Results of surveys for the wart-biter bush-cricket *Decticus verrucivorus* at Lydden Temple Ewell NNR in 2015, with notes on the status of the species since its re-introduction to the site

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Report to the Kent Wildlife Trust

Final version
Submitted November 2015

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Summary

Surveys conducted in 2015 suggested that Lydden Temple Ewell NNR supported a population of around 100 *D. verrucivorus* during the early adult period. A review of the status of the species since its re-introduction to the site between 1993 and 1996 puts this result into context. The population size in 2015 was broadly consistent with the numbers that the site (or compartment Ly1, specifically) was expected to support when the re-introduction was being planned, i.e. a "cautious" estimate of 90 adults in an average year. It is also broadly consistent with numbers recorded annually since the re-introduction. Although data are limited or unavailable for some years, the early adult population appears most often to have been in a range of around 50-200. However, numbers have varied beyond this range, reaching a peak of around 450 in 2001 and 2002, but falling to a very low level in 2003, when favourable habitat structure failed to develop over most of the area occupied by the species, and again in 2005.

During the re-introduction of *D. verrucivorus* to Lydden, individuals were released almost exclusively into compartment Ly1, where the most favourable habitat occurred. Subsequently, this compartment has tended to support the main population, and *Decticus* can now be regarded as well established here. However, some parts of Ly1 are of particular importance to the species, notably the roughly central "shallow valley" feature, where favourable habitat structure tends to develop most consistently. *Decticus* has also spread into the adjacent compartment (Ly2), where it can probably be regarded as established and where good numbers have been recorded in some years. Scattered records of *Decticus* have also been obtained from Ly3 in a few years, but it is very doubtful whether adults have successfully reproduced in this compartment on a regular basis. Consistent with this general assessment, most records in 2015 came from Ly1 (and were concentrated around the "shallow valley" initially), with some individuals also encountered in Ly2, but no records were obtained from Ly3.

The habitat at Lydden appeared favourable to *Decticus* over a larger area in 2015 than in the previous two years. In particular, the structural mosaic required by the species was better developed in Ly1 and Ly2. Whilst *Decticus* is probably secure in Ly1, it remains vulnerable should good patches of taller, tussocky vegetation fail to develop, as in 2003. A combination of rabbit grazing pressure and sensitivity of the habitat to dry conditions contributes to this potential threat. It would be desirable to generate optimum habitat over a greater area, and more consistently from year to year. However, it is recognised that this is not straightforward to achieve. Some priorities for scrub clearance in Ly1 are highlighted, although small, scattered scrub elements can help to promote the development of tussocky vegetation. It is suggested that control of rabbits be considered, and that numbers of avian predators be monitored.

1. Introduction

1.1 The status of Decticus verrucivorus in England

In Britain, *Decticus verrucivorus* has probably always been confined to southern England, and may always have been rare and very localised (e.g. Cherrill, 1993). However, it may also have been substantially under-recorded, particularly early in the twentieth century, and may consequently have occurred at (and been lost from) many more sites than were ever documented. Known historical localities for the species are considered by Ragge (1965, 1973), Marshall (1974) and Marshall & Haes (1988). Whatever the true historical status of *Decticus* in Britain, concerns for its survival in the 1970s and 1980s led the species to be included on Schedule 5 of the Wildlife & Countryside Act 1981 and classified as RDB2 Vulnerable (Shirt, 1987). Despite these measures, however, *Decticus* was clearly in significant danger of extinction as a British insect by the late 1980s. Of six populations that were apparently viable in the early 1970s, two were extinct, and three others were yielding records of only small numbers of individuals. The one reasonably robust population (at Castle Hill NNR in East Sussex) became the focus of a programme of autecological research, initiated by the Nature Conservancy Council and led by Val Brown and Andrew Cherrill. Outputs of this work (Cherrill, 1989, 1993; Cherrill & Brown, 1990a,b, 1991a,b, 1992a,b, 1997a,b; Haes et al., 1990; Cherrill et al., 1991) were important in elucidating the ecological requirements of the species. For the first time, it was possible to make informed recommendations for site and habitat management, and realistically to consider (re)introduction of the species to unoccupied sites.

A (re)introduction programme was initiated in the early 1990s, focusing on two sites, Lydden in Kent and Mount Caburn in East Sussex (Cheesman, 2015a), with the last releases being made at the latter site in 2000. Also in the early 1990s, formal monitoring of all extant *Decticus* populations began, with most survey work undertaken by John Shaughnessy. This continued until 2002, when agency funding ceased, although a more limited programme of work continued until 2008. The results of this population monitoring are available in a series of annual reports (see Appendix 1). Little information on the status of *Decticus* at any of its English localities was then obtained until 2013, when Natural England re-instigated site surveys and other work on the species (Cheesman, 2013, 2014, 2015b).

1.2 Life-cycle and habitat requirements

It is not the purpose of this report to review the life-cycle, ecology and behaviour of *D. verrucivorus*, which are described in detail in the published research outputs cited above (with further observations occasionally made in annual monitoring reports). However, the following summary points are worth noting here, as they have particular relevance for the interpretation of survey data and the assessment of species status.

Decticus lays its eggs in the soil, where they usually overwinter twice before hatching (i.e. most offspring of the adults recorded in 2015 will be expected to emerge from the soil as nymphs in 2017). However, the emergence of some nymphs may be delayed longer, with eggs potentially taking up to seven years to hatch (Ingrish, 1984). Hatching typically occurs in April, and the insects develop through seven nymphal instars before reaching the adult stage, typically by early August. Adults are then usually present in the field until the beginning of October.

Historically, *Decticus* is considered to have occurred on heathland in England, but it is safer to regard the insect as a species of high-quality calcareous grassland. This is the habitat

with which it has been most strongly associated, where its ecological requirements have been investigated, and where it currently survives. In this habitat, *Decticus* is confined to more-or-less south-facing slopes, owing to its thermophilous character (see below). Little high-quality calcareous grassland survives on flat ground, owing to past agricultural activities, but the species would probably occupy such areas, provided that they were open and sunny.

Decticus is omnivorous, but rather selective in its diet. It consequently requires a diverse, flower-rich sward that supports numerous small to medium-sized invertebrates, including grasshoppers (acridids). However, the structure of the habitat is also an important limiting factor. The species requires a small-scale mosaic, comprising short sward with small patches of bare ground interspersed with taller, denser vegetation, ideally provided by tussocky grasses such as *Brachypodium*. However, without appropriate management, the latter can rapidly form dense, continuous stands which lack the diversity of forbs and invertebrates, and the structural heterogeneity, required by *Decticus*. Early instar nymphs tend to be found in the short-sward areas, where the warmth maximises their rate of development. Later instar nymphs tend to move into the taller, tussocky vegetation, where they and subsequently the adults benefit from cover and concealment from (particularly avian) predators. Adult males also climb the taller vegetation to stridulate. However, adult females return to short-sward areas to lay their eggs in the patches of bare ground.

The combination of flower- (and invertebrate-) rich calcareous grassland of the correct type, with suitable structural heterogeneity at an appropriate scale, across a wide enough area with a favourable aspect, is rarely found. Even where it does occur, it can be difficult to maintain in an ideal condition for *Decticus*. Habitat management requirements may vary between sites and between years, depending on local conditions. Broadly, however, a regime of winter grazing by cattle is recommended, and grazing by sheep is strongly discouraged, especially over summer. Weather conditions can significantly influence the development of the habitat, particularly its vertical structure, following winter grazing. For example, the development of the taller, tussocky elements required by *Decticus* may be inhibited by extended dry periods. The sward may also be too uniformly short on sites (or parts of sites) that experience high levels of rabbit grazing. Weather conditions also affect the *Decticus* population directly, as the species requires warm, sunny conditions to ensure a good hatch, nymphal development and survivorship, and adult survivorship and reproductive output.

Although fully winged, *Decticus* is effectively flightless in England. Some adults may wander away from a population centre over the course of a season, although most appear not to, possibly over distances of 100m or more. Hence, peripheral records can occur, and eggs could be laid and subsequently hatch in peripheral areas. Generally, however, it appears that *Decticus* spreads only very slowly within a site, even when favourable habitat is available away from an existing population centre. That said, favourable habitat is rarely (if ever) continuous across a large area of a site, which may inhibit dispersal, as the species seems reluctant to move significant distances through unsuitable habitat.

1.3 Survey methods

Although it is a large and striking insect (at least in the adult stage), *Decticus* can be a remarkably difficult species for which to conduct surveys. This is partly because it is exceptionally well camouflaged amongst vegetation, and partly because of its elusive behaviour, particularly in later life-stages. Methods for monitoring *Decticus* populations were developed under the original autecological research programme (see Cherrill & Brown, 1997a), and a simplified prescription for monitoring was subsequently prepared for English Nature (see Brown et al., undated [1996]). Detailed demographic studies require data on a

range of life-stages, but sufficient information for general population monitoring can be obtained from surveys conducted in the adult period only.

Nymphs tend to be found initially in open areas of short sward, although there is a risk of trampling them while moving through the habitat, particularly when denser vegetation predominates. Comprehensive surveys for the smallest, earliest instars rely on painstaking, close examination of the ground and vegetation in the search area, but mid-instar nymphs are more visible and easily located in the short turf. Late instar nymphs and adults tend not to be found so readily in open areas, preferring the cover of taller, tussocky vegetation. Again, especially where the vegetation is uniformly dense (and in cool conditions when the insects are sluggish) there is a risk of trampling. However, provided that the habitat comprises the desirable mosaic of short sward and more tussocky patches, and the insects are active, a *Decticus* count can be conducted by a slow walk-survey through the search area, carefully observing the ground and nudging taller growth to “flush out” concealed individuals. This requires concentration, and individuals that are disturbed often drop or retreat into a tussock rather than moving into the open. Detection of adults where the population density is low, or where vegetation is more or less uniformly dense, may be achieved most effectively by listening for stridulating males.

In areas where the population density is reasonably high, it is possible to apply walk-surveys for adults to defined transects or blocks, with individuals ideally being caught and held in a suitable container at the point of capture to ensure against “double counting”. Estimates of the size of the overall population can then be obtained by multiplying up, using approximations of the total area occupied, based on more casual observations made across the wider site and knowledge of the extent of favourable habitat. However, where population density is low and/or the areas occupied are small and localised (which is often the case), transects and blocks are ineffective and estimates of population size rely on more casual walk-surveys across the wider site (e.g. see Lydden sections in Cheesman et al., 1998, 2000). Particularly in such situations, the detection of stridulating males is invaluable. This is often the most effective way of locating adults, provided that conditions are right for stridulation, i.e. sunny and warm. Frustratingly, however, even when conditions appear to be good, not all males can be relied upon to stridulate, and some will inevitably go undetected (e.g. see Lydden sections in Brown et al., 1997a and Cheesman et al., 1998). Nonetheless, particularly when based on counts obtained independently on a number of visits to a site, on different dates, in good conditions, a reasonable minimum estimate of adult population size can be obtained by doubling the numbers of stridulating males. This assumes a 1:1 sex ratio in the adult population, and there is no clear evidence to suggest that this assumption is invalid. However, it has been questioned, not least because direct observations of adult females are often very few. In some respects, this is unsurprising when a survey focuses principally on the detection of stridulating males, and low female counts have been noted at most (if not all) *Decticus* sites when using this approach. Nonetheless, in some years, even John Shaughnessy, with his unrivalled experience of *Decticus* fieldwork, found the paucity of adult female records at Lydden “disconcerting” (Cheesman et al., 1998), and speculated on whether it represented a true imbalance in the sex ratio that could be attributed to habitat characteristics at the site. For example, Cheesman et al. (2000) suggested that the relative isolation of patches of taller, tussocky vegetation and the particular openness of short turf areas at Lydden (cf. Section 2.1.1) might increase the exposure of ovipositing females, leading to disproportionate predation of these individuals, resulting in an uneven sex ratio in the adult population. However, the following year, adult survey data based on transects and blocks found very similar numbers of males and females at Lydden, even quite late into the season (Cheesman & Shaughnessy, 2001), suggesting that low female counts obtained during casual surveys were simply an artefact of the survey method.

2. The status of *Decticus verrucivorus* at Lydden to 2014

A colony of *D. verrucivorus* was reported from Lydden in 1967 (Dolling, 1968), and assumed to be the same (or a remnant of a wider) population known from the same locality decades earlier (e.g. Burr, 1936). Unfortunately, however, it appears that the Lydden population was extinct by the late 1970s. The loss of the colony seems to have resulted from the effects of two consecutive dry summers (1975 and 1976) and the introduction of summer grazing to control *Brachypodium*. Brown & Shaughnessy (1991) and Shaughnessy & Brown (1992) suggested that these factors combined catastrophically to reduce both the species' food supply (of flowering forbs, developing seedheads and invertebrates) and the availability of taller, tussocky vegetation in which late instar nymphs and adults could shelter from avian predators, at a time when numbers of corvids were very high on the site, attracted by a pig farm immediately below the Reserve (cf. Section 2.1.1).

As noted in Section 1.1, a (re)introduction programme for *Decticus* was established in the early 1990s, with activities focusing on two sites, Lydden in Kent and Mount Caburn in East Sussex. Early results from Lydden were summarised by Cheesman (2001), but the activities and outcomes of the (re)introduction programme have since been reviewed in detail by Cheesman (2015a). Based largely on the latter, the re-introduction and subsequent re-establishment of *D. verrucivorus* at Lydden are summarised below. However, aspects of habitat development and its influence on the species are considered in more detail here than in Cheesman (2015a), notably in the following section and in Sections 2.3 and 4.

2.1 The Reserve and habitat at Lydden

When the re-introduction of *D. verrucivorus* to Lydden was being considered in the early 1990s, the site comprised just three compartments (Ly1, Ly2 and Ly3), managed as a Local Nature Reserve by the Kent Trust for Nature Conservation (now the Kent Wildlife Trust, KWT). The area of the Reserve subsequently expanded significantly, both to the southeast and northwest (see Map 1), and the site was declared a National Nature Reserve in 1998. Despite its relatively small size, the early 1990s Reserve encompassed the area (mostly in Ly1) where *Decticus* had last been recorded in the 1970s (see Map 3). It was decided to focus the re-introduction here, not because of the historical presence of the species, but because this was where the most favourable habitat occurred. Since the re-introduction of the species, *Decticus* has never been recorded beyond Ly1, Ly2 and Ly3 (see Section 2.3), although the potential for spread to other parts of the Reserve has been considered (e.g. see Shaughnessy, 2007). The topography and certain other features of compartments Ly1, Ly2 and Ly3 are shown on Map 2.

2.1.1 Compartment Ly1

In relation to habitat and the requirements of *Decticus* (cf. Section 1.2), Shaughnessy & Brown (1992) noted that "[Ly1] is classed as a *Brachypodium pinnatum* grassland, and this species is indeed abundant. However, within the proposed release areas, there is a good mixture of short and sparse turf dominated by *Festuca ovina,* along with the tufts and tussocks of *Brachypodium.* Although *Brachypodium* is generally dominant over the whole slope, there is also a wide distribution of short turf areas. Thus, the former can supply shelter, whilst the latter provide oviposition sites and forbs in close proximity.... Floral diversity is very high [and] small Orthoptera species were noted to be abundant at several points across the slope; a good food source of *Decticus.* A feature very favourable to *Decticus* is the presence of a belt of taller, forb-rich lush vegetation along much of the

bottom of the slope... Such vegetation should provide a valuable refuge for late instar and early adult insects…. *Decticus* is very vulnerable to predation if the vegetation fails to provide sufficient shelter. Although this is very unlikely to happen in the *Brachypodium-Festuca* system at Lydden, a further positive feature of the site, since the 1970s, is the decrease in the Magpie population. This is due to the permanent closure of the pig farm below the Reserve." Shaughnessy & Brown (1992) also drew comparisons between the habitat in Ly1 and that found at Castle Hill NNR, noting that the latter (although supporting some areas similar to Lydden) was characterised more by *Bromus erectus-Festuca ovina* grassland. This was considered to have implications for the likely population densities of *Decticus* that might be achieved at Lydden, relative to those at Castle Hill NNR (see Section 2.2 below). Cheesman et al. (2000) further explored the significance of habitat differences between the two sites: "Unlike at Castle Hill NNR, where *Bromopsis erecta* [=*Bromus erectus*] and small tufts of *Brachypodium* are present throughout all short turf areas, there is a rather restricted height distribution of the Ly1 vegetation…tall dense patches of *Brachypodium* stand as islands, sharply demarcated from the surrounding short turf. At Lydden, the short turf areas are strongly dominated by *Festuca ovina,* with none of the mix of taller components which give the variability of intermediate heights as at Castle Hill NNR. Clearly, in Ly1, any *Decticus* moving across the short turf areas would be very exposed…It has long been thought that the vegetation structure of Ly1 gives opportunities to predators of *Decticus*" (cf. potential implications of this for adult females, in particular, discussed in Section 1.3).

Beyond this general assessment of the habitat in Ly1, a number of finer points are also worth noting, including based on observations made since the re-introduction of *Decticus*. The lay-out and topography of the compartment (see Map 2) are such that there is a pronounced depression at one end, adjacent to the woodland that borders Ly1 to the southeast (cf. Figure 6). Roughly in the centre of the southwest-facing slope that runs across the compartment is a much more subtle depression, generally referred to in past *Decticus* monitoring reports (and here) as the "shallow valley" feature (cf. Figure 7). A path runs roughly southwest from the entrance to the compartment (above the woodland edge depression) and then turns northwest, more or less following the top of the main slope. Much of the area above the line of the path is fairly flat and supports patchy scrub. However, towards the boundary with Ly2 (i.e. on the northwestern side of Ly1), there is an area above the path which is relatively free of scrub. This was outside the area of Ly1 designated as supporting favourable *Decticus* habitat when re-introduction was being planned (cf. Map 3), and very few records of the species have been obtained from here since a population has been re-established in the compartment. The failure of *Decticus* to exploit this area may reflect the lack of slope, but probably relates also to the quality of the habitat it supports. For example, Cheesman et al. (1999) noted that cattle on site over winter 1998/99 had "been effective at breaking up the extensive area of tall, dense *Brachypodium*" at the top of the Ly1 slope, which had been "advancing and thickening up again in the last two years, subsequent to a previous heavier graze by cattle."

The shallow valley nominally divides the main slope of Ly1 into southeastern and northwestern sections (e.g. see past monitoring reports). It is an important feature for *Decticus*, as experience demonstrates that the *Brachypodium* in the shallow valley almost invariably develops reasonable height and density (sometimes rather uniformly, sometimes more sparsely as fringes along terracettes) even when the rest of the main slope is dominated by short turf. As such, it can provide a refuge for late instar nymphs and adults when structural heterogeneity is otherwise lacking on the slope (e.g. see past monitoring reports and Section 2.3 below). A well-defined patch of tall, rather rank vegetation typically develops below the shallow valley feature, but slightly away from the very bottom of the compartment, possibly reflecting a disturbed area created by past scrub removal. This area can also provide shelter for later life-stages of *Decticus* (e.g. see Cheesman et al., 1999). The extent to which tussocky vegetation develops on the main slope itself is rather variable

between years, depending significantly on weather conditions and intensity of rabbit grazing, in combination with the effects of winter cattle grazing (which is, broadly, the main feature of habitat management recommended for *Decticus* sites). Although the presence of significant patches of scrub on the slope of Ly1 is undesirable from a *Decticus* perspective, small patches can be very valuable, providing foci around which tussocky grass can develop when taller vegetation is otherwise sparse on the slope.

2.1.2 Compartment Ly2

As shown on Map 3, the historical distribution of *Decticus* at Lydden extended beyond Ly1 and into the adjacent Ly2. Although it was clearly hoped that *Decticus* would ultimately become established in this compartment as well as Ly1, the habitat in most of Ly2 was considered to be less favourable to the species during the re-introduction and as the re-establishment progressed. For example, in 1997, when the first records of *Decticus* were obtained in Ly2 away from the boundary with Ly1 (see Section 2.3), the compartment was not considered suitable to support its own self-sustaining *Decticus* population, owing to low relative abundance of forbs and insufficient heterogeneity of vegetation structure. Continuation of winter cattle grazing, which was already in place and which had had beneficial effects in Ly1 over a number of years, was recommended (Brown et al., 1997a). Two years later, the majority of Ly2 was still considered sub-optimal for *Decticus*, as "*Brachypodium* was too dense to be ideal, and forbs were much less frequent than in Ly1" (Cheesman et al., 1999). However, in the longer term, Ly2 was seen as having the potential to provide habitat which could afford *Decticus* greater concealment from predators than the *Brachypodium* "islands" (cf. above) available in Ly1 (Cheesman et al., 2000).

As shown on Map 2, the main slope of Ly2 forms an apron, with the central part facing southwest. Most of the slope lies below the line of the path that crosses the compartment. Above the path, and towards the northeastern corner of Ly2, the area is rather flatter, and effectively forms a continuation of the flatter, upper northwestern section of Ly1 (cf. above); as in Ly1, few *Decticus* records have been obtained from this area. The upper part of Ly2 becomes more scrubby towards the top of the compartment, particularly in the northern corner adjacent to Ly3. As in Ly1, the bottom edge of Ly2 below the main slope supports a belt of rather rank but quite forb-rich vegetation. This is most expansive in the flattish area in the western corner of Ly2 below the slope, which invariably supports a sizeable block of more or less uniformly tall and rather dense vegetation. It appears from past monitoring reports (see also Section 2.3 below) that these areas below the slope can provide important refuges for *Decticus*, when the vegetation on the main slope fails to provide sufficient shelter. The general impression from past monitoring reports is that the abundance of flowering forbs has increased on the main slope of Ly2 during the period of *Decticus* re-establishment (cf. paragraph above), but that the vegetation structure tends to remain rather uniform.

