

Vegetation mapping for the protection of old-growth spinifex and pīngao dunes on the uplifted Marlborough coast



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Cover image

Old-growth spinifex dune near Long Point on the Marlborough coast

Photo: Shane Orchard

Abbreviations

DOC	Department of Conservation
ECPG	East Coast Protection Group
GIS	Geographic Information System
GPS	Global Positioning System
MBIE	Ministry of Business, Innovation and Employment
MDC	Marlborough District Council
MPI	Ministry for Primary Industries
QEII	Queen Elizabeth II
RECOVER	Reef Ecology and Coastal Values, Earthquake Recovery
UC	University of Canterbury

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1 Introduction

The University of Canterbury's RECOVER project (Reef Ecology and Coastal Values, Earthquake Recovery) is a research programme funded by the Ministry of Business, Innovation and Employment (MBIE), and supported by the Ministry of Primary Industries (MPI). It has been evaluating recovery from the 7.8 M_w Kaikōura earthquake in the coastal environment between Oaro in the south and Marfells Beach in the north. The project has documented a wide range of biological and physical impacts in the coastal environment over the past four years. These include the widespread mortality of habitat-forming species that support characteristic ecosystems and natural resources on the coast (Alestra et al. 2021; Schiel et al. 2019; Tait et al. 2021). Due to the popularity of the coast for recreational use, interactions between people and the recovering environment are an important influence on recovery processes. These interactions may include threats to the natural environment but also the potential for positive interventions that could help to restore natural ecosystems and resources – including those that have been degraded in the past.

Physical effects of uplift at the coastline include the seaward movement of shorelines and creation of new land above the reach of the tide, leading to a widening of beaches (Orchard et al. 2020; Orchard et al. in press). This has also provided a greater opportunity for off-road vehicle access to sections of the coast previously protected by headlands that were impassable at high tide (Marlborough District Council 2019; Orchard 2020). MDC management responses have included the development of a proposed bylaw to reduce the impacts of motor vehicle use in the area (Marlborough District Council 2021). Changes in the position of the sea-level on the landscape also affect the location of characteristic ecosystems such as sand dunes and storm beaches as they recover to a new norm. Notable changes include the establishment of new dunes closer to the sea which could potentially lead to the degradation of old dune systems that may experience reduced sand supply as a result. Wildlife habitat has also been affected by these uplift and re-assembly effects although the specific impacts remain largely unknown.

This report contributes to a collaborative project between the Marlborough District Council (MDC) and University of Canterbury (UC) which aims to help protect and promote the recovery of native dune systems on the Marlborough coast. It is centred around the mapping of dune vegetation and identification of dune protection zones for old-growth seed sources of the native sand-binders spinifex (*Spinifex sericeus*) and pīngao (*Ficinia spiralis*). Both are key habitat-formers associated with nationally threatened dune ecosystems (Holdaway et al. 2012), and pīngao is an important weaving resource and Ngāi Tahu taonga species. The primary goal is to protect existing seed sources that are vital for natural regeneration following major disturbances such as the earthquake event. Several additional protection zones are also identified for areas where new dunes are successfully regenerating, including areas being actively restored in the Beach Aid project that is assisting new native dunes to become established where there is available space.

1.1 Dune vegetation maps

The dune vegetation maps show the extent of the native vegetation remnant and a protection zone for management interventions such as targeted marram (*Ammophila arenaria*) control. These areas

also provide focal points for other protection initiatives such as fencing, other forms of browser control, signage, or interpretation materials.

Two types of dune protection zones have been identified in this project. For old-growth dune remnants the protection zone is designed to provide a perimeter defence around the established area. For new dune recruitment zones including the Beach Aid restoration sites, the dune protection zone encompasses the area undergoing transition towards new dunes. Marram control and other interventions in these new dune areas will need to be worked around the establishing plant cover more closely than is expected to be the case for the protection of old-dunes.

1.2 Beach Aid project

Beach Aid is a restoration and recovery initiative established by UC, MDC, Department of Conservation (DOC) and East Coast Protection Group (ECPG). It is based on research on the recruitment of spinifex after the earthquake that showed striking spatial patterns in where new plants are found. These patterns highlighted linkages with the location of old-growth dune remnants which emphasise the importance of protecting these existing seed sources. The patchy natural recruitment pattern also suggested that widespread seed availability may not be the case and that the ability of native dune plants to colonise newly available areas may be recruitment-limited as a result. The identification of large gaps in the pattern of recruitment is consistent with this interpretation.

The Beach Aid project is designed to test this hypothesis directly by re-introducing native plants to potentially suitable areas and monitoring the results. Initial trials in the summer of 2020 have shown good survival and growth rates in both spinifex and pīngao at the trial site on Aerial Beach south of Cape Campbell (Figure 1) and new dune landforms are beginning to develop on the uplifted beach (Orchard et al. 2020). The most recent plantings have extended the Aerial Beach northwards and established a second trial site further south. Beach Aid is an opportunistic restoration strategy that could be readily expanded to many localities across the earthquake-impacted coast. It provides a novel response to the earthquake by identifying advantageous aspects of the disaster recovery context that can be engineered to enhance natural resources and reverse previous degradation trends.

