TAHAKOPA BAY, OTAGO

RECOMMENDATIONS FOR MARRAM CONTROL

A Report to the
Department of Conservation (Otago Conservancy)

by

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Dedication

This report is dedicated to Mr Bill Chinn
recently of the Department of Conservation
Stewart Island

Bill died in tragic circumstances in July 1999

Contents

EXECUTIVE SUMMARY

1. Tahakopa Bay contains dune plant communities of national significance. The coastal dunes contain the largest remaining area of pingao on the east coast of the South Island between Bank's Peninsula (Kaitorete Spit) and Fortrose Spit (Southland). A representative collection of dune plant species are also present. These occur in a series of stabilised blowouts that are at least 52 years old.

2. The coastal dunes of Tahakopa Bay are dominated by marram grass which occupies approximately 80 per cent of the coastal dunes. Pingao and most other dune plant species will be lost if marram is not eradicated. The Department of Conservation (Otago Conservancy) intends to eradicate marram from Tahakopa Bay with work commencing in late 1999.

3. The coastal dunes comprise an area of about 10 hectares. Marram occupies approximately 80 per cent of this area (79,335 m^2). In comparison the area of pingao totals 139 m^2. Pingao occurs in 12 of the 32 coastal segments surveyed. Six sites, blowouts 4, 8, 23 and 25-27 contain 92 per cent of the pingao present. The largest area of pingao covers approximately 34 m^2.

4. The efficiency and effectiveness of three methods of applying herbicide to marram are discussed. We recommend the Department employ vehicle-mounted spray pumps. Though relatively expensive in the first instance the use of pumps will be cost effective over the course of the eradication programme compared with knapsacks. We estimate it will take approximately 4-7 years to eradicate marram using knapsacks and 2-3 years using motorised pumps. Ongoing eradication to prevent reinfestation will be necessary regardless of the method employed in the initial programme.

5. A long-term monitoring programme should be initiated prior to marram eradication to determine (1) the effectiveness of the spray method(s) employed; (2) the impact of marram eradication on dune stability; and (3) the rate of recovery of pingao and other dune plant species.

1.0 INTRODUCTION

The Department of Conservation (Otago Conservancy) plan to undertake Marram grass (*Ammophila arenaria*) control at Tahakopa Bay (Figure 1). The Department of Geography, University of Otago, have (since 1996) researched aspects of the ecology and geomorphology of the dunes bordering Tahakopa Beach. The following report was unsolicited. It was written to assist the Department eradicate marram grass at Tahakopa and so safeguard and restore the very important native dune flora of this beach.

Our work over the last three years has focused on aspects of the ecology of pingao (*Desmoschoenus spiralis*), the invasion ecology of marram and geomorphology of the dunes of southern New Zealand. We are interested in several questions including why pingao survives at Tahakopa and not adjacent beaches (e.g. Tautuku). This work has entailed two inventories of pingao (September 1996 and May 1999), a general survey of dune flora (May 1999) and ongoing study of the geomorphology and ecology of the Tahakopa coast.

2.0 COASTAL ENVIRONMENT

The coastal dunes of Tahakopa Beach are dominated by the exotic sand binder marram grass with a range of native species scattered along the dunes including pingao and other exotic species. These dunes are the result of the most recent phase of a prolonged period of coastal development within an exposed sandy embayment. The Tahakopa sand barrier comprises a sequence of dune ridges covered in medium to dense podocarp forest (Allen, 1978). These ridges extend between 1 and 2 km inland. Their age has not been determined, however, the landward margins of similar features in New Zealand date from the last marine transgression, approximately 6,000 years ago.

