THE IMPORTANCE OF EILEAN NA MUICE DUBH (DUICH MOSS) SSSI TO GREENLAND WHITE-FRONTED GEESE

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1. USE OF EILEAN NA MUICE DUBH SSSI BY GREENLAND WHITE-FRONTED GEESE

1.1 Eilean na Muice Dubh (Duich Moss) is the regular winter roost of over 600 Greenland White-fronted Geese (Anser albifrons flavirostris). The most recent count found over 830 geese using the site in autumn 1985. This represents over 5% of the world population of this goose. International agreements to which UK is a party accept that a site holding 1% of a population is internationally important. Whilst roosting together as one large group, the site is used by several flocks which feed separately and discretely elsewhere in central Islay during the day.

1.2 The information in this report summarises some of the past studies on the bog with respect to the geese, with particular emphasis on information collected during winter 1985/86. Additional to this report, photographs are available of some of the goose feeding areas on the site showing botanical characteristics.

Summary of use

1.3 The main roost area (A in Figure 1) is the most intensively used part of the site. Birds arrive at dusk to this area from the north (Tallant Farm area) and from the east (Avenvogie and Mulindry Farms). Few geese have been seen flighting to the bog from the east (Laggan area). Area A has several dubh lochans of moderate size, as well as smaller Sphagnum cuspidatum/Erioporum angustifolium dominated hollows and pools. The larger pools are used for roosting whilst the smaller pools are used for feeding.

1.4 Area B is a wet Sphagnum dominated flow containing several small pools and wet hollows. Birds have been seen settling in this area, and piles of droppings deposited at roost have been found. Single scattered droppings and remains of Eriophorum angustifolium indicate its use as a feeding area. It is probable that after initially settling in Area A, geese then walk out to feed on this wetter area.

1.5 Area C is similar to area A, but without the same amount of open water. To the west of the pools, regular use extends to a naturally flushed area flowing north-westwards. Botanically this is a poor-fen and here both piles of droppings from roosting birds, as well as scattered individual droppings (indicating feeding) are found. Uprooted, eaten remains of C. rostrata and other Carex spp. are commonly found in this area.

1.6 Scattered droppings and remains of eaten food plants have been found elsewhere on the site, particularly in the wettest hollows and flushed, and almost all the pools show signs of use from time to time.

Autumn roost counts: 1985

1.7 On 24 October a co-ordinated count of birds arriving at Eilean na Muice Dubh was made. A total of 611 birds arrived between 16.30 hrs and 18.15 hrs. About half the geese came from the north and east with about a quarter from the south-east and north-west. The direction from which birds arrive at a site may not necessarily reflect the areas from which they have come. Roost flights at other sites have been watched re-orientating between feeding and roost areas with changes of direction.

1.8 A further count, also co-ordinated, was made on 7 November. This found a total of 831 Greenland Whitefronts arriving to roost. A total of 225 arrived from the NNE, 586 from the WSW and none from the NE. Further non-coordinated counts on the 6 and 9 of November found 300 and 875 going to roost respectively.

Signs of goose feeding and roosting on the bog surface

1.9 Evidence indicating past use

Droppings: No other species of geese has ever been seen on this site or is known from past accounts. The presence of goose droppings, whether as roost piles or as individual droppings (indicating mobile, feeding birds) was taken as evidence of past Greenland Whitefront use. Goose droppings weather initially such that the surface blackens in contrast to the green chlorophyll rich inside to the droppings. Subsequently, the surface bleaches after long exposure to rain and sun, but the inside remains green. The colour and texture of the dropping thus allows some crude estimation of the length of time since deposition.

Dropping remains: Where a dropping has been deposited in a pool, it quickly breaks down to a pile of fibrous plant fragments that is often clearly visible against the bottom peat or Sphagna. Where the pool remains undisturbed, such remains are visible for a long time and often show clearly identifiable food remains.

Eriophorum angustifolium shoots: Greenland White-fronted Geese eat shoots of Eriophorum angustifolium in a very typical manner, pulling up the plant and then eating the stem-base and bottom 4-5 cm of stem. The remains of the stem are then discarded on the pool surface. No other species of goose is known to eat this plant in this way and remains were taken to indicate White-front use of the area.

Other plant remains: Other bog plants are exploited in a similar fashion with remains being found on the surface of the pools. These species include Nymphea alba, Menyanthes trifoliata, Tricophorum ceaspitosa, Carex rostrata, Eriophorum vaginatum etc.

Carcasses: A search was made for dead bodies and other remains, as through the winter birds die of natural causes on roost sites such as this.

Evidence of recent use

1.10 At the end of the winter, signs of goose use were found in many areas of the bog (Figure 2). The distribution of these signs in relation to the main hydro-morphological units on Eilean na Muice Dubh are shown in Figure 3. Since droppings break down over periods of time (see above), this reflects use in the latter half of the winter particularly.

1.11 It should also be noted that since geese tend to use different areas in different winters, thus allowing regeneration of uprooted Eriophorum angustifolium from Sphagnum cuspidatum dominated pools (section 4.6), areas mapped in one season do not equate to the total area used by birds

over a long period of time. Indeed, small pools and hollows containing young Eriophorum plants, presumably regenerating following exploitation in previous years, were often found adjacent to pools where heavy exploitation of Eriophorum had occurred in 1985/86.

1.12 As well as indirect signs of use, three recently dead carcasses and a pair of Greenland White-fronted Goose wings were found on the site.

1.13 Goose use was specifically concentrated in areas with very wet soft ground conditions and feeding areas were very often associated with parts of the bog with high ground cover of Sphagnum magellanicum. This species is a good indicator of high, stable water-tables. In 1985/86, use was made of all three of the main hydro-morphological features of the bog: the pool complexes, the Sphagnum dominated flows and the poor-fen flushes (Figure 2). Typical feeding areas within each of these categories are described below.

1.14 Pool complexes

A typical pool complex is that at NR 326560. The edge vegetation has been heavily modified by long term guanotrophy due to roosting geese, and most pools have the immediate edge vegetation dominated by vigorous growths of Juncus effusus. Although the larger pools have open water communities (the A2 and A3 communities of Lindsay, Riggall & Burd 1984), many of the smaller pools have an A1 (shallow water/pool edge) community dominated by Sphagnum cuspidatum and S. auriculatum. These shallower pools have considerable feeding potential being often dominated by emergent Eriophorum angustifolium. Whilst stems and rhizomes of Menyanthes trifoliata and Nymphaea alba are sometimes taken from the larger, deep, open water pools, the pools are more commonly used for roosting, bathing and preening.

1.15 As well as the abundant Juncus effusus, the bank edges have a zone of modified vegetation extending back some 3-4m from the pools. This area is characterised by several species not usually encountered on ombrotrophic bogs but whose presence here is explained by the nutrient influence of the geese. These include dense stands of mixed Sphagnum palustre and Aulocomnium palustre together with much Hylocomium splendens and Pleurozium schreberi. Grass dominated areas are frequent consisting mainly of Agrostis and Festuca species. In places there are large, vigorous hummocks of Empetrum nigrum benefiting from the more enriched conditions. Ulex gallii and Galium palustre are similarly encouraged.