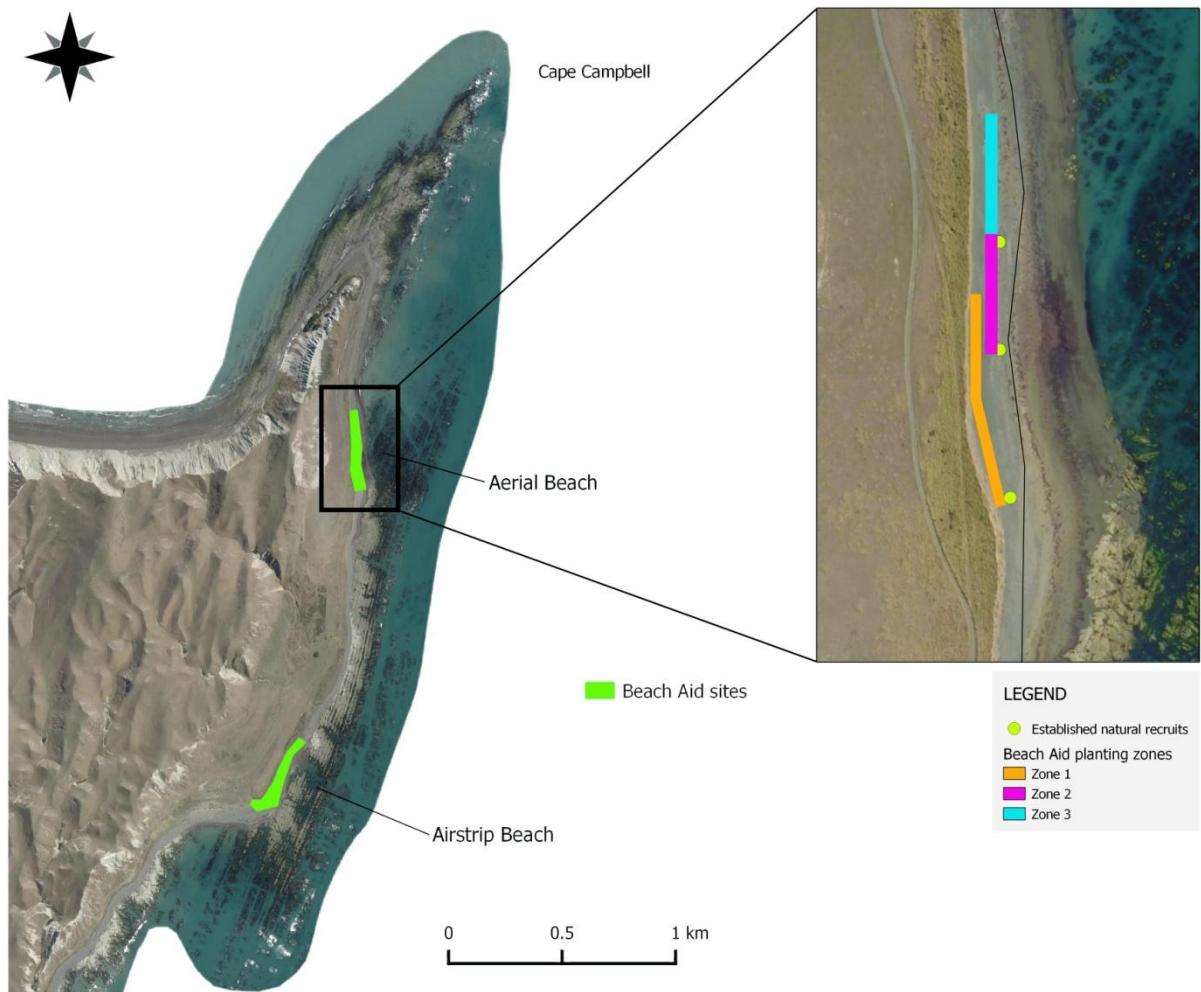


Figure 1. (a) Location of the two initial Beach Aid restoration sites on the Marlborough coast. (b) Layout of the trial site at Aerial Beach south of Cape Campbell showing three planting zones for the re-establishment of spinifex that differ in their configuration between the old dune toe and position of new post-quake high tide line. The old dunes at this site are dominated by marram with no native sand-binder present.

1.3 Scope of report

The remainder of this report provides a brief summary of the mapping results and a series of maps that identify the dune protection zones.

Each map also shows the location of:

- Old-growth native dune remnants throughout the study area and an associated set of dune protection zones that mainly consist of a buffer on the landward edge.
- For the new dune areas, the location of new spinifex recruits as mapped in the summer of 2021 and an indicative footprint of the area requiring protection to assist these dunes develop.

Additional information on three sandy beach sites that have been the subject of transect-based monitoring (Mussel Point, Long Point, and Aerial Beach south of Cape Campbell) is available in Orchard et al. (2020).

2 Methods

2.1 Old growth dune remnants

A campaign to map the 'old growth' dune remnants was begun in the summer of 2018 and continued over three summers to obtain and refine the data set. In the initial two years, data was collected in conjunction with the mapping of shorebird nesting grounds using census surveys of the coastline between the Waima / Ure River and Marfells Beach. These involved a field team of two or three people walking the coastline in sections and data being collected as points and lines using held-held GPS devices. In the third summer (2020) further dedicated surveys were undertaken to complete the dune mapping that incorporated additional data collection on the condition and vegetation composition of old dune remnants and adjacent areas to be identified as protection zones. These surveys also ground-truthed maps prepared from the initial surveys, and identified the landward extent of the larger remnants. The latter had been difficult to complete accurately in some areas due to the time involved to survey old dunes extending considerable distances inland and challenging nature of the terrain.

2.2 Post-earthquake recruits

In conjunction with the above surveys, we identified the location of post-earthquake recruits (new plants) of the two indigenous sand-binding species spinifex and pīngao. New recruits were measured as point locations for individual plants with a resting height of >20 cm. Plants smaller than this are generally newly sprouted recruits which can be abundant in places but were observed to often perish soon after establishment. Point data for individual plants was recorded was taken at the apparent centrepiece of the colony where there were several runners present. Additional measurements included the spread (length of long axis and perpendicular width) of each new plant. In the first summer (2018) this was completed for a limited number of sites only. In 2019 the mapping was scaled up to the whole coast in combination with the mapping of banded dotterel / pohowera nesting grounds. These surveys were repeated the following year in conjunction with the old dune remnant mapping as above.

2.3 Mapping of protection zones

Mapping of point and polygon data was completed in QGIS v3.12 (QGIS Development Team 2021) based on the GPS data, notes and photographs collected in the field. Two forms of dune protection zone were identified as described below:

Old-growth protection zones

For old-growth dune remnants, the dune protection zone includes the remnant and an adjacent area on its landward boundary that is currently dominated by invasive plant species (primarily marram) and will be targeted for control. These buffer zones were mapped to provide a minimum width of 5 m and up to 10 m, generally following the mapped boundary of the dune remnant but in some cases aligning with natural features such as the edge of an existing patch of marram or a dune crest or gully in the landscape.

New dune protection zones

New dune protection zones are identified for a few key sites of interest that have high densities of new recruits or are the focus of active restoration efforts. They differ from the above because of the generally sparse vegetation cover. These sites represent newly regenerating dunes and their position is generally seaward of any old dunes as a consequence of coastal uplift. At some locations, such as on the beach north of Long Point, the new recruit zone is over 50 m from the old dune toe (see examples in Orchard et al. 2020). Regular marram control is expected to assist native dunes to gain an upper hand in the formation of new dunes at these uplifted sites. In addition to those highlighted in this report, there are many other new dune zones on other beaches along the earthquake-uplifted coast.

Dune protection zones are mapped as polygons that overlap the values to be protected and included a buffer zone to be monitored and / or managed for potential threats. The nature of these threats appears to be different for spinifex and pingao dunes as is described in the results. Summary statistics were calculated for the area of the old dune remnants and number of new recruits. The area of the buffer zone was also calculated separately to provide logistical guidance for marram control and other protection methods on the ground.

Maps are provided in A4 format at 1:5000 scale, accompanied by centroid coordinates and shapefiles. In the future this mapping would be ideally repeated to evaluate the success of dune protection and regeneration effort and inform the marram control programme following an adaptive approach.

3 Results and discussion

3.1 Old-growth spinifex

A total of 48 old-growth spinifex remnants were mapped as individual polygons in this project. These occupy a total area of 33.3 ha. Repeat mapping undertaken during the different field campaigns suggests that the old-growth spinifex dunes were relatively stable over the study period, although it is difficult to gauge the extent of new marram invasion at some sites, especially where it is interspersed with the native sandbinders.

Appendix 1 provides vegetation maps for the spinifex remnants. This set of 18 mapped polygons includes most of the known old-growth dune remnants with the exception of a few smaller patches and includes all of the larger and most intact spinifex dunes. These include some sites that have retained close to 100% cover of native dune species despite the presence of marram nearby and are considered to be priority sites as established strongholds (Figure 2).

The dune protection zones represent a combined area of 9.4 ha of which 6.2 ha represents the buffer zones for protection of the old-growth remnants. A breakdown of these areas is shown in Table 1.



Figure 2. Two examples of old-growth spinifex dunes in the Booboo Stream area north of Long Point. Several large remnants in this area have retained close to 100% cover of native dune plants and the area as a whole is an important source of seed for the adjacent coastline.

Table 1. Dune protection zones for old-growth spinifex.

