CHAPTER 2 METHODS

2.1 INTRODUCTION

Islands, where comparatively high numbers of Choughs are concentrated in discrete areas, provide good opportunities and facilities for ecological study (*e.g*. Bullock 1980, Bullock & del-Nevo 1983, Roberts 1985, Warnes 1982, Still 1989, and McKay in prep.) but the ecology of mainland Choughs has been little studied (*cf*. Owen 1985). Objective research on the species has occurred principally in North Wales and on Islay. Of the above studies, Ian Bullock pioneered work into Chough behavioral ecology on Anglesey and the Isle of Man, followed notably by Warnes on Islay, and Roberts on Bardsey. The Islay effort is continuing (*e.g.* Monaghan *et al*. (1989), Still (1989), and McKay (in prep.). Within Europe generally there is growing interest (see Bignal & Curtis 1989). This body of work has greatly increased knowledge whilst at the same time revealing paradoxes and gaps.

Published work on the Chough in West Wales relies largely on the censuses of Donovan (1973) and Roderick (1978). The Nature Conservancy Council (NCC) in Dyfed-Powys, Wales was concerned about the status of the species (see, *e.g*. Gamble 1984, Gamble & Haycock 1988), therefore the Welsh and Cornish/English interests were integrated into the research objective explained in Section 1.2.

The methods employed in this study are essentially twofold and of a comparative nature:

(1) broad comparison of Welsh areas within current Chough range, and Cornwall currently outwith Chough range, comparison of resources used by Choughs within the Welsh areas, again related to Cornwall; and

(2) comparison of past land-use regimes with present day regimes within and between Wales and Cornwall. This duality of habitat assessment required the selection of 2 levels of study areas: (i) large scale uniform selection of 1km squares including both used and unused habitats, inland and coastal (2.2); and (ii) smaller observational study areas within these (2.3).

Regarding bird observation, unlike the island communities referred to above, *i.e*. South Stack (Anglesey), Bardsey, Islay and the Calf of Man, the Choughs in Dyfed are scattered thinly along an extensive mainland coastline. Practical and technical problems beset the study of low density populations, especially when distributed through 5 separate study areas over more than 100km of coastline (2.5.2). The Cornwall element was located *ca.* 120km across the Bristol Channel (a road journey of >480km). The Cornish effort was spread over 4 sub-areas (all historically important for Choughs) separated along >230km of coast (2.3). A study circuit of all study sites involved a round trip of *ca*. 1500km every 6-8 weeks.

2.2 BACKGROUND HABITAT ASSESSMENT

Habitats in Wales and Cornwall were sampled in order to assess broad features of land type. Bunce & Shaw (1973) have stressed the importance of objectivity and standardisation in ecological sampling and surveying techniques. To maximize the benefits of this study, it was designed to be compatible with a similar study on Islay (Bignal *et al*. 1988, Curtis *et al*. 1989), but comparison is beyond the scope of the present study. The full methodology is given in Section 4.2.1. Six areas (3 each in Wales and Cornwall; see Appendix II and Figure 2.1), subdivided on the Ordnance Survey (OS) km square grid matrix (Figures 2.2 - 2.5), were used for the initial assessment. These were selected to provide fundamental habitat data within principal Chough and ex-Chough regions. A

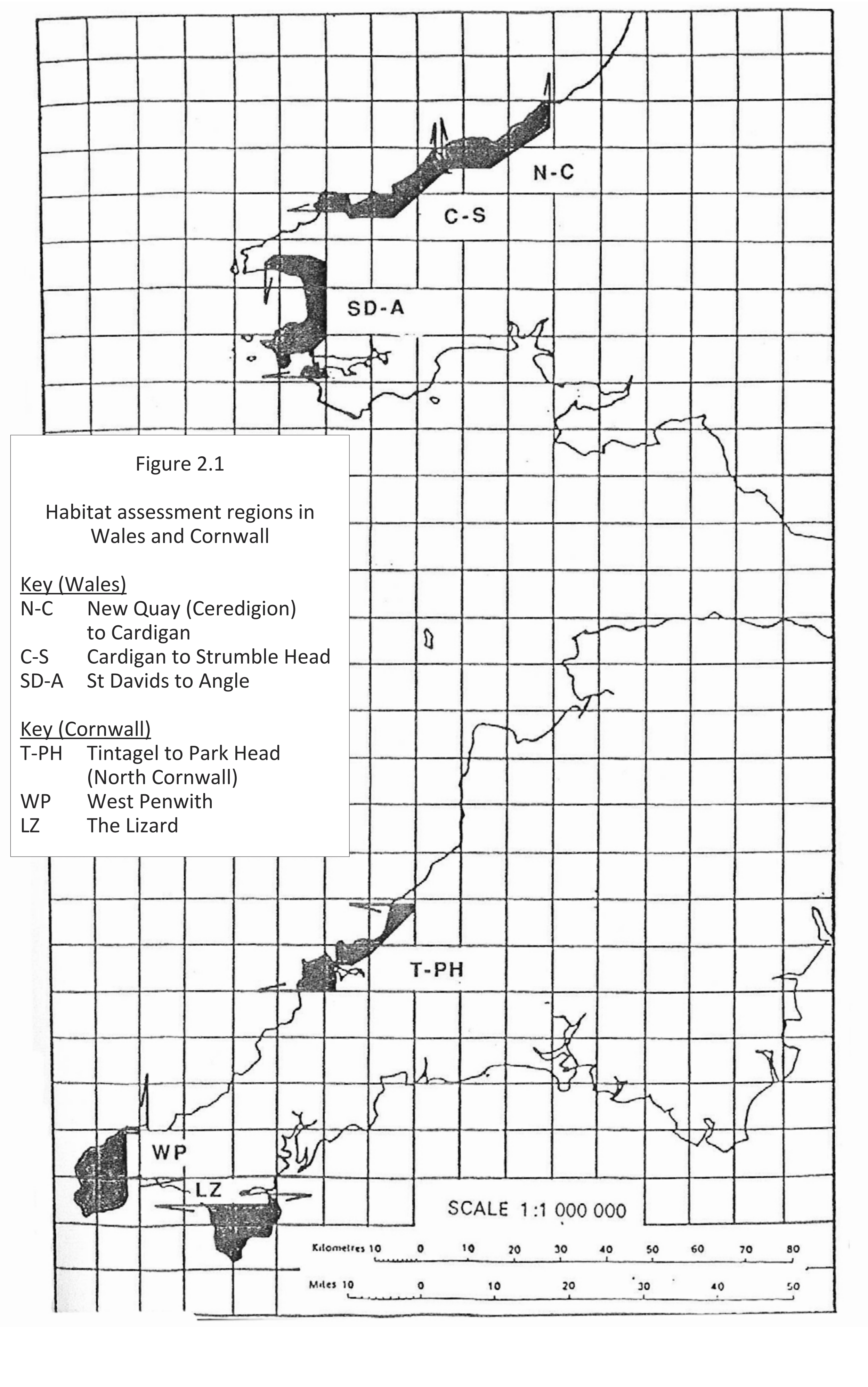


Figure 2.1

Habitat assessment regions in Wales and Cornwall

<u>Key (Wales)</u>

N-C New Quay (Ceredigion) to Cardigan
C-S Cardigan to Strumble Head
SD-A St Davids to Angle

<u>Key (Cornwall)</u>

T-PH Tintagel to Park Head (North Cornwall)
WP West Penwith
LZ The Lizard

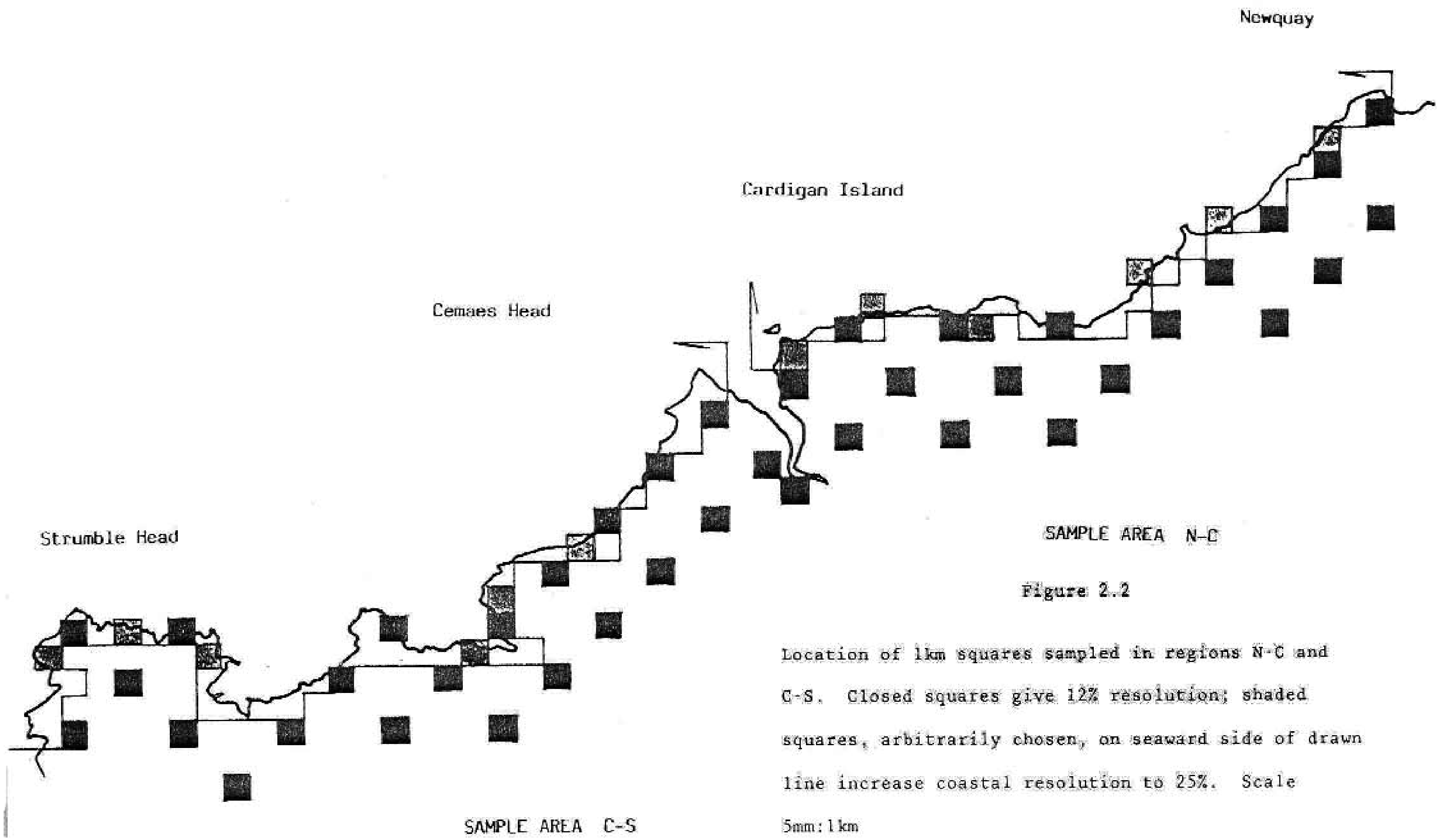
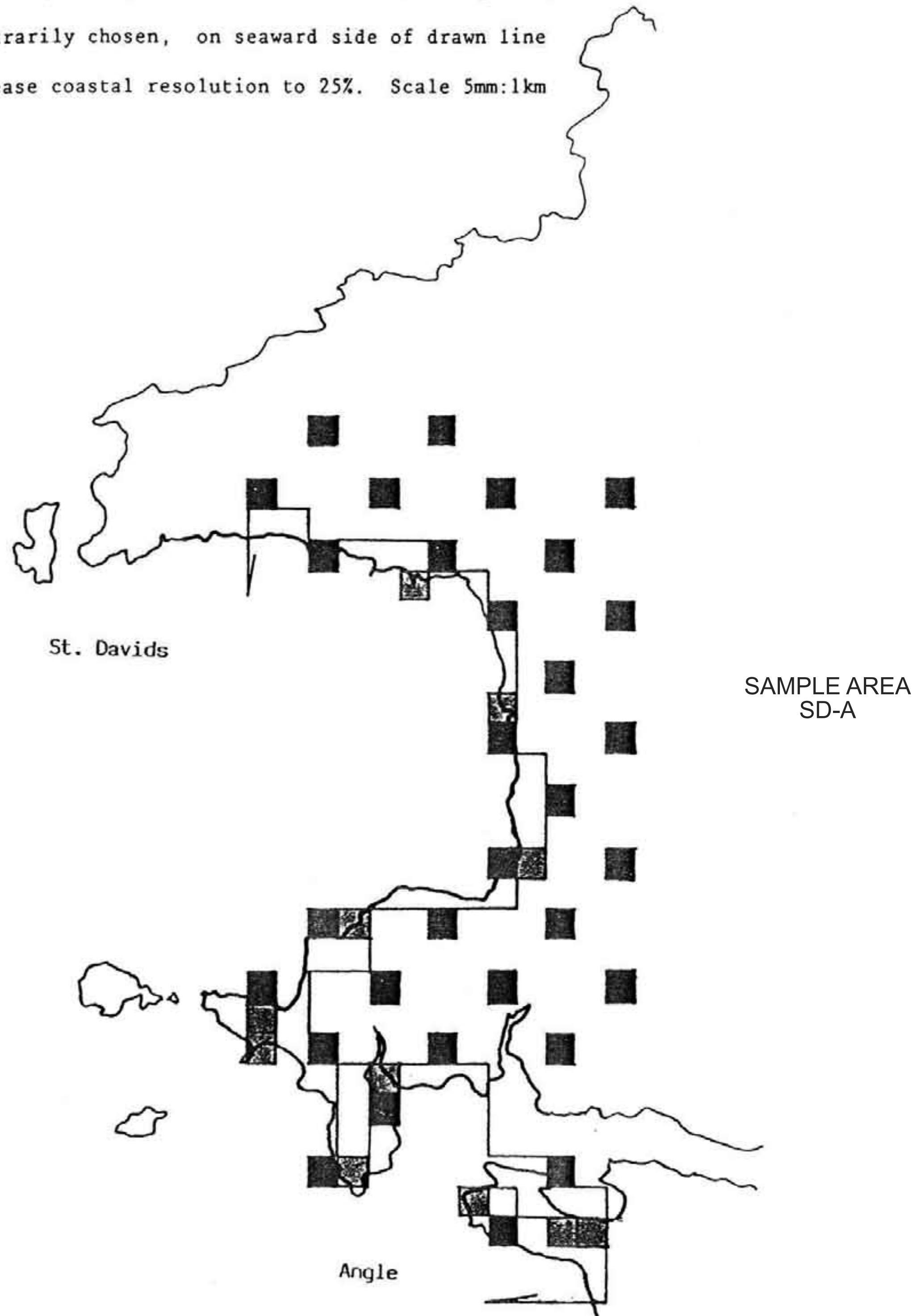