1.16 The shallower pools have Sphagnum dominated A1/T1 lawns (waters edge/land edge) grading into them. As well as Eriophorum angustifolium several of the slightly enriched pools have dominant Carex limosa and other Carex sp. Some Tricophorum cespitosa and Eriophorum vaginatum was recorded as being taken from the very softest areas where geese could pull apart the tough fibrous tussocks formed by these species. Further back from the waters-edge, in areas not modified in the manner described in 1.15 above, hummocks and expanses of Sphagnum papillosum and S. magellanicum occur.

1.5.9 Sphagnum dominated flow areas

The approximate extent of Sphagnum dominated flow areas on Eilean na Muice Dubh is shown in Figure 3. Typical of these is the area which extends into the Phase 1 zone of Scottish Malt Distillers planning consent (NR 333553). This area shows signs of considerable goose use during 1985/86 (photographs available) and the area is used for both feeding and roosting. Carcasses, droppings and food-plant remains were all found in the area.

1.18 The habitat is characterised by very high ground cover of Sphagnum species, mainly S. papillosum, S. magellanicum, and S. tenellum with hummocks of S. rubellum, S. imbricatum and S. fuscum. Wetter A1/T1 lawns (Lindsay et al 1984) have S. cuspidatum and S. auriculatum. Within the Sphagnum carpet grow many leafy liverworts including Pleurozia purpurea and Odontoschisma sphagni. In areas where the ground is naturally very wet, large shallow mud bottomed pools have been created by the action of roosting and feeding geese. This is particularly the case in the north-eastern corner of Phase 1 where there are signs of heavy goose use. Here S. recurvum is present in the A1 community indicating slight enrichment.

1.19 Eriophorum angustifolium is abundant and eaten from the wetter areas. Carex panicea occurs, and in drier areas Myrica gale, Erica tetralix and Eriophorum vaginatum forms an open structured T2 (low ridge) community with Cladonia spp. Scattered Menyanthes plants are found throughout the wetter areas and the thick stems of these are occasionally taken by the geese. Rhyncospora alba is locally very abundant in areas with permanently high water-tables. In some areas it grows in association with Campylopus atrovirens in A1 hollows, indicating rapid surface run-off of precipitation.

1.20 Poor-fens and seepage areas

Natural drainage areas on the bog are of two types; old 'peat-pipes' which have collapsed internally to give deep, steep vegetated gullies which cut into the bog particularly from the north, and seepage areas which have developed poor-fen conditions due to the quantity and quality of the run-off. Goose use is confined to these latter, naturally flushed areas.

1.21 Deep open water is uncommon in these areas, and the flush in Phase 1 at NR 328551 is typified by flowing water through the site. Schoenus nigricans is frequent in the A1/T1 zone and Juncus bulbosus, a species frequently taken by Greenland Whitefronts is also common. The mud-bottoms of the wettest areas are frequently disturbed by geese, preventing permanent colonisation and maintaining the shallow open water areas. On the margins of these, and on the frequent 'islands' used for roosting, Molinia caerula and Narthecium ossifragum are abundant. Succisa pratensis, an indicator of poor-fen conditions, is common throughout. Carex rostrata is present and eaten by the geese.

1.22 Upstream, the flushes become less dominated by Sphagnum palustre and Sphagnum recurvum and more by the Sphagna typical of more ombrotrophic conditions such as S. papillosum, S. magellanicum, and S. tenellum. Sphagnum cuspidatum, S. auriculatum and Rhycospora alba are all found in some of the drainage areas at the head of these flushes.

1.23 The flushes typically have a broad band of Molinia dominated rand on either side of the wettest areas and extending for some 100m or so on either side of the streams.

1.24 Other important flush areas for the geese occur on site at NR 335553 and NR 334559. The latter shows many signs of use, especially along its south-western edge farthest from the Laggan Moss cuttings.

2. FEEDING SELECTIVITY OF GREENLAND WHITE-FRONTED GEESE

2.1 Traditional habitat selection by Greenland White-fronted Geese has been discussed by Owen (1976), Owen, Atkinson-Willes & Salmon (1986), Ruttledge & Ogilvie (1979) and Mayes (1984). The current distribution of the Greenland Whitefront along the west of the British Isles in winter is bounded by the 4° January isotherm (Belman 1981). Their winter range thus includes some of the areas of highest rainfall in Britain (excluding inland montane and upland areas). This distribution of wintering flocks is a reflection of their winter use of underground plant parts in peatland areas. Peatlands in other areas of Britain would be unavailable for long periods in winter due to prolonged periods of freezing conditions.

2.2 In the past, it seems probable that the race was dependant almost exclusively on areas of raised and blanket bog (Owen 1976, Ruttledge & Ogilvie 1979, Fuller 1982). The earliest studies of winter diet showed that many typical bog plant species were taken in these situations: Eriophorum angustifolium (Ruttledge 1929; Cadman 1953, 1957); Rhyncospora alba (Cadman 1953, 1957; Pollard & Walters-Davies 1968); Tricophorum cespitosa (Campbell 1947). Other food plants more recently identified in the diet of bog-feeding geese on Islay include: Carex panicea, Carex rostrata, Cladium mariscus, Menyanthes trifoliata, Juncus bulbosus, Eriophorum vaginatum, Eleocharis multicaulis and Nymphea alba (Stroud unpubl). Narthecium ossifragum has been found eaten on Irish boglands (Mayes 1984).

2.3 All these species are either aquatic or grow in the very wettest and thus softest parts of peat-bogs. Pollard & Walter-Davies (1968) demonstrated the importance of the softness of substrate in the extraction of Rhyncospora alba. This was of great importance in the selection of feeding area on Cors Caron (Tregaron Bog).

2.4 Semi-natural and agricultural habitats are also used in some areas of the winter range - increasingly so in some areas. However, where birds feed during the day on pastures, they still resort at night, or in the event of disturbance, to peatlands (Ruttledge & Ogilvie 1979). In an analysis of all known roosts in Argyll, a county holding over 80% of the British population, some 33 of 42 roosts (over 78%) were found to be closely associated with peatland areas (Stroud 1985a).

2.5 A range of poor quality agricultural grasses have been identified as comprising the bulk of the diet on farmland: Deschampsia flexuosa, Agrostis tenuis (Pollard & Walters-Davies 1968), Agrostis spp, Anthoxanthum odoratum, Cynosurus christatus, Festuca rubra, Festuca ovina, Festuca pratensis, Holcus lanatus, Lolium spp, Equisetum spp, (Mayes 1984), Glyceria fluitans (Pollard & Walters-Davies 1968; Mayes 1984).

2.6 Dicotyledons are also taken from cultivated areas. Rannunculus acris and R. flammea roots and stem-bases, and Trifolium repens stolons being commonly taken (Mayes 1984; Owen in Cramp & Simmons 1977). Additionally, the stem-bases and roots of Cardamine pratensis, and the over-wintering bulbils of Triglochin palustre are taken from poorer, permanent pastures on Islay (Stroud unpubl).

2.7 In the main wintering areas of Islay and Wexford, use of autumn stubbles is commonplace. Here spilt barley grain is eaten in large quantities if and whilst available. At Wexford, winter wheat is also taken (Owen in Cramp & Simmons 1977). No winter cereals are grown on Islay so this is not available to wintering geese here. At both Wexford and Islay, potato eating has been recorded, but generally root crops are an unimportant food item in contrast

to related grey goose species such as the Greylag Goose (Anser anser). Feeding in sugar-beet fields has been recorded at Wexford (Cramp & Simmons 1977).

