LUNDY CABBAGE: PAST, PRESENT, FUTURE

by
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ABSTRACT
Lundy is unique amongst British islands in having plants and insects that are known from nowhere else. How the ancestors of Lundy cabbage and its beetles may have come to be on Lundy is largely a mystery. They must have colonised Lundy sometime after the last Ice Age, at which time rising sea levels may not yet have turned it into an island. Lundy cabbage appears to have common ancestry with a closely related species including population(s) around the Bristol Channel, but the origins of the beetles are so far unclear and subject to current research. In recent times, numbers of Lundy cabbage have fluctuated greatly, probably in response to changes in rabbit abundance, but its range on Lundy is much less variable. Careful management, particularly of grazing animals and invasive rhododendron, is needed to ensure that this unique community continues to flourish.

Keywords: *Lundy cabbage, BAP, endemic, phylogeography, rabbit, rhododendron, sea-levels*

INTRODUCTION

Lundy is Britain's only offshore island that has its own endemic plant species with endemic insects feeding on it (Compton *et al.,* 2002). Reflecting this, the plant and its insects are listed on the United Kingdom Biodiversity Action Plan and have conservation action plans (UK BAP, 2001, Compton and Key, 1998), and have been the subject of conservation-related studies supported by Natural England (previously called English Nature) and others (Key *et al.,* 2000). We have been monitoring the plant and its insects since 1993, studying various aspects of their conservation ecology and evolutionary background, and developing plans to manage various aspects of their habitat to ensure its future on Lundy.

Here, after briefly describing the natural history of the species, we look at how such an interesting plant and insect community could have come to be present on Lundy, look at their distribution on Lundy and how numbers of plants have fluctuated in recent years, before speculating on the future for the plant and its insects.

THE PLANT AND ITS INSECTS

Lundy cabbage *Coincya wrightii* (Figure 1, bottom) is a short-lived perennial ruderal or pioneer member of the Brassicaceae, inhabiting sparsely vegetated rock on sea cliffs and is a quick coloniser of bare soil after disturbance, but is a poor competitor against regenerating grass swards (Compton and Key, 2000). It is restricted to the cliffs, some of the Sidelands (the steep, usually grassy slopes between the top of the sea cliffs and flatter area of the plateau) and rock outcrops (Buttresses) of the south-eastern coast of Lundy, from around Marisco Castle northwards to the Knights Templar Rock.

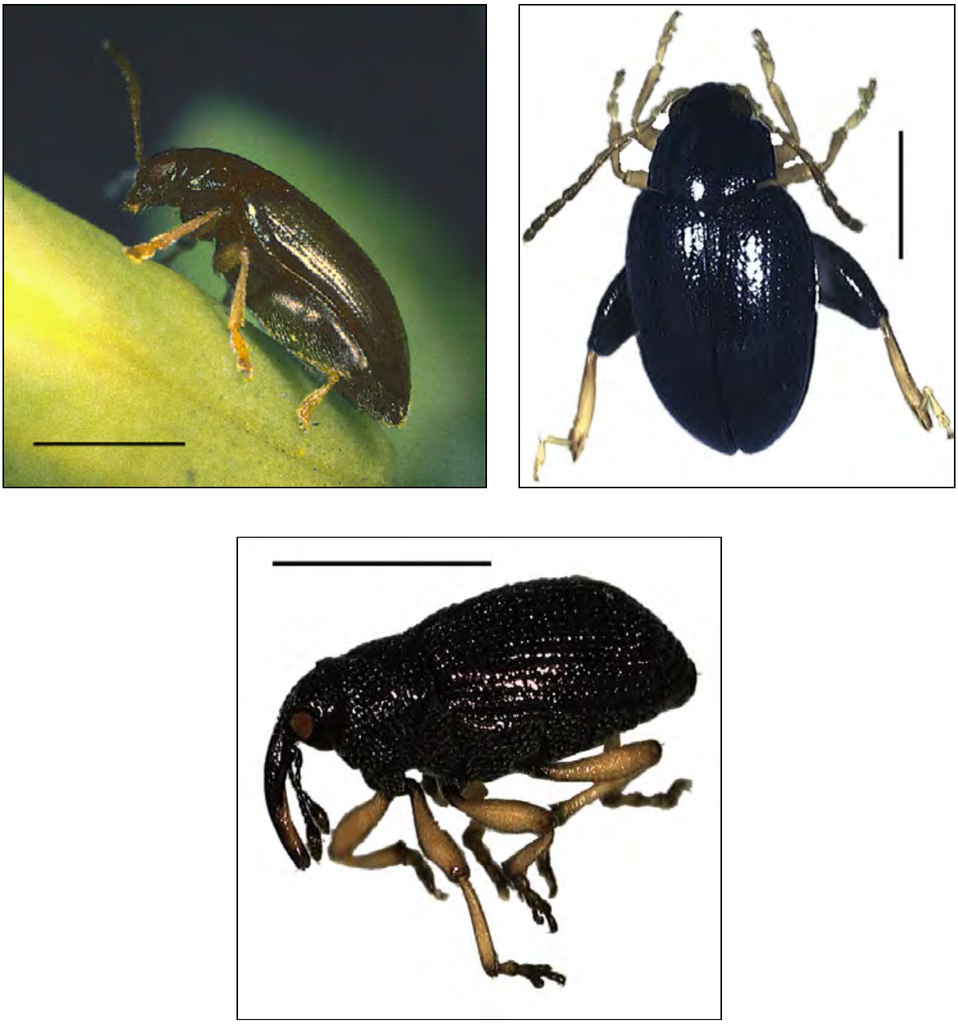
We have found that most of the insects that feed generally on other plants in the cabbage family also feed on Lundy cabbage, for example caterpillars of the large, small and green-veined white butterflies *Pieris brassicae, P. rapae* and *P. napi* occasionally defoliate individual plants, and a large number of insects of many orders have been found feeding on it (Compton & Key, 2000). Of particular interest are three beetles, two of which seem to be entirely restricted to Lundy. Best known is the ‘bronze Lundy cabbage flea beetle’ *Psylliodes luridipennis* (Chrysomelidae), (Figure 2, top left) whose larvae produce mines in the leaf petioles and stems. This has been shown to be a distinct species (Craven, 2002) that has so far never been found elsewhere. In the same genus, the ‘blue Lundy cabbage flea beetle’ has similar biology and appears to be a short-winged form of the widespread species *Psylliodes napi*, (Figure 2 top right) which on Lundy we have occasionally also found on bitter cress *Cardamine* spp. and Danish scurvy grass *Cochlearia danica*. Genetic studies are under way to ascertain the evolutionary relationship between populations from Lundy and other British and European populations of this beetle. It may be that this is just a widespread form of a beetle that happened to be found on Lundy first.

