Department of Conservation
Te Papa Atawhai

OIA 19-E-0589

27 September 2019

[redacted]

[redacted]

Dear [redacted]

Thank you for your Official Information Act request to the Department of Conservation, dated 25 July 2019. You requested the following:

1. *Please list the 24+ threatened species supposedly endangered by Mason Bay marram.*
2. *What, other than marram, could have an adverse effect on those species?*
3. *In what way does constantly moving sand improve conditions for those species?*
4. *Please specify continuing research done, with dates, in the decade preceding eradication into the status of those 24+ species – i.e. Justification for decision.*
5. *What were the numbers at those times for the threatened species?*
6. *Please supply details of each annual assessment of those threatened species since eradication began.*
7. *What species, apart from those considered threatened, have been adversely affected by the eradication programme?*
8. *Please supply research information gained on the effect of marram poisoning chemicals on the kiwi population and on the availability of their food supply.*
9. *What are the specifics of comparison between kiwi occupation and regularly used burrows before and since eradication?*
10. *Why have there been none of the promised regular updates and public discussion since 2012?*
11. *How far has the treated area extended since the promise at its inception that no more than 10% of the area would be part of the programme for 10 years, in order that assessment could be thorough and part of the public updating?*
12. *How embedded as historical fact and the reason for eradication has become erroneous statement that marram was planted to enable farming near Island Hill?*
13. *What protection has been implemented on the sites of early Maori middens?*
14. *How far is it planned to continue marram eradication and to what year?*
15. *How much has the marram eradication cost to date?*
16. *What is its continuation expected to cost?*
17. *How much more native forestation will be destroyed before the department becomes concerned?*
18. *What research has been done into how marram eradication has enhanced visitor experience?*
19. *What research has been done on the percentage of visitors attracted to Mason Bay just to see a transgressional sand dune system?*
20. *In view of the global urgency about climate change, will the Department of Conservation regularly review policies that work against recommendations for the planting of more trees and the protection of coastlines from rising sea levels?*

On 2 September 2019 we extended your request to 2 October 2019 due to the large quantity of information sought.

The department wishes to include the below contextual information in reference to issues raised in your letter which may not have been directly posed as questions.

Conservation values of New Zealand sand dunes

Dune systems and their associated environments, habitats and species contribute to New Zealand's distinctive natural character. They contain animal and plant species that are found nowhere else.

A botanical survey of all New Zealand sand dunes, published in 1992 by the former Department of Scientific and Industrial Research (DSIR) (Partridge, 1992; Johnson, 1992) found that of the 606 dune systems surveyed only 53 retained high conservation values; and many of these were small systems with a limited range of values. The distribution of threatened plants has been well understood and augmented by subsequent studies of the biology, ecology and distribution of other critically threatened species such as *Euphorbia glauca* and *Gunnera hamiltonii*.

Active sand dunes have been identified as Naturally Rare ecosystems and assessed as being Nationally Endangered.

The sand dune inventory undertaken by DSIR evaluated, scored and ranked individual dune systems. Mason Bay was one of 30 priority dunes identified in the South Island, having a score of 18. Only four sites scored higher, with another seven sites having the same score.

The Ministry for the Environment 2007 publication *Protecting our places - Introducing the national priorities for protecting rare and threatened native biodiversity on private land* established four national biodiversity priorities and Mason Bay met three of these as follows:

National Priority 2: To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity.

Mason Bay is one of the largest dune systems in New Zealand and also contains wetland areas.

National Priority 3: To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types not already covered by priorities 1 and 2.

Active sand dunes and dune deflation hollows have both been identified as originally rare/naturally rare ecosystems and both are present at Mason Bay.

National Priority 4: To protect habitats of acutely and chronically threatened indigenous species.

All of these dune systems contain weeds and all southern New Zealand dune systems contain marram grass. The department has an obligation to protect a range of threatened plant and animal species on behalf of all New Zealanders.

Without active management this important element of New Zealand's biodiversity would be lost since marram displaces these species.

Impact of marram grass on conservation values

The presence of high densities of marram grass negatively impacts threatened plant species via direct and indirect processes. Burial is the most striking 'direct' effect. The density and growth habit of marram results in rapid accretion (vertical growth) of dunes at rates that cannot be sustained by native plant species which become buried as a result. Furthermore, once widespread, marram results in the general cessation of sand movement and substrate stability. After this happens, a range of other exotic species can establish which overgrow and further displace native species.

The marram-induced, unnaturally large foredune has adverse effects on native dune flora through starving plant communities further inland of sand and nutrients which would be naturally transported by winds. The enlarged foredune has effectively severed the natural connection between the beach and the inland areas of the active dune system.

The steep face of the foredune is a significant impediment to the movement of penguins and marine mammals, such as sea lions and fur seals, which seek resting refuge in natural dune systems.

Sand inundation into forested areas

Sand dunes are a naturally dynamic ecosystem with sand movement being an integral part of the ecosystem function. Marram grass is a much more effective sand binder than native dune species. The establishment and expansion of marram has resulted in changes in the dune form and sand movement.

Sand inundation of forest is occurring at two localised sites at Mason Bay. This is unrelated to marram grass control since, in both of these cases, sand was naturally migrating inland prior to the commencement of marram grass control work in 2000.

The boundary between the present, active, dunes and the vegetated inland dunes is well defined by soil formation. The inland dunes have some soil development and include a manuka and wetland species composition. This indicates that there has been an earlier phase of dune formation and migration across the Island Hill Flats to the Scott Burn at the base of Mount Rakeahua. The low level of soil development suggests that these dunes stabilised recently, probably within the last 500 years, well before the commencement of farming at Mason Bay.

A post-graduate surveying dissertation by Chris Garden established that the landward margins of the active dunes have changed over the last 60 years, since the first aerial photographs taken in 1958, in three ways.

1. Some margins are stable, and in the process of being recolonised by vegetation.
2. A few sections are active dunes which are migrating into the adjacent vegetation.
3. Some sections are stable and vegetation has neither advanced nor retreated and so have changed little since 1958.

Six sections of the dune system have been particularly active since 1958 as shown in Figure 1 (Garden, 2012):

A – A confined parabolic dune (U-shaped dune with two trailing arms on the windward side) in the Northern Dunes
B – A parabolic dune
C – The dunes that formed and then inundated "Shag Lake"
D – The dune downwind of "Mutton Flat" and to the north of Duck Creek
E – Dunes south of Big Sandhill
F – Dunes between the main "Central Dunes" and Martin's Creek

