Memorandum

To	Laurence Barea
CC	John Climo
From	Nicholas Singers, Plant Ecologist for the Mt Messenger Alliance
Date	20/3/2018
Subject	**Offset Indices**
Reference	

Dear Laurence,

This memo provides additional information which was used to assess ecological integrity in the offset calculator for the proposed offset site, considering current pest impacts and forecast changes. I have also provided additional information (Table 1) which provides a summary of pest impacts on dominant plant species or guilds and what can be expected with management. This is essentially the background for forecasting changes in condition measures in the calculator. Tables 2, 3 and 4 summarise all values of ecological integrity and percentage cover scores used in the Biodiversity Offset Calculator.

Background

The attributes used within the biodiversity offset calculator are ecological integrity (for habitat improvements from integrated pest management) and percentage canopy cover (for kahikatea trees). It is my opinion that 'ecological integrity' is the most appropriate attribute for assessing changes in ecosystem health.

Monitoring to assess ecological integrity is summarised by Lee *et al.* (2005) for measuring change in ecosystem health with management. The definition of ecological integrity is provided in Lee *et al.* (2005) which was sourced from the Canada National Parks Act 2000. The definition is described as:

"A condition that is determined to be characteristic of its natural region, and likely to persist, including abiotic components, and the composition and abundance of native species and biological communities, rates of change, and supporting processes".

To provide quantitative measures of ecological integrity for the Mt Messenger offset proposal (following Lee *et al.* 2005) would have required collecting data on (for at least the offset and bench mark sites); net primary production, mast flowering and seeding (at least for tawa), native dominance, size class structure of canopy

dominants, demography of widespread animal species and representation of plant functional types and animal guilds. It is my opinion that if quantitative data for some of these measures was collected e.g. size class structure of canopy dominants, the interpretation of the data would have been very similar to observations from Recce surveys and field work — for example there is widespread recruitment failure of canopy dominants such as tawa and kamahi and palatable understorey species. Other essential data required to develop a quantitative measure of ecological integrity, such as masting of tawa, would have required at least 3–5 years of data capture.

The method used by Leathwick (2016) for 'Zonation' is the only method known to me that attempts to score ecological integrity (termed 'ecological value') in a methodical manner. Further results from this are now being implemented by regional councils to conserve a full range of ecosystems. The method is described within the Biodiversity Offset Calculation (October 2017).

The process compares current ecological integrity against the 'potential or desired state' which has a value of 1 (or 100 converted to a %). Potential ecosystem descriptions from Singers & Rogers (2014), bench mark sites and historic plot data from Parininihi–Mt Messenger area (National Forest Survey Plot data 1940's) were used to provide an understanding of 'potential or desired state'. My interpretation of 'potential state' is somewhat equivalent to what the ecosystem composition and abundance of native species and biological communities would be, if people arrived in New Zealand today, but accepting the current biological composition of communities (e.g. accepting human induced extinctions to date). Some examples of ecosystems, such as nature reserves maintain this condition today.

The supplementary offset report (January 2018) provides the most recent (revised) calculations based on inclusion of the private land in the Mangapepeke Valley and improvements with vegetation mapping information. Year 0 indices were made using qualitative data collected during the field assessment specifically from Recce Plot data as well as focused assessment of indicator species during general walk through surveys, such as possum browse on a range of palatable canopy and sub-canopy species and notes on the severity observed (summarised in Table 1).

Further information has been provided from draft evidence (Table 5 and Figure 1) which show, at the vegetation community level, the amount of habitat present (ha) in the proposed offset area, compared to what the model calculated.

The model has been applied very conservatively such as; including high bench mark values, aggregation of some lower quality vegetation communities at the impact site with those of higher quality and using the higher Ecological Integrity score. Forecast changes in ecological integrity with offset actions at the offset site are similarly conservative and are based on expected outcomes from achieving all pest control targets. The area of offset required to be managed was manipulated by varying hectare values, so no net loss was achieved at year 10. This calculated the total area required to be managed for all vegetation communities at 230 ha. For WF8 and WF13/14 this amount is based on forecast overall improvements of ecological integrity from 5% and 5.25% respectively by managing possums, ungulates and predators to low levels over 10 years. The difference in gains made in Ecological Integrity between WF8 and WF13/14 at Year 35 is due to kahikatea forest being less responsive to changes due to pest management.