2.8 Use of salt-marshes is not common, but a few flocks do seem to feed in such areas. The Dyfi Estuary flock regularly graze both on the saltings, where they take Festuca rubra, and also on the mudflats of the estuary where they eat Spartina townsendii shoots (Fox & Stroud 1986). Similar marsh grazing is found at a few other Scottish sites. However, the only flock known to eat Spartina townsendii is the Dyfi flock.

2.9 In summary, whilst poorer agricultural pastures are used by Greenland Whitefronts during the day for feeding, all birds resort at night onto bog areas to roost. Here they principally feed on Eriophorum angustifolium and Rhyncospora alba from the wettest areas of the bog. Evidence from activity budget and other studies shows that the food taken on the bog roosts at night is significant: in the region of 20% of the daily total food intake (Stroud unpubl).

3. EFFECT OF PROPOSED DEVELOPMENT ON GREENLAND WHITEFRONTED GEESE

3.1 The main bog plants eaten by Greenland White-fronted Geese, such as Eriophorum angustifolium, Juncus bulbosus and Rhyncospora alba, are those found growing in the very narrow vegetation zone just above and below the water-table. As such these species are particularly sensitive to changes in the long-term position of the water-table. NCC has presented evidence to show that widespread changes to the water-table and hydrology of the bog can be expected if the drainage and peat-cutting continues as proposed. These hydrophilous food plants will be detrimentally affected by any such changes in distribution and abundance.

3.2 Although apparently making up a minor part of the winter diet of the Greenland White-fronted Goose, the importance of Eriophorum angustifolium is great. The part of the plant selected is the stem-base (Phillips 1953), a swollen area of rhizomatous tissue that in winter holds very high concentrations of carbohydrates and other plant nutrients (Shaver & Billings 1976). Chemical composition of stem-bases is shown in Table 1. Stem-bases of Eriophorum show great increase of organic carbohydrate content with age due to the fact that they are continually growing. With each new leaf produced by the plant, another node and short internode is added to the stem-base. As a result, the amount of Total Non-structural Carbohydrate (TNC) in Eriophorum stem-bases ranges from 1.94 mg per stem-base in young shoots to 12.34 mg per stem-base in mature plants (Shaver & Billings 1976).

3.3 On average, Greenland Whitefronts consume some 15-35%, by weight, of Eriophorum angustifolium shoots (Figure 4). However, changes in the relative proportions eaten of different sized plants (Figure 5) occur as the winter proceeds. This is related to underlying growth changes occurring in the plant as spring approaches. In spring, a higher proportion of larger plants is consumed. This is in line with a maximisation of carbohydrate intake (see 3.2 above) to optimise spring physiological condition. The largest, oldest plants have greatest TNC stores and are actively selected.

3.4 Both Reed (1976) and Fox, Madsen & Stroud (1983) draw attention to the role of micro-nutrients in the determination of breeding success of arctic nesting geese. The role of their traditional bog foods in supplying the necessary trace-elements for successful reproduction as well as being a high carbohydrate food source may well be of crucial importance for successful breeding (Fox, Madsen & Stroud 1983). Takahe (Notornis mantelli) also select a very high carbohydrate winter diet of fern rhizomes. Balanced micro-nutrient intake is also considered important in determining successful breeding in this species (Mills et al. 1980).

3.5 In a study of the nutrition of Lesser Snow Geese (Anser caerulescens caerulescens), Thomas & Prevett (1980) found that these geese ate large quantities of over-wintering Triglochin palustre bulbils on their spring staging grounds. Such bulbils are common in many of the areas used by Greenland Whitefronts. Because the precise nutrient requirements of wild goose species are unknown, the nutrient levels of the bulbils were compared with commercial goose ration formulas (Table 2). The over-wintering bulbils were found to be almost ideally balanced in terms of micro-nutrients and contained only 5-7% fibre; a level that would not interfere with soluble carbohydrate digestion.

3.6 In a possibly analagous situation, Gauthier et al. (1984) studied spring accumulation of fat by Greater Snow Geese (Anser caerulescens atlanticus) in two different habitats. Fat accumulation and body weight gain was found to be significantly greater in traditionally used Scirpus-dominated, fresh-water marshes, than in recently invaded salt-water, Spartina-dominated marshes. On departure to the breeding grounds, males which had fed in traditional Scirpus marshes carried 23% more fat, and females 9% more fat than those using the more recently utilised Spartina marshes. This weight difference in females was equivalent to some 50g of extra fat, the energetic equivalent of an extra 2.5 eggs (Gauthier et al. 1984).

3.7 Reed (1976) pointed out that pasture and cereal crops are clearly attractive to most geese and seem superficially adequate for winter needs from a nutritional point of view. However, a 'farmland' diet, particularly in early spring, may not be ideally balanced for the specific requirements of breeding. One would expect geese to know what to select at the proper time, but it is possible that the 'new' agricultural habitat simply does not contain all the elements necessary to satisfy a physiological system which evolved to cope with a quite different range of foods (Reed 1976). The continued use of some peatland vegetation by Greenland White-fronted Geese in the face of abundant alternative habitat probably reflects factors of this kind. Thus the consumption of traditional bog plants, nutritionally attractive, may well be essential for a well-balanced diet, enhancing spring weight gain and subsequent breeding success.

3.8 Breeding success of this population of goose is consistently low (Owen 1978, Stroud 1984a, 1984b, 1985b, Wilson & Norriss 1985, Ruttledge & Ogilvie 1979). In 1983, from a world population of 17,670 geese only an estimated 724 pairs successfully reared young (Table 3).

3.9 Conditions on the wintering areas have been found to be of importance in determining subsequent breeding success of goose populations. Cabot and West (1973) found that, for Greenland Barnacle Geese (Branta leucopsis), there was a strong positive correlation between mean winter temperature and mean brood size (a measure of summer productivity) the following autumn. They considered that winter temperatures directly affected the growth of vegetation on the wintering areas of the Barnacle Geese. Following mild winters, there was lush, high quality forage available, allowing rapid accumulation of fat reserves. Birds returned to Greenland in good condition and had high breeding success.

3.10 Using individually marked geese, Ebbinge et al. (1982) showed that spring conditions and weight gain in the Wadden Sea was a major determinant of the breeding success of Dark-bellied Brent (Branta bernicla bernicla) nesting in Taymyr, arctic Siberia.

3.11 Whilst precise energy and nutritional budgets are not completely understood, it would be premature to state that bog-plant feeding by Greenland Whitefronts does not affect subsequent fat accumulation and thus breeding success. Certainly, these analagous studies of other geese suggest that this may well be the case. In conservation terms, any potential lowering of an already low level of productivity should be avoided if at all possible due to the long time this small population would take to recover from such a reduced recruitment.

4. THE NEED TO CONSERVE EILEAN NA MUICE DUBH AS A GOOSE ROOST

4.1 The distribution of known Greenland White-fronted Goose roosts on Islay is shown in Figure 6. Although minor roosts may remain to be discovered, all the major roosts are shown. All Islay roost sites are either on peatland areas or on lochs with adjacent peatlands that are used for feeding. The broad selection of these habitats as roost sites reflects the winter distribution of the Greenland White-fronted Goose in areas with oceanic blanket and raised mires in the western British Isles. The type of roost and nocturnal feeding sites used by the Islay wintering geese (Stroud 1985a) is typical of those used by Greenland Whitefronts wintering elsewhere in Argyll, and indeed in Britain (Ruttledge & Ogilvie 1979).