Loss of flight in insects is often said to be associated with life on islands (Roff, 1990), but we have recently found previously unrecorded populations of short-winged *P. napi* on Danish scurvy grass in North Devon and on other crucifers elsewhere in the U.K. and Europe, although always in mixed populations of long- and short-winged forms, unlike Lundy where all recorded individuals have had short wings. All individuals of *Psylliodes luridipennis* that we have investigated have been fully winged and we have often observed it in flight.

The third species, the ‘Lundy cabbage weevil’ (Figure 2, bottom), is also flightless and, from its pale yellowish/brownish legs in contrast to the black legs of the ‘typical’ form, is currently described as variety *pallipes* of the common cabbage leaf weevil *Ceutorhynchus contractus* (Curculionidae). (The precise nomenclature of *C. contractus* is currently under review and the name *C. minutus* has recently also been used (M.G. Morris, in prep.)). Larvae of this weevil mine the leaves of Lundy cabbage, and also Danish scurvy grass. Not all weevils of the species on Lundy have yellow legs, and the pale-legged form is far more common on Lundy cabbage than on Danish scurvy grass. We have found the distribution of leg colour morphs between the two host plants and between geographical locations on Lundy to be complex and baffling and are currently undertaking genetic studies to sort out the relationships between them and related beetles across Europe.

Figure 1: Isle of Man cabbage *Coincya monensis monensis* from Three Cliffs Bay, Gower (top left) and Wallasey dunes, Merseyside (top right) and Lundy cabbage *Coincya wrightii* from the cliffs above Landing Bay, Lundy (bottom)

Figure 2: Bronze Lundy cabbage flea beetle *Psylliodes luridipennis* (top left), blue Lundy cabbage flea beetle *Psylliodes napi* (Lundy form) (top right) and Lundy cabbage weevil *Ceutorhynchus contractus pallipes* (bottom). Scale bar = 1 mm



We have found all three species of beetle to occur throughout the range of their foodplant, occurring on plants growing in vertical sea cliffs, inland in Millcombe, and colonising plants seeded into experimental exclosures within the range of the foodplant in less than a year.

PAST

How did Lundy come to gain this unique community of plant and beetles? They or their ancestral forms could not have survived on Lundy through the last Ice Age, which at its maximum resulted in ice sheets that extended as far south as what is now the Bristol Channel. The area, including Lundy, will have experienced a tundra-like climate far too cold for these species. This means that Lundy cabbage and its beetles must either be relict species that were once more widespread (or that do occur elsewhere, but have yet to be discovered), or be 'new' taxa that have diverged *in situ* on or around Lundy, or, of course, the individual species of the assemblage may have different origins.

Together with Cinderella Grout, who was working on a Marie Curie fellowship at Leeds University, we have been using molecular genetic techniques to investigate the relationships between Lundy cabbage and other species of the genus *Coincya*, most of which are found in the Iberian Peninsula. Preliminary results suggest that Lundy cabbage is genetically very close to some populations of the Isle of Man cabbage *Coincya monensis monensis*, in particular to a single population of it growing on the Gower Peninsula in South Wales (Figure 1, top left), only 47km to the north-east. This population appears to be quite isolated genetically from other populations, currently referred as the same subspecies, in the rest of Britain and, together with *C. wrightii*, is actually closer to coastal populations considered to be *C. monensis cheiranthos* in Northern Spain (Cinderella Grout, unpublished data).

C. monensis is a very widespread, mainly annual species, with many named subspecies in Europe, especially in the Iberian Peninsula (Leadlay & Heywood; 1990). In the U.K. there are usually thought to be two subspecies. The Isle of Man cabbage *Coincya monensis monensis* (Figure 1 top) is endemic, associated with coastal dunes in the west, including the Isle of Man, and the Welsh, N.W. English and Scottish coasts. Subspecies *cheiranthos* (wallflower cabbage) is a ruderal plant of docklands and waste ground, fairly widely distributed but particularly so in South Wales, where it is spreading (Preston *et al*., 2002). It is considered to be a recent introduction from mainland Europe where it is very widespread. It is unfortunate that the populations of *C. monensis monensis* recorded from the South Devon and Cornish coasts, always considered to be casuals (Stace, 1997) and last seen in the early twentieth century (National Biodiversity Network data), and those thought to be *C. monensis cheiranthos* from North Devon from the 1950s or '60s are now extinct and no genetic material remains to include in our study.

How might the Lundy cabbage - or its predecessor - have arrived on Lundy and maybe changed to become the plant we now call Lundy cabbage? To examine this we needed to be able to follow the history of Lundy from the end of the last Ice Age to when it eventually become habitable for the plants and animals present today. In particular it was important to establish at what point rising sea levels turned Lundy into an island and what were the likely climatic and ecological conditions at that time.

The reconstruction and dating of past environments is a complex problem, needing to take into account uplifting of the Earth's crust as the weight of ice reduced, the counteracting rise in sea level due to glacial meltwater and subsequent effects of erosion and deposition of sediments.

We examined how and when Lundy became an island by combining existing estimates of post-glacial sea level rise with the present day topography of Lundy and North Devon and the bathymetry of this area of the Bristol Channel, and then linked this to what is known of past climates to infer what conditions may have been like on Lundy at the time (Craven, 2002). To do this we obtained depth data for the area of the Bristol Channel around Lundy from Admiralty charts using *Leadline*, a geographical information system tool designed by Tony Pilkington of the Geographic Information Unit at English Nature for the programme MapInfo. 'Artefacts' such as ship wrecks were digitally removed, as well as recently deposited sand banks including the two 'Banner Banks' to the N.E. and N.W. of Lundy which are the result of scour and deposition by currents of the modern Bristol Channel (Figure 3) (Stride, 1982). These banks were 'flattened' by taking the depths at their bases and replacing the values over the banks with a uniform value (-30 m). Finally we combined depth contours with terrestrial ones from the Ordnance Survey 1:50000 dataset and converted them all to a triangular irregular network (wire-frame model) using Intergraph Terrain Analysis, and used the MapInfo programme to generate a series of maps showing sea level rise at 2m intervals (Figure 4).