The design of the proposed offset area expects pest densities will be kept to targeted levels within at least 255ha, if not greater (Figure 1 and Table 5). The draft pest management proposed includes possum, ungulate and mustelid control over 1085ha and year round rodent control over a core 420ha, to achieve the desired low pest densities in the 255 ha. It is expected that the greatest change over time will occur with regeneration of seedlings to sapling and tree size classes, with comparatively lesser improvements in canopy condition (including canopy productivity) of long lived species.

Changes in percentage cover of planted kahikatea are similarly conservative (Table 3).

References

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Regards

Nicholas Singers

Plant Ecologist for the Mt Messenger Alliance

Table 1: Expected change of condition for components considered within the canopy and understory condition indices for the in the proposed offset area with threat management. Information about the diet and impacts of possums was sourced from Montague (2000) for goats from Sweetapple & Burns (2002) and from personal knowledge and field monitoring experience monitoring from a range of plant species and forest communities including tawa-kamahi forest in the Matemateaonga Ecological District. [1] = assumes no change with myrtle rust.

Ecosystem type	Component	Sub-component	Expected change of condition with proposed management			
			Possum control to very low levels (<3% RTC)	**Stock exclusion, goat and pig control to low levels**	**Predator control (rat control to very low levels (<5% tracking)**	**Overall**
WF8: Kahikatea, pukatea forest	Canopy trees	Kahikatea	Minor improvement in productivity (fruiting) and possibly recruitment in some suitable habitats e.g. manuka, as possums eat kahikatea fruit. More fruit should also be available for native birds. Seedlings or trees are not palatable to possums	No change. Seedlings and saplings are not palatable	Minor improvement in productivity and possibly recruitment as rats eat kahikatea fruit. More seed will potentially will be available for native birds and recruitment.	Minor benefit. **Given abundance in impact area Kahikatea trees need to be off-set through restoration planting and not integrated pest management**
		Pukatea	No change expected. Pukatea is not a favoured possum dietary component.	Recruitment failure currently present, especially in main Mimi catchment where cattle are present. Change in recruitment is likely to be moderate to	No change. Seed is small and wind dispersed, unlikely to be affected greatly by rodent herbivory.	Moderate to significant improvement expected with recruitment especially in Mimi valley with cattle exclusion and goat control.

				significant.		
		Swamp maire	Moderate to heavy browse currently present. Significant improvement in canopy condition, and fruit, seed production is expected.	Recruitment failure currently present. Change in recruitment is likely to be moderate to significant with goat control.	Moderate (fleshy fruits are eaten by rodents)	Significant[1] improvement to canopy condition, productivity and recruitment expected with possum and ungulate control
	Sub-canopy trees	Large-leaved highly palatable species including kamahi, mahoe, kaikomako	Moderate browse evident. Moderate improvements in canopy condition and productivity (flowers, fruits eaten by possums) expected.	Recruitment failure currently present of many large-leaved species. Significant improvement expected with goat control.	Moderate (Fleshy fruits and seed are eaten by rodents)	Significant improvement to recruitment and moderate improvement to canopy condition and productivity
	Sub-canopy shrubs and ground tier	Ramarama[1], hangehang-e, native daphne, pikopiko	No change	Recruitment failure currently present. Significant improvement with goat control (Recruitment failure present)	No change	Significant improvement to recruitment expected with ungulate control
	Native dominance	Very minor cover of ground cover and shrub weeds including African clubmoss, gorse and pampas in open areas				Minor improvement expected with herbicide removal of pampas and gorse. Natural suppression of ground cover weeds with dense canopy and sub-canopy developing