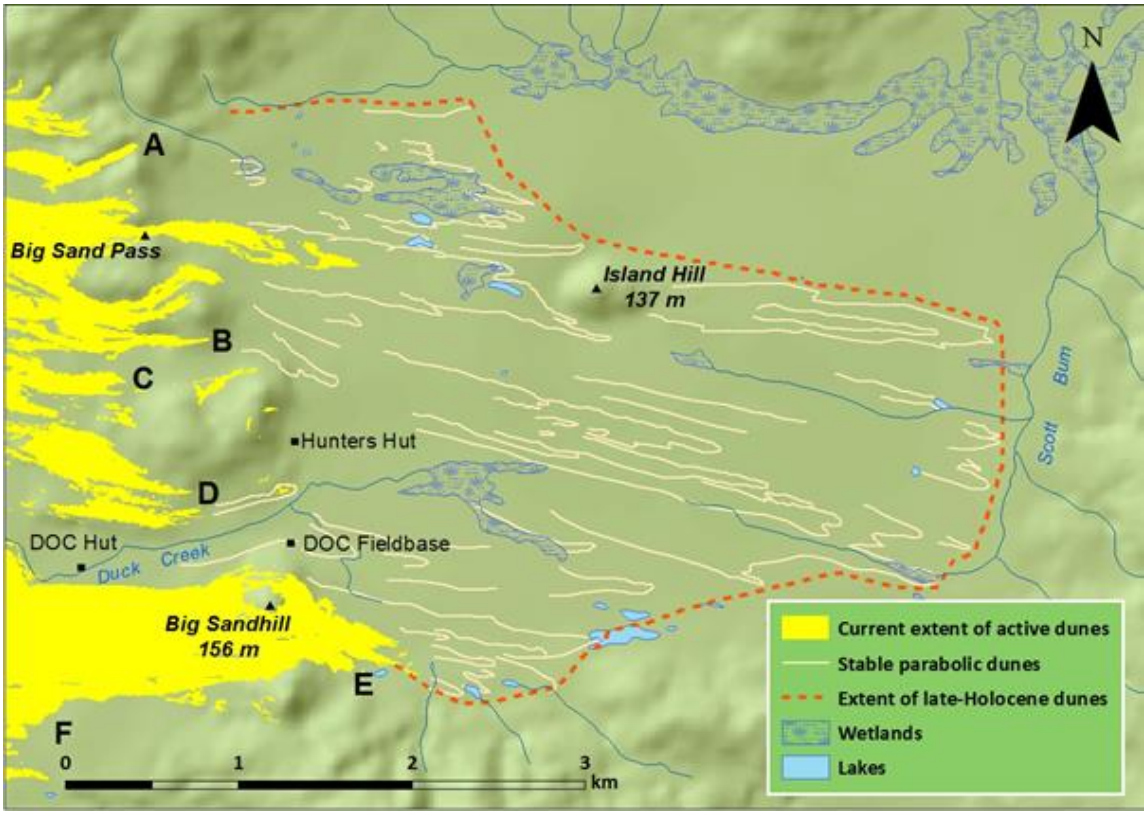

Figure 1. Extent of active and inland (stable, vegetated) dunes, northern Mason Bay (University of Otago). The labels A – E identify sites where the active margins of the dune system have been monitored since 2009.

Between 1958 and 1977 dunes were actively advancing into the hinterland vegetation at the above sites prior to the commencement of the dune restoration programme. Areas A, B and F have been active since at least 1958. No marram control has occurred in the vicinity of Area C and so the accelerated dune movement seen here cannot be attributed to the dune restoration programme. This is also true in Area D, which was active during the 1960s and 1970s, prior to the commencement of marram control.

Area E is downwind of the extensive "Central Dunes", where marram operations have been active since 2000. Relatively little marram and small marram-related dunes were present in the "Central Dunes", east of the Mason Bay hut, at this time. The large marram-formed dunes occurred east of the "stonefield"; these comprised a large foredune and adjacent parabolic dunes, mainly within 1000m of the shoreline. Marram has been eradicated from sections of these dunes since 2010.

Some sand has blown downwind of these landforms and could potentially have contributed to the migration of dunes in the vicinity of Area E which was already occurring prior to the commencement of the dune restoration programme. Moreover, most of the sand released by erosion of the foredune, where marram has been eradicated, has accumulated in the immediate lee of the foredune (Figure 2); and, the former marram-formed parabolic dunes have been recolonised by native species.

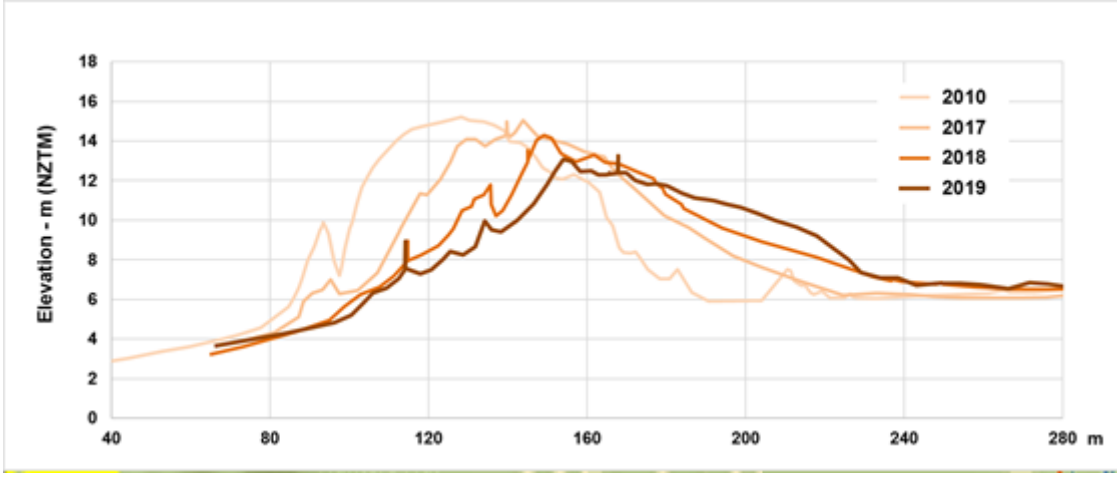

Figure 2. Cross-sectional change, foredune section P6, 2010 to 2019 (University of Otago).

As you will note from the above examples, the sand dunes were advancing into the hinterland of Mason Bay and entering scrub and forest long before the commencement of the marram eradication program. This is a natural process associated with active dune systems. National Parks are designated to protect such processes.

Relatively small areas of scrub and forest vegetation have been affected by this process since at least 1958. In general, dunes are advancing along pathways transgressed by dunes when the historic inland dunes formed.

Finally, most of the sand mobilised by marram eradiation has been trapped by native vegetation, which is now flourishing in the post-marram environment. Marram operations have had no significant effect on the stability or instability of the margins of the dune system or resulted in the burial of large tracts of native forest.

The impact of projected sea level rise resulting from climate change

The projected average sea level rise by 2100 is between an estimated 0.5 and 1.0 metres. The Mason Bay foredune has developed since the introduction of marram grass. A high continuous foredune did not exist prior to the early 1950s, when marram self-introduced, likely from plantings at Kilbride in the 1930s.

Photographs by Edgar Williams show that no foredune was present in the location of the current foredune in 1935. The immediate hinterland, within 1km of the shoreline, then compromised an undulating dune field with a patchy cover of pikao, and other dune-related plant species in particular micro-habitats.

Furthermore, marram caused the dunes to prograde (build seaward) about 70 metres between Martin's Creek and Duck Creek.

The erosion of the foredune, and the formation of dunes and native plant communities inland of the foredune is being closely monitored by the University of Otago on an annual basis. The currently most eroded section of the foredune received the first round of marram control in December 2010. Significant erosion of this section of foredune only commenced in 2015 (Figure 2). Since 2015 almost all of the sand eroded from the front face of the foredune has accumulated behind the foredune or been trapped by a combination of marram and pikao within 300m of the shoreline.

We expect that an undulating dune topography, with individual dunes of between three to five metres high, will form over the next 10 to 20 years. The shoreline will likely return to its pre-marram position over the same period.

The elevation of the dunes behind the foredune will remain high after marram eradication and restoration of native species. Current sea level rise predictions indicate that there is no chance that the sea will one day flood large areas of the dune system. Furthermore, the hinterland of the dune system slopes upward as one moves inland such that an elevation of six metres above the current high tide level is attained just 400 metres inland of the present shoreline (Figure 3).

Figure 3: The topography along P6 transect across the beach, foredune and deflation surface of Parabolic 6 (University of Otago, April 2019). The current mean high-water spring tide elevation is indicated by the dashed blue line.

