



A Review of the Silver-studded Blue in Cornwall 2020

2020 Silver-studded Blue SpeciesNet Report

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Silver-studded Blue Phenology Analysis

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Silver-studded Blue SpeciesNet Report – Cornwall

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Cover design: David JR Foster

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UK BMS

Butterflies- EB Ford



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Supplement

Silver-studded Blue Phenology Analysis written by Jerry Dennis (Page 55)

1. Introduction

- **Species Champion Programme** -The Silver-studded Blue butterfly has been included in the Butterfly SpeciesNet programme – a Butterfly Conservation (BC) initiative. The Cornwall Butterfly Conservation branch (CBC) is developing the Species Champion programme and aims to increase our knowledge and conservation requirements for species that are poorly understood or at risk in our county. Each Species Champion specialises in one species of butterfly or moth and aims to study its behaviour, abundance, range and habitat requirements. Results of these studies will help the branch to determine the most effective monitoring and conservation activities for a particular species should the need arise in the future. Currently the following species have ‘champions’: Silver-studded blue, Grizzled Skipper, Marsh Fritillary, Grayling, Dingy Skipper, Pearl-bordered Fritillary, Small Pearl-bordered Fritillary and Small Heath. Reports produced by the species champions will be made available to other organizations and landowners to assist management for the dedicated species.
- This report is a review of all the known sites in Cornwall and includes information from preceding Silver-studded Blue SpeciesNet reports. This report needs to be treated as a working document to assist land managers and all feedback is greatly welcomed and appreciated.
- Distribution maps for Cornwall are provided in the main document. More detailed maps and brief description of the main areas in Cornwall where the Silver-studded Blue is regularly recorded are outlined in the appendices.
- As with all recording it is accepted that data is dependent on recording effort and absence of a record does not necessarily indicate the species is extinct in these areas.
- Transect data provides a very good indication of the status of the butterfly and the combination of casual records and transect/timed count data enables CBC/BC to gain the best picture possible. It is recognized that more recording effort and transects/timed counts are required in certain areas. These areas have been highlighted. Formal timed counts have been carried out at 10 sites and Silver-studded Blue is regularly recorded in sufficient numbers for research on 4 transects.
- There has been some excellent partnership working and this has greatly assisted in understanding this species and how best to protect it in the future.
- This report includes a special supplement analysing the phenology of the Silver-studded blue. This report is written by Jerry Dennis and follows the main report.

2. Status of the Silver-studded Blue

FAMILY: Lycaenidae

COMMON NAME: **Silver-studded Blue**

SCIENTIFIC NAME: *Plebejus argus*

Cornish name: Glesek sterennek

Status in Cornwall: Resident (not on the Isles of Scilly)

Percentage of 1km squares occupied in Cornwall: 3% 2009-2018 (38% 10km squares); 3% 1976-2008 (43% 10km squares)

Legal protection: Section 41 Species of Principal Importance (NERC Act 2006)

National status: Red List of British Butterflies; IUCN criteria: Vulnerable (VU)

UK National rate of change in abundance: 47% increase (1976-2019)

South-west England rate of change in abundance: 28% decline (1979-2018); 42% increase (2009-2018)



Female silver-studded blue

3. Identification



This beautiful diminutive butterfly is the smallest of the ‘Blues’ resident in Cornwall. It is regarded as a flagship species and is indicative of a healthy, well-functioning ecosystem such as the dune systems at Penhale and Hayle. It can reliably be distinguished from other members of this family once subtle, but key, differences are identified. In both male and female Silver-studded Blues, the under wings can have silvery-blue centres to the black spots along the outer edge – hence the name Silver-studded Blue. Confusingly though these studs are not always present, especially in the female, or may be very small.

It is common to confuse the male Brown Argus with the female Silver-studded Blue, and the male Silver-studded with the male Common Blue. The male has leaden-blue upper wings with a metallic sheen. These upper wings are bordered by a thick charcoal margin, fringed by white fringe (cilia). When fresh, the Silver-studded Blue is clearly distinct from the male Common Blue but with faded specimens it is essential to check the under wings. The female upper wings are generally brown with diffuse orange crescent-shaped markings (lunules) and often with a powdering of blue scales varying in density. The underwings of the female are brown and the males silvery-blue.

Originally the butterfly was considered to have four subspecies (Ravenscroft and Warren, 1996) namely *Plebejus argus* (Linnaeus 1758), the most widespread lowland species; *P. argus* subsp. *cretaceus* (Tutt 1909) found in the south of England; *P. argus* subsp. *masseyi* (Tutt 1909) recorded in north-west England and *P. argus* subsp. *caernensis* (Thompson 1937) found in Wales (Emmet and Heath, 1990). This classification is not, however, accepted by all lepidopterists in the UK (Thomas, 1983 cited in Emmet and Heath, 1990). At present the British population is now

represented by the nominate subspecies, *P. argus* subsp. *argus*, with the exception of the population found on the Great Orme and nearby areas in north Wales, where it is replaced by the subspecies *P. argus* subsp. *caernensis*. Former populations of subspecies *masseyi* and *cretaceus* are now extinct.

4. Larval foodplants

On the calcareous habitats such as the sand dunes the caterpillar is thought to feed mainly on Common Bird's-foot-trefoil (*Lotus corniculatus*) and also other members of the Pea (Fabaceae) family such as Common Restharrow (*Ononis repens*) and possibly young gorse plants.

On heathland the preferred foodplant will normally be members of the Ericaceae family such as Bell Heather (*Erica cinerea*), Cross-leaved Heath (*E. tetralix*), Cornish Heath (*E. vagans*) and Heather (Ling) (*Calluna vulgaris*). However, on the heathland sites there are members of the Pea (Fabaceae) family present including gorse. Further investigation is required to discover the preferred foodplant within this habitat.

5. Habitat and Ecology

- The butterfly is mainly found in three habitats in the UK: lowland heath, calcicolous grassland and sand dunes. The 'mossland' populations of the north are now extinct with the exception of a small population in Snowdonia.
- In Cornwall, as well as heathland populations, large colonies are found on the sand dunes of the north coast. The Silver-studded Blue butterflies on these sand dunes appear to be larger and more brightly coloured than the heathland forms (*P. argus* subsp. *argus*) and are similar to the extinct *P. argus* subsp. *cretaceus* form. These forms are referred to as ecotypes or races and legally are not afforded special protection.
- The dunes support a typical calcareous flora with a mosaic of bare ground, short turf often cropped by rabbits, interspersed with patches of longer grasses such as Marram (*Ammophila arenaria*) and scrub. This mosaic of habitat is essential to cater for the butterfly's different requirements during its life cycle. Scrub and Marram provide shelter, resting and roosting places.
- On heathland the habitat includes a mixture of heathers, gorse (*Ulex* spp.), vetches, and other plants. As with the dune habitat, areas to roost are essential. The colonies are usually but not always to be found on warm south-facing slopes, or in areas otherwise protected from strong winds. There is no limit to the areas where the butterfly will seek out shelter from old walls, sand dune bowls, scrub, hedges and even the bunkers of the old explosive works on Upton Towans.



Cudden Point – south coast heath



Godrevy headland – north coast heath 2019

- The butterfly lives in close-knit colonies of varying size and was originally thought not to wander more than about 50 metres from them (Thomas & Lewington, 2010). More recently though, this view has been modified and, in some cases, a small proportion of adults have been observed up to 1.5km from their colonies but within the metapopulation; the maximum distance recorded is four kilometres (Asher *et al.*, 2001). This revised view has been

supported by observations in Cornwall, where at Upton and Gwithian Towans, and at the group of colonies north of Botallack, movement between colonies has been recorded (J. Wacher and S. Foster - personal unpublished research 1997 - 2002). The movement documented has been within a metapopulation and was found to be from breeding areas to evening roosting areas. However, it must be stressed movement within a metapopulation will be hampered by barriers such as desolate car parks, large areas of scrub or woodland and other unsuitable habitat.

