

Struan Jno. T. Robertson
"Torranroy"
Dornoch
Sutherland IV26 3HR.

from:

SMYTH, J.S. and MATHER, A.S.

BEACHES OF EAST SUTHERLAND AND EASTER ROSS










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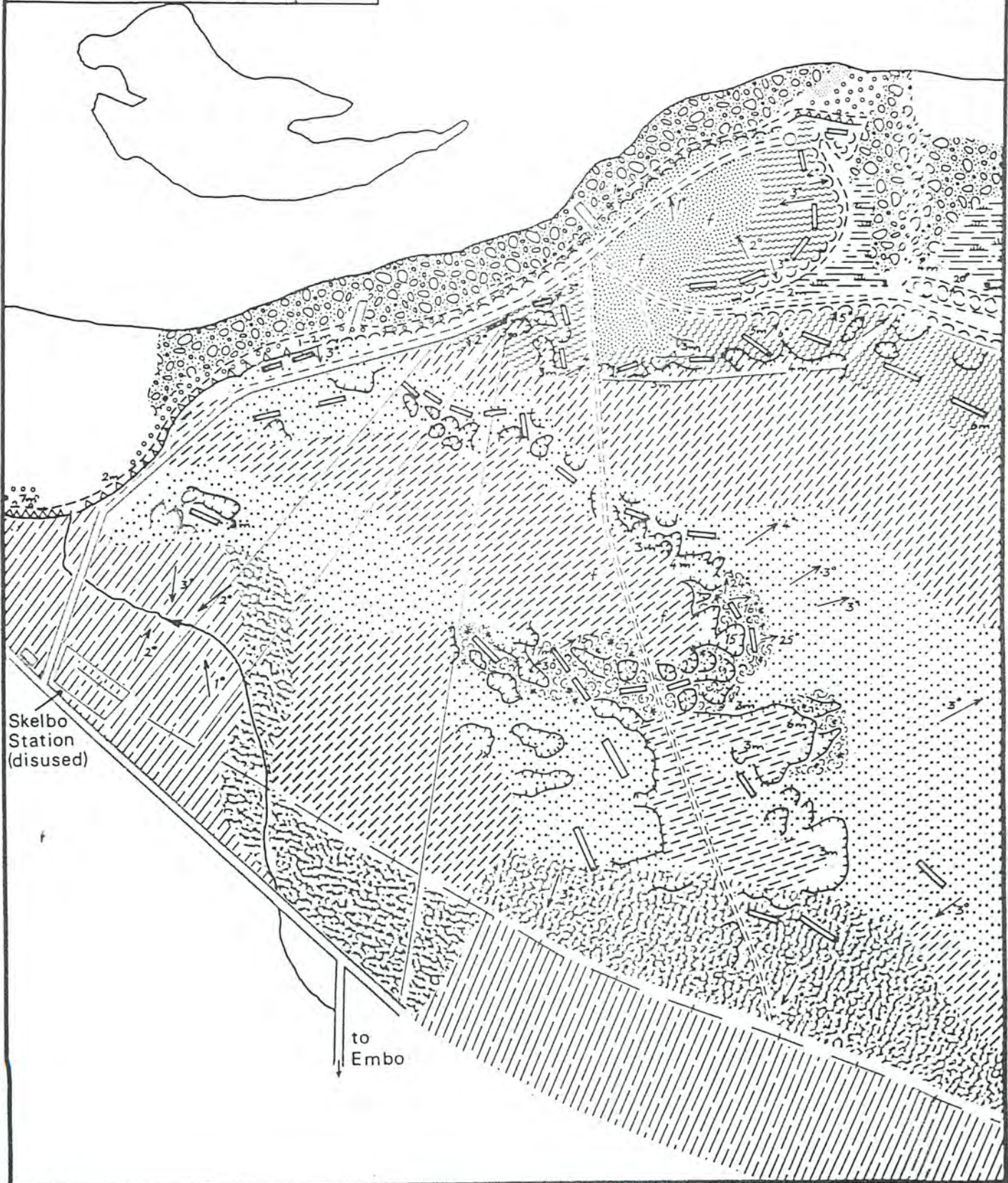
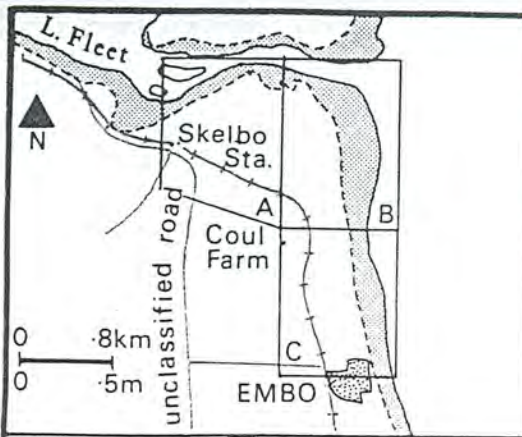
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








Jo-anne Ayer
Parcels Desk.

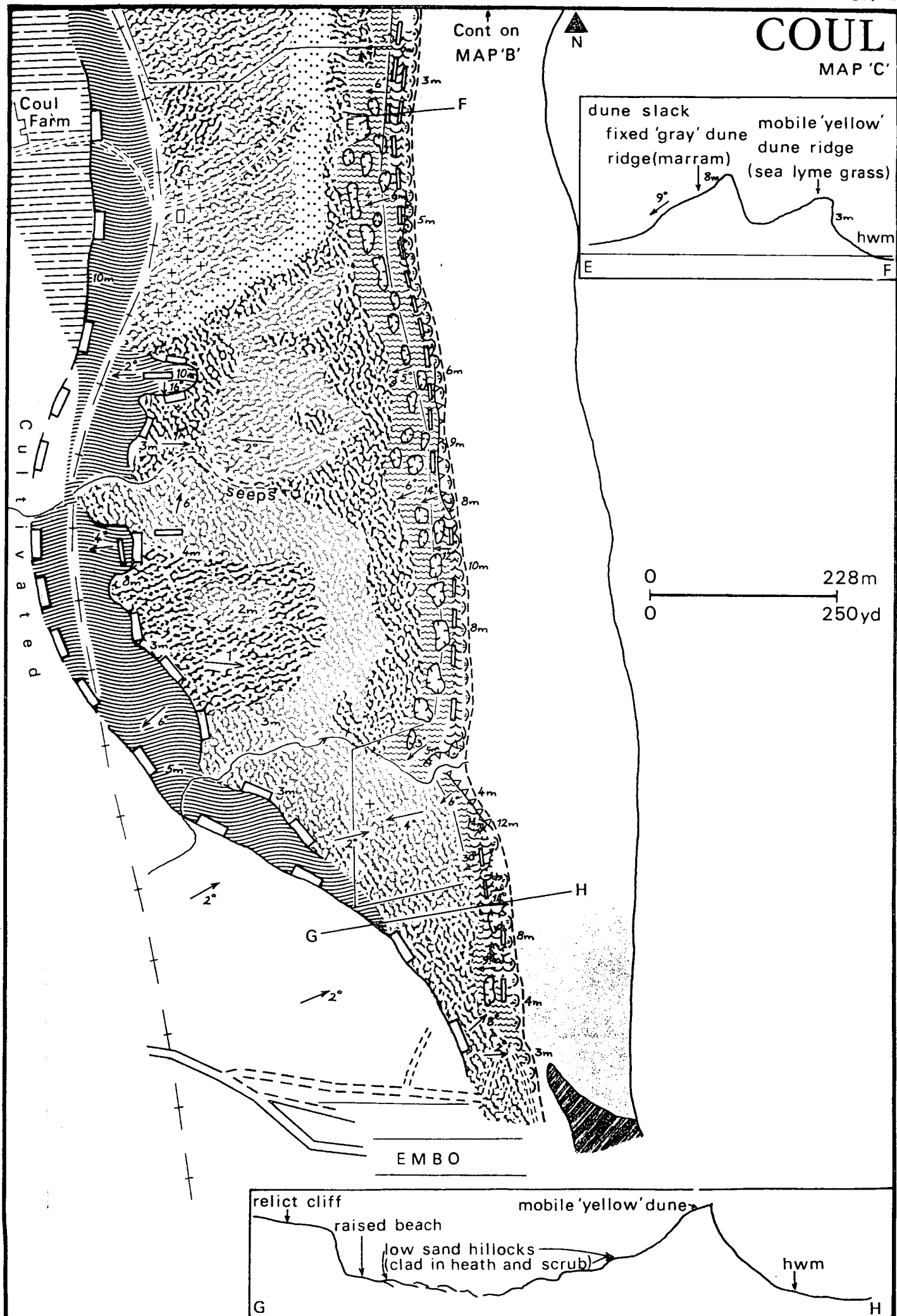
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on sandflats (near h.w.m.)
-  Dune slacks - mainly wet grassland
-  Sand plains (dune slacks) - wet
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-  Steep, deeply dissected dunes clad
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sand platform (mainly dune heath or
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-  Improved or semi-improved grassland
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-  Dry flat dune pasture or machair
-  Low sand hillocks, with dune heath
vegetation, on raised beach










COUL

MAP 'A'



- M
-  Plantago-Armeria colonisation on sandflats (near h.w.m.)
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6.7.5. Coul Links - note the wet slack, and the contrast between dune heath and dune pasture areas.