4.2 A few roost sites hold large numbers of geese, many hold smaller numbers. Numbers using individual sites correlate roughly with the size of the site suggesting that the geese regulate roost use to maintain a more or less fixed spacing or density of feeding birds at night. The lesser roosts do not, in themselves, qualify for protection as Sites of Special Scientific Interest, and indeed several have been lost due to changes in land-use, principally through coniferous afforestation (Stroud 1985a). Thus the relative importance of the remaining, undisturbed, major roosts such as Eilean na Muice Dubh, increases with the loss of these minor roosts.

4.3 Analysis of sightings of individually marked geese (Fox & Stroud in press), shows that winter use of roosts and feeding areas is traditional. There have been no moves between wintering sites recorded within a winter and very few between winters. In six years, only some 4% of marked birds have changed wintering area, and these in circumstances to suggest movement was induced by mate loss.

4.4 Ruttledge (1973) and Ruttledge & Ogilvie (1979) documented desertions of wintering areas in Ireland following drainage or disturbance of bog and wetland roost and feeding areas. Such desertions were apparently not associated with corresponding local population increases elsewhere at the time these areas were deserted. This indicated to Ruttledge & Ogilvie (1979) that damaging changes to the quality of traditional wintering areas resulted in local extinctions of wintering flocks following reduced breeding success and spring body condition of wintering geese.

4.5 There is a high risk that such a situation would follow the drainage and peat-cutting at Eilean na Muice Dubh. Given that birds roost at a fairly constant density (para 4.2 above), current and projected land-use change due to afforestation indicates that other Islay roosts would be insufficient to hold the number of birds displaced from Eilean na Muice Dubh. Such a displacement (as opposed to extinction), even if it occurred would most probably result in a lowering of condition and hence breeding success. Breeding success is already low in this population (Ogilvie 1978; Table 3).

4.6 It could be argued that peat-cutting would only slightly reduce the area available for feeding, thus affecting only a small proportion of the roosting birds at Eilean na Muice Dubh. Aside from the hydrological damage which would undoubtedly cause widespread and irreversible damage to the vegetation of the bog, there is evidence to show that the geese use bog areas in a cyclical fashion. Geese extract Eriophorum angustifolium growing in damp Sphagnum filled pools and hollows. After extraction of all suitable plants, birds move to the next suitable pool/hollow within the site. Recolonisation of the hollow by Eriophorum takes 2-3 years (Stroud unpubl). Figure 7 shows how birds exploited a series of bog pools on Islay in the autumn before moving to a nearby area of pools later in the winter. These pools were not revisited for at least a year following this concentration of foraging here, thus allowing recovery of the Eriophorum food resource.

4.7 Thus, in any one year, the area used by roosting and feeding geese is not necessarily the minimum area needed to provide an adequate long-term food supply. Such considerations are important in the present situation.

4.8 In summary:

1. All Greenland White-fronts on Islay return at night to feed and roost on peatland areas.

2. Loss of peatland habitat in Ireland between the 1950s and 1970s was a major factor resulting in a halving of the wintering population there.

3. The population has remained apparently stable in Scotland because habitat loss, until recently, has not been so severe.

4. Recent developments in forestry technology have begun a process of loss to the blanket mires of Scotland on a scale similar to that experienced in Ireland.

5. The impact of such habitat loss is unlikely to show in the population instantly due to the long maturation period before breeding in this goose.

6. Recent protective measures, eg cessation of shooting has lowered mortality and will have temporarily masked any longer term downward trend in this population.

7. Counting techniques have recently improved resulting in higher totals for some areas and non-comparability of recent counts with earlier totals.

8. Exceptional weather in 1985 resulted in very large numbers of young temporarily inflating the population.

9. Small areas of peatland on Islay cannot support the thinly scattered wintering population as long as they continue to be lost to commercial afforestation.

10. As a major roost, the geese use virtually the entire area of Duich Moss.

11. Over and above any hydrological impact, loss of any part of Duich Moss would result in an increase in roosting density to the detriment of optimal feeding.

12. Dispersion of birds to other smaller sites would increase the risk of guanotrophy there and a lowering of overall roost quality.

13. Whilst factors mentioned above have temporarily increased the population in some areas, site-based habitat conservation remains crucial to the long-term conservation of this goose.

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Table 1. Wet and dry weights per unit length and percent of wet and dry weights for nonstructural carbohydrates. Values are in mg/mm or percent.

Species Tissue	Age	fresh wt/ length	dry wt/ length	% dry wt	Sugar dry wt %	Sugar wet wt %	Sugar wt/ length	Storage Polysaccharides dry wt %	Storage Polysaccharides wet wt %	Storage Polysaccharides wt/ length	TNC dry wt %	TNC wet wt %	TNC wt/ length
Eriophorum													
Roots	new	0.10+.01	0.02+.01	23+2	17.46	3.97	.0037	5.15	1.17	.0011	22.61	5.14	.0049
Rhizomes	new	1.86+.15	0.19+.01	11+1	28.05	3.04	.0540	13.67	1.48	.0263	41.71	4.52	.0803
	mature	1.43+.10	0.23+.02	17+1	9.25	1.53	.0214	17.41	2.88	.0404	26.65	4.14	.0618
	old	1.83+.38	0.31+.07	17+1	8.56	1.49	.0266	9.43	1.64	.0293	17.99	3.14	.0558
Stembases	young			16+1	8.87	1.41		37.40	5.98		46.36	7.39	
	old			16+1	8.55	1.36		26.09	4.15		34.64	5.51	

From: Shaver & Billings (1976).

Table 2 Amino acid percentages in T. palustris bulbs (x, N = 2). The estimated availability of each amino acid as a percentage of the diet is related to their recommended levels in commercial goose rations.[a,b,c] From Thomas & Prevett (1980).

		T. palustris bulbs	
	Amino acid	Amino acid available from diet[e]	Amino-acid level in goose starter diet[d]
Essential amino acids			
Lysine	6.12	0.54	0.67
Arginine	10.26	1.09	0.70
Threonine	3.28	0.35	0.55
Leucine	5.46	0.58	
Isoleucine	3.04	0.32	
Valine	5.34	0.57	
Methionine	0.47	0.05	0.26
Cystine	0.64	0.07	0.23
Tyrosine	1.27	0.13	
Phenyalanine	2.70	0.29	
Histidine	2.72	0.29	
Non-essential amino acids			
Alanine	8.17	0.87	
Glycine	7.67	0.81	
Proline	10.35	1.10	
Serine	4.79	0.51	
Glutamic acid	18.49	1.96	
Aspartic acid	9.20	0.98	

a Values expressed as molar percentage of total amino acids exclusive of tryptophan, which is destroyed by acid hydrolysis. Values for T. palustris are the average for the 2 locations.

b Availability derived from the product of percent amino acid and percent crude protein x protein digestibility/100. Protein digestibility was estimated at 0.81, the average digestibility of crude protein in commercial cereal grains of low fibre content (Summers and Leeson 1977).

c Domestic goose starter and finishing rations (Summers and Leeson 1977).

d Percentage of total diet by weight for 5 critical amino acids.

e Calculated using 13.11 as percent crude protein, and 0.81 for protein digestibility.

