc5.Lr0.00003.bag.frac0.75	5	0.00003	0.75	No model		

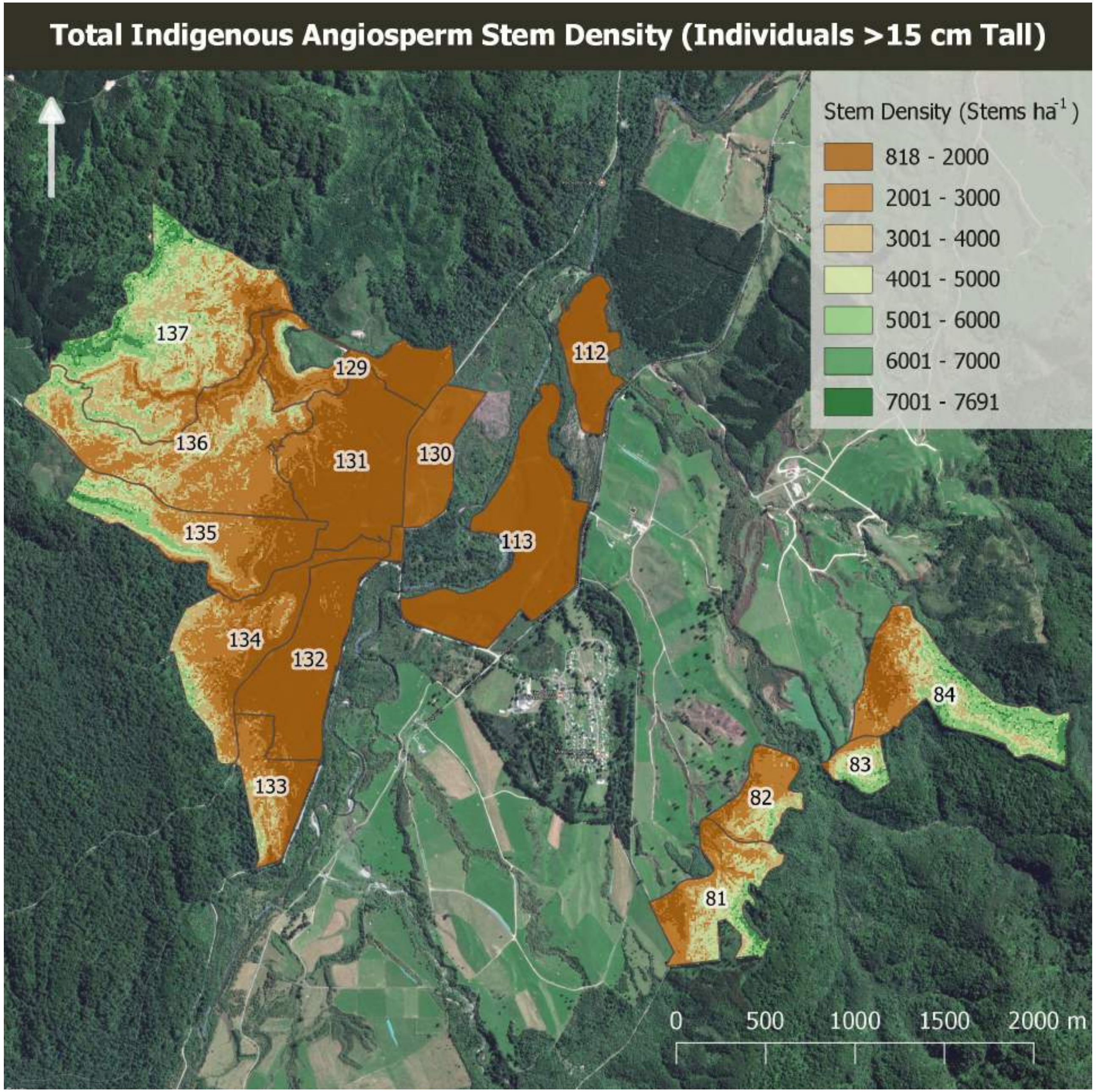
Explanatory variables dropped from model:	CV deviance	CV SE
Elevation, slope.	No model	
Model not simplified as no benefit in CV statistics.		

Appendix D: Mapped Predictions for Response Variables

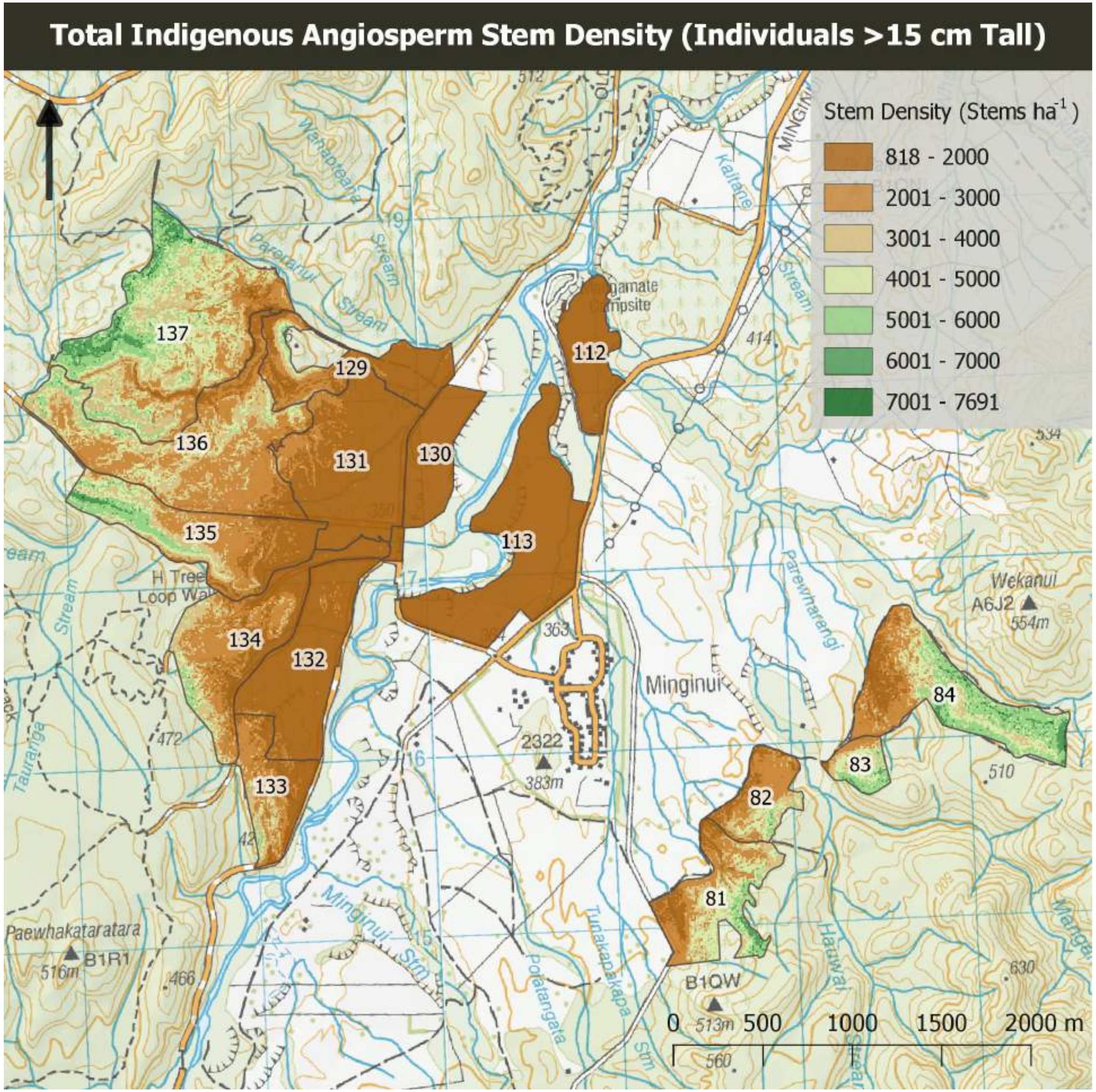

Total Indigenous Woody Stem Density (Individuals >15 cm Tall)
Stem Density (Stems ha^{-1})
842 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 6000
6001 - 7000
7001 - 8140
137
129
112
136
131
130
135
113
134
132
133
84
83
82
81
0
500
1000
1500
2000 m

Forbes Ecology



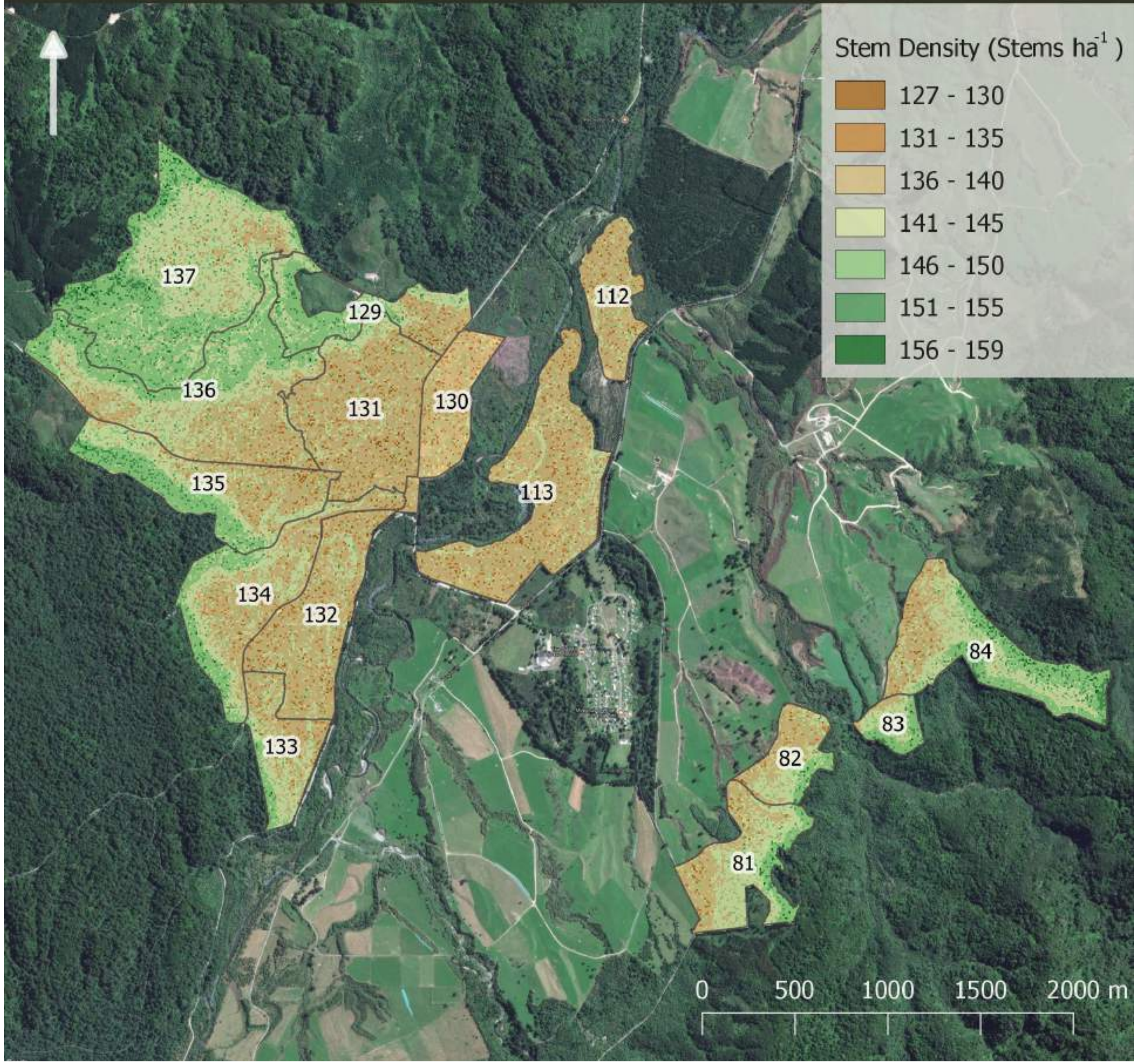


Total Indigenous Angiosperm Stem Density (Individuals >15 cm Tall)
Stem Density (Stems ha-1)
818 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 6000
6001 - 7000
7001 - 7691
137
129
136
131
130
112
113
135
134
132
133
84
83
82
81
0 500 1000 1500 2000 m