Mason Bay is home to the largest active dune system in southern New Zealand and a stronghold for a range of dune-related species, both rare and commonplace. It is an exceptional site in terms of the range of habitats, the mosaic of landscapes, number and extent of dune-related plant, animal and geomorphic-adapted species. It also contains an exceptional array of freshwater systems, ephemeral and semi-permanent, about which we know little.

This dune system is one of the most important in New Zealand and its conservation is of paramount importance to the survival of New Zealand's southern coastal biodiversity.

Please find your questions and our responses listed below:

1. *Please list the 24+ threatened species supposedly endangered by Mason Bay marram.*

   Please find the following list of identified Nationally and locally threatened species recorded from Mason Bay. In additional there are threatened fauna present including birds, lizards, fish and invertebrates.

	Species	**Threat category**	**Importance at Mason Bay**
1	*Crassula peduncularis*	Nationally Critical	Only recorded location for Southland
2	*Gunnera hamiltonii*	Nationally Critical	National stronghold
3	*Puccinellia raroflorens*	Nationally Critical	Only dune location known nationally
4	*Libertia peregrinans*	Nationally Vulnerable	National stronghold
5	*Ranunculus recens*	Nationally Vulnerable	National stronghold
6	*Acaena microphylla* var. *pauciglochidiata*	Declining	
7	*Acaena pallida*	Declining	
8	*Coprosma acerosa*	Declining	National stronghold
9	*Euphorbia glauca*	Declining	
10	*Euphrasia repens*	Declining	
11	*Ficinia spiralis*	Declining	National stronghold
12	*Geranium sessiliflorum* var. *aremarium*	Declining	National stronghold
13	*Gunnera arenaria*	Declining	National stronghold
14	*Lachnogrostis ammoebia*	Declining	
15	*Leptinella serrulata*	Declining	
16	*Linum monogynum var. monogynum*	Declining	
17	*Luzula celata*	Declining	
18	*Mazus arenarius*	Declining	National stronghold
19	*Myosotis pygmaea*	Declining	National stronghold
20	*Pimelea lyallii*	Declining	National stronghold
21	*Poa billardierii*	Declining	National stronghold
22	*Raoulia* sp. aff. hookerii "coastal"	Declining	National stronghold
23	*Sonchus kirkii*	Declining	
24	*Anisotome lyallii*	Relict	
25	*Centrolepis minima*	Naturally uncommon	
26	*Chaerophyllum* sp. "minute flower"	Naturally uncommon	
27	*Coriaria spp. "Rimutaka"*	Naturally uncommon	National stronghold
28	*Craspedia robusta* var. *pedicellata*	Naturally uncommon	National stronghold
29	*Gingidia flabellata*	Naturally uncommon	
30	*Juncus pusillus*	Naturally uncommon	
31	*Leptinella traillii* ssp. *traillii*	Naturally uncommon	
32	*Myosotis rakiura*	Naturally uncommon	

2. *What, other than marram, could have an adverse effect on those species?*

   Aside from marram, the main risk to threatened species are other exotic weed species that establish populations following dune stabilisation by marram. Gorse, broom and tree lupin are examples of other pest plants that are currently present at Mason Bay.

   Deer species are known to browse on threatened plants such as *E. glauca* while the tomato leaf rust virus has been detected on *G. hamiltonii* at Mason Bay.

   Feral cats may impact on flocking Southern New Zealand Dotterel but no evidence of this has yet been noted.

   Climate change may pose a risk to some species, particularly if periods of drought become more frequent and intense.

3. *In what way does constantly moving sand improve conditions for those species?*

   The sand at Mason Bay only begins to move when wind speeds exceed 10 metres per second (approximately 40 kilometres per hour). These wind speeds are normally reached during westerly conditions but can also occur during periods of north-easterly winds.

   The topography of the dune system funnels and modifies these winds so that there are areas which are relatively more or less exposed and as a result receive more or less sand deposition. Consequently, a range of habitats result, with burial (the rate of sand accumulation) being one of the main factors.

   The dune related flora referred to above are adapted to different rates of burial such that those areas that experience the highest wind flow, and the highest rates of sand deposition, will contain just a few species whereas areas that receive minor rates of sand deposition will contain a greater species diversity. There is a spectrum of varying plant communities along this scale of increasing sand deposition.

   The rare species present each have their own habitat requirements, for some this is a specialised niche. Some of the species occur primarily in mobile sand, others in stabilised sand or dune slacks (wetlands). Sand movement creates a range of varied habitats for native species which are adapted to a range of burial conditions, sand abrasion and hydrological conditions and so sand movement is essential to their survival.

4. *Please specify continuing research done, with dates, in the decade preceding eradication into the status of those 24+ species – i.e. Justification for decision.*

The justification for embarking on dune restoration at Mason Bay is related to:

- Knowledge of the impact of marram grass on native species
- Awareness of the vulnerable state of threatened species to extinction at Mason Bay
- Conservation values of Mason Bay
- Studies of the Doughboy Bay dune system (where marram grass resulted in the formation of particular dune landscapes and the loss of dune-specific species)
- Dune systems where marram has not established (e.g. Smoky Beach).
- Refinement of restoration methodologies at Doughboy Bay which provided the confidence to proceed with the larger scale project at Mason Bay

Please see the attached list of references including work by Hilton, Woodley, Duncan, Konlechner and others at Doughboy Bay, and analysis of the impact of marram grass on native species.

Since dune restoration (including marram grass eradication) at Mason Bay commenced in 2000 the University of Otago has been contracted to, among other things, study the change in dune landscapes as the dunes are restored; measure how the dune system margins are changing; the establishment of new dune habitat for native plant species; and the decline of marram-dominated habitat. A census of the distribution of all of the threatened plant species referred to above has not been completed, except for *E. glauca*, *G. hamiltonnii* and *F. spiralis*.

Reports by Hugh Wilson indicate *E. glauca* was once widespread between Duck Creek and Martins Creek, primarily within a few hundred metres of the shoreline. This habitat was largely converted by marram between 1978 and 1998 and *E. glauca* has almost been completely displaced. The last extensive colony at Duck Creek was lost by 2010. Surviving *E. glauca*, present at isolated locations in the hinterland of the dune systems, particularly near Big Sandhill, are suffering from deer browse and are in decline.

G. hamiltonnii at Mason Bay is surveyed every two to three years and the data indicates the central dunes colony is expanding in area.

F. spiralis is generally used as an indicator of native species abundance in dune systems and as an indicator of 'naturalness'. Photo point monitoring reveals the increasing density and extent of pikao in areas where marram has been successfully controlled.

5. *What were the numbers at those times for the threatened species?*

   Detailed population data for all threatened species cannot be easily obtained. For example, *G. hamiltonii* covers an area of several hundred square metres but is likely to be a single individual.

   Measuring the change in area of suitable habitat is a more robust metric, for example, we know that the area containing *F. spiralis*, a healthy dune indicator species, has increased from 106 hectares in 2002/03 to 309 hectares in 2018/19 (Figure 4).

   We estimate that the habitat of the above referenced threatened plant species would have been completely lost over several decades if dune restoration was not initiated.