- The Silver-studded Blue usually produces only one brood of adult butterflies in Britain. Professor Wacher during the course of his studies discovered evidence of a second brood. His work has inspired others to research further and there has been evidence, albeit it limited, of the suspected second brood.
- **Relationship with ants** - One of the most fascinating features of this butterfly is the relationship with black ants belonging to the genus *Lasius*. This amazing relationship never ceases to delight and inspire young and old when they learn of this fascinating intricate cycle of life.

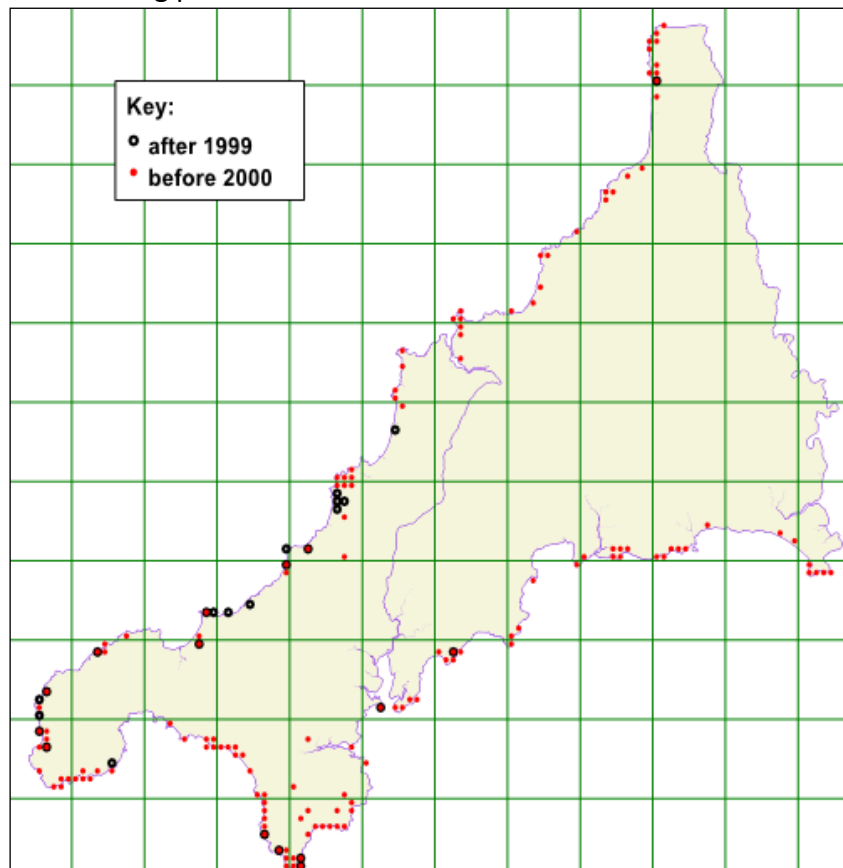
The females only lay eggs where they detect suitable ant pheromones and lay their eggs near nests of the black (*Lasius* spp.) ants with which they form a mutualistic relationship. Once the eggs hatch the ants chaperone the larvae. It is possible that the ants guard against attacks from predatory organisms like wasps and spiders as well as parasites. However, as yet, there is no evidence to support this view. The ants probably pick up the larvae soon after hatching and place them in ant chambers beneath plants, rocks or stones. They pupate within or close to ant nests where they are tended by ants until the adults emerge. In return, the ants receive sustenance in the form of a sweet fluid produced by the larvae (from a gland on their back).



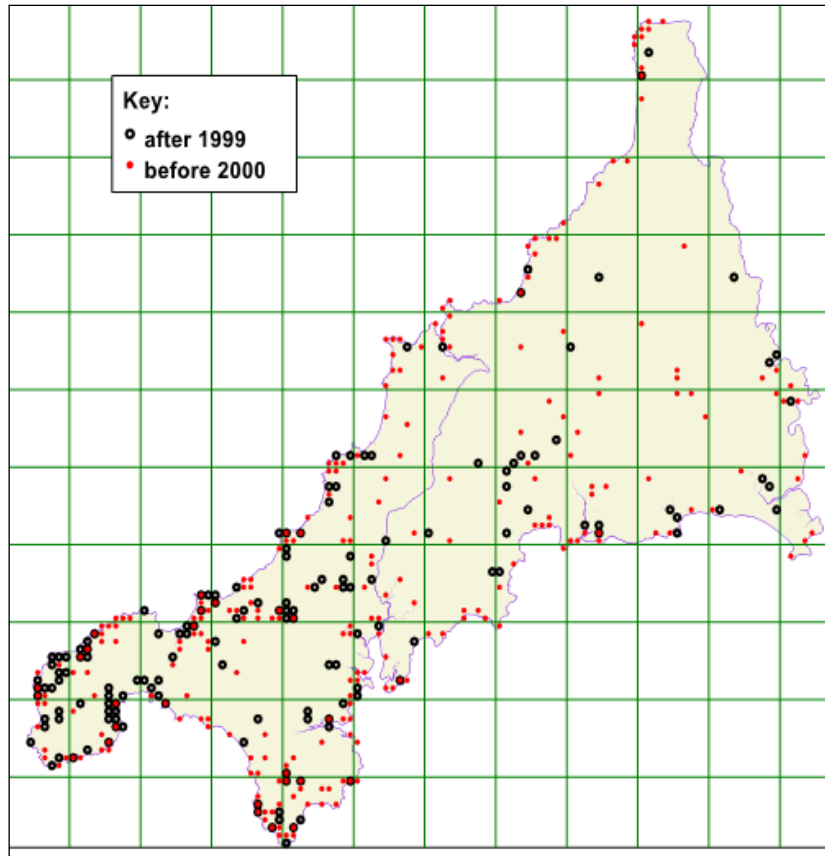
4th instar caterpillar. Photo: Copyright British UK Butterflies

- At present it is believed there are two species of ant that form a relationship with the butterfly in the UK. In the past in Cornwall it was assumed that on heathland, the most commonly associated species are the black ants *Lasius niger* and on calcareous sites *L. alienus*. These two species have been positively identified with the butterfly in Cornwall : *Lasius alienus* at Upton Towns (D. Hoare , L. Munns) and Godrevy Warren (S. Foster); and *L. niger* at St. Gothians Sands Local Nature Reserve (S. Foster).
- *Lasius alienus* has now been split into *Lasius alienus* and *Lasius psammophilus*; the ants on the Cornish dunes are mainly *Lasius alienus*. *L. psammophilus* has not been identified with the butterfly as yet. *Lasius niger* has also been split into two species - *Lasius niger* and *Lasius platythorax*. *Lasius platythorax* has not been recorded in Cornwall but it is possible that earlier records of *L. niger* could have been *L. platythorax*. This ant occurs in cooler areas (e.g. shady woodland) than *L. niger* (Pontin 2005). It is possible that wetter heathland sites may be worth searching more carefully. It is believed by BWARS that most heathland black ants are now very likely to be *Lasius platythorax* especially in areas where the heathland has become more shady. It is definitely worth keeping this under consideration when researching the ant communities in Cornwall.