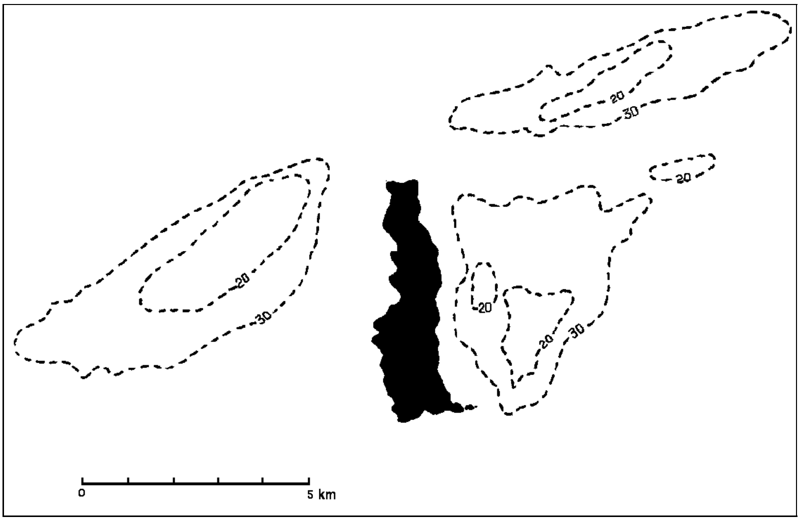
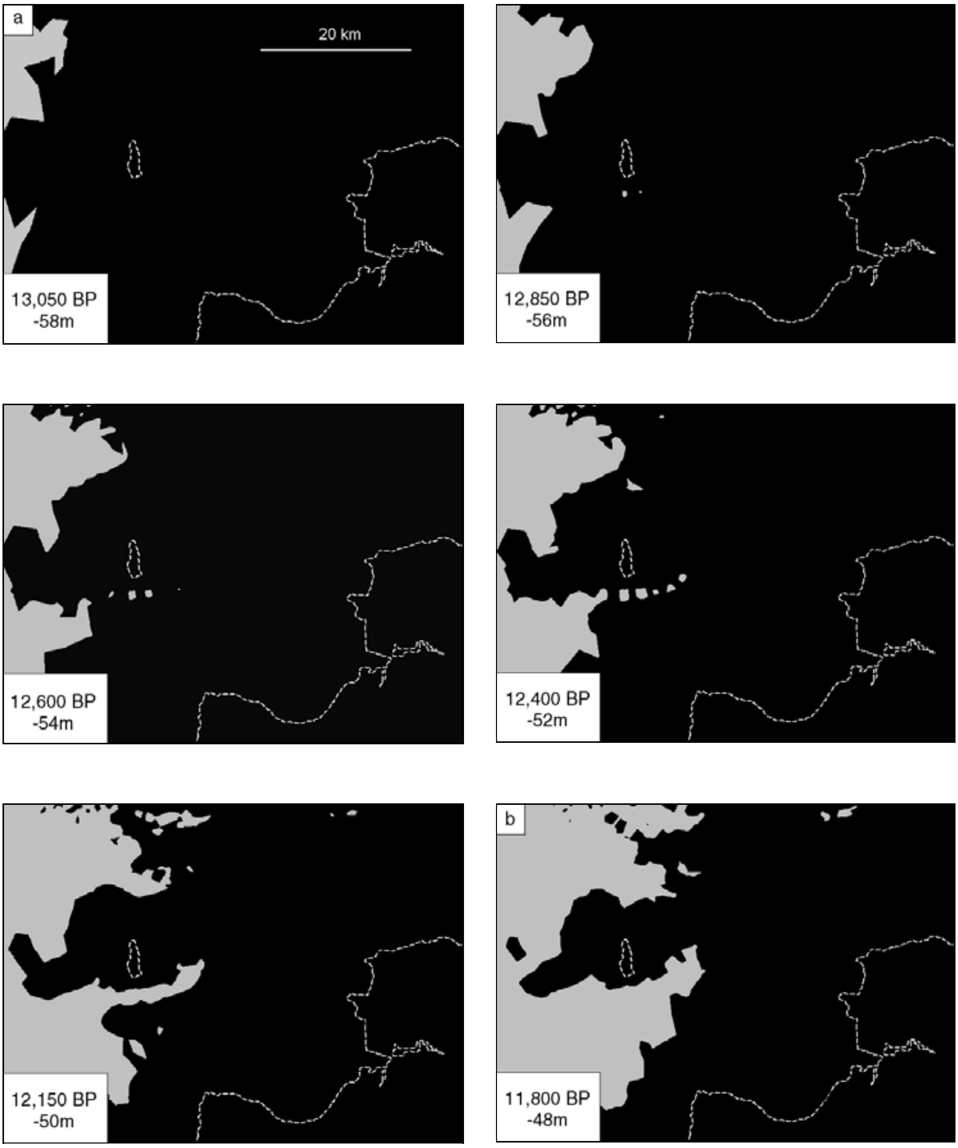