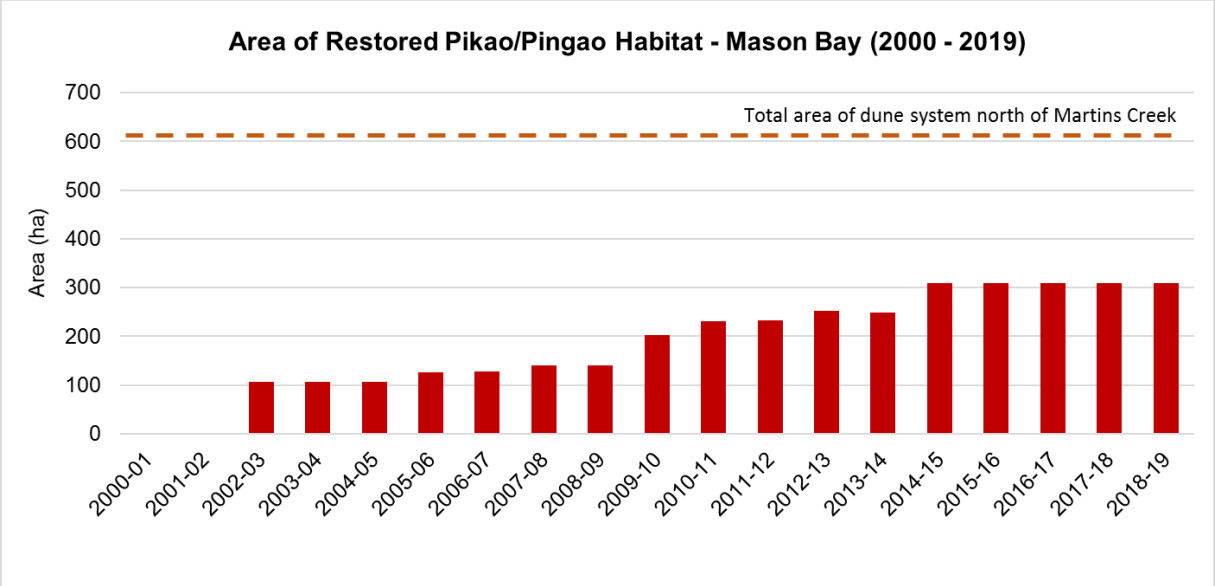

Figure 4: Cumulative area of *F. spiralis* by year indicates the progressive restoration of natural dune habitat that supports native biodiversity values including threatened species.

6. *Please supply details of each annual assessment of those threatened species since eradication began.*

   The presence and location of threatened species is known from several botanical surveys. It would be very difficult, however, to conduct an annual inventory of each species due to the prohibitive resourcing requirements.

   At present monitoring involves:

   (i) periodic surveys of foredune, parabolic dune and stone field development at Mason Bay;
   (ii) triennial survey of the southern and northern dune systems at Doughboy Bay;
   (iii) biennial and opportunistic survey of the numbers or range of *E. glauca*, *F. spiralis* and *G. hamiltonnii*, as indicators of dune system biodiversity;
   (iv) surveys of marram recruitment in restoration areas;
   (v) periodic survey of archaeological sites;
   (vi) observation and mapping of tree lupin distribution; and
   (vii) the occurrence of other exotic species.

7. *What species, apart from those considered threatened, have been adversely affected by the eradication programme?*

   To our knowledge no native species, including non-threatened, have been adversely affected by the dune restoration programme.

   The few, small areas of forest that are being inundated by sand through natural processes are unrelated to the dune restoration programme.

8. *Please supply research information gained on the effect of marram poisoning chemicals on the kiwi population and on the availability of their food supply.*

   The herbicide (haloxyfop-P-methyl) used in the dune restoration programme is grass-specific and absorbed by the foliage and roots. Once absorbed it is transported to the meristematic tissues where it inhibits growth.

   The Environmental Risk Management Authority (ERMA) reviewed and approved a new herbicide containing haloxyfop-P in 2009 (ERMA 2009). This assessment identified a low acute risk to the aquatic environment and uncertainty relating to a lack of chronic aquatic organism data, but that appropriate use would reduce the level of these risks to negligible.

   We have no reason to believe that this grass-specific herbicide affects the kiwi population either directly or through effects on food availability.

9. *What are the specifics of comparison between kiwi occupation and regularly used burrows before and since eradication?*

   Regular monitoring of the kiwi population at Mason Bay began in 1993 following an earlier study from 1988 to 1990. This involves catching and banding kiwi, calculating their territory size through radio transmitters and then reassessing the data set every five years.

The area targeted for the study is the previously farmed area at Island Hill (Figure 5) rather than within the extent of marram control operations.

The data so far shows that one of the 2013 territories were lost in 2018 and that two other territories divided into two new ones, thus producing a net increase of one territory over that five-year period.

It is estimated that the local kiwi population have declined by 1.4% between 1993 and 2018 and this has been linked to the reduction of cleared, retired farmland area due to the rapid regeneration of scrub, flax and tussock communities in these areas.

The earlier kiwi monitoring from 1988 to 1990 investigated three territories in the dunes and three on the retired farmland and found that territory sizes were over four times larger in the dunes and this was attributed to food availability being scarce when compared with the farmland. This study found kiwi sheltering under marram but didn't locate any burrows.

Field operations after the commencement of marram control have discovered approximately two burrows which were thought to be day roosts rather than nesting burrows.

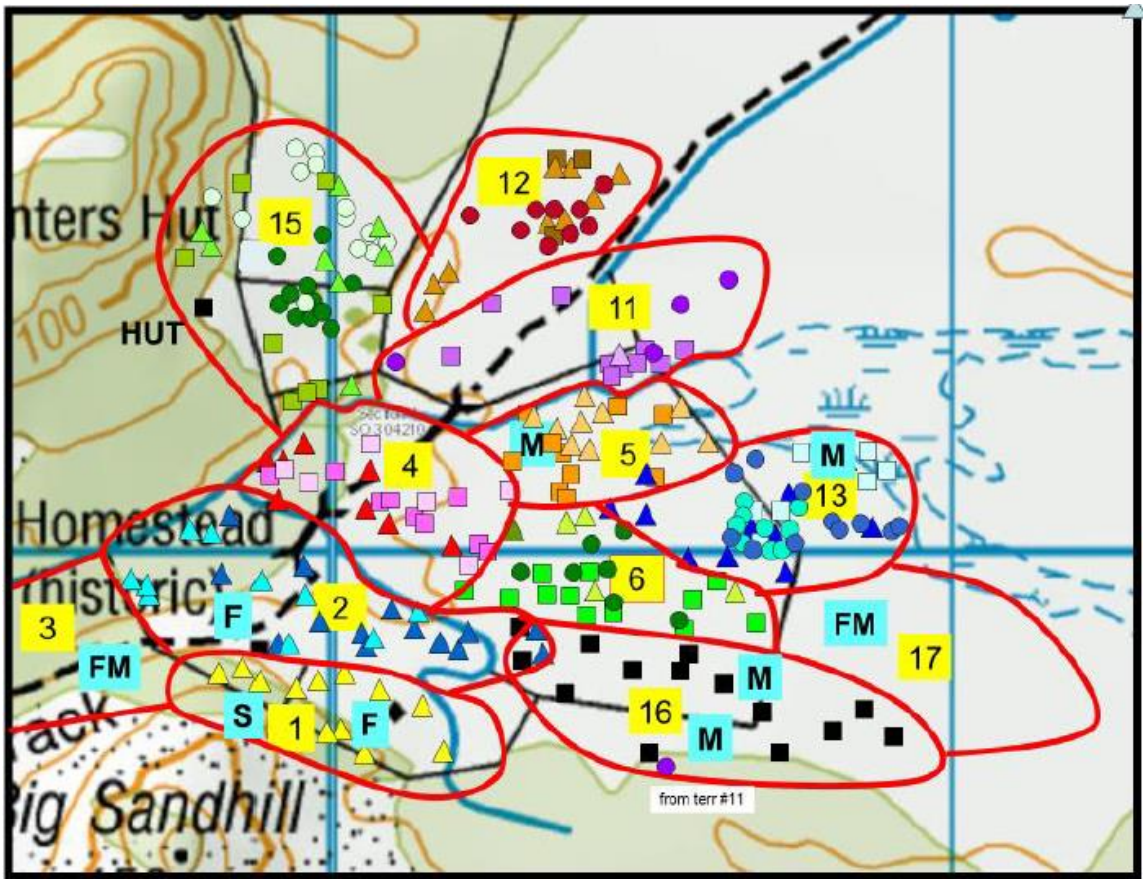

Figure 5: Capture and radio-telemetry locations of Rakiura tokoeka in the Mason Bay study area in February 2018. Each different-coloured shape represents a different bird: females (squares), males (triangles) and subadults or chicks (circles). Additional birds seen or heard are shown with approximate locations: adult female (F), adult male (M) and subadult (S).