- Please note: In order to take an ant species in attendance with the caterpillar, permission must be granted from the landowner. In addition if the site is a SSSI then additional permission from NE is required.
- Marcus Rhodes in the course of his PhD studies has identified the following ant species present on various sites. Species present are as follows: *L. niger* at Wheal Maid, Little Beside and Poldice and *L. alienus* at Penhale Sands, Penrose and Cudden Point.
- **Distribution of ant species in Cornwall.** Please note that the following maps are by no means a true reflection of the extent of their distribution but at least it is a starting point.



Lasius alienus



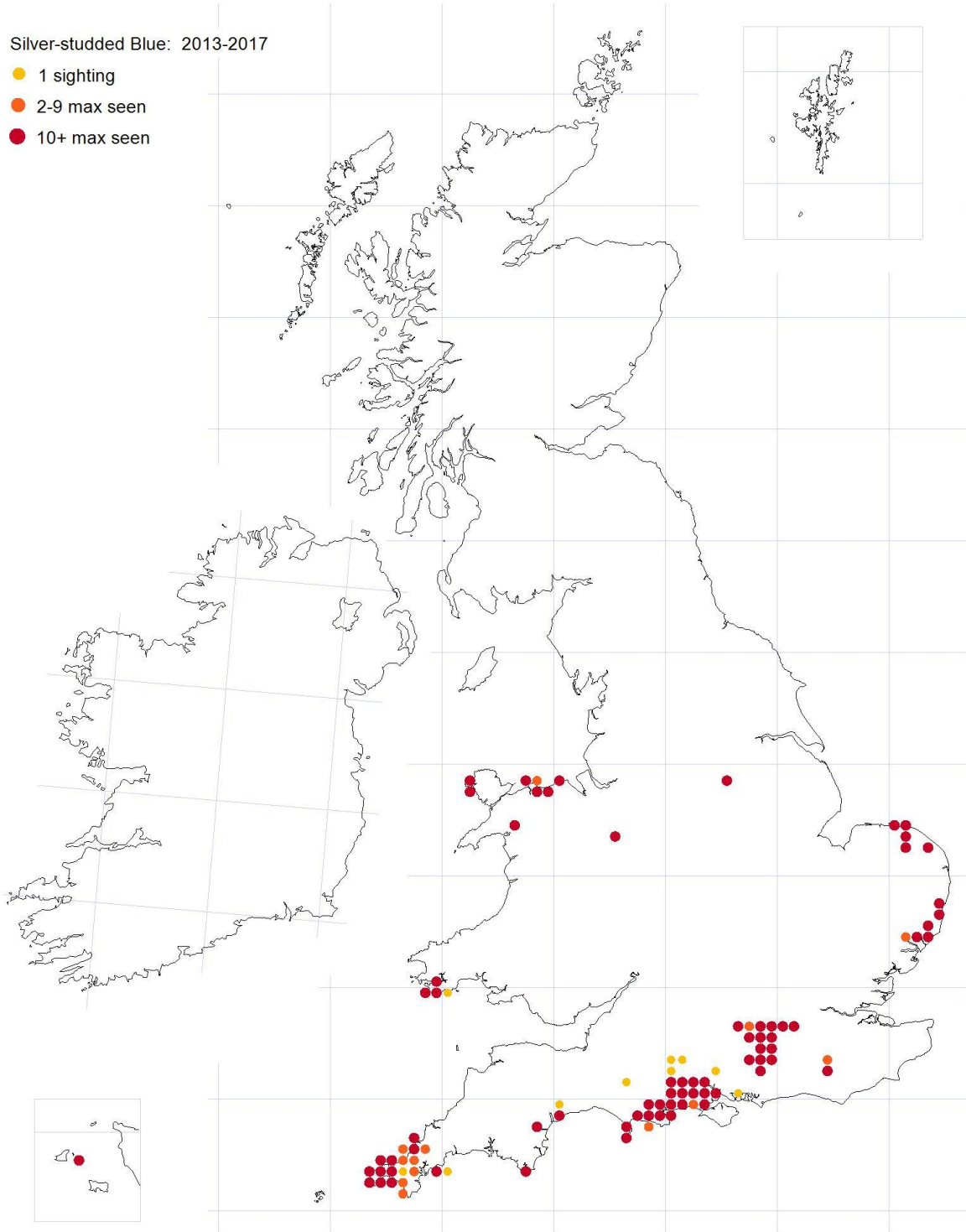
Lasius niger

6. Distribution

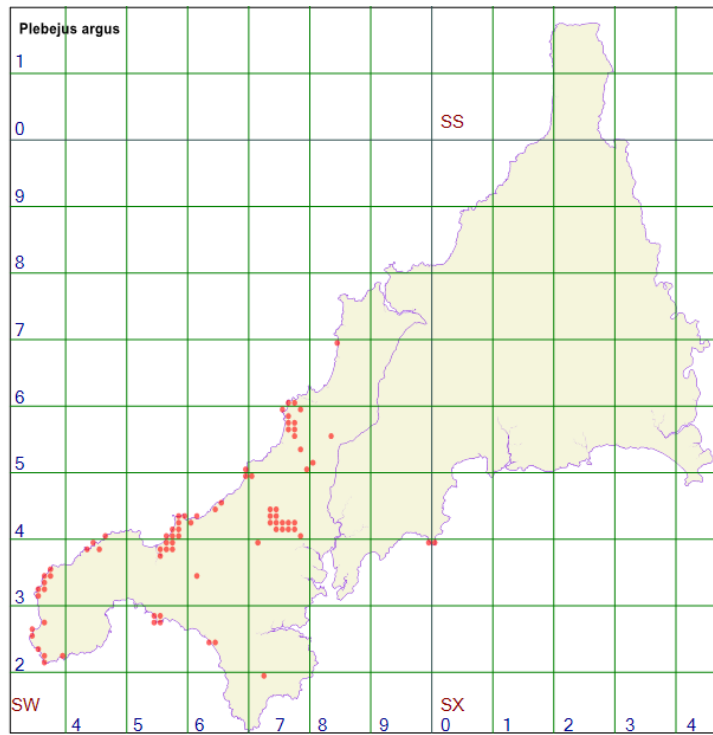
6.a UK

Silver-studded Blue: 2013-2017

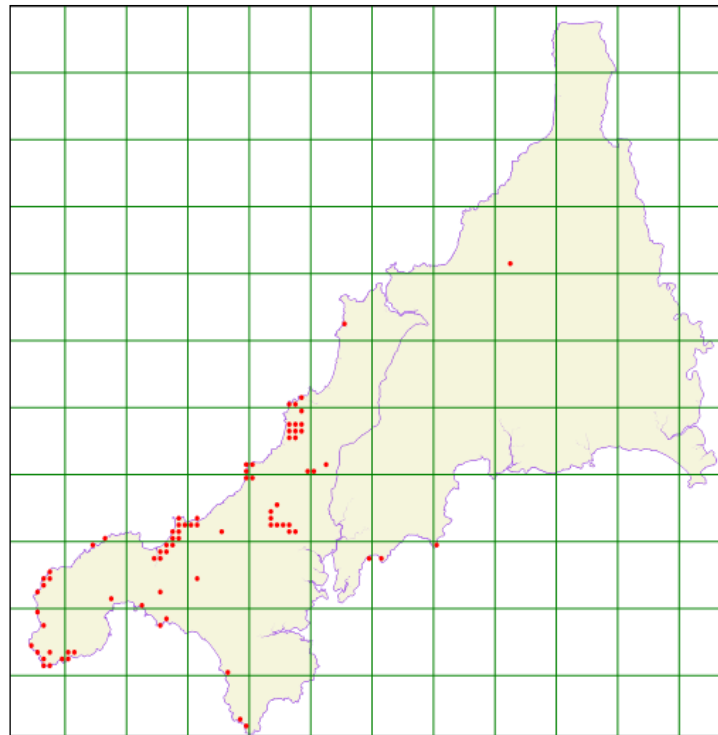
- 1 sighting
- 2-9 max seen
- 10+ max seen