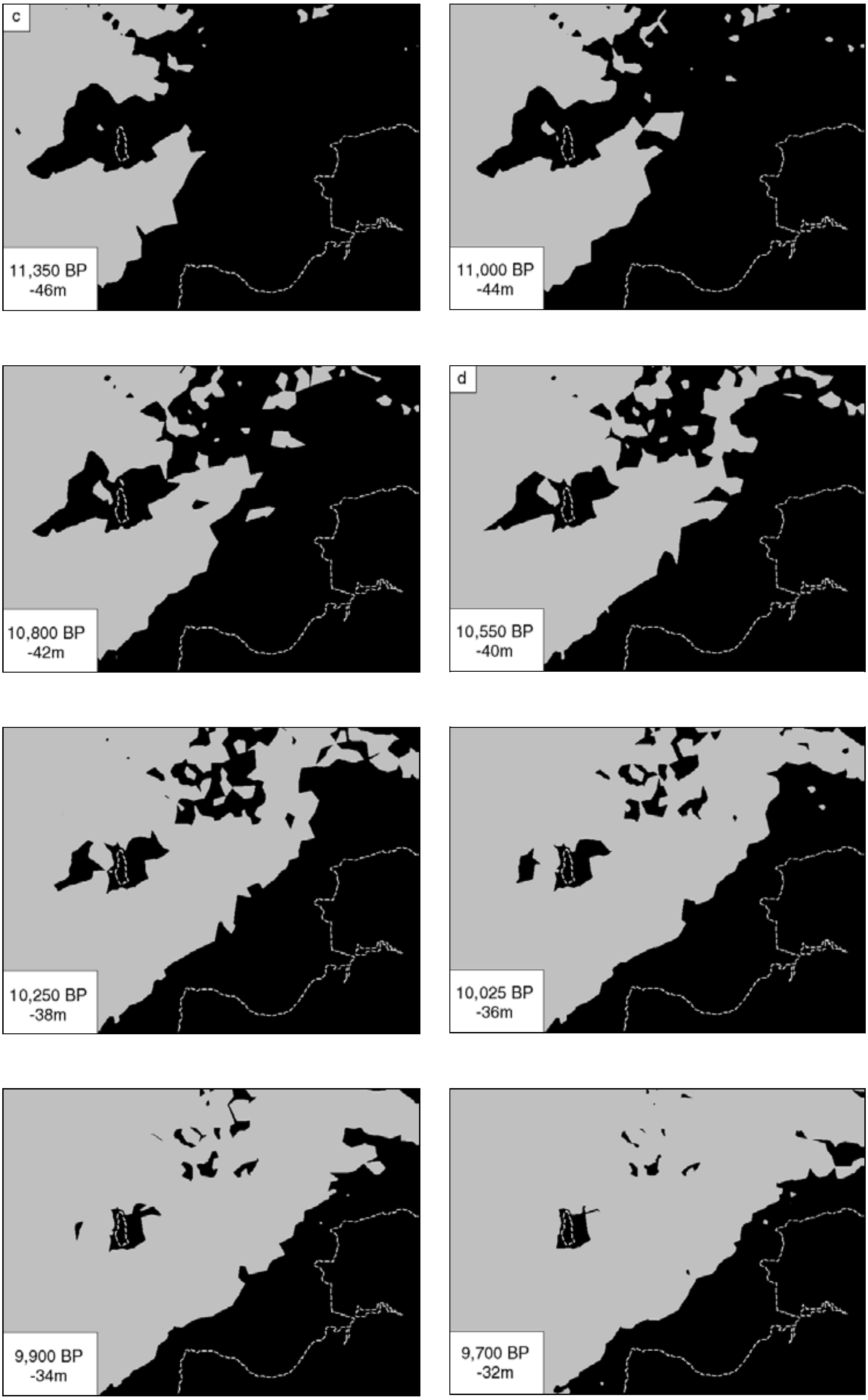
Figure 3: Map showing the sea depths surrounding Lundy in metres plotted from Admiralty Charts. The 'Banner Banks' to the north-east and north-west are recent accumulations of sediment and were excluded for modelling purposes

Using a sea-level curve developed by Lambeck for an area in the Celtic Sea located just to the west of Lundy, we added a time-scale for the sea level rise which allowed us to infer climatic conditions. The majority of climate data used in this work were amalgamated by the Quaternary Environments Network (Adams, 1997), based on pollen, fossil insect and past lake level data (Anderson, 1997; Atkinson *et al*., 1987; Harrison *et al*., 1996 respectively).

At the last glacial maximum, 25,500 years ago (Eyles & McCabe, 1989), a tongue of ice probably extended southwards into the Celtic Sea as far as the Scilly Isles (Scourse *et al*., 1990), although the main margin of the ice sheet did not reach as far south as the southwest of England (Jones & Keen, 1993; Doody, 1996). When the ice melted, the shoreline is believed to have remained stationary until about 14,000 years ago because crustal rebound matched sea level rise (Lambeck, 1995). At this time the coastline was still well to the west of Lundy (Figure 4: -58m).

Figure 4: Modelled changes in Lundy and North Devon shorelines, produced at 2m depth intervals with dates in 'real' years, changing in response to sea level rise since the last glaciation. Present day coastline dotted. Fine detail (lakes/small islands/ fine coastal detail etc.) are likely to be artefacts of the modelling process and are best ignored. Additional information: (a) middle of the Older Dryas cold period with subsequent warming of conditions; (b) the Younger Dryas ends marking the start of the Holocene; (c) the climate continues to warm but conditions are still cooler than present day; (d) climate begins to warm slightly. Sea = grey. Land = black