Table 3. Breeding performance of different population segments of the Greenland Whitefronted Goose in 1983. Data: Wilson & Norriss 1985; Stroud 1984[b].

			PRODUCTIVITY		
AREA	% Young	Mean Brood size	Total popn	Estimated total young	Estimated total families
Wexford	12.3%	3.37	6258	769	228
Other Irish sites	13.9%	2.40	3230	449	187
Islay	9.9%	2.66	4592	455	171
Other Scottish sites	9.2%	2.40	3503	322	134
Welsh sites	10.5%	2.67	93	10	4
TOTAL	11.34%	2.77	17,670	2005	724

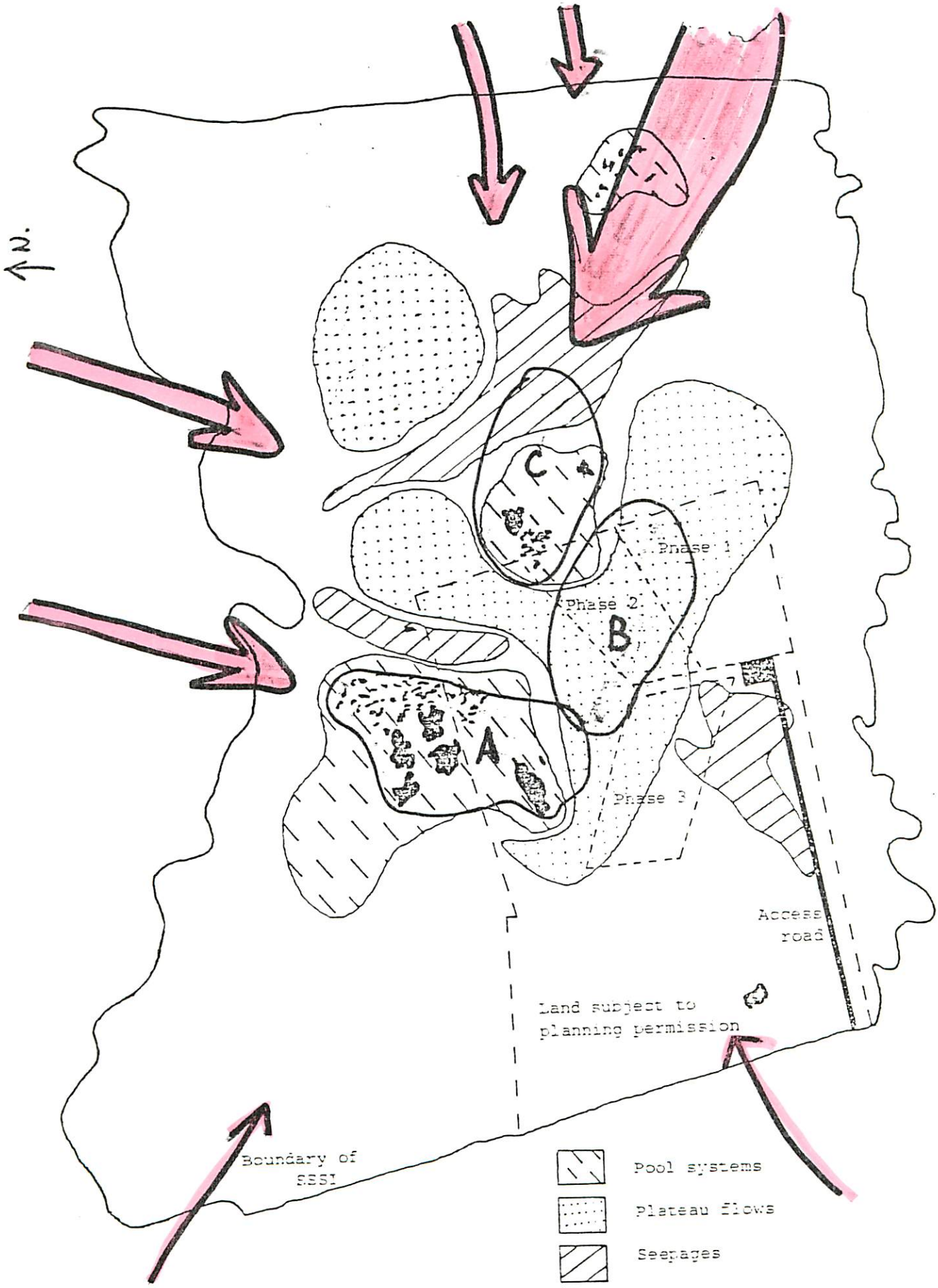
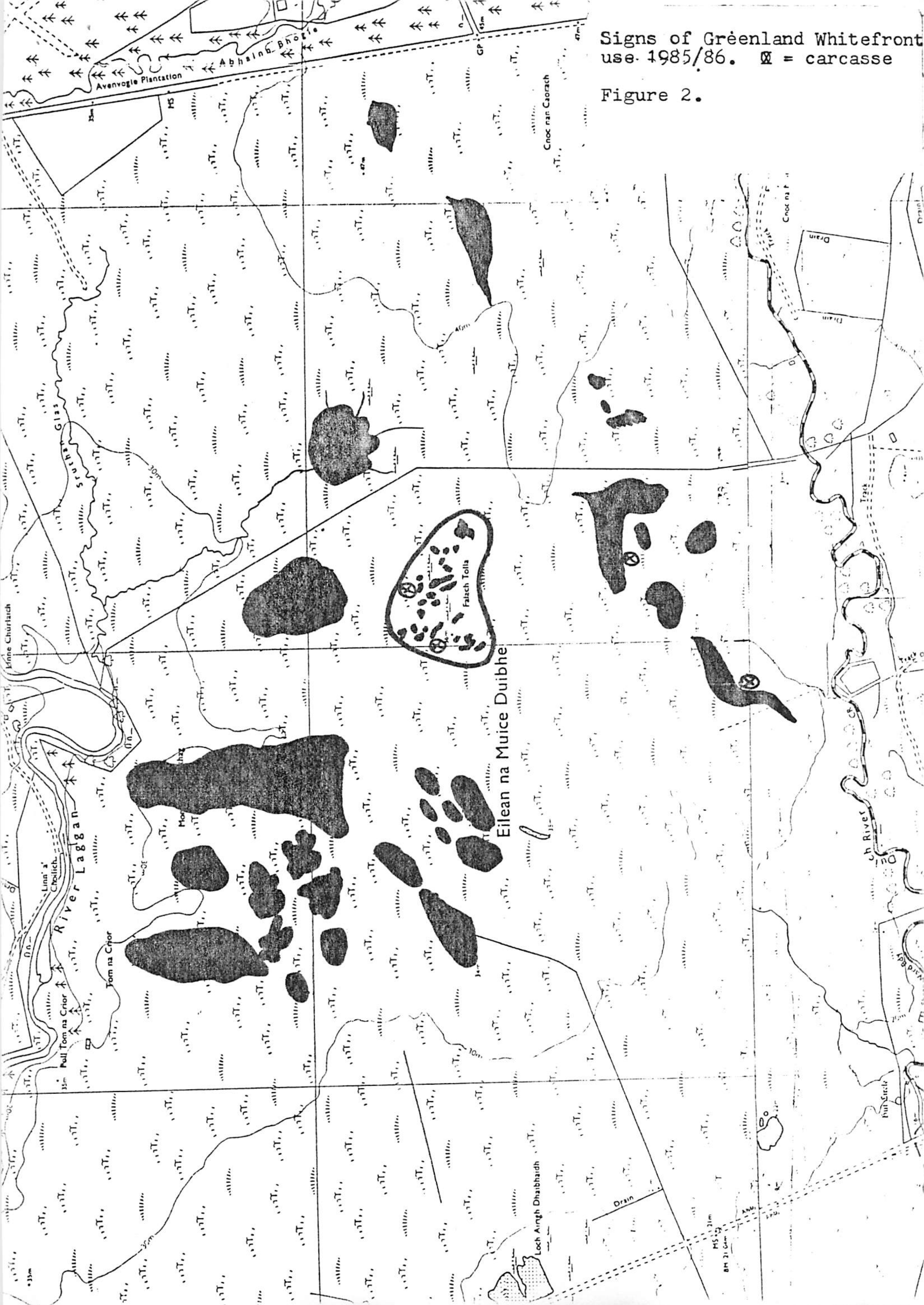