ID	Centroid coordinate (NZTM)		Total area (m ²)	Area of spinifex (m ²)	Area of buffer zone (m ²)	Map number
	X	Y				
1	1699592	5369426	2027	647	1380	Map 1
2	1700275	5369946	1909	981	928	Map 2
3	1700332	5370022	2194	1063	1131	Map 2
4	1700557	5370063	8013	2391	5622	Map 2
5	1700771	5370232	2643	1299	1345	Map 2
6	1701205	5372522	37228	16131	21097	Map 3
7	1701723	5373048	956	324	632	Map 3
8	1702634	5374057	264	99	165	Map 4
9	1702715	5374112	207	86	121	Map 4
10	1702797	5374271	246	84	162	Map 4
11	1702822	5374304	720	397	323	Map 4
12	1702850	5374376	135	29	106	Map 4
13	1702963	5374643	1636	595	1041	Map 4
14	1703065	5374771	417	147	270	Map 4
15	1703090	5374811	371	128	243	Map 4
16	1703122	5374865	102	31	72	Map 4
17	1705144	5377133	338	161	177	Map 5
18	1702216	5379822	35016	7902	27114	Map 6

3.2 Old-growth pīngao

A total of 13 old-growth pīngao remnants were mapped as individual polygons occupying a total area of 0.17 ha respectively. Appendix 2 provides vegetation maps for the pīngao remnants. The eight dune protection polygons represent a combined area of 1.4 ha (Table 2). Five of these are associated with small and generally isolated pīngao remnants located south of Needles Point. An isolated but healthy pīngao dune is located at the foot of an old-growth spinifex dune south of Long Point (Map 6). A relatively large dune protection area is mapped for the cluster of pīngao remnants at Canterbury Gully (Map 7), along with the footprint of a discernible previous dune (Figure 3). The largest pīngao remnant is located south of Airstrip Beach and appears to be faring better but is flanked by dense marram stands to the north and south (Map 8).

In contrast to the spinifex remnants, marram invasion does not appear to be a pressing issue at many of the pīngao remnants which may suggest that other factors are contributing to pīngao decline. Exceptions include the apparent loss of a pīngao colony south of the Needles that has now been overtaken by marram. Only a few only pīngao root structures remain to evidence its demise (Figure 4). This example also indicates the speed at which changes are taking place.

Dead root mats were prominent at all of the old-growth pīngao remnants in 2021. They suggest that much greater vegetation cover existed previously that has since perished and has not been replaced by new recruitment. These observations highlight a precarious situation for the future of pīngao on this coast since there has been very little pīngao recruitment to offset the loss of old-growth dunes

(see below). Action to save the remaining seed sources is recommended in view of the conservation status of pīngao as an ‘at risk’ species (de Lange et al. 2018) and as a taonga species for Ngāi Tahu (New Zealand Government 1998; Te Rūnanga o Ngāi Tahu 2014).

Recommendations for consideration include:

- detailed monitoring of all remaining pīngao dune remnants include those mapped here and any others discovered in future field work
- further research to establish the drivers of decline which at present are not clear. The comparison that can be made with spinifex (which appears to be doing much better) may offer important insights for resolving unknowns through future research.
- active steps to protect the remaining pīngao dune remnants informed by the above research or trialled in association with it. These steps include the establishment of dune protection zones for marram control as documented here and also the consideration of:
 - visual or physical barriers to provide perimeter protection from disturbance threats.
 - the control of browsers such as rabbits and hares.
- increasing the focus on actively reintroducing pīngao in suitable areas as a component of the Beach Aid restoration project. A programme of seed collection from the old-growth remnants detailed here and other nearby sources is recommended to support the propagation of pīngao seedlings and ensure that restoration plantings are eco-sourced.

Table 2. Dune protection zones for old-growth pīngao.

ID	Centroid coordinate (NZTM)		Total area (m ²)	Area of pīngao (m ²)	Area of buffer zone (m ²)	Map number
	X	Y				
1	1693599	5361031	574	27	547	Map 1
2	1694930	5362458	20	2	18	Map 2
3	1695014	5362467	106	32	74	Map 2
4	1695212	5362695	64	12	52	Map 2
5	1696075	5363519	186	34	152	Map 3
6	1699608	5369425	69	24	45	Map 4
7	1703915	5375930	10752	100	10652	Map 5
8	1705180	5377241	2261	1492	768	Map 6



Figure 3. Dead pīngao (*Ficinia spiralis*) root mats provide evidence of the native dune ecosystem that used to exist at this site near Canterbury Gully on the Marlborough coast.



Figure 4. Recent loss of pīngao dunes. The arrows in all images point to old root mats of dead plants. (a) A pīngao colony recorded by MDC staff south of the Needles that has now perished. Only the old root mats were found in the 2021 census survey (. (b) View of the now marram-dominated vegetation at the site in (a). (c) another pīngao remnant dune located south of the Needles that is holding on but showing signs of decline.

3.3 New dunes

3.3.1 Spinifex recruits

Over twice as many new spinifex recruits ($n = 577$) were mapped in the most recent census survey (2021) compared to the year before. However, there were also many areas in which previously recorded recruits were no longer present the following year, indicating that mortality had occurred. This indicates that the observed recruitment pattern is resulting from a dynamic series of gains and losses. Although a detailed analysis of these effects is beyond the scope of this report, some examples of interesting recruitment patterns in relation to the position of old-growth dune remnants were shown in an earlier report (Orchard et al. 2020).

3.3.2 Pīngao recruits

There have been very few pīngao recruits identified in the entire area over the three years of survey effort. Only a single pīngao recruit has been recorded in the new space created on uplifted beaches in marked contrast to the establishment of spinifex, marram and other coastal vegetation (Figure 5). The only other new recruits recorded were at the Canterbury Gully site where they fall within the area covered by the old dune protection zone and may be relatively old plants that have remained small in stature. They were recorded in the initial surveys in 2018 and no new plants have been recorded there since.



Figure 5. Only a single new recruit of pīngao (*Ficinia spiralis*) has been recorded on the uplifted beaches between the Waima River and Marfells Beach over 3 years of annual surveys (pictured here).

3.3.3 Focus areas for new dunes

Focus areas for the creation of new dunes include the beaches north and south of Long Point, south of Cape Campbell, and to the east of Mussel Point. Vegetation maps are provided for five of these locations in Appendix 3. Three of these are located in different sections of the Mussel Point beach that have been selected as focus areas for management through discussions with MDC staff (Mike Aviss, pers. comm.). These areas feature a high density of new spinifex recruits and include the location of the only recorded pīngao recruit in the new dune zone. The high recruitment levels observed here most likely reflect the influence of the significant old-growth dunes further west on Marfells Beach additional to the QEII covenanted remnant on the hillslope behind Mussel Point which provide seed sources. The remaining two new dune vegetation maps cover the Beach Aid restoration sites south of Cape Campbell. At both sites there is now a combination of natural recruited and planted spinifex. Pīngao plantings are also being trialled at the Aerial Beach site at are doing well at the time of writing.

The five polygons represent a combined area of 6.7 ha (Table 3). The area of native dune cover was calculated from the spread measurements of individual recruits and therefore does not include the contribution of additional areas that have been planted. As described in section 1, the protection zones in these new dune areas are primarily open sand in contrast to old-dune situations. Invasive species such as marram are present as isolated clumps that can be periodically targeted for removal to assist the regeneration of native dune vegetation at these sites.

Table 3. New dune protection zones.