WF13/WF14	Emergent trees	Rimu	No change	No change	Minor improvement in productivity and possibly recruitment as rats eat rimu fruit and more seed will potentially will be available for native birds and recruitment	Minor improvement in productivity and possibly recruitment with rat control
		Miro	Moderate Improvements in productivity and minor improvements in canopy condition.	Recruitment failure currently in areas of high goat abundance. Moderate improvement with recruitment expected.	Miro seed is heavily eaten by rodents. Moderate to significant change in recruitment expected with rodent control.	Moderate improvements in canopy condition, productivity and recruitment
		Thin-barked totara	Moderate to significant change in canopy condition and productivity	No change	Minor change (rats eat seed)	Moderate to significant improvements in canopy condition, minor improvements in productivity and recruitment
		Northern[1] rata	Moderate to significant change in canopy condition and productivity, especially flowering and seed production	Minor change. Some terrestrial seedlings may develop such as on ridges and root plates. Note: most seedlings are above the browse tier	No change	Moderate to significant improvements in canopy condition, in productivity
	Canopy trees	Tawa (see Knowles and Beveridge	Low to moderate current browse levels,	Significant change in recruitment (goats and pigs	Tawa seed is not readily eaten by rodents.	Significant improvement in recruitment with possum,

		1982)	fruits heavily targeted. Moderate change in canopy condition expected and significant change in productivity (fruiting)	eat fallen tawa seeds and goats eat seedlings)	Minimal change in recruitment expected with rodent control.	goat and pig control and minor improvement in canopy condition and productivity
		Kamahi	Significant change in canopy condition and productivity (flowering)	Recruitment failure except epiphytic regeneration. Significant change in recruitment expected	No change	Significant improvement in canopy condition productivity and recruitment
		Pukatea				(as in WF8 above)
		Hard beech	Browse of beech flowers and green seed likely occurring. Minor change in productivity expected.	No change. Hard beech not preferred dietary component for ungulates.	Hard beech seed is targeted by rodents. Moderate to significant change in recruitment expected with rodent control.	Moderate to significant change in recruitment with rodent control.
	Sub-canopy shrubs and ground tier	Hangehange, native daphne, large leaved coprosma, five-finger, fuchsia, pate, wineberry, pikopiko, *Astelia* spp.	Minor to moderate improvements with some species e.g. wineberry & fuchsia	Recruitment failure currently present. Significant improvement expected with goat control	Minor change of flowering fruiting species eaten by rodents.	Significant improvement to recruitment expected with ungulate and possum control of most species
	Native dominance	Minimal weeds present. Pampas present on some				Minor improvement expected with herbicide removal of pampas.

		landslips and canopy gaps				Natural suppression of widespread species with improvements in canopy and sub-canopy cover.

WF8: Kahikatea, pukatea communities

Table 2: Values sued in the offset site for determining ecological integrity for WF8: Kahikatea, pukatea communities (Year 10 is highlighted in red to indicate the point of no net loss calculated).

Year	Current condition	Canopy condition	Understorey condition	Native dominance	Raw EI	% EI used in model	% improvement since year 0
0	0.85	0.8	0.6	0.95	0.3876	39	
1	0.85	0.81	0.605	0.95	0.395715	39.5	0.5
5	0.85	0.82	0.62	0.95	0.410533	41	2
10	**0.85**	**0.84**	**0.65**	**0.95**	**0.440895**	**44**	**5**
15	0.85	0.85	0.68	0.95	0.466735	47	8
20	0.85	0.87	0.71	0.95	0.498793	50	11
25	0.85	0.87	0.75	0.95	0.526894	53	14
30	0.85	0.88	0.79	0.95	0.561374	56	17
35	0.86	0.88	0.8	0.96	0.581222	58	19
Bench mark site							
Hutiwai Stream	0.95	0.95	0.9	0.98	0.796005	80	

Discussion

YEAR 0 Current condition: Largely advanced logged and potential fire affected (mostly secondary) forest with relict large, typically hollow kahikatea and pukatea, now largely pole trees c. 60-80 years+.

Canopy condition: Widespread possum browse of palatable species including swamp maire, some individuals scoring 4=possum browse of FBI scores, also FBI scores of 2 & 3 for mahoe and kaikomako.

Understorey condition: Recruitment failure of key canopy species including swamp maire and pukatea with cattle and goat browse. Near absence of palatable ferns and large leaved shrubs in the understorey, except near to Kiwi Road track.