2.1.3 Compartment Ly3

Whilst Ly1 and Ly2 were the main focus for *Decticus* re-introduction and re-establishment, the spread of the species into Ly3 was clearly desirable, if not necessarily expected in the short term. In the event, since the re-introduction, records of *Decticus* from this compartment have been relatively few and rather sporadic (cf. Section 2.3). Relative to Ly1 and Ly2, the topography of Ly3 is rather complicated (see Map 2). The ground slopes down along the boundary with Ly2 (particularly steeply at the southern end), opposite a main slope which varies in aspect from southeast- to southwest-facing. This arrangement effectively forms a bowl around three sides of a lower, flatter area at the bottom of the compartment. This lower area tends to support rather tall, rank and scrubby (but locally species-rich) vegetation. That along the boundary with Ly2 also tends to be rather tall and dense, whilst the vegetation on the main slope opposite tends to be mostly short sward.

However, when and where rabbit grazing is less intense, localised patches of more tussocky and flower-rich vegetation can develop on the main slope.

2.2 Re-introduction (1993-1996)

To facilitate the species' re-introduction, two parts of the Ly1 slope (Area A in the southeastern section and Area B in the northwestern section) were initially designated for *Decticus* releases, based on the distribution of favourable habitat (see Map 3). A series of releases was then made in 1993, 1994, 1995 and 1996, with stock either translocated from Castle Hill NNR or derived from a captive-rearing programme led by London Zoo (ZSL). Numbers released on each occasion are summarised below and in Table 1, and further details are given in Appendix 2 and Cheesman (2015a); the areas into which releases were made are shown on Maps 3-6.

In preparation for the re-introduction, Shaughnessy & Brown (1992) considered the differences in habitat between Lydden and Castle Hill NNR (cf. Section 2.1.1 above). It was concluded that "Under normal conditions, *Decticus* is found in [those parts of Castle Hill NNR that most resemble Lydden] at an average adult density of $0.003m^2$. A colony at Lydden should occupy 3 hectares, thus giving 90 adults in an average year. This estimate is somewhat cautious; the release sites, with more favourable vegetation, would be expected to hold higher densities, possibly up to $0.007m^2$ in an average year" (Shaughnessy & Brown, 1992). The estimate of 3ha occupancy suggests that the colony was not expected to extend much beyond the main slope of Ly1 in the first instance. However, the reference to more favourable vegetation in "the release sites" (presumably Areas A and B – which were each approximately 25x25m) emphasizes the importance of local variation in habitat quality to the density, distribution and overall size of the anticipated *Decticus* population.

In early August 1993, 54 adults were brought from Castle Hill NNR and released as male/female pairs, each into a separate patch of *Brachypodium* in either Area A or B (see Map 4). Post-release surveys provided some evidence of reasonable survivorship (Shaughnessy & Brown, 1993). From late June to late July 1994, 91 late-instar nymphs reared at ZSL were released in the vicinity of Areas A and B (see Map 5), as were 27 individuals reared to adulthood in Brighton and three adults from Castle Hill NNR (Shaughnessy & Brown, 1994). Again, post-release surveys provided some evidence of reasonable survivorship. As noted in Section 2.3, Lydden supported a small number of locally-hatched *Decticus* in 1995, progeny of the first individuals released on the site in 1993. This locally-hatched population was substantially augmented with captively-reared individuals, a total of 307 late-instar nymphs and adults being released between late June and mid-August, across the area of suitable habitat in Ly1, and in Ly2 close to the boundary with Ly1 (see Map 6). Unfortunately, however, post-release surveys located only small numbers of individuals, and it was concluded that survivorship of the stock released in 1995 was poor (Shaughnessy & Brown, 1995). As noted in Section 2.3, Lydden again supported a small number of locally hatched *Decticus* in 1996; at the end of August, this population was augmented with 14 adult females from Castle Hill NNR, released in the vicinity of Area B (Brown et al., 1996) (see Map 7). This was the last release made at Lydden under the re-introduction programme, with the exception of a single adult female translocated from Castle Hill NNR in 1998. The latter was (at least partially) of the yellow/purple colour form (see Cherrill & Brown, 1991a), and was released at Lydden to enhance the probability of survival of these rare colour variants from the Castle Hill NNR population (Cheesman et al.,1998).

2.3 Population re-establishment (1995-2014)

Estimates of the size of the *Decticus* population at Lydden (based on numbers in the early adult period) are summarised in Table 1. Further details are given below, and in Appendix 2 and Cheesman (2015a); the estimated distribution of the population in each year is shown on Maps 8-22.

Surveys in early summer 1995 found small numbers of locally-hatched nymphs in and around Areas A and B in Ly1, indicating offspring from the first release of *Decticus* made in 1993 (Shaughnessy & Brown, 1995). It is speculatively suggested that Lydden subsequently supported a very small number (probably <10) of locally-hatched adults in 1995 (see Table 1). However, it became impossible to distinguish these individuals from those reared in captivity, once releases began later in the summer (see Section 2.2). Hot and dry conditions in early summer delayed these releases, partly due to concerns over the development of favourable habitat in Ly1. Although, ultimately, the vegetation structure in and around the release areas "remained suitable for *Decticus* throughout the summer", the apparently poor survivorship of released stock may have been influenced by habitat factors, in combination with predation pressure from kestrels and carrion crows (Shaughnessy & Brown, 1995). However, there were also concerns that the captively-reared individuals released were not as physically robust as wild stock (Cheesman, 2015a).

Surveys of Lydden in 1996 again found small numbers of locally-hatched nymphs in Ly1 (including within Areas A and B) in early summer. This was followed by records of three final instar nymphs in late June, and four adults in early August (Brown et al., 1996). On that basis, it is speculatively suggested that Lydden supported a population of around 10 locally-hatched adults in 1996 (see Table 1). Although welcomed, this result was considered rather disappointing, given that the 1994 release of >100 individuals had been hoped to generate greater numbers of offspring. Indeed, it was suggested that the locally-hatched *Decticus* recorded in 1996 might have comprised solely the offspring of individuals released in 1993, and hatching after three years (Brown et al., 1996). The condition of the habitat at Lydden was considered favourable to *Decticus* in 1996, although plans to remove a proportion of the scrub from the slopes of Ly1 were welcomed, and it was noted that "an even greater level of scrub clearance would further benefit *Decticus*, by discouraging avian predators (noticeably magpies)" (Brown et al., 1996).

The precise distribution of the locally-hatched population of *Decticus* at Lydden in 1995 and 1996 is difficult to determine, given the small numbers of individuals involved and other confounding factors. Observations made in 1993 indicated that individuals dispersed away from the release areas to some extent, notably down the slope (Shaughnessy & Brown, 1993). However, it might reasonably be expected that the 1995 and 1996 populations were principally centred on Areas A and B (see Map 8).

The large release (of >300 individuals) made in 1995 provided the potential for a sizeable locally-hatched population at Lydden in 1997, although expectations were significantly lessened by the apparently poor survivorship of the released individuals (see Section 2.2). There was also the potential in 1997 for Lydden to support the first "second generation" of locally-hatched *Decticus*, i.e. progeny of individuals that had hatched on the site in 1995. Surveys in 1997 indicated the presence of *Decticus* around Area B and across much of the lower slope of Ly1 (see Map 9), and it was conservatively estimated that the locally-hatched *Decticus* population comprised around 50 individuals in the early adult period (Table 1). Adult records also included two isolated stridulating males found in Ly 2, c.100m from the boundary with Ly1 (see Map 9), although Brown et al., 1997a give no indication that Ly3 was searched for *Decticus* in 1997, probably because the species would not have been anticipated to have spread that far. The presence of *Decticus* in Ly2, so far from the boundary with Ly1, provided welcome evidence of the species' ability to disperse (at least

over modest distances) within a site, although it was impossible to determine when, and from precisely where, the movement had occurred. The last release in 1995 had been made just inside Ly2, close to the boundary with Ly1. Perhaps, therefore, it is most likely that one (or more) of the females in that group dispersed northwest into Ly2 before laying eggs, or that individuals hatching in 1997 from eggs laid close to the boundary in 1995 subsequently moved further into Ly2. Brown et al. (1997a) noted the potential for continued spread of *Decticus* into Ly2, provided that the quality of the habitat could be improved.

Surveys in 1998 found adults widely distributed across the lower to mid-slope areas of Ly1, with one stridulating male recorded on the boundary with Ly2, and another c.5m into this adjacent compartment (Cheesman et al., 1998) (see Map 10). However, it is not made clear how widely Ly2 was surveyed, and there is no indication that Ly3 was searched. As in 1997, a conservative estimate is that the locally-hatched *Decticus* population at Lydden in the early adult period comprised around 50 individuals in 1998 (Table 1). The character of the habitat in Ly1 appears to have been broadly similar to that in 1996 and 1997, with tussocky *Brachypodium* developing locally and providing the heterogeneity of structure required by *Decticus*, but with significant areas of short sward reflecting the pattern of rabbit grazing on the slope (Cheesman et al., 1998).

In 1999, *Decticus* occurred in good numbers across the lower to mid-slope of Ly1, and just over the boundary into Ly2; in addition, a thorough search of Ly2 away from the boundary with Ly1 located c.10 stridulating males spread widely across the slope (Cheesman et al., 1999) (see Map 11). Ly3 was also visited, and one stridulating male located there, close to (and about halfway along) the boundary with Ly2 (see Map 11). Whilst numbers of individuals were noted to decline in the late nymphal to mid-adult period, it can be estimated that the size of the population at Lydden in the early adult period in 1999 was approximately 250 (Table 1). Cheesman et al. (1999) noted that the habitat available to *Decticus* in Ly1 was “very favourable”. However, with the exception of the area immediately adjacent to the boundary with Ly1, the habitat in Ly2 was much less suitable.

Initial surveys in 2000 found *Decticus* across the lower slope of Ly1 in good numbers, although these were somewhat lower than in the previous year. Surveys later in the season indicated a concentration of adults around the roughly central “shallow valley” feature in Ly1, but records extended to the northwest of this and into Ly2, where there was another concentration close to the boundary with Ly1 (Cheesman et al., 2000). In addition, a small number of stridulating males were found scattered more widely across the Ly2 slope (see Map 12), but it is not clear whether Ly3 was surveyed. Overall, in the early adult period, it is estimated that the Lydden population comprised approximately 150 individuals in 2000 (Table 1). Cheesman et al. (2000) noted that Ly1 and Ly2 were relatively heavily grazed by cattle in winter 1999/2000. Although vegetation structure was slightly slow to develop following this, the Ly1 slope was adjudged to be “in very good condition” overall by early June. However, it was noted that some important areas of taller, denser vegetation failed to develop their typical character. Notably, that in the shallow valley (and in the forb-rich, rather rank patch of vegetation below it at the bottom of the slope) remained rather open and stunted throughout the summer. It was suggested that this may have contributed to the lower numbers of *Decticus* recorded in 2000, relative to the previous year, by exposing adults (possibly females, in particular) to predation by kestrels and corvids which remained a source of concern at Lydden. In Ly2, however, the heavy over-winter grazing appeared to have had broadly positive effects on habitat quality, in reducing the predominance of *Brachypodium* and possibly enhancing the abundance of flowering forbs (Cheesman et al., 2000).

Surveys in 2001 (Cheesman & Shaughnessy, 2001) recorded large numbers of *Decticus* across most of the slope of Ly1, with this distribution extending for up to c.25m into Ly2; a thorough search of Ly2 away from the boundary with Ly1 located c.30 stridulating males

spread widely across the compartment, particularly on the lower, central slope section, but with some individuals also closer to the boundary with Ly3 and on the flatter area above the Ly2 main slope (see Map 13). Ly3 was also visited, and five stridulating males located there, two close to the boundary with Ly2, the others in the centre of the compartment, low on the main slope (see Map 13). Although the density of adults had more than halved by late summer, some *Decticus* were still present in Ly1, Ly2 and possibly Ly3 at the end of September (Cheesman & Shaughnessy, 2001). Based on survey results, it is estimated that the population of *Decticus* at Lydden during the early adult period in 2001 comprised approximately 450 individuals (Table 1). Cheesman & Shaughnessy (2001) noted that the vegetation in Ly1 was very similar in 2001 to that in 2000. Overall, however, a slow advance of *Brachypodium*, and the possible need for summer grazing in future to check this, was noted. Ly2 was still adjudged to support a lower abundance of flowering forbs that Ly1, and it was suggested that heavier grazing may be required to reduce *Brachypodium* on the main part of the slope; the gentler, lower slope of Ly2 was described as “still dominated by rank grasses, mainly *Brachypodium*”, but with a high abundance also of some other species such as *Centurea*.

In 2002, large numbers of *Decticus* were recorded across the lower to mid-slope of Ly1 and extending c.100m into Ly2 across the lower to mid-slope; out-lying males were found north of this main distribution, one quite high on the main slope of Ly2 c.40m from the boundary with Ly3, and one in Ly3 itself just beyond the Ly2 boundary (Cheesman & Shaughnessy, 2002) (see Map 14). As in 2001, it is estimated that the population of *Decticus* at Lydden during the early adult period in 2002 comprised approximately 450 individuals (Table 1). In relation to habitat, Cheesman & Shaughnessy (2002) noted that vertical structure was a little slow to develop following winter grazing, but that favourable areas for *Decticus* ultimately developed in all three compartments. The removal of scrub from the slopes of Ly1 the previous autumn was noted with approval. Ly2 was considered to show continuing improvement, although the main slope still tended to support rather large, uniform areas of taller vegetation, in contrast to the patchy *Brachypodium*/short turf mosaic in Ly1, and the lower, flatter part of Ly2 remained dominated by tall dense *Brachypodium*. Although forb abundance in Ly2 was “only moderate” on the mid- to upper slope, species favoured by *Decticus* (such as *Lotus* and *Leontodon hispidus*) were considered to have “increased markedly over the last 2-3 years” elsewhere in the compartment. In general, it was suggested that summer grazing, although detrimental to *Decticus*, would be needed at some stage, to keep *Brachypodium* in check across the three compartments.

Owing to the cessation of agency funding (see Section 1.1), only limited survey work was possible in 2003, providing a rather incomplete picture of the Lydden population. However, it seems that adult numbers might have matched those of 2001 and 2002, had dry conditions not severely impeded development of the habitat, resulting in significant mortality in the late nymphal/early adult period (Shaughnessy & Cheesman, 2003). Mid-instar nymphs were found in very good numbers on the central lower slope of Ly1. However, by the late nymphal/early adult stage, numbers were probably reduced by about half, as most of the vegetation on the Ly1 slope was too short to provide shelter. Individuals were concentrated in the few areas with taller vegetation, notably the roughly central “shallow valley” feature, the forb-rich patch of rather rank vegetation below this on the slope, and in the belt of similar vegetation along the very bottom of the compartment (see Map 15). By early to mid-August, the condition of the habitat on the Ly1 slope had deteriorated further, and it was judged to be incapable of supporting adults in any numbers. Shaughnessy & Cheesman (2003) described conditions in Ly1 as “particularly drought affected. All slope vegetation was particularly short and dessicated, and even in the ‘shallow valley’, the *Brachypodium* had experienced significant die-back. There was hardly any vegetation on the slope, or above, which could have supported *Decticus*. Even the tall forb areas below the slope were no longer lush and dense, but were now brown, stunted and open.” Late instar nymphs and early adults were found also on the central lower slope of Ly2, so the

species again extended well into this compartment (see Map 15), but numbers were not high and short vegetation dominated the slope. By early to mid-August, scattered stridulating males were mainly restricted to the flatter area at the bottom of the slope, in the taller, denser vegetation there, although a few were also found towards the top of the main slope and along the boundary with Ly3 (Shaughnessy & Cheesman, 2003) (see Map 15). It is difficult to estimate the size of the *Decticus* population at Lydden in 2003, given the limited survey data and the rapid decline in numbers that appears to have occurred in the late nymphal/early adult period. However, it seems reasonable to suggest that the number of individuals entering the early adult period might have been in the range of 100-200 (Table 1), but that relatively few of these individuals survived for long enough to express more than a fraction of their reproductive potential.

Survey work was limited again in 2004, providing only an incomplete picture, particularly of the adult population, the size and distribution of which largely has to be inferred from observations made earlier in the season. It should also be noted that, for the third year running, dry conditions at least slowed the development of vertical structure in the habitat, restricting its suitability for later life-stages. Mid- to late instar nymphs were recorded in very good numbers (broadly comparable to those found in 2001 and 2002) in Ly1, with greatest densities on the lower to mid-slope, in the central and northwestern sections, as previously (Shaughnessy & Cheesman, 2004). Later in the season, however, the vegetation on the slopes of Ly1 was still considered “rather too short” with *Brachypodium* patches developing little height structure. This was particularly the case in the southeastern section, where the only taller vegetation developed “around some of the scrub elements”. The shallow valley feature, however, did develop vegetation that was at least moderately favourable to *Decticus*. Late instar nymphs were recorded in reasonable numbers in Ly2, “widely distributed across the lower half to two-thirds of the slope”, but these individuals were rather concentrated in limited areas where tussocky patches had developed, the vegetation on the slope being “mainly too short” (Shaughnessy & Cheesman, 2004). However, it was presumed that *Decticus* was also present in the “plentiful taller vegetation” below the main Ly2 slope. Following a limited search, ten final instar nymphs were found also in Ly3, mostly in the lower section adjacent to Ly2, but including two at the bottom of the main slope in the central area. In terms of available habitat, it was noted that the Ly3 slopes were “almost uniformly short, with few forb flowers”, although taller growth was scattered throughout the flatter area at the bottom of Ly3, where the vegetation “had a generally lowish, lush and dense character” (Shaughnessy & Cheesman, 2004). A brief survey at the end of September confirmed that a few adults were still present in Ly1 and Ly2 late in the season. Habitat factors (lack of structural heterogeneity) are likely to have constrained adult numbers and distribution in 2004, but there is no reason to believe that survivorship into and through the adult period was dramatically impaired, as in 2003 (see above). Also, the very good numbers of nymphs recorded on the site in 2006 indicated a strong reproductive output from the 2004 population (Shaughnessy, 2006). It is therefore suggested rather speculatively that the number of *Decticus* present at Lydden in the early adult period in 2004 was in the range of 100-200 (Table 1), and that the broad distribution pattern was as shown on Map 16.

Extremely limited survey work took place in 2005, based on just a single visit made in early May, with searches conducted in Ly1 only (Shaughnessy, 2005). These indicated that numbers of early instar nymphs were very low, and records came almost exclusively from around the roughly central “shallow valley” feature (cf. Map 17). Only a small (and possibly a very small) hatch had been anticipated in 2005, given the rapid crash in the adult population which almost certainly occurred in 2003 (see above), although eggs laid prior to 2003 and hatching after more than two years would have been expected to mitigate this to some extent. It is likely that nymphs were present more widely (including in parts of Ly2) than the single 2005 survey revealed, if only very locally and at rather low density. Habitat development in Ly1 and Ly2 appeared to be favourable at the time of the one survey

(Shaughnessy, 2005), so subsequent survivorship was probably reasonable, ensuring that some adults (at least) were present later in the season. Unfortunately, however, survey data from 2005 are insufficient even to make a speculative estimate of the adult population size at Lydden in that year.

Only limited survey work was possible in 2006. However, large numbers of late instar nymphs (broadly comparable to those found in 2001 and 2002) were recorded across much of the slope of Ly1. A brief search of the central part of the slope of Ly2 also confirmed the presence of late instar nymphs there, and it was "presumed that there were very many…[possibly quite evenly distributed]…on the slope" (Shaughnessy, 2006). Although no further visits were made to the site, there was no specific reason to expect a substantial population decline following the survey of late instar nymphs. Although Ly2 was considered to support "far too much *Brachypodium* [evenly spread] on the slope", with little short turf except in the southeastern part of the compartment (Shaughnessy, 2006), this should not have significantly reduced adult survivorship and habitat structure appears to have been generally good in Ly1. On that basis, it is speculatively suggested that the number of *Decticus* present at Lydden in the early adult period in 2006 was in the range of 200-300 (Table 1), and a broad distribution pattern (based on that of late instar nymphs) is suggested on Map 18.

Thanks to funding from KWT, survey effort was significantly enhanced in 2007. However, the weather intervened (and affected the *Decticus* population); a very warm and sunny spring led to an early hatch and rapid nymphal development initially, but a cold and wet summer resulted in adults appearing unusually late and impeded survey work (Shaughnessy, 2007). Only a small (possibly very small) population was anticipated, given the restricted reproductive output presumed from 2005 (see above). In the event, surveys indicated the presence of *Decticus* in small to moderate numbers, patchily distributed across Ly1 and Ly2, with a few individuals also located in Ly3 (Shaughnessy, 2007) (see Map 19). Other notable observations made during these visits to the site included a surprising lack of *Decticus* records from the roughly central "shallow valley" feature in Ly1, and greatest numbers in Ly2 being towards the top of the main slope, centrally and to the western side of the compartment (cf. Map 19). Shaughnessy (2007) suggested that some structural heterogeneity had developed on the slopes at Lydden by the early adult period, albeit rather patchily. The vegetation along the scrub edge at the bottom of the Ly1 slope had clearly become tall, lush and dense, as usual, and the shallow valley (as previously) supported relatively dense vegetation that would have been expected to act as a refuge for *Decticus* - hence the surprise that no records of the species were obtained from here. Shaughnessy (2007) went on to note that rabbit grazing had had a detrimental affect "with the result that the slopes of Ly1 were too heavily grazed…Over much of the slope previously suitable for *Decticus*, short turf areas was [sic] too short, with the additional problem of reduced forb flower abundance. Height structure became dominated by extremes; very short turf and taller established *Brachypodium* patches. This situation is not favourable to *Decticus*". Ly2 exhibited "a good suitability of vegetation for *Decticus* over much of the slope", with (as previously) rather tall, dense vegetation developing at the bottom of the slope. In this compartment, "the effect of heavy rabbit grazing was mainly apparent in the southeastern part, particularly low on the slope. The area of *Brachypodium* patches running up the slope close to the fence with Ly1, holding many *Decticus* in previous years, was grazed heavily, and *Decticus* was absent there in 2007." In relation to Ly3, Shaughnessy (2007) notes that "Much very suitable vegetation was present on the slopes" and that the bottom area contained taller vegetation, as previously. However, as noted above, very few records of *Decticus* were obtained in this compartment in 2007, consistent with past results. Visits in mid- to late September failed to locate *Decticus* in Ly1 or Ly2, suggesting that the adult population may not have persisted late into the season (Shaughnessy, 2007). Based on the survey data obtained, it is estimated that the number of

Decticus present at Lydden in the early adult period in 2007 was approximately 100 (Table 1).