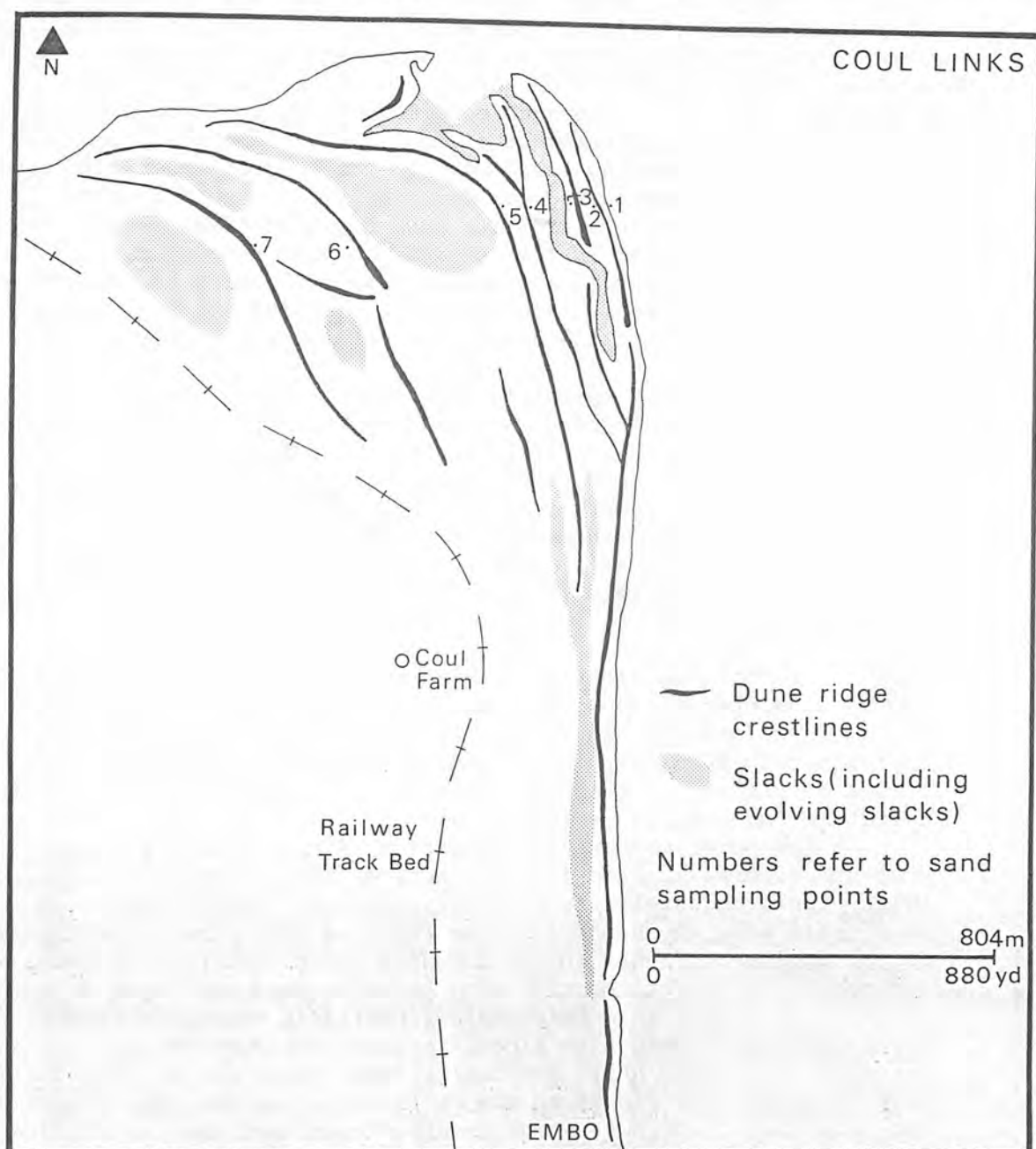


6.8.1. The coastal edge at Embo caravan site. Stones have been tipped to counteract trampling damage.



6.8.2. Embo beach and dunes - central section. A large active blow-out, in which trampling has accelerated rates of deflation.

are believed to be of sand. The delta has probably developed over a long period of time, with its inner part being constructed mainly of fluvio-glacial sediments which are not now readily moved. The profile and distribution of sediments on the inner, inter-tidal part of this submarine delta are highly dynamic, and vary with prevailing marine conditions. It is thought that mobile sand ridges, built up near or below low water mark, migrate landwards over the deltaic surface in rather irregular fashion. These migrating ridges are the source of nourishment for the upper part of the beach, which although thick and flat is sharply defined from the lower, thin beach by a sharp break of slope.



The sediment supply system at the entrance to Loch Fleet is extremely complex, and cannot be fully understood without long and detailed monitoring. In general terms, however, construction is the dominant process on this part of the beach, but the accumulation of sand seems to proceed irregularly.

The coastal edge adjacent to this section of beach is mainly accreting,

although the tip of the outermost spit has been trimmed back by basal undercutting. Rates of accretion vary considerably even over short distances; some sections display vigorous backshore colonisation by sea lyme grass, while others are much more static, and the behaviour of the coastal edge probably varies through time as well as from place to place. Episodes of poor sediment nourishment, perhaps associated with the irregular landward migration of sand bars, may occasionally interrupt the dominant process of accretion.

The south part of the beach, from point A to Embo, is much simpler in plan and profile. Both beach and offshore ground are gently sloping, and a submarine bar, lying about 500m off high water mark and extending southwards from the submarine delta at the mouth of Loch Fleet, helps to dissipate wave energy. The offshore ground is sand covered, and the beach is well nourished although both nourishment and beach width tend to decrease in the extreme south near Embo. Most of the coastal edge behind this section of beach reflects the relatively copious nourishment of the beach. The edge ranges from 6 to 10m in height, and is accreting along most of its length. Under-cutting is absent except for a very short section near the stream mouth to the north of Embo.

The north beach, fronting onto the Loch Fleet shore, is very different. Strong scouring action in the entrance channel removes most of the fine-grade material, and pebbles and lag deposits form the main beach materials. Some sand and shell fragments have accumulated in the sheltered inlets between the dune-capped spits, but the beach does not readily supply suitable sediment for dune construction.

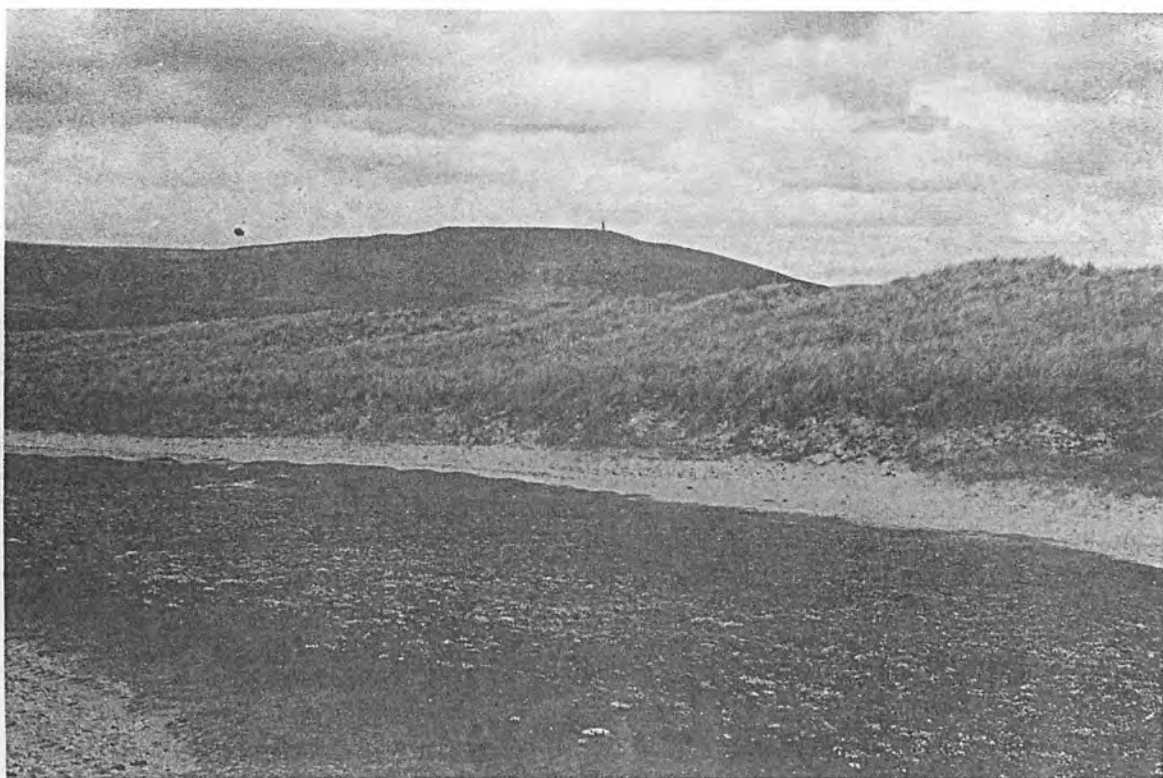
The processes operating on the beach are extremely complicated, and involve not only the 'normal' marine agencies but also the estuarine process around the mouth of Loch Fleet. The relative intensities of these marine and estuarine processes have varied through time as the Littleferry spit has developed, and their operation has proceeded through changing sea levels and fluctuating rates of sediment supply. Sand supply for beach and dune construction however, is probably still being maintained south of the loch outlet, but the rate of supply is likely to vary and episodes of retreat may intervene between longer periods of accretion.

.3 The most interesting feature of Coul Links is the richly varied and highly developed system of dunes. In the south part of the beach complex the dune system is relatively simple, and has the form of a single ridge. At a point approximately 500m north-east of Coul Farm, this single ridge fans out into a series of ridges, in which the younger outer members have a smaller radius of curvature than the older inner ones.