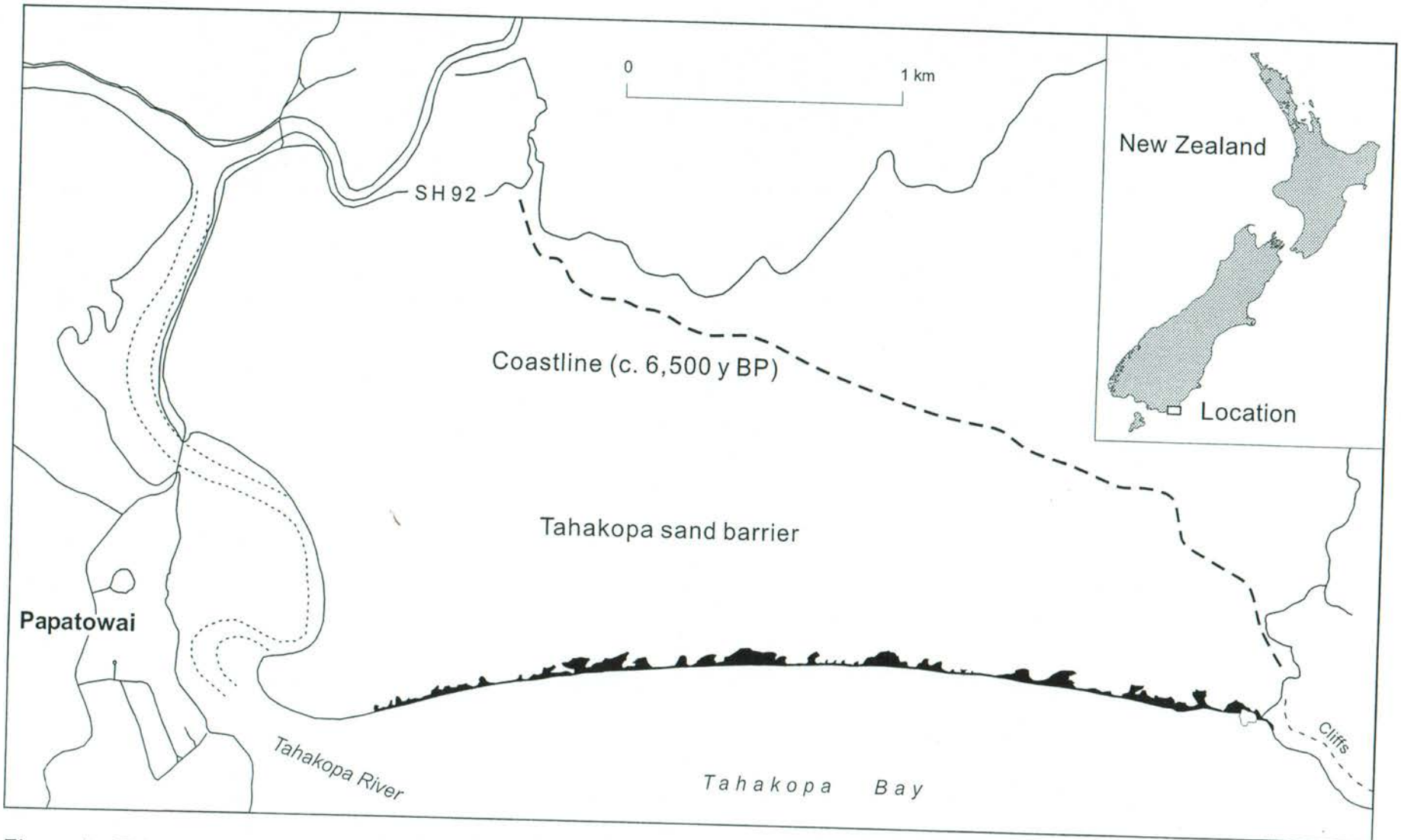


Figure 1. Tahakopa sand barrier and coastal dunes (shown in black)

The Tahakopa barrier is a progradational landform - it has built seawards during the current inter-glacial sea-level stillstand in episodes related to variations in marine climate and sediment supply. However, over at least the last 5 years or so the margins of the dunes have been eroded by wave action. Foredune forms occur near the Tahakopa River but since we first observed the Tahakopa coast in 1996 the dunes have culminated in a beach scarp - an erosional feature. Whether the current phase of erosion is a short term reversal of coastal development and progradation will resume, or an adjustment to a major change in environmental conditions is unknown. Progradation may have ceased due to a decline in sediment supply. The effects of people on the dune flora may also be important (e.g. the introduction of rabbits and marram).

The coastal dunes of Tahakopa Bay (those unconsolidated, semi-vegetated, dunes adjacent to the sea) have an unusual geomorphology. These dunes extend inland approximately 80 m from the shoreline but are discontinuous alongshore. In plan view they appear as a series of parabolic-shaped features separated by narrow strips of marram-covered dune, shrubs or podocarp forest (Figure 2). They probably represent blow-out like dune forms produced as a result of some disturbance or combination of disturbances. They appear to be of uniform age and orientation and probably formed in historic times (they are present in aerial photographs taken in April 1948). Some contain dead totara of considerable size. These trees show the effects of wind shear and were probably growing close to the pre-disturbance coastline. Their death may have coincided with the event or events that triggered destabilisation of the foredune and formation of the blowouts. The event might have been a southerly storm of unusual ferocity.

Strictly speaking these features are not blowouts, though hereafter we refer to these landforms as "stabilised blowouts". Their morphology contains elements of a number of dunes forms. They are not parabolic dunes or transverse dunes, though they are generally parabolic in shape and have relatively gentle seaward (stoss face) surfaces and a steep landward (slip) face.

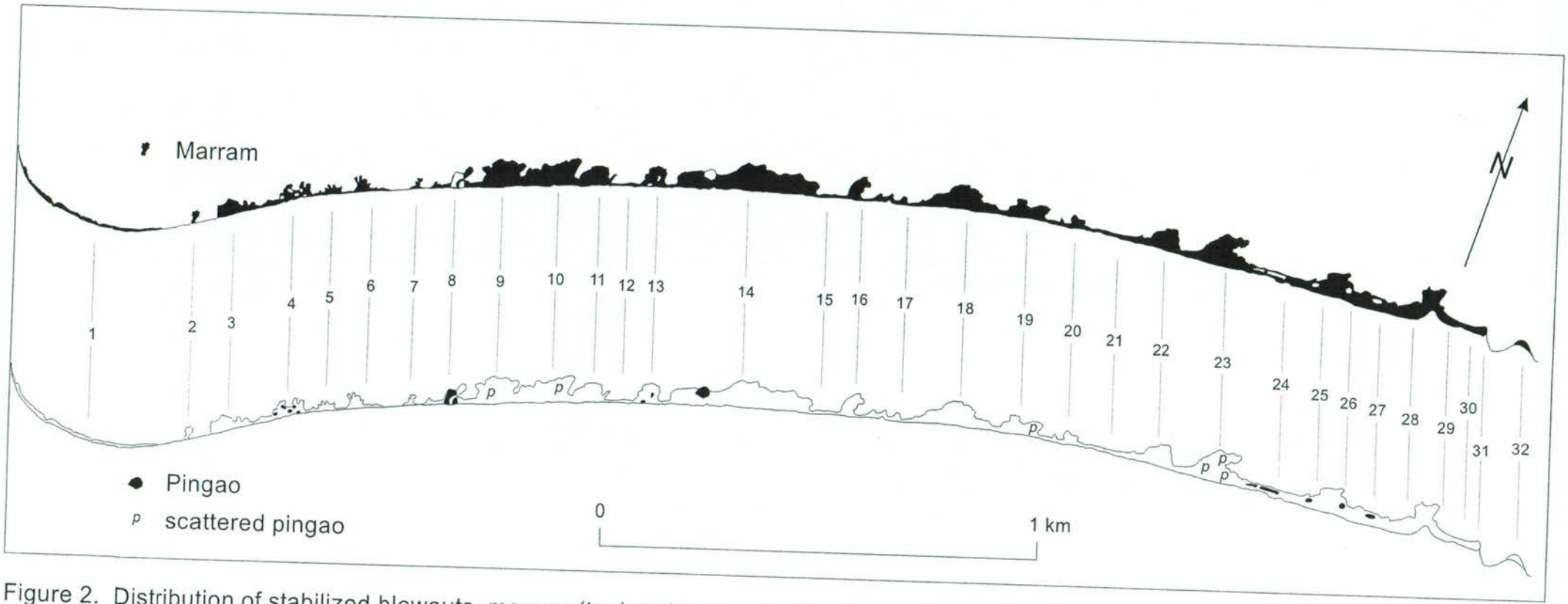


Figure 2. Distribution of stabilized blowouts, marram (top) and pingao (bottom) at Tahakopa Beach.