c
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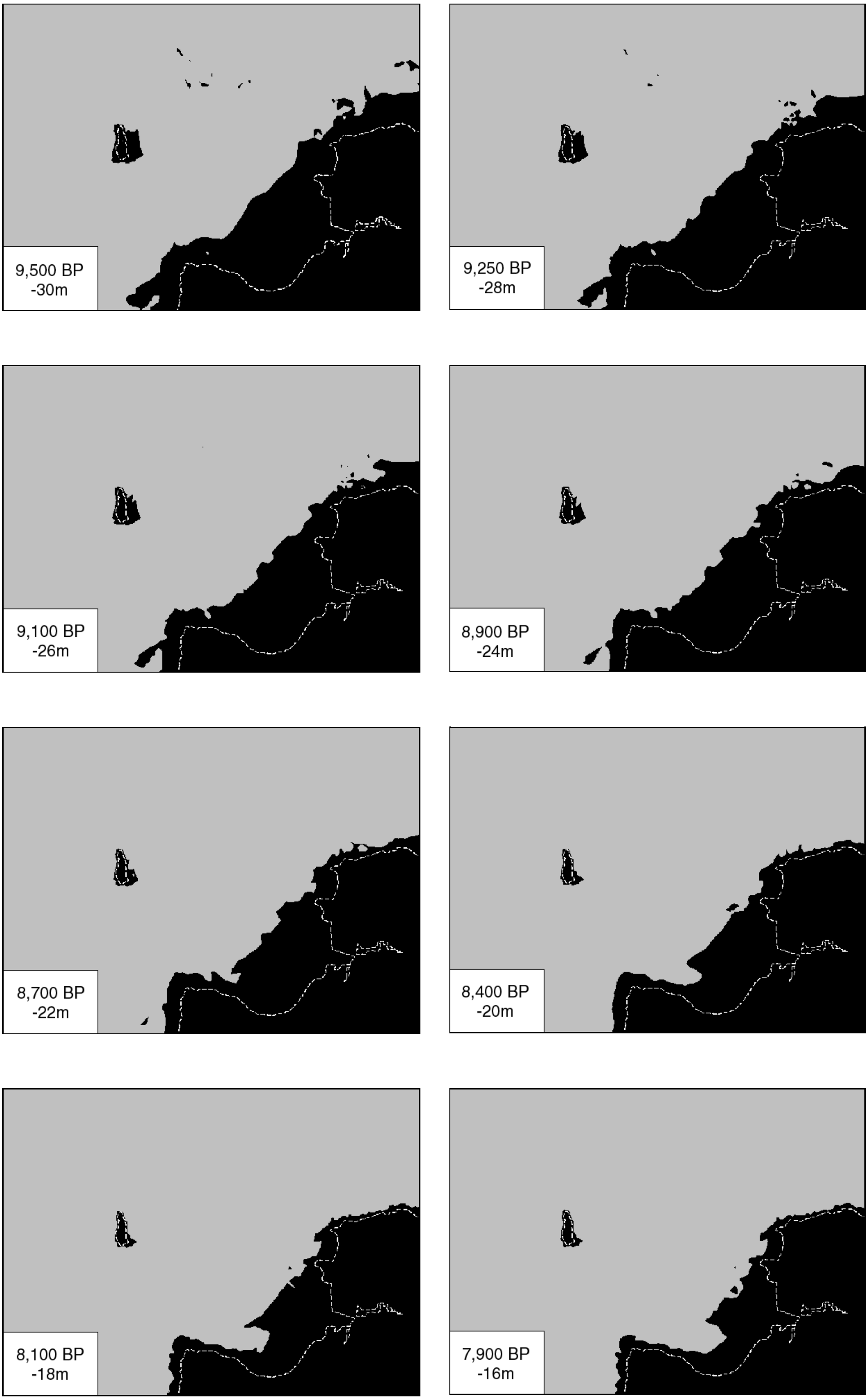
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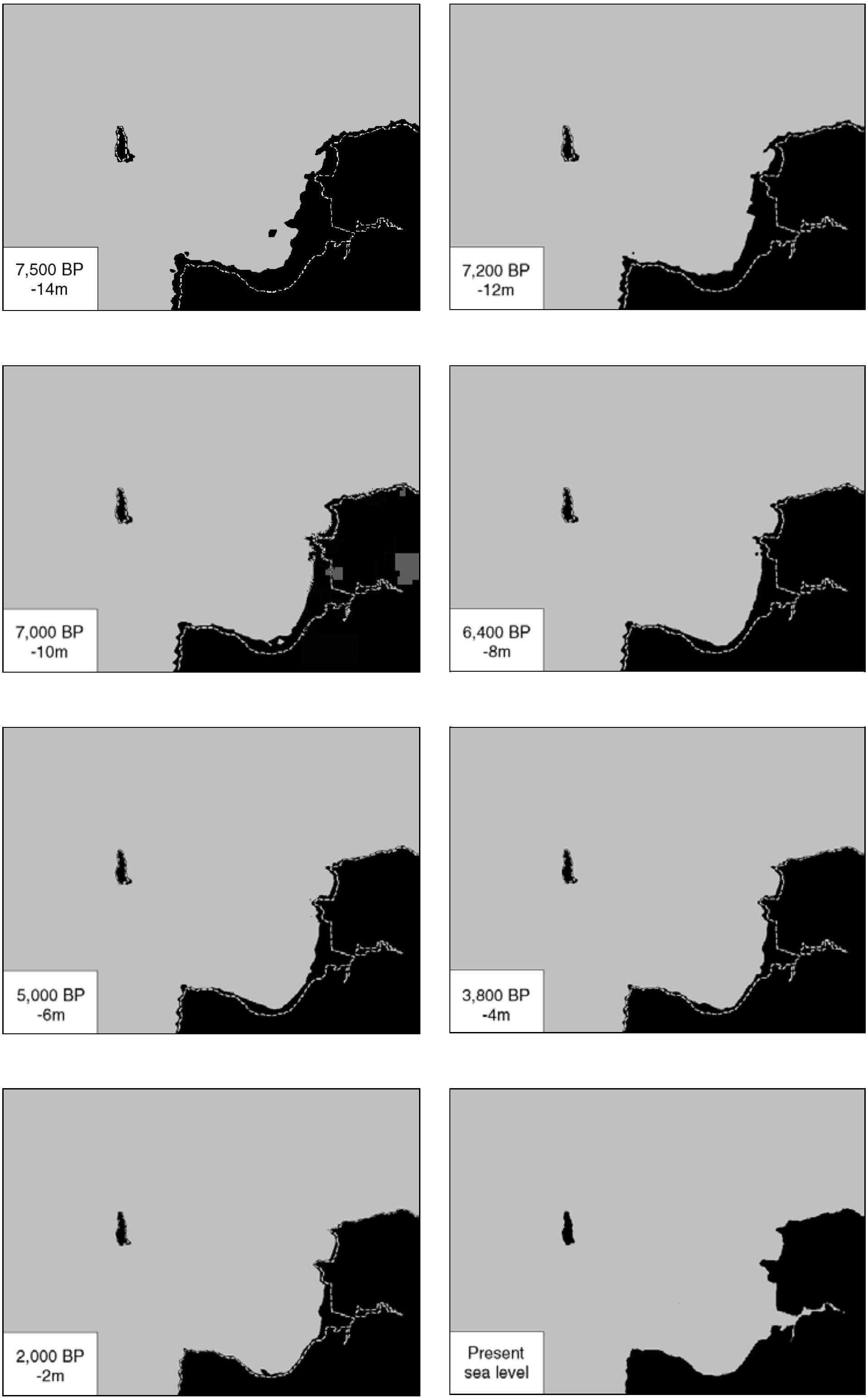
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-6m
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-4m
2,000 BP
-2m
Present
sea level

The climate remained very cold and dry after the glacial maximum, but shortly before 14,500 years ago it temporarily grew warmer and moister (Adams, 1997), but was followed by two periods of much colder conditions (the Older and Younger Dryas) which ended about 11,500 years ago when the current warm period began. From this time onwards climatic conditions started to become suitable for Lundy cabbage and its insects in the area.