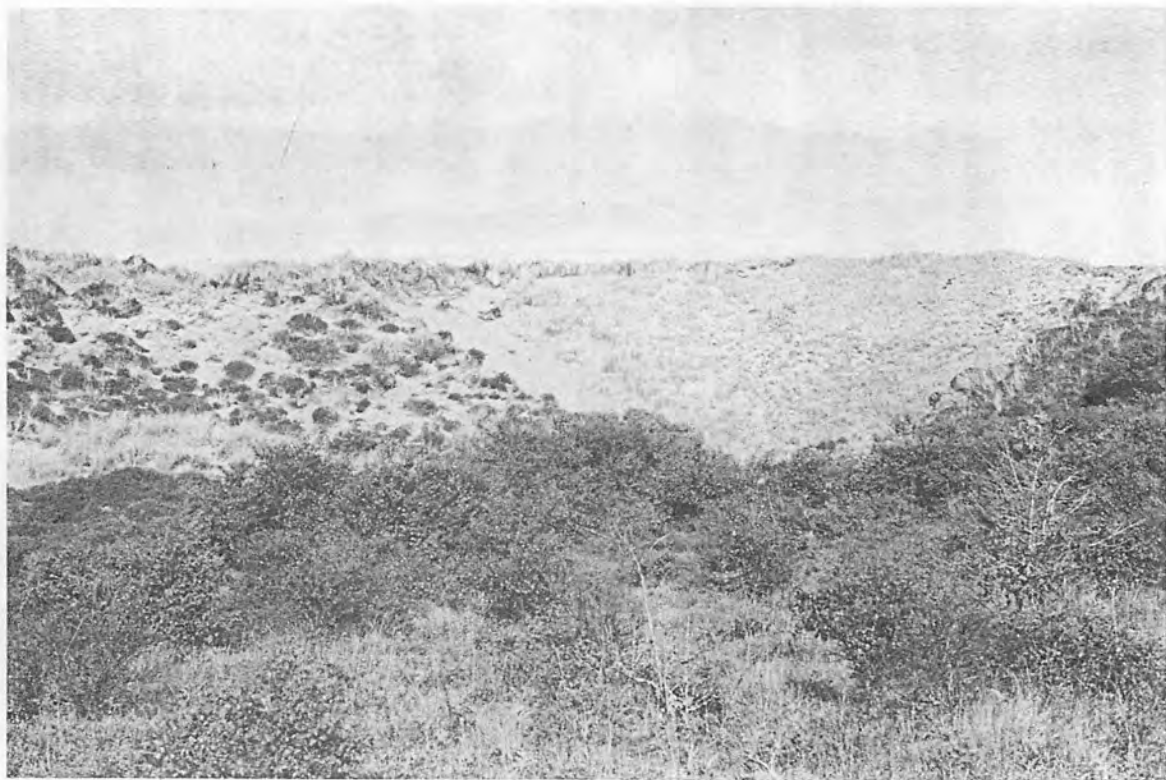
The outer members of the series of ridges have partially coalesced, but only the outermost ridge is still active. The others are now fixed under a mature Marram turf, and stability is relatively high. Active blow outs are concentrated in a small area where the foredune ridge is very narrow and fragile. Accretion is the dominant process in the foredune ridge, but all the outer set of ridges are modest in height, mostly lying below 8m, and the input of sand has resulted in widening rather than heightening. Partially vegetated sand flats, occasionally inundated during very high tides, separate the dune ridges in the north east corner of the beach unit. Eventually these flats may be sealed off by further growth of the dune ridges to the north east, and may thus gradually evolve into dune slacks. If northwestwards growth of spit and dune is still continuing, however, it is proceeding very slowly, and complete closure is not imminent. Nevertheless it seems probable that the Coul beach complex has grown towards the north-east by repeated spit extension and dune-slack enclosure. The next stage in its evolution, the sealing of the embayment B, may well be delayed by the proximity of the actively scoured entrance channel to Loch Fleet, which may tend to inhibit the accumulation of sufficient sand to effect the sealing.



6.7.1. Coul Links - rapid accretion on the coastal edge near the north-east corner.



6.7.2. Coul Links - vegetating sandflat, still very occasionally inundated, between dune ridges.



6.7.3. Coul Links - scrub invading damp slack behind high parabolic dune.



6.7.4. Coul Links - south end near Embo village. A path has been trampled along the dune crest.

The inner dune ridges (nos. 5,6,7) are more massive and widely spaced. All three ridges are highest in their central parts, reaching to over 15m, and become lower and more subdued towards their flanks. The highest sectors coincide with the points where there is least topographic shelter; dune height is closely associated with exposure. Heath and scrub have replaced dune pasture, but the dunes have not yet become completely fixed. A number of active blow outs have cut deeply into ridge 6, and fine parabolic forms have developed. Steep "alpine" dune topography, with precipitous slopes, has been created by opposing easterly and westerly winds. Parts of the ridges have become almost obscured in areas of streamlined sand hillocks, possibly derived from sand eroded and transported from other dunes. The rather featureless zone of hillocks between ridges 5 and 6 may, for example, have come from the destruction of the southern part of ridge 5 during an erosional episode. Similarly, rather featureless accumulations of now fixed blown sand conceal raised shorelines to the landward of ridge 7.

Large flat-floored slacks separate the innermost dune ridges. Much of the area of these slacks is now under wet moor or scrub, but the lowest slacks (notably the one to the landward of ridge 7) are winter lochs and support more hydrophytic vegetation.

The series of dunes and slacks may have evolved in a manner similar to that of the outermost dune area. The development of each dune ridge, resting on a sand spit, eventually enclosed a flat-floored depression which now forms a slack. With greater availability of sediment during the post-glacial period, not only would the process of closure be faster than at present, but larger dune ridges could also form.

The dunes at Coul Links are very varied in form, and subtle variations in exposure seem to have exerted important influences in the development of relief. At present, the dunes are relatively quiescent, although by no means completely stabilised. The complexity of the links is such that if instability is triggered off in any part of the area, its effects could be transmitted in magnified form to all other parts.

.4 The simple model of a beach complex composed of beach, dunes and machair does not apply at Coul because of the formation of multiple dune ridges. There is no clear distinction between the dune and machair zones, but on morphological grounds, the gently undulating areas lying to the west, south and south-east of dune ridges 6 and 7 may be regarded as a form of machair. This machair is however very different in appearance from typical west-coast machair.

The undulating sandhills have been constructed during periods of windblow from the surrounding dune ridges, but their surface is now fixed under dune heath in which some scrub is invading in places. The influence of the underlying relief is slight, except in the extreme south where there is only a very thin cover of sand over raised beach deposits or bedrock, and where the landward extent of sand is sharply defined by a relict cliff line. Elsewhere, blown sand is thicker and masks the underlying topographic features, while the relict cliff line is poorly developed to the north and north-west of Coul Farm.

.5 Coul Links have evolved under the interaction of extremely complicated marine and aeolian processes, operating on an irregular pre-existing landscape during changing sea levels. The beach complex has tended to grow gradually towards the north-east as strongly curved, dune-capped sand spits have been added. This growth is probably still continuing, but at an unknown rate; the next major stage in evolution may be the closure of the incipient slack area at B by the westwards growth of the outermost spit.

Some of the existing dunes are still being modified. Of the inner, older ridges, ridge 6 is the most active. The central part of this ridge is relatively strongly exposed to both the east and the west, and the opposing winds have

formed very steep dune topography. Most of the large parabolic blow outs face west, but eastwards sand drift from them has been resisted by east winds and the redeposited sand has been formed into "alpine" dune features.

The main foredune ridge is also being modified. The seaward part of the ridge is still unfixed, but blow outs are few except in the section immediately north of Embo where rapid deflation is occurring. There is more trampling damage in this section of the dunes than in any other part of Coul Links, and the instability may have been triggered off by this damage.

.6 The links have a strong ecological interest in the form of a long vegetation succession, from embryo dunes through dune pasture to heath and scrub.

Sea lyme grass is the main pioneer species and grows vigorously on the embryo dunes at the top of the backshore. The main foredune ridge is clad in Marram, with increasing proportions of mosses, herbs and grasses landwards. Ridges 3 and 4 are also fixed under dune pasture, in which Marram growth is less vigorous, while dune heath occurs landwards from ridge 5. Large areas are dominated by ling and bell heather, but crowberry, rose scrub and juniper are also widespread. Part of the dune heath zone has been burned, but recolonisation is taking place. Soil development increases landwards, with increasing horizon differentiation and acidity and decreasing carbonate content.

	CaCO ₃ %	pH
Beach sand	12.7	-
1 Embryo dune	8.9	9.1
2 Yellow fore dune	8.6	7.3
3 Fixed dune	5.7	6.6
4 Fixed dune	2.5	6.4
5 Fixed dune	0.0	5.9
6 Fixed dune	0.0	5.6
7 Fixed dune	0.0	4.7

(Numbers refer to sampling points indicated on map on page 35)

With increasing age and stage of soil and vegetation development, the proportion of carbonate decreases and acidity increases. The point where carbonate ceases to exist in the soil coincides with the transition between dune heath and dune pasture, and the soil continues to become more acid as heath species become more dominant. In parts of the inner dune area, the heath gives way locally to scrub, which is more extensive than in most other beach units in the north of Scotland. Scrub is the last stage in the succession towards tree growth, and may have survived at Coul Links because of low grazing intensities.

The dune slacks are also ecologically interesting. The lowest areas in the north-east of the beach complex are still occasionally inundated by salt water, but are being colonised by thrift and plantain (plate 6.7.2). In more highly developed and more typical dune slack behind the main foredune ridge, the marshy grassland is occasionally flooded to form winter lochs. The wet moorland in the large flat slack between ridges 5 and 6 has been partially improved by surface cultivation and slagging, while scrub grows extensively in the slack between ridges 6 and 7. A variety of scrub species, including broom and birch, grows in the better drained but sheltered zones between the older dunes and slacks.