10. *Why have there been none of the promised regular updates and public discussion since 2012?*

    Regular dune restoration programme updates are provided to the local community through contributions to the Stewart Island News publication including a standing open invitation for any interested parties to raise questions, concerns or ideas regarding the programme.

    The department also regularly reports on progress at Mason Bay to the Southland Conservation Board which represent the New Zealand public and Kaitiaki Roopu o Murihiku which facilitates our Treaty partnership.

    The department will endeavour to facilitate a public meeting on Rakiura to provide further opportunity for information reporting, sharing and feedback on the programme.

11. *How far has the treated area extended since the promise at its inception that no more than 10% of the area would be part of the programme for 10 years, in order that assessment could be thorough and part of the public updating?*

    The programme has progressed carefully after a reasonable assessment of the gains made. Figure 6 shows the annual extent of marram control between 2000 and 2019.

    The area under restoration management expanded very little between 2010 to 2019, while the results of monitoring were assessed to inform a medium to long-term strategy (Figure 6).

12. *How embedded as historical fact and the reason for eradication has become erroneous statement that marram was planted to enable farming near Island Hill?*

    The invasion of marram into the dune systems at Mason Bay resulted from two processes. Marram was planted at Kilbride in the 1930s and spread north, by marine dispersed rhizome, and inland, by seed. This is the main reason for marram being present in the dune systems of Cavalier, the lesser dunes north of Cavalier, and the Central and Northern Dune systems north of Martin's Creek to the northern end of Mason Bay.

    The marram that was planted in the Central and Northern dune systems was highly localised. These plantings contributed very little to the overall area of marram and the process of marram invasion. These areas were east of Big Sandhill, at the top of Mutton Flat, and north of Martins Creek. Marram planted at Mutton Flat related to the migration of sand towards the old deer paddock and was clearly related to farming.

    However, in general, the establishment of marram through Mason Bay was a consequence of farming operations at Kilbride, at a much earlier time. The Island Hill farmers introduced some marram, but this was of much less significance. Marram can also arrive from mainland New Zealand via marine dispersal of rhizome.

13. *What protection has been implemented on the sites of early Maori middens?*

A number of archaeological sites have been identified, surveyed and recorded during fieldwork at Mason Bay. These are mostly deflated ovens and shell midden.

These sites have already been disturbed by dune movement and coastal processes. Our focus is on recording sites and gaining any information that these sites may reveal.

The department has a reporting protocol where iwi are notified of all archaeological discoveries made during our field work and a subsequent course of action is agreed to.

You may be interested to read the referenced study (Hilton *et al.* 2018. Burial, erosion and transformation of archaeological landscapes: case studies from southern New Zealand [Aotearoa]) which considers the interactions between geomorphic and archaeological landscapes.

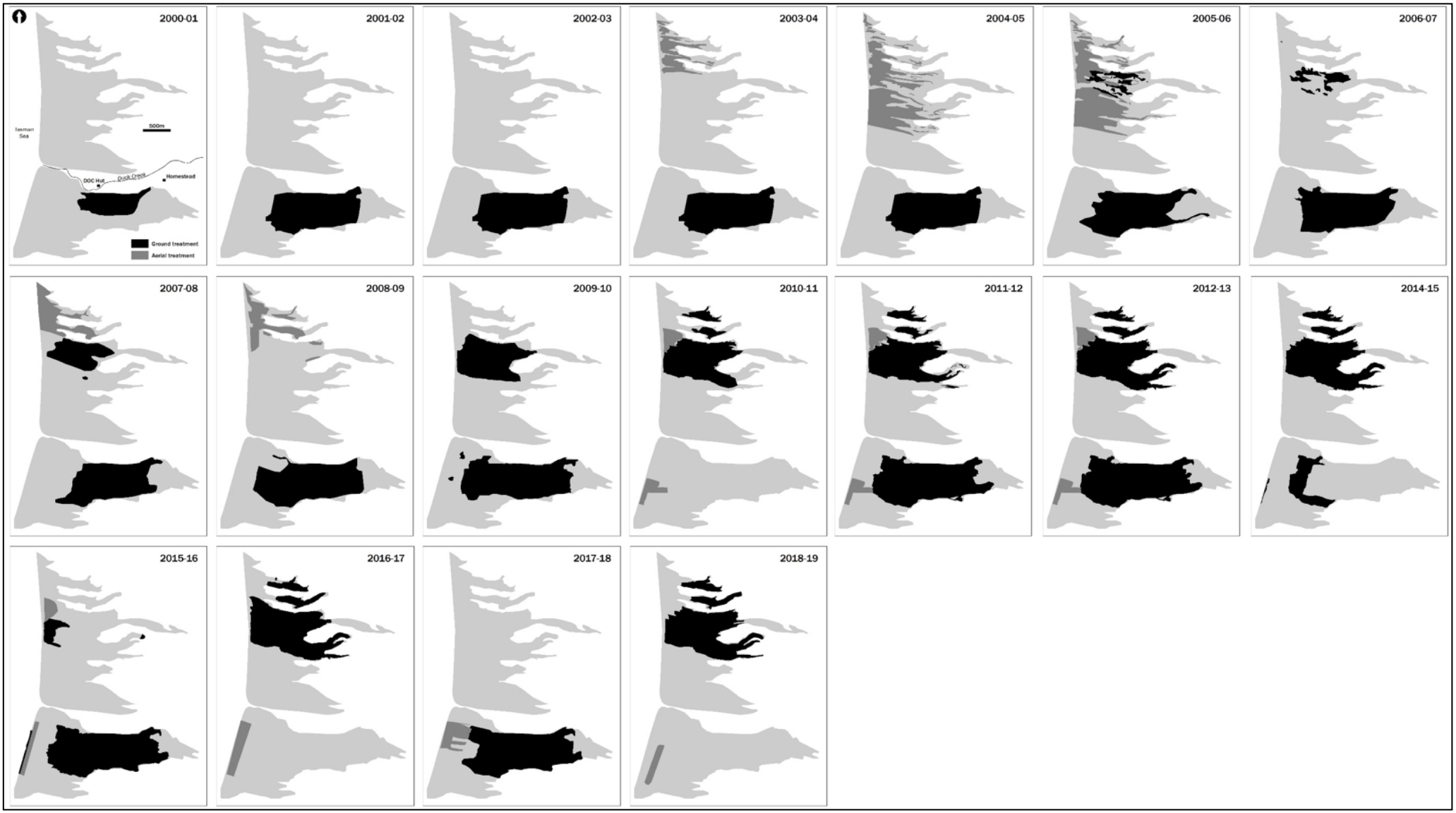

Figure 6: Annual marram control areas shown in black (ground control) and dark grey (aerial control) against the extent of the active dunes shown in light grey.

14. *How far is it planned to continue marram eradication and to what year?*

    The department aims to complete restoration efforts as soon as possible before moving into a surveillance phase where localised control of reinvading marram prevents re-establishment of a large infestation in a similar way to the approach to marram control at Smoky Beach and Doughboy Bay.