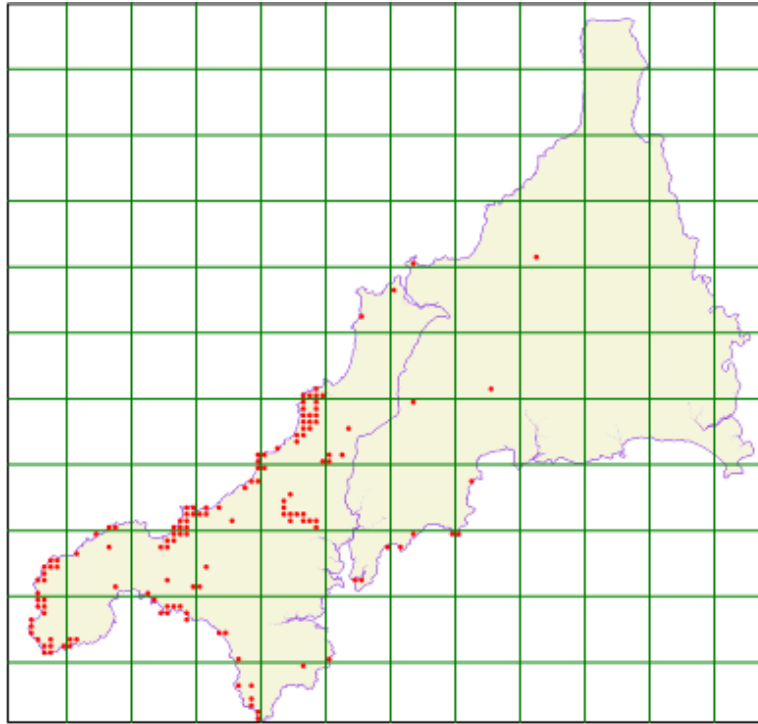
6b. Distribution in Cornwall



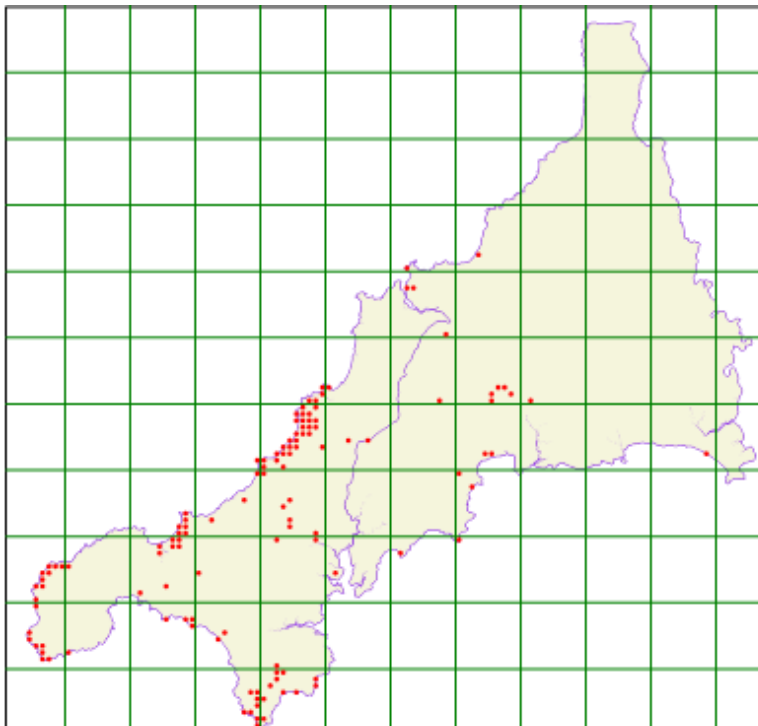
2019 (1% km sq)



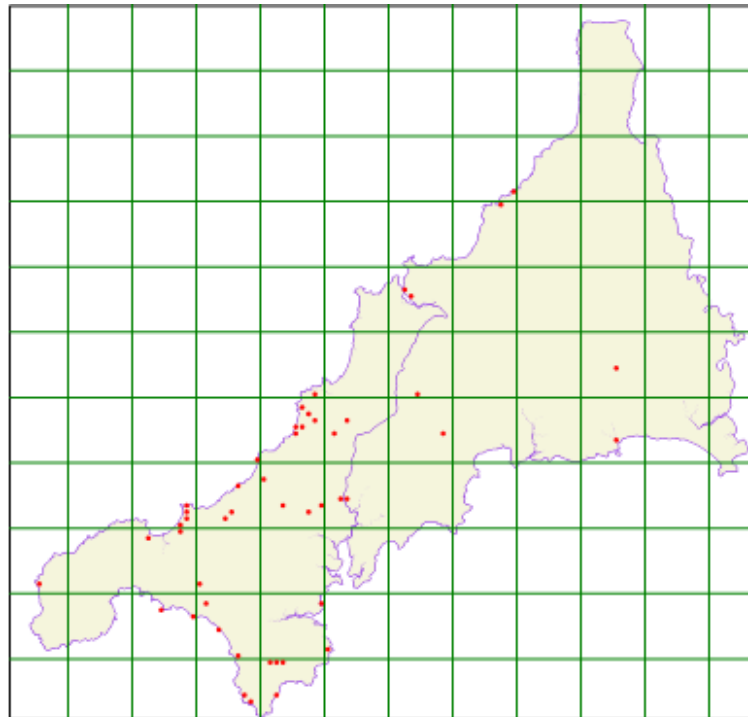
2018 records (2% 1km sq)



2009- 2018 (3% 1km 43% 10km)



1976-2008 (3% 1km 43% 10km)



PRE 1976 (1km 1% 10km 40%)

Due to the research carried out by the late Professor John Wacher in late 20th/early 21st century the distribution of the Silver-studded Blue in Cornwall has been found to be greater and more abundant than earlier butterfly publications indicated. A *Butterfly Book for the pocket* by Edmund Sanders (1939) describes the butterfly as being more common in the north of England and also present in Scotland. This is quite different to today and acts as a salutary lesson. The Silver-studded Blue has declined enormously during the past century because much of its habitat has been destroyed and is now virtually absent from four-fifths of its former range. Its overall decline in range at a 10km square level has been 71% since 1800. In addition collectors have had a very detrimental effect on the butterfly especially in areas where populations of the subspecies *masseyi* were found (*Butterflies* EB Ford).

Whilst the UK has suffered these declines, Cornwall has fared much better. Due the industriousness of early naturalists, a picture emerges of a genuine increase in both abundance and distribution. Building on this early work Professor John Wacher added greatly to the understanding of the Silver-studded Blue.



Professor John Wacher (1927-2012) - Pendeen - June 1999

In Cornwall the Silver-studded Blue has nearly always been restricted to the western half of the county, although it has historically been recorded near Boscastle and Liskeard. In the west it is largely confined to the coastal regions, and some of the strongest colonies are found on the dunes at Penhale, Godrevy to Hayle and one very weak colony on Lelant Towans, which may not survive, since clearly the Hayle Estuary forms a barrier across which reinforcing adults cannot travel.