We include this brief discussion of the geomorphology of the Tahakopa dunes because of our interest in explaining the presence of pingao or, rather, explaining why pingao is present in Tahakopa Bay but absent from neighbouring Catlin's beaches. Tautuku has very little pingao in comparison, though it is a similar late-Holocene sand barrier. Discussion of this topic is beyond the scope of the present report. It is sufficient to note here that the development of these features appears to have provided habitat for pingao. Furthermore, erosion of the former foredune or coastal margin and deposition of fresh sand further inland may have provided a catalyst for pingao growth.

3.0 CONSERVATION VALUES

The botanical values of the coastal dunes of Tahakopa Bay are exceptionally high. The Sand Dune and Beach Vegetation Inventory of New Zealand identified Tahakopa as one of the South Island's top 30 dunelands (Johnson, 1992). Tahakopa is the only beach in Otago to have relatively large areas of pingao. Indeed, it is the only beach between Kaitorete Spit and Fortrose Spit, a length of coast of about 450 km, to contain substantial areas of pingao, although with the help of agencies and local communities some pingao communities are being successfully established and enhanced on several beaches around Dunedin. Only one other site north of Tahakopa on the east coast of the South Island is considered of national importance (Kaitorete Spit). The area of pingao at Tahakopa is relatively small compared to, say, the high-ranking Stewart Island beaches, however, the almost complete loss of pingao and other native species along the east coast of the South Island means Tahakopa is of very high conservation value.

Pingao may be considered a keystone species. Where pingao is lost (as a result of competition with marram for example), a range of other native plant and invertebrate species are usually also lost or present in small numbers,, for example, the native sand daphne (*Pimelea lyallii*). Other native plants (e.g.

Acaena novae-zelandiae) persist under a sparse marram cover, depending on local circumstances, but their long-term survival may be threatened.

4.0 MARRAM DISTRIBUTION AND DENSITY

Marram grass is the primary sand binding species in the Tahakopa Bay dunes. It covers about 80 per cent of the surface area of the blowouts (Figure 2).

Where marram grass is present it is generally very dense (Figure 3). We recognise four density classes 1-25%, 26-50%, 51-75% and 76-100%. The lower densities are associated with areas of pingao (e.g. blowout 8); a cluster of small blowouts (4-8) near the Tahakopa River; and the seaward margins of some blowouts (e.g. 10, 11, 14, 23). The reason for the first is self evident. The relatively low density of marram in blowouts 4-8 may be related to the geomorphology of the blowouts along this length of coast. These blowouts are located along the southern third of the beach which is relatively sheltered. There may be less sand movement and, therefore, less opportunity for marram invasion. Finally, the low density of marram along the seaward margins of several blowouts is probably related to the current phase of erosion.

5.0 PINGAO DISTRIBUTION AND DENSITY

Pingao is present in 12 of the 32 coastal segments surveyed. We estimate a total area of 139 m^2 remains. This represents close to 0.001 per cent of the total area of the blowouts. It is not evenly distributed alongshore. Six sites, blowouts 4, 8, 23, and 25-27, account for about 92 per cent of the total area of pingao. The areas range from 0.25 m^2 to 34.5 m^2 (Table 1). Significant stretches of coast have no pingao.