Our model suggests that the widening estuary of the proto-Taw/Torridge (Figure 4: -52m to -54m) to the south of 'Lundy', then an isolated large granite hill or tor, eventually left 'Lundy' on a peninsula by the end of the Younger Dryas (Figure 4: -50m to -44m) extending southwest from what is now the middle of the Bristol Channel. This closely corresponds to the map produced by Gardner (1968), although our dating is somewhat different. As sea level rose, this spit reduced in area and its 'neck' narrowed until Lundy became an island (Figure 4: -42 to -38m) between 10,800 and 10,550 years ago, at a point when the climate was probably slightly cooler than now, but beginning to warm (Adams, 1997), and when conditions in southwest Britain were particularly mild.

Previous estimates of when Lundy became an island vary considerably (Table 1).

Table 1: Estimates of the date of isolation of Lundy as an island

Upper Palaeolithic 45,000-11,700 years ago	Schofield & Webster (1990)
10,800-10,550 years ago	This study
9,000 years ago	Gardner (1968)
>8900 years ago	Lambeck (1995)

Lambeck's (1995) calculations suggested that Lundy might have become isolated earlier than 8,900 years ago, but this model was acknowledged to have inadequate data for some areas, one of which was the Bristol Channel. As we used a sea level curve generated by a more recent version of Lambeck's model (personal communication from K. Lambeck to J. Scourse, 1999), coupled with detailed bathymetric data for the area around Lundy, our predictions of palaeoshorelines should be more accurate than has been possible before. Unfortunately, just as Gardner found in the 1960s, there remain insufficient data to estimate how much the present floor of the Bristol Channel has been altered by post-glacial sedimentation and erosion, and so the results of our model similarly must be treated with caution.

Over the next thousand years land to the northeast of Lundy slowly disappeared, but may have played an important role by providing 'stepping stones' for plants and animals colonising Lundy during this period (Figure 4: -40m to -32m). The distance between Lundy and North Devon increased as the coast receded towards its present day position (Figure 4: -30m to -2m).

From about 9,000 years ago, conditions were slightly warmer and moister than present, with another brief cool phase 8,100 years ago, though not as severe as the Younger Dryas (Adams, 1997). Temperatures rose to probably their highest since the Ice Age, between 7,900 and 4,500 years ago (Adams, *op. cit.*) whereupon the climate became largely similar to that of today.

Our results therefore suggest that the ancestors of Lundy cabbage and its beetles may have had the opportunity to colonise Lundy across land during a few hundred years around 10,800 years ago or may subsequently have been aided by 'stepping stone' land to the north east.

As Lundy became an island it would have been a high, flat-topped hill or tor standing out from flat plains and estuaries that are now beneath the sea. Widespread sand, including dunes, will have stretched along the proto-Taw/Torridge estuary, around Lundy northwards across a smaller Severn estuary to the Gower peninsula, probably providing wide expanses of habitat for dune plants such as the Isle of Man cabbage. One possible origin for the Lundy cabbage is that its progenitors, or a form ancestral to both it and the Gower (and Devon?) population(s) of *C. monensis monensis*, may have been isolated on sands around Lundy, possibly adapting to rockier conditions and persisting as the plant we know as Lundy cabbage today.

PRESENT

Our current studies of Lundy cabbage started in 1993 and since then we have been taking annual counts of the numbers of plants in flower across its whole range and, in a few accessible areas, also counting individuals that are not in flower (seedlings, non-flowering rosettes and plants prevented from flowering by herbivores). These data have provided insights into its distribution and fluctuations in abundance, and some of the factors that are influencing its population dynamics. Our views on the drivers influencing fluctuations in its numbers have changed considerably over this period, highlighting the value of such relatively long term data sets.

The overall range of Lundy cabbage has changed very little since 1993, in marked contrast to the numbers of plants that flower. It remains restricted to the coasts of the relatively sheltered south-eastern half of the island, extending inland only a couple of hundred metres in Millcombe. A combination of the effects of grazing and competition from other plants, notably grasses on deeper, moister soils on some of the Sidelands, determines its distribution. Few are found on the less steep areas within its range that are readily available to grazing animals, although in 'good' years, such as 2006, the plants colonise the grass and bracken-clad Sidelands just to the north of Millcombe and in the Marisco Castle fosse. The plants there rarely flower, however, and do not persist as they are grazed off. We have shown that a number of introduced grazing animals significantly impact on the Lundy cabbage; feral goats, Soay and domestic sheep and, in particular, rabbits.

The limiting role of grazing is evident on the cliffs and rock outcrops, where plants are restricted to the steepest sections inaccessible to goats and Soay sheep; on a small outcrop about 100m north of St Helena's Combe, which used to project above one of the main rhododendron patches, Lundy cabbage now only persists within a protective dense growth of bramble after clearance of the rhododendron.

Evidence for the role of competition from other vegetation comes from some of our experimental exclosures, where areas free of grazing animals temporarily supported Lundy cabbage. After a while, however, a dense grass sward developed and Lundy cabbage disappeared, especially on deeper, moister soils which support lush growth of Yorkshire fog *Holcus lanatus* and red fescue *Festuca rubra*. In such circumstances, disturbance from grazing animals may favour the cabbage. We failed in an experimental attempt to establish Lundy cabbage in an exclosure on one of the more grassy areas of the Sidelands just to the north of Hangman's Hill in 1997. Despite our initial clearance of grasses and other plants prior to seeding, the resultant Lundy cabbage seedlings were rapidly out-competed by grass regeneration.

We have shown that Lundy cabbage is also subject to competition (and indeed elimination in places) by the alien shrub *Rhododendron ponticum* (Compton *et al*, 1997, 1999) and the area of rock outcrop and cliff face available to the cabbage has been reduced since its rapid population expansion really started after a fire in 1926. We have shown that all populations of Lundy cabbage are vulnerable to supplanting by rhododendron and so it poses a continual threat as long as it remains on the island. Colonisation of cliffs by Lundy cabbage after clearance of rhododendron is, however, rapid and spectacular and the immediate threat that rhododendron poses has been reduced somewhat in recent years, thanks to the past and current efforts of the island's wardens, rangers, numerous volunteers, and the cliff-climbers of *Ropeworks*, led by Angus Tillotson.