Whilst the very large populations of this species are found on sand dunes, where they can be seen in the thousands, there are significant colonies inhabiting heathland sites many of which are old mining sites.

The butterfly is found in a succession of colonies on the coast of West Penwith. The original strongholds of colonies running northwards from Botallack to Pendeen Watch and with another group of colonies north of Gwennap Head, appear to have spread and in 2018 there were numerous sightings from Pen Enys Point west of St Ives all along the coastline of West Penwith to an area close to Penberth Cove in the south. West Penwith has proved to consistently hold resilient colonies of the butterfly. Some of these colonies are estimated to be important large colonies. For instance, Enys Zawn, cliffs close to Pendeen, recorded 214 butterflies in a 50 minute timed count in 2014 and 287 in 2015 (R. Symonds).

On the south coast, stretching from east of Penzance to Porthleven, there is a large heathland colony east of Cudden Point, and reasonable-sized colonies have been recorded from the Perranuthnoe area; however colonies at Rinsey Cove and Trewavas Head are still small and weak. Colonies have also been reported on the dunes between Porthleven and Loe Bar. Many of these colonies are isolated and considered weak. However, in 2019, on a 1.1 km transect line 33 individuals (M. Rhodes) were recorded which is encouraging.

Whilst most of the colonies of the butterfly are found in the coastal regions of Cornwall, the inland sites are of great interest.

Most of the inland sites in Cornwall are heathland and the vast majority are inextricably linked to old mining sites (the Lizard appears to be the exception). The presence of heavy metals present in the mining waste has arrested succession on these sites. Without mining and the resultant waste much of the heathland would have disappeared to development or agriculture. Most of the agriculture has resulted in modified soils in order to grow crops such as daffodils and brassicas leaving little room for the butterfly's habitat. In addition, much heathland has succeeded to scrub and woodland. Another threat to the butterfly's habitat is the invasion of alien plants. Mining sites are further discussed in chapter 9 - Heritage and Biodiversity.

On the Lizard peninsula the butterfly has always been recorded but in small numbers. The Lizard appears to be the only area in Cornwall that contains inland heathland sites where there is no evidence of a link with past mining activities.

In 2015 there were no records submitted, however in 2018 and 2019 there were several records which is encouraging. These colonies appear small and fragmented. It is possible that the butterfly has been overlooked on the vast areas of heath. In F.N.H. Smith's book *The Moths and Butterflies of Cornwall and the Isles of Scilly*, the author states that '*the butterfly is common on all the heaths and downs on the Lizard*'. It is possible that more concerted searching will discover more colonies. One site, Croft Pascoe Plantation, holds a significant population and is of interest as the habitat is different from the mining sites. The heath is wetter and contrasts with the normally drier heaths of most of the mining sites. Marcus Rhodes commented that this wet heath with tall, dense vegetation, interspersed with *Molinia* is very reminiscent of the "wet heath" habitat that the butterfly can be found on in parts of Surrey, Purbeck and the New Forest (and where it has been suggested that *L. platythorax* may be the host ant species).

When examining the distribution maps it is obvious that there are many fewer inland sites in Cornwall, many of which are small and remote. Another inland area of interest is Breney Common where there have been records in the past but no records submitted since 2010. There are also no recent records from the Goss Moor area since 2010.

7. Analysis of trends

In the UK the long-term trend shows a significant decline in distribution and a moderate increase in abundance, with the recent trend over the last decade (2010-2019) showing a moderate increase in distribution and a stable abundance. There are only two transects in Cornwall that contain sufficient Silver-studded blue data to provide trends. Two more transects are providing excellent data and will provide trends in the future. Of the Cornish transects Upton Towans provides the most long-term data on abundance. This transect, started in 2010, features regularly

as one of the top Silver-studded Blue transects in the UK. The Upton Towans data indicates a stable population with a gentle upward trend. The Gwithian Green transect first recorded the butterfly in 2010 and in the last six years there has been a steady increase in numbers indicating a small breeding colony has been established.