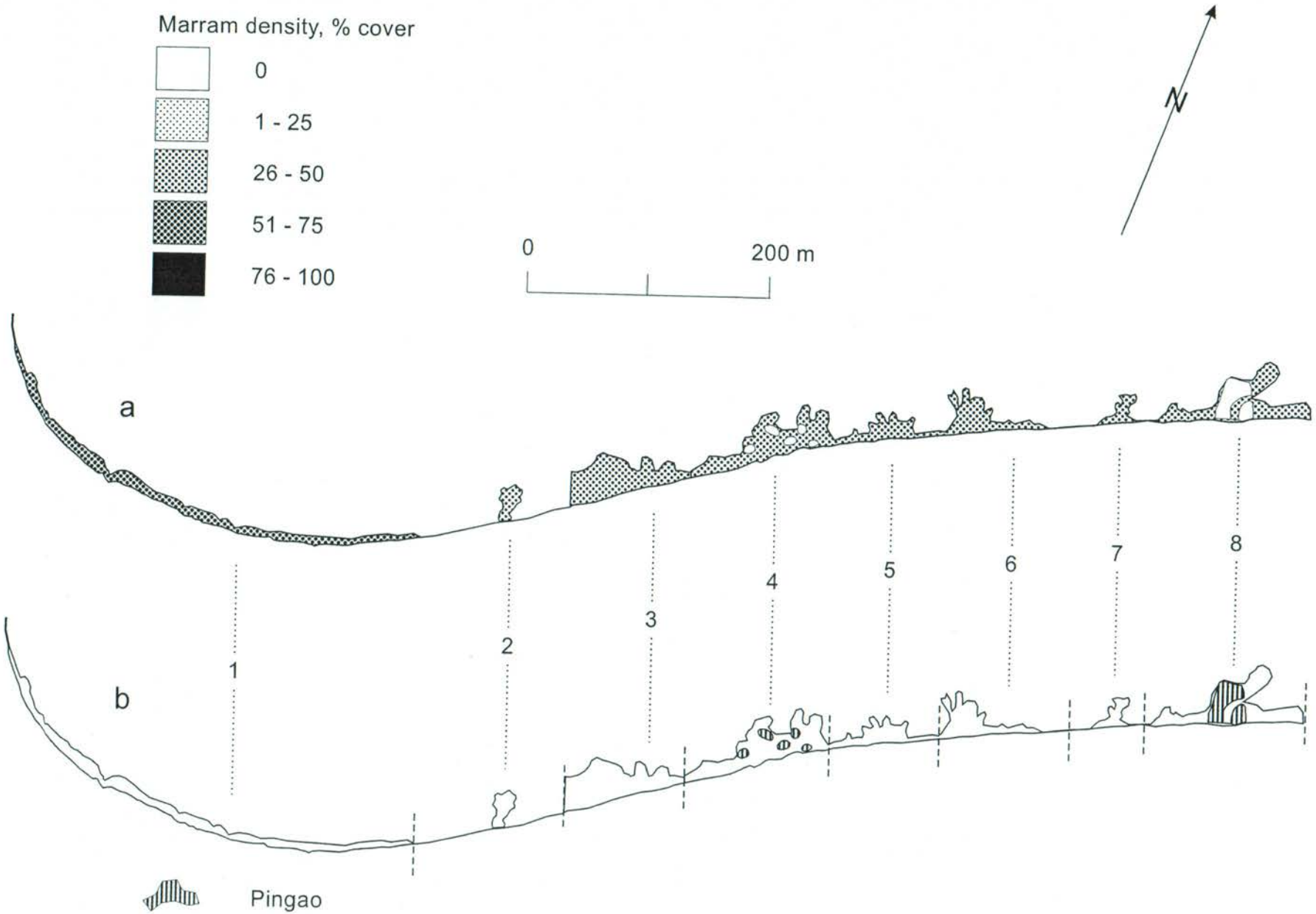
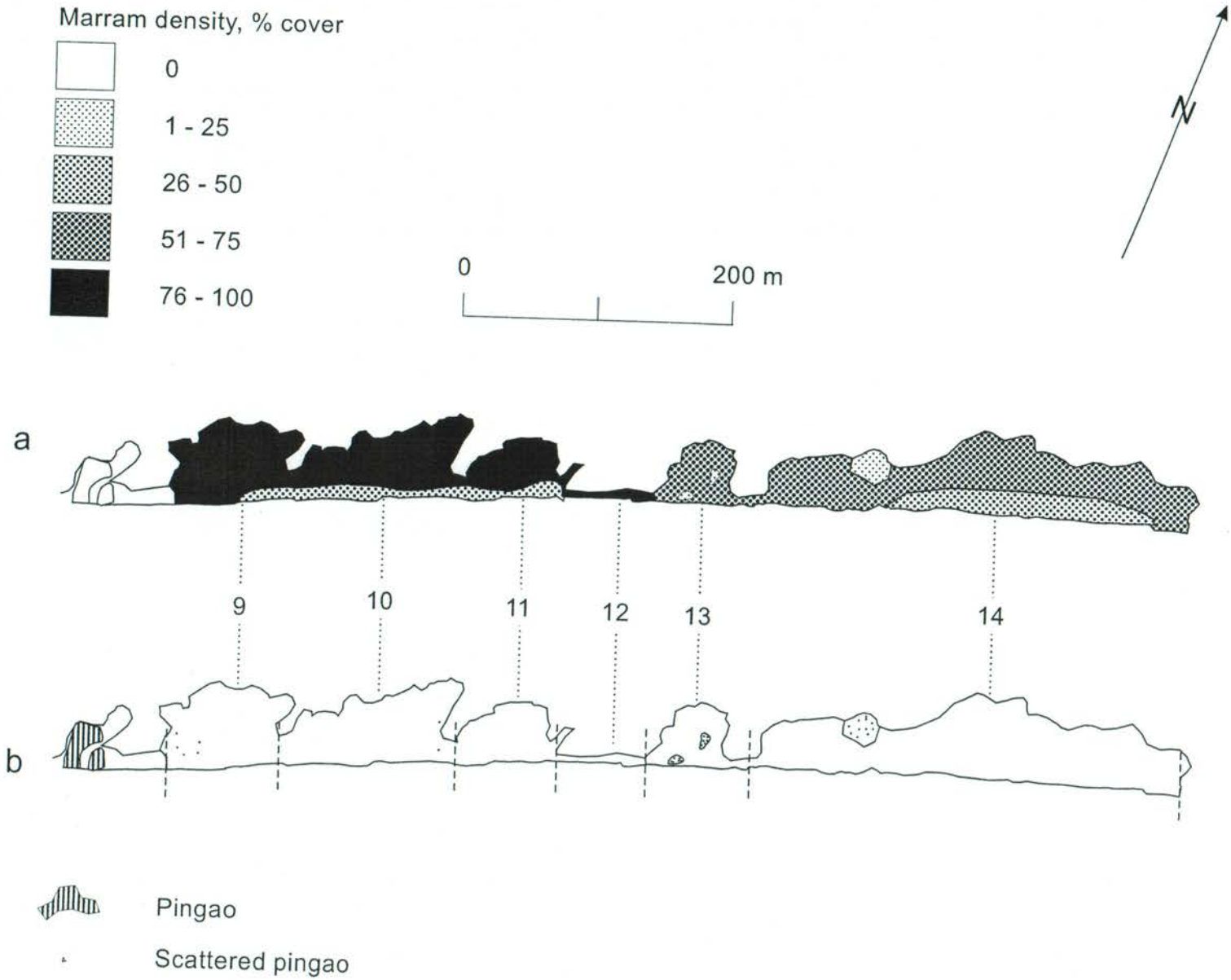


Figure 3. Location and density of marram (a) and location of pingao (b), Tahakopa Bay