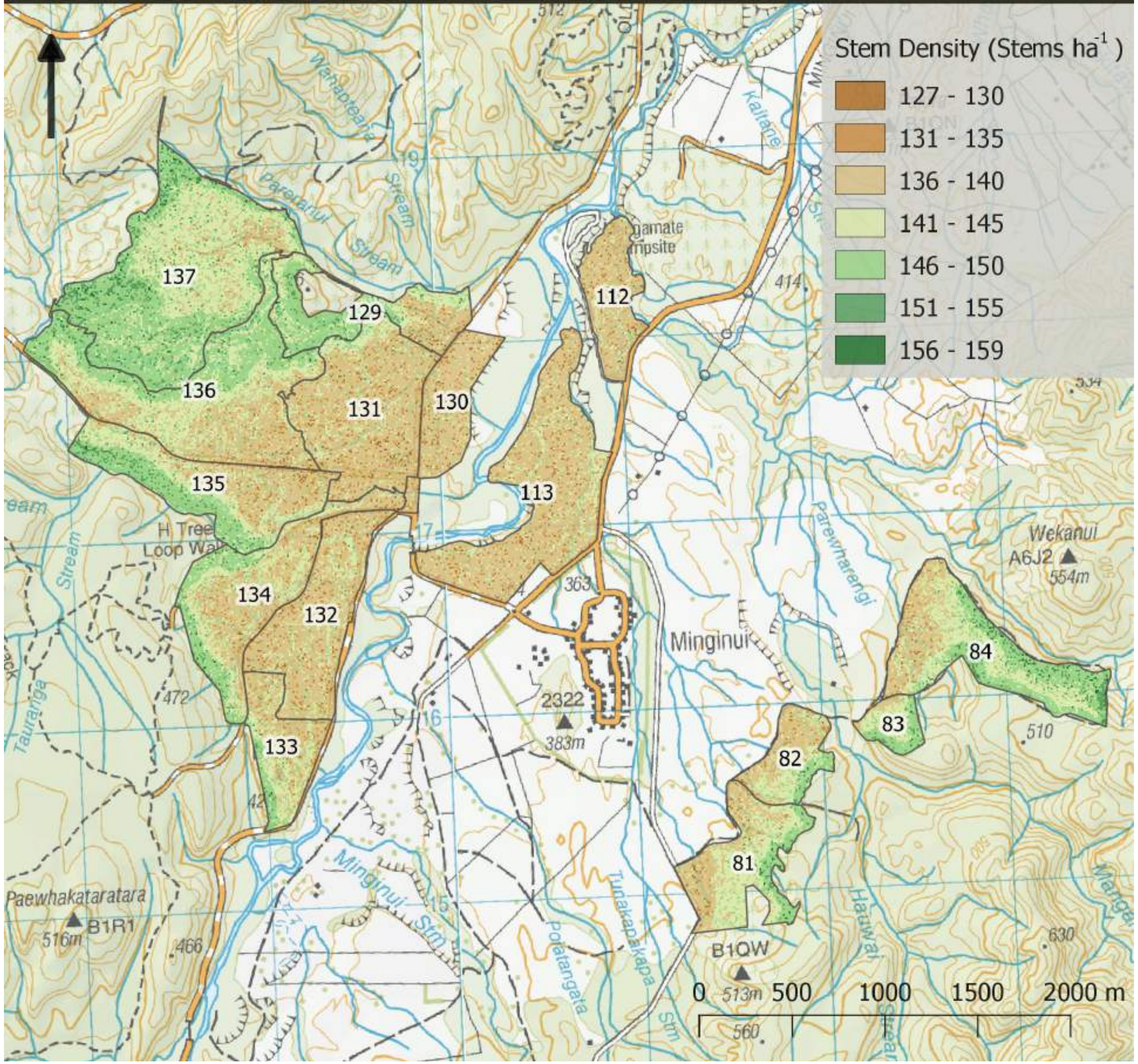
Total Indigenous Angiosperm Stem Density (Individuals >15 cm Tall)
Stem Density (Stems ha⁻¹)
818 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 6000
6001 - 7000
7001 - 7691
137
129
136
131
130
135
113
112
134
132
133
84
83
82
81
Minginui
H Tree Loop Walk
Wekanui
A6J2
554m
2322
383m
B1QW
513m
Paewhakataratara
B1R1
516m
0 500 1000 1500 2000 m

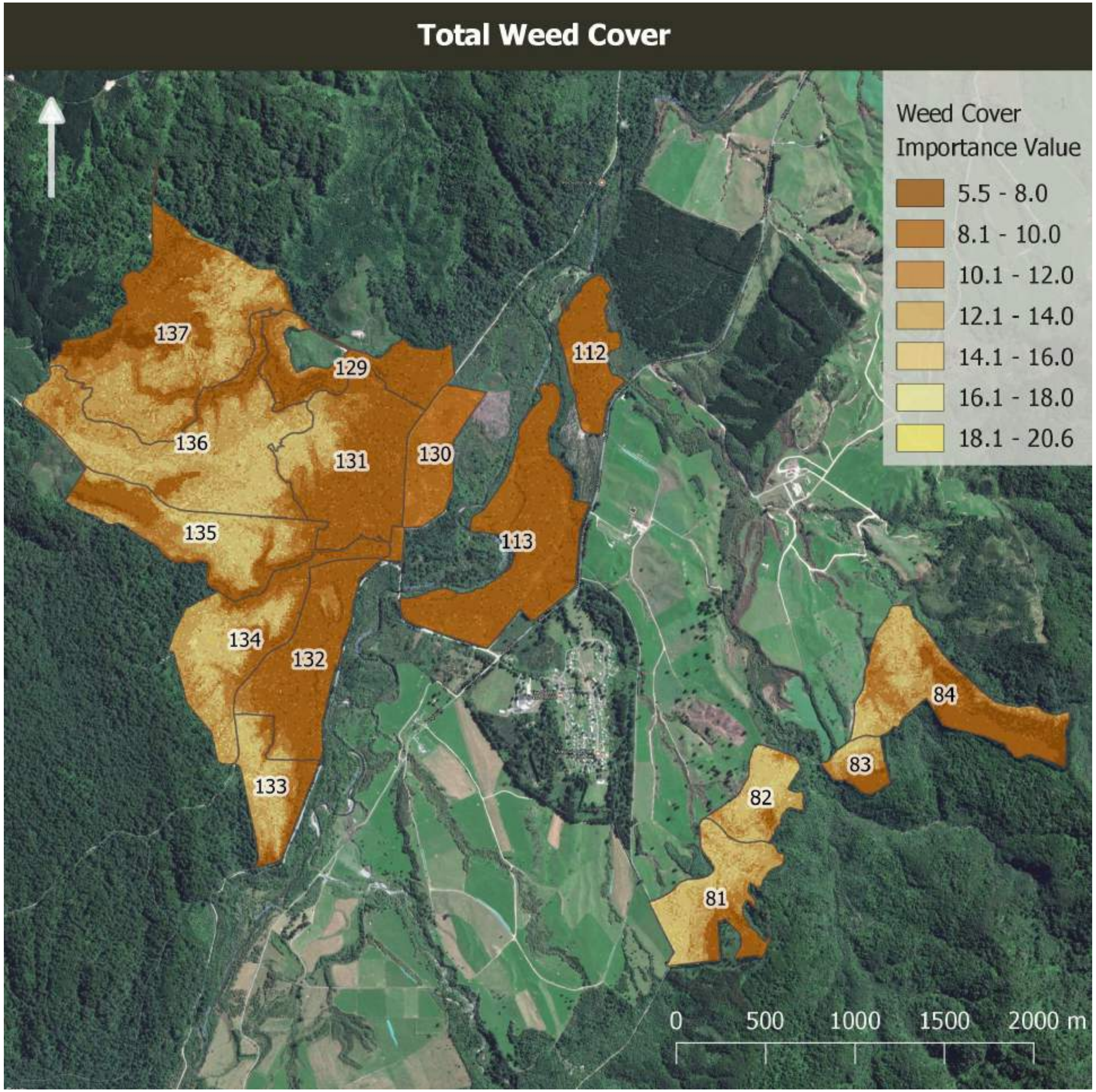
Total Podocarp Stem Density (Individuals >15 cm Tall)