Figure 1. Map of Eilean na Muice Dubh showing main vegetation types, area subject to planning consent and main areas used by Greenland White-fronted Geese. Also indicated are main flight lines to roost from feeding areas elsewhere on Islay.

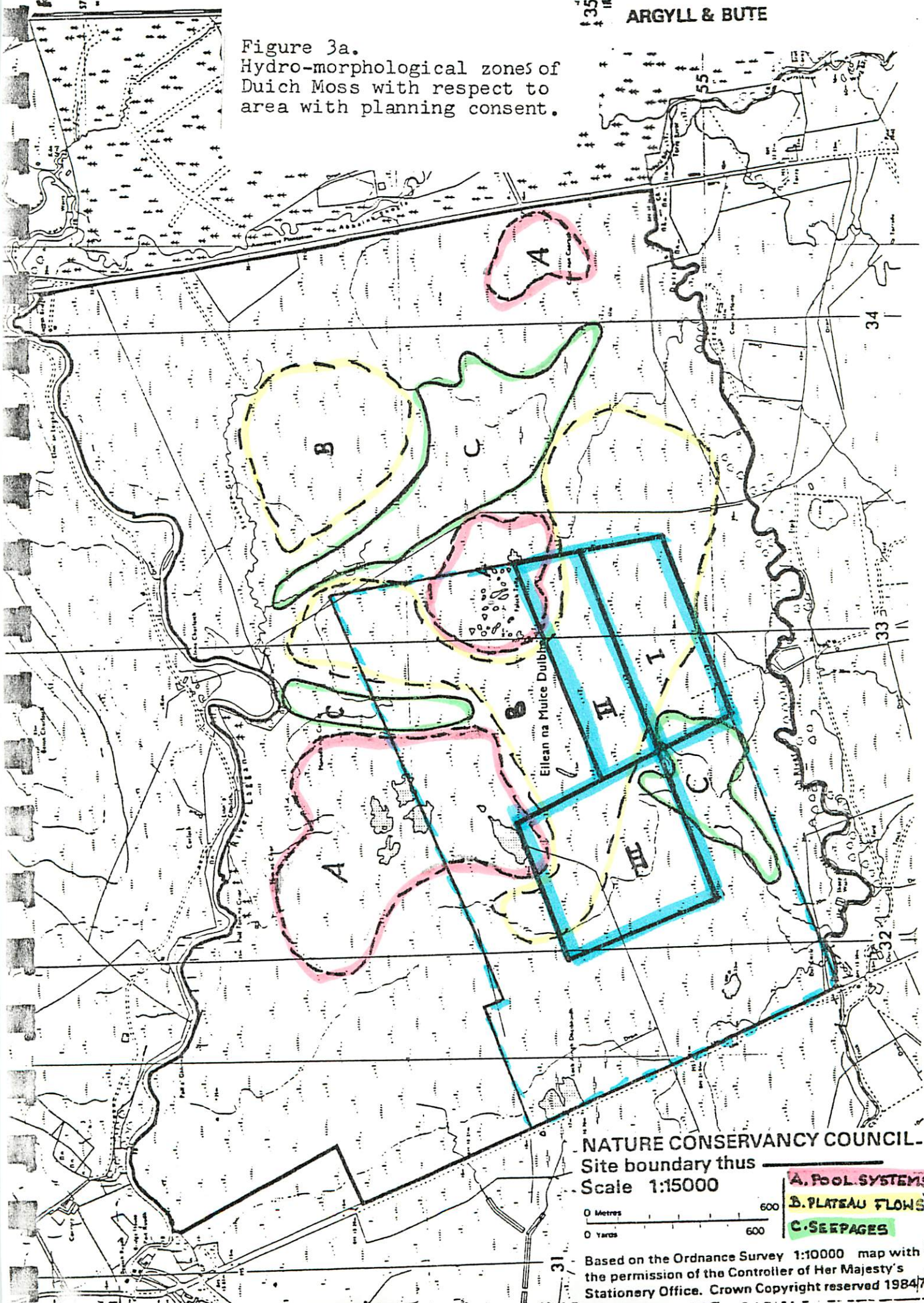


Signs of Grèenland Whitefront use 1985/86. ⊠ = carcasse

Figure 2.

EILEAN NA MUICE DUIBHE
ARGYLL & BUTE

Figure 3a.
Hydro-morphological zones of Duich Moss with respect to area with planning consent.