Unfortunately, no formal surveys for *Decticus* were carried out at Lydden in 2008, 2009, 2010, 2011 or 2012 (cf. Section 1.1 and Map 20). Not even casual records appear to exist for the first four of these years, although observations obtained by a KWT volunteer in 2012 at least confirmed the presence of adults in Ly1 and Ly2 (Cheesman, 2013). With the re-instigation of agency funding for work on *Decticus* in 2013, a visit was made to Lydden in mid- to late August to make a rapid assessment of the condition of the site and to conduct a brief survey for the species. This confirmed that adults were present in Ly1, but not in large numbers, probably reflecting a paucity of taller, tussocky vegetation; although this had developed, as previously, in the shallow valley, the main slope areas on either side of this feature were dominated by rather uniform short sward, although some structural heterogeneity was maintained by tussocks of grass developing around the base of scrubby vegetation where this occurred. Parts of Ly2 were also visited in 2013, but much of the vegetation on the main slope below the path also lacked heterogeneity in vertical structure, being dominated by relatively uniform short sward, and no *Decticus* were encountered (Cheesman, 2013); Ly3 was not visited. In part, the lack of vertical structure on the main slopes of Ly1 and Ly2 may have reflected the relatively dry summer conditions, although the vegetation was reasonably green, and did not show obvious signs of drought stress. It is likely that pressure of rabbit grazing also contributed; this is not specifically noted by Cheesman (2013), but cf. Cheesman (2014). Unfortunately, survey data from Lydden in 2013 are insufficient to make even a speculative estimate of the size of the *Decticus* population, or to determine its likely full distribution (cf. Map 20). However, it was clear that adult numbers were only small by the time of the site visit and that, even earlier in the adult period, the habitat would not have supported large numbers.

In 2014, a visit in early September confirmed the presence of adults in small to moderate numbers in Ly1, particularly around the roughly central “shallow valley” feature; two stridulating males were also recorded immediately over the boundary into Ly2 (Cheesman, 2014) (see Map 21). Some time was spent in Ly3, but no evidence of *Decticus* was found in that compartment. Based on the survey data obtained, it is speculatively and conservatively estimated that the number of *Decticus* present at Lydden in the early adult period in 2014 was at least 50-100 (Table 1). It seems likely that (as in 2013) numbers may have been constrained by availability of favourable habitat. Much of the main Ly1 slope again comprised rather uniform, short sward, with structural variation most obvious in and around the “shallow valley” (where taller *Brachypodium* developed, as historically) and in the areas low on the slope where sparsely tall vegetation graded into denser, ranker vegetation right at the bottom of the compartment (Cheesman, 2014). These were the areas from which most of the 2014 *Decticus* records were obtained. Some structural heterogeneity occurred on the main slope areas, but (as previously) this was mainly where *Brachypodium* became tussocky around scrub saplings and more established scrub patches. Cheesman (2014) noted that the vegetation on the main slope of Ly2 below the path also had a rather uniform structure. Over large areas, the sward was uniformly short or only sparsely tall, and appeared quite dense, with few obvious patches of bare ground. Although the part of Ly2 immediately above the path (and particularly the area adjacent to the boundary with Ly1) was rather more variable in structure, it did not appear to be as rich in flowering forbs as the lower parts of the slope. As previously (and as in Ly1), the habitat of the main Ly2 slope graded into denser, ranker vegetation right at the bottom of the compartment; a similar gradation was noted along the boundary with Ly3, where taller, ranker vegetation had developed along much of the fence line. Whilst hot and dry conditions earlier in the 2014 summer may have contributed to the rather uniform short sward across most of the main slope areas in Ly1 and Ly2, it seems likely that rabbit grazing was another (possibly more) important factor (Cheesman, 2014).

With funding from KWT, a much more thorough survey for *Decticus* was possible at Lydden during the adult period in 2015 than had been possible in any year since 2007. Full details are given in Section 3 below, but a brief summary is appropriate here. Moderate numbers of *Decticus* were found in Ly1, with a small number of scattered records obtained also from Ly2, but with no evidence of the species in Ly3. Records from Ly1 initially appeared to be concentrated around the "shallow valley" feature, but were subsequently obtained more widely across the compartment, particularly on the lower and mid-slope areas (see Map 22). The habitat in Ly1 and Ly2 appeared to be more favourable to *Decticus* than in the previous two years (see above), with well-developed tussocks and patches of *Brachypodium* providing heterogeneity of structure over reasonable areas. Given this, the estimated early adult population of 100 (Table 1) was a little disappointing. The small population relative to the extent of suitable habitat may simply reflect conditions in previous years (especially 2013), which may also explain the initial concentration of records around the "shallow valley". However, it was noted that corvids were active over the *Decticus* compartments in large numbers in 2015, so predation pressure may also have constrained adult numbers and contributed to their decline through the season.

With such limited data available from the immediately preceding years, it is interesting to note that *Decticus* records in both 2014 and (initially, at least) 2015 were concentrated around the "shallow valley" in Ly1. In combination with the relatively modest population sizes estimated for those years, this would appear to suggest that the Lydden population was under pressure from a lack of structural heterogeneity on the main slopes in the preceding years. As noted above, short sward predominated on the slopes in 2013 (possibly driving the pattern of records seen initially in 2015) and in 2014 (suggesting that records in 2016 may also be concentrated around the "shallow valley), but the distribution of adults in 2014 suggests that this habitat constraint goes back at least as far as 2012.

Finally, it is worth noting briefly that individuals with at least partial characteristics of the yellow/purple colour form (see Cherrill & Brown, 1991a) have been recorded amongst locally-hatched *Decticus* at Lydden. These include individuals which must have been derived from translocated or captively-reared stock released at the site prior to the specific transfer of a yellow/purple adult female from Castle Hill NNR in 1998 (cf. Section 2.2). For example, one of the nymphs recorded in 1996 was "of the purple/pink [=yellow/purple] colouration type" (Brown et al., 1996), and a small number of individuals recorded in 1999 were partially of the "orange-pink" [=yellow/purple] colour form (Cheesman et al., 1999). One adult male found in Ly2 in 2001 was "of the partial apricot-pink/purple [=yellow/purple] form" (Cheesman & Shaughnessy, 2001) and "Several examples of the partial form of apricot-pink [=yellow/purple] *Decticus* were recorded in 2002…and the form appears to make up about 2-3% of the population" (Cheesman & Shaughnessy, 2002). Shaughnessy & Cheesman (2004) noted that three (out of 123) mid- to late instar nymphs found in Ly1 were "of the partial orange-purple [=yellow/purple] form" and Shaughnessy (2006) reported that six (out of 120) late instar nymphs recorded in Ly1 were at least partially of the "orange/pink [=yellow/purple] type".

Table 1: Summary of *D. verrucivorus* releases and estimated field populations at Lydden 1993-2015 (further details are given in the text and in Appendix 2)

Year	Individuals released	Approximate field population of adults*	Level of survey providing estimate of field population
1993	**54 adults** (Translocation from Castle Hill NNR)	-	-
1994	**121 late instar nymphs/adults** (Captively-reared stock, except three adults translocated from Castle Hill NNR)	-	-
1995	**307 late instar nymphs/adults** (Captively-reared stock)	<10	Limited
1996	**14 adults** (Translocation from Castle Hill NNR)	10	Good
1997		50	Good
1998	**1 adult** (Translocation from Castle Hill NNR)	50	Good
1999		250**/***	Good
2000		150	Good
2001		450**	Good
2002		450	Good
2003		Uncertain, but possibly 100-200 initially, with numbers then declining very rapidly	Limited
2004		Uncertain, but possibly 100-200	Limited
2005		Unknown, but undoubtedly very low	Very limited
2006		Uncertain, but possibly 200-300**	Limited
2007		100	Good
2008		Unknown	No survey
2009		Unknown	No survey
2010		Unknown	No survey
2011		Unknown	No survey
2012		Unknown	No survey
2013		Unknown, but certainly not high	Very limited
2014		At least 50-100	Limited
2015		100	Good

* estimates tend to be conservative, and refer to numbers in the early adult period.
** estimate revised from that given previously in Appendix 1 to Cheesman (2013, 2014) and similar running summaries of *Decticus* populations appended to earlier monitoring reports, following reassessment of survey data provided in the monitoring report for this year.
***estimate revised from that given previously in Cheesman (2001)

3. The status of *Decticus verrucivorus* at Lydden, 2015

Five survey visits were made to Lydden during the adult period to assess the size and extent of the *Decticus* population at the site in 2015. Unfortunately, the weather during August and early September (the main adult period) was disappointing, with relatively few hot, sunny and still days providing ideal survey conditions. Nonetheless, conditions were broadly suitable for *Decticus* survey during all of the 2015 visits to Lydden. As location of adults was principally achieved by listening for stridulating males (see below), surveys were suspended during periods without direct sunshine, when stridulation tended to abate. Breezy conditions during the first three visits caused some problems, and appeared to exacerbate general background noise from road, rail and farm traffic, aircraft overhead, and activities in a small industrial unit below Ly2/Ly3 and farm buildings low on the opposite side of the valley from Ly1. It is notable that, whilst stridulating males could be heard and located approximately under these conditions, very few were successfully approached and sighted. Not only did the swirling breeze and background noise make it difficult to precisely locate stridulating males, they appeared to be exceptionally sensitive to disturbance, falling silent when approached within 3-4m. With less breezy conditions during the final two visits, precise location of stridulating males became much easier, and they proved much easier to approach. Consequently, the majority of males heard on these occasions were also sighted.

As with previous surveys for *Decticus* at Lydden (cf. past monitoring reports), locations were marked on a site map using by-eye estimation. In addition, a GPS unit was used to estimate grid references for most individual or groups of records. For the sake of completeness, these grid references are given here to the nearest 1m. However, imprecision in GPS readings is such that **locations determined by this method may be reliable only to the nearest 10m**.

3.1 7th August survey

The first visit to Lydden in 2015 was made on 7 August. Conditions were reasonably warm, sunny with very occasional periods of light cloud, and with a moderate but gusting and somewhat cooling breeze. A bank of more persistent cloud arrived by mid- to late afternoon, when survey work was suspended. The main purpose of this visit was to make a relatively rapid, preliminary assessment of Ly1 and Ly2, to estimate the size and extent of the adult *Decticus* population and inform survey strategy for subsequent visits.

Four stridulating males were encountered in the depression adjacent to the woodland edge on the southeastern side of Ly1 (see Map 23). Three were towards the top of the depression, on the northwestern side of the feature, near the edge of regrowth from earlier scrub clearance, grouped around TR 27997 45128 (see Figure 1); one was amongst relatively dense *Brachypodium* in the central area at the bottom of the main slope of the depression (at around TR 27993 45095). Between the depression and the roughly central shallow valley feature (i.e. on the main Ly1 slope in the southeastern section of the compartment), two diffuse clusters of stridulating males were encountered (see Map 23): at the top of the slope, adjacent to the shallow valley, at least six males were present in an area of patchy but rather continuous *Brachypodium*; lower on the slope, and somewhat away from the shallow valley (around and below TR 27890 45092), at least four males were recorded in *Brachypodium* tussocks amongst shorter, more open sward. On the opposite (northwestern) side of the shallow valley, two diffuse clusters of males were also recorded (see Map 23). Again, these were at the top of the slope, immediately adjacent to the shallow valley (two males heard stridulating) and lower on the slope, rather further into the northwestern section of the compartment (at least three males). Whilst working around

these areas, at least three males were heard stridulating from within the shallow valley itself. Despite searching, the main Ly1 slope in the northwestern section of the compartment yielded no further records of *Decticus* until two males were encountered fairly low on the slope, one close to the boundary with Ly2 (TR 27709 45165) and one on the fenceline itself (see Map 23).

Figure 1 – One of three adult male *Decticus* stridulating from towards the top of the woodland edge depression in Ly1, 7 August 2015.

Searches of Ly2 made on 7 August concentrated on the area below the path, and recorded no evidence of *Decticus* on the main slope in the southeastern two-thirds of the compartment. However, closer to the boundary with Ly3, males were heard stridulating. A single male was encountered close to a patch of scrub immediately below the path (TR 27662 45327). At the bottom of the main slope, adjacent to the sizeable stand of rather rank vegetation, two males were recorded around TR 27635 45335 and two more around TR 27621 45298 (see Map 23).

Ly3 was not visited on 7 August, and the parts of Ly1 and Ly2 above the path were not searched (all have tended to yield only sporadic and isolated records of *Decticus* in the past, and do not tend to contain large areas of suitable habitat). In addition, however, the strip along the very bottom of the slope in the southeastern two-thirds of Ly2, and continuing along the very bottom of the slope in Ly1, which can support *Decticus*, was not surveyed – this was the intended "return route" at the end of the day, but conditions deteriorated before it could be walked.

Based on results obtained on 7 August, it was concluded that *Decticus* was present at Lydden (certainly in Ly1) in reasonable numbers, but not at sufficient density to justify the use of transects (cf. Section 1.3). It was therefore decided to use a combination of systematic and casual walk-survey methods on subsequent visits to the site.

3.2 22nd August survey

The second visit to Lydden was made on 22 August. Conditions were very sunny and very warm all day, but breezy. Based on the results of the earlier visit and the historical

distribution of *Decticus* at Lydden, two areas were selected for a more systematic search than had been possible on 7 August. These were the main slope of the southeastern section of Ly1 (between the depression adjacent to the woodland edge and the shallow valley feature) and the the northwestern section (between the shallow valley and the boundary with Ly2) below the path. In both cases, sweeps were made across the slope at roughly 10m intervals, listening for stridulating males and looking out for other individuals "walked up" in the course of the survey. In addition, the area in and immediately around the shallow valley feature was investigated with similar survey effort, but taking available routes through the generally denser vegetation here. Five stridulating males were encountered on the main slope of the southeastern section, all on the mid- to lower part of the slope (see Map 24). The localities of these individuals were recorded as TR 27880 45058, TR 27885 45031 and TR 27858 45053, with one male approximately 5m northeast, and another approximately 10m south, of a patch of scrub at TR 27900 45054. In and around the shallow valley, three males were heard stridulating (see Map 24). The localities of these individuals were recorded as TR 27862 45113, TR 27864 45123 and TR 27855 45161, the latter being higher on the slope than the other records, just below the path at the top of the shallow valley on the northwestern side. On the main slope in the northwestern section of Ly1, seven stridulating males were encountered (see Map 24). Three of these were in a small area centred on TR 27764 45158, whilst the localities of the others were recorded as TR 27760 45180, TR 27734 45182, TR 27726 45162 and TR 27723 45142.

A survey of the main slope of Ly2 on 22 August, concentrating on the area below the path, recorded three stridulating males, distributed widely across the compartment (see Map 24). One individual was 5m from the boundary with Ly1 at around TR 27689 45201, one was on the central part of the slope at around TR 27660 45269, and the third was closer to the boundary with Ly3 at around TR 27636 45322.

Ly3 was not visited on 22 August, nor were the depression adjacent to the woodland in Ly1 or the parts of Ly1 and Ly2 above the path surveyed.

3.3 28th August survey

Lydden was visited again on 28 August. It was initially cool with overcast skies, which delayed the start of survey work, but became clearer and warmer by late morning. Whilst it remained warm in the direct sunlight, a breezy wind became quite gusty and cooling during the day. The main focus of the visit was an assessment of Ly3, and of the slope of Ly2 above the path (see below). However, on the outbound walk to Ly3, a single sweep was made across Ly1 and the main slope of Ly2 below the path. This followed a route down the depression adjacent to the woodland in Ly1, across the bottom of the main slope in the southeastern and shallow valley sections of the compartment, up and across the main slope in the northwestern section to the stile, down the Ly2 slope immediately adjacent to Ly1, and then across the lower to mid-slope of Ly2. No *Decticus* were encountered in the depression adjacent to the woodland, but one male was heard at the bottom of the slope in the southeastern section (at around TR 27888 45036), close to the locality of one of the records obtained six days earlier (see Map 24). Three further males were heard low on the slope below the shallow valley feature, one on the southeastern side (at around TR 27847 45095) and two on the northwestern side. The GPS reading taken for one of the latter [TR 277794 45140] appears to be some way from the true locality of the record, which was probably closer to TR 27829 45110, based on the by-eye position sketched on a site map at the time and as shown here on Map 24; the second of the two individuals was c.15m above this on the slope. No *Decticus* were encountered on the main part of the slope in the northwestern section of Ly1, or on the Ly2 slope immediately adjacent to Ly1 below the path. However, one male was heard more centrally and fairly low on the Ly2 slope (at

around TR 27636 45258) and another just below the path closer to the boundary with Ly3 (at around TR 27669 45372) (see Map 24).

A search of Ly3, covering all areas except the upper main slope and the northern section of the compartment beyond this, yielded no evidence of *Decticus*. A search of the area above the path line in Ly2, concentrating on the lower 50m section, recorded one stridulating male, centrally in the compartment and just 3m above the path (at around TR 27696 45292) (see Map 24). One final record of *Decticus* was obtained on 28 August, on the return journey across Ly1 along the path. A male was heard stridulating c.10m below the path on the northwestern side of the shallow valley (at around TR 27847 45161), close to the locality of one of the records obtained six days earlier (see Map 24).

3.4 10th and 11th September surveys

Consecutive visits were made to Lydden on 10 and 11 September. Conditions were warm and sunny throughout both days, and the breeze was noticeably lighter than on the three visits made earlier in the summer. This appeared to have a significant influence on the ease with which stridulating males, once heard, could be located precisely and approached; almost all the stridulating males recorded during the September visits were seen as well as heard. These visits also yielded the only direct sighting of an adult female made during the 2015 surveys.

On 10 September, the southeastern section of Ly1 below the path line, including the depression adjacent to the woodland and the shallow valley feature, was surveyed first, using the systematic approached described above. Five stridulating males and one male/female pair were encountered (see Map 25). The males were distributed widely across the southeastern section, although none were recorded in the depression adjacent to the woodland. One was found at the top of the slope (at around TR 27938 45125), and another at the bottom of the slope (at around TR 27883 45045). The other three were recorded on the mid-slope of the southeastern section, at around (from east to west) TR 27921 45049 (see Figure 2), TR 27921 45079, and TR 27893 45091, the last of these being towards the shallow valley. A further stridulating male on the southeastern side of the shallow valley itself (at around TR 27870 45129) was found to have a female in close association (see Section 3.6).

The northwestern section of Ly1 above the path line was also surveyed systematically during the 10 September visit, but this area produced no records of *Decticus*. Other survey work on the day comprised a looping walk, intended to cover areas that have generated *Decticus* records in the past, but from which 2015 records were few or lacking. The route was along the bottom edge of the northwestern section of Ly1 close to the scrub line, the southeastern corner of Ly2, the bottom edge of Ly2 close to the scrub line, the strip of Ly3 immediately adjacent to the Ly2 boundary (bottom two-thirds only), the bottom of the Ly2 main slope, and the side of the Ly2 main slope immediately adjacent to the Ly1 boundary. This route produced just one *Decticus* record, a stridulating male being encountered low, and roughly centrally, on the main slope of Ly2, at around TR 27606 45233 (see Map 25; Figure 3).

Figure 2 – Adult male *Decticus* observed on the mid-slope of the southeastern section of Ly1, 10 September 2015.

Figure 3 – Adult male *Decticus* observed on the main slope of Ly2, 10 September 2015.

On 11 September, the northwestern section of Ly1 below the path line was surveyed systematically. In order to reach this area, the depression adjacent to the woodland and the main slope of the southeastern section of the compartment were crossed, generating three casual records of stridulating males. These were all on the main slope, at around TR27913 45054, TR 27895 45049 and TR 27912 45065, all close to localities of records obtained the previous day (see Map 25). In addition, a fourth stridulating male was heard on the

southeastern edge of the shallow valley, below the area where the pair of *Decticus* had been observed 24 hours earlier (see Map 25), although this individual could not be located precisely enough to take a GPS reading. The search of the northwestern section of Ly1 yielded records of six stridulating males (see Map 25). Four were in a cluster on the mid-slope, in an area approximately centred on TR 27756 45178 (see Figure 4), and another roughly halfway between this location and the shallow valley (at around TR 27790 45151). The remaining male was located closer to the boundary with Ly2 (at around TR 27706 45167), on the edge of a well-established patch of scrub, where it was using bramble as a stridulatory perch.

Figure 4 – One of a number of adult male *Decticus* encountered on the mid-slope of the northwestern section of Ly1, 11 September 2015.

Ly2 was also surveyed on 11 September, concentrating on the main slope below the path line and (in particular) the area adjacent to the boundary with Ly1. This search yielded one stridulating male, on the main slope towards the Ly1 side of the compartment but some way from the boundary (at around TR 27657 45222) (see Map 25).

3.5 Survey conclusions

The preliminary survey made on 7 August recorded *at least* 29 stridulating males, 24 of these in Ly1, mostly in or around the shallow valley, and the remainder in Ly2, on the Ly3 side of the compartment (see Map 23). Weather conditions, although acceptable, were not ideal. Even in ideal conditions, not all males present are expected to be stridulating (cf. Section 1.3), and it is likely that some stridulating males were not recorded as the survey was conducted quickly over a relatively large area in order to make a rapid assessment of the population. It is also possible that some losses to the initial adult population would already have occurred, as all *Decticus* had probably been adults for at least one or two weeks. On this basis, and assuming a 1:1 sex ratio, it is cautiously estimated that the early adult population at Lydden in 2015 was around 100. This is rather disappointing, given that the structure of the habitat was better than in the previous two years (see Section 3.7) and it was felt that the site could consequently have supported greater numbers of *Decticus* adults.

The 28 August survey concentrated on areas (i.e. Ly3 and the part of Ly2 above the path line) beyond the expected main distribution of *Decticus*. Most (if not all) of the casual records obtained elsewhere on the site on 28 August could reasonably be regarded as duplicating those obtained six days earlier (see Map 24). The 22 August survey had, by contrast, concentrated on areas where *Decticus* was considered most likely to be found, and recorded 15 stridulating males in Ly1 and three in Ly2 (see Map 24). Although, again, weather conditions were not ideal, the numbers of *Decticus* encountered on 22 August were again considered a little disappointing, and it was felt likely that a real decline in population size had occurred since the 7 August visit.