Numbers of Lundy cabbage in flower have fluctuated considerably, but not erratically. A very distinct pattern has emerged of widely separated peaks and troughs in plant numbers varying up to ten-fold (Figures 5 and 6). We now consider that these changes in abundance are driven largely by the huge variations in the number of rabbits, driven by outbreaks of myxomatosis that have taken place over the same period (Compton *et al*., 2004). With almost no predators, rabbits thrive on Lundy, leading to very closely-cropped swards, bare ground and erosion. Myxomatosis first arrived on the island in 1983 and the numbers of rabbits crashed, as they have done three times subsequently. In response, the populations of many plant species, including Lundy cabbage, rapidly recover and flower profusely. Pioneer species such as the cabbage, which are favoured by bare ground and disturbance, respond particularly dramatically. This effect is relatively short lived, however, as rabbit numbers inevitably quickly recover, and regeneration of the cabbage is subsequently suppressed by a combination of competition with other plants followed by intense rabbit grazing.

We have found that fluctuations in numbers of Lundy's special beetles are intimately linked with the abundance of their host plant. In the early 2000s, when the Lundy cabbage was scarce, it was very hard to find its dependent insects and few plants appeared to have any of the unique species of beetle on them. The beetles' distribution became very patchy, with perhaps the highest numbers remaining on a small population of the cabbage near the beach at Quarry Bay. Cabbage numbers recovered rapidly in 2005 and 2006, but the recovery of its beetles seemed to be lagging behind. While numbers of all the beetles increased, they had very large numbers of plants to recolonise, making them more difficult to find. *Ceutorhynchus contractus*, including var. *pallipes*, seemed to recover much more rapidly than either *Psylliodes* species, perhaps because it has more generations in a year and has had its alternative food plant (scurvy grass) to fall back on. The winged *Psylliodes luridipennis*

Figure 5: Variation in Lundy cabbage numbers between years with low numbers of rabbits (2006 top) and high numbers (2005 bottom). Sideland population along beach road, just south of the turn into Millcombe

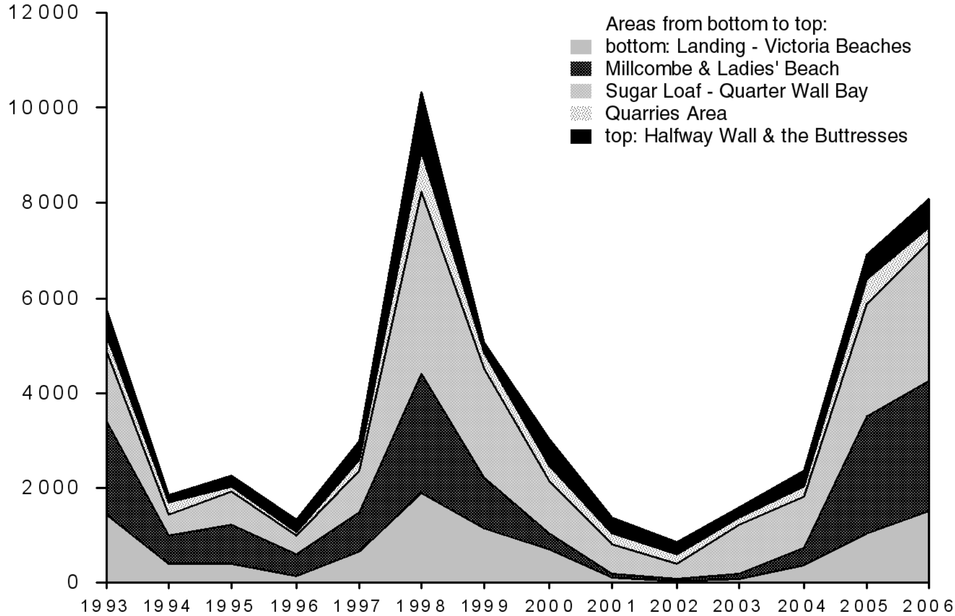

Figure 6: Number of plants of Lundy cabbage in flower in the main areas of its distribution between 1993-2006. Data from 1993 approximated from incomplete data by interpolation of numbers based on average proportion of total count contributed by each counting unit for all units in subsequent years

has seemed to be able to recolonise more quickly than the flightless *P. napi.* What effect such repeated population bottlenecks may be having or have had on the genetics of the beetles, we do not know.

FUTURE

The continuing survival of Lundy cabbage is more or less assured for the time being. Its numbers show no sign of long-term decline, while the Millennium Seedbank at the Royal Botanic Gardens at Kew has thousands of Lundy cabbage seeds which could be used in an emergency, although hopefully this is unlikely ever to be necessary. Awareness of its ecological needs has improved and has informed the management of the domestic sheep and larger feral mammals to accommodate the plants' needs and these seem now to pose less of a threat to the plant within in its current range than in the past.

Work on the rhododendron is by no means complete and more clearance is still needed, urgently in some areas, such as the cliffs above and to the south of Quarry Bay where it is still actively invading areas of Lundy cabbage. Continual clearance without the objective of its eradication is clearly unsustainable and, until this highly invasive species is entirely eliminated from Lundy it will remain a threat and could very quickly re-colonise all the areas so far cleared, undoing all the hard work and negating the financial resources that have gone into its control.

Whether Lundy cabbage numbers continue to fluctuate in the way we have seen in recent years is likely to be dependent mostly on future management of rabbit numbers. 'Boom and bust' cycles in rabbit numbers driven by myxomatosis will probably mean continuation of the cycles in the numbers of the plant and insects, with unpredictable implications for their genetic diversity. Rabbit numbers stabilised at a low level would probably result in fewer Lundy cabbage destroyed by grazing, with less disturbance and erosion and fewer areas of bare ground into which the cabbage may regenerate. Vegetation on the Sidelands could become even more dense and grassy, maintaining the absence of Lundy cabbage there. In such a scenario overall numbers of Lundy cabbage would be likely to be more stable, perhaps at a figure somewhere between the highs and lows of the recent past, and the dramatic 'shows' of the plant that were witnessed in the post myxomatosis years of 1993, 1998 and 2005-6 might not be seen again, at least on the Sidelands. For the insects, the implications of recent observations are that wildly fluctuating populations of Lundy cabbage may be more of a problem for them than for the plant itself.