NATURE CONSERVANCY COUNCIL.
Site boundary thus
Scale 1:15000

0 Metres 600
0 Yards 600

A. POOL SYSTEMS
B. PLATEAU FLOWS
C. SEEPAGES

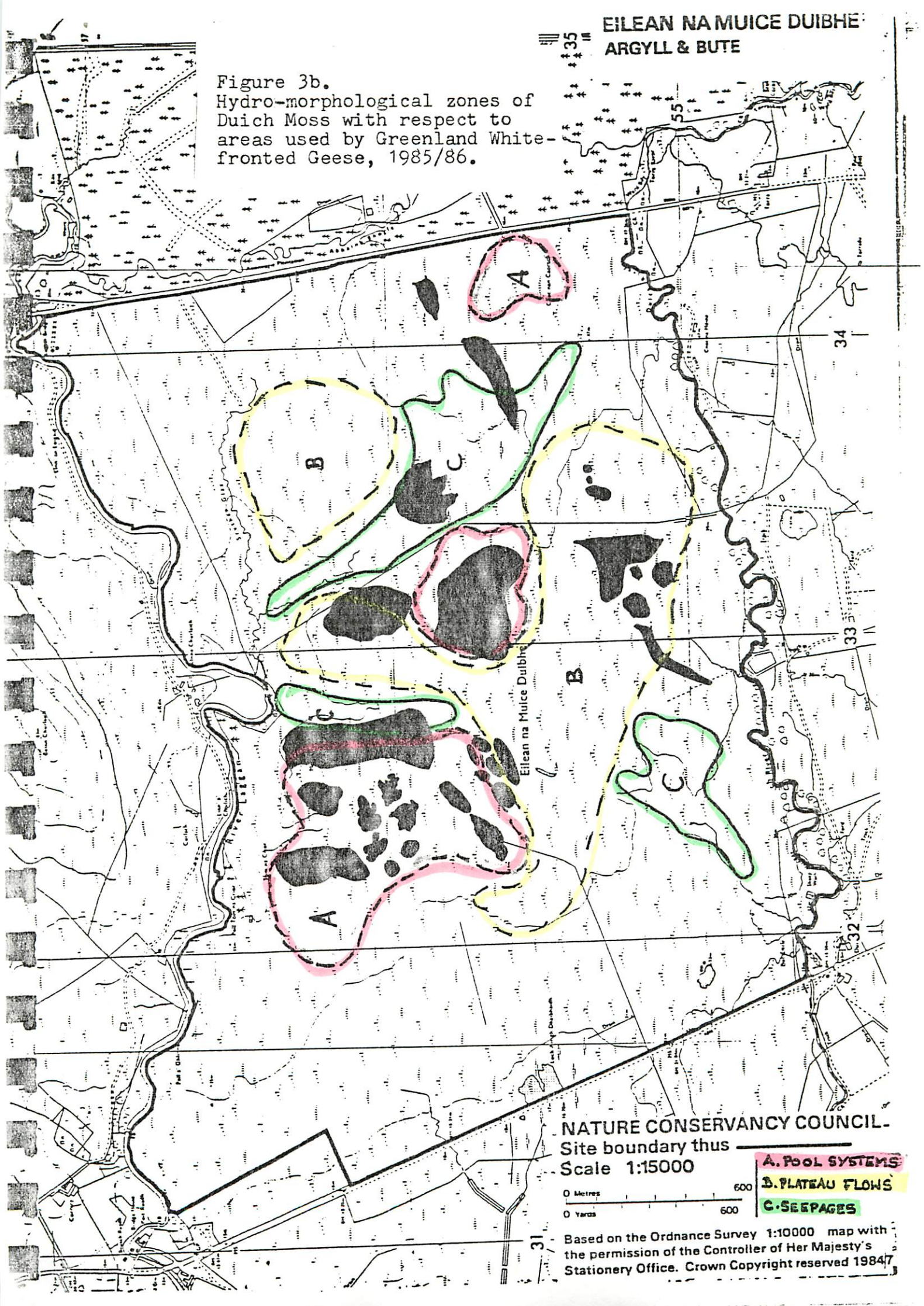


Figure 3b.
Hydro-morphological zones of Duich Moss with respect to areas used by Greenland White-fronted Geese, 1985/86.

Figure 4 Weekly changes in proportion of Eriophorum eaten on a bog roost on Islay.
Mean values with sample size.

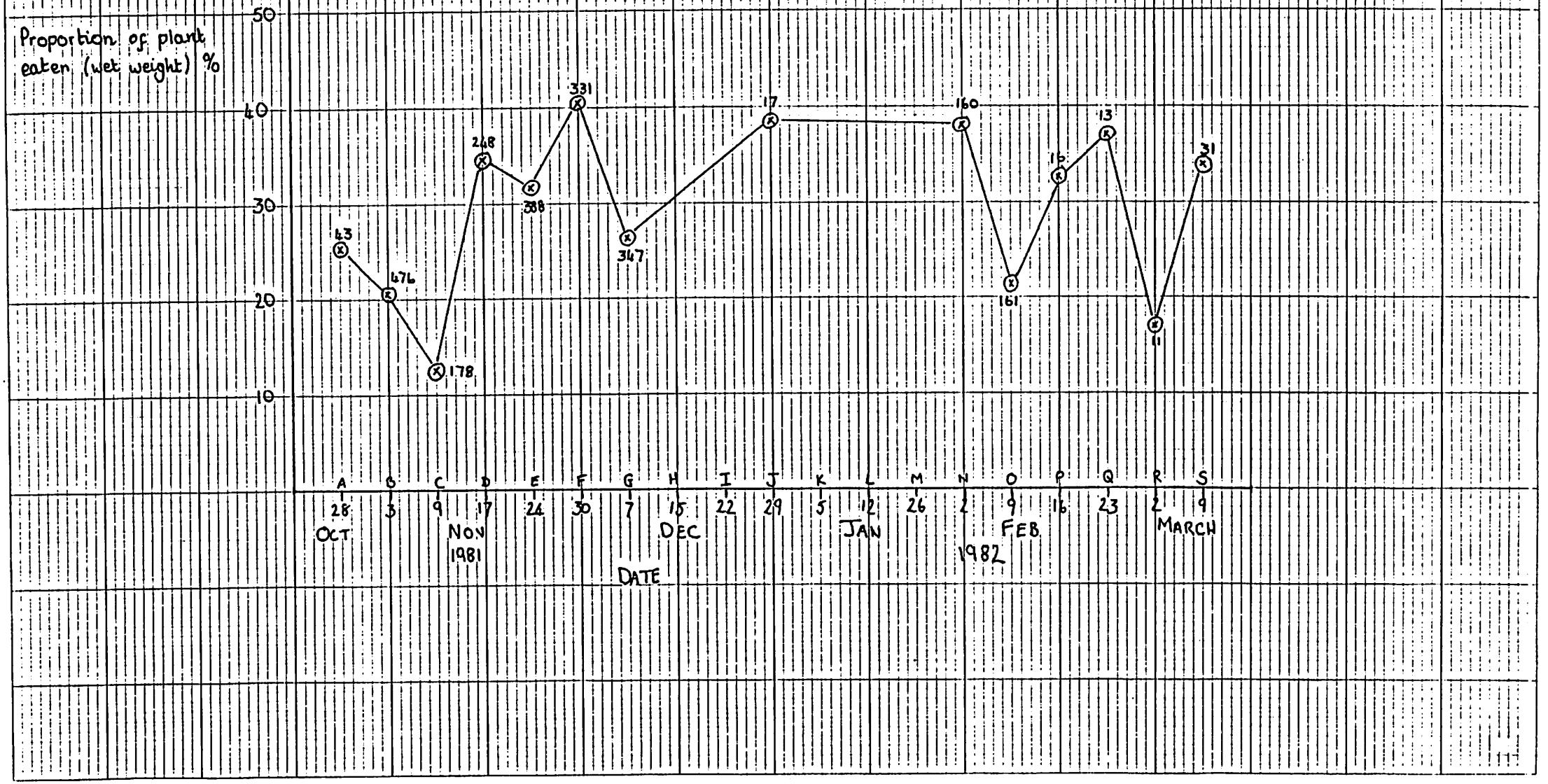


Figure 5 Changing proportions of Eriophorum grazed during winter 1982/83 on a bog roost on Islay.
Regression lines during three periods in winter.