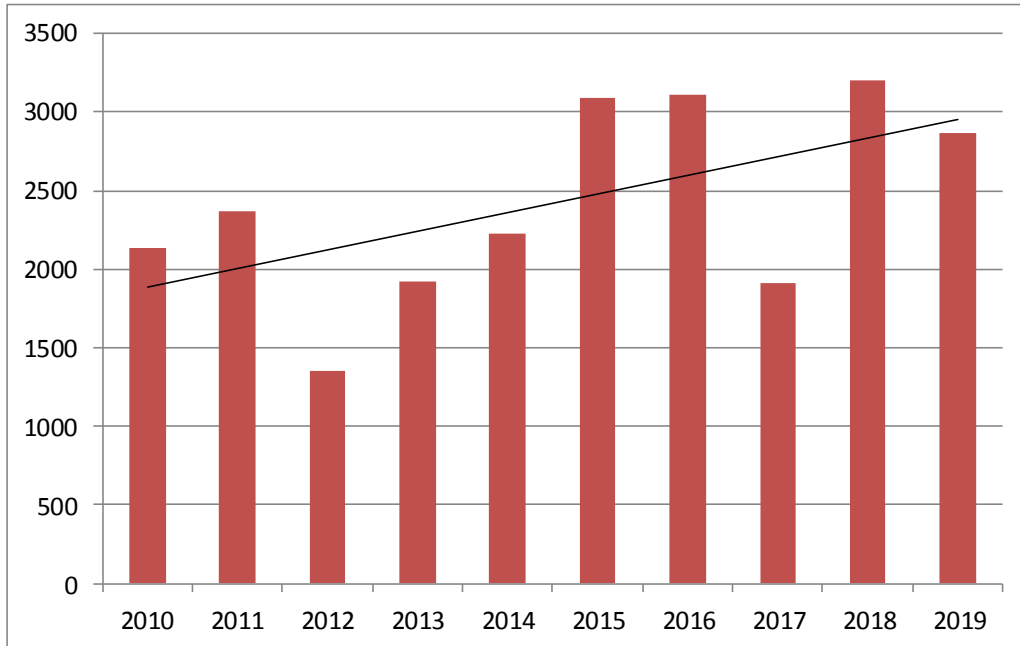


Table 1 Silver-studded Blue – Upton Towans Transect

Gwithian Green LNR Transect Silver-studded Blue records

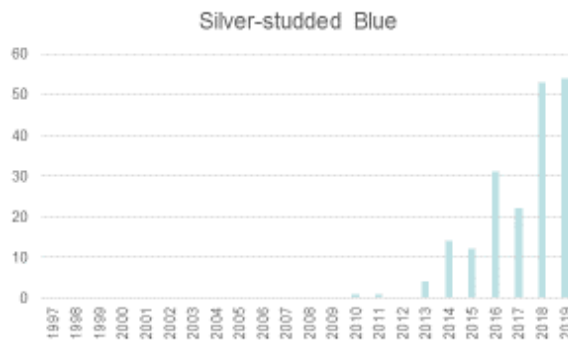


Table 2. Gwithian Common (Green) LNR transect

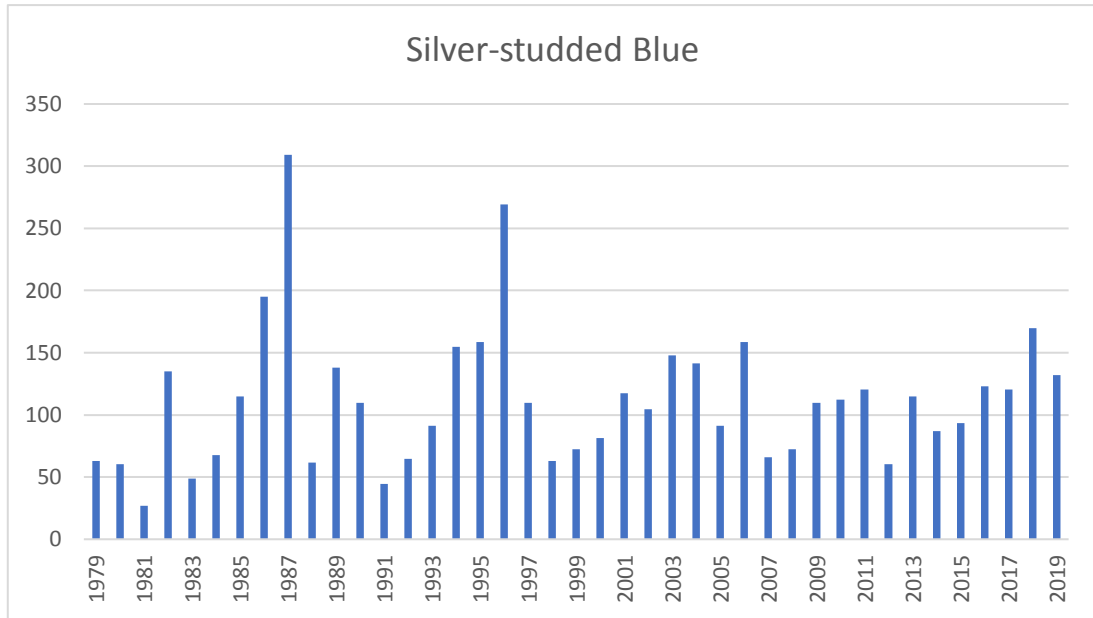


Table 3a. 1979 - 2019 UK BMS

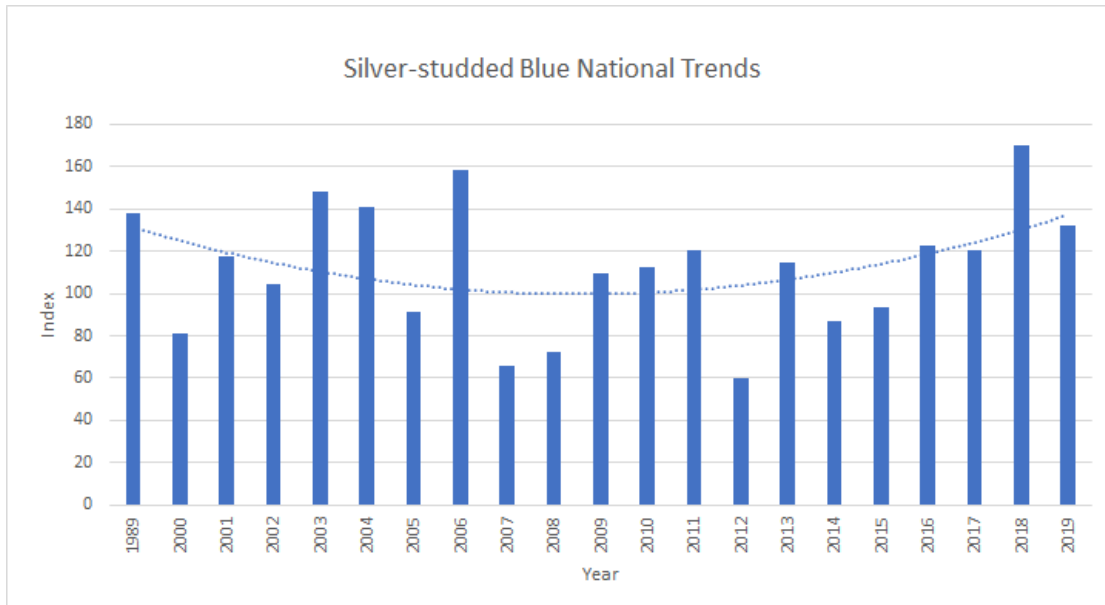


Table 3b. UKBMS (scaled, as per UKBMS, so that the 'average' index is 100 (more strictly, the average log index is 2.00).

On a site visit to Cudden Point in 1999, 500 Silver-studded Blues were recorded. During the early years of this century there was a significant decrease in numbers. In the last few years the numbers appear to be recovering and timed count results indicate an increasing trend. This is very much in line with the trends indicated on the transects.

Despite concern about a decline in numbers in Cornwall at the end of the last century (J. Wachter and S. Foster - personal unpublished research 1997 - 2002), in the last ten years distribution appears to have expanded especially along the West Penwith coastline. There has also been an increase in numbers submitted to the Cornwall database.

The good news that this butterfly has made a good recovery in the last decade and especially in 2018 is backed up by the South-west England trend. In 2018 the butterfly underwent a healthy expansion in both range and abundance. This was possibly a 'dispersal' year and on-going research is attempting to establish whether any new 2018 sightings are now new breeding colonies. 2019 transect data indicates that numbers have held up reasonably well at Upton Towans with just a small decrease in numbers and there was a small increase at Gwithian Green. Overall 2019 abundance was down on 2018 but less surveys were carried out so interpreting this data is always complicated. 2020 transect data on three sites indicates a decline on 2019 numbers but until all data has been analysed at the end of the season it would be wrong to jump to any conclusions at this stage.

Understanding the reasons for the upturn in the fortunes of this rare butterfly over the last few years is open to debate. It is still a matter of conjecture as to the reasons for this expansion. The relationship with the ant is very important and without the ant present on site it is unlikely that the butterfly will form a new colony. In some areas, conservation work either planned or accidental, has improved the habitat and become more favourable. However, in other areas such as Gwithian Green where the ant species has always been present but Silver-studded Blue was never recorded, it is difficult to understand why colonisation of the Green has only taken place in recent years. It is possible that the adjacent population at St. Gothian Sands LNR on reaching a critical level has over-spilled on to the Green.

Naturally under-recording in the past is always a factor but many of the sites such as along the north coast of West Penwith have expanded; these have always been carefully searched so in this instance it is not a case of previous under-recording. Another area that has made a significant increase in numbers is Godrevy Headland.

Climate change has been put forward as a possible influencing factor and further research is being carried out by Marcus Rhodes(PhD student). In addition Jerry Dennis with the assistance of the author of this report is investigating phenology. The transect at Gwithian Green is in its 24th year and provides very useful data.

8. Conservation

- **Management**- The maintenance of suitable habitats is of prime importance, particularly in, and around, the neighbourhood of existing colonies; landowners and land managers should be made aware of the requirements (Ravenscroft and Warren, 1996). Conservation management is required at the landscape-scale in order that this butterfly maintains metapopulations and any local extinction can then be recolonized naturally. There are many factors to consider when undertaking management and most sites will require a site specific plan. The specific requirements of the Silver-studded Blue's life cycle contribute to its highly restricted distribution and mean that it is threatened both by direct habitat loss (development and isolation) and declining habitat quality through inappropriate site management. Conserving ecologically distinct populations and maintaining genetic variation below the

level of taxonomic species is critical to an effective conservation programme for the species, as the Cornish ecotypes are considered important and should be conserved (pers. comm. Butterfly Conservation).

- **Landscape.** Managing this butterfly on a landscape-scale is essential. A contiguous landscape whilst essential for the butterfly also results in safeguarding some of Cornwall's most beautiful scenery and in some cases near-wilderness. These areas have a powerful and profound effect on people and have always been areas of tranquillity and inspiration.



Penhale -copyright : Cornwall Wildlife Trust

In these areas one can still easily hear a sky lark sing and the more alert hear the choughs calling and witness them prodding the soil looking for invertebrates.