Taken together (and accounting for likely duplicate recording across the two days) the surveys conducted on 10 and 11 September can be seen as having recorded 12 stridulating males (and one female) in Ly1 and at least one (possibly two) stridulating males in Ly2 (see Map 25). Survey conditions were better on these days than during the earlier visits, but numbers were still somewhat lower than previously, possibly indicating a further decline in population size as the season progressed.

The apparently rather modest number of *Decticus* adults recorded at Lydden in 2015 relative to the extent of favourable habitat may indicate i) a relatively small hatch followed by good survivorship of nymphs, or ii) a larger hatch followed by significant losses in the later life-stages. It is impossible to determine which, and there is some circumstantial evidence to support either scenario. On one hand, although survey work in 2013 was very limited, it was sufficient to conclude that numbers of adults were only small and that the habitat would not have been expected to support large numbers in that year (see Section 2.3 above; Cheesman, 2013). On this basis, a large hatch in 2015 would not have been anticipated. On the other hand, there is some indication that predation pressure in 2015 may have been significant, given the number of corvids active over the site (see Section 3.6). Although the reasonable quantity of taller, tussocky vegetation on the slopes of Ly1 and Ly2 would have provided cover for late instar nymphs and adults, avian predators may have reduced numbers of *Decticus* prior to the surveys reported here. They may also have contributed to the fall in numbers observed between the surveys, although some decline in the population would have been expected during the season in any year.

3.6 Other observations

As noted in Section 1.1, *Decticus* can be vulnerable to avian predators in the late nymphal and adult life-stages, especially where insufficient tall, tussocky vegetation is available to provide cover. This has particular resonance at Lydden, where the extinction of the species in the 1970s has been linked to a failure of such vegetation to develop at a time when predation pressure from corvids (in this case, magpies attracted by an adjacent pig farm) was very high (see introductory paragraphs to Section 2). Lack of cover from predators was not initially seen as a threat to the re-introduction and re-establishment of *Decticus* at Lydden (see Section 2.1.1). However, predation was suggested as one explanation for the poor survivorship of the re-introduction stock released in 1995 (see Section 2.3) and it was subsequently noted that the character of the habitat in Ly1, with its sharp contrast between tussocks and the closely-cropped short sward between them, might provide predators with particular “opportunities” (see Section 2.1.1) and that adult females might be especially vulnerable (see Section 1.3).

Kestrels were noted hunting over the slopes of Ly1, Ly2 and Ly3 during the 2015 survey visits, but only as occasional individuals, and this is not unusual on *Decticus* sites (see past monitoring reports). However, the number of corvids (probably jackdaws and/or rooks) observed at Lydden during the 2015 visits was a source of considerable concern. The birds

were initially encountered during the first visit (7 August) when crossing the TE compartments to get to the Ly section of the Reserve. Cattle were present in TE4, and the birds seemed to be attracted by this. However, it soon became apparent that they were not restricting their attention to areas where livestock were present. By 1500 on 7 August, a flock of 40+ corvids was swirling above the upper slopes of Ly1 and Ly2, with individuals swooping down to investigate the lower slopes and a number stationed on fence posts along the Ly1/Ly2 boundary. During the visit on 22 August, a flock of 30+ was active on the upper slopes of Ly3. Corvids were encountered again on 28 August, only a small group were hunting over the Ly1 slopes initially, but a very large flock appeared over the compartment later in the day. Although no large aggregation was encountered during the 10 September visit, around a dozen birds were active over Ly2/Ly3 in the early afternoon. The following day, corvids were again present in the general area, although they showed little interest in the *Decticus* compartments on this occasion.

As noted in Section 1.3, low (or very low) numbers of records of adult females are not unusual when surveys for *Decticus* are focused on stridulating males. This proved to be the case at Lydden in 2015, when only one adult female was encountered. As noted in Section 3.4, pursuit of one of the stridulating males heard on 10 September revealed a male/female pair. The stridulating male was carefully approached, and was located low down on the edge of a *Brachypodium* tussock, accompanied by the female. The two were just a couple of inches apart, facing away from one another. Although the male was partially concealed, the female was well-positioned to be photographed (see Figure 5). While the shot was being arranged, the male remained in position and kept stridulating. As the shot was being taken, the male moved away, but only a few inches, and still kept stridulating. This was remarkable, given the general tendency of stridulating males to fall silent when approached, and to drop or scuttle away into dense vegetation when approached closely. Given this experience, it was interesting to note the following day that one of the males encountered in the northwestern section of Ly1 also exhibited an unusual reluctance to move away or cease stridulation when disturbed. This individual was photographed (image not included with this report) and, despite taking some evasive action, remained in sight and kept resuming stridulation as further shots were attempted. Perhaps this behaviour indicated that a female was present in the immediate vicinity? It is interesting to note also that three other males were present and stridulating nearby, which may reinforce the suggestion that a female was in the area, or provide an alternative explanation for the behaviour of the original male.

Figure 5 – Adult female *Decticus* observed on the southeastern side of the shallow valley in Ly1, 10 September 2015.

3.7 Habitat

Overall, in terms of its favourability to *Decticus*, the habitat at Lydden in 2015 appeared to be much better than in the previous two summers (cf. Cheesman, 2013, 2014), particularly in terms of vertical structure. In 2013 and 2014, vegetation on the main slopes of Ly1 and Ly2 lacked structural heterogeneity across much of their extent. Both the southeastern and northwestern sections of Ly1 were dominated by short-sward on the open slopes, with most of the structural diversity provided by taller grass in and around the shallow valley, and by tussocky vegetation developing around scrub saplings and longer-established patches of scrub. The main slope of Ly2 was dominated by short-sward or rather uniform areas of only sparsely taller grass, with few distinct tussocks. However, in 2015, there were many more areas on the main slopes of both compartments that supported tussocks or well-developed patches of *Brachypodium* - indeed, some were rather too large and continuous from the perspective of ideal *Decticus* habitat.

The woodland edge depression in Ly1 supported broadly similar habitat in 2015 to that observed there in 2013 and 2014. Based on observations made in all three years (but 2015 in particular) it is noted that a relatively uniform and dense patch of *Brachypodium* is developing amongst scrub saplings in the central area of the depression. On the southeast-facing bank (which is less shaded than the opposite bank, and therefore of more potential value to *Decticus*), a more varied structure occurs, with short sward amongst localised, tussocky *Brachypodium* patches. Some of the latter have developed around scrub saplings. Lower in the depression, where the sward is generally more uniformly short, much of the structural heterogeneity that does occur arises from such tussocks associated with scrubby elements of the vegetation. This poses a minor problem, as it would be desirable to remove much of the scrub growth (cf. Section 3.8.2), but without eliminating the tussocks. The upper part of the depression includes areas of vigorous woody regrowth where substantial patches of scrub have been cleared previously. An impression of the habitat in the woodland edge depression in 2015 can be gained from Figure 6.

In 2015, as in most years, the shallow valley in Ly1 supported more consistently tall *Brachypodium* growth than the open, main slopes. Also as noted previously, this growth formed distinct fringes along terracette-like lines running across the slope of the valley (see Figure 7). It is interesting to note that *Decticus* records from Ly1 were concentrated around this area during the first 2015 survey on 7 August (see Map 23). Some of the scrub in the shallow valley is now becoming quite substantial, including a hawthorn bush towards the bottom of the feature on its northwestern side, under which a rabbit warren has developed. The development of structural heterogeneity in the vegetation of the shallow valley does not appear to be dependent on the presence of scrub elements, as can be the case elsewhere in Ly1, and removal of scrub from the feature would be highly desirable (cf. Section 3.8.2). To either side of the top of the shallow valley (and particularly to the southeast), *Brachypodium* had formed some rather dense and uniform patches. An even larger, dense patch had developed low on the slope, between the bottom of the shallow valley and the well-defined rank patch previously noted close to the very bottom of the compartment (cf. Section 2.1.1). It was noted that Agrimony was especially abundant in this rank patch in 2015.

Significant parts of the open, main slope in the southeastern and northwestern sections of Ly1 remained as uniformly short sward in 2015. However, much more than in 2013 and 2014, good patches of taller, tussocky *Brachypodium* had also developed, forming more of a structural mosaic over parts of the slope. An impression of this can be gained from Figure 8. Some of the tussocky *Brachypodium* was associated with scrub elements, but other tussocky patches had developed in the absence of these. Scattered, relatively small scrub

saplings may represent a valuable feature on the slope, providing foci for the development of tussocks in years when these do not otherwise develop. However, some scrub patches on the slope (notably in the northwestern section) are now rather large and well-established (cf. Section 3.8.2).
As noted in Section 2.1.1, the part of the northwestern section of Ly1 above the path line tends not to have produced many *Decticus* records in the past (and none were obtained here in 2015). The structure of the habitat in this area was reasonably good in 2015, with some rather large and dense patches of *Brachypodium*, but good heterogeneity otherwise. However, the density of flowering forbs seemed substantially less here than on the slopes of Ly1 below the path line (particularly in the southeastern section). There was evidence of a reasonable diversity of forbs, but few were abundant, even locally, except *Euphrasia* which flourished in the shorter, rabbit-grazed areas. Some of the scrub-edge areas were more flowery than the open areas, but tended to be rather rank in appearance. Overall, the impression was that the area was recovering from a period when the *Brachypodium* had become very dense, out-competing the forb component of the sward; cattle grazing may have helped to open up the *Brachypodium* and create a greater diversity of structure, but with forbs slow to proliferate in response. This is rather speculative, but is consistent with observations made in earlier years that this area was in particular need of grazing (cf. Section 2.1.1).

Although much of the main slope of Ly2 remained structurally rather uniform in 2015, some tussocks and denser/taller areas of *Brachypodium* had developed locally, providing more of a structural mosaic than had been apparent in the previous two years. However, it was interesting to note that the strip of the Ly2 slope below the path line and immediately adjacent to the boundary with Ly1 was particularly uniformly short. This is the part of the compartment that was initially most favourable to *Decticus*, although it was subsequently reported to comprise uniformly short sward, e.g. in 2007 (cf. Section 2.3). Certainly, the lack of structural heterogeneity here in 2015 made the area unsuitable for the species. Also, and as noted in 2014 (Cheesman, 2014), whether short or tall, the sward across the whole of the main Ly2 slope in 2015 appeared rather denser and lacking in areas of bare ground than the sward on the main slope in Ly1.

The area of flatter ground at the bottom of the Ly2 slope, in the western corner of the compartment, supported rather uniformly tall and rank-looking vegetation in 2015. This has been a consistent feature of Ly2 over a number of years, and the area has been considered to provide useful cover for the later life-stages of *Decticus* when taller, tussocky vegetation is lacking on the main slope (see Section 2.3). Although such vegetation did occur on the main slope in 2015, it is interesting to note that four out of the five stridulating males recorded in Ly2 during the 7 August survey were on the edge of this area of flatter ground (cf. Map 23). As in previous years, the part of Ly2 above the path line, although structurally heterogeneous locally, appeared rather forb-poor when compared with the main slope below.

In Ly3 in 2015, the rather rank vegetation along the boundary with Ly2 was particularly tall and dense along the southwestern third of this strip, where the slope forms a steep bank down to the “valley bottom” of the compartment, with scrub building on a narrow, flat area at the top of this bank along the Ly2/Ly3 fenceline. The northeastern two-thirds of the strip, which slopes less steeply (effectively forming a continuation of the Ly2 slope) supported rather more open, but still tall and dense, vegetation. The valley bottom of Ly3 supported tall, rather rank vegetation, including significant patches of ragwort, in amongst developing scrub. The main slopes of Ly3, on the northern side of the compartment, can be considered in two units (cf. Map 2). The western unit comprises a slope which principally faces south to southeast. A mixture of vegetation occurred on this slope, but it was notable that the lower part was uniformly very short grazed, and supported many rabbit burrows. Higher up the slope, the vegetation structure became more mixed, but was still dominated by short sward

across large areas. The eastern unit comprises a slope which turns from west-facing to southeast-facing. Again, this supported a mixture of vegetation. The lower parts graded into the rankish vegetation of the valley bottom, while the mid-slope supported a mixture of close-grazed sward and areas of somewhat longer grass, including a few, small, localised tussocks. Although the habitat might have been suitable for *Decticus* in these limited areas, it was far from favourable overall. In addition to the predominance of short sward on the main slopes, abundance of flowering forbs appeared to be rather low, both features being attributable to a high level of rabbit grazing. With the lack of significant areas of suitable habitat on the main slopes, and only sporadic records obtained from this compartment in previous years, the apparent absence of *Decticus* from Ly3 in 2015 was no great surprise.

Figure 6 – View looking down into the woodland edge depression in Ly1, 28 August 2015 (southeast-facing bank to the right).

Figure 7 – View looking down across the “shallow valley” in Ly1, from the top of the feature on the northwestern side, 28 August 2015.

Figure 8 – View looking down across the northwestern section of the main slope of Ly1 (below the path line), 11 September 2015.

3.8 Management issues and recommendations

Overall, the habitat management at Lydden has clearly succeeded in maintaining conditions favourable to *Decticus* since its re-introduction to the site. Nonetheless, the sensitivity of the species to habitat quality will always leave it potentially vulnerable, as at other sites, and it would be desirable to generate optimum habitat over a greater area and more consistently from year to year. Unfortunately, there is probably no simple means by which this can be achieved.

3.8.1 Grazing (including by rabbits)

Discussions with Pete Forrest (KWT, then site manager) in 2014 indicated that Ly1, Ly2 and Ly3 were grazed by cattle as a single unit, each year for the month of October only (Cheesman, 2014). Broadly speaking, such a winter cattle grazing regime is very much what would be recommended on any *Decticus* site, and there is no immediate evidence that it is inappropriate for Lydden. In an ideal world, the stocking density and duration of winter cattle grazing might be adjusted, including some confinement of stock to particular compartments (or parts of compartments) to provide for more tailored management. It is recognised, however, that it is generally impractical to "micro-manage" livestock grazing on an annual basis in this way, although occasional refinements may be required to ensure that benefits are maximised.

A significant complication in designing an "ideal" grazing regime for *Decticus* is that the impact of livestock needs to be balanced against other influences on the development of favourable habitat, such as weather effects and rabbit grazing, which can themselves vary considerably from year to year. This is a challenge at all *Decticus* sites, to some extent, but may be of particular significance at Lydden. Firstly, the development of all-important vertical structure in the grassland vegetation at this site appears to be more sensitive to weather conditions in spring and summer than at other sites (Shaughnessy & Cheesman, 2004; Cheesman, 2013, 2014). For example, the effects of two consecutive hot, dry summers seem to have contributed to the extinction of *Decticus* at Lydden in the 1970s (see introductory paragraphs to Section 2). Hot and dry early season conditions led to concerns over habitat development which delayed, and may have affected survivorship following, the 1995 *Decticus* releases (see Section 2.3). Subsequently, dry conditions at least slowed the development of vertical structure in 2002 and 2004, either side of a year (2003) when such conditions suppressed its development almost completely, resulting in a dramatic crash in the *Decticus* population (see Section 2.3). Secondly, rabbit grazing appears to be particularly important in influencing sward structure at Lydden. Experience from other sites has demonstrated how severely excessive rabbit grazing can degrade *Decticus* habitat. For example, the impact of rabbits on the south-facing part of Newmarket Hill (part of Castle Hill NNR) during the 1990s was sufficient to eliminate favourable habitat from most of the slope, which became dominated almost entirely by closely-cropped short sward (see past monitoring reports). However, work to push back a dense belt of encroaching scrub (which provided cover for rabbits) from the top of the slope in 1999 (see Cheesman et al., 1999), combined with direct measures to reduce rabbit numbers, allowed the structural mosaic required by *Decticus* to recover. Whilst the impact of rabbits at Lydden is not quite this severe, the habitat observed on the slopes of Ly3 in 2015, for example, was certainly unsuitable for *Decticus* over large areas as a result of their grazing pressure. There is also little doubt that rabbit grazing is an important factor influencing the development of structural heterogeneity on the main slope of Ly1. This has probably been the case for many years, and likely contributes significantly to the pronounced demarcation of short-sward areas and "islands" of *Brachypodium* noted in Section 2.1.1. Concern over the impact of rabbits on

Decticus habitat in Ly1 has been noted before (e.g. Cheesman et al., 1998; Shaughnessy, 2007; Cheesman, 2014). However, the real risk to *Decticus* in any given year is that rabbit grazing pressure and dry weather could combine to produce slopes on which the sward develops almost no vertical structure (Shaughnessy, 2007; Cheesman, 2014).

It is probable that the rabbit population across Ly1, Ly2 and Ly3 already experiences periodic lows, e.g. under the influence of myxomatosis. Nonetheless, it is recommended that the potential benefits of rabbit control in these compartments be considered. This will require further exploration of the practicalities of such work, links to scrub management (e.g. see below), and any potential adjustments to the current livestock grazing regime that might be required to compensate for reduced rabbit grazing.

3.8.2 Scrub

Scrub control in the *Decticus* compartments at Lydden (particularly Ly1) has been noted previously as a significant consideration (e.g. cf. Brown et al., 1996; Brown et al., 1997a), and remains a concern. Notwithstanding the practical (e.g. resource) constraints, however, scrub clearance is not an entirely straightforward issue here. As noted at various points in this report (and previously, e.g. Cheesman et al., 1998, Cheesman, 2013), *Brachypodium* tends to form tussocky growth around scrub patches and even at the base of small, individual saplings (e.g. of hawthorn or rose). This can be extremely valuable to *Decticus* in providing refuges for later life-stages when the sward on the open slope is otherwise uniformly short. When tussocks and patches of taller *Brachypodium* develop anyway (as in 2015), the role of those associated with scrub is less important. However, whilst a relatively sparse scattering of young scrub growth may provide a useful "safety net", ensuring the development of some structural heterogeneity, the presence of larger bushes and scrub patches is undesirable. On that basis, some current priorities for scrub control in Ly1 include:

a) Scrub developing in the shallow valley feature. As noted elsewhere, this is the part of the compartment where good structural heterogeneity tends to develop most readily, even without scrub elements. There are now some quite sizeable bushes here, including a hawthorn towards the bottom of the feature on the northwestern side, under which a rabbit warren has developed. It is recommended that these be removed.

b) Larger scrub patches on the main slope on the northwestern side of the compartment. For example, there are two adjacent scrub patches on the low to mid-slope, close to the boundary with Ly2 (principally bramble and dogwood, but also supporting some hawthorn, *Vibernum* and rose). The larger of the two (closest to Ly2) conceals a sizeable rabbit warren. These scrub patches will soon coalesce into a single unit, and it would be desirable to intervene before they do. It is recommended that larger patches of scrub like these be removed.

c) The scattered scrub in the woodland edge depression on the southeastern side of the compartment. This appears to have been a target for management efforts in recent years (e.g. see Cheesman, 2014), but remains quite dense in places. It is recommended that the scrub elements here continue to be thinned out, and that the regrowth at the top of the depression (where at least one larger patch of scrub was previously removed) continues to be controlled.

3.8.3 Predators

Cheesman (2013) noted that historical problems with corvids at Lydden had receded, but this may have been an over-optimistic assessment. Certainly, the number observed during surveys of compartments Ly1, Ly2 and Ly3 in 2015 was a surprise and a concern (see Section 3.6). It seems likely that these birds will have contributed to predation pressure on the *Decticus* population, although precisely to what extent is unknown (cf. Section 3.5). Nor is it clear whether this was an exceptional year for the birds, or whether the local population has steadily increased over a number of years, or whether such an increase might be expected to continue.

It is recommended that available data be examined to determine whether there is any clear trend in the corvid population at Lydden, and that numbers continue to be monitored.

4. Conclusions and prospects for *Decticus verrucivorus* at Lydden

Summer 2015 marked 20 years since the first *D. verrucivorus* hatched at Lydden following the species' extinction at the site in the 1970s and its subsequent re-introduction in the early 1990s. Based on a review of the status of *Decticus* at Lydden since the re-introduction (Section 2.3 above; Cheesman, 2015a), it seems clear that the species is now well established in Ly1. This compartment was the main focus of the re-introduction programme, being adjudged to contain the greatest continuous area of favourable habitat when releases were made in 1993-96. However, the species has now spread naturally across the adjacent compartment, and can probably be regarded as established in Ly2 as well.

As would be expected, the size of the *D. verrucivorus* population at Lydden varies from year to year, and data are limited or unavailable for some years (notably 2008-2013). However, it appears to be broadly consistent with the expectations of the re-introduction programme. Although focused on Ly1, this made a "cautious" estimate that the site might support 90 adults in an average year (Section 2.2 above; Shaughnessy & Brown, 1992), and in most years for which data are available the early adult population at Lydden appears to have been in a range of around 50-200 (cf. Table 1). In "good" years, numbers have substantially exceeded this, e.g. reaching a peak of around 450 in 2001 and 2002. However, the population has also experienced some quite dramatic "lows", notably when numbers crashed in 2003, and (reflecting the species' typically two-year life-cycle) remained very low in 2005.

The population crash in 2003 illustrates the sensitivity of *D. verrucivorus* to annual variations in habitat quality, apparently resulting from a failure of taller vegetation (notably tussocks of *Brachypodium*) to develop on the slopes of Ly1 in what was an exceptionally dry year. This deprived late instar nymphs and adults of their preferred conditions and (perhaps critically) opportunities for concealment from predators. The fact that this was one of three consecutive years when dry conditions led to concerns over the development of the habitat (Section 2.3 above) emphasises the potential vulnerability of *Decticus* at Lydden. Nonetheless, since the re-introduction, sufficient favourable habitat appears to have developed in Ly1 annually to support a reproducing population of adults, albeit a small (or very small) one in some years. Some parts of Ly1 are particularly important in providing favourable habitat structure, notably the shallow valley, in and around which some taller, tussocky vegetation seems to develop (2003 being a notable exception) even in years when such habitat largely fails to develop on the open slopes. The significance of this has been recognised for a number of years, and the recent distribution pattern of *Decticus* may indicate that the shallow valley has been important for the persistence of the species in Ly1 during the period for which no population data are available (Section 2.3 above). Such observations also highlight the potential importance of scattered scrub elements on the slopes of Ly1, as *Brachypodium* often becomes tussocky around these, even when the sward is otherwise mostly uniformly short. In this respect, the presence of small scrub patches and individual saplings of species such as hawthorn are beneficial to *Decticus*, although they can rapidly form larger patches and mature bushes which are probably of greater benefit to predators and which can rapidly displace the grassland community locally, and this can be slow to recover following scrub clearance, resulting in patches dominated by rank vegetation and scrub re-growth. Whilst *Decticus* is probably secure in Ly1, the combination of rabbit grazing pressure and sensitivity of the vegetation to dry conditions represents some threat to the species, through the potential failure of vertical structure to develop (Section 3.8.1 above). It would be desirable to ameliorate this threat by ensuring optimum habitat

over a greater area, and more consistently from year to year, although there is probably no simple means by which this can be achieved.