Forbes Ecology

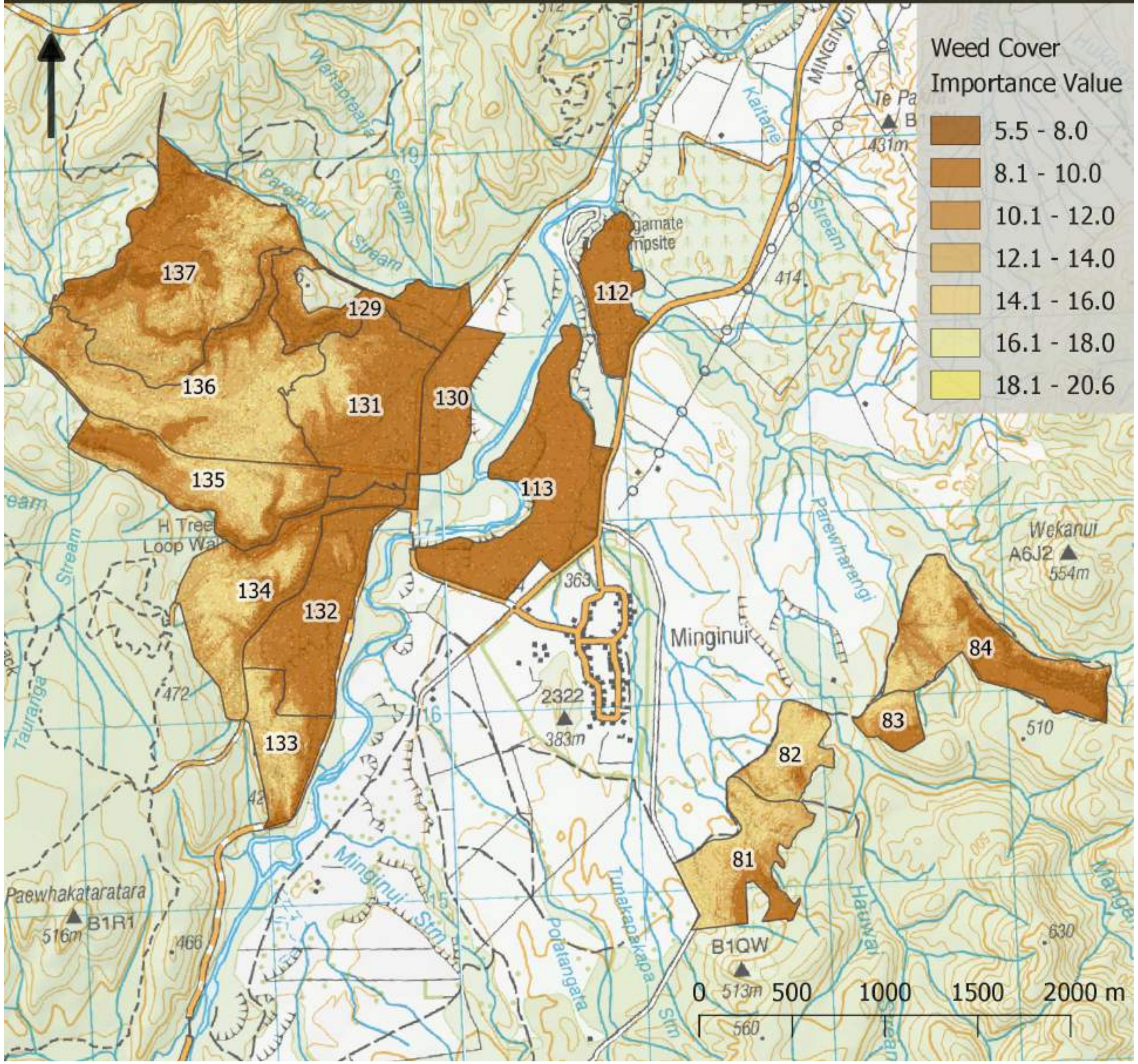
Total Podocarp Stem Density (Individuals >15 cm Tall)

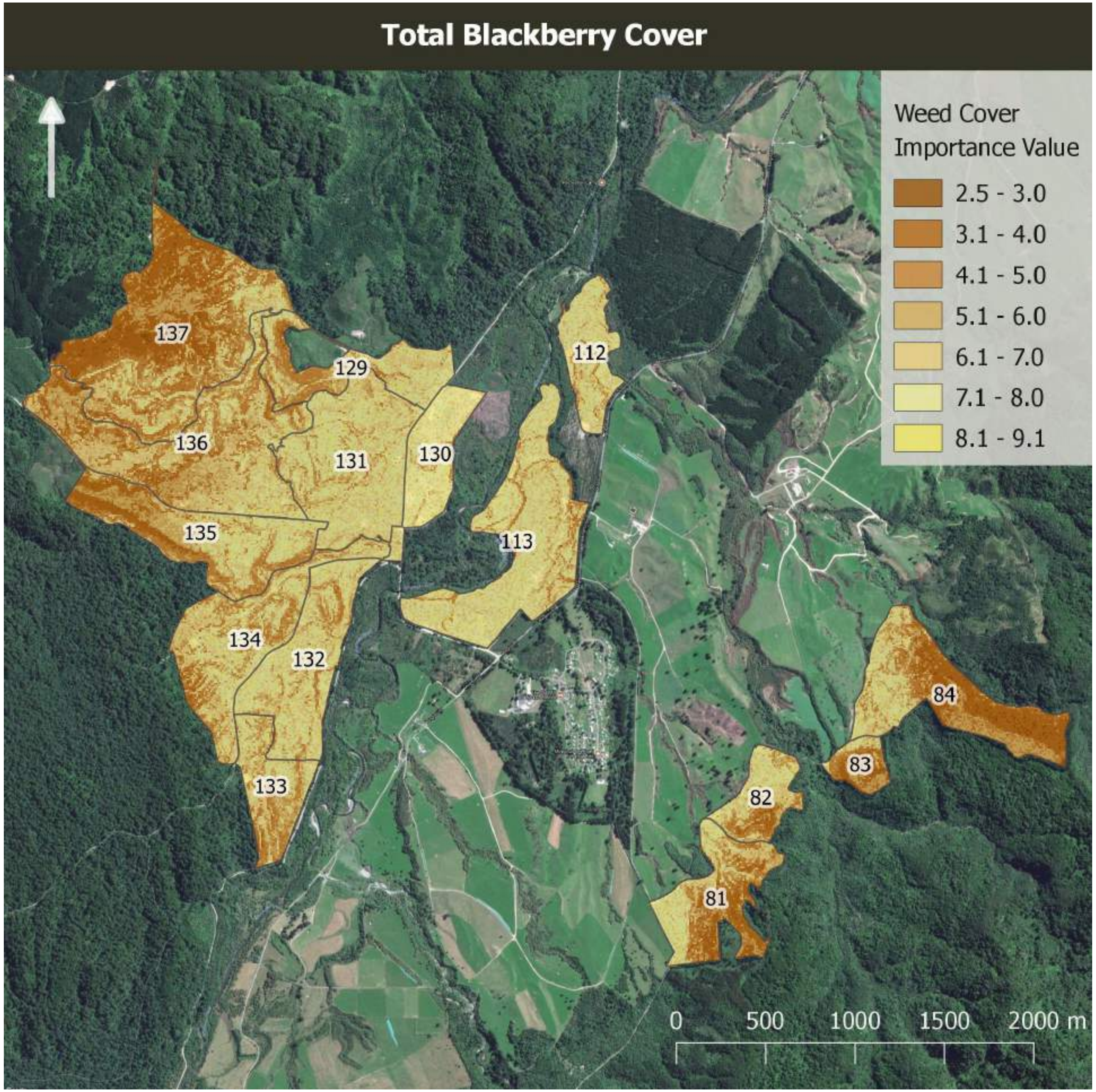



Total Weed Cover
Weed Cover
Importance Value
5.5 - 8.0
8.1 - 10.0
10.1 - 12.0
12.1 - 14.0
14.1 - 16.0
16.1 - 18.0
18.1 - 20.6
137
129
136
131
130
112
135
113
134
132
133
84
83
82
81
0
500
1000
1500
2000 m