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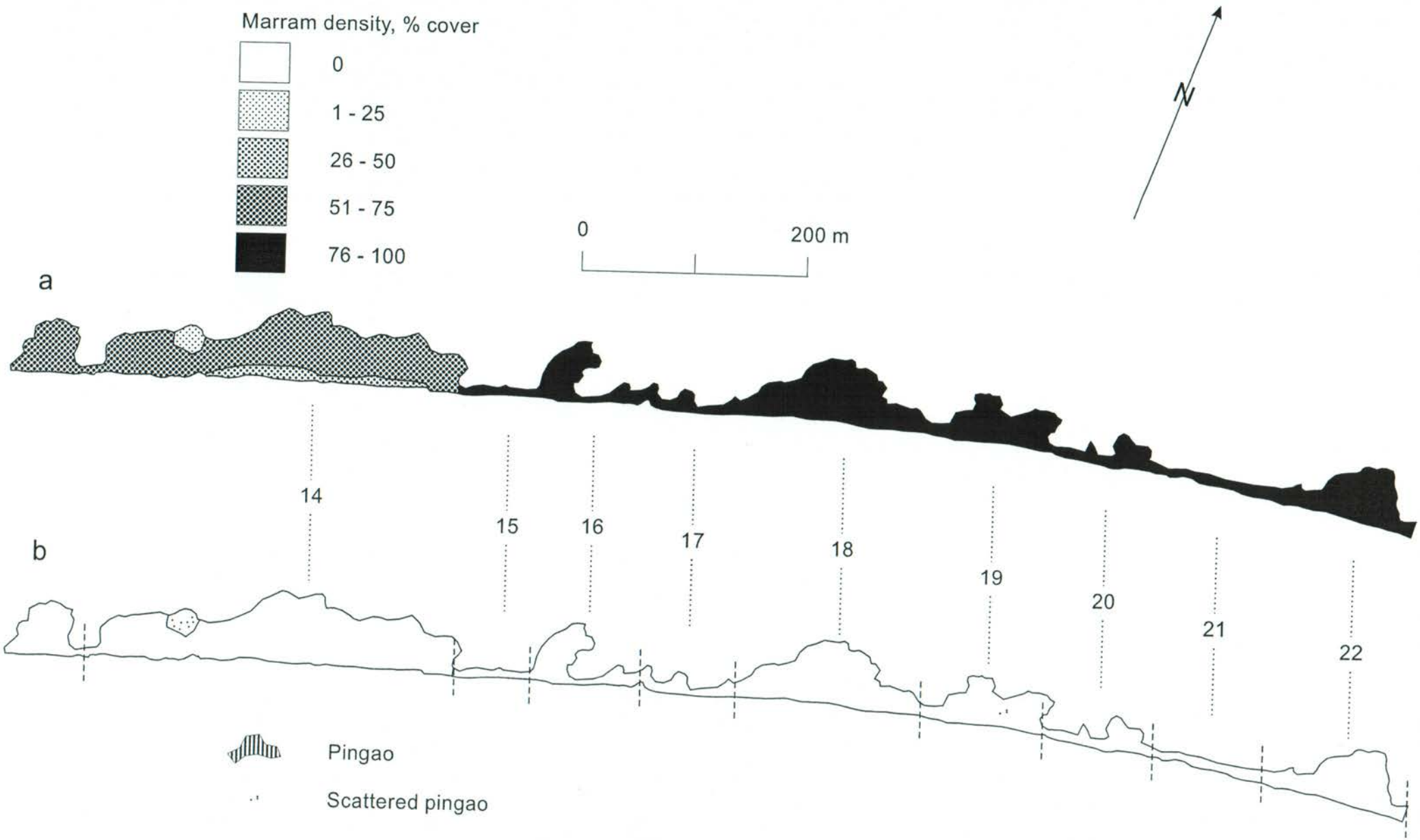

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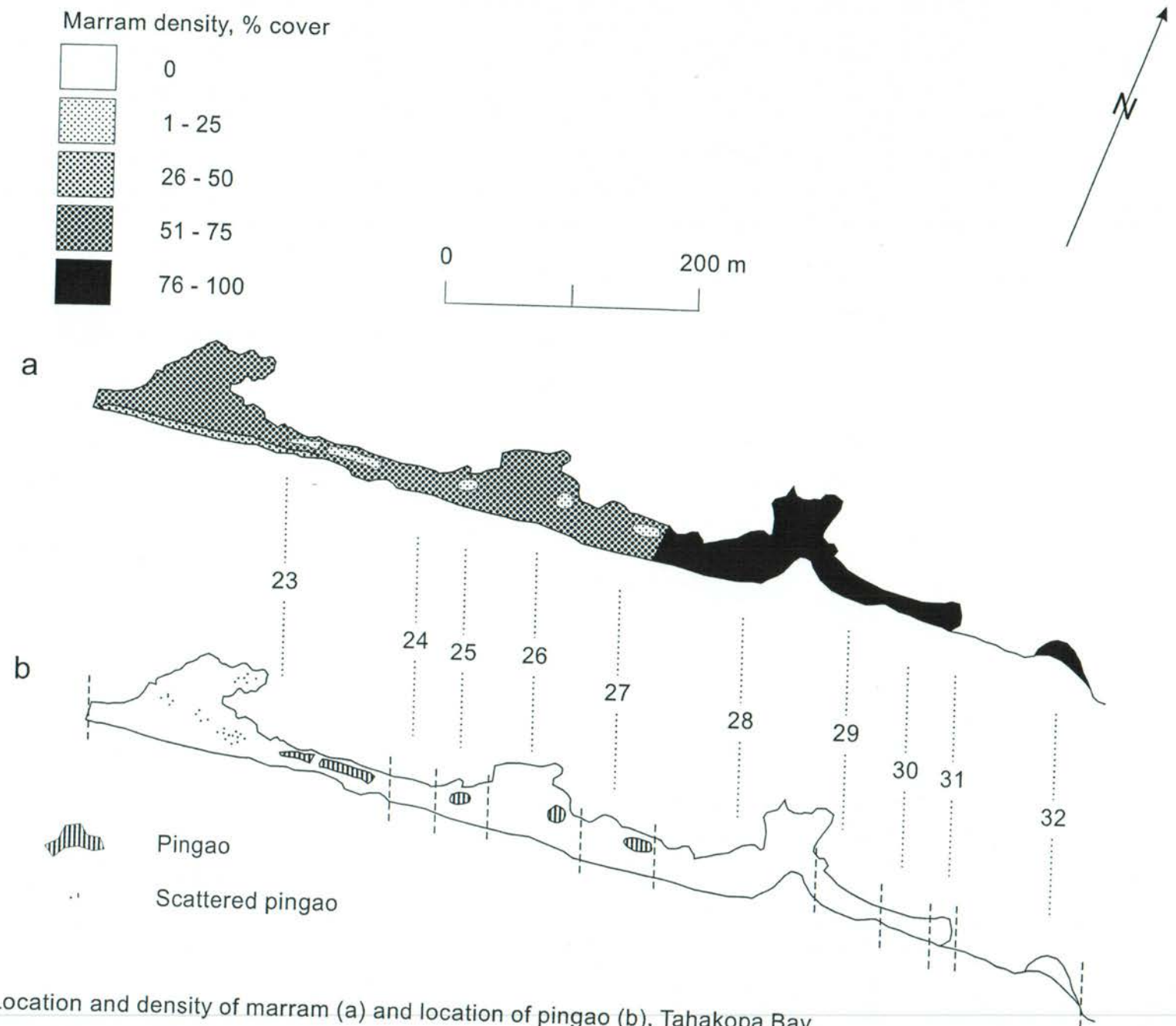