.7 The links are owned by Cambusmore Estate, and are used for low intensity rough grazing, and especially for the outwintering of cattle. A number of fences have been erected to divide the links into compartments, and the more vulnerable section of the dunes in the extreme northeast has been completely fenced off. Weeds have been introduced, especially around the silage pit and feeding area in the northwest, but there is no evidence that the agricultural use of the links has resulted in adverse physiographic effects.

Arable land is confined to the west of the access road to Coul Farm, but efforts have been made to improve the grazing of parts of the drier dune slacks by surface cultivation. A small area due east of the farm has been afforested.

Small quantities of sand are taken from a number of points in the north and northeast parts of the beach complex, but physiographic damage has not resulted.

.8 Coul Links are little used for recreation except by anglers and birdwatchers. Informal beach recreation is largely confined to the extreme south section of the beach complex adjacent to Embo. Both recreational activity and trampling damage are very strongly concentrated in this small area, where physiographic and ecological interest are probably less than elsewhere.

Vehicular access is possible from the north west, but only by means of a rough track protected by an unlocked gate near the former Skelbo Station. Knowledge of such a means of access is confined to locals or to tourists with large-scale maps, and numbers using the track are small. Vehicular access is not possible at the south end of the beach, but pedestrian access from Embo is easy.

.9 The scientific interest of Coul Links is more outstanding than its recreational potential. Therefore it is suggested that the present pattern of use should be maintained, and no action be taken to promote recreational use.

The links are at present relatively stable, but probably less so than the beach complexes at Golspie-Littleferry or Dornoch. Likewise, access is not difficult, but the Dornoch and Golspie beaches are better located in relation to the main tourist routeways. The provision of a service infrastructure is also better at both Golspie and Dornoch. Thus the recreational attractiveness of Coul is less than at the neighbouring beaches, but the scientific interest is outstanding not only locally but also regionally and probably nationally. Therefore it is suggested that the present pattern of use be retained, and no action be taken to promote recreational use.

The existing intensity of recreational use at the north end of the beach complex is not incompatible with conservation, and can be permitted to continue without implementing specific management measures. Some trampling damage has resulted from recreational use of the dunes immediately north of Embo, however, and there are indications that stability is deteriorating. Most of the damage is concentrated in a dune-crest pathway, and cannot be effectively remedied without closure of the pathway by fencing, and diversion of the pedestrian traffic either along the beach or else along the more stable lower part of the dune backslope. Such action is probably not immediately necessary, but may become imperative in two or three years if the present intensity of use is maintained. If remedial action is not then taken, much of the dune ridge for about 300m north of Embo could be mobilised.

Current agricultural use is causing little environmental damage, but if pasture improvement were to proceed on a large scale there could be a danger that successional patterns in vegetation might be concealed and hence

the scientific interest of the links seriously impaired. Afforestation over large areas would have a similar effect. Burning of the dune heath is also highly undesirable since it carries a real risk of triggering off dune instability and uncontrollable sand blow.

Despite the strong physiographic and ecological interest of the links, very little detailed investigation has yet been made. It is suggested that a detailed scientific investigation of the area is desirable.

.10 Coul Links is unique in the north of Scotland because of its number of concentric dune ridges. The dune scenery is highly diverse, and physiographic and ecological interest is strong. The links are used as rough grazing, but recreational use is very limited. It is suggested that conservation be regarded as the primary use, and no effort be made to promote recreation.

6.8 Embo

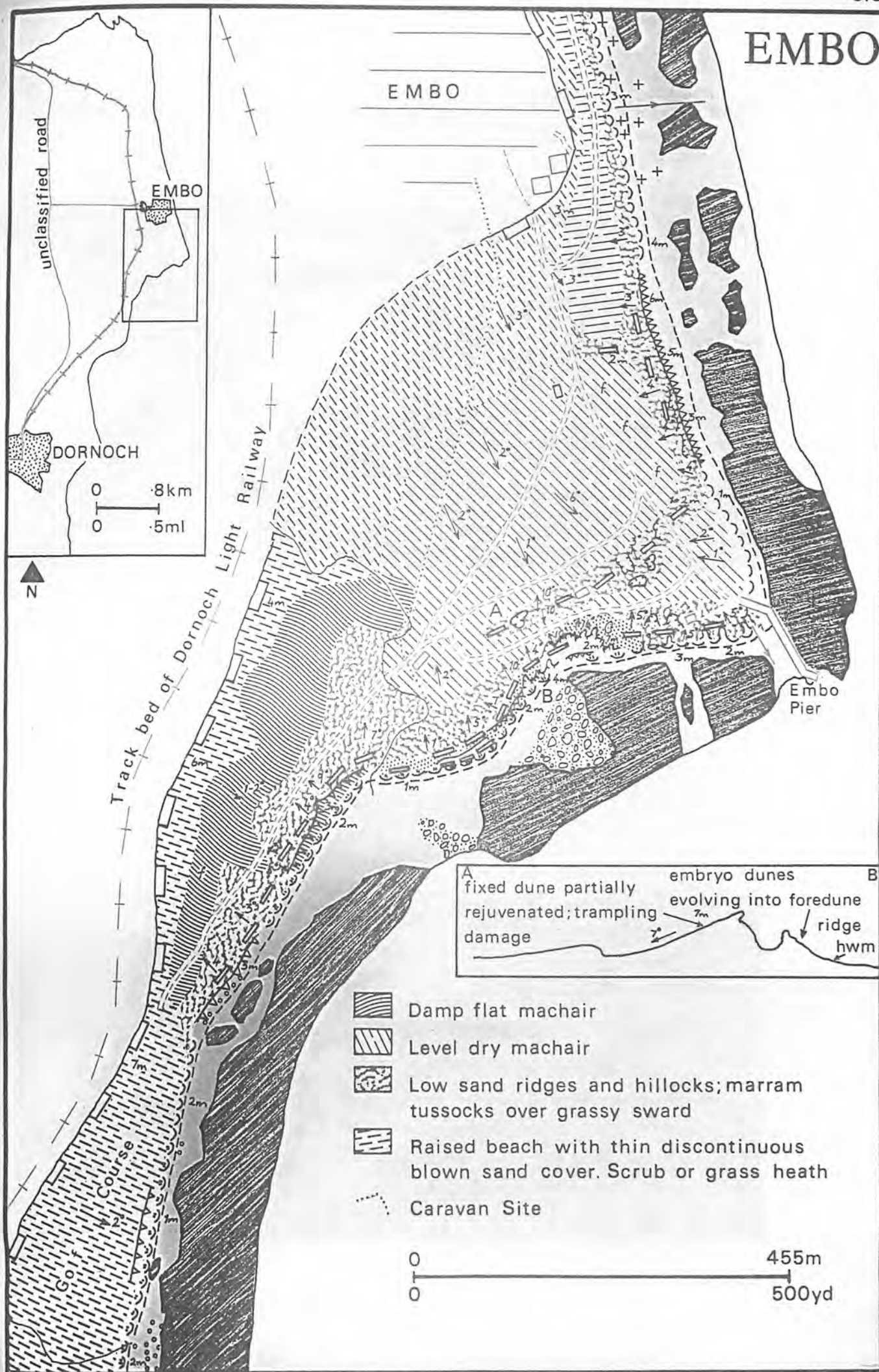
.1 The coast between Loch Fleet and the Dornoch Firth is low and sandy, and is backed along much of its length by a dune ridge of variable height. For approximately 2km south from Embo, however, the sandy beach is very thin and narrow, and occurs only in the form of a narrow fringe at the top of a rock platform. Dunes are poorly developed, and there is no continuous foredune ridge.

A very large caravan site has been established on Embo Links, and both the beach and the adjacent links are intensively used. Trampling damage is obvious in some parts of the beach complex, but the unit is relatively resilient, and instability has not been transmitted from the damage areas to other parts of the beach unit.

.2 In contrast with the neighbouring beaches of Coul and Dornoch, Embo beach is narrow and thin. Most of the lower part of the inter-tidal zone has been swept bare of sand, and the beach is poorly nourished. Patches of rock alternate with sand ground offshore.

The beach consists of three main sectors, with different orientations and sand characteristics. In the most northerly sector, from Embo village to the pier, the sandy beach becomes narrower and thinner southwards. Rock outcrops first appear in the inter-tidal zone opposite the north end of the village, and the proportion of sand cover decreases southwards. Near the pier, the sand beach is only a few metres wide, forming a very narrow fringe at the top of the rock platform. The second sector runs northeast to southwest and also consists primarily of a rock platform, with a narrow sandy fringe. The rock platform is covered in places with immobile lag cobbles, and large quantities of sea weed have accumulated near high water mark. At the west end of this sector, near the stream mouth, the rock platform dips and is overlain by thicker sand. The third sector, running north-south, similarly consists mainly of a rocky inter-tidal zone with a narrow fringe of sand and some shingle in places.

The sandy beaches in all three sectors are thus very narrow, and the supply of sand to the beach is extremely paltry. Despite the relative uniformity of the beach, the nature of the coastal edge varies widely. Behind the north beach sector, part of the coastal edge is in the form of a sand cliff up to 5 or 6m in height. The base of the cliff is undercut by wave action, and turf blocks slump down the cliff face, aided in their movement by trampling. At the extreme south end of this sector, near the pier, a low terrace of made ground has been built out, and the natural coastal edge is no longer visible. The coastal edge behind the north sector is, however, one characterised by instability and retreat, and reflects the poverty of sand supply to the beach.