It is very important that vulnerable areas such as the Gwithian LNRs are upgraded to SSSI status so future generations will be able to continue to benefit from our landscape. Further information relating to the request for SSSI status can be found in the following report: *2017 Silver-studded Blue Butterfly Report to NE* - S. Foster, Biological Surveyor



March 2020 - view from Godrevy Warren looking southwards over part of the Gwithian LNRs that desperately need SSSI status

One of the most beautiful contiguous landscapes is the coastline from St Ives to Land's End. Gurnard's Head below forms part of this landscape and holds a colony with unusual colouration the adult female.



Gurnard's Head - West Penwith 2019

- **Indicator species - other fauna and flora.**



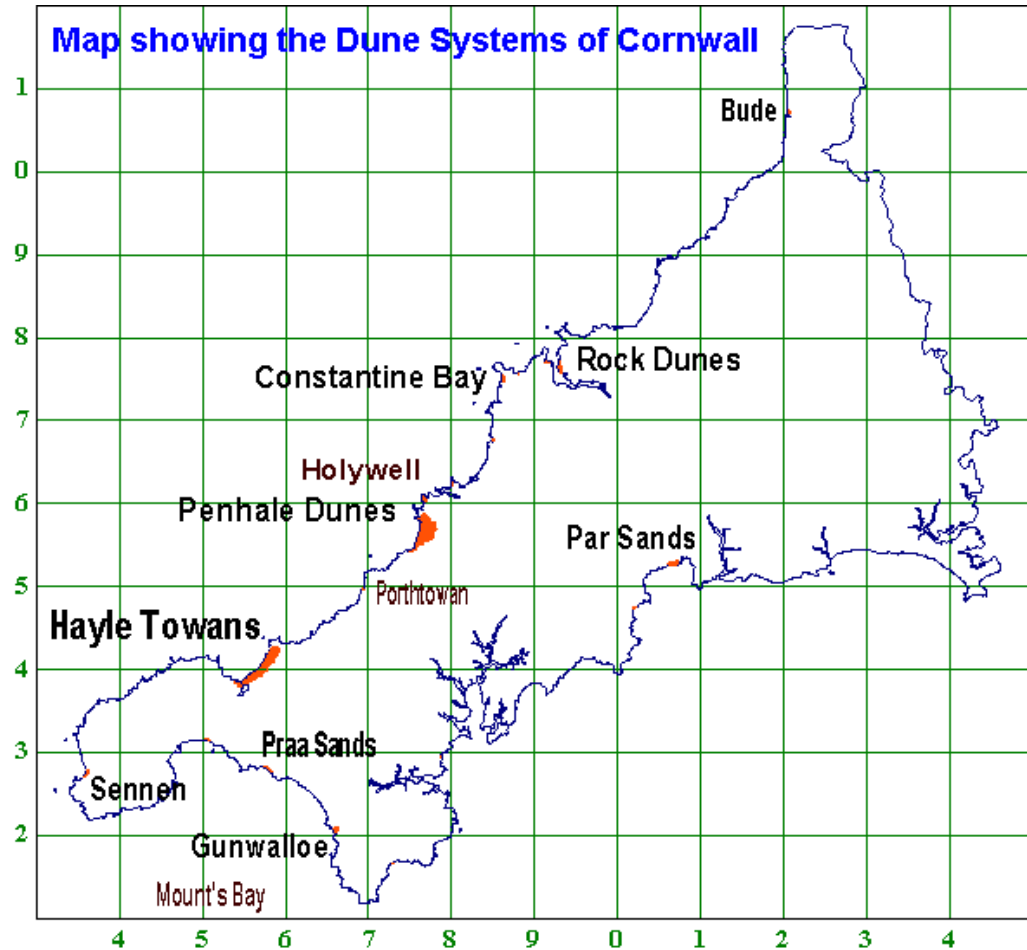
Choughs



Godrevy Warren-dune grassland flora

The Silver-studded blue is not just a small blue butterfly. It is an excellent ambassador for both the sand dunes and heathland of Cornwall. Its presence indicates healthy, well-functioning ecosystems. Many other species thrive in these areas. When searching for caterpillars in the spring one cannot help but be spellbound by the abundance of rare plants and invertebrates.

In general sand dune systems support a rich and diverse flora and indeed the Hayle Towans are undoubtedly the richest place in Cornwall for vascular plants, where approximately a fifth of all the plants recorded in Cornwall have been found. To put it in perspective, 20% of the flora has been found growing on less than 0.2% of the land surface (*The Richness of sand Dunes in Cornwall* – Dr Colin French). 11% of the total heathland in the UK is found in Cornwall.



Map - *The Richness of sand Dunes in Cornwall* – Dr Colin French

- **Environmental change.** Butterfly populations are also used as indicators for environmental change due to their rapid and sensitive responses to subtle habitat or climatic changes, and to reflect the responses of other wildlife. The Silver-studded blue fulfills this role well and the present studies of phenology and climate change bear this out.
- **Re-introduction/introductions** is not the answer to any decline or absence from any areas. Sadly, there are still those that chose to collect butterflies

from the wild, breed and release. There are guidelines on BC and CBC's websites. In the UK there are a few instances where it might be appropriate to do a regulated, licensed and well monitored programme but in many cases even these fail. It is much more appropriate to use our limited resources to conserve and allow our rare butterflies to expand naturally through conservation management. It is ecologically and economically far better to protect species and habitats than allow to disappear and decades later spend a fortune in the vain hope of restoring. Those in Cornwall that choose to release butterflies are only causing a distraction to the serious work of understanding our butterflies and the causes of losses and gains. Much work has been invested in monitoring our butterflies through recording, timed counts, transects and practical conservation work and it really is counter-productive when misguided people release butterflies into the wild. In addition, collecting has led to the extinctions of some of our rare species.

- **Carbon Sequestration.** We do not have tropical rain forests in the UK but it is often overlooked how important a role that other ecosystems such as the dune systems and heathland contribute towards sequestration of carbon. We certainly do not want them covered by trees!

Key points:

1. Understanding the dynamics of the ant species associated with the butterfly. This was highlighted by Lorraine Munns in her recent research at Studland Peninsula (Masters research-*What are the factors influencing the presence of *Plebejus argus* (the Silver-studded Blue butterfly)*).
2. This species is particularly reluctant to cross obstacles and potential breeding areas separated by unsuitable habitat are effectively isolated. Dense bracken or scrub seems to form insurmountable barriers on many of the heathland sites.
3. It is very important to provide legal protection for vulnerable sites such as the Gwithian Local Nature Reserves to provide a contiguous landscape.
4. Godrevy Warren which is currently in an agricultural stewardship scheme with scrub removal and grazing by rare breed cattle is an excellent example of best management practice.