Figure 2.2

Location of 1km squares sampled in regions N-C and C-S. Closed squares give 12% resolution; shaded squares, arbitrarily chosen, on seaward side of drawn line increase coastal resolution to 25%. Scale 5mm:1km

Figure 2.3

Location of 1km squares sampled in region SD·A. Closed squares give 12% resolution; shaded squares, arbitrarily chosen, on seaward side of drawn line increase coastal resolution to 25%. Scale 5mm:1km



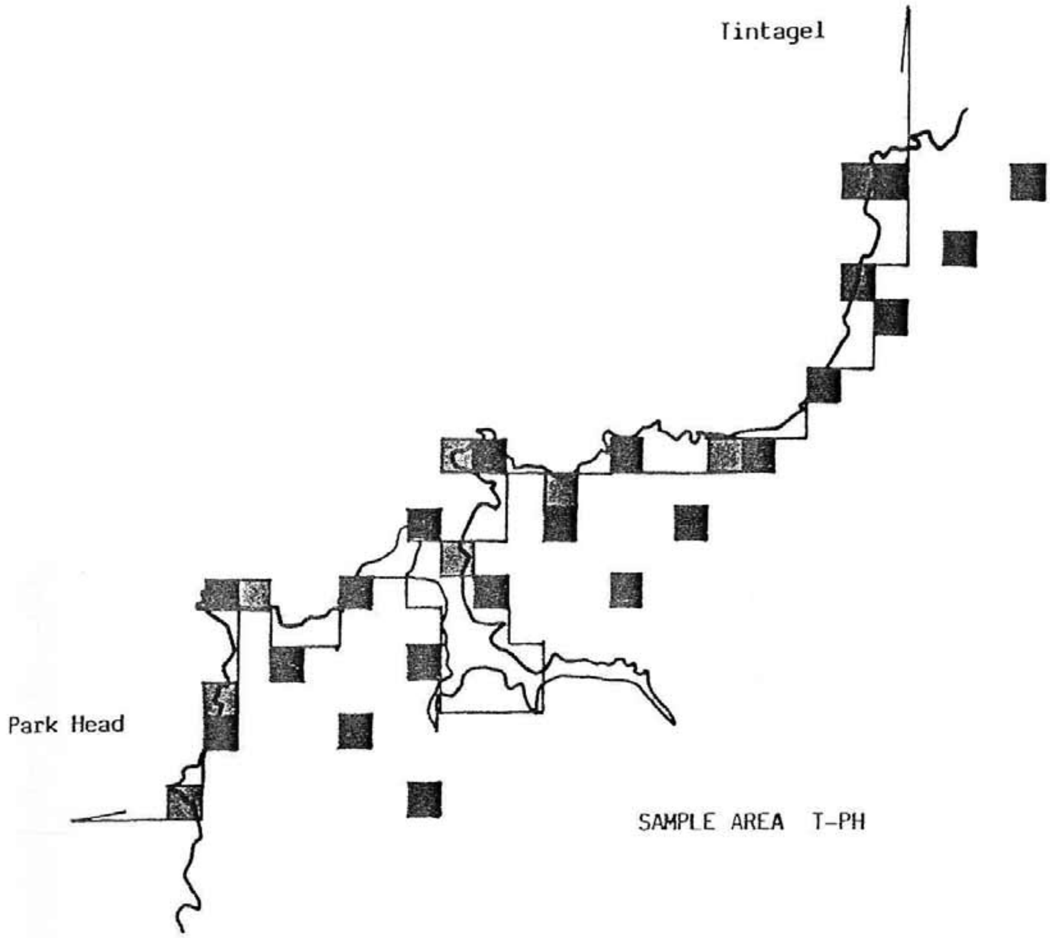


Figure 2.4

Location of 1km squares sampled in region T-PH. Closed squares give 12% resolution; shaded squares, arbitrarily chosen, on seaward side of drawn line increase coastal resolution to 25%. Scale 5mm:1km

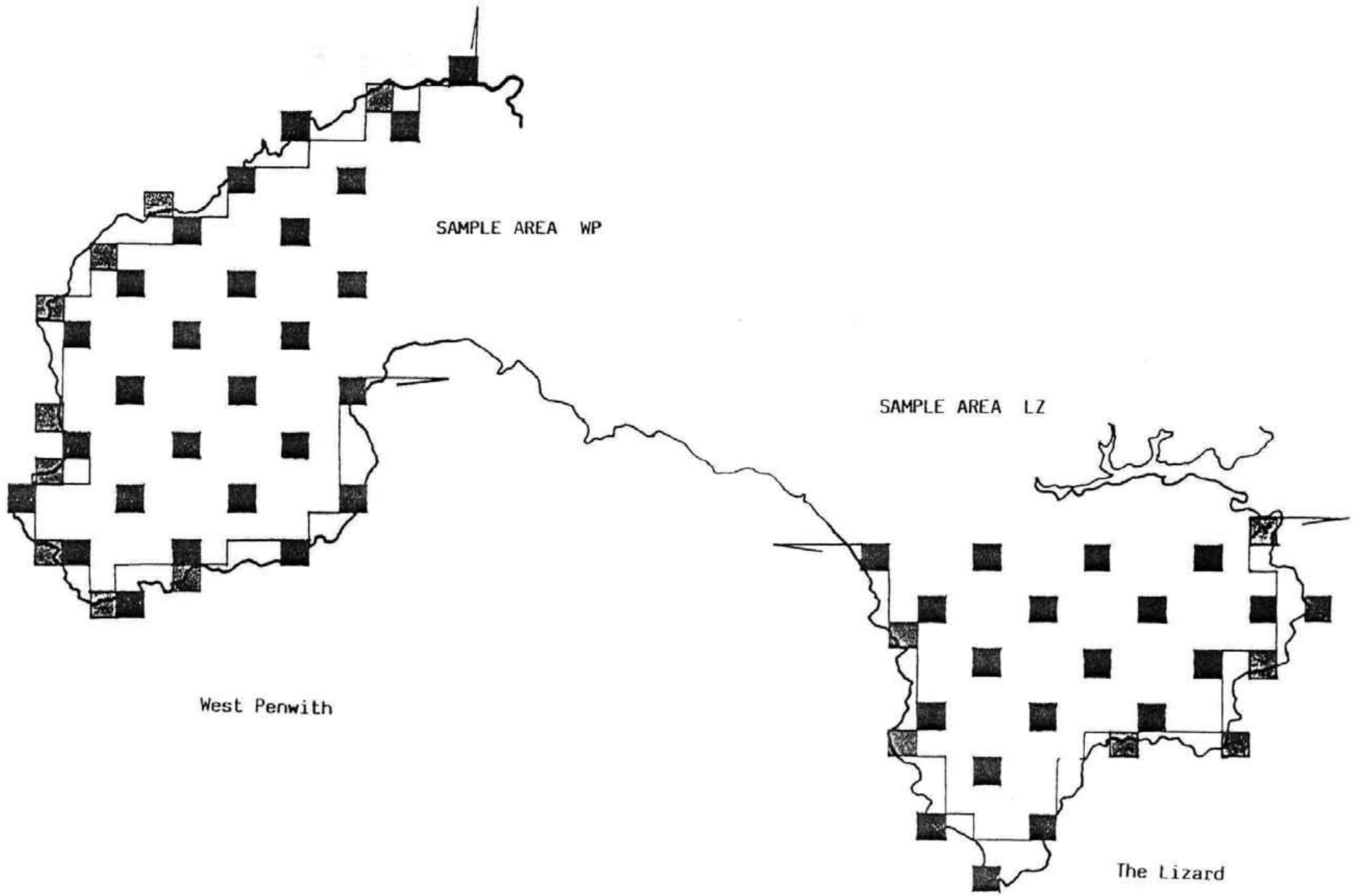


Figure 2.5

Location of 1km squares sampled in regions WP and LZ. Closed squares give 12% resolution; shaded squares, incrementally chosen, on seaward side of drawn line increase coastal resolution to 25%. Sclae 5mm:1km total of 184 $1km^2$ (94 in Wales and 90 in Cornwall) were selected as shown in Table 2.1.

Within the separate study blocks, the sample 1km2 were surveyed 'field-by-field' on 1:10,000 scale maps, and annotated (see Figure 4.1), as recommended within the Institute of Terrestrial Ecology project, *Changes in the Rural Environment*, for natural, semi-natural and agricultural features. Vegetation cover types plus all species with a frequency of >19% within a minimum mappable unit of 1/25ha and a minimum mappable length of 20m (1/50km) were recorded. Descriptive information such as agricultural usage and vegetation heights were also recorded because of their effect on the presence and availability of food resources. The environmental data were transformed into raster as described in Section 4.2.1.