Forbes Ecology

Total Weed Cover

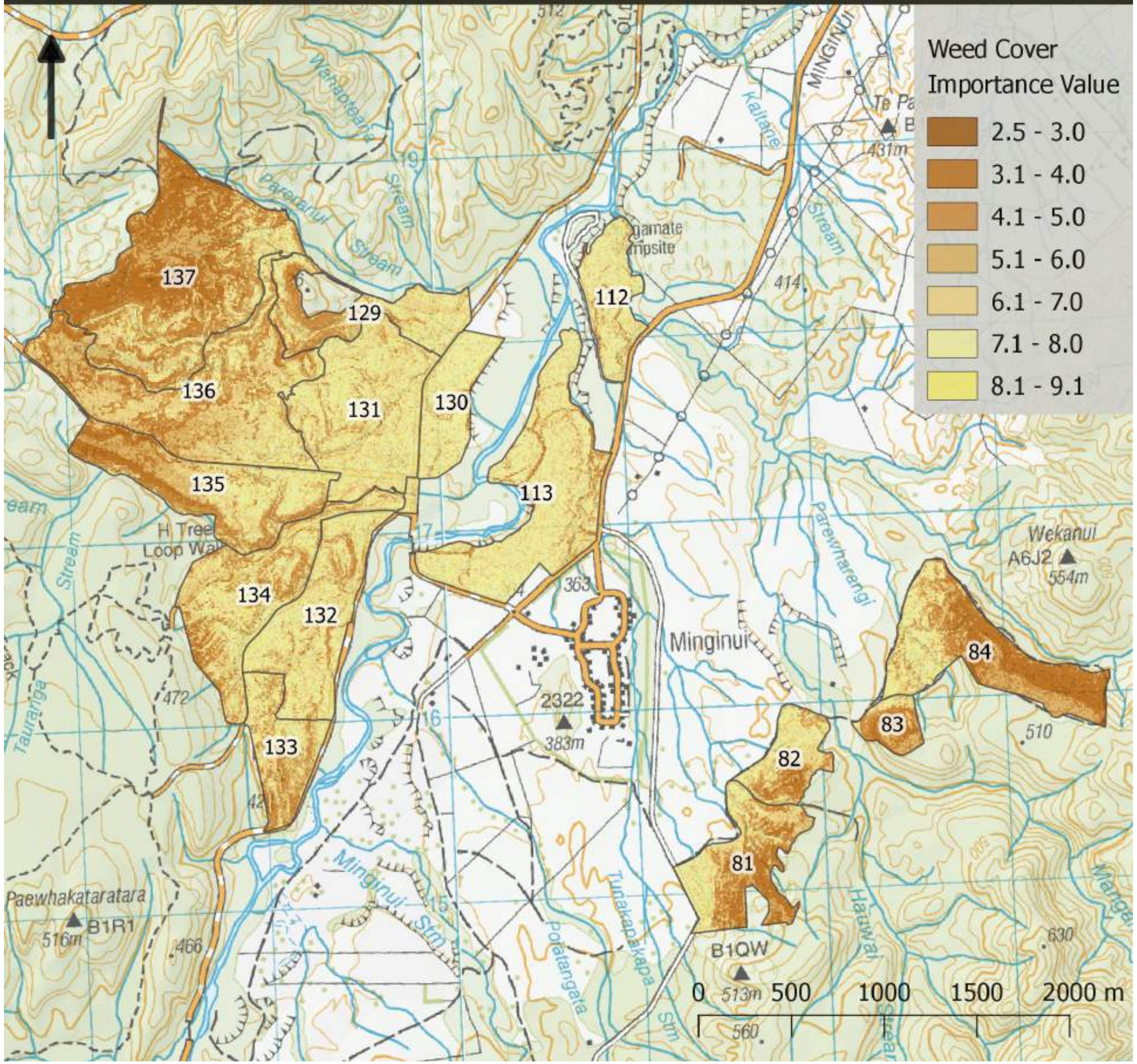




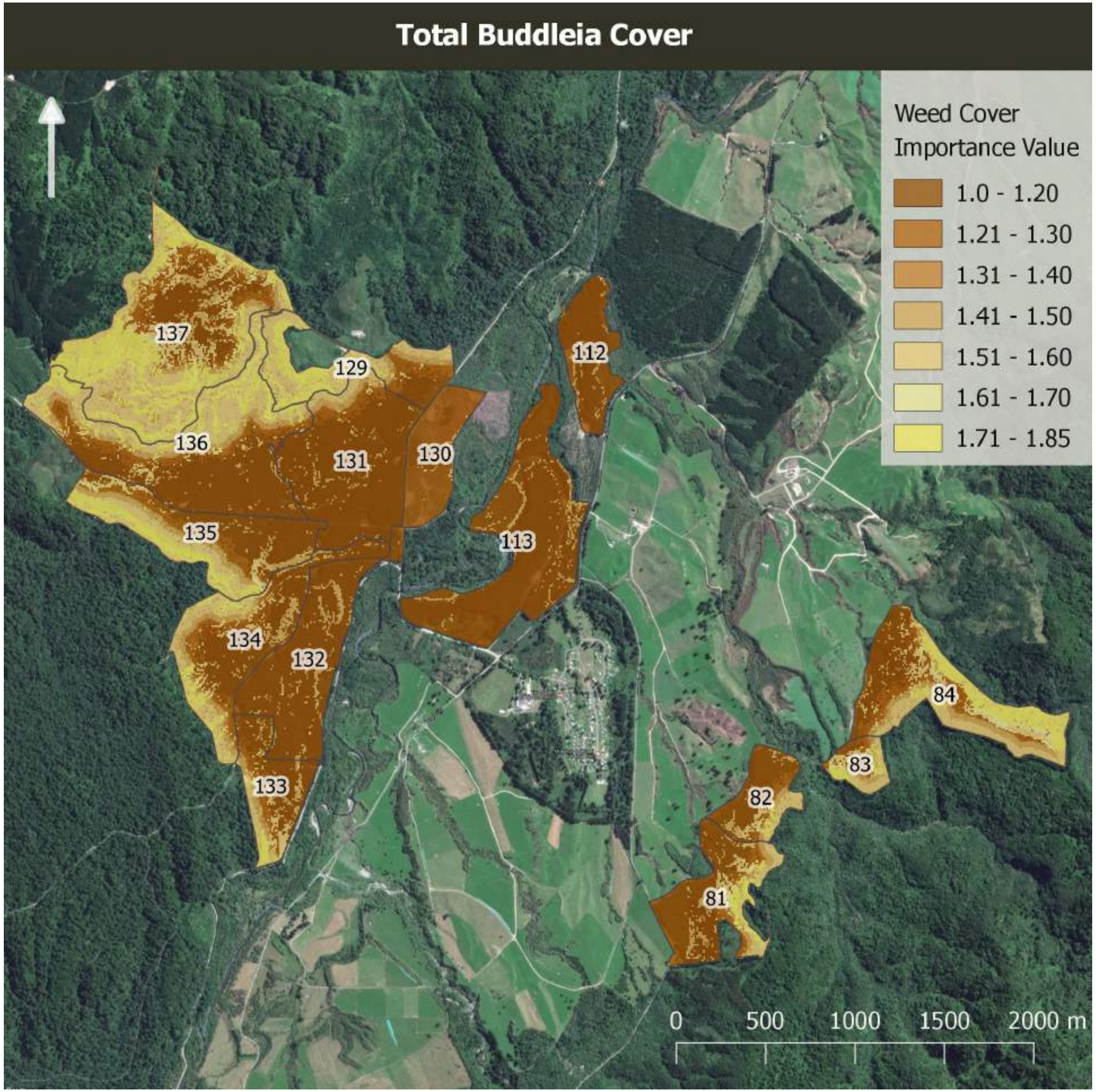
Total Blackberry Cover
Weed Cover Importance Value
2.5 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
7.1 - 8.0
8.1 - 9.1
137
129
136
131
130
112
113
135
134
132
133
84
83
82
81
0
500
1000
1500
2000 m