Figure 3. Location and density of marram (a) and location of pingao (b), Tahakopa Bay

Pingao is found in a range of geomorphic settings within the blowouts, from the seaward margins of the blowouts to relatively sheltered sites along the landward margins of the coastal dunes. Most plants appear healthy but many are unthrifty or moribund. Many of the larger areas of pingao (e.g. blowout 8) are associated with a range of species more commonly found on relatively stable dune surfaces (listed in Appendix 1).

Table 1: Total Area of Marram and Pingao at Each Site, Tahakopa Bay

		Marram		Pingao	
SITE	AREA (m^2)	% Coverage	Area (m^2)	% Coverage	Area (m^2)
1	3432	80	2745.6	0	0
2	562	30	168.6	0	0
3	3187	60	1912.2	0	0
4	2375	30	712.5	0.5	12
5	1875	50	937.5	0	0
6	1315	40	526	0	0
7	2062	35	721.7	0	0
8	2375	30	712.5	1.05	25
9	5437	95	5165.15	0.028	1.5
10	6000	95	5700	0.008	0.5
11	3250	70	2275	0.03	1
12	625	75	468.75	0	0
13	2562	80	2049.6	0.14	3.6
14	15562	90	14005.8	0.03	4.8
15	250	90	225	0	0
16	1687	95	1602.65	0	0
17	1562	90	1405.8	0	0
18	7812	95	7421.4	0	0
19	2937	95	2790.15	0.009	0.25
20	500	90	450	0	0
21	1125	85	956.25	0	0
22	6813	90	6131.7	0	0
23	6500	75	4875	0.37	24
24	4687	75	3515.25	0	0
25	1625	70	1137.5	2.12	34.5
26	4067	70	2846.9	0.5	20
27	2187	70	1530.9	0.55	12
28	5063	85	4303.55	0	0
29	687	80	549.6	0	0
30	562	80	449.6	0	0
31	250	80	200	0	0
32	937	90	843.3	0	0
TOTALS	**99870**		**79335**		**139**

Why has pingao survived along the Tahakopa Bay coast but been lost from nearby Waipati and Tautuku Beaches? We speculate the survival of pingao at Tahakopa is related to the distinctive geomorphology of the Tahakopa Bay coastal dunes. The blowouts described above may have been colonised by pingao following their formation then subsequently invaded by marram grass. Pingao can persist for a time (but probably not reproduce and colonise new habitat) in situations where sediment accumulation is low.

The current area of pingao may seem very small in comparison with the area of marram, but our experience of marram control on Stewart Island is that pingao re-establishes very quickly. Pingao growth was observed to be vigorous at most sites sprayed with herbicide to eliminate marram grass even where the pre-spray density of pingao was low. It may be that Pingao seed remains viable for some time; concealed pingao plants are released following spraying; or seed is transported long distances by wind from surviving plants. Whatever the reason, pingao is likely to recolonise the Tahakopa blowouts relatively rapidly following marram eradication. New pingao plants are as likely to establish in areas remote from existing pingao as close to these plants.

6.0 CHANGE IN AREA OF PINGAO

Pingao was probably very much more common along the Tahakopa coast in the past that it is today. Marram invasion studies at Mason Bay have shown pingao can be displaced over a matter of decades in situations of dune mobility. It would be valuable to learn how extensive pingao was at Tahakopa and how long the remaining areas of pingao are likely to persist.

The presence of pingao along the Tahakopa coast has been noted in several reports. Unfortunately these do not record the area or precise location of pingao. Allen (1978, p.153) notes that marram "dominates the seaward dunes

with occasional patches of pingao". Ward and Munro (1989, p.287) repeat this description. They concluded marram grass was a threat to the native dune communities "especially that dominated by pingao, even in the short term" and recommended a programme of marram eradication by spraying "be initiated immediately".

The Coastal Resource Inventory (1990) notes that Tahakopa contains the largest remaining area of pingao in the Catlins.

We first surveyed pingao along Tahakopa Beach in September 1996. The location of pingao was recorded and each area of pingao described but no attempt was made to derive area estimates. The 1996 results are similar to the findings reported here, however, two pingao sites were noted in 1996 but not 1999 (near the boundary of blowouts 14 and 15; and near the centre of blowout 10). In 1996 we recorded 40 or so moribund plants in blowout 10 and a few plants in blowouts 14 and 15. A number of plants in blowouts 4, 8 and 12 may have been lost as a result of ongoing wave erosion of the dune face since a visit to the beach in September 1998. The midden present in blowout 3 (or thereabouts) was destroyed sometime during 1998 by erosion so the coast must have retreated 3-5 m along this stretch of Tahakopa Beach.