Table 2.1 Kilometre squares surveyed in habitat assessment. The 12% background sample was increased incrementally on coastal squares to give *ca*. 25% resolution

Kilometre Squares			
Study Block	Grid Sample *ca*. 12%	Additional Coastal *ca*. 25%	Total
New Quay-Cardigan	18	6	24
Cemaes-Strumble	23	6	29
St Davids-Angle	31	10	41
Total Wales	72	22	94
Tintagel-Park Head	20	9	29
West Penwith	27	9	36
The Lizard	18	7	25
Total Cornwall	65	25	90
GRAND TOTAL	137	47	184

Each $1km^2$ was effectively mapped 3 times (see Figure 4.1), yielding 7,500 packets of descriptive information. Additional physiographical details were recorded, *e.g*. topography was assessed for cliff height and natural nest sites but since this can be safely assumed not to have changed significantly over time it is excluded from the present analysis. Similarly, woodland and scrub were measured but these are negative features since, as with long vegetation they prevent access to invertebrate food resources. The scrubbing over of headlands and clifftops consequent upon a reduction in grazing was suggested as a contributory factor in the decline 20 years ago (Darke 1971; see Chapter 4). Whittaker (1947) was the first to record a link between grazing and Choughs, but it was not to be demonstrated for a further 30 years (Bullock 1980, Bullock & del-Nevo 1983).

2.3 THE OBSERVATIONAL STUDY AREAS

2.3.1 INTRODUCTION AND SELECTION CRITERIA

Selection of the study areas within the regionalised blocks was based principally on Chough distribution taken from, in Wales, NCC unpublished data, information from local naturalists, and notes made during the mapping survey described above; and, in Cornwall, knowledge of ex-distribution acquired from the literature (3.1 *et seq*.). Supplementary information may be gleaned from old place names, such as 'Chough's Ogo' (=Chough's cave) on the Lizard, Cornwall (see Figure 2.13). Boundaries of study areas were determined by bird exploitation (see Chapter 6 and Appendix VIII) established during pursuit periods (2.5.2) and surrounding visible area.

The selection criteria were:

Wales. Topography in key Chough regions to have comparable physiography to Cornwall. The study sites were chosen to provide a representative selection of the habitats exploited by Choughs in West Wales excluding the Old Red Sandstone region near St. Anne's Head in the far south. This area was not selected because (i) it has no physical equivalent elsewhere in the region or in Cornwall, and (ii) it is already the subject of a Chough-related inquiry (Gamble & Haycock 1988). For similar reasons and access problems, the island reserves of Skomer and Ramsey also received less attention. All these areas, however, were visited on one or more occasions, and their wardens provided valuable data. The two islands were, however, visited for study periods of several days (see Appendices V and VI). All Welsh study areas, with the exception of the northerly section (Mwnt-Cemaes; see Section 2.3.2), were linked and traversed by the Pembrokeshire Coast Path, which is administered by the Pembrokeshire Coast National Park (PCNP), and is largely of SSSI (Site of Special Scientific Interest) status.

Cornwall. Ex-Chough areas with (i) a history of recent occurrence (*e.g*. North Cornwall); (ii) a discrete area with on-going sympathetic management and scientifically important (*e.g*. the Lizard); and (iii) strategic importance (*e.g.* West Penwith/Lands End), *i.e.* an area of great historic importance, compact with an extended coastline and forming a continuum between (i) and (ii). See Table 7.3 for detailed rationale.

2.3.2 THE WELSH STUDY AREAS

STUDY AREA W1: MWNT-CEMAES (Figure 2.6a-c, and see Appendix VIII).
The northernmost area (4°38-46'W, 51°06-08'N), effectively bisected into two sub-areas by the Teifi estuary and the town of Cardigan. The Cemaes section (*ca*. 145ha) was located to the west in Pembrokeshire and the Mwnt section (*ca*. 85ha) to the north-east of the Teifi in Ceredigion. Long gently declining vegetated slopes and cliffs of Ordovician rocks (0-100m), bounded to landward by a variable maritime mosaic of occasionally grazed semi-natural heath or scrub grassland, giving way to low-intensity pastoral-based agriculture of essentially upland character. In 1988 (and possibly 1989), one pair of Choughs nested unsuccessfully at Mwnt. At Cemaes, one of two pairs nested successfully in 1988 (the unsuccessful pair being possibly too disturbed by a nearby Peregrine eyrie); in 1989, both pairs were successful, the neighbours at the Peregrine site moving farther away around a headland.

Much of the ownership is controlled by conservation interests (National Trust (NT) and Dyfed Wildlife Trust) with guidance from the NCC. Both sub-areas were subjected to visitor pressure. Reliable figures for Mwnt, deriving from a NT carpark, show that over 5 years (1985-1989), the mean usage was 10,910 cars per annum (s.d. 1,178), peaking during school holidays, when good

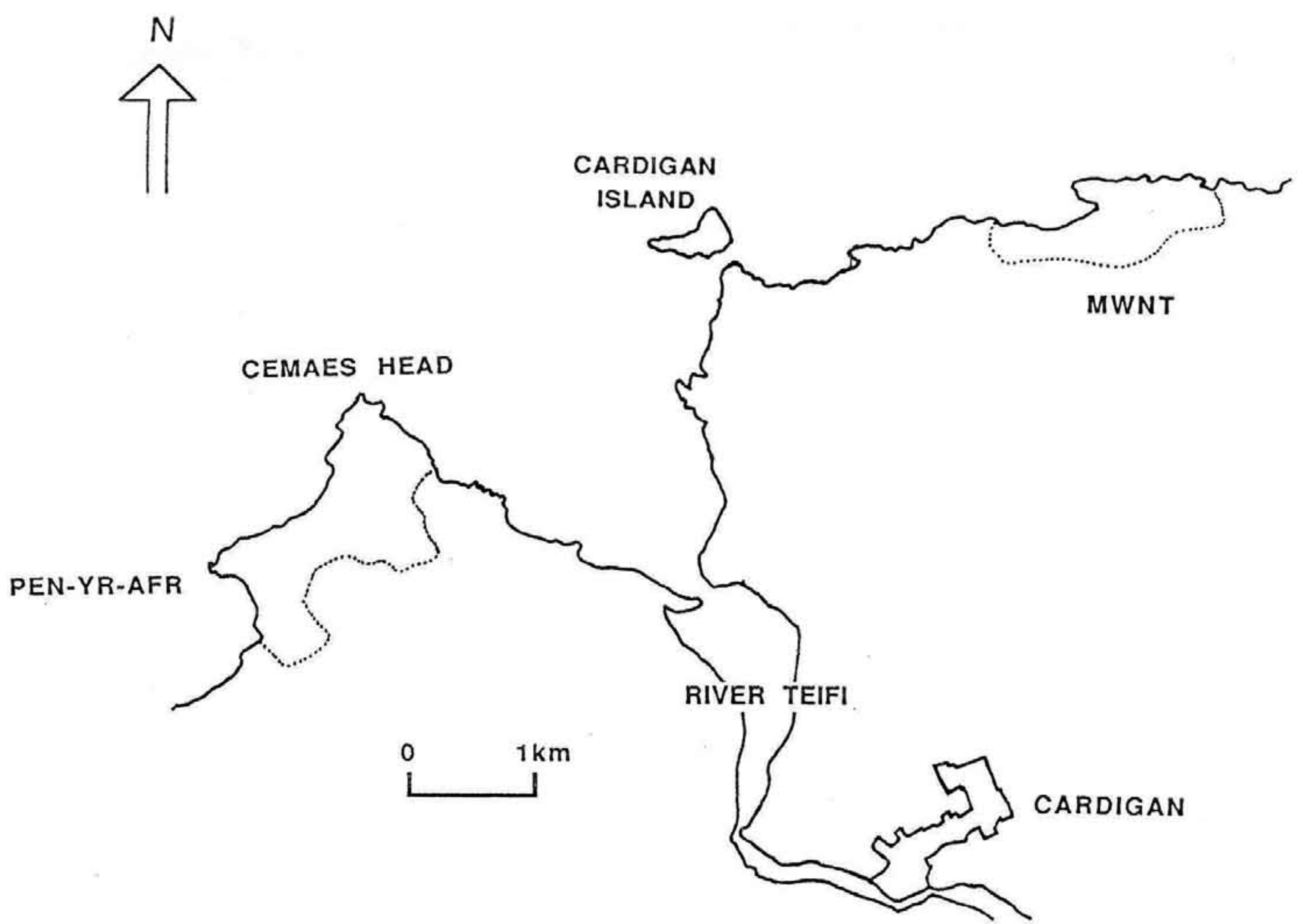
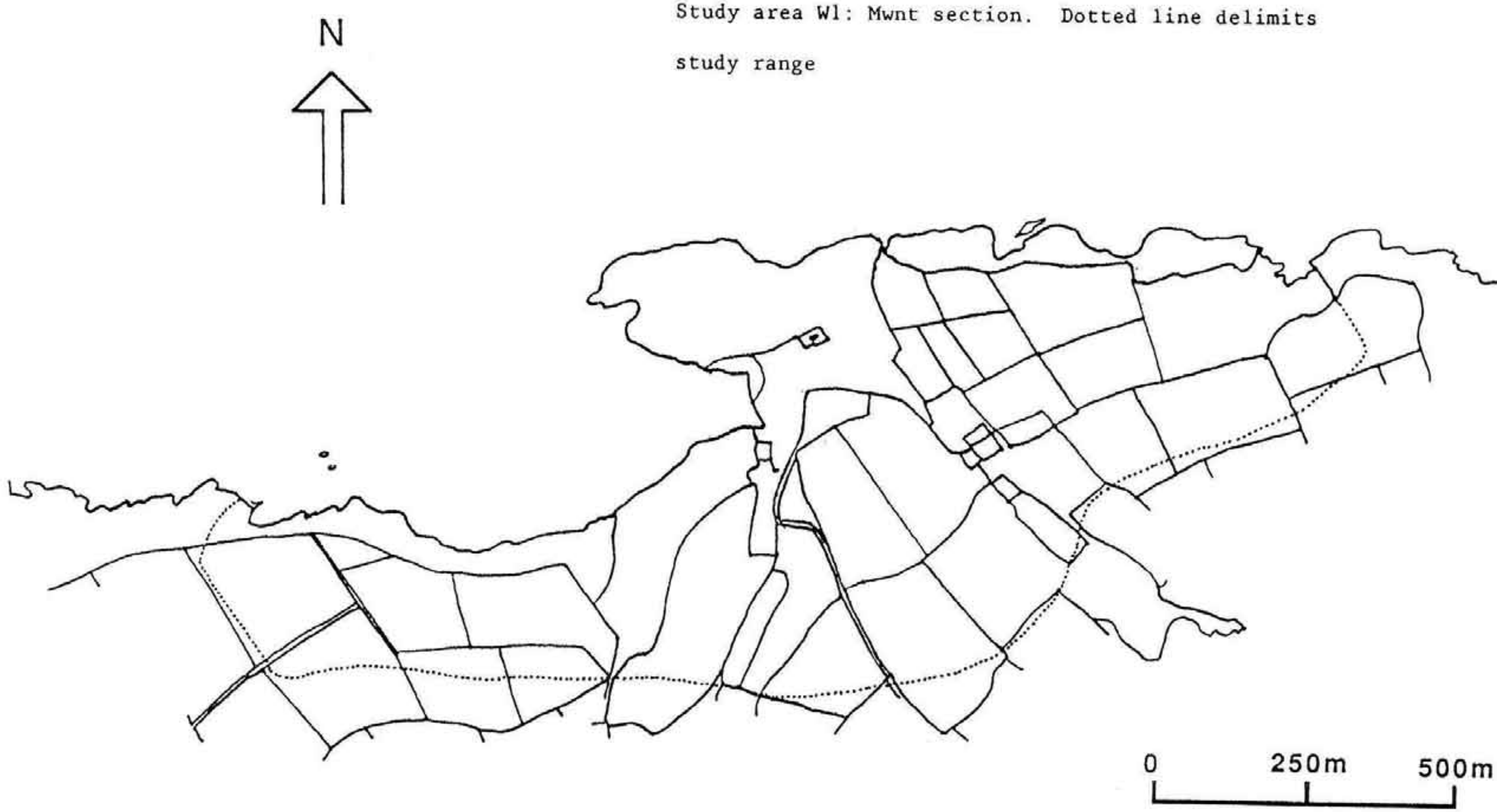


Figure 2.6a

Study area W1. Dotted lines show eastern Mwnt section (see Figure 2.8b) and western Cemaes section (see Figure 2.8c) separated by Teifi estuary and the town of Cardigan.