Forbes Ecology

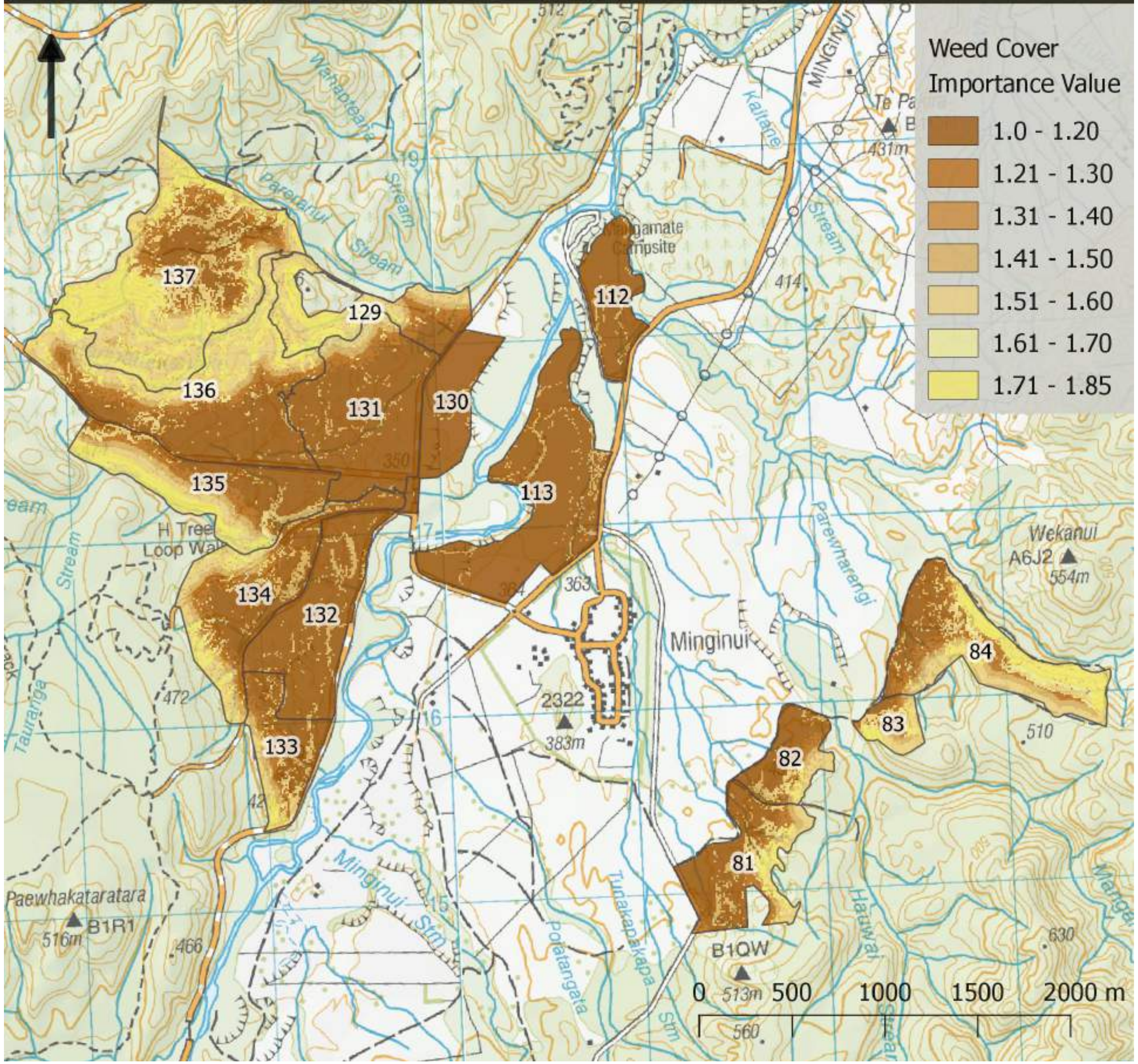
Total Blackberry Cover

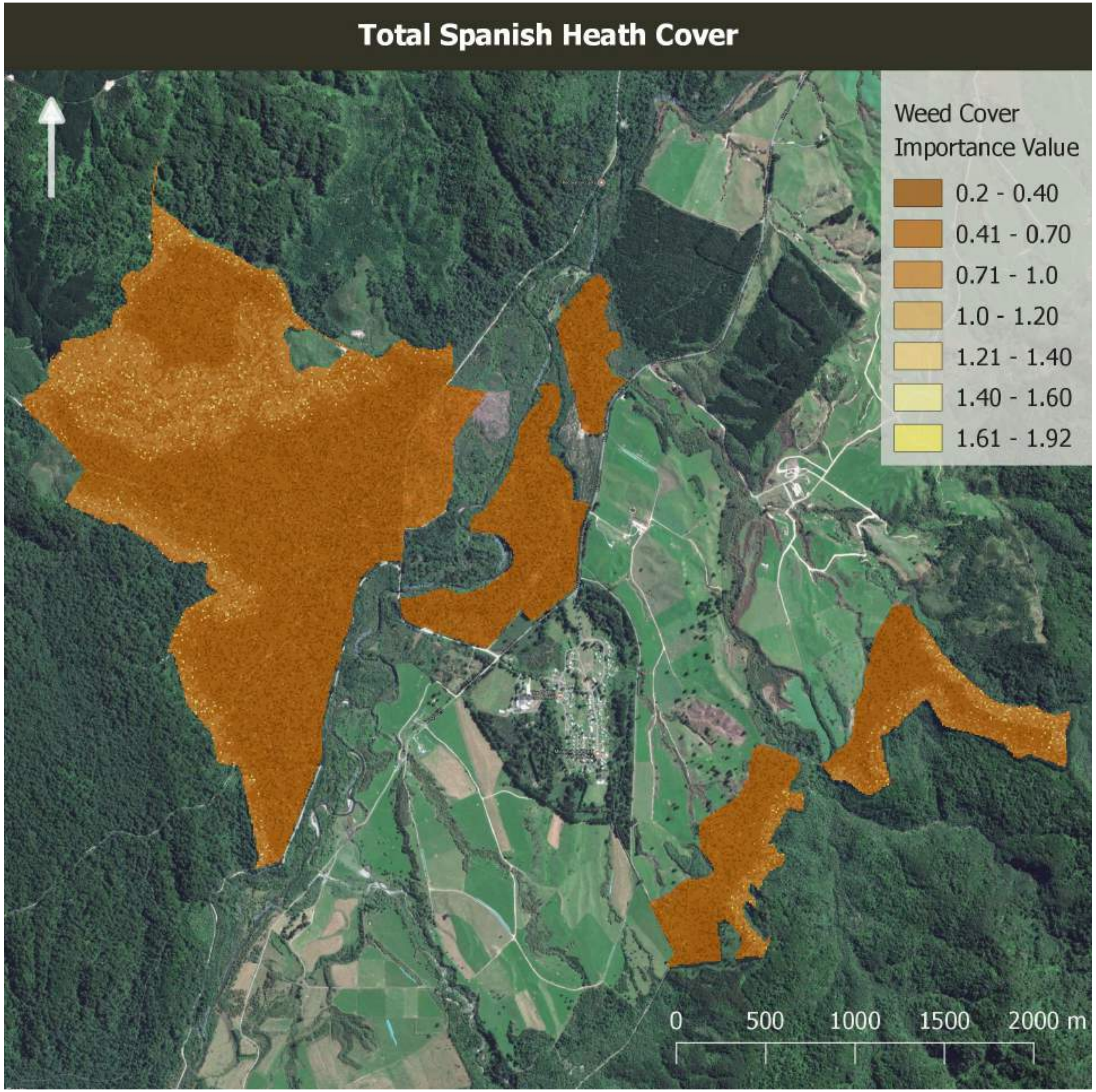


Forbes Ecology

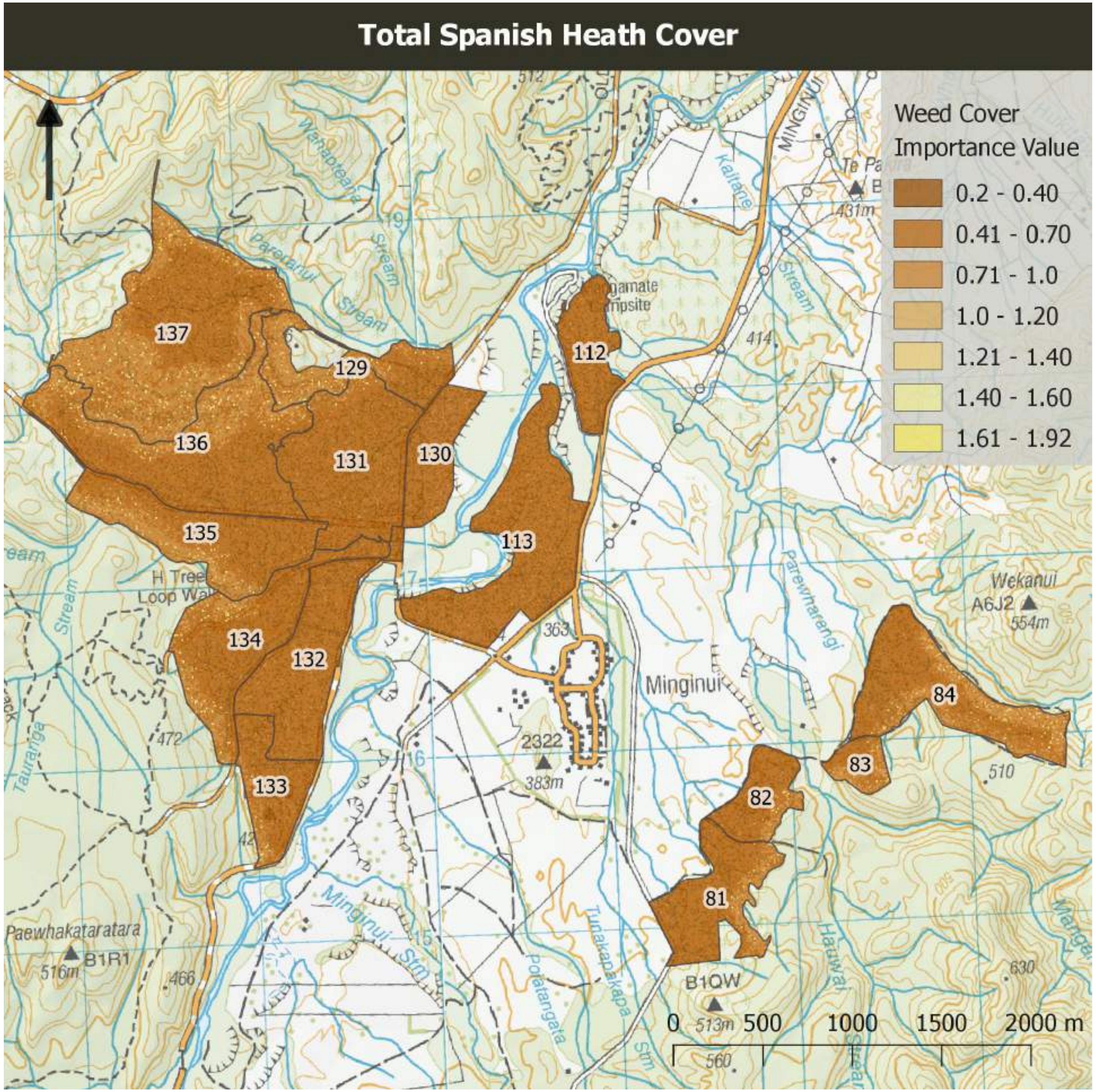


Total Buddleia Cover

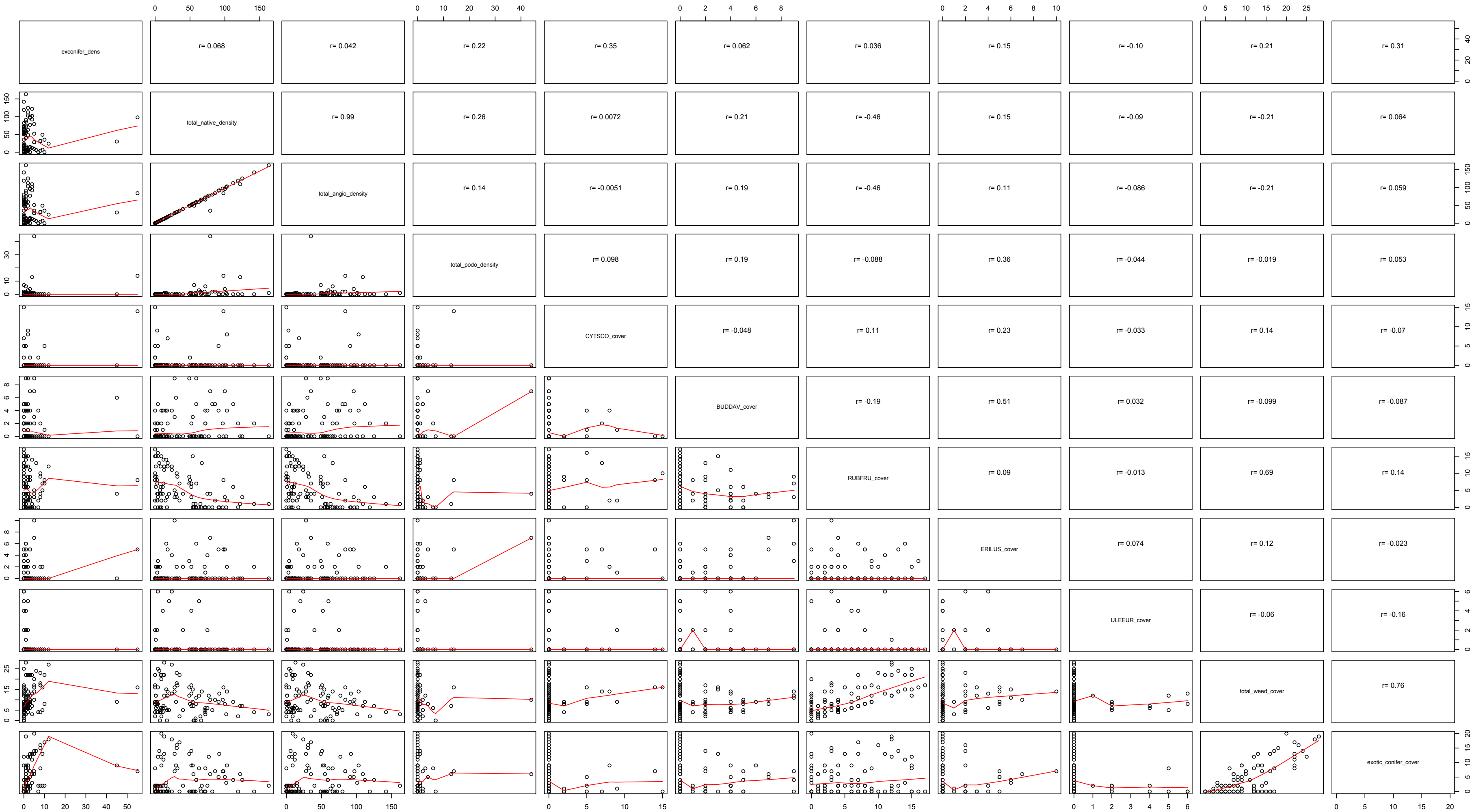



Total Spanish Heath Cover
Weed Cover Importance Value
0.2 - 0.40
0.41 - 0.70
0.71 - 1.0
1.0 - 1.20
1.21 - 1.40
1.40 - 1.60
1.61 - 1.92
0
500
1000
1500
2000 m

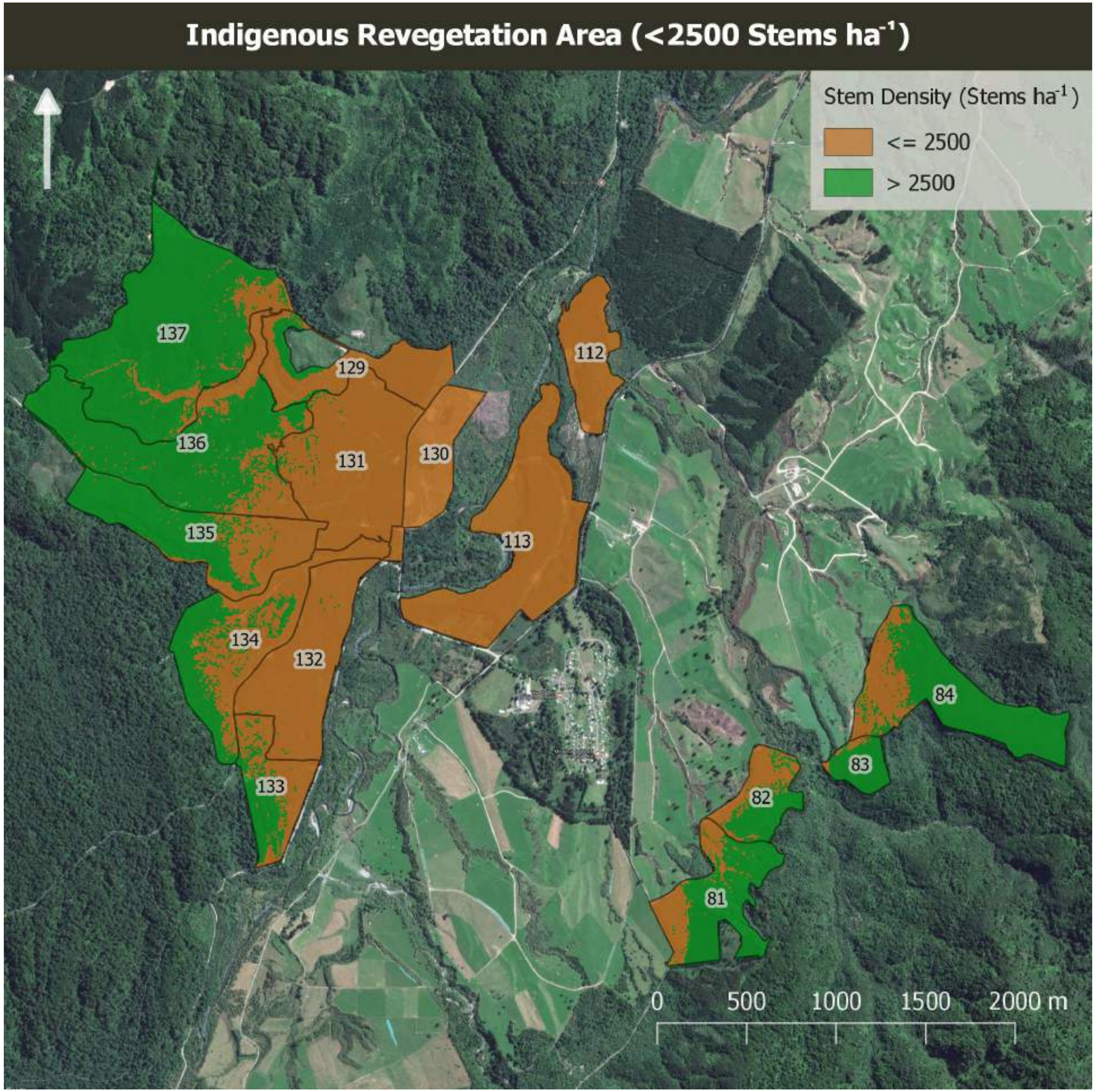
Forbes Ecology



Appendix E: Scatterplot Matrix Showing Associations and Pearson Correlation Coefficients Among Response Variables