    The total length of the project is dependent on our ability to prevent reinvasion from neighbouring areas, including other beaches, and exhausting the large seed banks that have built up over the last nine decades. By increasing the scale of annual operations, we hope to reduce the overall length of the programme through reducing the amount of re-establishment and addition to the seed bank.

    If current resourcing levels continue we can expect the eradication programme to last several more decades, however, further resourcing in the short term will help us reduce this timescale.

15. *How much has the marram eradication cost to date?*

    The department underwent a significant restructuring process in 2013 during which project management and accounting processes changed.

    Prior to 2014, work programmes were categorised by task relating to threat or value managed, for example "weed control". The work at Mason Bay was weed control and so the accounting was combined with a range of other weed control projects across Stewart Island/Rakiura under the then "weed control programme" and so it is not possible to isolate the specific costs associated with Mason Bay during this time.

    Work programmes were categorised according to locations following the 2013 restructure and so the following annual spend data is available:

    - 2014/15 - $177,089.00
    - 2015/16 - $147,287.00
    - 2016/17 - $158,335.00
    - 2017/18 - $122,806.00
    - 2018/19 - $138,842.00

16. *What is its continuation expected to cost?*

    The total remaining cost is dependent on our ability to increase the scale of marram control in the short term. The more we can achieve in the short term, the less our on-going costs will be, reducing the whole-of-life investment required in the programme (refer to the response to question 14).

    Once eradication has been achieved there will be on-going but much smaller surveillance costs to maintain the conservation gains made.

17. *How much more native forestation will be destroyed before the department becomes concerned?*

    Please refer to our response above on pages 3, 4 and 5 regarding the natural process of sand inundation into adjacent forests. The areas where this is occurring at Mason Bay are unrelated to the marram control operations on site.

18. *What research has been done into how marram eradication has enhanced visitor experience?*

    Kathryn Lyttle completed a Masters of Science Communication on visitor understanding of, and support for, the Dune Restoration Program in 2013. She found that 68% of respondents thought it was a good idea to remove marram grass, 28% had no view, and 4% were against the work. She also found that there is a high level of interest in the dunes; and that the "overwhelming intentions of people seemed to be that they wanted to do what was ecologically best for the dune systems, but they were not always sure what that entailed" (p.68).

    We are confident visitors to the Rakiura National Park would prefer to experience a natural, dynamic dune system, with a diverse New Zealand native biodiversity. Rakiura's dune systems make up a characteristic part of the landscape and so form part of the experience appreciated by visitors to places like Mason Bay.

19. *What research has been done on the percentage of visitors attracted to Mason Bay just to see a transgressional sand dune system?*

    Kathryn Lyttle found that most people visited Mason Bay in the hope of seeing kiwi or as part of completing the North-West and Southern Circuit tracks.

    A Mason Bay public hut visitor survey made similar findings in 2018.

    It is accepted that only a small proportion of visitors will be particularly interested in the geomorphic landscape and dynamic processes of a restored dune system, but we aim to tell the story of successful ecosystem restoration well so that visitors to Mason Bay can incorporate this aspect into their overall experience.

20. *In view of the global urgency about climate change, will the department of Conservation regularly review policies that work against recommendations for the planting of more trees and the protection of coastlines from rising sea levels?*

    The department is committed to regularly reviewing all policies and work programmes to ensure that the most recent data, innovations, knowledge, feedback and context are applied to make the best decisions possible.

Please refer to the introductory context provided on pages 3, 4 and 5 regarding sand inundation of forested areas and pages 5 and 6 regarding rising sea levels and coastal protection with regard to the Mason Bay dune system.

A naturally functioning dune system has an ability to buffer the effects of climate change.

Please note that this letter (with your personal details removed) and enclosed documents will be published on the department's website.

If you wish to discuss this with the department, please contact [redacted]

Yours sincerely,

[redacted]

[redacted]
Director Operations, Southern South Island

Appendix 1. References

Berry, A., 2005. An Evaluation of Spatial Representations for Coastal Vegetation Mapping. Bachelor of Applied Science (Hons) – Environmental Management, University of Otago, 129pp.

Buckley, E.C.B., 2015. Increased Sedimentation and Habitat Change Following Dynamic Dune Restoration, Mason Bay, New Zealand. Unpublished Master of Science Thesis, University of Otago, 107pp.

Buckley, E.C.B., M.J. Hilton, T.M. Konlechner and J.M. Lord, 2016. Downwind sedimentation and habitat development following Ammophila arenaria removal and dune erosion, Mason Bay, New Zealand. Journal of Coastal Research 75, 268-272.

Duncan, M., 2000. The Impact of Marram Grass (Ammophila arenaria) on Indigenous Dune Plant Diversity. Unpublished Master of Science, University of Otago, 140pp.

EFSA (European Food Safety Authority), 2014. Conclusion on the peer review of the pesticide risk assessment of confirmatory data submitted for the active substance haloxyfop-P. EFSA Journal 12(12):3931, 33 pp. doi:10.2903/j.efsa.2014.3931.

ERMA(Environmental Risk Management Authority), 2016. New Zealand Evaluation and Review Report: Application HSR09042. Application for Approval to Import or Manufacture Crest 520 for Release. Environmental Risk Management Authority, Wellington.

Garden, C., 2012. Integrated GPS-GIS for Dune System Monitoring. Bachelor of Applied Science (Hons) – GIS, University of Otago, 80pp.

Geange, S., 2012. The Impact of Post-foredune Sedimentation on Community Composition, Mason Bay, Stewart Island. Bachelor of Science (Hons) Dissertation in Ecology, University of Otago. 70pp.

Hart, A. , 2004. Plant-Geomorphology Interactions in an Active Long-Walled Parabolic Dune System, Stewart Island. Unpublished Master of Science thesis, University of Otago, 164pp.

Hart, A., Hilton, M., Wakes, S.J. and Dickinson, K., The impact of marram grass on foredune morphology and backdune dynamics, Coast to Coast, Australian National Coastal Management Conference 2004, 19-23 April, Hobart, Tasmania, Australia (2004).

Hart, A., Hilton, M.J., Wakes, Dickinson, K., 2012.The impact of Ammophila foredune development on downwind aerodynamics and parabolic dune development, Journal of Coastal Research, 28, 112-122.

Henderson, R. and Hilton, M.J., 1998. State of the environment monitoring of habitat change in the duneland environment. New Zealand Marine Sciences Society and Australian Society for Phycology and Aquatic Botany, Joint Conference, University of Otago, 8-11 July.

Henshaw, N. The Dispersal of Marine Debris in Southland by an Exceptional Storm Event, 18 September, 2003. Bachelor of Applied Science – Environmental Management, University of Otago (2004).

Hesp, P.A. & Hilton M.J. (2013) Restoration of Foredunes and Transgressive Dunefields: Case Studies from New Zealand (2013). In, Martinez, M.L., Gallego-Fernandez, Hesp, P.A., (Eds) Restoration of Coastal Dunes. Springer Series on Environmental Management, pp 67-92. Springer.

Hesp, P.A., Hilton, M.J. and T.M. Konlechner, 2017. Flow and sediment transport dynamics in a slot and cauldron blowout and over a foredune, Masons Bay, Stewart Island (Rakiura), New Zealand. Geomorphology 295, 598-610.

Hilton, M.J., 2001. An Interpretation of Dune Environments of Stewart Island (Rakiura). A report for the Department of Conservation, Southland Conservancy, DOC Research Investigation No. 3289, 45pp.

Hilton, M.J., 2006. The loss of New Zealand's active dunes and the spread of marram grass (Ammophila arenaria). New Zealand Geographer 62, 2, 105-121.