Figure 2.6b

Study area W1: Mwnt section. Dotted line delimits study range



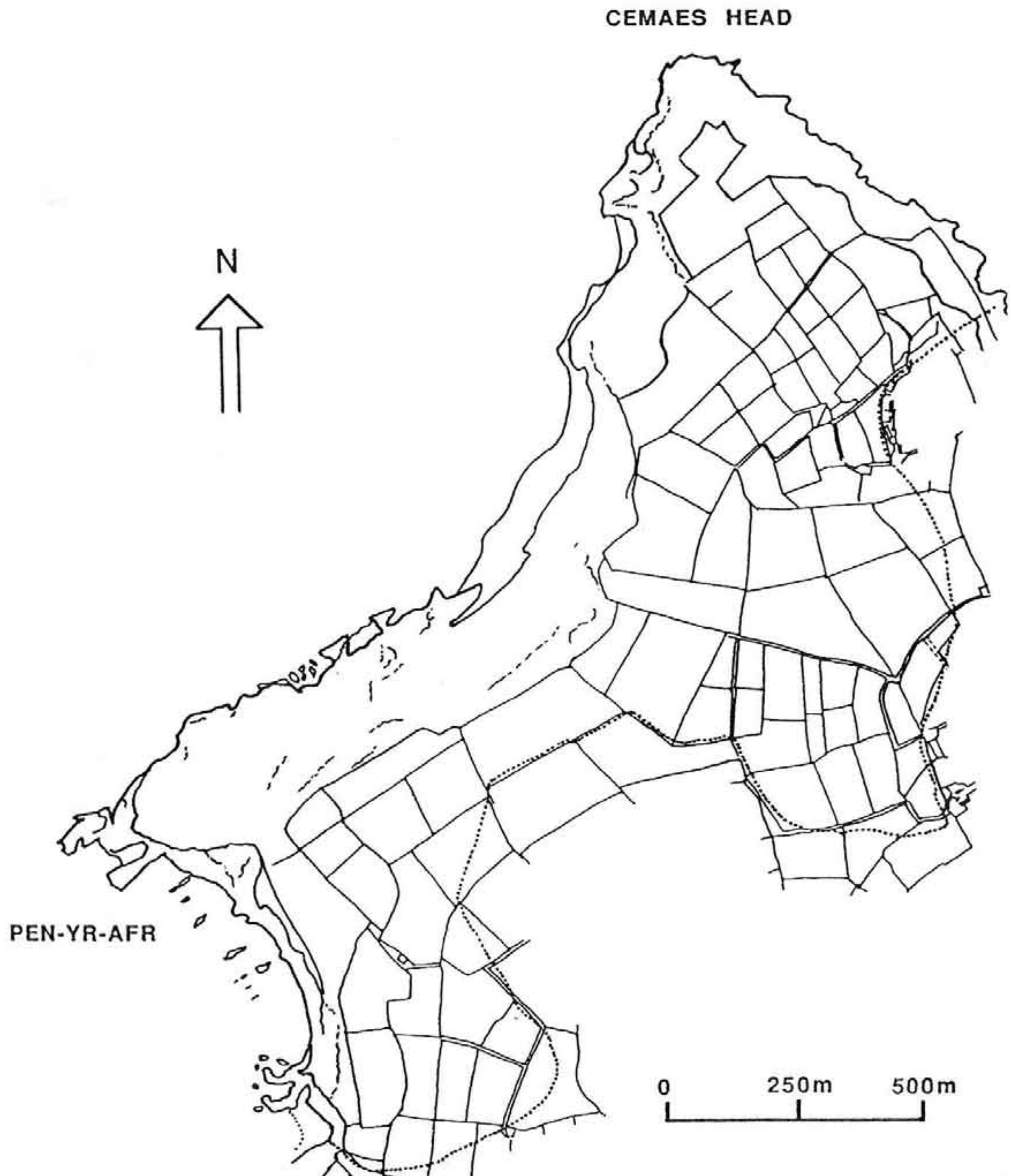


Figure 2.6c

Study area W1: Cemaes - Pen-yr-Afr section. Dotted line delimits study range beach, public amenities and proximity to Cardigan make it popular with local people (E. Gwynn pers. comm.). No such facilities and no beach at Cemaes result in reduced usage: the path being mainly used by serious walkers: usually <25 per day in the summer (pers. obs.); the path is little used in the winter. At Mwnt, the beach and open spaces are popular with dog-walkers throughout the year, especially in the evenings, when walkers are rare everywhere.

STUDY AREA W2: STRUMBLE (Figure 2.7, and see Appendix VIII).
Strumble Head lies to the west of Cemaes (5°02-06'W, 52°00-03'N). It has been formed by dolerite intrusions of igneous rock into Ordovician sediments. [Igneous headlands and eroded sedimentary coves form a typical geological pattern of the region (George 1970)]. Both Strumble and Cemaes are NW trending headlands with, therefore, predominantly SW and NE aspects. Cliffs climb to about 80m, and are bounded to landward by species-rich maritime heath and mixed agriculture. A popular Youth Hostel at Pwllderi attracts considerable usage to the area which diffuses around the headland, although this declines considerably in the winter when the Youth Hostel is closed. The study area (*ca*. 275ha) was believed locally to support many (+6 pairs) of Choughs (R. Spicer pers. comm.) but only one pair bred (successfully) in 1988-89. Strumble Head is a nationally important 'sea-watching' site, and most observer-effort concentrates on this activity; but since my work showed that the resident pair of Choughs foraged over most of the area, it is possible that over-estimation has occurred (see Section 1.3.2), further emphasising the need for a colour-ringing programme in West Wales (Chapter 7).

STUDY AREA W3: NEWGALE-SOLVA (Figure 2.8, and see Appendix VIII).
Situated at the north of St. Bride's Bay, east of St. David's Head (5°08-13'W, 51°-51'N), the area is in a higher grade agricultural neighbourhood than the more upland areas W1 and W2. The coastline has a southerly aspect, characterised by two reef-like promontories: Dinas Fawr and Dinas Fach, both of which supported successful nest sites. The larger promontory, Dinas Fawr, was grazed in summer, and because of its aspect, receiving exposure from both the south and west, supported the most feeding sites (Appendix VIII). Dinas Fach lacked southerly exposure and was ungrazed. The cliffpath is very steep in places, climbing to *ca*. 100m. Despite the promontories, it forms a more linear stretch of coast than the remaining three sites; the study area (*ca*. 125ha) is elongated by the intensive agricultural hinterland. The landscape has been shaped and the promontories formed by intrusions of basic rock into the Ordovician System; sheer cliffs alternate with 45° vegetated cliffslopes, often scrub-covered.

STUDY AREA W4: MARLOES (Figure 2.9, and see Appendix VIII).
The Marloes peninsula forms the south-western tip of Wales, opposite Skomer Island (5°11-15'W, 51°42-44'N). It comprises mainly a plateau about 40m high on a W-E axis near Dale and St. Anne's Head, and includes Gateholm Island - once a Chough nestsite (D. Saunders pers. comm.): total study area *ca*. 257ha. The interior agriculture is largely intensive sheep and arable, but at the southern end there is a disused World War II airfield, currently used for grazing. The westernmost tip, known as the 'Deerpark' is a NT owned property managed for its natural history interest. There are plans to reintroduce grazing to Gateholm Island (S.B.Evans pers comm.). The geology is Silurian with contemporaneous igneous intrusions. Cliffs and steep cliffslopes dominate. The shaded northern sector shown in Figure 2.9 (*ca*. 70ha) was never seen to be used by Choughs during the entire study period.

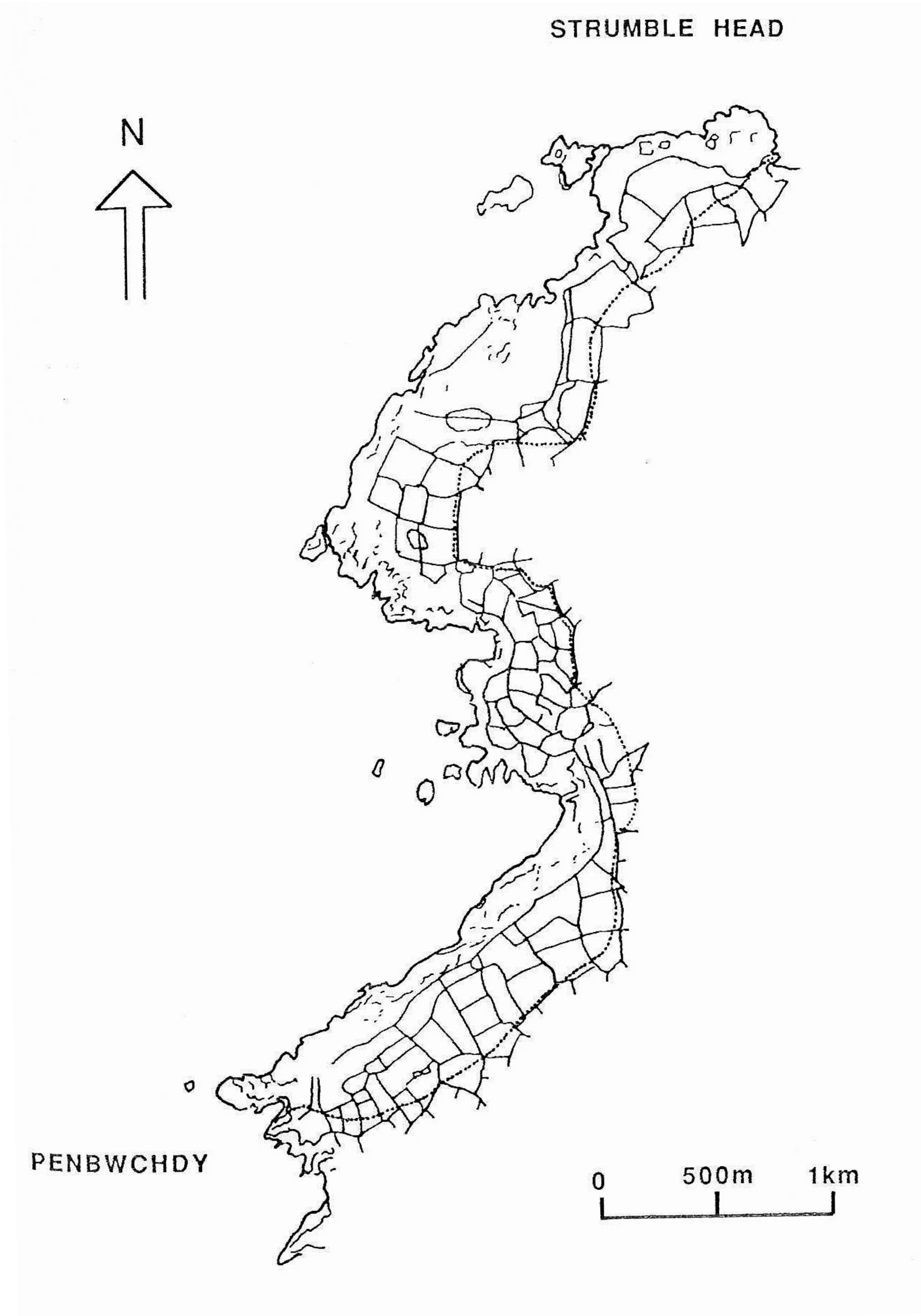


Figure 2.7

Study area W2. Strumble Head - Penbwchdy.
Dotted line delimits study range.