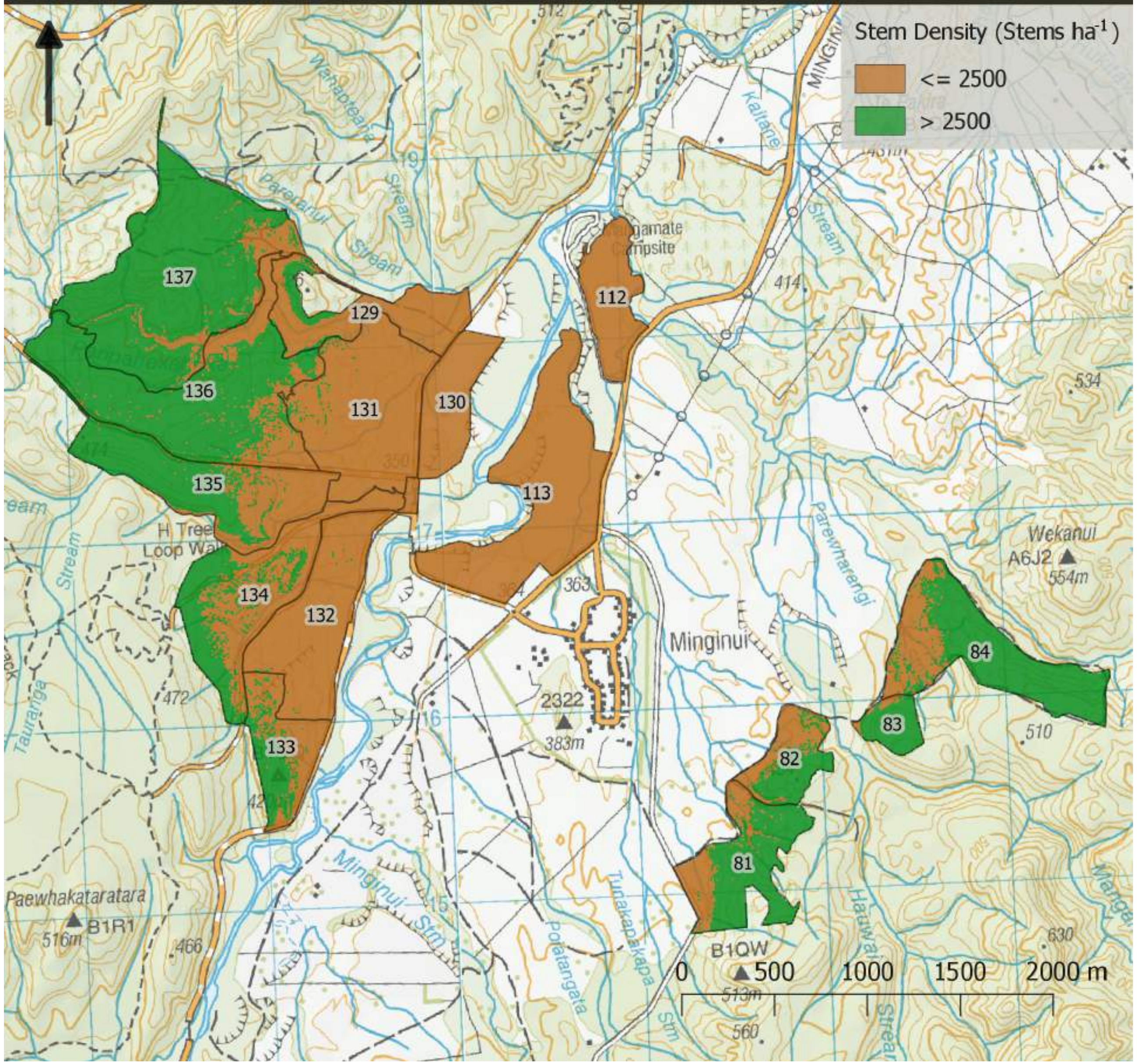
Appendix F: Recommended Indigenous Planting and Blackberry Control Areas

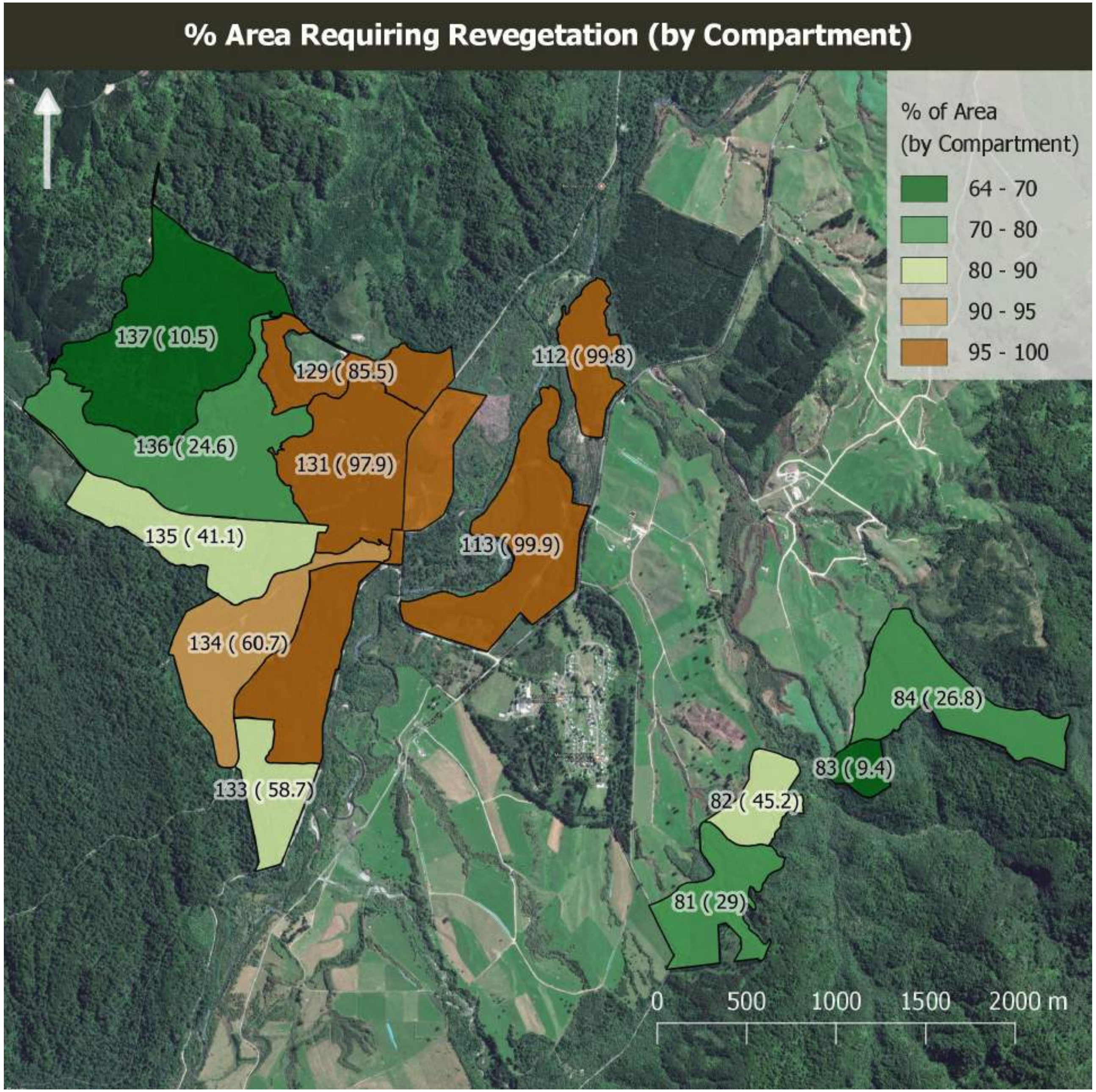


Indigenous Revegetation Area (<2500 Stems ha⁻¹)
Stem Density (Stems ha⁻¹)
<= 2500
> 2500
137
129
112
136
131
130
135
113
134
132
84
83
82
133
81
0
500
1000
1500
2000 m