Hilton, M., Earl-Goulet, J. and Macauley, U. (1998) Marram Control Impact Assessment: Doughboy Bay, Stewart Island, Consulting Group, University of Otago (1998) 29pp.

Hilton, M. and Duncan, M. (2000) Marram Grass Control, Doughboy Bay, Stewart Island, Interim Report to the Department of Conservation (Southland), 56pp.

Hilton, M., Woodley, D. and Hart, A. (2002) Effectiveness and Impact of Herbicide Control of Ammophila arenaria (Marram Grass): Doughboy Bay and Mason Bay, Rakiura National Park. Report to the Department of Conservation (Southland), 94pp.

Hilton, M. & Woodley, D. (2003) The Impact of Marram Grass Eradication in the Southern Dunes of Doughboy Bay, Rakiura National Park, Stewart Island. Report to the Department of Conservation (Southland), Department of Geography, University of Otago, 65pp.

Hilton, M. (2005) A Report on the Effectiveness of Marram Grass Eradication, Rakiura National Park, Stewart Island. Report to the Department of Conservation (Southland), Department of Geography, University of Otago, 88pp.

Hilton, M.J., Konlechner, T.M., McLachlan, K., Lim, D. and Lord, J., 2019. Long-lived seed banks of Ammophila arenaria prolong dune restoration programs. Journal of Coastal Conservation, 23, 461-471.

Hilton, M.J., Walters, R., Greig, K. and T.M. Konlechner, 2018. Burial, erosion and transformation of archaeological landscapes: case studies from southern New Zealand (Aotearoa). Progress in Physical Geography: Earth and Environment https://doi.org/10.1177/0309133318795844

Hilton, M.J., W. Nickling, S. Wakes, D. Sherman, T. Konlechner, M. Jermy, & P. Geohegan, 2017. An efficient, self-orienting, vertical-array, sand trap. Aeolian Research 25, 11-21.

Hilton, M.J., Arens, S.M. & Konlechner, T.M. (2014). The efficiency of mechanical (Holland) and chemical (New Zealand) methods of Ammophila arenaria eradication for dune habitat restoration. EUCC workshop and conference – Integrated Coastal Dune Management in Europe, Merlimont, France, 17–19th June 2014.

Hilton, M.J. & Konlechner, T.M., 2013. The Geomorphic Development and Restoration of a Marram Foredune, Mason Bay, Stewart Island, New Zealand. Poster presentation, The 44th Binghamton Geomorphology Symposium Coastal Geomorphology and Restoration, New Jersey Institute of Technology, 18-20th October 2013.

Hilton, M.J. & Konlechner, T., 2011. Incipient foredunes developed from marine-dispersed rhizome of Ammophila arenaria. Journal of Coastal Research 64, 288-292.

Hilton, M.J. and Konlechner, T. M. ,2010. A review of the marram grass eradication program (1999-2009), Stewart Island, New Zealand. In: S.M. Zydenbos (ed.) The New Zealand Plant Protection Society Inc. and The Council of Australasian Weed Societies Inc. - 17th Australasian Weeds Conference, 26-30 September 2010, Christchurch, New Zealand (2010), pp386-389.

Hilton, M.J., D. Woodley, C. Sweeney & Konlechner, T., 2009. The Development of a prograded foredune barrier following Ammophila arenaria eradication, Doughboy Bay, Stewart Island. Journal of Coastal Research 56, 317-321.

Hilton, M.J., Harvey, N. and James, K., 2007. The impact and management of exotic dune grasses near the mouth of the Murray River, South Australia, Australasian Journal of Environmental Management 14, 4 220-230.

Hilton, M.J., Harvey, N., Hart, A., James, K. and Arbuckle, C., 2006. The impact of exotic dune-grasses on foredune development in Australia and New Zealand: A case study of Ammophila arenaria & Thinopyrum junceiforme. Australian Geographer 37, 3, 313-335.

Hilton, M.J., Duncan, M. and Jul, A., 2005. Processes of Ammophila arenaria (Marram Grass) invasion and indigenous species displacement, Stewart Island, New Zealand, Journal of Coastal Research 21, 1, 175-185.

Hilton, M.J., Macauley, U. and Henderson, R. (2000) The New Zealand Active Duneland Inventory, Department of Conservation (Wellington), 152pp. [ISBN 0478219687].

Holdaway R. J., Wiser S. K. and Williams P. A. (2012) Status assessment of New Zealand's naturally uncommon ecosystems. Conservation Biology 26, No. 4 619-629.

Huiskes, A.H.L., 1977. The natural establishment of Ammophila arenaria from seed, Oikos 29: 133–136.

Henderson, R., 1998. An Evaluation of GPS and GIS Technology for Monitoring Duneland Habitat. Master of Planning, University of Otago.

Johnson, P. 1992: The Sand Dune and Beach Vegetation Inventory of New Zealand. II. South Island and Stewart Island, DSIR Land Resources Scientific Report Number 16, DSIR Land Resources: Christchurch, 278 p.

Jul, J., 1998. A Model of Marram (Ammophila arenaria) Invasion, Mason Bay, Stewart Island. Postgraduate Diploma in Wildlife Management, University of Otago. 42pp.

Jul, A., Hilton, M. & Henderson, R., 1999. Patterns and Processes of Marram Invasion, Mason Bay, Stewart Island and Recommendations for Marram Management. Report to the Department of Conservation, Department of Geography, University of Otago, 42p.

Jul, A. and Hilton, M.J., 1998. Patterns and processes of marram invasion, Mason Bay. New Zealand Ecological Society and Ecological Society of Australia, Annual Conference, University of Otago, 24-27 November (poster).

Jul, A. and Hilton, M.J., 1998. Invasion patterns and processes of marram invasion, Mason Bay, Stewart Island. New Zealand Marine Sciences Society and Australian Society for Phycology and Aquatic Botany, Joint Conference, University of Otago, 8-11 July 1998.

Kelly, M., 2012 Marram-forced foredune progradation in southern New Zealand. Master of Science, University of Otago. 160pp.

Konlechner, T. & Hilton, M.J. (2008) An Assessment of the Potential to Eradicate Exotic Grasses from Whenuahou (Codfish Island). Report to the Department of Conservation, Southland Conservancy, 30 March 2008, 42pp.

Konlechner, T.M., Orlovich, M.J. Hilton, 2016. Restrictions in the sprouting ability of an invasive coastal plant, Ammophila arenaria, from fragmented rhizomes", Plant Ecology, 217, 521-532.

Konlechner, T.M., E.C.B. Buckley, M.J. Hilton and S.J. Wakes, 2016. Downwind dune dynamics following Ammophila arenaria invasion. Special Issue: Journal of Coastal Research, 1, 268-272.

Konlechner, T.M., Ryu, W., Hilton, M.J. & D.J. Sherman, 2015. Evolution of foredune texture following dynamic restoration, Doughboy Bay, Stewart Island, New Zealand. Aeolian Research, 19, 203-214.

Konlechner, T.M., Hilton, M.J. and Lord, J., 2015. Plant community response following the removal of the invasive Lupinus arboreus in a coastal dune system. Restoration Ecology, 23, 607-614.

Konlechner T.M., Hilton M.J., and Arens S.M.,2014. Transgressive dune development following deliberate de-vegetation for dune restoration in The Netherlands and New Zealand. Dynamiques environnementales. EUCC workshop and conference – Integrated Coastal Dune Management in Europe, Merlimont, France, 17–19th June 2014. ISBN: 978-2-86781-819-6.

Konlechner, T., Hilton, M.J. and Orlovich, D., 2013. Accommodation space limits plant invasion: Ammophila arenaria survival on New Zealand beaches, Journal of Coastal Conservation, 17, 463-472.