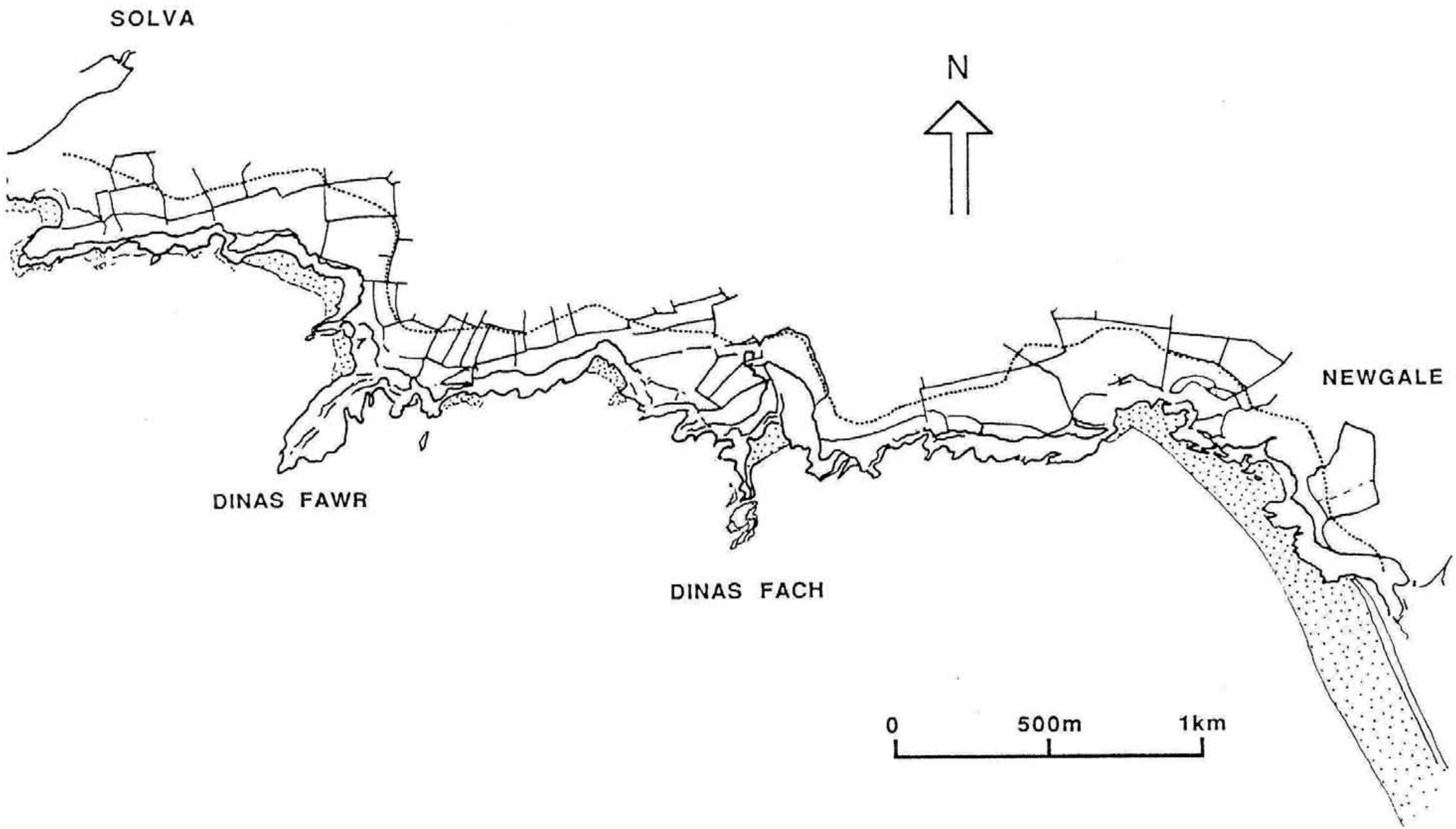


Figure 2.8

Study area W3. Solva (Solfach) - Newgale.
Dotted line delimits study range.

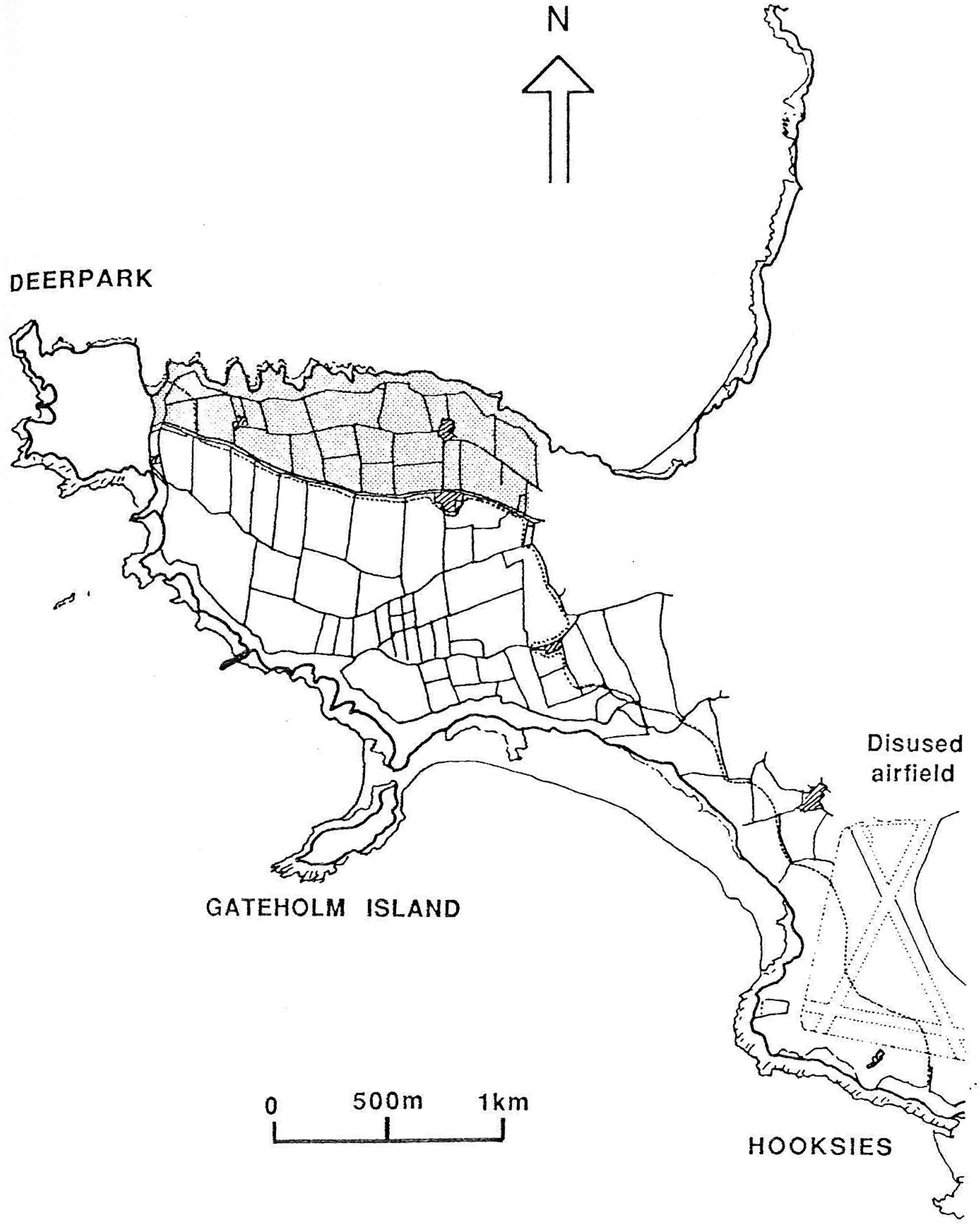


Figure 2.9

Study area W4. Marloes peninsula.
Dotted line delimits study range. Shaded area indicated northern section, unused by Choughs during project time.

2.3.3 THE CORNISH STUDY AREAS

STUDY AREA C1: PENTIRE-CANT (Figure 2.10).

Pentire Head (4°56'W, 50°34'N) was formed by volcanic extrusions of pillow lava >60m thick, and intrusions of greenstone into Middle Devonian slates (Edmonds *et al*. 1975). It has a NW orientation, akin to Study Areas W1 and W2, and is located on the Camel estuary north of Padstow. An unsubstantiated report records an unsuccessful breeding attempt at Pentireglaze ("a traditional site of great but unknown antiquity" (Penhallurick 1978) in 1947, and they certainly bred there between 1930 and 1944 (*ibid*). Ray in 1662 reported 'great flocks' nearby (Ray 1678). Pentire is a National Trust property. The interior is mainly mixed arable and sheep farming. The cliffs are *ca*. <60m high and rock outcrops and grass or scrub cover the moderately steep coastal slopes. It and nearby beaches are popular with visitors in the summer and with locals during weekends at all times.

The Cant section is a small site on the north side of the Camel estuary to the east of Pentire (4°54'W, 50°31'N), included to enable further invertebrate studies. Cant Hill is privately-owned, 75m high, with unimproved summit pasture and improved inland slopes, both grazed by sheep. *Ulex* scrub clothed the steeper slopes overlooking the estuary.

STUDY AREA C2: WEST PENWITH (Figure 2.11).

Most of the West Penwith coast was important historically for Choughs (see Figure 3.2). The particular site at Treveal, on the NW facing coast (5°33'W, 50°12'N), was selected because of recent occupancy by Choughs, disappearing *ca*. 1870s (Penhallurick 1978), and for logistical reasons, NT ownership and residency of warden, and an agriculture and physiography superficially, at least, resembling Study Areas W1 and W2, including rough grazing by cattle.

STUDY AREA C3: THE LIZARD(Figure 2.12).

The west side of Lizard Point (the most southerly part of Britain) is historically important for Choughs. The Predannack cliffs (5°15'W, 50°0'N), south of Mullion, is an area where Choughs were in 'tolerable abundance' (1856; see Figure 3.2) but possibly gone by 1870 due in part to the activities of egg collectors (Penhallurick 1978). Predannack is owned and managed by conservation interests: NT and NCC. The geology of the Lizard is amongst the oldest, most complex and interesting in Britain (Edmonds *et al*. 1975). The Predannack cliffs are basically hornblende-schists of *ca*. 50m and levelling into a plateau of largely unimproved or semi-improved grass with heath and scrub elements. The more intensively managed fields were down to either improved cattle-grazed grass or arable. Grazing within the study area was by equines and sheep.