In almost all years for which data are available, at least some records of *D. verrucivorus* have been obtained from Ly2, and in some years numbers in this compartment have been very good. The only releases made in Ly2 (in 1995) were very close to the boundary with Ly1, so the subsequent spread of *Decticus* across the compartment represents unassisted movement of the species. What cannot be determined clearly is the extent to which individuals move between compartments in any given year. However, it is more probable that adults successfully reproduce in Ly2, albeit in small numbers in some years, than that individuals recorded here ordinarily hatch in Ly1 and then disperse into the adjacent compartment. It seems likely, therefore, that the species can be regarded as established in Ly2. Although the habitat in most of this compartment was not initially considered to be as good as that in Ly1 (Section 2.1.2 above), the re-introduction programme hoped that *Decticus* would ultimately spread into and become established in Ly2. Habitat quality on the main slope here seems to have improved over the years, at least in terms of the abundance of flowering forbs, but there may still be work to do in promoting the development a structural mosaic over a wide area if the compartment is to realise its full potential for *Decticus*.

Whilst *Decticus* has been found in Ly3 in some years (and may have gone undetected, although present there, in others), records have been relatively few, particularly away from the boundary with Ly2. It seems extremely unlikely that the species can be regarded as established in this compartment, a conclusion which is re-emphasised by the paucity of favourable habitat found on the slopes in 2015. The areas of rather rank vegetation in Ly3 have the potential to shelter individuals “spilling over” from more typical *Decticus* habitat, and this would explain records obtained previously along the Ly2/Ly3 boundary (with Ly2 acting as the source). However, with better habitat lacking from Ly3 itself, it is likely that (as previously) only sporadic records will occur on the main slopes, as and when numbers in Ly2 are sufficient to provide individuals that will wander further into the adjacent compartment. Should the habitat on the slopes of Ly3 improve, establishment could occur, and this would open up the possibility of further natural spread of *Decticus* across the site to Ly4, as previously noted by Cheesman & Shaughnessy (2002) and Shaughnessy & Cheesman (2004).

The potential for the spread (or successful translocation) of *Decticus* to parts of Lydden beyond Ly1-3 is not considered further here, but is discussed briefly in past monitoring reports, including Cheesman & Shaughnessy (2002) and Shaughnessy & Cheesman (2004), and is assessed in more detail by Shaughnessy (2007).

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Appendix 2: Summary of *D. verrucivorus* releases and field populations at Lydden Temple Ewell NNR, 1993-2015.

		Field population		Details and notes
	Individuals introduced	**Approximate no. adults***	**Distribution summary**	
1993	54	-	-	54 adults (27♂♂ + 27♀♀) from Castle Hill NNR released in Ly1 Areas A+B (see Map 4)
1994	121	-	-	118 captively-reared late instar nymphs and adults (including at least 35♂♂ + 56♀♀) and three adults (2♂♂ + 1♀) from Castle Hill NNR released in Ly1, in the general vicinity of Areas A+B (see Map 5)
1995	307	<10	In and around Ly 1 Areas A+B (see Map 8)	283 captively-reared late instar nymphs and adults (152♂♂ + 131♀♀) released across the area of suitable habitat in Ly1; 24 captively-reared adults (12♂♂ + 12♀♀) released in suitable habitat in Ly2, close to boundary with Ly1 (see Map 6) The estimated field population of <10 adults, and their distribution, is rather speculative, based on small numbers of locally-hatched nymphs found early in the summer; once the 1995 releases began, it became impossible to determine whether individuals encountered on the site had hatched there or been introduced; locally-hatched nymphs were found only in and around Areas A+B, despite wider searching
1996	14	10	In and around Ly 1 Areas A+B (see Map 8)	14 adults (all ♀♀) from Castle Hill NNR released in Ly1 in the vicinity of Area B (see Map 7) The estimated field population of 10 adults is rather speculative, based on small numbers of locally-hatched nymphs found early in the summer (half of these within Areas A+B) and four adults recorded subsequently, but before releases were made
1997		50	In and around Area B and across the lower slope of Ly1; two isolated males in Ly2, some distance from the boundary with Ly1 (see Map 9)	A survey in late May indicated reasonable numbers of mid-instar nymphs in and around Area B (although this is where searching was concentrated); subsequent, wider surveys for adults indicated their presence here and across much of the lower slope of Ly1; two stridulating males were also recorded in Ly2, some distance from the boundary with Ly1
1998	1	50	Across the lower to mid-slope of Ly1; one male in Ly2, c.5m from the boundary with Ly1 (see Map 10)	One partial yellow/purple adult ♀ from Castle Hill NNR released in Ly1 A survey in mid- to late May recorded promising numbers of mid-instar nymphs in and around Areas A+B and across the lower slope in Ly1; surveys in early August suggested that a minimum of 40 adults were present across the area of suitable habitat in Ly1; one stridulating male was located on the boundary with Ly2, and another c.5m into this adjacent compartment

1999		250**/***	Mostly across the lower slope of Ly1 and into the adjacent part of Ly2; c.10 stridulating males across Ly2 more widely, and one in Ly3 close to the boundary with Ly2 (see Map 11)	Surveys in mid- to late June recorded very good numbers of late instar nymphs (and a few early adults) across the lower slope in Ly1; nymphs were also found in Ly2, within 10m of the boundary with Ly1 and low on the slope (an extension of the Ly 1 distribution), but none were found further into this compartment, despite searches; surveys in late July and early August recorded good numbers of adults with a similar distribution to that earlier noted for nymphs; in addition, a thorough search of Ly2 away from the boundary with Ly1 located c.10 stridulating males spread widely across the slope; Ly3 was also visited, and one stridulating male located there, close to (and about halfway along) the boundary with Ly2
2000		150	Mostly around the "shallow valley" feature in Ly1, but scattered records also on the lower to mid-slope adjacent to Ly2; in Ly2 close to the boundary with Ly1, but a few scattered records of stridulating males across Ly2 more widely (see Map 12)	Surveys in late May and early June recorded good numbers of mid-instar nymphs across the lower slope in Ly1 (Ly2 was visited to assess habitat but not searched for nymphs); subsequent surveys suggested that numbers of late instar nymphs and adults were somewhat lower than in 1999; records of adults indicated a concentration of *Decticus* around the "shallow valley" feature in Ly1, but records extended to the northwest of this and into Ly2, where there was another concentration close to the boundary with Ly1; in addition, a small number of stridulating males were found scattered more widely across the Ly2 slope
2001		450**	Across most of the slope of Ly1 and well into the adjacent part of Ly2; c.30 stridulating males across Ly2 more widely, and a few in Ly3 also (see Map 13)	Surveys in late May and June recorded large numbers of nymphs across most of the slope of Ly1, although numbers were much fewer at the very top of the slope and in the south-eastern corner of the compartment; nymphs were also fairly numerous for up to c.25m into Ly2 (an extension of the Ly 1 distribution), and may have occurred at low density further across this compartment, although none were found in casual searches; surveys in mid- to late July recorded substantial numbers of adults with a similar distribution to that earlier noted for nymphs; in addition, a thorough search of Ly2 away from the boundary with Ly1 located c.30 stridulating males spread widely across the slope, particularly on the lower section, but with some individuals also on the flatter area above the main slope; Ly3 was also visited, and five stridulating males located there, two close to the boundary with Ly2, the others in the centre of the compartment, low on the main slope; surveys at the end of August/beginning of September confirmed the broad pattern of distribution, although the density of adults had more than halved by this time; nonetheless, some adults were still present in Ly1, Ly2 and possibly Ly3 very late in September
2002		450	Across most of the lower to mid-slope of Ly1 and much of the lower to mid-slope of Ly2; some stridulating males beyond this distribution to the north, including one in Ly3 (see Map 14)	Surveys from early April to mid-July recorded large numbers of nymphs across the lower to mid-slope of Ly1; this distribution extended into Ly2, where nymphs were also found on the lower, central part of the slope, well away from the boundary with Ly1, albeit in lower numbers; surveys in mid-July recorded substantial numbers of adults with a similar distribution to that earlier noted for nymphs, across the lower to mid-slope of Ly1 and extending c.100m into Ly2 across the lower to mid-slope; in early September, out-lying males were found stridulating north of the main distribution, one high on the main slope of Ly2 c.40m from the boundary with Ly3, and one in Ly3 itself just beyond the Ly2 boundary

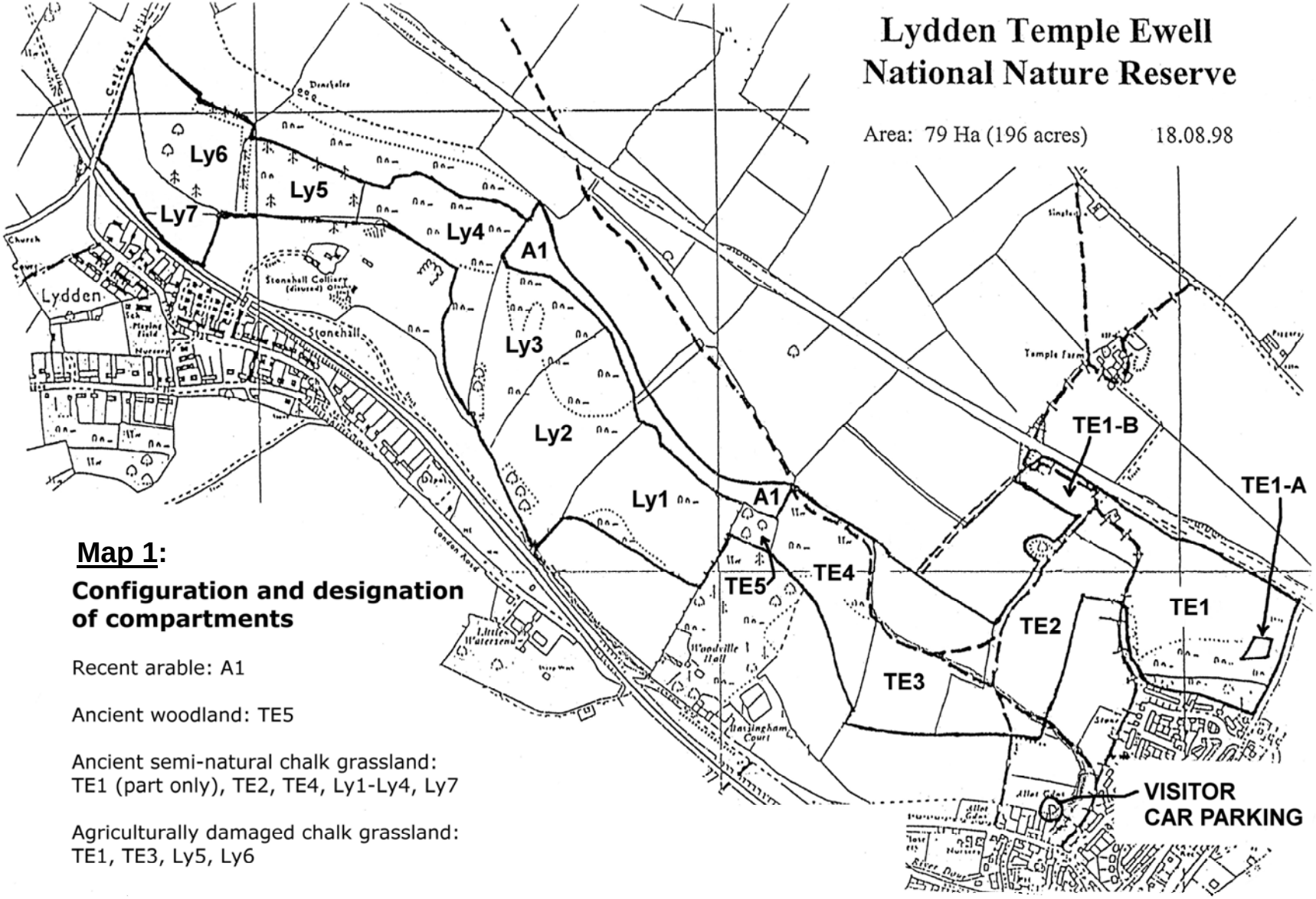
2003		Uncertain, but possibly 100-200 initially, with numbers then declining very rapidly	Nymphs possibly distributed widely across Ly1 and well into Ly2 (as in previous two years); adults confined to limited areas of suitable habitat, very sparsely distributed in and around these compartments (see Map 15)	Only limited survey work was possible in 2003, providing a rather incomplete picture; however, it seems that the population might have matched that present in 2001/2002, had dry conditions not impeded the development of the habitat to such an extent that numbers declined substantially in the late nymphal and early adult period In late May, mid-instar nymphs were found on the central lower slope of Ly1 in very good numbers, perhaps broadly comparable to those present in 2001/2002; in early July, VII instar nymphs and adults in Ly1 were found concentrated in limited areas with taller vegetation (e.g. the "shallow valley" feature), most of the vegetation on the slope being too short to provide shelter; even at this stage, numbers may have been reduced to roughly half of those recorded in 2001 and 2002; adults were found on the central lower slope of Ly2, so the species again extended well into this compartment, but numbers were not high and short vegetation dominated the slope; by early to mid-August, the condition of the habitat on the Ly1 slope was found to have deteriorated, and it was judged to be incapable of supporting adults in any numbers; scattered stridulating males were encountered in Ly2, mostly along the bottom of the main slope, but also towards the top of the main slope and along the boundary with Ly3
2004		Uncertain, but possibly 100-200	Nymphs (and presumably adults) distributed widely across Ly1 and Ly2, with small numbers in Ly3 also (see Map 16)	Only limited survey work was possible in 2004, providing a rather incomplete picture, particularly of the adult population; habitat factors (lack of structural heterogeneity) are likely to have constrained adult numbers, but there was no reason to believe that survivorship into and through the adult period was dramatically impaired, as in 2003 A survey in early June recorded mid- to late instar nymphs in very good numbers (broadly comparable to those found in 2001/2002) in Ly1, with greatest densities on the lower to mid-slope, in the central and north-western sections, as previously; in late June, late instar nymphs were recorded in reasonable numbers in Ly2, "widely distributed across the lower half to two-thirds of the slope" (but rather concentrated in limited areas where tussocky patches had developed) and were presumed also to be present in taller vegetation below the main slope; following a limited search, ten final instar nymphs were found also in Ly3, mostly in the lower section adjacent to Ly2, but including two at the bottom of the main slope in the central area; a brief survey at the very end of September confirmed that a few adults were still present in Ly1 and Ly2
2005		Unknown, but undoubtedly very low	Unknown, but undoubtedly very localised; probably encompassing some parts of Ly2 as well as Ly1 (see Map 17)	Extremely limited survey work took place in 2005, based on just a single visit made in early May, with searches conducted in Ly1 only; these indicated that numbers of early instar nymphs were very low; records came almost exclusively from around the "shallow valley" feature A small (possibly very small) hatch had been anticipated in 2005, given the rapid crash in the adult population which almost certainly occurred in 2003; it is likely that nymphs were present more widely (including in parts of Ly2) than the single 2005 survey revealed, if only very locally and at rather low density; habitat development appeared to be favourable at the time of the one survey, however, so subsequent survivorship was probably reasonable, ensuring that some adults (at least) were present later in the season

2006		Uncertain, but possibly 200-300**	Late instar nymphs (and presumably adults) distributed widely across Ly1, and probably across Ly2 also, at least on the central part of the slope (see Map 18)	Only limited survey work was possible in 2006, providing a rather incomplete picture, particularly of the adult population In mid-May, a search of the central part of Ly1 confirmed the presence of promising numbers of mid-instar nymphs there; a survey in late June recorded large numbers (broadly comparable to those found in 2001/2002) of late instar nymphs across much of the slope of Ly1; a brief search of the central part of the slope of Ly2 confirmed the presence of late instar nymphs there, and it was "presumed that there were very many…[possibly quite evenly distributed]…on the slope"; despite the lack of surveys during the adult period, there were no specific reasons to expect poor survivorship following the survey of late instar nymphs
2007		100	Patchily across Ly1 and Ly2, with a few individuals in Ly3 also (see Map 19)	Survey effort was significantly enhanced in 2007, but the weather intervened (and affected the *Decticus* population); a very warm and sunny spring led to an early hatch and rapid nymphal development initially, but a cold and wet summer resulted in adults appearing unusually late and impeded survey work A survey in late April confirmed the presence of early instar nymphs in reasonably promising numbers (given the likely small number of adults in 2005) in parts of Ly1; thorough surveys in mid-late July and mid-August indicated the presence of late instar nymphs and adults in small to moderate numbers, patchily distributed across Ly1 and Ly2, with a few individuals in Ly3; notable observations included a surprising lack of records from the "shallow valley" feature in Ly1, and greatest numbers in Ly2 being towards the top of the main slope, centrally and to the western side of the compartment; surveys in late September failed to locate *Decticus* in Ly1 or Ly2, suggesting that the adult population may not have persisted late into the season
2008		Unknown		No surveys
2009		Unknown		No surveys
2010		Unknown		No surveys
2011		Unknown		No surveys
2012		Unknown	Present in Ly1 and Ly2	No surveys; casual records confirmed the presence of adults in Ly1 and Ly2
2013		Unknown, but certainly not high	Present in Ly1, at least	Casual survey confirmed the presence of adults in Ly1, but not in high numbers, possibly reflecting a lack of heterogeneity in habitat structure
2014		At least 50-100	Present in Ly1, particularly around the "shallow valley", and also in Ly2, close to the boundary with Ly1 at least (see Map 21)	An attempted survey in early August was impeded by poor weather conditions, but a survey in early September confirmed the presence of adults in small to moderate numbers in Ly1, particularly around the "shallow valley" feature; two stridulating males were also recorded immediately over the boundary into Ly2; as this survey was conducted relatively late in the season, adult abundance may have declined somewhat from its peak, although it seems likely that (as in 2013) numbers may have been constrained by availability of favourable habitat

2015		100	Patchily across Ly1, with small numbers in Ly2 also (see Maps 22-25)	Surveys from early August to early September recorded moderate numbers of adults in Ly1, with a small number of scattered records obtained also from Ly2, but no evidence of the species in Ly3; records from Ly1 initially appeared to be concentrated around the "shallow valley" feature, but were subsequently obtained more widely across the compartment, particularly on the lower and mid-slope areas; habitat in Ly1 and Ly2 appeared to be favourable to *Decticus* over wider areas than in the previous two years, and the rather modest adult population relative to the extent of suitable habitat may have reflected conditions in previous years (especially 2013), although predation pressure may also have been a factor

* estimates tend to be conservative, and refer to numbers in the early adult period.
** estimate revised from that given previously in Appendix 1 to Cheesman (2013, 2014) and similar running summaries of *Decticus* populations appended to earlier monitoring reports, following reassessment of survey data provided in the monitoring report for this year.
*** estimate revised from that given previously in Cheesman (2001).