6.8.3. Embo - caravan site and beach.



6.8.4. Embo beach and dunes - south and central sections, note narrowness of sandy beach fringe.

In contrast, the coastal edge behind the east-west beach sector shows more signs of accretion, despite the narrowness of the sandy beach fringe. Accretion is not occurring throughout the length of this section of the edge, but is confined to the west end and a section near the centre. The remainder of the coastal edge is nevertheless relatively stable (in relation to wave action) although a previous episode of retreat is evidenced by a low grassed-over cliff landward of part of the present edge.

The coastal edge behind the north end of the south beach sector is prograding in the form of a low embryo dune ridge about 2m in height, and backed by a now-healed cliff edge of about the same height. Further south, the coastal edge becomes more neutral as shingle begins to occur at the top of the beach, but the neutral stretches alternate with sections in which there is a slight tendency to accretion.

There is less erosion along the coastal edge than might be expected from the nature of the beach. There are indications, however, that more active episodes of retreat have occurred in the relatively recent past, and the present quiescence may well be only short lived.

.3 Characteristics of dune morphology and processes correspond to a large degree with the three main beach sectors.

Behind the north sector, a low, maturely vegetated ridge slopes gently landwards. The ridge may represent the attenuated remains of a former foredune ridge, much of which has been consumed by coastal-edge retreat. Morphologically, the ridge is very subdued, and its surface is firmly fixed by a close turf. Stability remains comparatively high despite high intensities of trampling pressure, which is manifested on the seaward edge by severely trampled pathways which would probably have developed into active blow outs but for infilling with stones (plate 6.8.1).

The foredune ridge is better developed behind the east-west sector, and both height and slope are much greater than on the first or third sectors. Most of the dune ridge is fixed, but part of the dune has been seriously affected by a large, active blow out (plate 6.8.2). This blow out may have formed from the coalescence of several linear blow outs formed by trampling, and indeed such linear blow outs are in evidence near the pier. This dune section is the part of the beach complex most urgently in need of management, and unless remedial measures are implemented the damaged area is likely to grow inexorably. A second, lower ridge runs parallel to this foredune ridge some distance to the landward. Although the ridge is fretted by a number of healed blow outs, stability is relatively high at present, and the ridge serves the useful function of providing some screening and shelter.

Dune height tends to decrease southwards along the third beach sector, and indeed a definite foredune ridge dies out about 300m south of the stream outlet. The limited extent of dune in this sector is at present stable in relation to aeolian processes, but there is clear evidence of undercutting in the past.

The dune component of the Embo beach unit is thus, like the beach itself, rather poorly developed. The foredune ridges have been partially consumed by coastal retreat or by wind erosion associated with trampling damage, but instability is limited by the subdued forms of the dunes and by relatively mature vegetation cover.

.4 The foredune ridges, or their attenuated remains, grade almost imperceptibly into a flat or gently undulating links area. In the transition zone between dunes and links, Marram growth of very poor vigour is widely separated by areas of low grassy sward. Much of the machair is thin, especially towards its landward margin where it overlies raised beach deposits. The relict cliff-line of the post-glacial beach sharply defines the landwards extent of



6.9.1. Dornoch North - note the wide beach, and subdued foredune ridge.



6.10.1. Dornoch South - note vigorous accretion along the coastal edge.

machair behind the south sector of the beach; the landward limits behind the central and north sectors are much more gradual.

Morphologically, the machair consists of a smooth surface broken only by low fixed dune ridges running in an east-west direction behind the foredune ridge of the central beach sector, and a very faint ridge normal to the north sector. Both these ridges are securely fixed under a close turf in which Marram growth is poor, and the level machair is similarly stable. Despite the high pressure of recreational use, little serious damage has resulted from trampling of the links. This resilience is thought to be due to a combination of subdued, maturely vegetated surfaces, a relatively low energy environment, and the paving of the potentially most vulnerable vehicular tracks with protective gravel.

.5 The beach unit is probably at a late stage in its development, during which the main tendencies in further evolution are likely to be coastal retreat associated with the partial decay of wind-blown sand built features. The beach is thin and poorly nourished, and the coastal edge is exposed to wave action. The wide rock platform, however, dissipates much of the wave energy, and retreat, where it is taking place, is relatively slow. The main process operating in the dune zone is the decay of the foredune ridge behind the central sector of the beach. Erosional activity is prominent at present, and is likely to continue in operation unless remedial measures are implemented. Such measures are likely to be moderately efficacious; on the other hand little can be done to check coastal retreat short of expensive coast protection works.

In general terms, however, the overall stability of the beach unit is higher than might be predicted from examination of the beach alone. Damage is concentrated into a number of small areas, and the threshold of recreationally induced instability elsewhere is relatively high.

.6 One of the main features of the vegetation on Embo Links is the vigorous growth of sea lyme grass along much of the coastal edge. Despite the poverty of sand supply, sea lyme grass is growing luxuriantly along some sections of the coastal edge, and is succeeding in forming a embryonic dune ridge in places. Without such growth, it is likely that coastal undercutting would be a more active process than it is in present.

The area of actively forming, yellow dunes is, however, very small, and most of the dune area is fixed under a grassy sward with senile Marram growth. Weeds associated with cultivation have been introduced by earth tipping along parts of the coastal edge.

Most of the links carry dry grass communities in which fescue species play important roles, but gorse heath is invading from the landward, where the blown sand thins out against raised beach deposits and a relict cliff line. A wet slack zone lies between the dune backslope and the relict cliff edge south of the stream.

.7 Formerly, the primary land use of the links was agriculture, and traces of drainage-ditch patterns are still visible, especially in the damper landward area now under gorse heath. Part of the stream flowing through the area has been straightened in an effort to improve the drainage of the arable land behind the links. Agricultural use of the links is now confined to rough grazing, and there is no evidence that detrimental effects have resulted. The area is part of Embo Mains farm.

.8 Embo Links now form one of the largest caravan sites in the north of Scotland, centred around a site shop and restaurant on the south-east corner of Embo village. The total capacity of the site is 200 (75 static, 125 touring caravans). A network of metalled tracks has been laid out around the site, and

a number of toilet and washing blocks constructed. The intensity of use of the site is high, but relatively little damage has resulted. Damage has been concentrated along the vulnerable coastal edge, where trampling has initiated blow-out development in places. Remedial action has been attempted by tipping stones and earth in the damaged spots. Damage has been most serious along the central sector of the coastal edge, west of the pier. Here initially linear blow outs have coalesced to form an extensive damage area. Further deterioration is likely to occur since the blow out forms an attractive, sheltered playground for children from the caravan site.

Despite the localised damage, Embo Links are not unsuited for this type of intensive recreational use. Provided simple management measures are implemented, the current pattern of use can be maintained without serious environmental deterioration. Internally, there is little screening for the caravans, but the site is not strongly exposed to view from the Dornoch-Skelbo road and is almost invisible from the A9.

.9 Embo Links are probably one of the Highland beach units most suited for intensive recreational use, and there is no reason why caravanning should be seriously curtailed. Some relatively minor management measures are, however, required, and should be implemented as soon as possible. The first of these measures is the construction of an impassable fence along the coastal edge behind the north beach sector. The objective of this measure is to control trampling damage along the coastal edge by channelling all access through two or three points which can be protected by a sleeper staircase or other means. If such control is effected, there would be very much less danger of blow-out development resulting from trampling, and the need for tipping stones in the incipient blow outs would be removed.

Damage has progressed further in the dune zone behind the central beach sector, and will be less easily controlled. The first priority should be the exclusion of people by the construction of a ring fence around the damaged area and its environs: thereafter a suitable grass seed mixture should be sown and ideally protected by either latex or bitumen films. Sea lyme grass should be transplanted around the dune toe and lower part of the seaward slope.

The condition of the stream flowing into the central sector of the beach is unsatisfactory, especially since children play in its vicinity. Some of the toilet blocks on the caravan site at present discharge into it, via septic tanks, and the stream is turbid and unpleasant. It is understood that the site operator has alternative arrangements in mind, and it is to be hoped that these can be implemented as soon as possible.

.10 The sandy beach at Embo is in the form of a long narrow fringe at the top of a rock platform. The dune area is small, but the extensive gently sloping links are intensively used as a large caravan site. The beach unit is relatively suitable for such use, but some trampling damage has occurred along the vulnerable coastal edge. It is suggested that this damage could be at least partially controlled by simple management measures.

6.9 Dornoch North

.1 The north beach at Dornoch lies to the north-east of the burgh and consists of a simple beach arc hinged on rock platforms at either flank. A continuous ridge of low foredunes has evolved, but the blown sand forming the links is thin and does not extend landwards of a very distinct relict cliff-line which dominates the beach complex. The links form part of Royal Dornoch golf course, but the beach and dune zones are used for recreation at a lower intensity than the neighbouring beach to the south.

.2 The beach, which faces east, extends to approximately 1km in length and 150m in width. Its plan is uninterrupted by rock outcrops except on the flanks, and the beach material is moderately sorted medium sand (median diameter 0.22mm) with a carbonate content of 17.5 per cent. The offshore ground is sand floored, and shelves very gently at a gradient of approximately 1 in 375. The beach gradient is also gentle, at 4°, and a wide flat backshore consisting of a series of berms has been built up near high water mark. The main source of sediment appears to be the offshore ground, and supply is being maintained along most of the beach. At the north end of the beach, however, the sand is very thin, and a rock platform, thinly overlain in places by immobile larger deposits, is exposed. Rock exposure may increase in the future if sand supply diminishes, but at present the beach is relatively thick and well nourished. The coastal edge is low and stable, and is characterised by accretion along almost the whole of its length, reflecting the ample nourishment from the thick beach and wide backshore.