ID	Location	Area of native dune cover (m ²)	Area of protection zone (m ²)	Map number
1	Beach Aid site – Airstrip Beach	37	17593	Map 1
2	Beach Aid site – Aerial Beach	735	15756	Map 2
3	Mussel Point west	337	19369	Map 3
4	Mussel Point centre	166	6252	Map 4
5	Mussel Point east	571	8267	Map 4

4 Discussion

Implementation of the dune protection zones identified here will assist MDC and other stakeholders to achieve objectives for beach and dune conservation on the Marlborough coast. They have a primary focus on protecting existing seed sources and supporting the Beach Aid project to regenerate new dunes on uplifted beaches to obtain net gains from opportunities presented by the Kaikōura earthquake event.

Additional new dune protection zones could readily be added in the future as the overall project progresses. However, as new site requires additional resources it may not be possible to tackle some of the larger and more remote areas such as the beach north of Long Point mentioned above. In general, it is recommended that the old dune protection zones are maintained as a priority since these represent the major existing seed sources.

Priorities for the selection of further new dune protection zones are considered to be:

- all sites that are the focus of active dune regeneration efforts in the Beach Aid project.
- readily accessible sites with high densities of naturally-occurring recruits.

For both of the above situations it is recognised that the marram control operation will become progressively more difficult (and/or require a greater degree of precision) as the number and density of native dune plants increases. It is anticipated that the overall marram control programme will tend towards the spot removal of marram over time to help encourage pure stands of native sand-binders to develop and form primarily native 'new dunes'. Regular monitoring will be beneficial to identify the level of marram recruitment and / or regrowth to inform the frequency of control work.

5 Acknowledgements

We thank Marlborough District Council staff for collaboration on this project, with particularly thanks to Mike Aviss. We also thank local landowners and community members who have assisted with establishment of study sites and coastal surveys in support of this work. A large number of additional people have contributed to the Beach Aid project including MDC and DOC staff, ECPG members, local businesses and planting day volunteers. Funding for the RECOVER project was provided by the New Zealand Ministry of Business, Innovation and Employment (MBIE), and the Ministry for Primary Industries (MPI).

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Appendix 1 Old-growth spinifex maps