Appendix 3: Site maps



Map 1:

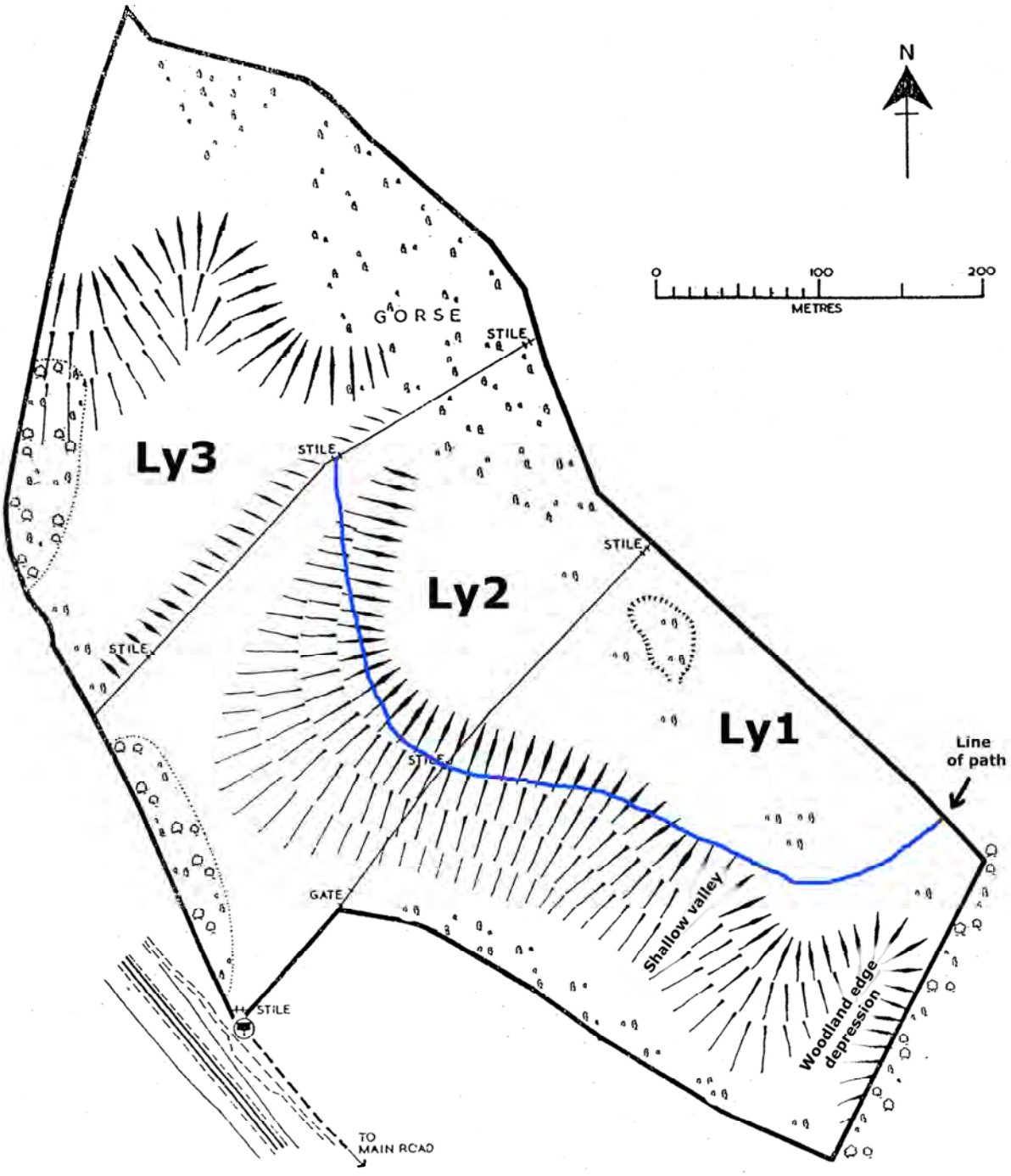
Configuration and designation of compartments

Recent arable: A1

Ancient woodland: TE5

Ancient semi-natural chalk grassland:
TE1 (part only), TE2, TE4, Ly1-Ly4, Ly7

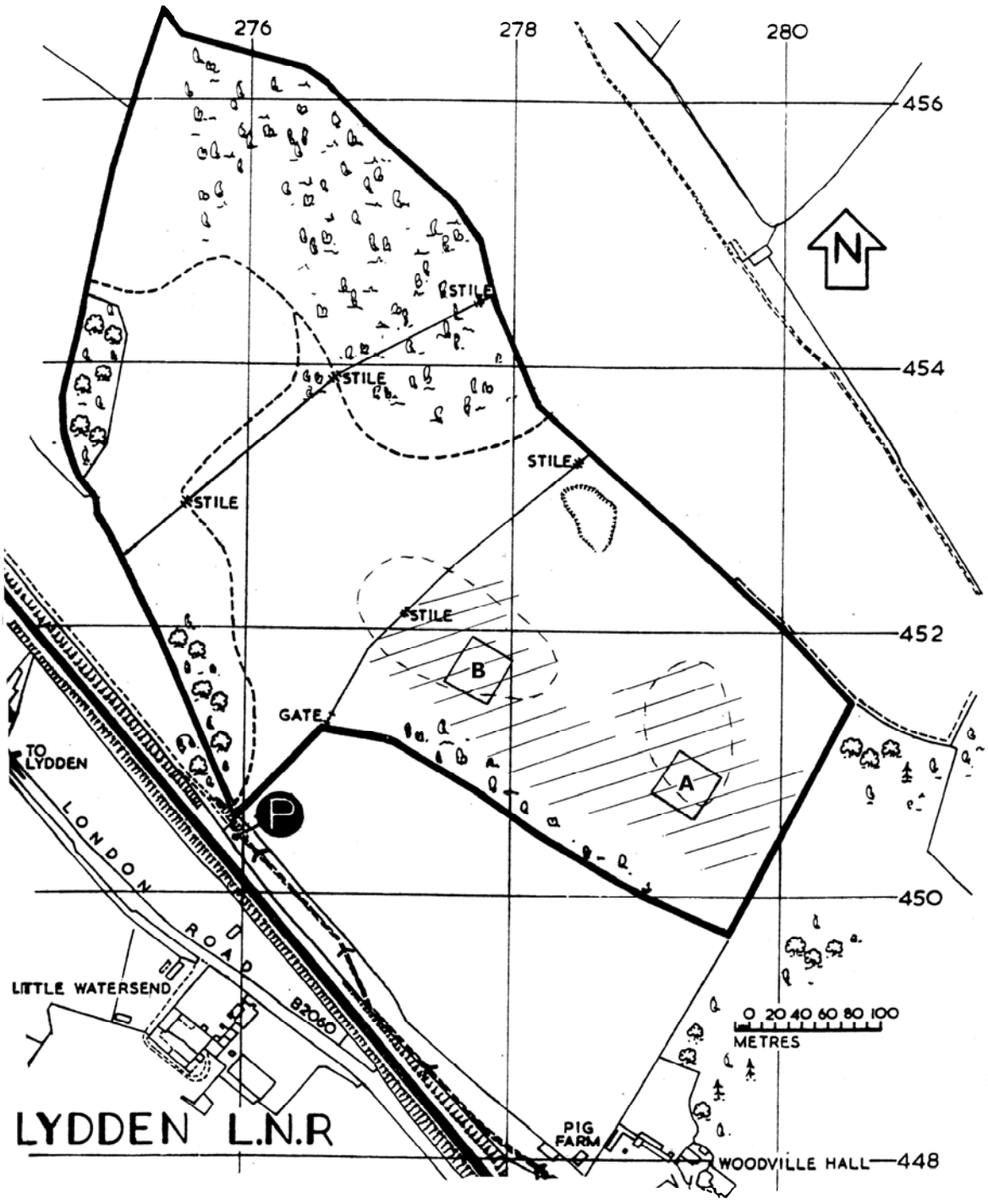
Agriculturally damaged chalk grassland:
TE1, TE3, Ly5, Ly6



Map 2:

Lydden Temple Ewell NNR

Topography and features of compartments Ly1, Ly2 and Ly3

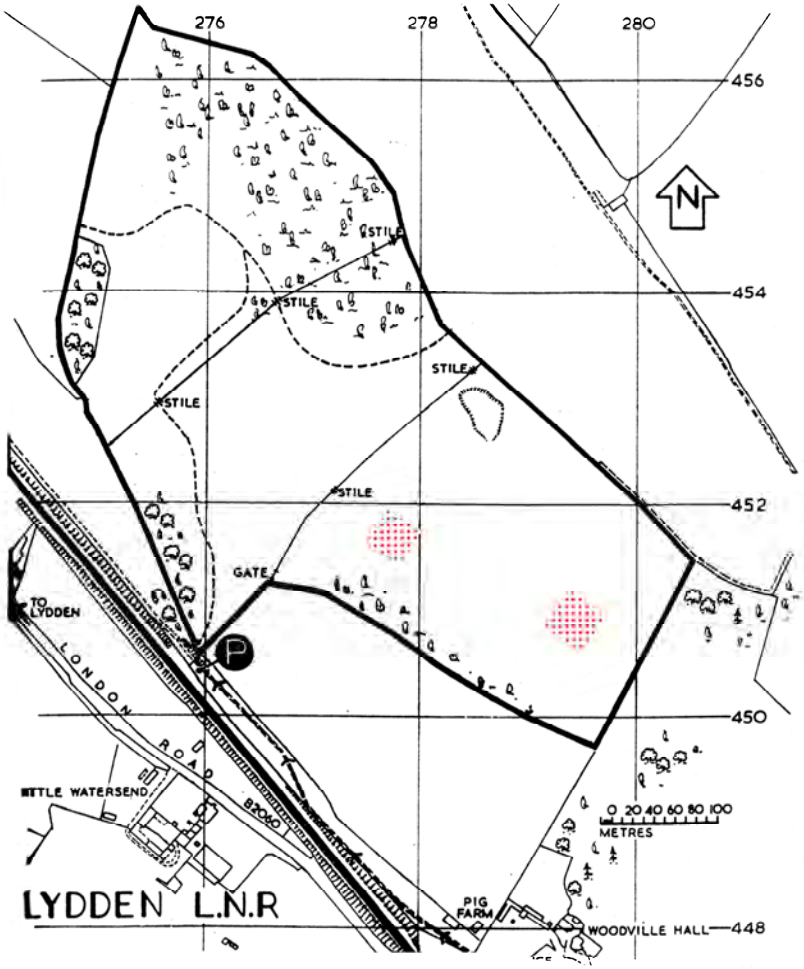


Map 3: Lydden Temple Ewell NNR in early 1990s

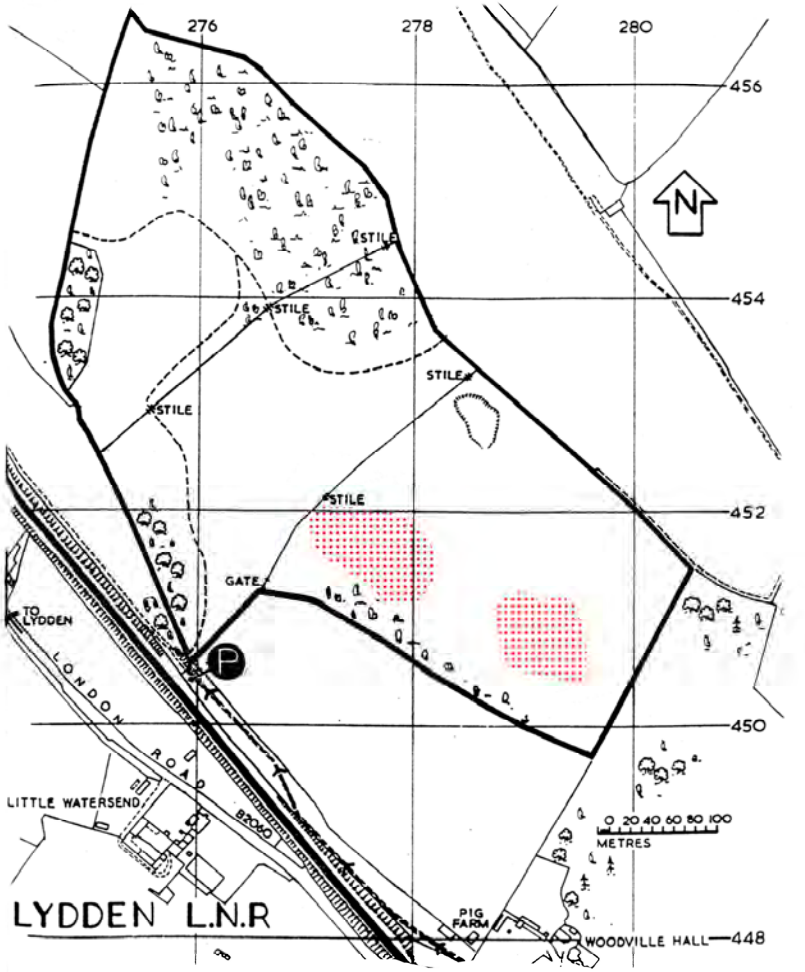
Historical distribution of *D. verrucivorus*

Area of habitat considered suitable for re-establishment of *D. verrucivorus*

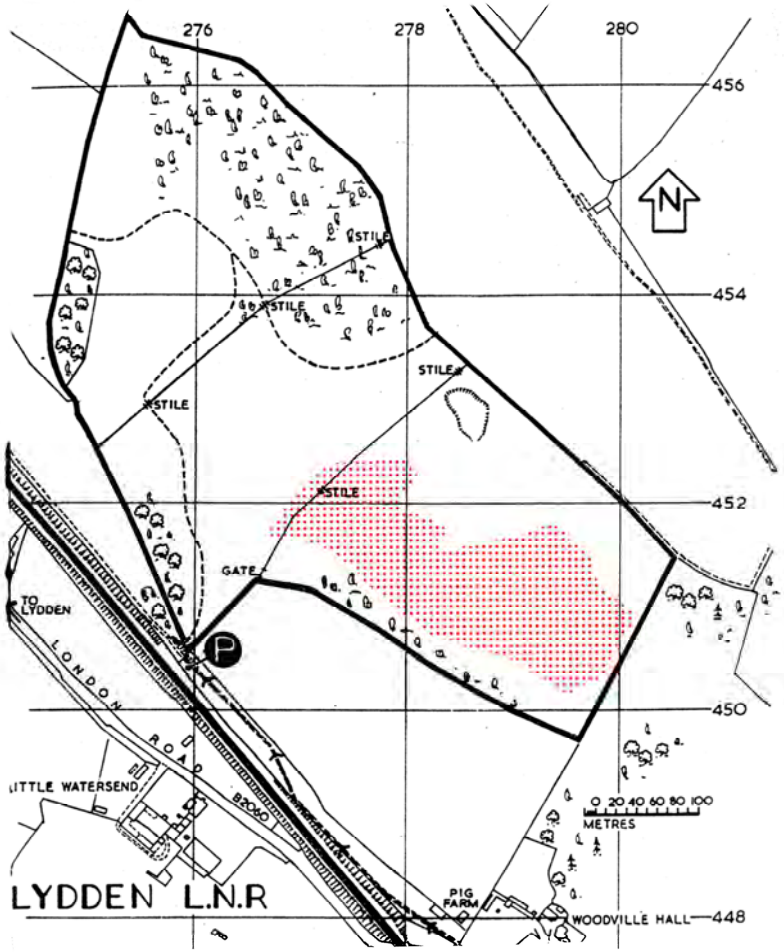
Areas selected for initial releases



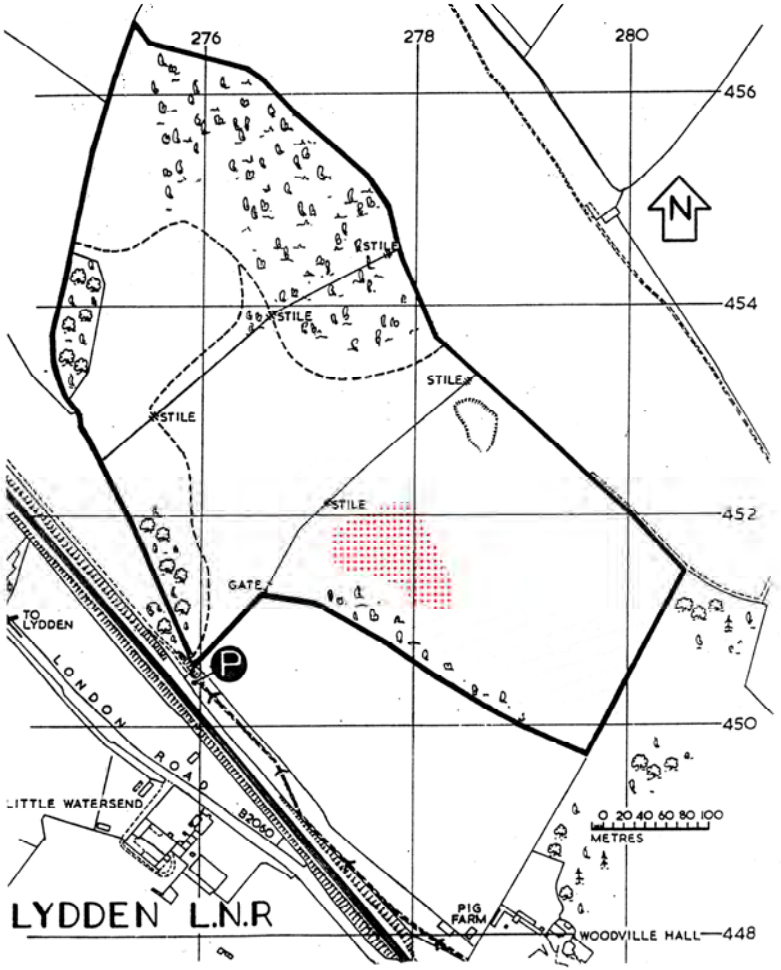
Map 4: Lydden Temple Ewell NNR
Areas of 1993 *D. verrucivorus* releases (red stippling)
Releases: 54 adults (translocations from Castle Hill NNR)



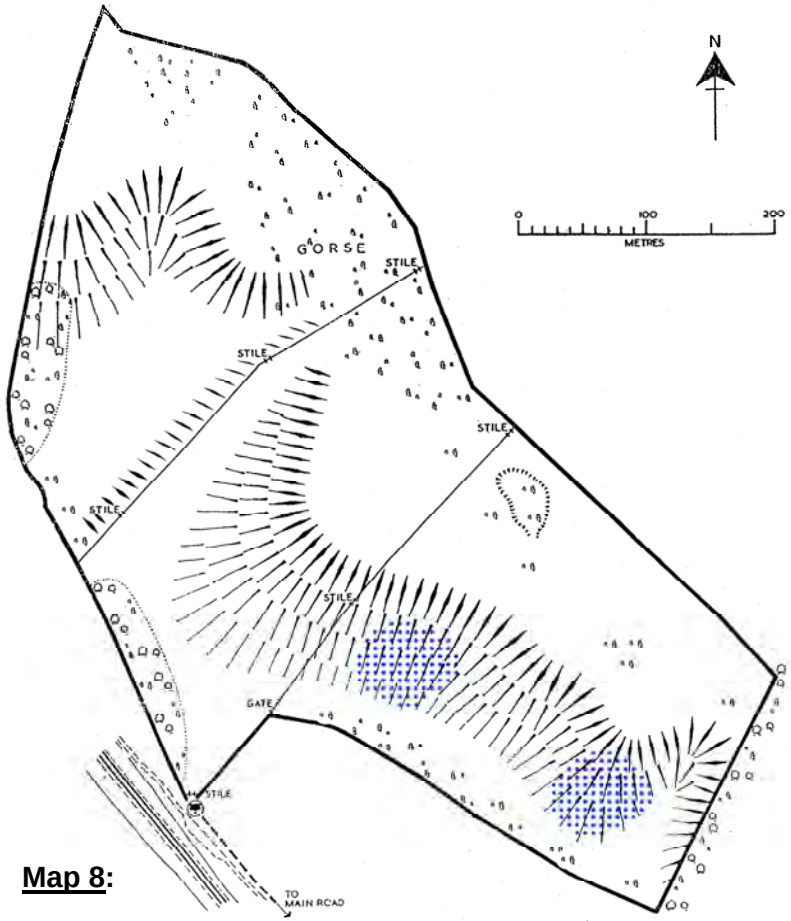
Map 5: Lydden Temple Ewell NNR
Areas of 1994 *D. verrucivorus* releases (red stippling)
Releases: 121 late instar nymphs/adults (mostly captive-reared stock)



Map 6: Lydden Temple Ewell NNR
Area of 1995 *D. verrucivorus* releases (red stippling)
Releases: 307 late instar nymphs/adults
(captive-reared stock)



Map 7: Lydden Temple Ewell NNR
Area of 1996 *D. verrucivorus* release (red stippling)
Release: 14 adult females (translocation from
Castle Hill NNR)



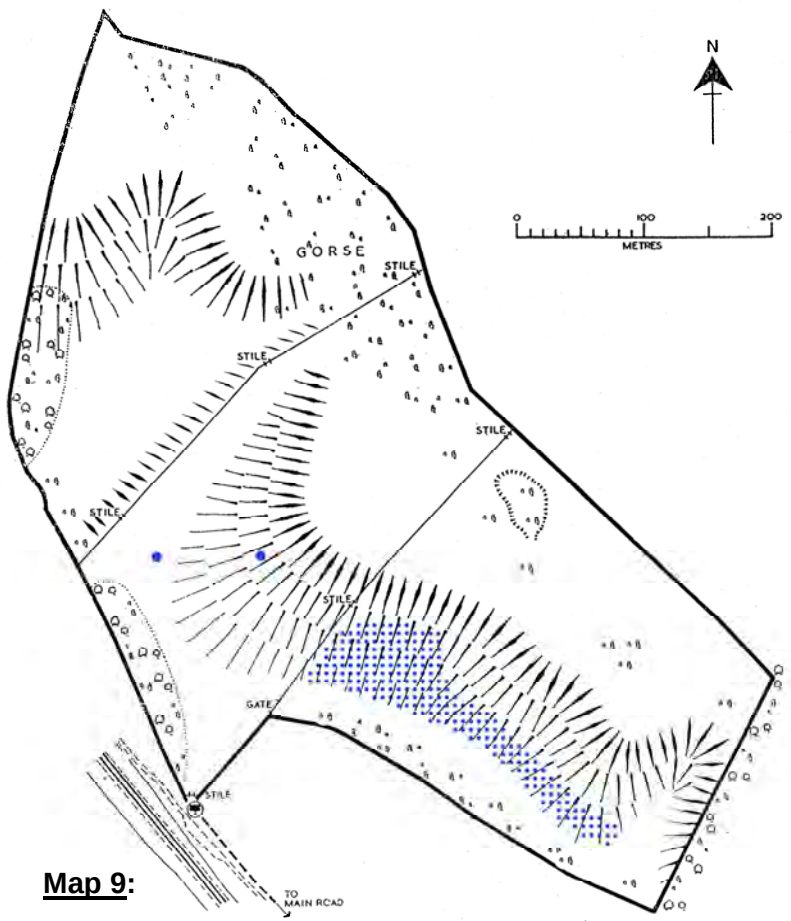
Map 8:

***D. verrucivorus* at Lydden Temple Ewell NNR, 1995/1996**

Likely areas with main concentrations of adults (blue stippling)

Estimated population size (early adult period) 1995: <10
Estimated population size (early adult period) 1996: 10

Estimates of population size and distribution based on limited survey data (1995) and good survey data (1996)