.3 A continuous dune ridge has formed along the whole length of the beach, but dune morphology is subdued both in height and in slope. A maximum height of about 7-8m is attained opposite the point where the backing relict cliff is lowest, and hence exposure to winds from the west is greatest. Backslope gradient also reaches a maximum at this point where there is maximum interaction between winds from west and from the seaward, but the slope is mainly gentle, rarely exceeding 6°. The seaward slope is also relatively gentle, mostly lying between 10° and 16°, and terminates in a belt of vigorous colonisation by sea lyme grass. The morphology of the dune ridge is thus conducive to stability, since there is an absence of steep slopes vulnerable to wind erosion. A number of healed blow outs scallop the dune backslope and lend to it a hummocky appearance, but there is very little activity at present on either the landward or seaward faces. A few incipient linear blow outs have developed at the south end of the beach, but these features have been initiated by trampling on the coastal edge rather than by purely natural processes. Control could be effected relatively easily.

.4 The links or machair zone occupies the narrow corridor between the base of the dune backslope and the dominating relict cliff cut by the post-glacial sea. The links have been extensively modified by the construction of tees and greens on the golf course, but are divided into two parts by a low and deeply serrated edge 1-2m in height running parallel to the main relict cliff. This edge is probably associated with a former sea level, and the blown sand cover behind it appears to be very thin. Most of the machair is thin, and is thought to be underlain by raised beach gravels. Apart from a few low, fixed sand hillocks, the machair is rather featureless, and like the dune zone, is characterised by a high degree of stability. This stability is reinforced by the intensive management of the golf course.

.5 The beach complex is not a highly dynamic unit, and most of the marine and aeolian processes are of a low intensity. The main process operating in the beach unit is the continued development of the foredune ridge as sea lyme grass colonises vigorously along the coastal edge. The condition of the beach indicates that this process is likely to continue in the foreseeable future, but there are some indications on the flanks of the beach that sand supplies are beginning to dwindle very slightly. If sand supplies were significantly reduced, accretion would be replaced by erosion as the dominant coastal-edge process. The danger that instability might be triggered off can never be ruled out since it is always possible that extreme marine and climatic conditions may coincide; nevertheless the beach unit is relatively stable, and physiographic changes will probably be slow and gradual.

.6 The narrow seaward face of the foredune ridge is yellow and unfixed, with vigorous colonisation of the top of the backshore by sea lyme grass. The transition to the grey dune, dominated by Marram communities, is abrupt, and most of the dune ridge is firmly fixed. Marram dies out towards the base of the dune backslope, where some broom and small amounts of rose, gorse and juniper are beginning to invade. This scrub growth is kept in check by mowing; indeed a feature of the links vegetation is the heavy modification by golf-course management. Much of the relict cliff-face is gorse clad.

.7 Traditional uses have been almost completely replaced by recreation, and are not of significance for the physiography of the beach unit. Small quantities of sand are taken from the dune backslope (see 6.9.8) and some gravel is taken from the terrace to the landward of the main relict cliff line. There is no evidence that extraction has had detrimental effects.

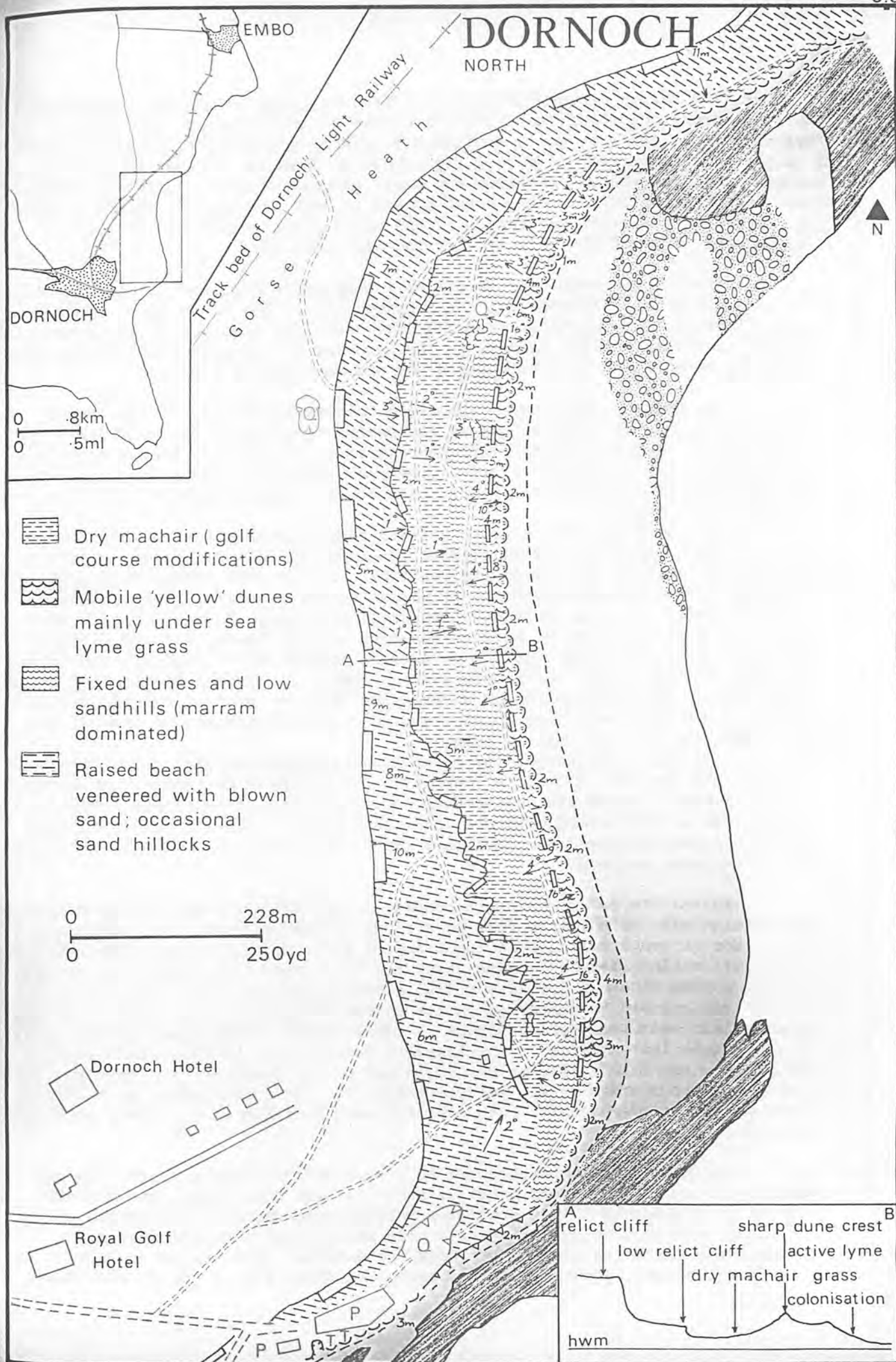
.8 The primary land use of the beach complex is now recreation; Royal Dornoch golf course occupies almost the entire links area. The golf links are intensively managed, and the landform-vegetation complex has been extensively modified by the laying out of tees, greens and fairways, and by mowing, fertilising and watering. This modification has tended to enhance the stability of the beach complex.

The south end of the beach unit is readily accessible on foot from Dornoch beach car park, and is popular for informal day recreation. A path has been trampled along the top of the south part of the dune ridge. This path is parallel to the shoreline, and hence normal to the potentially most damaging onshore winds. Thus blow outs have not developed along the path itself, but some trampling has occurred between the path and the beach, and a few linear blow outs have been formed on the vulnerable coastal edge. Most of these blow outs are small and only moderately active, and their further development could be halted by the construction of a dune-edge fence to prevent further trampling damage at the most sensitive points, and to channel beach access towards more resilient parts of the coastal edge.

Near the north end of the beach complex, some vehicle tracks have been incised into the dune backslope. Sand blow has occurred in places, but activity has now largely ceased and most of the bare areas have grassed over. Some of the tracks lead to small sand pits cut into the landward slope of the dune ridge, but quantities of extraction have been small, and the sand has been used mainly for golf-course purposes.

.9 The condition of the beach complex is satisfactory and the present uses may be continued with little fear of serious adverse effects. The main focus of management effort should lie in the trampled parts of the dunes at the south end of the beach; little need be done about the dune-crest path unless its condition seriously deteriorates. Completely free access along the whole length of the coastal edge should be curtailed by the construction of a fence along the length of about 150m where trampling damage is concentrated. Pedestrian traffic could thus be channelled towards less vulnerable parts of the coastal edge, such as the rock-cored section between the south end of the beach and the main car park. A watch should be kept on the vehicle tracks and small extraction pits at the north end of the beach unit, but no action need be taken unless their condition deteriorates.

.10 The beach complex is bounded by a well defined relict cliff line and consists of a well nourished beach, a broad but low dune ridge, and a links section of blown sand thinly overlying raised-beach deposits. The beach unit is stable, and is used primarily as a golf course with some informal day recreation towards its south end. These recreational uses are not resulting in significant damage, and there is no reason why they should not be continued.



6.10 Dornoch South

.1 The mouth of the Dornoch Firth is defined by two large marine-built forelands. On the south side, the Morrich More has grown outwards from a point near Tain; its equivalent on the north shore is the foreland of Dornoch Links. The foreland consists of three components, a wide, east facing sandy beach, a long narrow zone of low dunes and an extensive flat grassy plain. A large caravan site has been established on the north part of the links, and the adjacent dunes and beach are very intensively utilised for recreation.