CHANGES TO YEAR 10: Canopy improvements: Change due to recovery of canopy cover and productivity (flowering & fruiting) of species affected by possum browse, e.g. swamp maire, kamahi & mahoe. Understorey improvements with recovery of palatable ferns and seedlings in browse tier. No change. Ecological Integrity (%) increase of 5% over 10 years.

CHANGES FROM YEAR 10 TO YEAR 35: Canopy improvements: Gradual improvements as palatable species regenerate in canopy gaps, including pukatea, swamp maire, kamahi and understorey species like wineberry, pate, mahoe.

Understorey condition: Full range of palatable species develop in the browse tier but still occupying <50% composition at year 35, including recovery of even the most palatable species such as *Alseuosmia macrophylla*, fuchsia, king fern and kohekohe seedlings dispersed from Parininihi. Minor improvements in current condition and native dominance scores with general growth and composition and structural improvements. Small decline in weeds abundance e.g. African clubmoss with minimal ungulate disturbance and the development of a thick canopy and sub-canopy tiers. Net Ecological Integrity (%) increase of 19% over 35 years.

Kahikatea trees

Table 3: Kahikatea trees, change in percentage cover over 35 years

Year	Kahikatea % cover
0	0
1	2
5	6
10	16
15	26
20	37.5

25	50
30	60
35	65

Discussion

Initial planting of all species at 1.3m spacings with at least 40% (2600/ha) large sized kahikatea (e.g. PB5). Releasing and weed management will occur annually for at least 6 years, though mortality of 10% is expected, reducing final stocking rate of kahikatea to 30%. At Year 5, mean spread of individual trees was measured at 105 cm^2 (Marden & Phillips). At 30% stocking density this equates to potentially 17% cover — 6% was used in the calculator to recognised slower growth on impeded and seasonally flooded soils as described by Burns *et al.* (1999). Percentage cover at year 35 expected to be 65% based on a minimum of 1600 trees per ha with a canopy spread of at least 2.5m radius or canopy cover of 4.1m^2.

Table 4: WF13: Tawa kohekohe hinau podocarp forest and WF14: Kamahi tawa podocarp hard beech forest

Year	Current condition	Canopy condition	Understorey condition	Native dominance	Raw EI	% EI used in calculator	% improvement since year 0
0	0.95	0.8	0.6	0.96	0.43776	44	
1	0.95	0.81	0.605	0.96	0.446926	44.5	0.5
5	0.95	0.825	0.62	0.96	0.466488	46.5	2.5
10	0.95	0.84	0.655	0.96	0.505613	50.25	5.25
15	0.95	0.86	0.7	0.96	0.549024	55	9
20	0.95	0.87	0.8	0.96	0.634752	63	19
25	0.955	0.88	0.87	0.96	0.701902	70	26
30	0.96	0.9	0.915	0.96	0.750505	75	31
35	0.96	0.9	0.92	0.97	0.771034	77	33
Bench mark site							

Parininihi	0.95	0.95	0.95	0.99	0.848801	85	

Discussion

YEAR 0 Current condition:

Largely intact unlogged forest though some marginal vegetation damage may have occurred with early land clearance fires. Canopy condition: Widespread possum browse on palatable species including kamahi, thin-barked totara and northern rata, signs of past dieback including dead spars and logs especially on ridgelines indicative of past mortality. Kohekohe is almost extinct but was common in NZ Forest Survey Plots in 1940's. Better overall condition close to Parininihi (SH3) and worse eastward away from Parininihi treatment boundary. Understorey condition: Recruitment failure of key canopy species including tawa, kamahi, as well as others like hinau. Widespread ungulate induced understorey modification with ground cover vegetation replacement by unpalatable tree ferns, bush rice grass and hookgrass, with crown fern on ridges. Near absence of palatable ferns and small shrubs in the understorey, except next to Kiwi Road track or steep locations and refugia. Native dominance: minor invasive abundance of scattered incursions, e.g. pampas in canopy gaps.