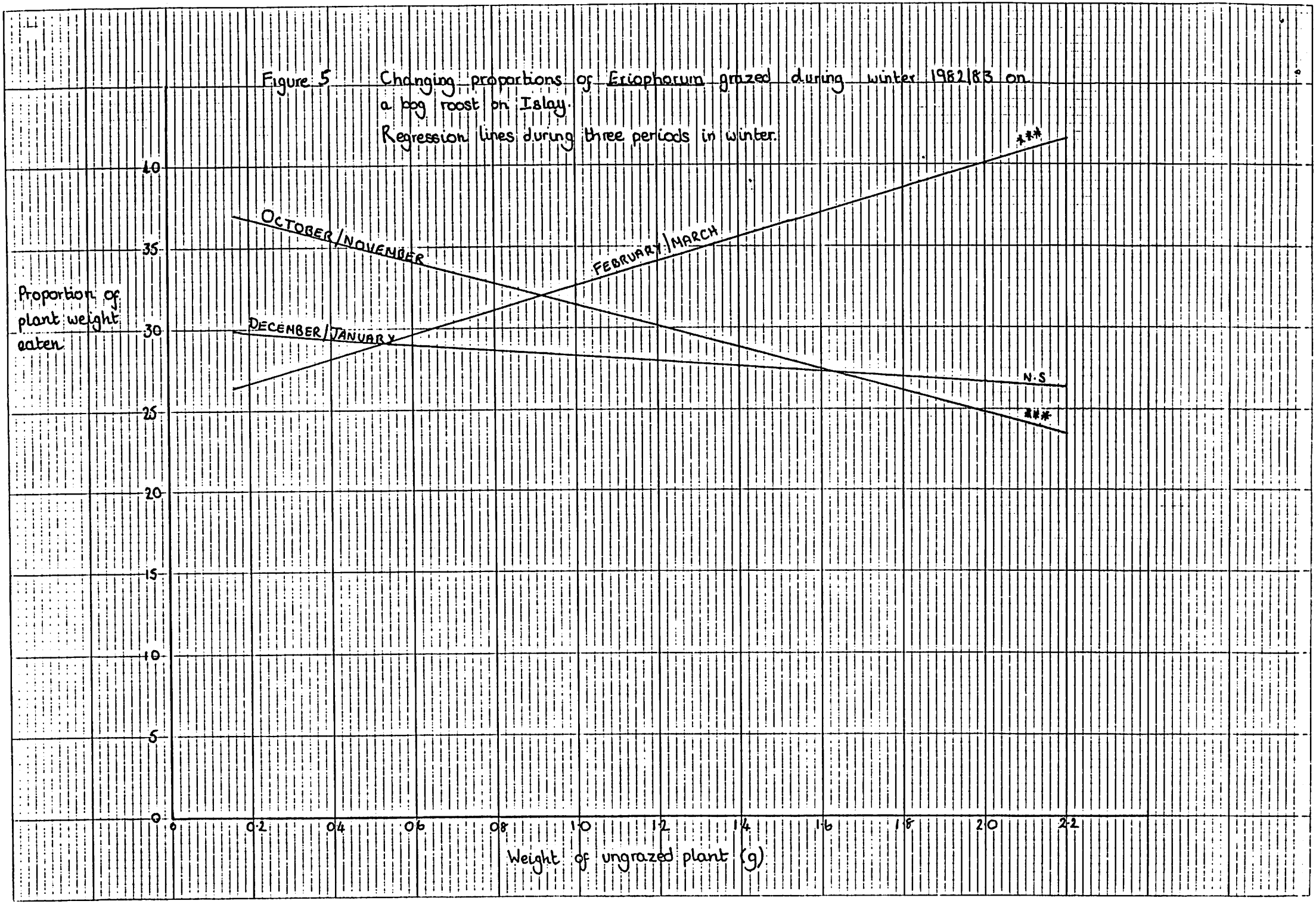


Figure 6 Goose count areas on Islay
(shading = roost sites)

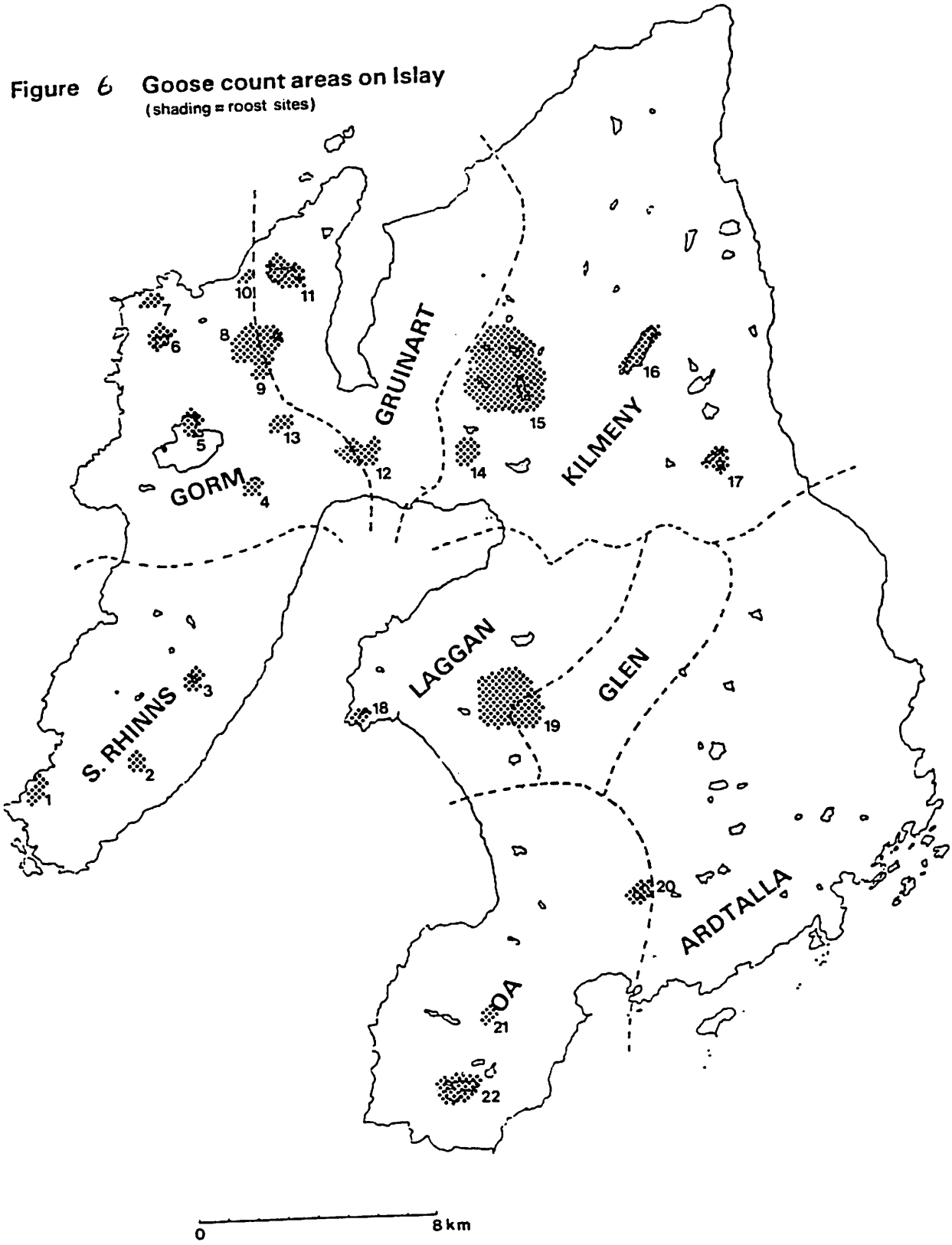


Figure 7 Change in use of a bog pool complex over the winter as reflected by weekly collections of all grazed Eriophorum plants within the pools. 1981/82. Islay.