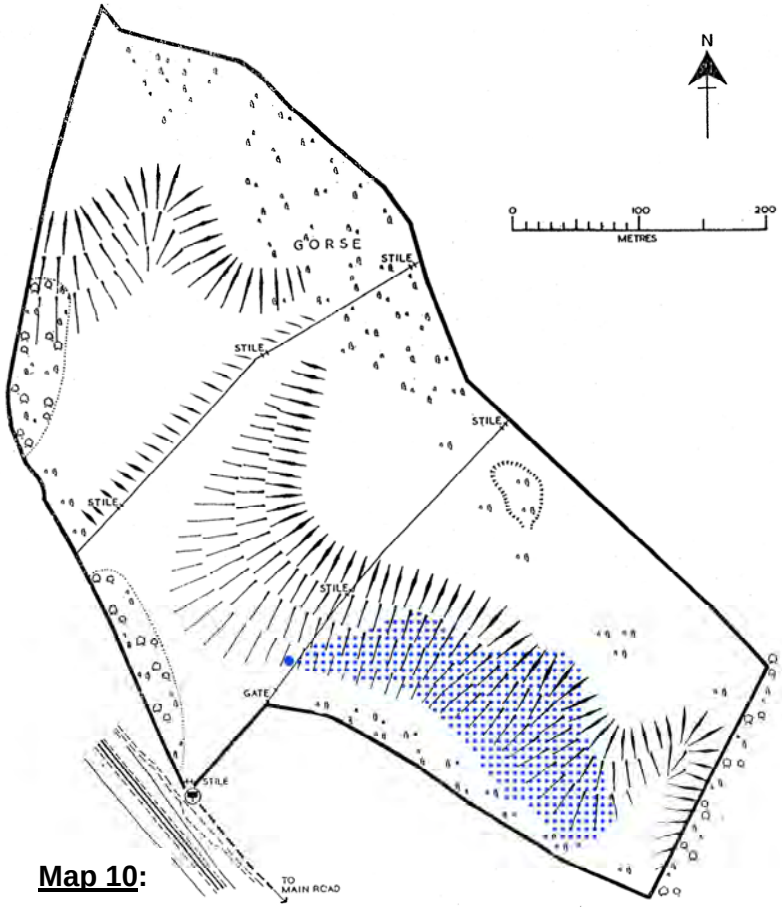
Map 9:

***D. verrucivorus* at Lydden Temple Ewell NNR, 1997**

Area with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 50

Estimates of population size and distribution based on good survey data



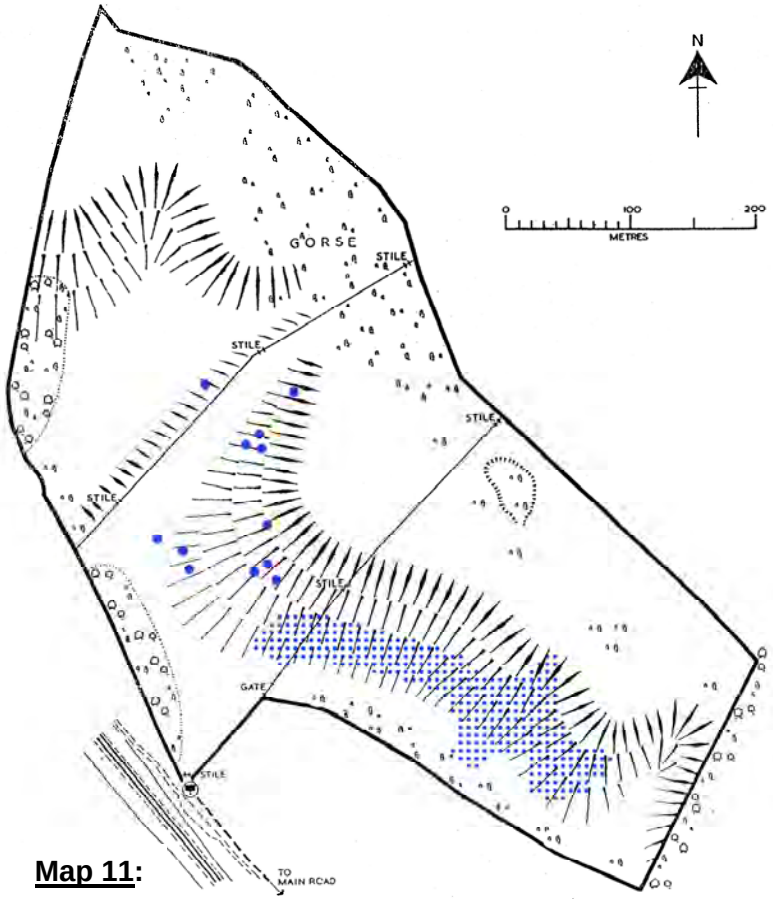
Map 10:

***D. verrucivorus* at Lydden Temple Ewell NNR, 1998**

Area with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 50

Estimates of population size and distribution based on good survey data



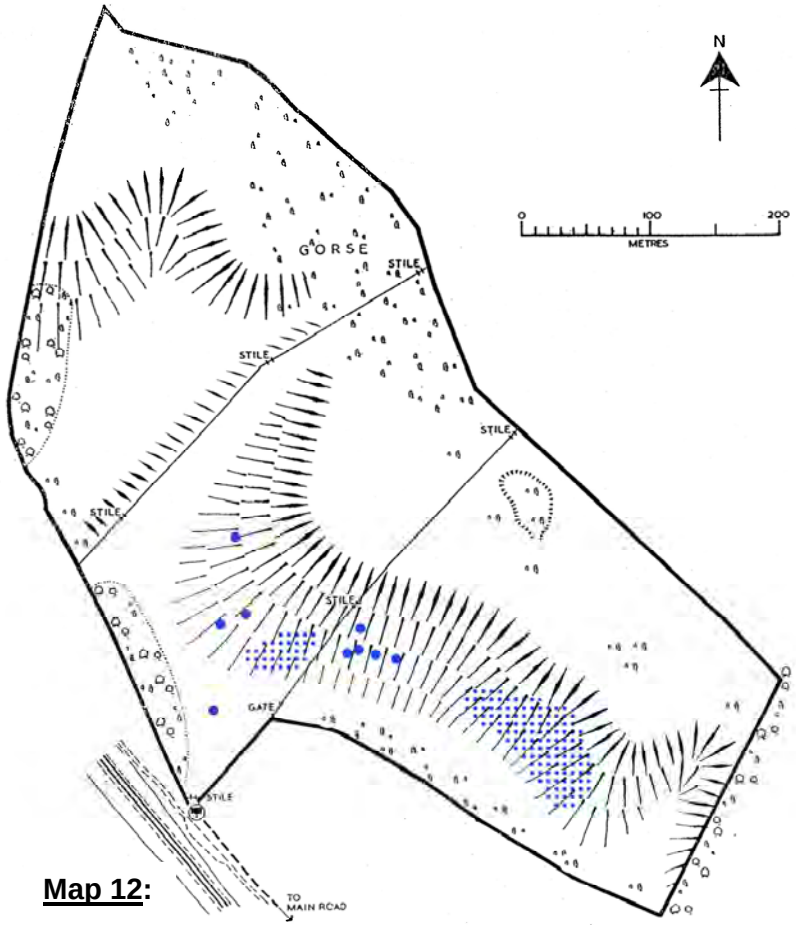
Map 11:

***D. verrucivorus* at Lydden Temple Ewell NNR, 1999**

Area with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 250

Estimates of population size and distribution based on good survey data



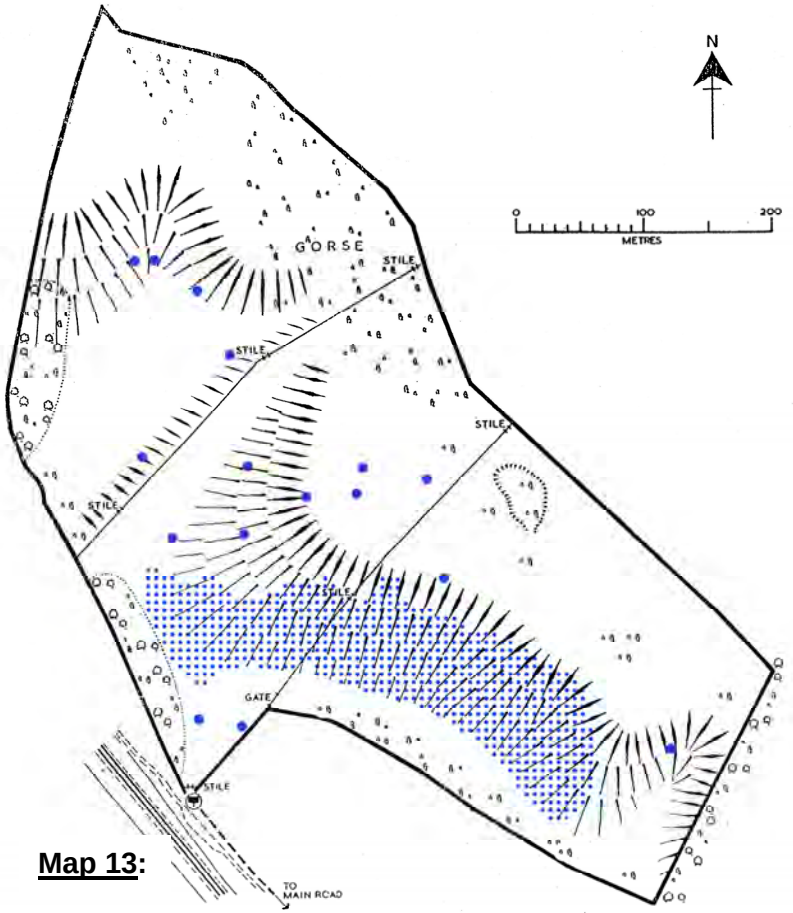
Map 12:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2000**

Areas with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 150

Estimates of population size and distribution based on good survey data



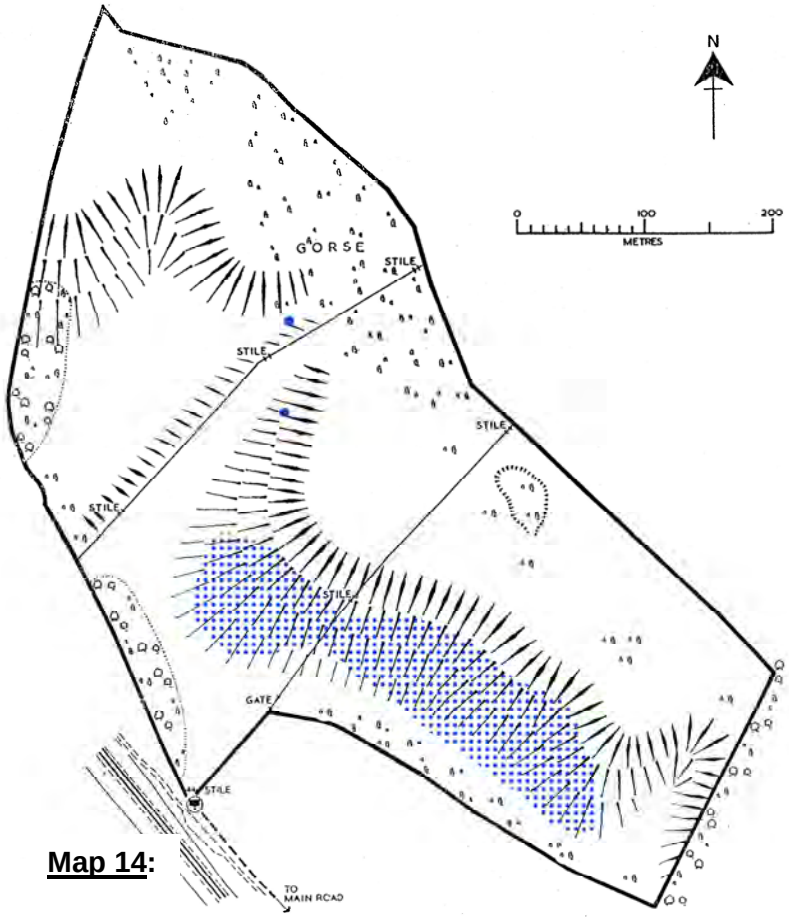
Map 13:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2001**

Area with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 450

Estimates of population size and distribution based on good survey data



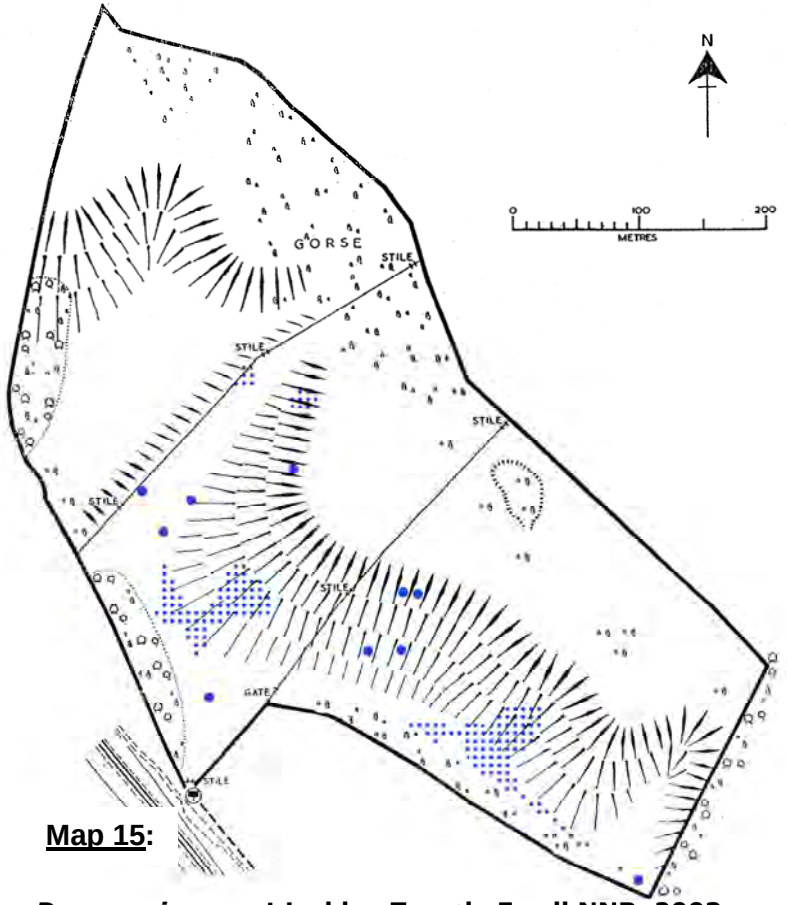
Map 14:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2002**

Area with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 450

Estimates of population size and distribution based on good survey data



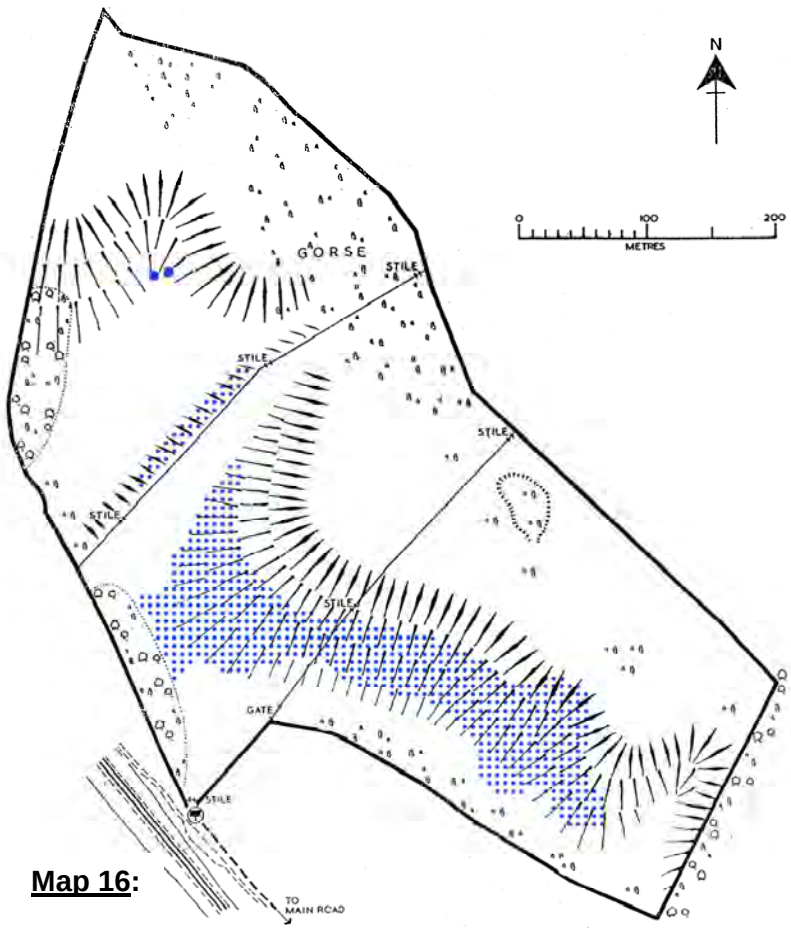
Map 15:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2003**

Likely areas with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period):
Possibly 100-200 initially, with numbers then declining rapidly

Estimates of population size and distribution based on limited survey data



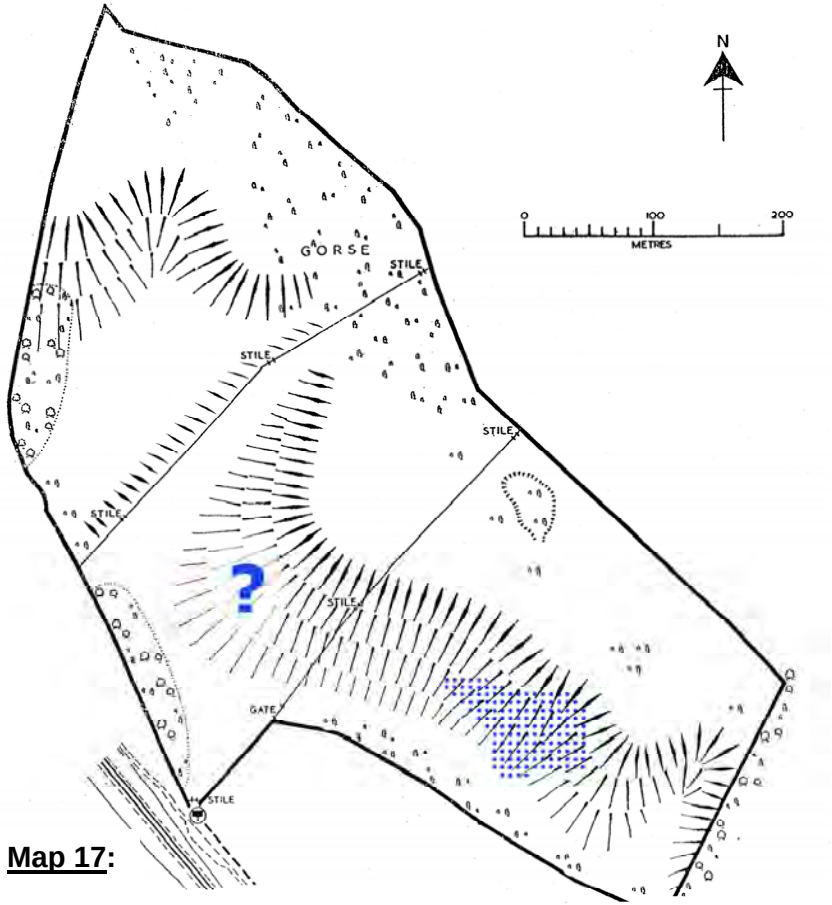
Map 16:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2004**

Likely areas with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): Possibly 100-200

Estimates of population size and distribution based on limited survey data (distribution inferred from survey report text)



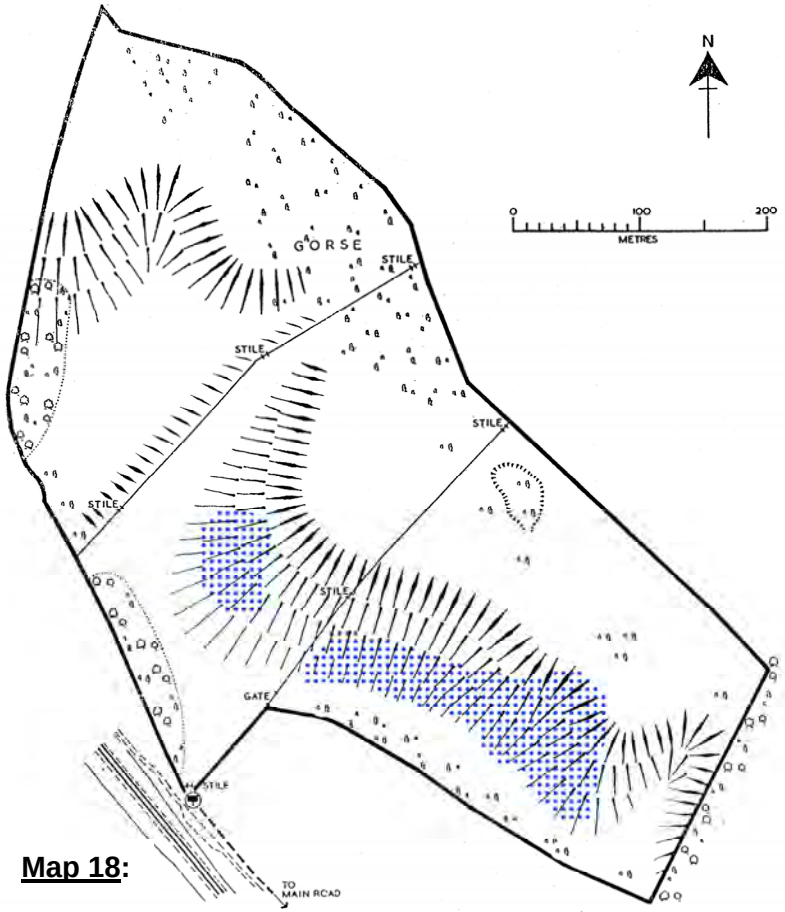
Map 17:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2005**

One area with likely concentration of adults (blue stippling)

Population size (early adult period): Unknown, but undoubtedly very small

Estimates of population size and distribution based on very limited survey data; distribution inferred from that of early instar nymphs and likely concentration of adults in limited area of suitable habitat