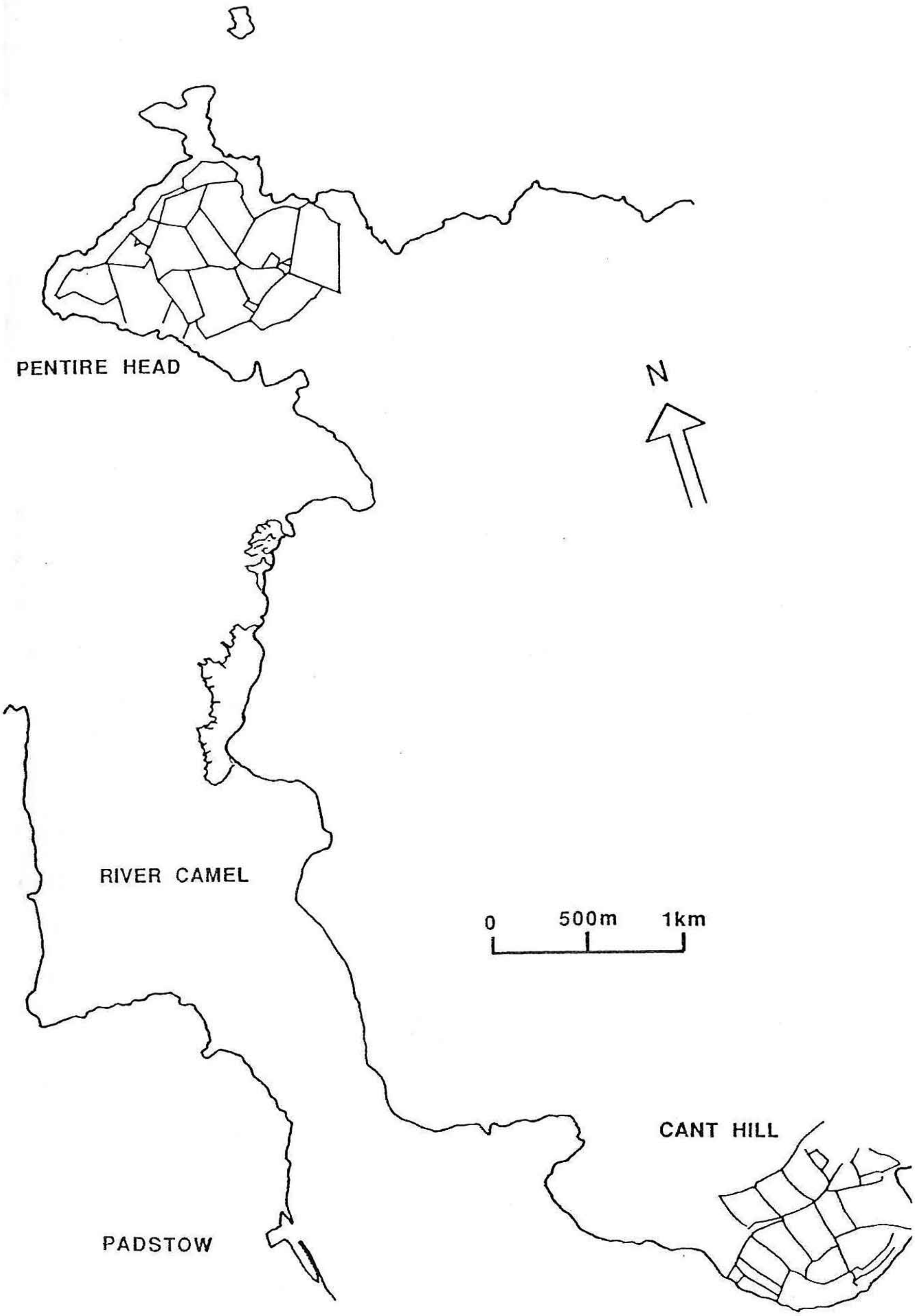


Figure 2.10

Study area C1. Pentire Head and Cant Hill.
Map showing eastern side of the Camel estuary. On the western side is Stepper Point and the town of Padstow.

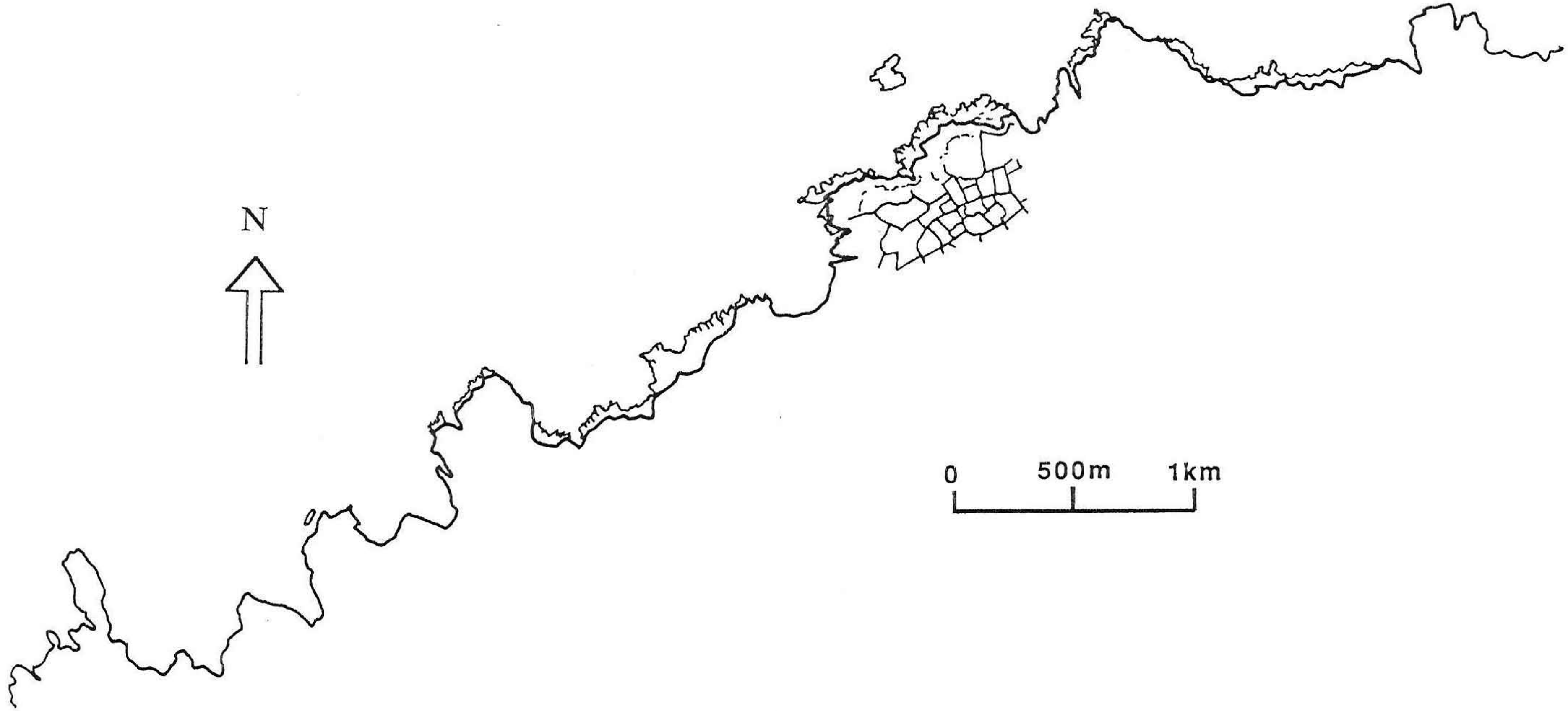


Figure 2.11

Study area C2. Treveal cliffs, West Penwith. Map showing northern section of the West Penwith coast near sampling area plus associated field system

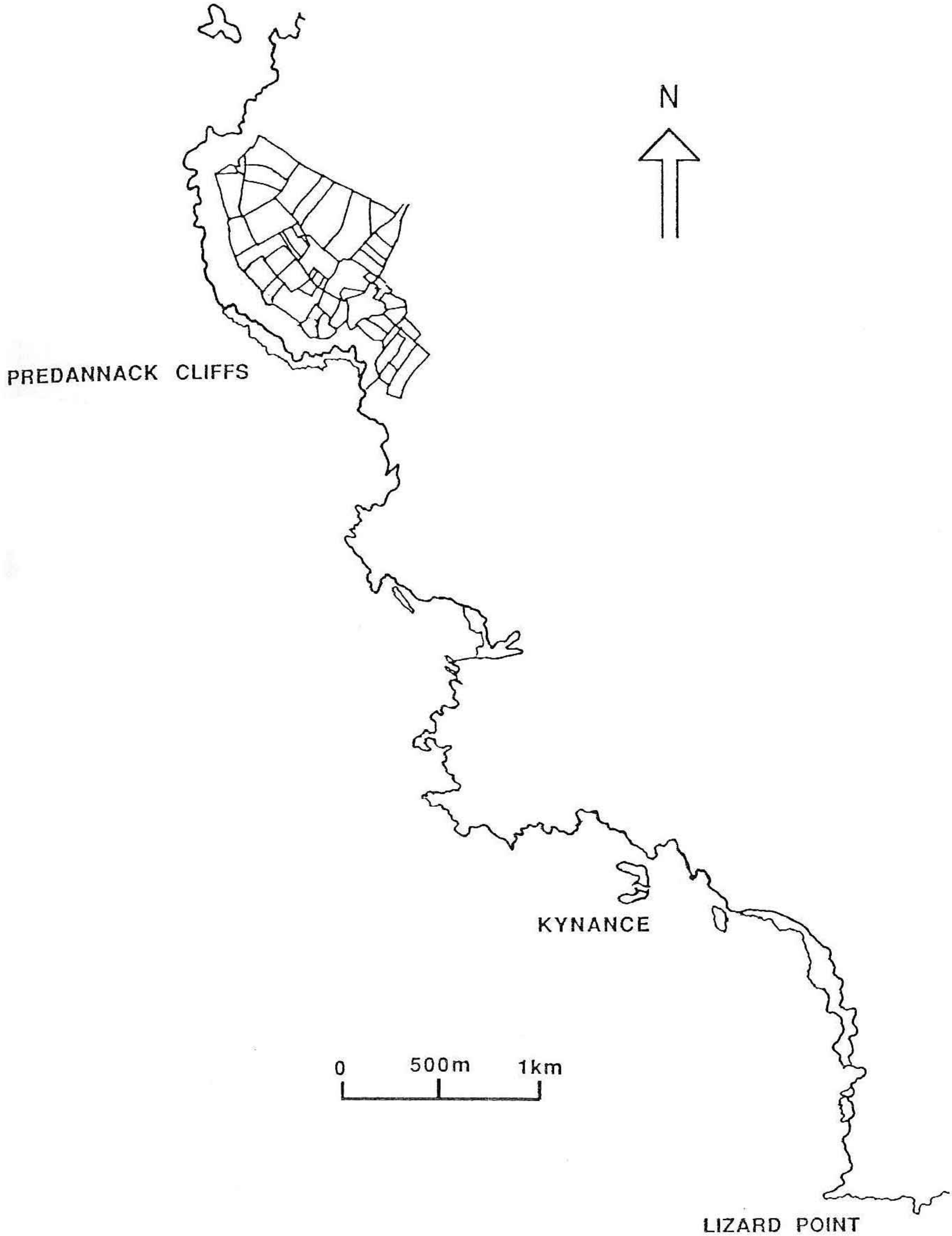


Figure 2.12

Study area C3. Predannack cliffs. Map showing western section of the Lizard coast near sampling area plus associated field system