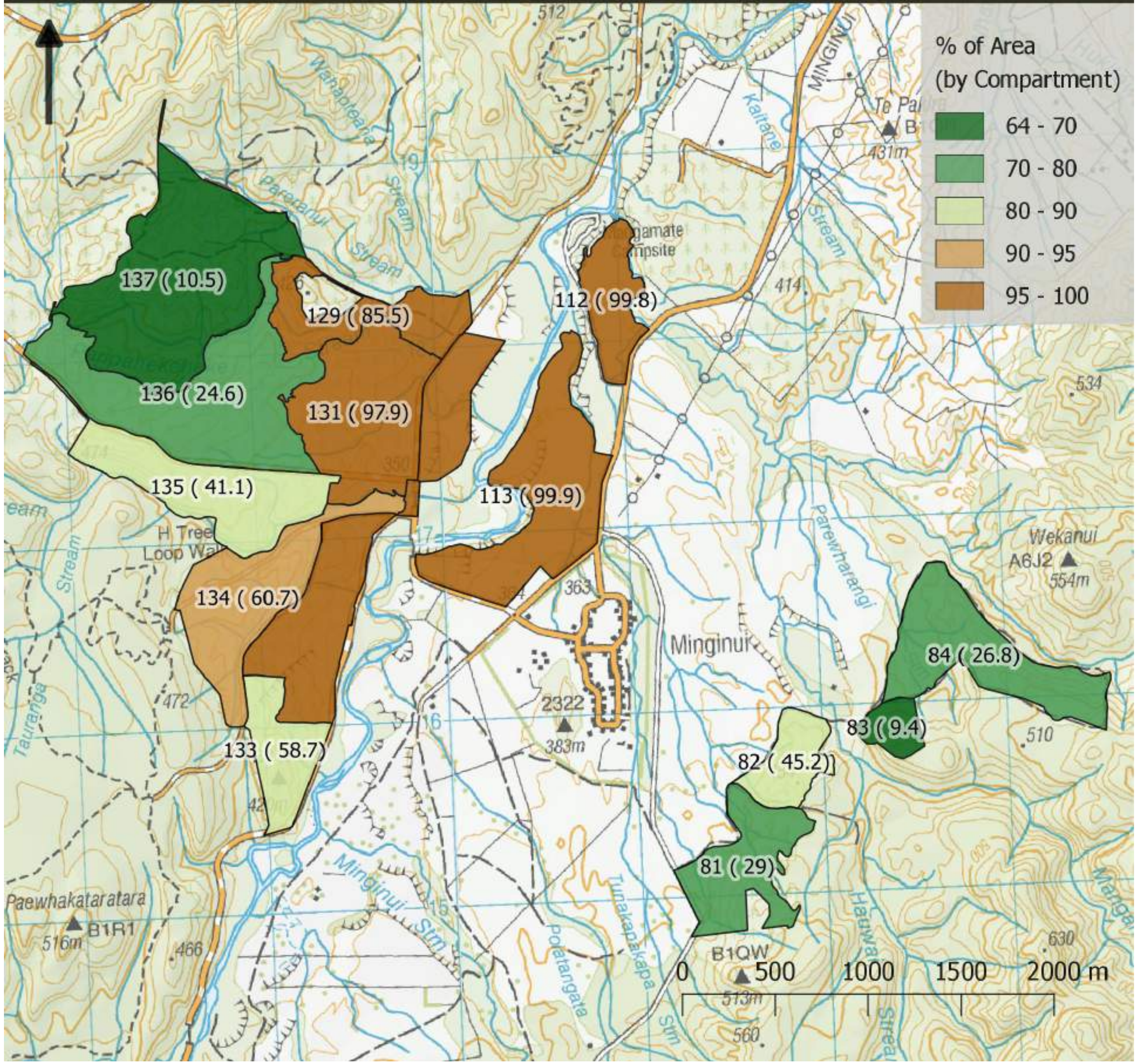
Forbes Ecology

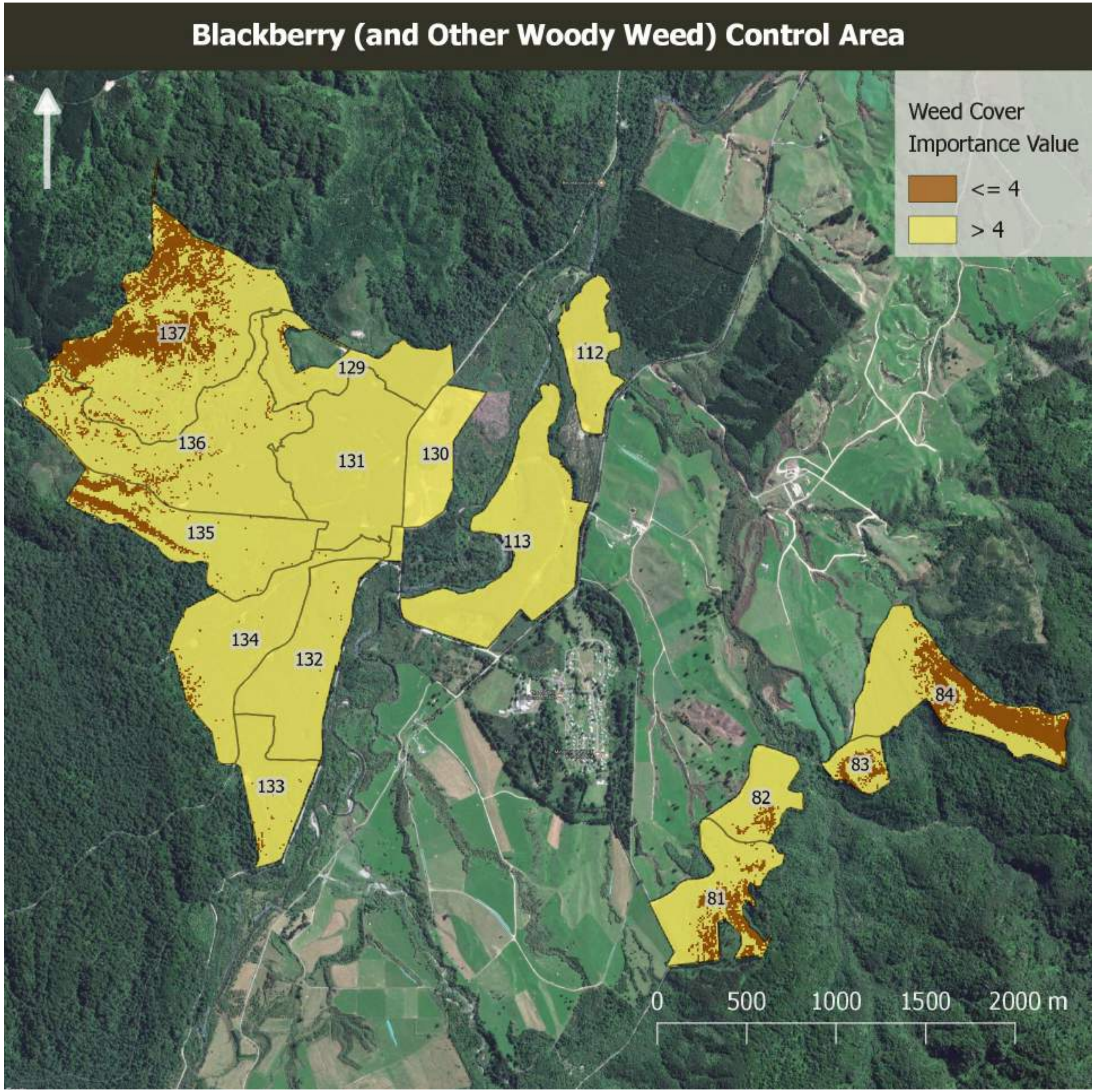
Indigenous Revegetation Area (<2500 Stems ha⁻¹)



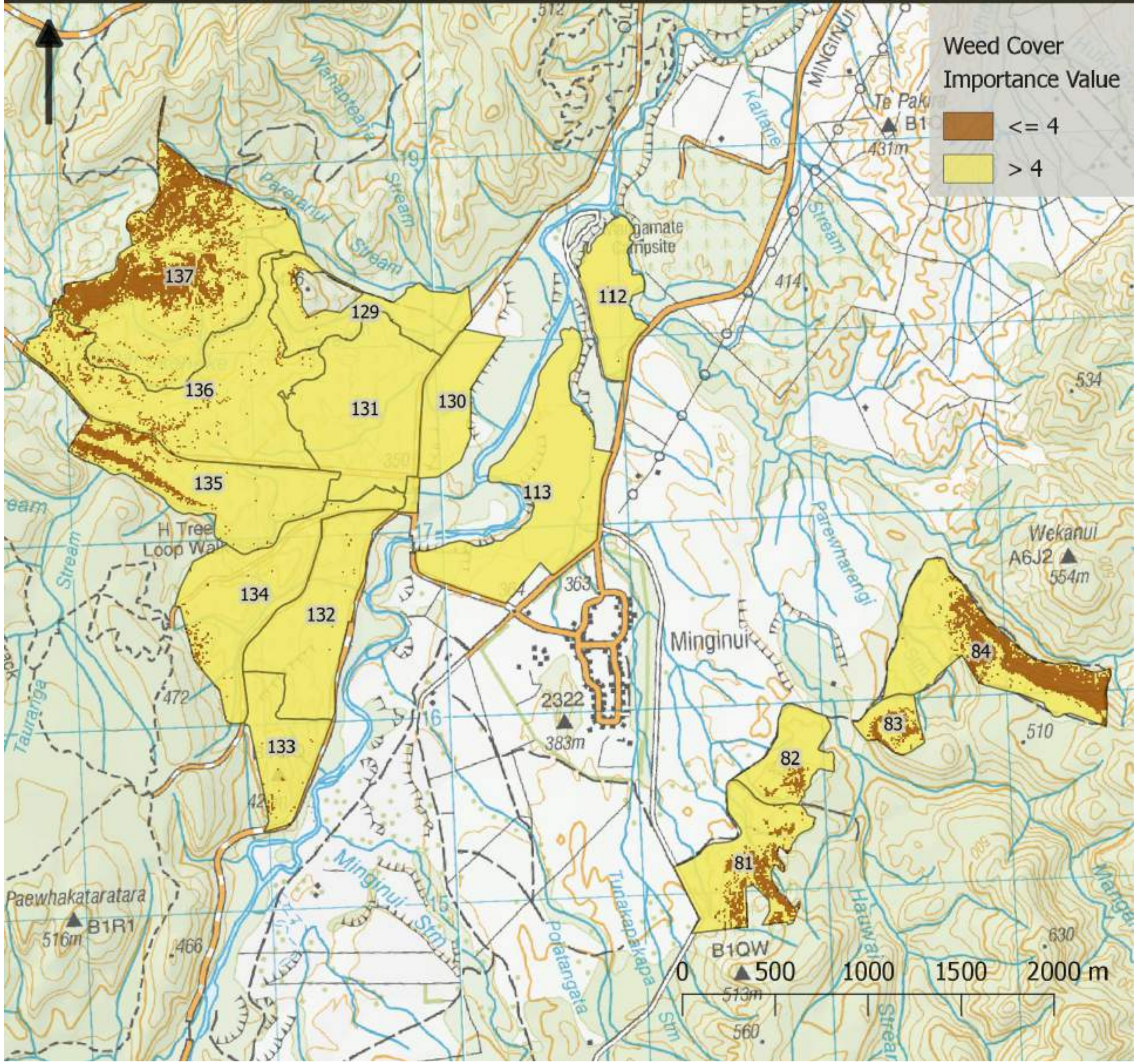

% Area Requiring Revegetation (by Compartment)
% of Area
(by Compartment)
64 - 70
70 - 80
80 - 90
90 - 95
95 - 100
137 (10.5)
129 (85.5)
112 (99.8)
136 (24.6)
131 (97.9)
135 (41.1)
113 (99.9)
134 (60.7)
84 (26.8)
83 (9.4)
133 (58.7)
82 (45.2)
81 (29)
0
500
1000
1500
2000 m

% Area Requiring Revegetation (by Compartment)