Konlechner, T. M. & Hilton, M.J., 2010. Ammophila arenaria (marram grass) persistence through seedling recruitment. Proceedings, The New Zealand Plant Protection Society Inc. and The Council of Australasian Weed Societies Inc. - 17th Australasian Weeds Conference, 26-30 September 2010, Christchurch, New Zealand pp390-393.

Konlechner, T.M. & Hilton, M.J., 2009. The potential for marine dispersal of Ammophila arenaria (marram grass) rhizome. Journal of Coastal Research, SI 56, 434-437.

Konlechner, T.M., 2008. The management challenge posed by marine dispersal of terrestrial plants in coastal dune systems, New Zealand Geographer 64: 154–156.
Lim, D., 2010. The importance of seed in the invasion of active dune systems by marram grass (Ammophila arenaia). Unpublished Master of Applied Science, University of Otago, 191pp.

Lyttle, K., 2014. The perception of dune restoration programmes. Unpublished Master of Science Communication thesis, University of Otago, 169pp.

Main, M., 2008. A Strategy for Marram Grass Eradication, Mason Bay, Stewart Island. Bachelor of Applied Science (Hons) – Environmental Management, University of Otago, 90pp.

MacLachlan, K., 2014. Temporal and spatial dynamics of the seed bank of Ammophila arenaria (marram grass). Unpublished Master of Science thesis, University of Otago, 179pp.

Ministry of Environment & Department of Conservation (2007) Protecting our places - Introducing the national priorities for protecting rare and threatened native biodiversity on private land. Ministry for the Environment, Wellington.

Moloney, J.G., 2017. Digital surface models and feature mapping from low cost UAV photography. Unpublished Master of Science thesis, University of Otago, 166pp.

Moloney, J.G.; Hilton, M.J.; Sirguey, P., & Simons-Smith, T., 2018. Coastal dune surveying using a low-cost remotely piloted aerial system (RPAS). Journal of Coastal Research, 34, 1244-1255.

Owens, S.J., Timmins, S.M. & West, C.J. (1996) Scoring the weediness of New Zealand's ecological weeds. In, Ed. Shepherd, R.C.H., Proceedings of the 11th Australian Weeds Conference, Melbourne, Australia, 30 September – 3 October 1996, pp.529 – 537, Weed Science Society of Victoria Inc.

Owens, S.J., 1997. Ecological Weeds on Conservation Land in New Zealand: a database – January 1997. Department of Conservation, Wellington, New Zealand, 67p.

Partridge, T. 1992: The Sand Dune and Beach Vegetation Inventory of New Zealand. I. North Island, DSIR Land Resources Scientific Report Number 15, DSIR Land Resources: Christchurch, 253 p.

Pattanapol, W., Wakes, S. J., Hilton M. J. and Dickinson, K. J. M., 2007. Modelling of surface roughness for flow over a complex vegetated surface, International

Conference on Applied Science, Engineering and Technology, Bangkok, Thailand, 14-16 December, 2007, pp 273-281.

Pattanapol, W., Wakes, S.J. & Hilton, M.J., 2011. Using computational fluid dynamics to determine suitable foredune morphologies in New Zealand. Journal of Coastal Research SI 64, 298-303.

Pattanapol, W., S. J. Wakes, Hilton, M.J. and Dickinson, K. J., 2008. Modelling of surface roughness for flow over a complex vegetated surface. International Journal of Mathematical, Physical and Engineering Sciences 2, 18-26.

Peddie, L., 2004. Strandline Conditions Favouring Marram Grass (Ammophila arenaria) Establishment from Sea-rafted Rhizome. Bachelor of Applied Science – Environmental Management, University of Otago.

Petersen, P.S., Hilton, M.J. & Wakes, S.J., 2011. Evidence of aeolian sediment transport across an Ammophila arenaria-dominated foredune, Mason Bay, Stewart Island. New Zealand Geographer, 67, 174–189.

Pope, P., 2005. The comparative seed ecology of Desmoschoenus spiralis (A.Rich.) Hook.f. and Ammophila arenaria (L.) Link. Unpublished MSc Thesis, Department of Botany, University of Otago. 156pp.

Pope, P., 2004. A Comparison of the Seed Ecology of Desmoschoenus spiralis and Ammophila arenaria. Unpublished Master of Science thesis, University of Otago, 156pp.

Pope, P., 2006. The comparative seed ecology of marram grass (Ammophila arenaria) and pingao (Desmoschoenus spiralis), New Zealand Garden Journal 9(1): 2–5.

Rathe, A. 2008. Turning Back the Tide: Reversing the Effect of Exotic Species Invasion on New Zealand's Active Dunes. Bachelor of Applied Science (Hons) – Environmental Management, University of Otago, 107pp.

Robinson, K., 2010. The Long Distance Dispersal of Yellow Tree Lupin (Lupinus arboreus) by Deer in Mason Bay, Stewart Island. Unpublished thesis for the degree of Postgraduate Diploma of Science in Ecology, University of Otago, 36pp.

Sibbmark, T., 2000. A Processed-based Classification of a Duneland Ecosystem, Mason Bay, Stewart Island. Unpublished Master of Science thesis, Uppsala University, Sweden. 26pp.

Sweeney, C.A. (2007) Environmental Change Following Ammophila arenaria Invasion and Eradication, Doughboy Bay, Stewart Island (Rakiura). Unpublished Bachelor of Applied Science Dissertation, University of Otago, 110pp.

Tayles, Q. & Thomson, D., 2002. Mason Bay Control Survey Report. Report to the School of Geography to provide survey control for the monitoring of parabolic dune 6. School of Surveying, 16pp.

Van der Putten, W.H. 1990. Establishment of Ammophila arenaria (marram grass) from culms, seeds and rhizomes. Journal of Applied Ecology 27: 188-199.

Wakes, S.J., M.J. Hilton and T.M. Konlechner, 2016. Topographic steering of oblique incident winds across a foredune-parabolic topography, Mason Bay, Stewart Island, New Zealand. Special Issue, Journal of Coastal Research, 1, 343-347.

Wakes, S.J., Maegli, T., Dickinson, K.J. & Hilton, M.J., 2010. Numerical modeling of wind flow over a complex topography. Environmental Modelling & Software, 25, 237-247.

Wakes, S.J., Hilton, M.J., Dickinson, K. & Maegli T., 2005. Using Computational Fluid Dynamics to investigate the effect of a Marram covered foredune; initial results. Proceedings, Coastal Engineering 2005 - Seventh International Conference on Modelling, Measurements, Engineering and Management of Seas and Coastal Regions, Algarve, Portugal, 13 - 15 April 2005.

Wakes S. J., Maegli T., Dickinson, K. J. M. & Hilton, M.J., Three-dimensional flow simulation over a complex dune system, Coastal Engineering, UK 19-21 May, 2008 p 221 (2008).

Weggery, J., 2005. Life at the Limit: Euphorbia glauca at Mason Bay, Stewart Island: A Bachelor of Applied Science dissertation in Environmental Management, University of Otago, Dunedin, New Zealand 95pp.

Williams P. A., Wiser S., Clarkson B. and Stanley M. C. (2007) New Zealand's historically rare terrestrial ecosystems set in a physical and physiognomic framework. New Zealand Journal of Ecology 31: 119-129.

Woodley, D., 2003. Secondary Dune Development and Vegetation Change Following Marram Grass Eradication, Doughboy Bay, Stewart Island. Unpublished Master of Science thesis, University of Otago, 95pp.

Woodley, D. and Hilton, M.J., A model of Ammophila arenaria necrosis, decay and sedimentation following herbicide application. Proceedings, Coasts & Ports Conference, Auckland, November (2003).