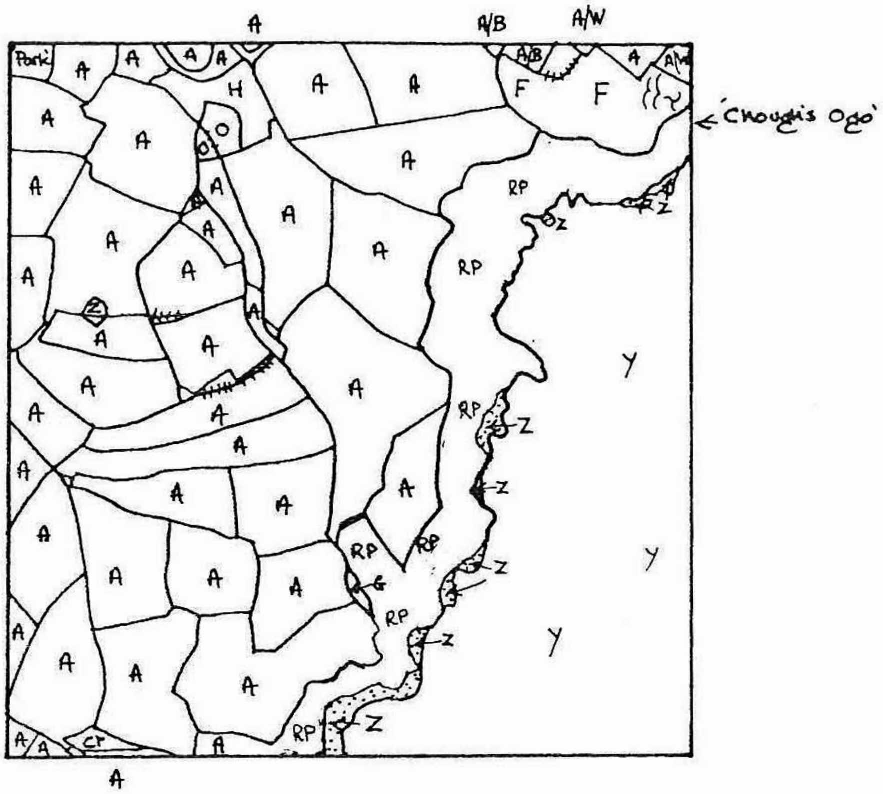


Figure 2.13

Example of 1km sq. annotated from tithe map data *ca*.1840. The cave 'Chough's Ogo' probably identifies an historic nesting site (see 2.3.1). Scored out hedge lines denote hedge or bank removal

Key:

A	Arable
B	'Banks'
Cr	Croft
F	Furze
G	Garden
H	Homestead
O	Orchard
RP	Rough pasture
W	Waste
Y	Sea
Z	Undefined

2.4 HISTORICAL HABITAT ASSESSMENT

The Chough's decline and disappearance from southern England is investigated mainly by reference to the historical literature (Chapter 3) and an assessment of changing land-use practices as revealed by tithe surveys (4.5 & 4.6). Owen (1985) examined the historical literature for evidence of the decline in England, paying particular attention to Cornwall and Wales. I have added a little new evidence and reinterpreted some of his data.

The Tithe Apportionments of the 1840s provide, with caution, a reliable insight into contemporary land-use (Kain & Holt 1981) for both Cornwall and Wales. The coastal 1km^2 mapped in the original habitat assessment (see Section 2.2, Figures 2.2 - 2.5) were reanalysed from tithe data to provide a measure of the quality and rate of habitat change. The maps were rasterized similarly so as to enable direct comparison although the available information was of a far less precise nature: broad variables such as 'pasture', 'arable', 'furze' etc. forming the parameters (see Figures 2.13 & 4.3). In addition to the map data, there were also aggregated acreages available for each parish, and these were compared to recent MAFF (Ministry of Agriculture, Fisheries & Food) census returns.

2.5 BIRD OBSERVATIONS

2.5.1 THE DETECTABILITY OF CHOUGHS

Physical location of the subject within the time available was problematical. Bullock (1980) and Roberts (1985), working respectively on South Stack and Bardsey island reserves to the north (Figure 1.2), were able to employ transect routes and 'pursuit days' "when groups of Choughs were watched all day." Roberts mentioned the advantages of "so many observer-hours on such a small and discrete area." In contrast, I occasionally spent entire days without locating a single Chough, and initially the concept of pursuit was replaced by one of dedicated search time (DST) (2.5.2).

The bird-watching literature claims that the Chough's distinctive cry (1.3.1) often draws attention to it. It would clearly be useful to know if this encouraged a bias: with negative records being interpreted as actual <u>absence</u> of birds rather than mere <u>non-visibility</u>, and whether poor visibility, due to weather conditions, decreased search success. Consequently, all presence cues - visible (VC) and audible (AC) - were recorded for one year from June 1988 in order to check their relative frequencies. To prevent a 'learning' or 'knowledge curve' affecting the results, only 'surprise' cues were counted, and those resulting from nest-watching or from where birds were <u>expected</u> were omitted.

The data presented in Figure 2.14 support the field guides. In all conditions, 63% of surprise encounters (n=228) were AC initiated. In poor visibility/bad weather, when the proportion might be expected to increase, the reverse applied and ACs decreased to <50% (n=21). This can possibly be explained by Choughs sheltering and remaining quiet in adverse weather (Borlase 1758; and see Section 6.3.1). During 3 days of observation on Ramsey Island in July 1989 (Appendix V) in excellent conditions, and in a situation comparable to the island reserves of Bullock and Roberts, 20 of 22 (91%) 'surprise' encounters, were of AC origin, possibly reflecting the higher density and/or better weather.

To establish whether the converse applied, *i.e*. did very windy or 'noisy' conditions reduce the number of ACs, cues in a wind velocity estimated as >6 on the Beaufort Scale (n=23) were subjected to a chi-square test; 14 (61%) were of VC origin ($X2= 1.608$; d.f. 1; N.S.). Although a small sample, the value is equivalent to that for ACs in 'good' weather, suggesting that there is, at most, only a

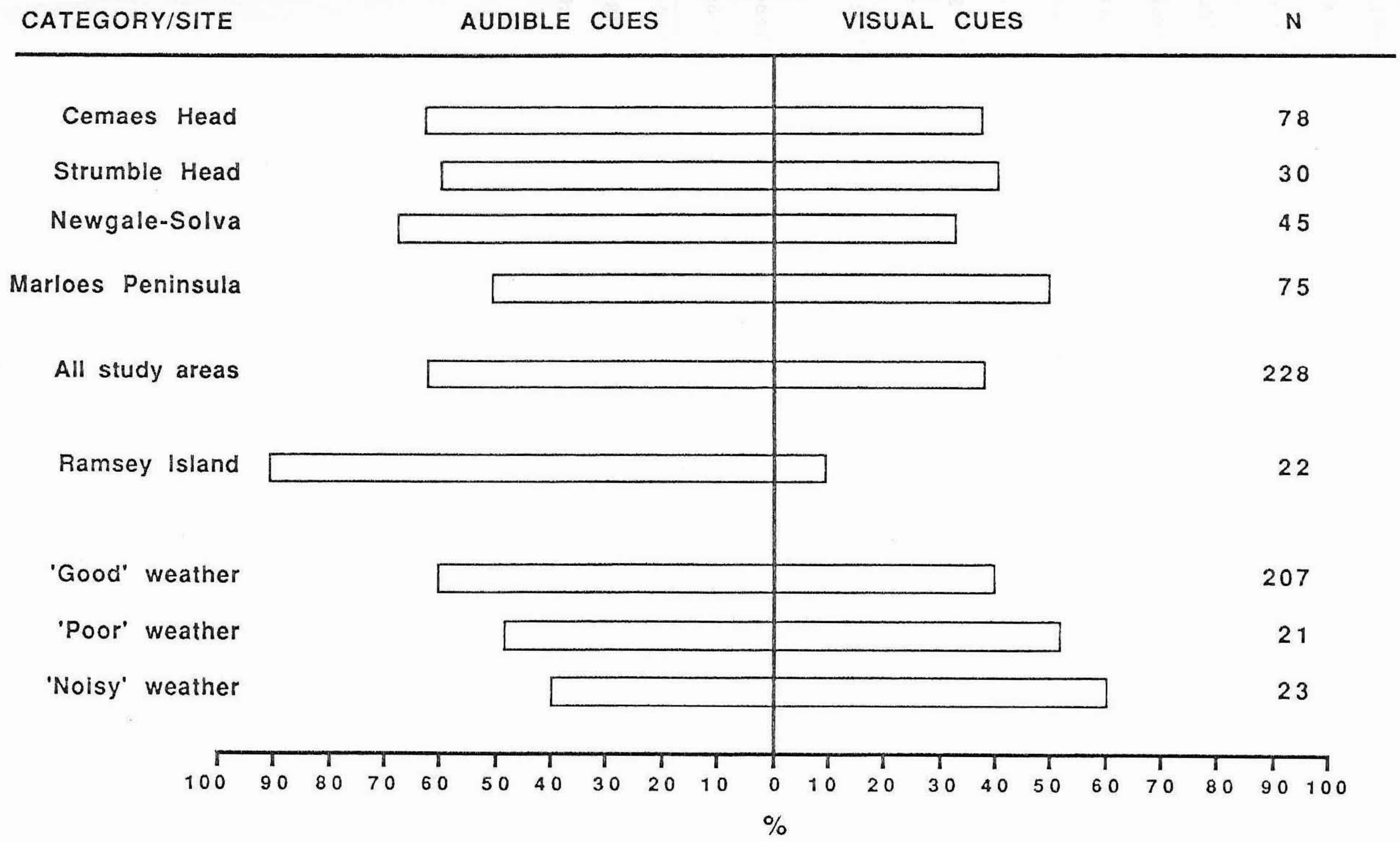


Figure 2.14

Proportion of Chough observations initiated from audible cues (AC) and visible cues (VC) by study area and different weather conditions.

low element of bias relative to weather conditions and, from the Ramsey data, densities of birds. Interestingly, at wind force 6, the AC:VC ratio was almost exactly equal.

It is possible that AC induced 'sightings' would have been subsequently detected by observer effort, but it cannot be known how many sightings were missed altogether; the data include only subsequently confirmed sightings. In conclusion, detection was probably independent of weather and topographical conditions, but search time was affected.

2.5.2 GENERAL OBSERVATIONS

Due to the low density of birds, scattered sites and initial poor success, the pursuit concept was replaced, as stated, by DST, in which an attempt was made to strengthen the evaluation of time budgets by assessing <u>non-usage</u> of ground patch types. By relating non-usage to usage and examining the results in relation to the availability of those patch types, negative data might increase in its significance and be less wasteful of effort. However, if these results were to be meaningful, it was necessary to know how Choughs spent their time when not under observation, and whether they were unobserved due to observer inefficiency, topography, habits or climatic factors, *e.g*. sheltering in hot/cold/wet/ windy weather (see Sections 2.5.1 and 6.3.1).

Rigorous interpretation of negative records was confounded by these variables, but, with a few notable exceptions, it was found that due to increasing knowledge of the birds' habits, negative records *per se* became virtually non-existent, and it was possible ultimately to drop DST and revert to Ian Bullock's (1980) pursuit concept. However, since time spent in the field on different inquiries was always logged, negative periods were available, if needed, by the simple equation:
$N_{-ve} = N - N_{+ve}$.

As stated, study sites were visited every 6-8 weeks. The whereabouts of Choughs was ascertained by routine searching of the ranges around known nest sites, which were regarded as focal centres. Family roosting occurs at or near nest sites in June and July (Williamson 1959; Cowdy 1962, 1973; Roberts 1985), and it is possible that low-density populations retain this behaviour for longer (pers. obs., *cf*. Still 1989). Methodical searching radiating away from foci was carried out until successful or it was assumed that the birds had been missed; the procedure was repeated until it was assumed that the birds were not present, whereupon wider areas were searched. At the outset, some entire days were negative. Subsequent information helped to explain these events which occurred only during the winter, due to shorter days, poor weather and reduced or temporarily non-linkage with the nest/roost place.

When found, pursuit commenced. Birds were observed by a 9x35 binocular or a x20-60 zoom-lens telescope. Every effort was made not to disturb the birds (and see p.165). Occasionally, it was unavoidable, as for example when the observer happened to be in a location desired by the Choughs. However, the subjects were generally found to be sufficiently 'trusting' to allow approach to *ca*. 60m (see also Section 6.3.3). Generally the birds were less approachable during the winter and autumn, presumably because they were not constrained by reproductive duties.