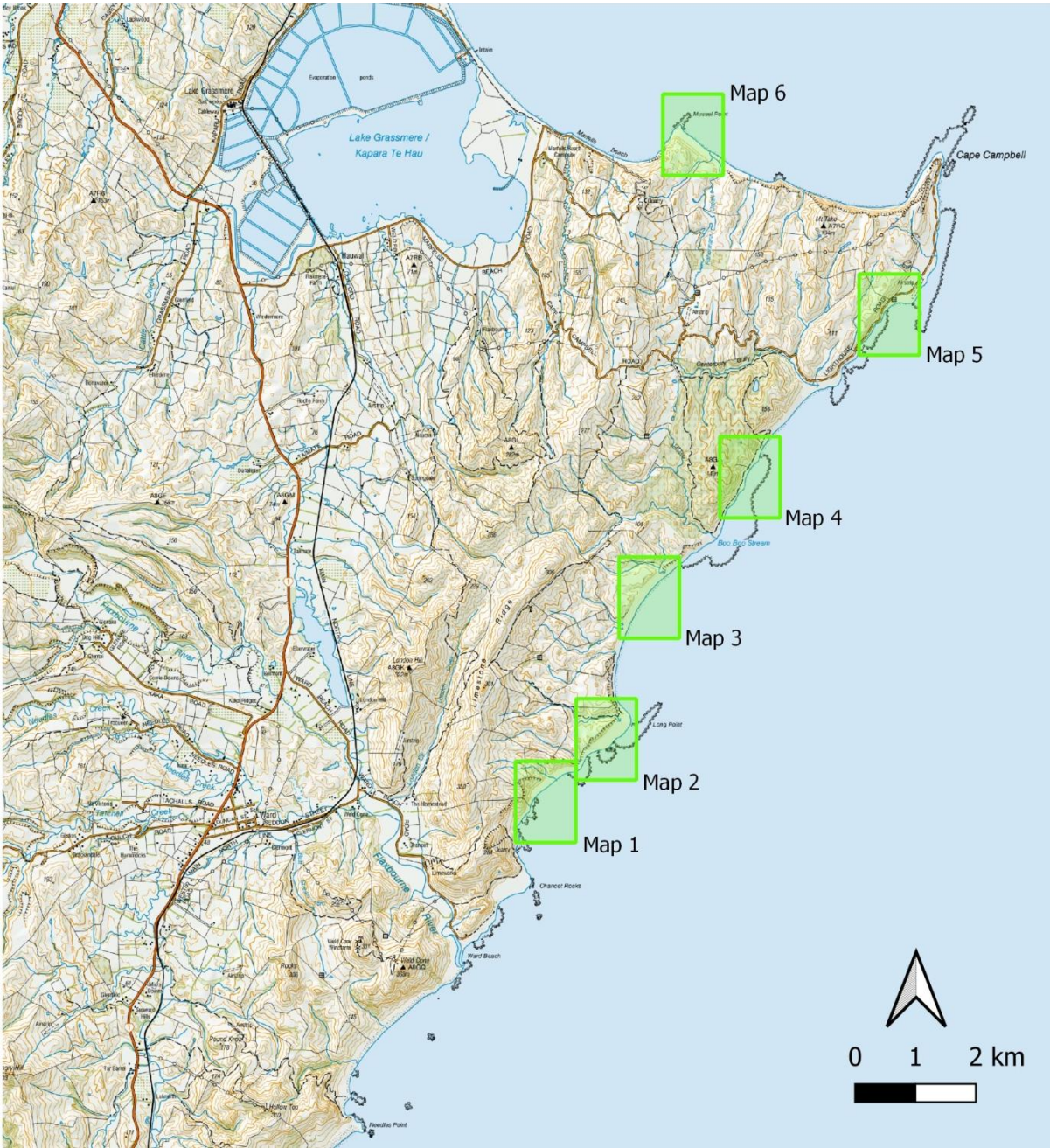
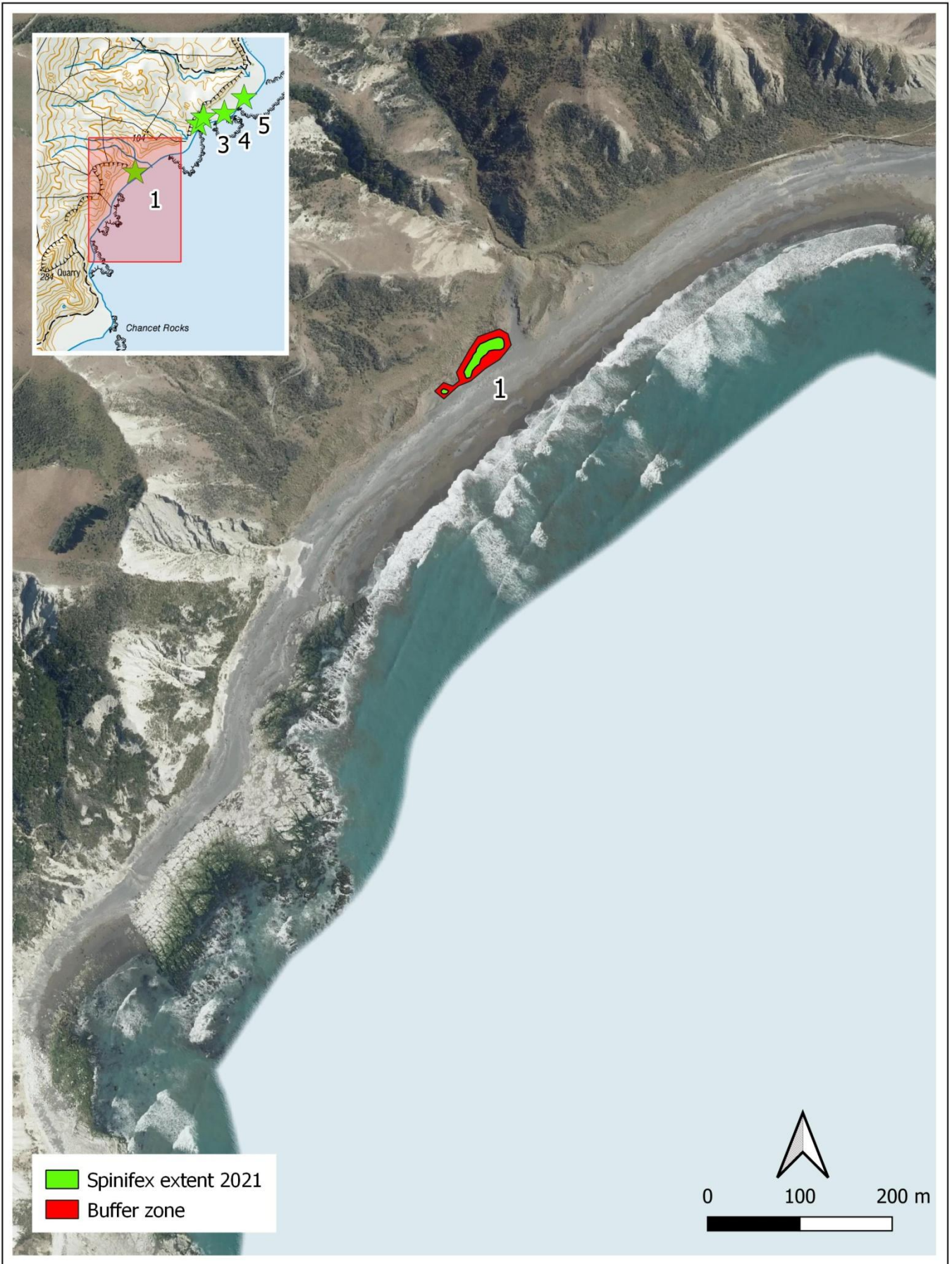
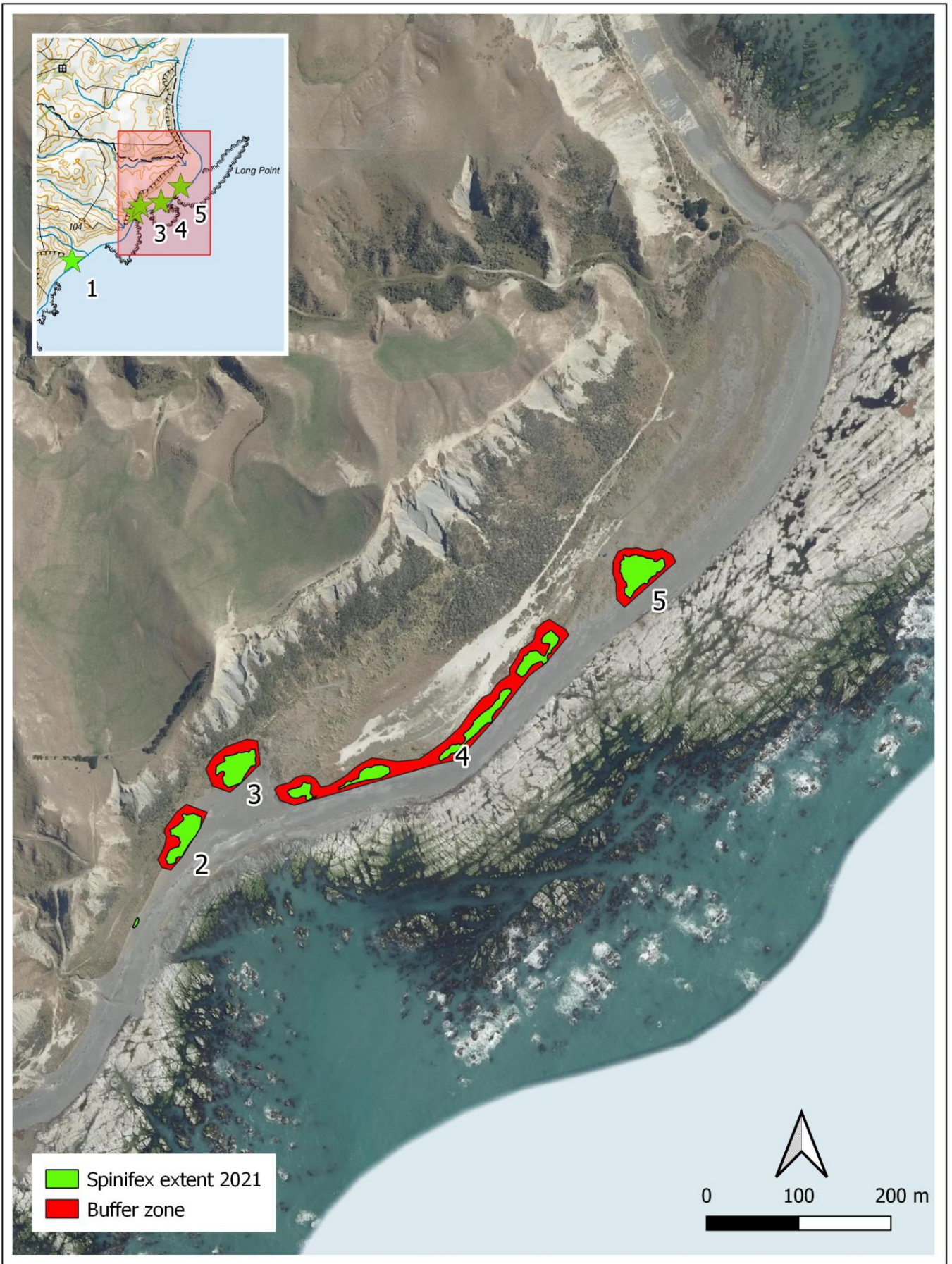