At Year 10: Current Condition: No change. Canopy Condition: 80%+ recovery c.f. desired state in terms of canopy condition of existing trees (e.g. foliar density, canopy spread and net primary production) of existing palatable canopy trees such a tawa, kamahi, thin-barked totara, northern rata and understorey species including mahoe, kaikomako. Major increases productivity of flowers and fruit especially of species heavily browsed by possums e.g. tawa. Kamahi, nikau palm, hinau, northern rata leading to enhanced recruitment. Understorey Improvements: Obvious recovery of palatable seedlings, saplings and ferns including canopy trees e.g. tawa, hinau, kamahi (on raised mounds), miro and sub-canopy shrubs e.g. hangehange, large leaved coprosmas, pate, wineberry and pikopiko in goat browse tier (<2m). Fast growing palatable species dominating regeneration of recent gaps and in manuka successions on slips. Large areas of bush rice grass, hook-grass and unpalatable tree ferns e.g. crown fern still present but declining as shrub and fern tier is recovering. Ecological Integrity (%) increase of 5.25% over 10 years.

Changes from Year 15 to Year 35: Canopy improvements: Gradual improvements as palatable species regenerate in canopy gaps, including pukatea, tawa, kamahi, miro, hinau and secondary species like wineberry, pate, mahoe, resulting in increases in productivity (fruiting, flowering). Sub-canopy: Full range of palatable species present in the browse tier and increasing as replacement process occur e.g. tree

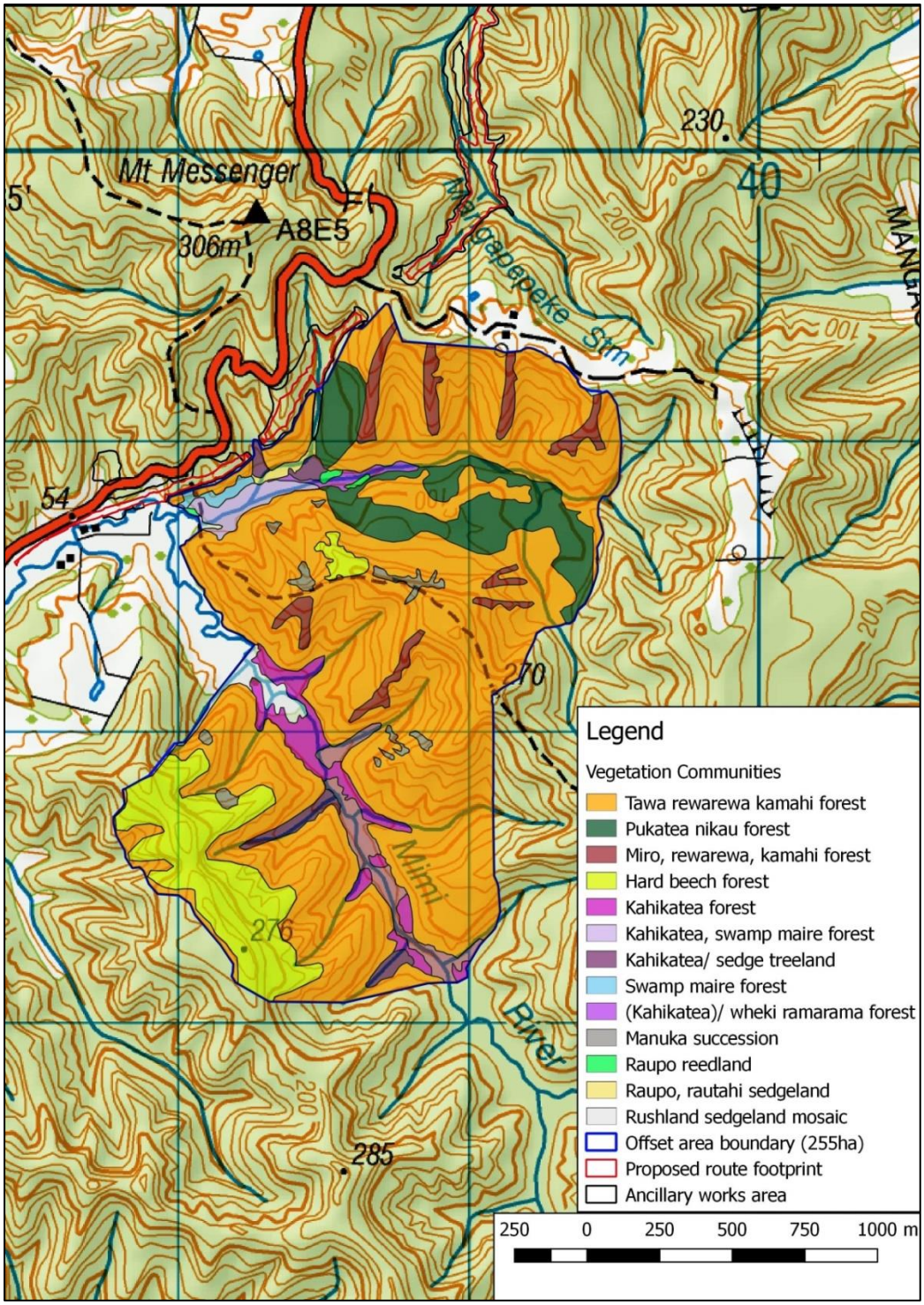
falls. At Year 35 species now present included *Alseuosmia macrophylla*, and pikopiko (*Asplenium* spp). Improvements in current condition values with general growth and composition and structural improvements. Decline of groundcover weeds e.g African clubmoss with less animal disturbance and thick canopy, sub-canopy tiers.