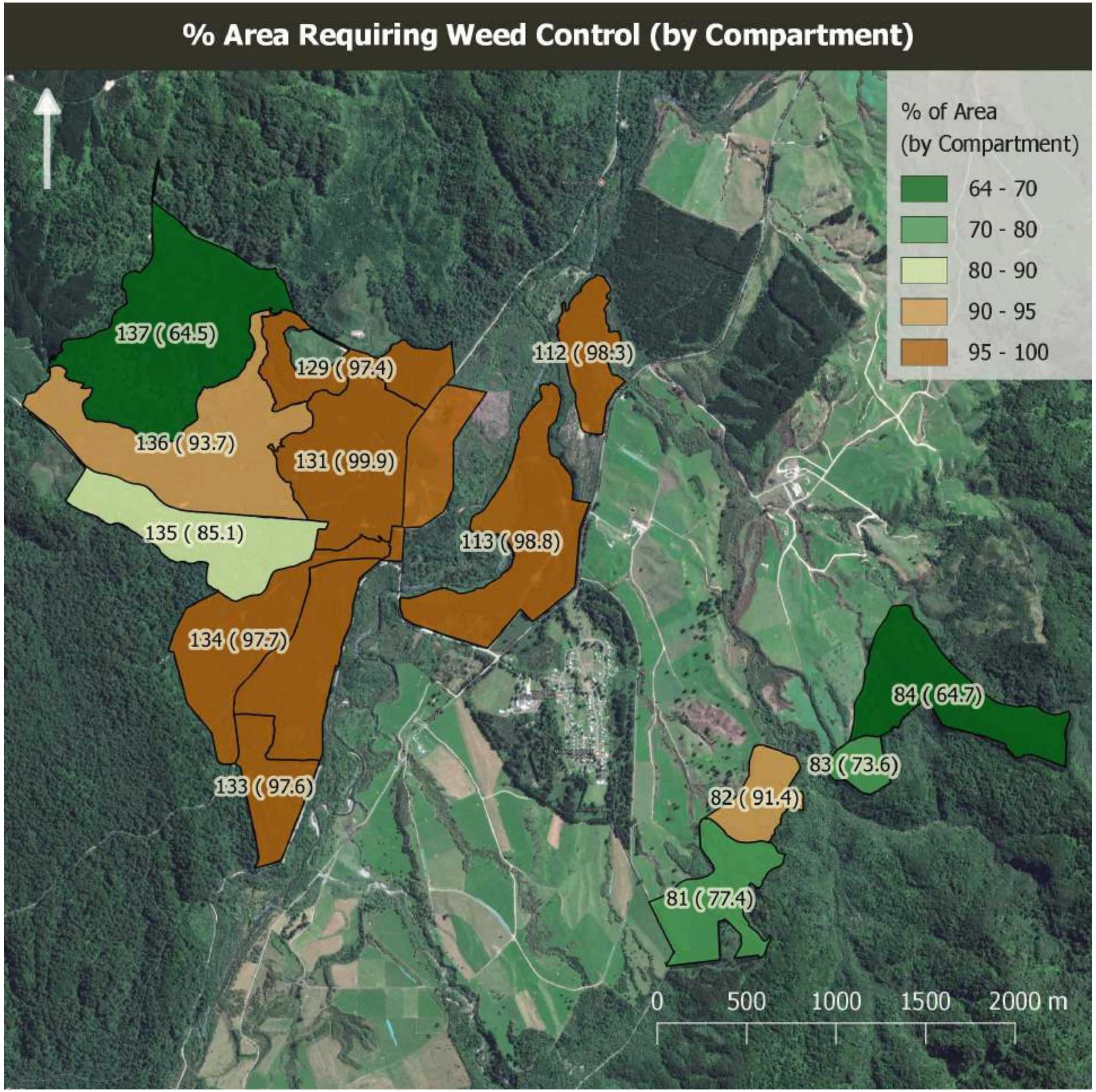



Blackberry (and Other Woody Weed) Control Area
Weed Cover
Importance Value
<= 4
> 4
137
129
136
131
130
135
134
132
133
112
113
84
83
82
81
0
500
1000
1500
2000 m

Blackberry (and Other Woody Weed) Control Area

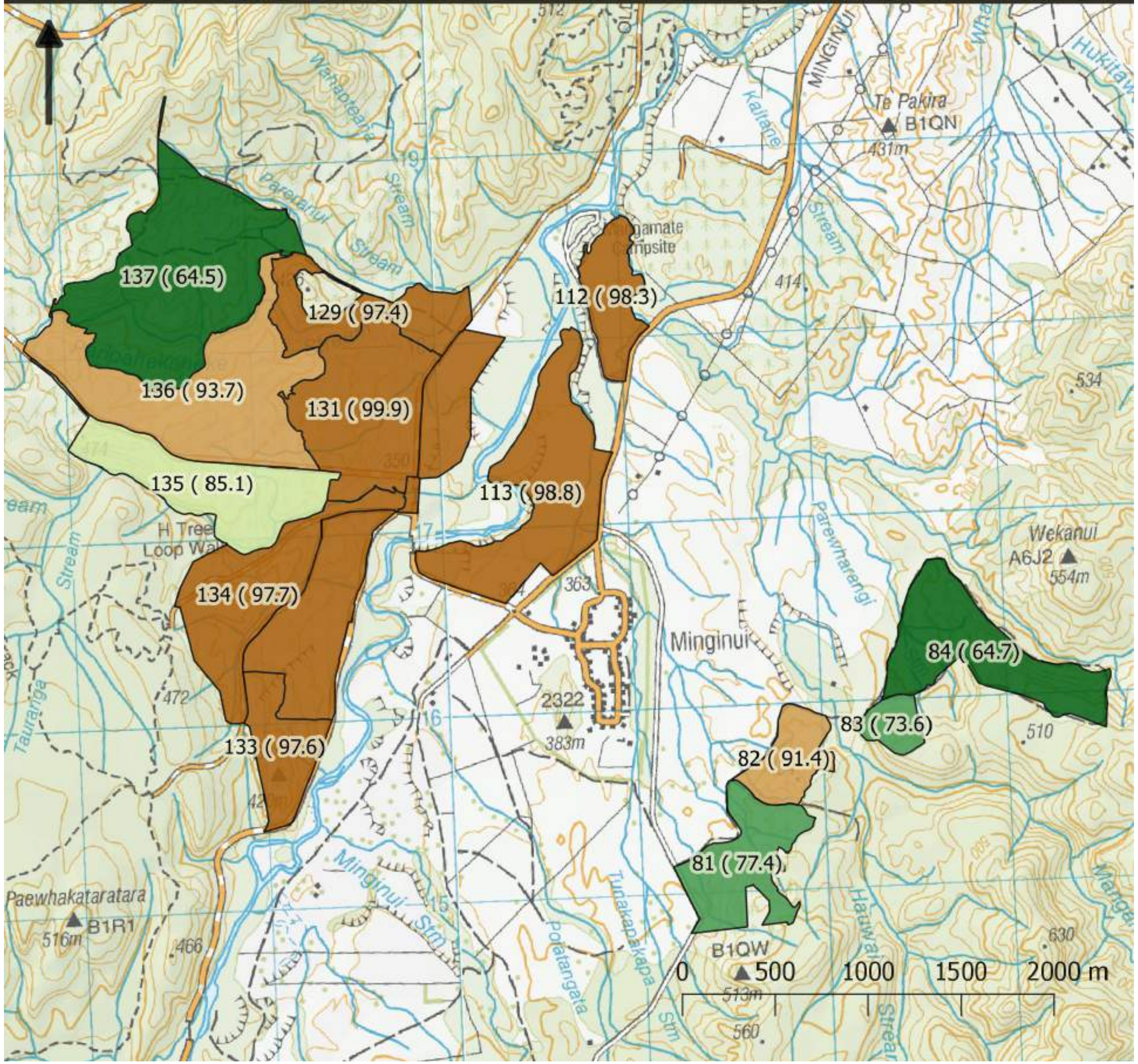


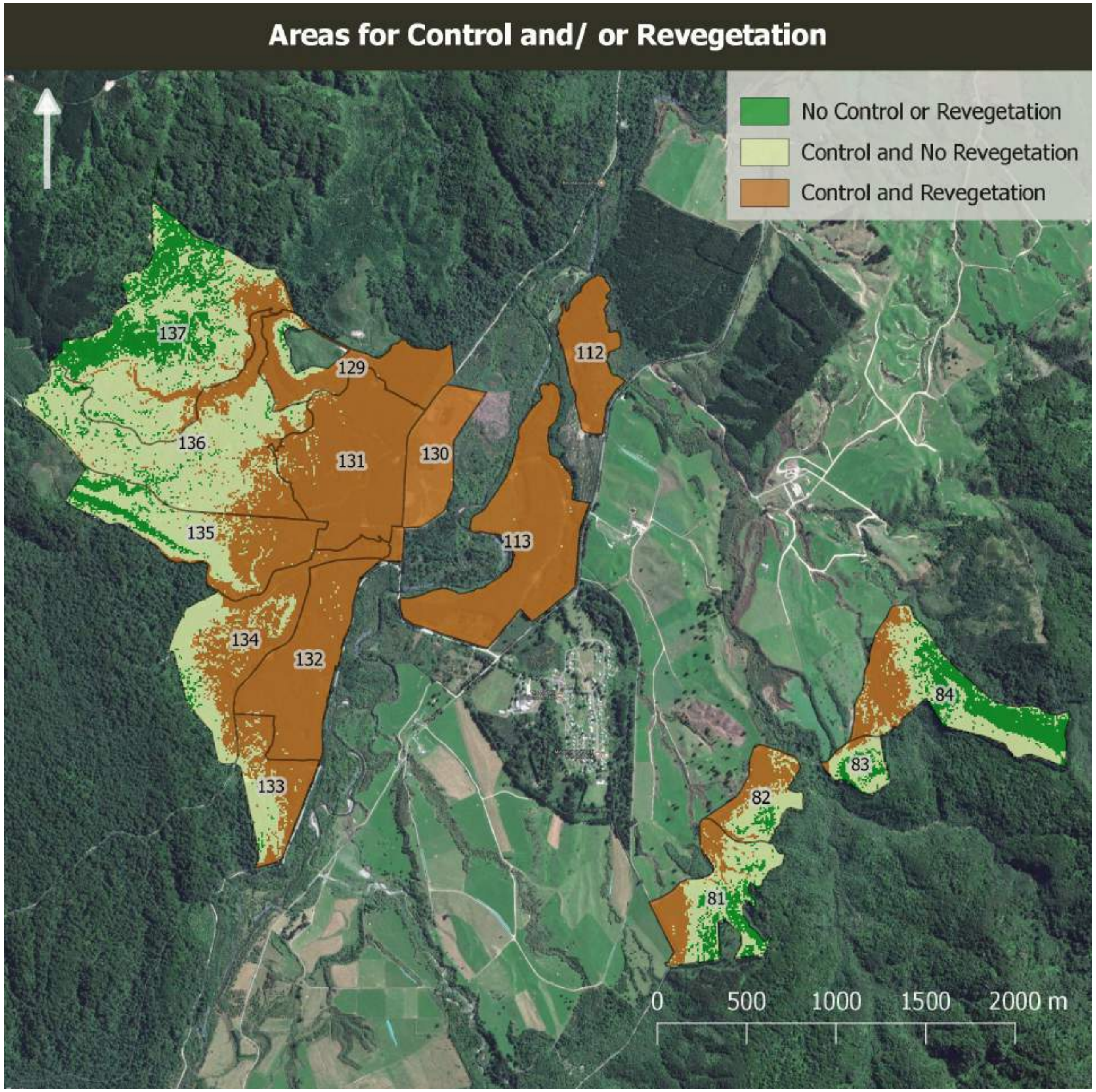
Forbes Ecology



Forbes Ecology

% Area Requiring Weed Control (by Compartment)




Areas for Control and/ or Revegetation
No Control or Revegetation
Control and No Revegetation
Control and Revegetation
137
129
136
131
130
112
113
135
134
132
133
84
83
82
81
0
500
1000
1500
2000 m

Areas for Control and/ or Revegetation