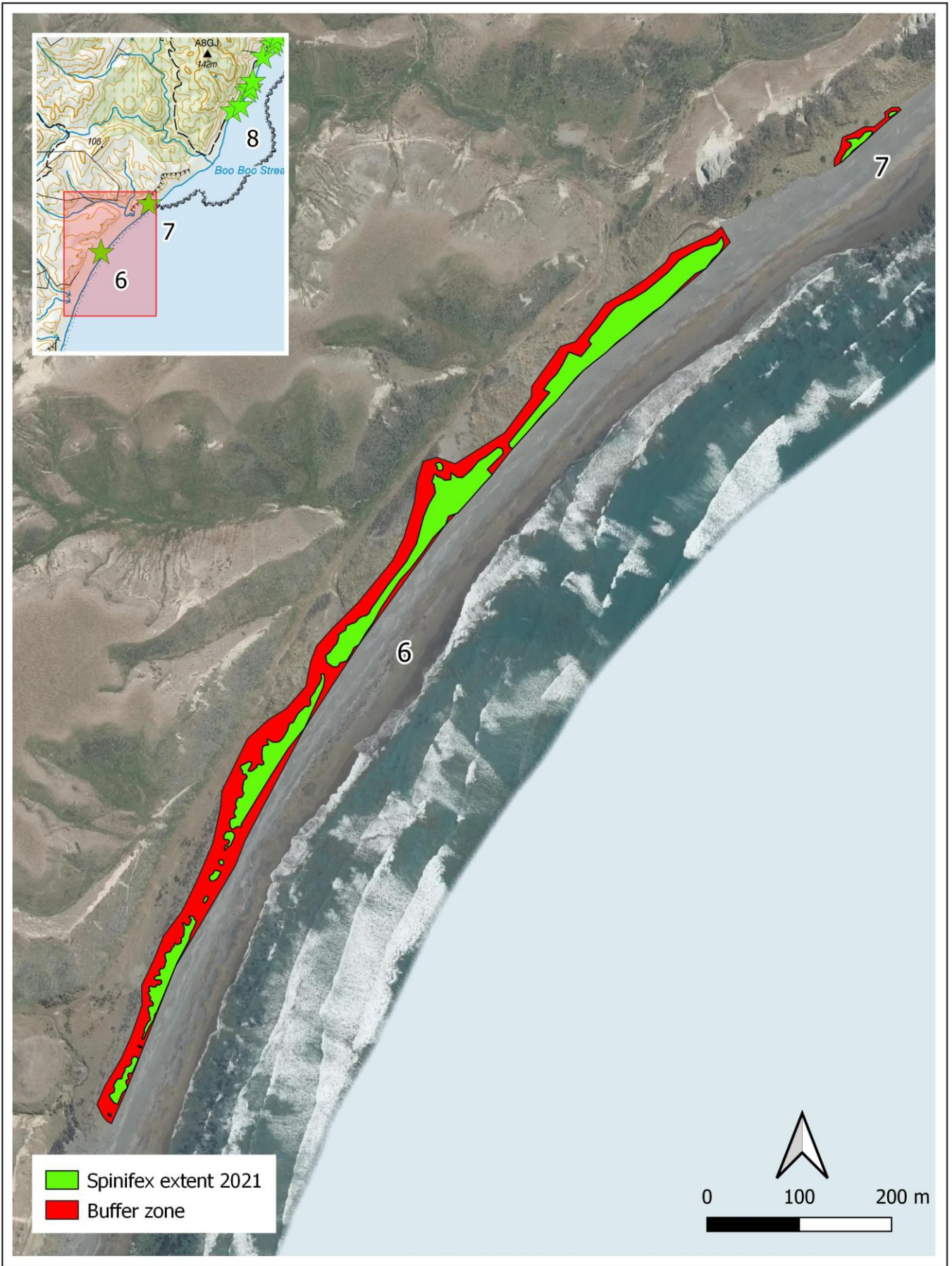
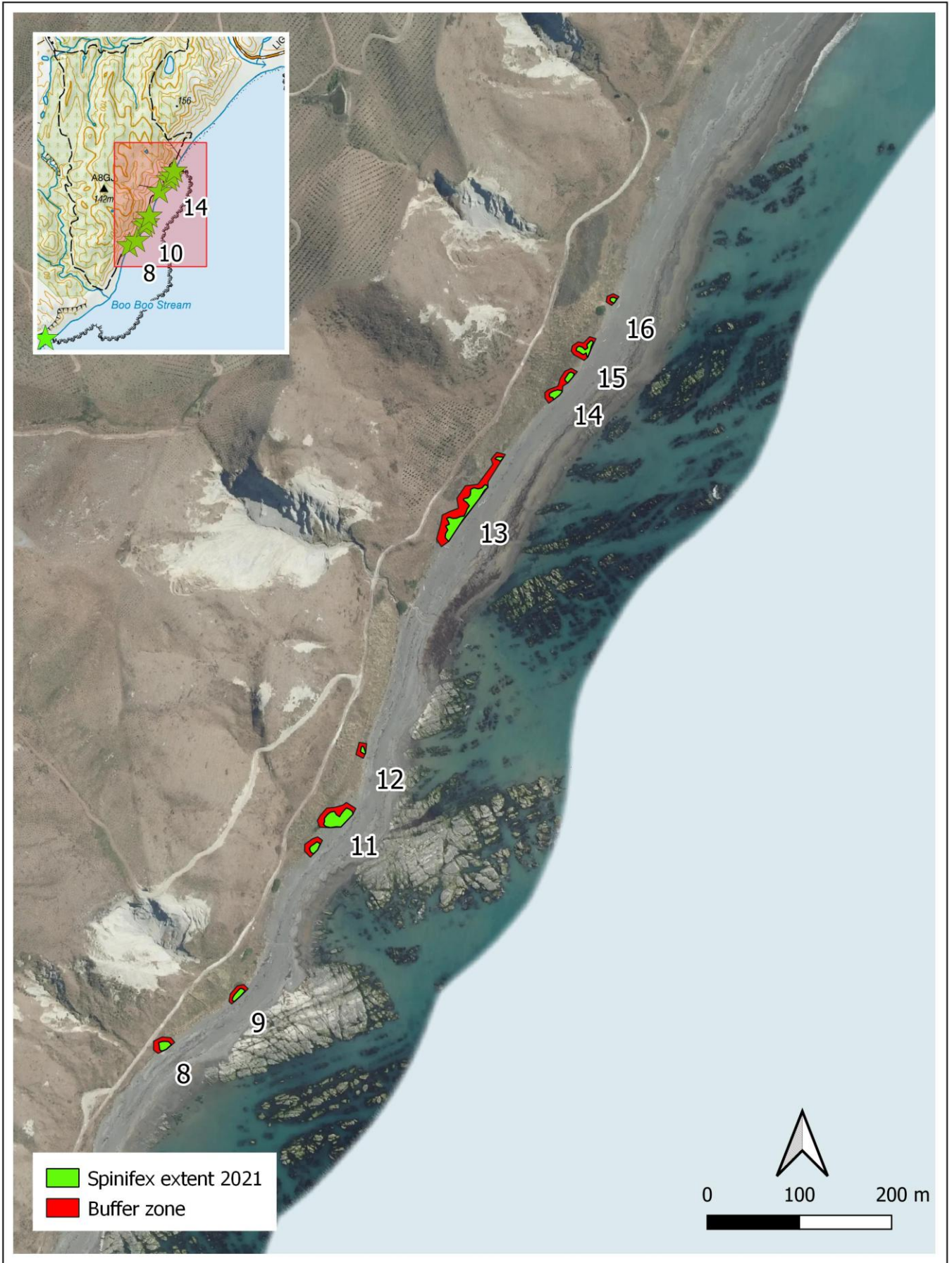