.2 The most attractive part of the beach complex is the flat, wide sandy beach which extends 2km southwards from the south-east of Dornoch burgh. The beach material is primarily medium sand (of median diameter 0.24mm) with a carbonate content of 14.6 per cent. A few very small patches of gravel occur on the lower part of the beach near its south end, but rock outcrops are confined to near the car park at the extreme north end. Low water mark off the centre of the beach is approximately 350m from the dune front, and the beach is thick and very gently sloping. A wide backshore, consisting of a series of coalescent berms, is built up during fine weather. The upper part of the inter-tidal zone has a gradient of only 3°, and the gradient decreases seawards towards and beyond low water mark. Gentle gradients are maintained offshore, where the average slope to the 5 fathom line is approximately 1 in 500. This slope is even flatter off the Point, where the sand banks of Gizzen Briggs are exposed during very low tides. Most of the sand flooring the offshore ground is thought to have emanated from the Dornoch Firth. Beyond the deep scoured outlet channel large quantities of sediment have accumulated in submarine-delta form from which material is supplied for the construction of both the Morrich More and Dornoch Links.

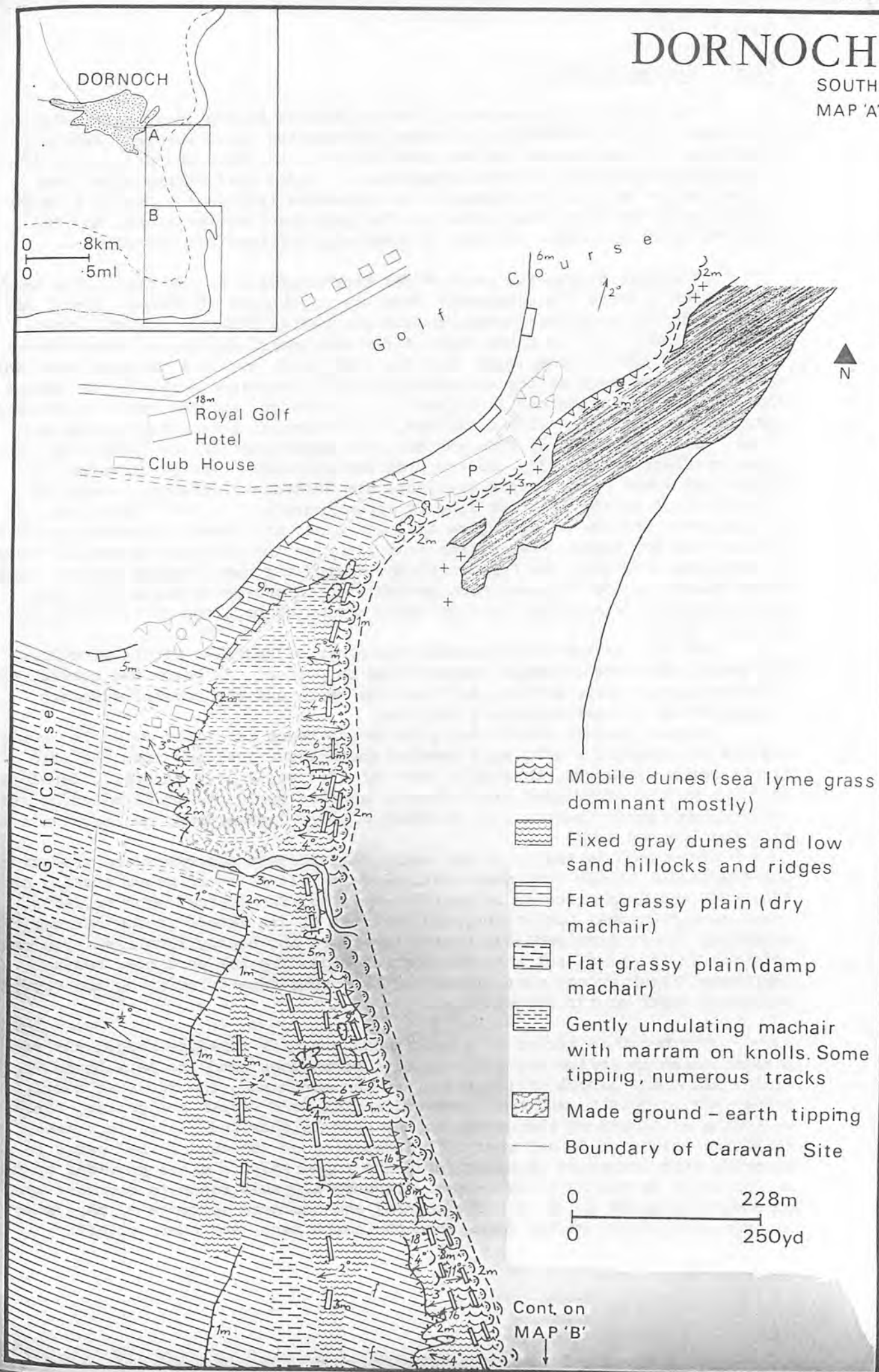
As well as providing a major reservoir of sediment within wave base, the gently shelving offshore ground helps to protect the beach and coastal edge from destructive wave action, and both the beach and the coastal edge are characterised by constructional features.

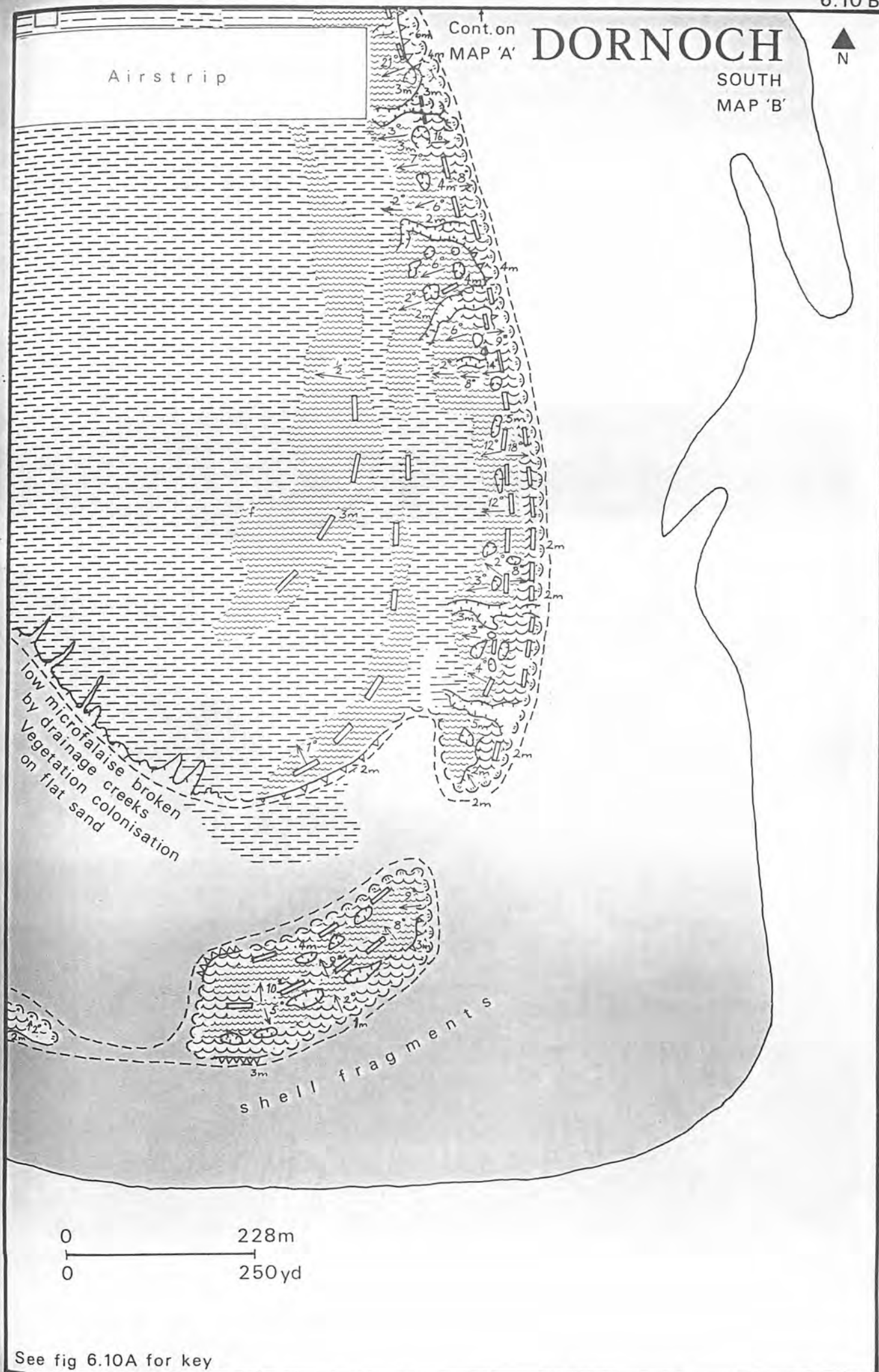
Unlike Dornoch North beach, the south beach is convex outwards in plan, and has the form of a sand spit growing southwards. Near its tip, the spit trends south-westwards, forming a hook which is still only partially developed. The plan of low water mark also suggests another evolving, south pointing spit, and this embryonic feature will probably migrate landwards to coalesce with the main dune-capped spit.

The beach is stable in the sense that present processes are producing constructional rather than destructional forms. It is by no means static, and the south end in particular is rapidly evolving. The coastal edge reflects these constructional conditions, and for most of its length is low but rapidly accreting. There have probably been a few short and highly localised erosional episodes in the past, but the few undercut edges are now protected behind embryonic ridges except where there has been some edge trimming by the southwards-deflected mouth of the Dornoch Burn.