Rabbit droppings, burrows and scratchings were widespread in 1996 but rabbit sign was less evident in 1999. Nibbled grasses and other sign were particularly common in blowouts 26-32 in 1999. Cattle sign was also noted at the eastern end of the beach.

There is, therefore, insufficient data to determine whether the area of pingao has declined along the Tahakopa coast in recent years or since marram was introduced (or arrived naturally). Some blowouts contain decomposing pingao root material but these remnants are not widespread. We can say that there appears to be very little if any colonisation of the blowouts by pingao and some of the larger areas of pingao are in relatively stable habitats where it is likely to

be overgrown by native shrubs (e.g. blowout 8). Colonisation of the blowouts by pingao should follow eradication of marram and concomitant destabilisation of the dune surface.

7.0 MARRAM ERADICATION METHODS

Marram is effectively killed using Gallant NF (New Formula) delivered by (1) knapsack (hand pump); (2) a motorised pump mounted on either a truck, tractor or ARGO (8-wheel, amphibious craft); or (3) helicopter. In this section we consider the effectiveness (capability) and the efficiency (cost-effectiveness) of these methods in relation to the marram problem at Tahakopa Bay.

Our understanding of the merits and limitations of the above methods is largely based on the experience of staff in DoC's Southland Conservancy, supplemented by our own observations of marram control operations on Stewart Island and at Fortrose Spit. Marram-control in Southland commenced in the late 1980s and DoC Southland now routinely spray marram using knapsacks and vehicle-mounted pumps. A helicopter was employed to spray marram for the first time in 1999.

The dilution of Gallant NF for marram is usually 15 ml/l for all techniques, although lower rates (10 ml/l) have been used with success. Two additives are usually employed: "Uptake" and a blue marker dye (Kiwi brand). Red dye should be avoided. It is not necessary to use fresh water for diluting Gallant NF, however, it is necessary to operate a settling tank if seawater is to be extracted from an open beach to avoid sand contamination. Supplying water and mixing chemicals is likely to keep one member of a spray team fully occupied.

There are significant differences in both the effectiveness and efficiency of the above methods of applying Gallant under the same environmental conditions.

The following analysis assumes the following conditions:- calm weather; experienced personnel; and one person mixing chemical, supplying water and attending to breakages and other problems.

Knapsack method:

The knapsack method is relatively slow, labour intensive and entails more work in subsequent years. One person should be able to spray approximately 2,200 m^2 of marram in a day (6 hours spraying/day) using a 15 litre knapsack. Thus, it would take about 36 person-days to spray the marram grass at Tahakopa Bay (excluding support personnel) in ideal conditions. The same area of marram could be sprayed in 26 person days if each person sprayed for 8 hours/day.

Ground-based mechanised methods:

The time required to spray the marram grass along Tahakopa Bay dunes would be significantly reduced were DoC to employ a mechanised spray pump mounted on either a tractor, truck or ARGO. These options would allow the use of one or two 100 m high-pressure hoses. The blowouts reach inland as much as 80 m from the base of the scarp (the line of mean high water spring tides), so almost all marram could be sprayed from a vehicle running along the toe of the foredune. DoC Southland have sprayed approximately 3 ha of marram in two days using the ARGO with one spray gun. It would, therefore, take a little over 5 days to spray the Tahakopa Bay dunes using the ARGO. The same area could be sprayed in half the time using a larger pump mounted on a tractor or truck equipped with two, 100 m, hoses. These estimates do not include time for preparation or cleanup or down time due to poor weather. The ARGO tank holds 250 litres. A typical truck-mounted tank holds 600 litres. A Tapanui firm charges $50/hour for an ARGO plus operator. The cost of a truck-mounted pump and operator is likely to be similar.

Helicopter application:

DoC Southland used a helicopter to spray approximately 7 ha of dense marram at Doughboy Bay in February 1999. The operation lasted about 6 hours. Examination of the site in June 1999 indicated the operation was very effective, although another examination during the 1999/00 growing season will be necessary to confirm the kill rate. Helicopter operations clearly entail low labour but high operating costs. The Doughboy helicopter operation cost around $2,500/ha (excluding DoC labour). A helicopter operation at Tahakopa would probably cost a similar amount.

Comparison of methods:

We have not undertaken a comprehensive costing of the above methods but will make some simple comparisons. The knapsack method is labour intensive, but otherwise involves the lowest initial cost. This is offset by the relative ineffectiveness of this method and the costs incurred in years 3-7. The knapsack method is susceptible to poor weather, strong onshore winds in particular. In contrast, the pump options permit spraying to occur in a wider range of weather conditions. Spray drift is less of a concern with Gallant, although care should be taken not to spray *Poa cita* (Silver tussock).

The effectiveness of the knapsack technique is likely to be significantly less than the other methods because of the difficulty of spraying the entire plant. In effect each plant must be sprayed twice. Kill rates with inexperienced operators can be as low as 50 per cent. Whatever method is employed it will be necessary to spray remaining marram in the years following the first operation. The eradication process might take 4-7 years if a low initial kill is achieved using knapsacks and 2-3 years if a pump option is employed (pump in year 1 followed by knapsacks in years 2 and 3).

In conclusion, the most efficient and effective means of controlling marram along Tahakopa Bay is to use a pump mounted on a 4-wheel drive vehicle.

Complete eradication will take between three and seven years, depending on the method used. Ongoing marram grass control, perhaps involving 1-2 person/days every year or so, will be necessary to destroy re-infestations.