Fig. A1. Key to old-growth spinifex maps.

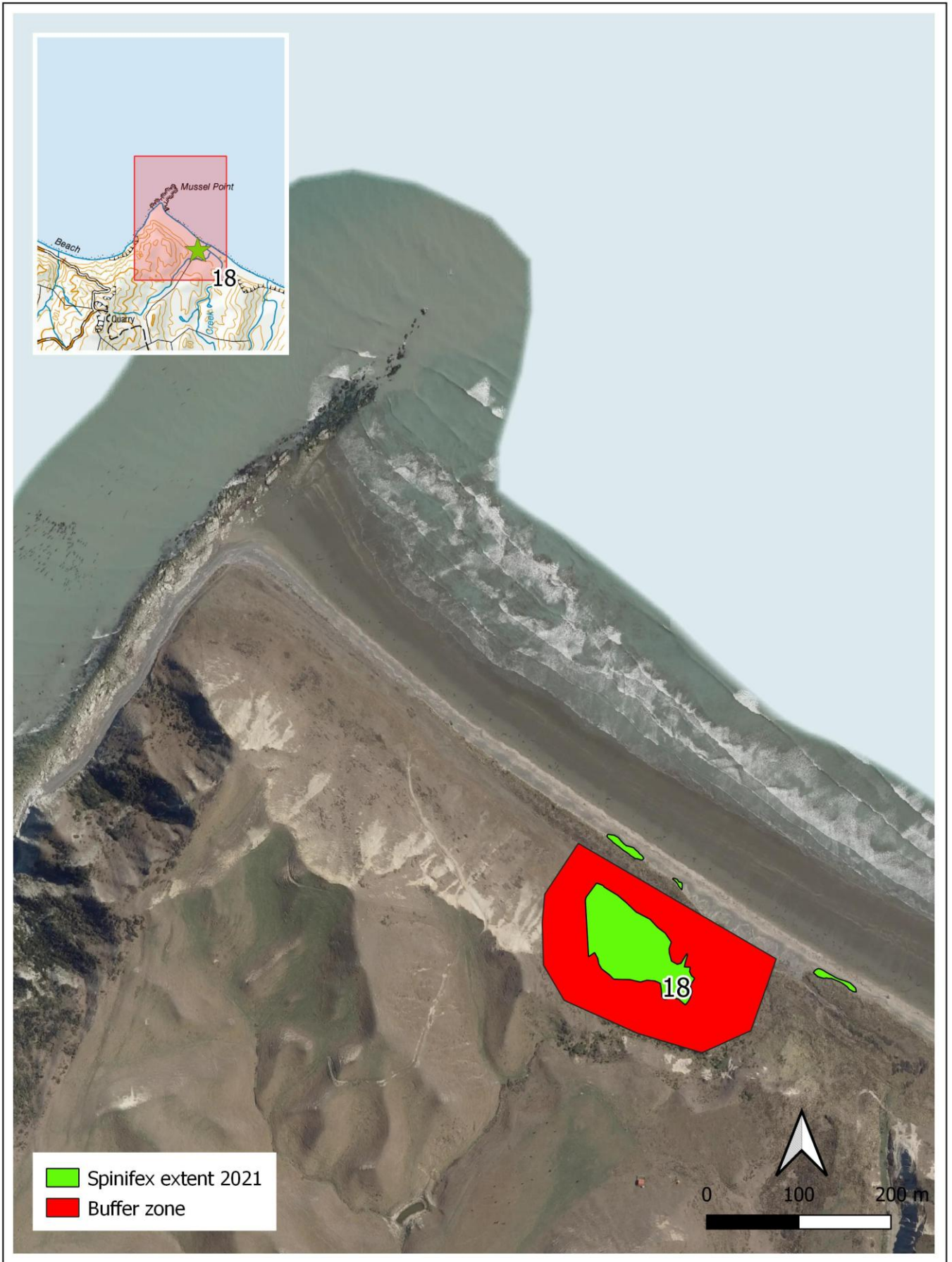












Appendix 2 Old-growth pīngao maps

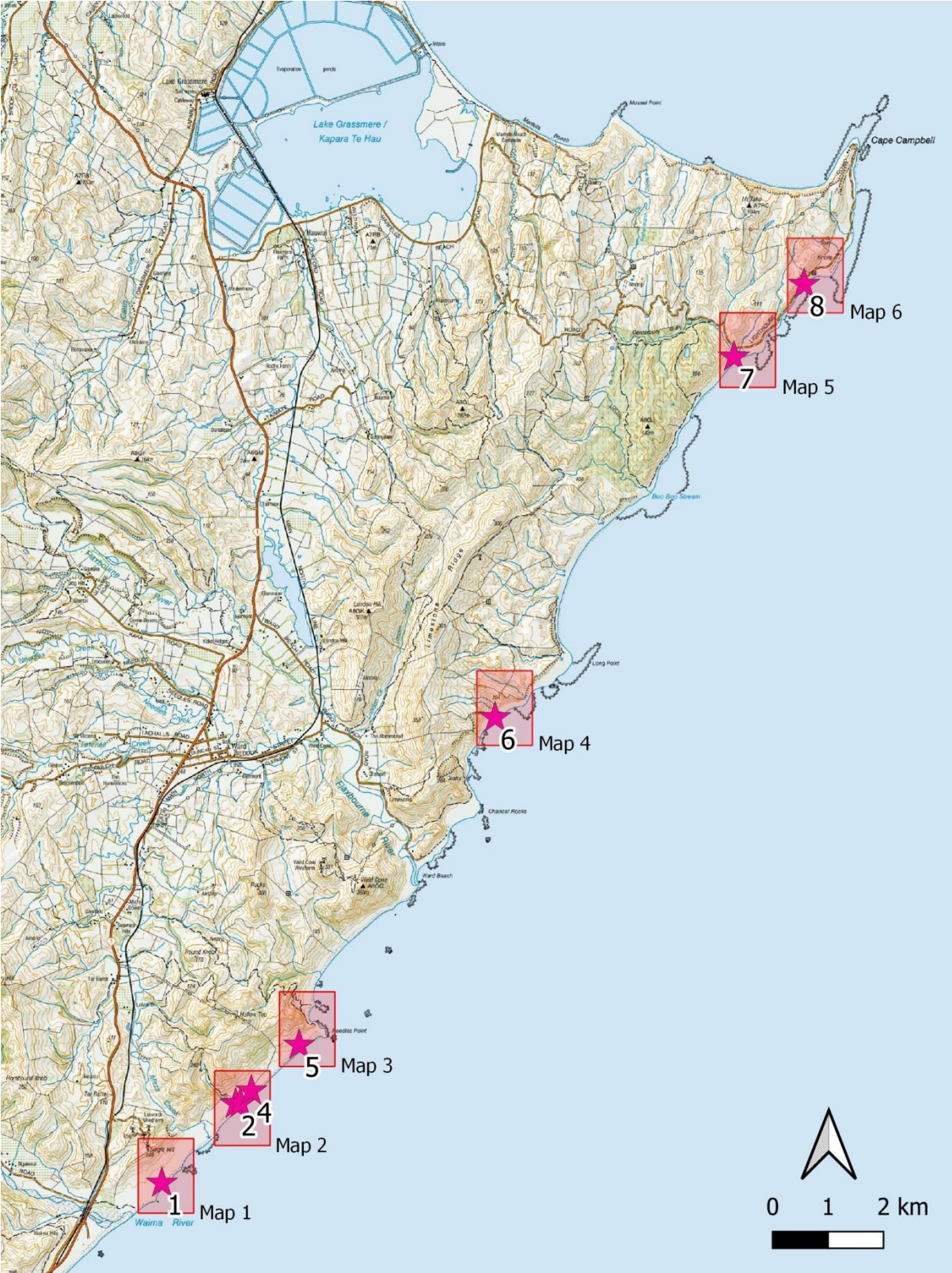


Fig. A2. Key to old-growth pīngao maps.