2.5.3 ACTIVITY PATTERNS

Activities and habitat selection were recorded, either in a notebook or on to a portable tape-recorder. The location and nature of all foraging events were noted by habitat variables (Table 2.2; see Chapter 4). Major categories tended to be one (or more) of the following: (i) 'broad' categories, such as 'maritime cliff' which, unqualified, denoted an absence of more precise information (occurring most often when birds foraged out of direct view); (ii) homogeneous

Table 2.2 Habitat variables; bold type indicates cliff/non-intensive agriculture (see Section 4.3.1)

	Major categories	Subdivisions	Comments
1	MARITIME CLIFF		unspecified
a		Top (eroded zone)	>horizontal <vertical
b		Edge (eroded zone)	<horizontal >vertical
c		Slope	usually grass clothed
d		Scree	unstable
e		Crevice/rock	>50% rock
2	SPARSE VEGETATION	open ground	therophytes (winter annuals) etc.
3	ROCK/VEGETATION	interface	<50% rock
4	SHALLOW EARTH		
5	EXPOSED SUBSTRATE		
6	MARITIME GRASS		[1] see footnote
7	MARITIME HEATH		
8	SEABIRD FLORA	Cliff community	*e.g. Lavatera arborea* *Beta* sp.
9	ROCK OUTCROPS		
10	PATH	Actual or influence	trampled/eroded ground
11	ANT-CREATED	Mounds	habitat shaped by ants
12	WALL/HEDGEBANK	'Mini-cliffs'	grazed/short/open vegetation
13	PERMANENT/ OLD GRASSLAND	unimproved	natural/semi-natural[1]
14	OLD-IMPROVED GRASS	Semi-improved	ca. > 7yrs old[1]
15	IMPROVED GRASS		ca. < 7yrs old inc. drilled/reseeded leys[1]
16	STONEY SUBSTRATE		
17	SPECIES-RICH	Herb-rich	indicative of 13 or 14 etc
18?	STOCK TYPE		unknown
a		Cattle	}
b		Sheep	}
c		Equines	} or combination
d		Rabbits	}
19	DUNG & DUNG-FEEDING	qualified by current, recent & mature/old	}{ not mutually exclusive }{ also indicates age of }{ grazing
20	ROUGH-GRAZING		
21	ARABLE		Cereal grain
22?	OTHER AGRICULTURE		unspecified, not a-e
a		Ploughed	
b		Silage/hay aftermath	
c		Roots/brassicas	
d		Ruderal/neglected	atypical
23	PROXIMITY OF NEST		{ qualifies habitat
24	PROXIMITY OF ROOST		{ selection

1 Vegetation heights were recorded by the parameters: short <25mm; medium 25-50mm; long-rank >50mm; variable.

habitats, *e.g*. 'improved pasture', 'dung' etc.; and/or (iii) prime feeding habitats, such as 'exposed substrate', 'therophyte zone' etc. Subdivisions refined the major categories so as to enable a precise description of resource use. In practice, categories and subdivisions were often combined. Supplementary data were collected, notably on prevailing weather conditions. Additional data were supplied by local naturalists who recorded observations on feeding incidents to the same criteria. This helped to extend the field period within the area covered.

Habitat usage and selection was enhanced by behavioral observations obtained by instantaneous sampling of focal animals as recommended by Altmann (1973). On every hour and half-hour, plus a first opportunity in case of sudden departure, detailed behavioral observations were taken by telescope over periods of one minute duration. To overcome the bias inherent in *ad lib* sampling, when two or more birds were in view, the nearest was selected or, if equidistant, the left-most. These 'focal minute' data were dictated onto audio tape and later transcribed to the nearest second by digital stopwatch. Behavioral data were gained from different habitats on vigilance (frequency and number of scans; see Appendix IX); feeding, including an estimation of success rates and prey; movements on the ground; flights; and other behaviours including resting, maintenance, interactions etc (Chapter 6).

'Feeding' included both *foraging* - actual *feeding*, with head down or horizontal and eyes scanning the ground (Feare et al.1974), and hunting- inclusive of all other activities integral to foraging, *e.g*. vigilance movements and locomotion between foraging patches. The other principal behaviours were associated with breeding (courtship, nest-building, incubation, care of young), inter-specific interactions, maintenance activities, resting, roosting and sheltering etc.

Usually pursuit was undertaken for at least two half-day periods at each study area per visit. Usually they would include morning and afternoon periods on separate days: the former beginning at dawn, and the latter ending when the birds went to roost. Profitable morning periods were occasionally continued into the afternoon if circumstances permitted, in order to compensate for negative searching.

Prevalent weather conditions and their changes were recorded throughout observation periods. Cloud cover was measured in increments of eighths: 0/8 (=no cloud) to 8/8 (=overcast). Temperature was measured in 5^{o}C bands: 0 = <0^{o}C, 1 = 0-5^{o}C, 2 = 6-10^{o}C ... 6 = >25^{o}C. Wind was measured on the Beaufort Scale: 0 = Calm ... 9 = Strong gale; and wind direction was also recorded using conventional compass points. Precipitation was registered on the following scale: 0 = dry, 1 = mist/light rain, 2 = steady rain, 3 = Heavy rain, and 4 = hail/snow.

During pursuit, feeding sites were marked for later sampling, and faeces were collected whenever possible. Evidence of digestion in Choughs can be seen after about two hours (Bullock 1980, and see Appendix X). To help matching of remains to feeding sites, only fresh faecal samples were taken. Occasionally, older samples were collected to check the prey assemblage. After bird observation was complete, a further day (or part thereof) was set aside for invertebrate sampling. Therefore, a minimum of 3 days was usually spent at each study area per visit. Unfortunately, no accessible roost site was found, and no pellets were examined from Welsh birds (but see Appendix IV).

2.5.4 INVERTEBRATE SAMPLING

Pursuit data, in particular feeding observations, were supported by invertebrate sampling. Feeding sites were visited immediately on departure of the birds and sampled directly or marked for later sampling. There were often clear signs of Chough activity: probe holes, faeces or disturbed ground

Figure 2.15

Transect of 5 x 1m soil cores (8 x 6cm) taken
for invertebrate samples.

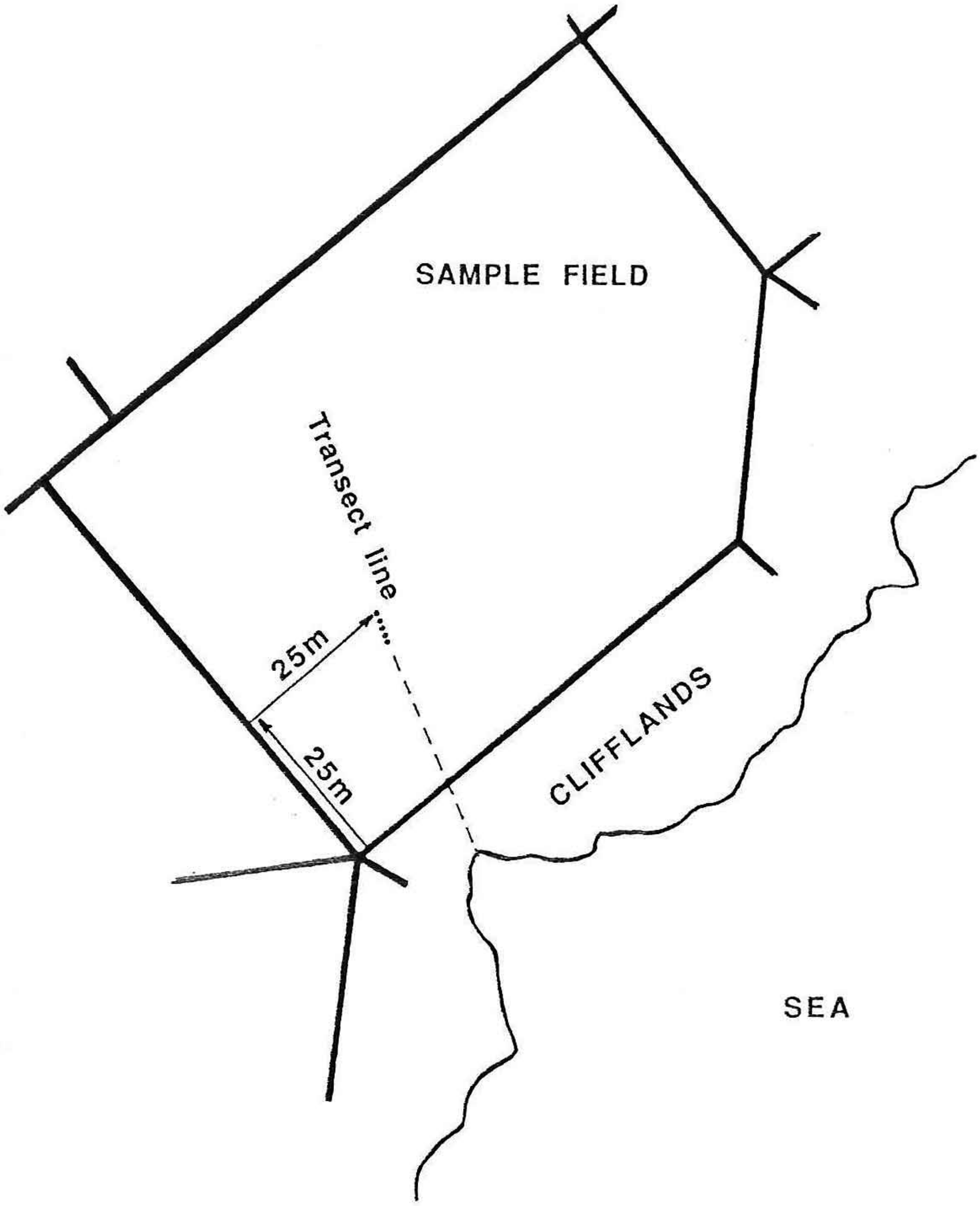


Figure 2.16

Strategy for arbitrary sampling of substrate in field (or monotypic patch), to avoid edge effect. Dashed line denotes most direct route to coast and vegetation. The primary objective was to identify the selected prey. Sometimes this was obvious: *e.g*. anthills, dung fauna, diptera colonies, tipulid larvae, earthworms and cereal grain, and some of these foods could clearly be seen to be taken during bird observation. At other times, prey was not obvious, such as when Choughs were feeding opportunistically. Feeding areas were sampled as near the feeding point as possible and compared to control sampling on adjacent ground which appeared similar yet unused, either within the same complex or adjacent to it (see Section 5.2.1).

Soil cores measuring 8x6cm were extracted unless prevented by geology, in which case an equivalent volume of substrate was taken by knife or trowel. Except when a prey focus was obvious, a minimum of 3 samples was taken from feeding sites, where feeding was scattered within a patch, a transect of 5 core samples at 1m intervals was taken (Figure 2.15); 5x1m transects were also used when sampling in unused habitats. In agricultural fields or where an edge effect might have confounded the results, the transect was begun at a point 25m from a field corner and 25m at right angles into the habitat being sampled (Figure 2.16). To eliminate observer bias, the precise starting point was randomly selected and the transect line directed towards the nearest coast point (after Hughes 1962).

2.5.5 FAECAL SAMPLING

Whilst the examination of cast pellets from both raptors and corvids has been quite widely practised (*cf*. Dugmore 1986, Howes 1975, and Yalden & Warburton 1979), even to the extent of identifying fossil remains (Girling 1977), much less research has been carried out with faecal material (*cf*. Ralph *et al*. 1985). Moreby (1987) has applied the technique to examine the diets of gamebirds, and Green & Tyler (1989) have studied faecal evidence from captive Stone curlews. To some extent, progress has been limited by the problems inherent in the identification of fragmentary material, although, for many years, paleontologists concerned with insect remains from Quaternary deposits have been dealing with such material with considerable success (for review, see Buckland & Coope 1990). Kenward (1976) pointed out the contribution which bird faeces made to archaeological insect assemblages by a study of modern building gutter assemblages in York.

In this study, faecal evidence provided direct and irrefutable evidence of Chough diet, and considerable effort was expended in both collecting samples and identifying the surviving components (5.2.2).