8.0 MARRAM ERADICATION STRATEGY

Eradication of marram in Tahakopa Bay will provide new habitat for pingao and release existing areas of pingao from competition. If knapsacks have to be used for reasons of economy it may be prudent to focus, in the first instance, on those blowouts that currently contain pingao (Numbers 4, 8, 9, 10, 11, 13, 14, 19, 23, 25, 26, 27 in Figure 3), least the weather or insufficient resources prevent DoC from spraying the entire area in year one. That said, our experience of Stewart Island beaches suggests it will be difficult to predict the location of pingao recolonisation. We suspect pingao seed remains viable for some time and/or is distributed widely from existing plants.

Some dune instability will follow marram eradication though there is little prospect of large-scale dune development and sand transgression. Marram remains as a dead straw for 2-3 years following spraying, depending on weather conditions. This straw appears to protect the underlying sands from wind erosion while native species reestablish. That said, the geomorphic response of the dunes to marram eradication cannot be predicted with total confidence. Dunes associated with pingao and other native species are naturally dynamic landforms. The change from marram to pingao should result in increased sedimentation and, possibly, expansion of the coastal dunes along Tahakopa Bay. Episodes of dune development are characteristic of the nature of sandy coasts - at most locations this nature has been lost.

9.0 MONITORING

The results of the proposed marram eradication at Tahakopa Bay will be of significant relevance to other similar programmes in southern New Zealand. Though similar operations have been successfully completed on Stewart Island, none, until recently, has been adequately monitored. Surveys of dune flora and dune morphology were not undertaken prior to marram eradication on Stewart Island. The Doughboy Bay monitoring will be the first systematic study of native dune flora recovery and dune stability following marram eradication. Careful study of the effectiveness of the Tahakopa eradication will greatly add to our knowledge of dune restoration along the southeast coast of the South Island.

We suggest a monitoring programme be initiated prior to or immediately following marram eradication at Tahakopa to (1) determine the effectiveness of the initial spraying operation; (2) to determine the impact of marram eradication on dune stability and morphology; and (3) to monitor the recovery of native dune species.

The effectiveness of the spray operation could be ascertained by surveying the area sprayed in February or March 2001 (assuming the initial spraying took place during the summer of 1999/2000). Future surveys of marram location and density could be compared with the data presented in Figure 3.

A network of dune/beach transects should be established along the coast to monitor dune morphodynamics. Profiles would be surveyed at 12-month intervals. Six transects would be adequate to measure both the changes in sand level and also changes in vegetation cover and composition. Three transects should be located in blowouts containing pingao (8, 12, 23) and three in blowouts currently dominated by marram (11, 18, 22). In addition, the total morphology of blowout 22 should be surveyed annually to develop a better understanding of the impact of marram grass clearance on dune morphology. Dune vegetation recovery would be monitored in two ways: (1) general survey

of pingao, as reported in the present study; and (2) ongoing monitoring of vegetation plots. The latter would probably entail the establishment of permanent 2 m diameter plots along the surveyed transects. Given the area of the coastal dunes (10 ha) and the natural variability in the distribution of native dune plants it is probably better (given time constraints) to monitor species diversity and abundance in permanent plots attached to the above dune/beach profiles (rather than sample randomly on each occasion). Further consideration needs to be given to the number of quadrats, the size of quadrats and what vegetation data will be recorded. Vegetation should also be recorded along the beach-dune profiles.

The location and area of pingao could be marked on our existing aerial photographs and located using GPS. Over time, say the next 10 years, we would expect the area and range of pingao and other native species to increase.

The above monitoring strategy should be able to be completed over a period of two days each year or every second year and should be continued for at least a decade.

10. RECOMMENDATIONS

10.1 The native dune vegetation of Tahakopa Bay is of national significance. Eradication of marram from the coastal dunes should be undertaken as soon as possible. The programme should be planned over 3-7 years in the first instance, depending on the spray method employed. Ongoing eradication will be necessary to control reinfestation.

10.2 The Tahakopa Bay marram is best eradicated using high pressure pumps mounted on either a tractor, truck or ARGO. The area of marram is too large to be efficiently controlled using knapsacks. If knapsacks must be used (1) operators should be given training by DoC staff familiar with marram and (2) consideration should be given to first spraying those blowouts that still contain pingao (4, 8, 9, 10, 11, 13, 14, 19, 23, 25, 26, 27).

10.3 The effectiveness of the proposed marram control programme should be carefully monitored to determine changes in sand movement and vegetation cover.

ACKNOWLEDGEMENTS

We are very grateful for information supplied by Mr Graeme Miller and Mr Murray Nieuwenhuyse, DoC (Southland) and Mr Terry Morecraft (formerly DoC Southland). Thanks to staff of the Herbarium, Forest Research, Rotorua, for plant identification.

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Appendix 1: Dune Plant Species, Tahakopa Bay, May 1999

Shrubs

Coprosma propinqua (small leaved coprosma)
Ozothamnus leptophyllus (formerly *Cassina Leptophylla*, cottonwood)
Psuedowintera colorata (pepperwood)
Myrsine australis (red mapou)

Herbaceous ground cover

Pseudognapalium ('coastal' cudweed)
Pratia arenaria (sand pratia)
Cyathodes fraseri
Cerastium sp. - probably *C. semidecandrum* or *C. glomeratum* (chickweed)
Astelia banksii (coastal astelia, also epiphytic)
Hydrocotyle novae zelandia var. montana

Woody ground cover

Coprosma acerosa (sand coprosma)
Pimelea spp.

Grasses/Sedges

Desmoschoenus spiralis (pingao)
Ammophila arenaria (marram grass)
Carax sp. (probably *Carex testacea*)
Anisotome lyallii (Lyall's carrot)
Poa cita (silver tussock)

Trees

Griselinia littoralis (broadleaf)
Podocarpus totara (totara)
Pseudopanax colensoi var ternatus (coastal five finger)
Fuchsia excoericata (tree fuchsia)
Pittosporum tenifolium (kohuhu)
Melicytus ramiflorus (mahoe)

Ferns

Lycopodium fastigiatum (lycopod)
Polystichum vestitum (prickly shield fern)
Blechnum novae-zelandiae (formerly B. minus)