Appendix 3 New dune maps

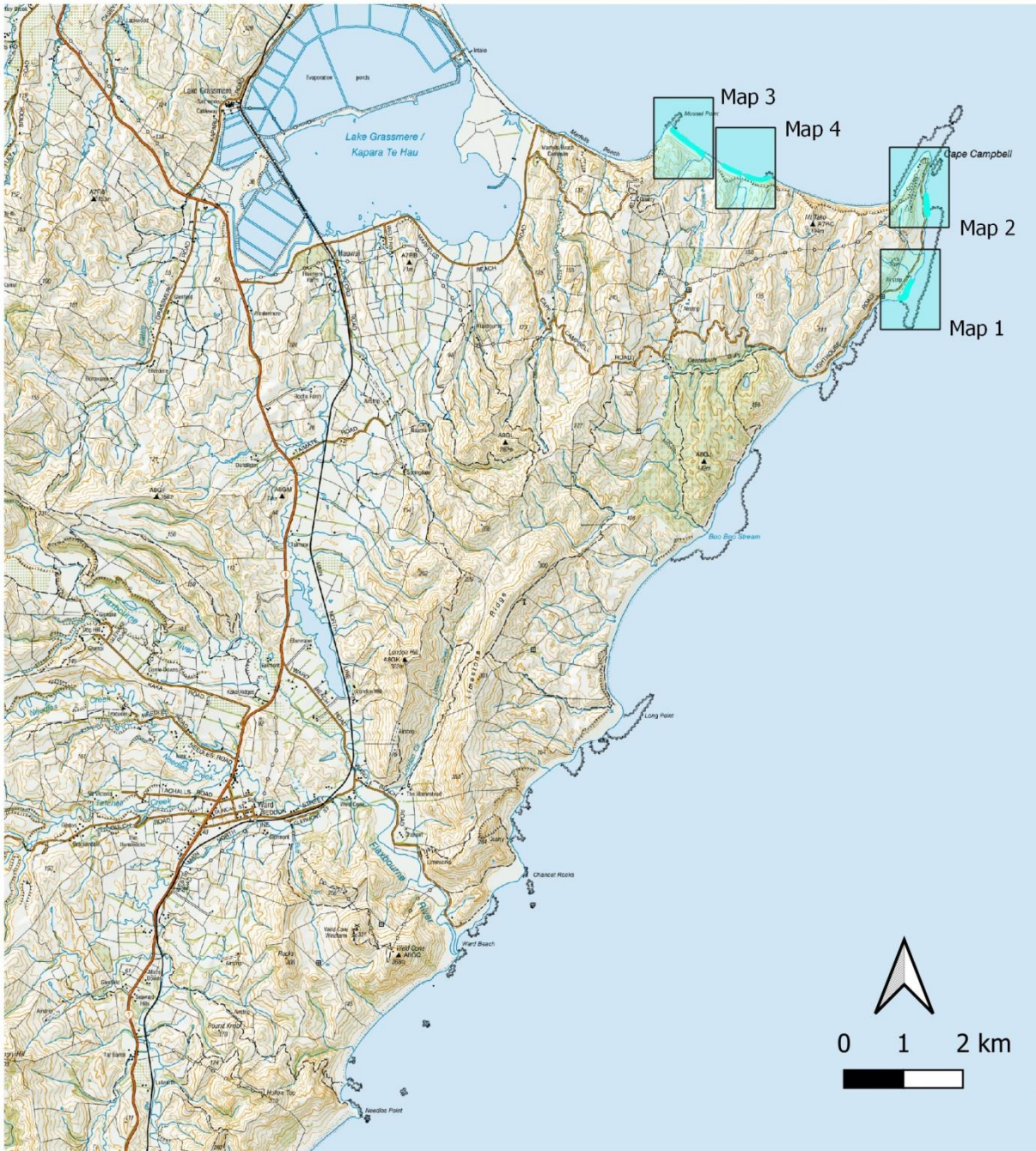
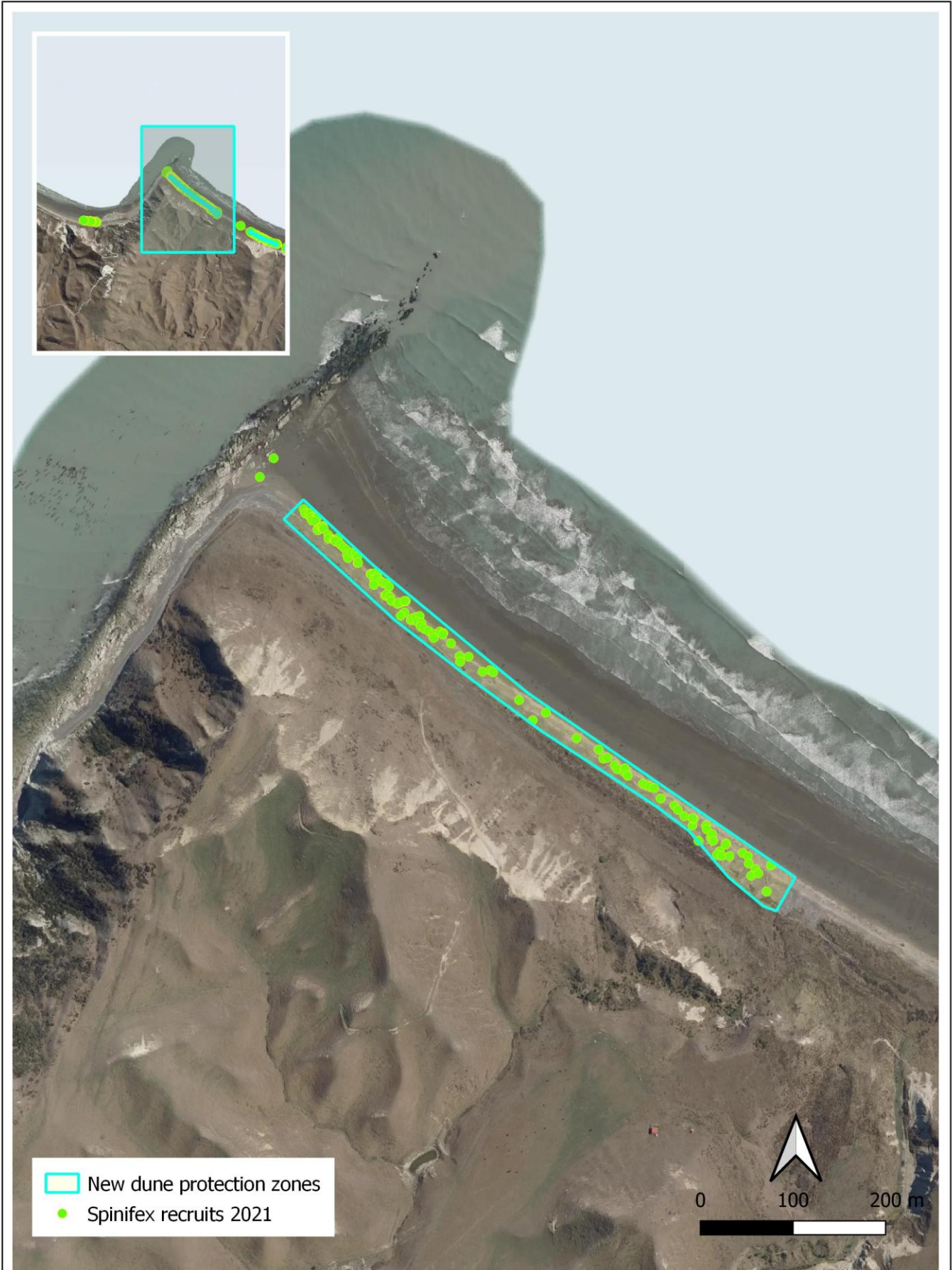


Fig. A3. Key to new dune maps.



New dune protection zones
● Spinifex recruits 2021





New dune protection zones
● Spinifex recruits 2021