Table 5: Comparison of offset amount (ha) calculated by the model and amount present in the offset site (251.422ha). Components have been grouped within best fit for 'like for like'. Modified primary and secondary communities are shown in italics. Manuka succession vegetation community has been offset by 1:1 planting but are also present in the offset site.

Offset amount calculated by the Model			**Amount present in offset area (255ha)**		
Biodiversity type	Biodiversity component	Required area of offset (ha)	Actual area of offset	Biodiversity component	Biodiversity type
WF8: Kahikatea, pukatea forest	Kahikatea, swamp maire forest & Kahikatea forest	15	15.490 (+0.490)	Kahikatea, swamp maire forest, Kahikatea forest, Swamp maire forest & Kahikatea/ sedge treeland	WF8: Kahikatea, pukatea forest
	Kahikatea/ exotic rushland treeland, *Pukatea treefern treeland & manuka scrub*	7	7.085 (+0.085)	*Kahikatea/ wheki ramarama forest & Wheki ramarama treefernland*	
	Nil	0	1.177 (+1.177)	Raupo, rautahi sedgeland (contains hukihuki) & Raupo reedland	
	Sub-total	**22**	**23.751** **(+1.751)**	**Sub-total**	
WF13: Tawa kohekohe, rewarewa, hinau, podocarp	Tawa rewarewa kamahi forest, Miro, rewarewa kamahi forest, Pukatea nikau forest, *Tawa, nikau,*	190	200.241 **(+10.241)**	Tawa rewarewa kamahi forest, Miro, rewarewa kamahi forest, Pukatea nikau	WF13: Tawa kohekohe, rewarewa, hinau,

forest	*treefern forest & Secondary broadleaved forest*			forest	podocarp forest
	Manuka succession	0	2.590	*Manuka succession*	
WF14: Kamahi, tawa, podocarp, hard beech forest	Hard beech forest, Tawa rewarewa kamahi forest & *Manuka, treefern, rewarewa forest*	18	24.840 **(+6.840)**	Hard beech forest	WF14: Kamahi, tawa, podocarp, hard beech forest
	Total	**230**	**251.422**	**Total**	

Figure 5 - Proposed offset site and broad vegetation communities present


Mt Messenger
A8E5
306m
Mangapepeke Stm
230
40
54
70
276
285
Mimi
River
Legend
Vegetation Communities
Tawa rewarewa kamahi forest
Pukatea nikau forest
Miro, rewarewa, kamahi forest
Hard beech forest
Kahikatea forest
Kahikatea, swamp maire forest
Kahikatea/ sedge treeland
Swamp maire forest
(Kahikatea)/ wheki ramarama forest
Manuka succession
Raupo reedland
Raupo, rautahi sedgeland
Rushland sedgeland mosaic
Offset area boundary (255ha)
Proposed route footprint
Ancillary works area
250 0 250 500 750 1000 m