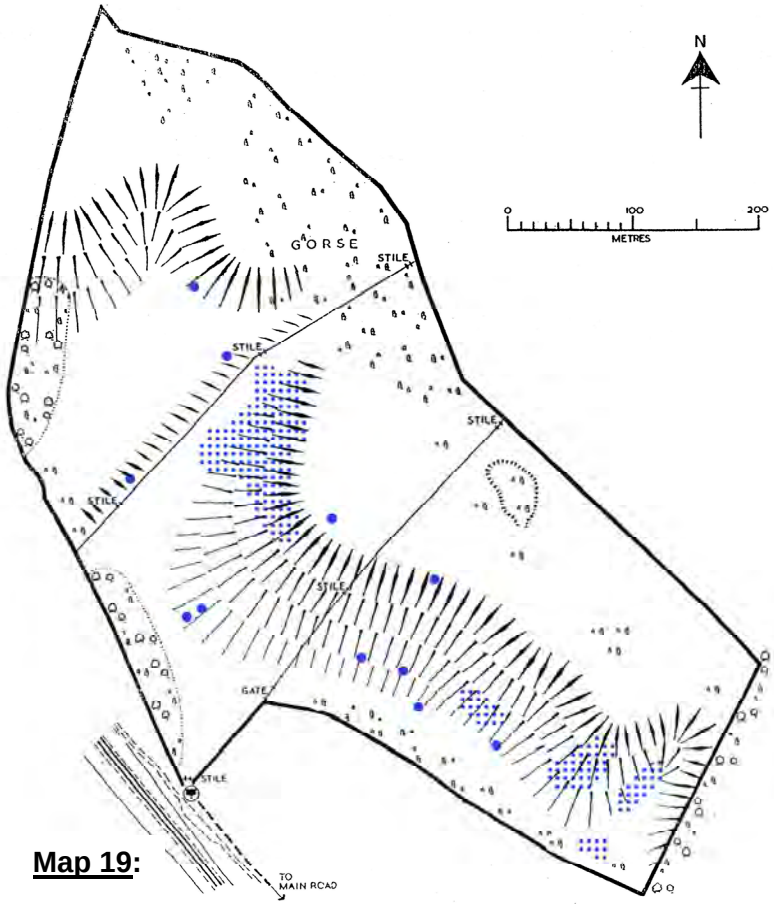
Map 18:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2006**

Likely areas with main concentrations of adults (blue stippling)

Estimated population size (early adult period): Possibly 200-300

Estimates of population size and distribution based on limited survey data; distribution inferred from that of late instar nymphs



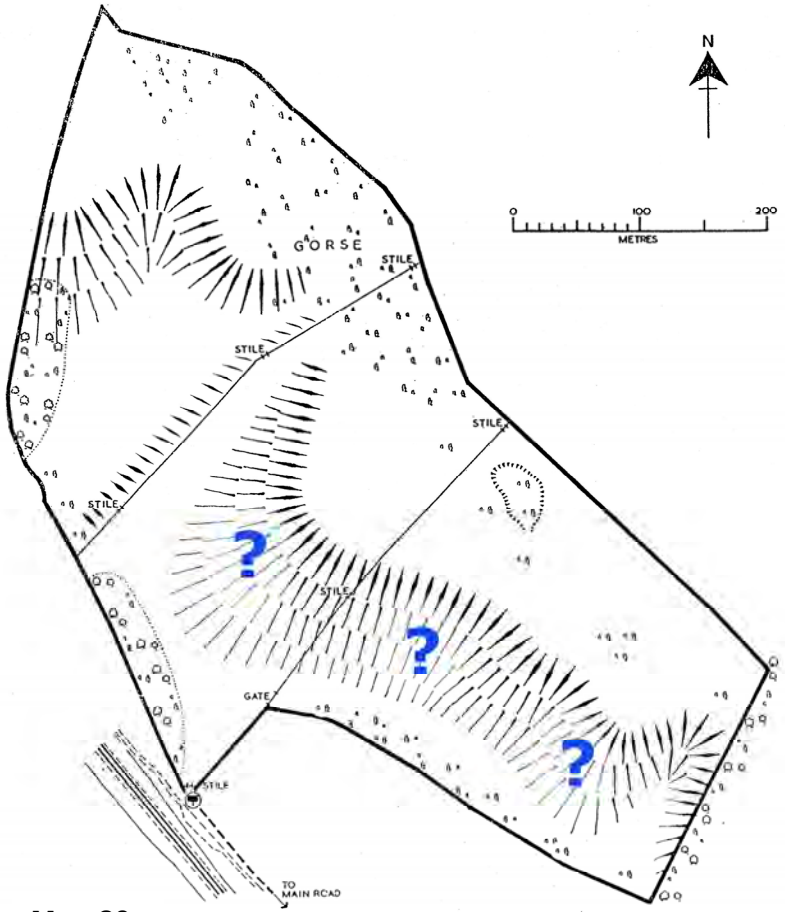
Map 19:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2007**

Areas with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 100

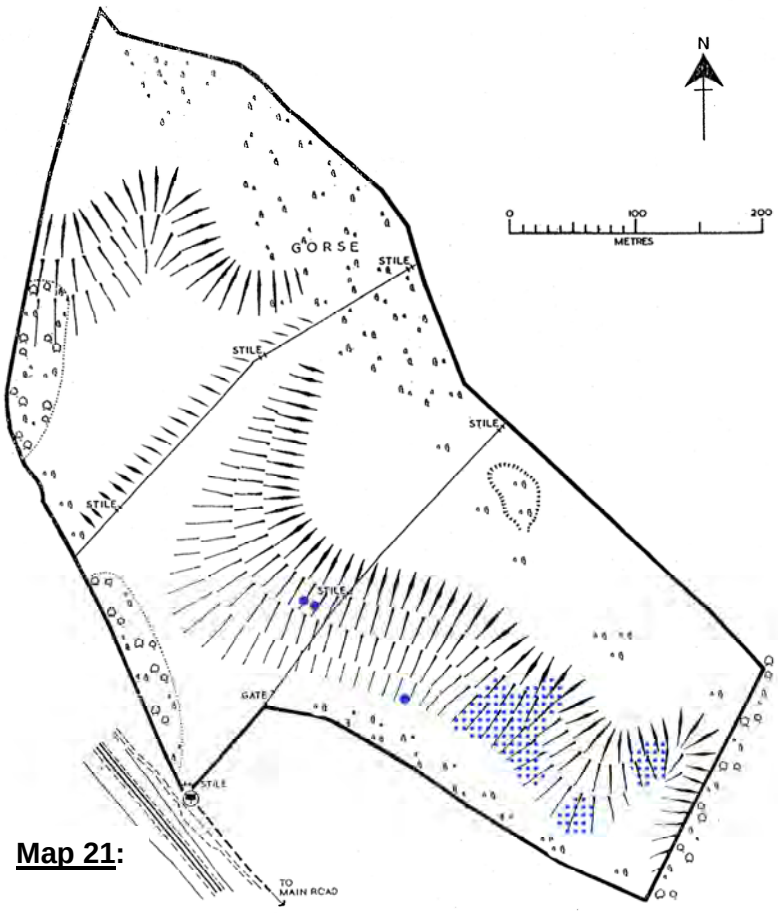
Estimates of population size and distribution based on good survey data



Map 20:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2008-2013**

Survey data insufficient to estimate early adult population size or distribution



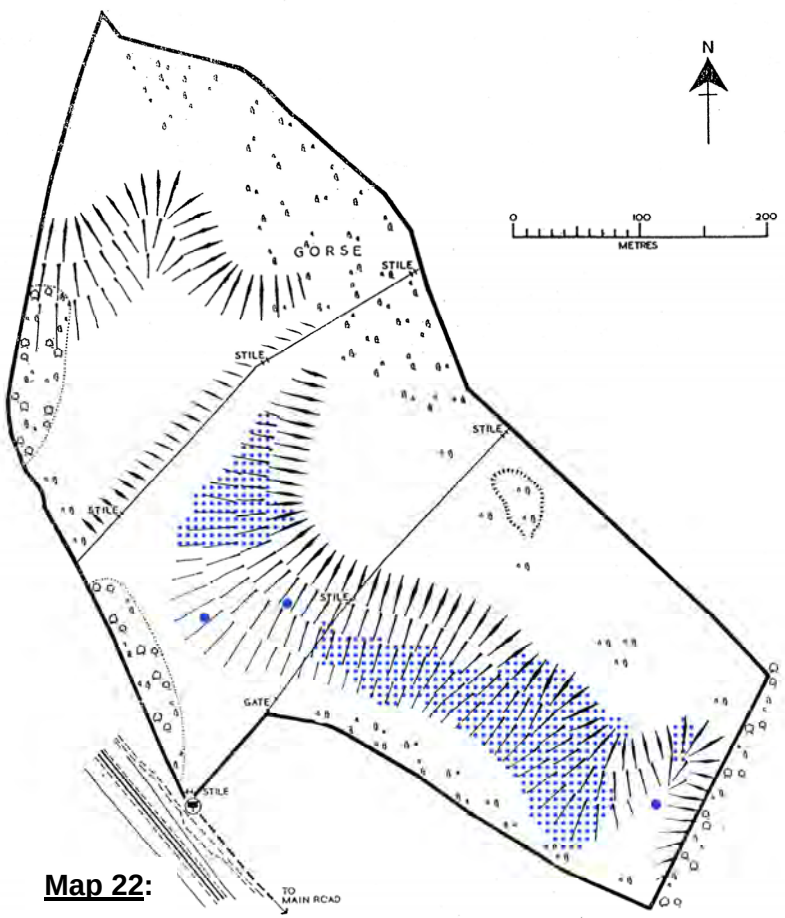
Map 21:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2014**

Likely areas with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): At least 50-100

Estimates of population size and distribution based on limited survey data



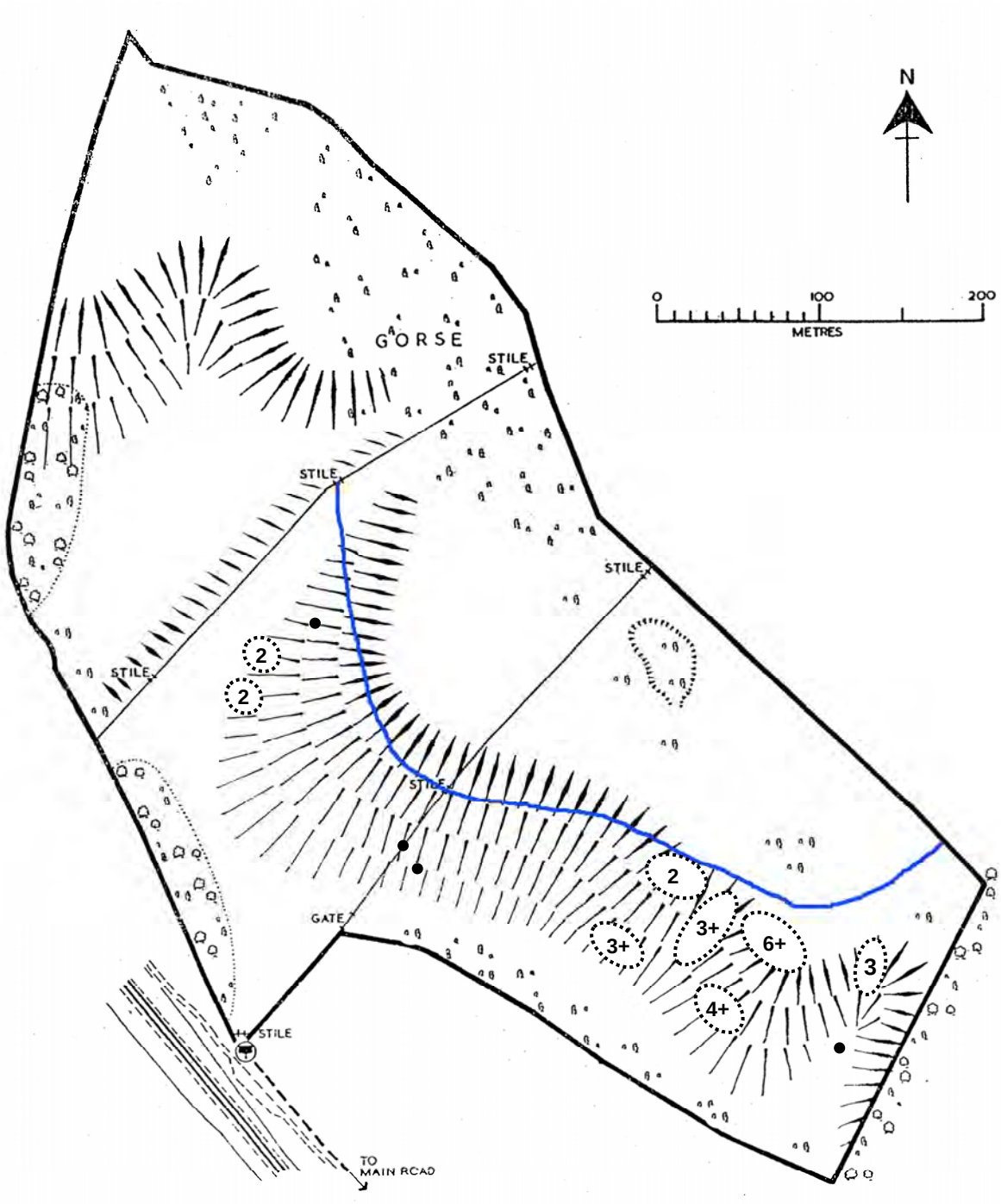
Map 22:

***D. verrucivorus* at Lydden Temple Ewell NNR, 2015**

Areas with main concentrations of adults (blue stippling) and records of out-lying individuals (larger blue dots)

Estimated population size (early adult period): 100

Estimates of population size and distribution based on good survey data

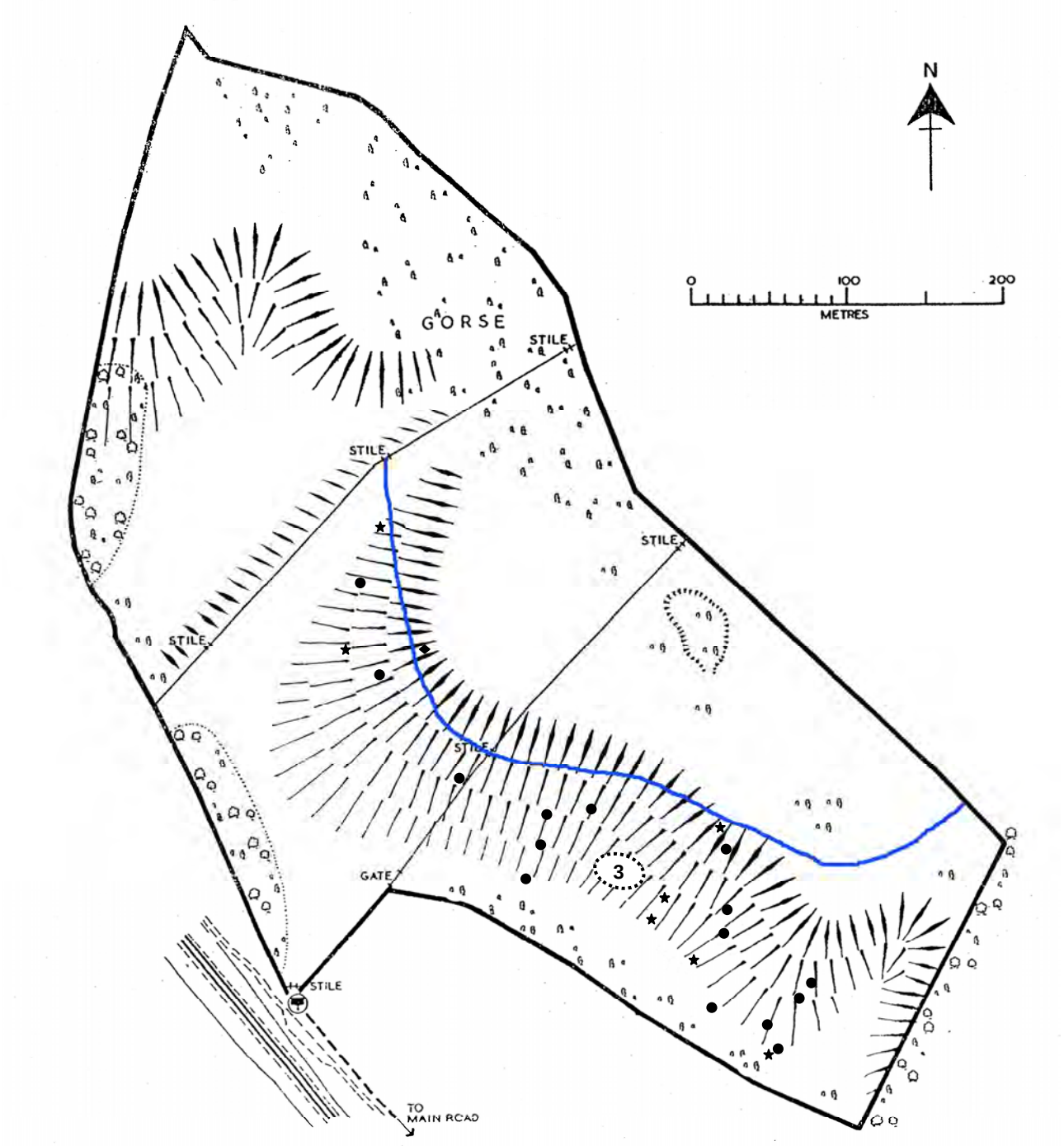


Map 23: **Lydden Temple Ewell NNR**
Results of preliminary *D. verrucivorus* survey, 7 August 2015

Areas searched: Ly1 and Ly2 below path (except rank vegetation along the bottom of each compartment)

Concentrations of stridulating males

- Individual stridulating males



Map 24: Lydden Temple Ewell NNR
Results of *D. verrucivorus* surveys, 22 and 28 August 2015

Areas surveyed 22 Aug: Ly1 and Ly2 below path (except depression adjacent to woodland at southeastern end of Ly1)

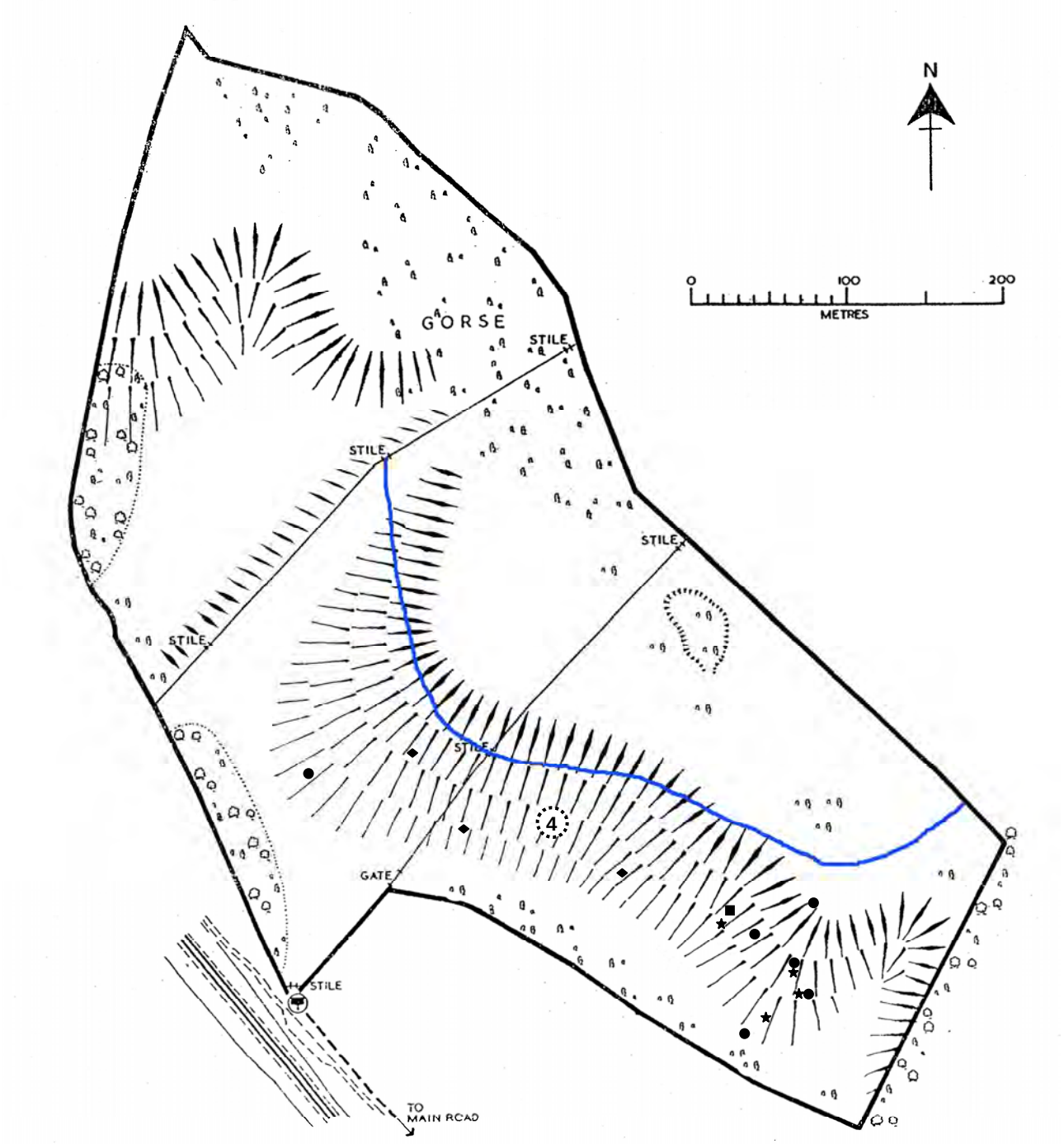
Areas surveyed 28 Aug: Ly2 above path and Ly3 (except northern section above main slope)

○ Concentration of stridulating males, 22 Aug

- Individual stridulating males, 22 Aug

◆ Individual stridulating male, 28 Aug

★ Casual records of stridulating males obtained while crossing unsurveyed areas, 28 Aug



Map 25: **Lydden Temple Ewell NNR**
Results of *D. verrucivorus* surveys, 10 and 11 September 2015

Areas surveyed 10 Sept: Ly1 (southeastern section below path, including depression adjacent to woodland and shallow valley feature, and northwestern section above path); along bottom edge of the northwestern section of Ly1 close to the scrub line, southeastern corner of Ly2, bottom edge of Ly2 close to the scrub line, Ly3 immediately adjacent to the Ly2 boundary (bottom two-thirds only), bottom of the Ly2 main slope, and Ly2 main slope immediately adjacent to the Ly1 boundary.

Areas surveyed 11 Sept: Ly1 (northwestern section below path); Ly2 main slope below path

- ● Individual stridulating males, 10 Sept
- ■ Male/female pair, 10 Sept
- ◆ Individual stridulating males, 11 Sept
- ★ Casual records of stridulating males obtained while crossing unsurveyed areas, 11 Sept
- ⬭ Concentration of stridulating males, 11 Sept