.3 The beach is backed by a continuous and wide foredune ridge, the seaward part of which is yellow and unfixed. Dune morphology tends to be subdued, but varies along the length of the ridge. At the north end, the ridge is mostly below 4-5m in height, and both landward and seaward slopes are gentle, rarely exceeding 6°. South of the stream mouth, both heights and slopes increase, attaining values of 8m and over 18°. Steepening of the dune relief seems to coincide with increases in exposure as the topographic shelter provided by the relict cliff to the north decreases. Although altitude tends to decrease again southwards towards the Point, the central and southern sections of the dunes contain much higher energy forms than the north part, and their stability is

SOUTH
MAP 'A'





See fig 6.10A for key



6.10.2. Dornoch south - note trampling damage in foreground.

correspondingly lower. Despite heavy trampling, no large blow outs have as yet formed in the north dunes, but several transverse deflation hollows have breached the foredune ridge in its southern half. Many of these hollows are now wholly or partially healed, but their occurrence demonstrates the potential instability of this section of the dunes.

Accretion along the coastal edge is reflected in a wide band of unfixed, yellow dune along the seaward face of the ridge. Accretion is still rapidly occurring, with very vigorous growth of sea lyme grass at the top of the backshore. Accretion and dune evolution have been most dramatic at Dornoch Point itself, where two small dune "islets" have formed on the hooked spit tip. Although these islets are low and fragile, they are increasing in size, and may be expected eventually to coalesce with the main foredune ridge.

The links behind the foredune ridge are interrupted by a number of faint Marram-clad ridges standing 1-2m above the surrounding level. These low, flat ridges probably represent the attenuated remains of former foredune ridges constructed at earlier stages in the evolution of the foreland.

.4 An extensive, rather featureless area of links has formed behind the shelter offered by the foredune ridge and its predecessors. Evolution is continuing at present in the lee of the dune "islets" at Dornoch Point; the level of the sand flats in the lee of the spit tip is gradually raised and vegetation colonises as the frequency of salt-water inundation decreases. This young machair is thus low and poorly drained; drainage improves northwards towards the higher, older machair, with a corresponding gradation in soil and vegetation development. Machair formation probably began during a higher sea level; the machair at the extreme north end of the links is rooted on a relict cliff, and is separated from the adjoining links surface by a scarp 1-2m in height. Apart from a few low and completely grassed scarps, the links are flat, featureless and stable. The north-east corner of the links has been heavily modified by the tipping of hard dry refuse between the main machair scarp and the dune backslope, so that the ground surface is now raised above its former low-lying, damp level. This part of the links has also been modified by stream migration, and latterly by the cutting of a new, straight channel for the burn.

.5 The beach unit is continuing to evolve by the growth of sand spits to the south and southwest. These spits eventually become dune-capped, providing shelter behind which the extensive sand flats gradually dry out to form links or machair. This evolution is the result of the interaction of estuarine, marine and aeolian processes, and relative or absolute changes in the intensities of any of these processes could readily alter the rate or direction of development. At present, however, there is no indication that the current pattern of development is likely to change. The dune "islets" near the spit tip will probably eventually coalesce, forming even more sheltered conditions in the sand flats behind, and thus encouraging the growth of the machair to the south of its present limit.

Dornoch Point is only one of a series of marine-built forelands in and around the Dornoch Firth. Its most distinctive feature is the almost complete absence of shingle. Normally, the absence of a shingle foundation for the spit-dune complex would tend to lessen its stability and resilience to erosional pressures. The general stability of the beach unit is, however, high, although it decreases towards the more dynamic south end. It is fortunate that access is easiest at the north end, and that recreational activity has been concentrated there.

.6 The vegetation pattern is strongly influenced by landform and particularly by slight variations in drainage conditions. Sea lyme grass is



6.10.3. Dornoch Point (1959) - the caravan site occupies the area near the top of the picture, mainly on the north side of the stream.

colonising very vigorously along a wide band at the coastal edge, and dominates much of the seaward face of the foredune ridge. Marram communities dominate the fixed landward section of the dunes, and extend, in senile form, to the old dune ridges landward of the main ridge. The drier parts of the links are vegetated by fescue-dominated grassy swards, but the vegetation cover on the youngest, lowest parts of the machair is incomplete and is largely confined to thrift and plantain. Agricultural weeds have been introduced in large quantities by tipping in the caravan site.

.7 The links are owned by Dornoch Town Council. Until recently their main use has been as rough grazing, but letting of the grazing is now sporadic. A few very small plots are cultivated in some of the drier parts of the links to the south-west of the area shown in figs. 6.10. There is no evidence that agricultural use has resulted in any physiographic damage.

An airstrip has been laid out in an east-west direction across the central part of the links, and its construction has involved some landform modification. The east end of the strip is cut into the dune backslope and the foredune ridge thus narrowed and steepened. Fill is most noticeable along the strip's south edge. The construction of the level surface has effaced the contrasts in drainage, soil and vegetation between the old dune ridges and the intervening damp machair hollows.

.8 Recreational use is very intensive, but is concentrated in a small area in the north-east corner of the beach complex. A large caravan site, with a capacity of 200 caravans, was developed rapidly during the 1960s, and the adjacent sector of the beach and dunes is intensively utilised for recreation by both caravan-site residents and day visitors.

The part of the links on which the caravan site is situated has been modified by the straightening of part of the Dornoch Burn, and by tipping to provide harder and drier standing. A network of metalled tracks has been laid out, and has precluded deep wheel-track rutting which might have developed into dangerous blow outs. Despite the high intensity of use, no serious damage has resulted from the laying out of the site or from vehicular access, but pedestrian traffic between caravans and beach has caused trampling damage in the intervening low dune ridge. Trampled pathways criss-cross the dunes, but the development of blow outs has been inhibited by the subdued dune topography combined with the high degree of topographic shelter from the neighbouring relict cliff. If the same level of trampling damage had been incurred south of the stream mouth, it is almost certain that widespread erosional damage would have resulted.

The north part of the beach and the adjacent dunes are also used intensively by day visitors, and during fine days in summer up to fifty cars may be seen in and around the car park at the end of the beach road. Trampling damage is widespread along much of the adjacent coastal edge, part of which is fortunately rock-cored and relatively resilient. Blow outs are nevertheless developing around some of the worst trampled points, and the entire section of coastal edge between the car park and the burn bears the imprint of heavy pressure. This pressure has thus far resulted in remarkably little wind erosion; had it been located on less stable physical conditions, the environmental repercussions might have been grave.

Part of the links to the west of the caravan site is used as a nine-hole golf course, and it is understood plans have been drawn up to extend the course to eighteen holes. The stability of the links is very high and physiographic damage is unlikely to result from golfing use.

.9 The absence of symptoms of severe damage, despite high intensities of use, reflects the suitability of much of the beach unit for recreation.

It is recommended, however, that high-intensity use should not be permitted to extend southwards from its present focus. The central and southern parts of the dunes are much less stable than the north part, and the introduction of trampling at intensities comparable to those on the north part of the dunes would almost certainly trigger off severe erosion. It is suggested, therefore, that the caravan site should not be expanded southwards, and that vehicular access for tourists should not be permitted beyond the south end of the existing site. The central and southern parts of the dunes are popular with family groups seeking less crowded conditions than exist opposite the caravan site, and there is no reason why access should be prohibited, provided that the people walk rather than motor to their favourite spots.

In the north dunes, near the caravan site and car park, trampling damage could be reduced by the simple expedient of channelling pedestrian traffic through a small number of controllable points. To achieve this objective, a strong fence should be constructed along the top of the coastal edge, with not less than six gaps left for through access to the beach. The gaps at the car park end should be protected by sleeper staircases; those nearer the stream would be best safeguarded by duckboard walks, which could if necessary be extended backwards across the dune ridge if trampling damage becomes severe. These measures would help to reduce many of the signs of wear and tear around the beach margin, and at the same time would permit the safe continuation of the present intensities of use.

The condition of the Dornoch Burn is not satisfactory. The stream is slow-flowing, turbid and encumbered with weed. Part of the course between Littleton and the west side of the caravan site has already been straightened, and this has helped to improve the flow in that part of the stream. But the real problem lies in the section between the caravan-site bridge and the outlet, and particularly at the point where the stream breaks through the dune cordon. Southward drifting sand blocks the stream mouth and deflects it to the south, with the resultant ponding back of flow and trimming of the neighbouring coastal edge. Canalisation of this section of the stream might result in some improvement, especially if flow could be confined to a narrow channel, but it is very doubtful if any real cure can be effected. Such a cure would involve the halting of south-drifting sand by a groyne to the north of the mouth. While this might help to improve stream discharge, it would also reduce sand supply to the beach and dunes further south and might well trigger off erosion of the coastal edge and the development of vigorous wind erosion of the dunes. The disadvantage would thus exceed the benefit, and therefore the construction of a sand trap is not recommended.

.10 Dornoch Links is a large, sand-built foreland, with a sandy beach and foredune ridge along its eastern margin. Stability is relatively high, and reaches a maximum at the north part of the beach, where a large caravan site has been developed. The present pattern and intensity of use are not discordant with the physiography, and minor management measures could ensure the effective conservation of the main recreation area. It is recommended that the caravan site should not be further extended to the south, as dune instability might be triggered off by the passage of people between site and beach.

6.11 Cuthill Links

.1 The northern shore of the outer Dornoch Firth consists of a wide intertidal sandflat with a narrow fringing beach of mixed sediments. Landwards of the backshore, there extends a wide post-glacial strandplain consisting of raised shingle beach ridges on which varying thicknesses of blown sand have accumulated. The present characteristics of the shoreline are not favourable to sand accretion by wind blow from the beach, and it consists of a mixture of erosion and deposition,