Longer-term, it is by no means clear what climate change might have in store for the vegetation and wildlife of Lundy. Various conflicting models predict either considerable warming or cooling of the British climate, together with either reduced or enhanced precipitation in the west of Britain. However, the predicted climate scenarios for the next century or two are generally within the variation already seen during the post-glacial period and have probably already been experienced by Lundy cabbage and its fauna. Different climatic conditions will also influence the interplay between Lundy cabbage, competing vegetation, grazing animals and whatever additional species may colonise Lundy within the remainder of the current interglacial.

After that ... ?

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REFERENCES

Adams, J. 1997. Global land environments since the last interglacial: Europe during the last 150,000 years. Oak Ridge National Laboratory, TN, USA. *http://www.esd.ornl.gov/projects/qen/nercEUROPE.html* (Accessed 18.1.02).

Anderson, D.E. 1997. Younger Dryas research and its implications for understanding abrupt climatic change. *Progress in Physical Geography* 21, 230-249.

Atkinson, T.C., Briffa, K.R. & Coope, G.R. 1987. Seasonal temperatures in Britain during the past 22,000 years, reconstructed using beetle remains. *Nature*, 325, 587-592.

Compton, S.G. & Key, R.S. 1998. *Species Action Plan: Lundy Cabbage (Coincya wrightii) and its associated insects*. Unpublished report to Species Recovery Program, English Nature, Peterborough.

Compton, S.G. & Key, R.S. 2000. *Coincya wrightii* (O.E. Schulz) Stace. *Journal of Ecology*, 88, 535-547.

Compton, S.G., Key, R.S. & Key, R.J.D. 1999. *Rhododendron ponticum* on Lundy - beautiful but dangerous. *Annual Report of the Lundy Field Society 1998*, 49: 74-81.

Compton, S.G., Key, R.S. & Key, R.J.D. 2002. Conserving our little Galapagos - Lundy, Lundy cabbage and its beetles. *British Wildlife*, 13, 184-190.

Compton, S.G., Key, R.S. & Key, R.J.D. 2004. Lundy cabbage population peaks - are they driven by rabbits and myxomatosis? *Annual Report of the Lundy Field Society 2003*, 53, 50-56.

Compton, S.G. Key, R.S., Key, R.J.D. & Parkes E. 1997. Control of *Rhododendron ponticum* on Lundy in relation to the conservation of the endemic plant Lundy cabbage, *Coincya wrightii*. *English Nature Research Reports*, 263, 1-67.

Craven, J.C. 2002. *The Ecology and Evolution of the Bronze Lundy Cabbage Flea Beetle, Psylliodes luridipennis*. Master of Research Thesis. University of Leeds. 113pp.

Doody, J.P. 1996. Chapter 1.2 Introduction to the region. In *Coasts and Seas of the United Kingdom. Region 11 The Western Approaches: Falmouth Bay to Kenfig* (Eds. J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody, N.C. Davidson, & A.L. Buck), Joint Nature Conservation Committee, Peterborough, (Coastal Directories Series) pp. 13-18.

Eyles, N. & McCabe, A.M. 1989. The Late Devensian (<22,000 BP) Irish Sea basin: the sedimentary record of a collapsed ice sheet margin. *Quaternary Science Reviews*, 8, 307-351.

Gardner, K. 1968. Lundy - a Mesolithic peninsula? *Annual Report of the Lundy Field Society 1967*, 18, 24-28.

Harrison, S.P., Yu, G. & Tarasov, P.E. 1996. Late Quaternary lake-level record from northern Eurasia. *Quaternary Research*, 45, 138-159.

Jones R.L. & Keen D.H. 1993. *Pleistocene Environments in the British Isles*. London: Chapman and Hall.

Key, R.S., Compton, S.G. & Key, R.J.D. 2000. Conservation studies of the Lundy cabbage between 1994 and 2000. *Annual Report of the Lundy Field Society 1999*, 49, 74-81.

Lambeck, K. 1995. Late Devensian and Holocene shorelines of the British Isles and North Sea from models of glacio-hydro-isostatic rebound. *Journal of the Geological Society of London*, 152, 437-448.

Leadlay, E.A. & Heywood, V.H. 1990. The biology and systematics of the genus *Coincya* Porta & Rigo ex Rouy (Cruciferae). *Botanical Journal of the Linnaean Society*, 102, 313-398.

Morris, M.G. (in prep.) *Handbooks for the Identification of British Insects. True Weevils* 5(17c). Coleoptera : Curculionidae (Subfamily Ceutorhynchinae). Royal Entomological Society/Field Studies Council.

Preston, C.D., Pearman, D.A. & Dines, T.D. 2002. *New Atlas of the British and Irish Flora*. Oxford: Oxford University Press.

Richardson, S.J., Compton, S.G. & Whitely, G.M. 1998. Run-off of fertiliser nitrate on Lundy and its potential ecological consequences. *Annual Report of the Lundy Field Society 1997*, 48, 94-102.

Roff, D.A. 1990. The evolution of flightlessness in insects. *Ecological Monographs*, 60, 389-421.

Schofield, A.J. & Webster, C.J. 1990. Archaeological Fieldwork 1989. Further Test Pit Excavations South of Quarter Wall. *Annual Report of the Lundy Field Society 1989*, 40, 34-47.

Scourse, J.D., Bateman, R.M., Catt, J.A., Evans C.D.R., Robinson, J.E. & Young, J.R. 1990. Sedimentology and micropalaeontology of glacimarine sediments from the central and south-western Celtic Sea. In *Glacimarine Sediments: Processes and Sediments* (Eds. J.A. Dowdeswell & J.D. Scourse), Geological Society, London. Special Publication 53, 329-347.

Stace, C. 1997. *New flora of the British Isles. Second Edition*. Cambridge: Cambridge University Press.

UK BAP. 2001 Species Action Plan Lundy Cabbage (*Coincya wrightii*) *http://www.ukbap.org.uk/UKPlans.aspx?ID=232*