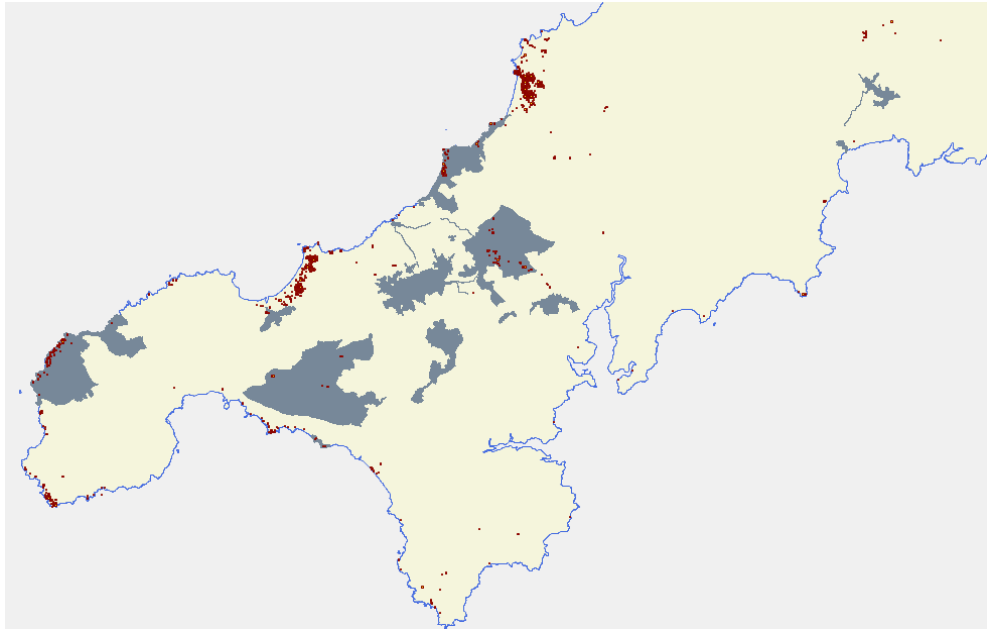
Godrevy Warren 2020



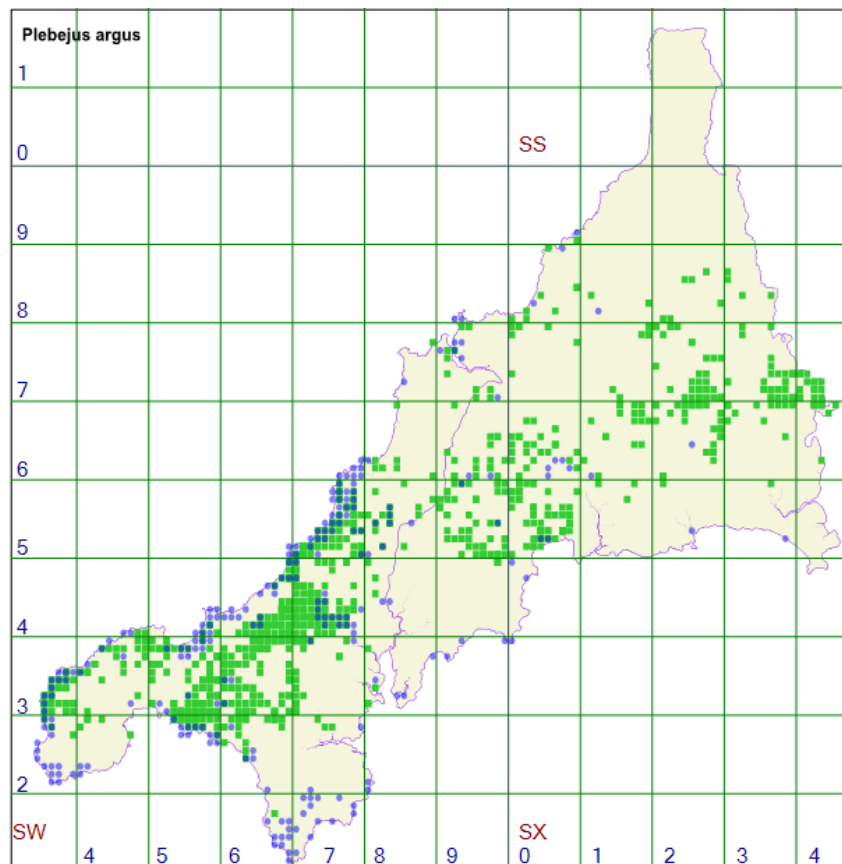
Rare White Shorthorn (Cumberland Whites) cattle grazing at Godrevy Warren

9. Heritage and Biodiversity

- It has already been mentioned that the vast majority of colonies outside the dune populations are inextricably linked to old mining sites. The following maps indicate this link.



World Heritage sites and Silver-studded blue distribution (red dots)



Mines and S-s blue (blue dots)

There are some colonies in West Penwith that appear to be outside of mining sites. However, with the assistance of Dr Colin French it has been possible to link some of the West Penwith colonies to medieval mining sites (*Tudor Tin Bounds -West Penwith-J A Buckley*).

- Several of our rare butterflies (e.g. Marsh Fritillary and Pearl-bordered Fritillary) have flourished in old mining sites, quarries etc. One only has to look at the high populations at the old explosive works at Upton Towans to realize that these areas hold significant populations. Species that have survived in areas of Cornwall due to past industries is a fascinating subject.



‘Dynamite’ – old explosive works at Upton Towans. Trevithick Society visit.
‘All hanging on every word’ of the late Bryan Earl.

Biodiversity and heritage are regarded so important that a separate report is being compiled at present.

A good example of a modern colonization is the expansion of the Silver-studded blue at St Gothian Sands LNR.



Copyright Cornwall Council Historic Environment Record 1987



Sand extraction site 1965 – now St Gothian Sands LNR



St Gothian Sands LNR April 2020

- In 2017 CBC received funding from the World Heritage Fund for a 'Mining for Butterflies' Project and much needed survey work was carried out on many of the mining sites in Cornwall and in Autumn 2019 practical conservation work started. The result of this comprehensive monitoring was to update the earlier records from these very important old mining sites. When the Cornwall Butterfly Atlas (2003) was written there was a smaller range and it is

very encouraging to see how this butterfly has colonised new areas or more thorough searching has discovered new sites. The most notable sites are found within the World Heritage sites such as Gwennap. For a period in the 19th century Gwennap was described as the “*richest square mile anywhere on Earth*”. Strong sites include Wheal Maid, Poldice, Goon Gumpas and Wheal Maid. Carnon Valley.

A very comprehensive report was prepared by Sarah Board BSc (Hons) MSc: *Mining for Butterflies: Site Assessments*



View eastwards along Poldice Valley with heathland – *Mining for Butterflies: Site Assessments*

9. Conclusion

Despite some very depressing news of extinctions, severe declines and losses of valuable habitat in the UK, the present status of the Silver-studded Blue in Cornwall does offer some good news.

A quote from Sir David Attenborough -

‘Landscapes are being restored, special places defended, and struggling species are being saved and brought back. Such successes demonstrate that if conservationists, governments, businesses and individuals all pull together, we can provide a brighter future for nature and for people.’

Ideally each county in the country should have a dedicated species ‘champion’ who collates county data which is forwarded to BC head office. From evidence supplied from other species ‘champions’, data from the UKBMS, timed counts and county and national records the following conclusion can be made. Conservatively, Cornwall can

be regarded as one of the three most important areas for the Silver-studded Blue in the UK.

All the above cannot happen without the support of BC's partners. The work already undertaken by the various organizations has greatly contributed to the Silver-studded Blue's present situation and is very much appreciated.

12. Future Work

It is essential to continue to fathom out the reasons why the Silver-studded Blue appears to be faring well in Cornwall. Climate change, good weather in the past two years, increased recording activity, good conservation work, dispersal from key sites are all considered as contributory factors. It could also be that Cornwall has not suffered such intensification of agriculture over the years as other parts of the country and a considerable amount of our coastal areas are relatively unspoilt. Much of the coastal area has legal SSSI status and, in addition, under the protection of responsible owners such as the National Trust and hopefully 'out of the hands' of developers.

However, it is important not to become complacent as the unexpected can always surprise us. At Studland, the dynamics of the ant populations has had a severe impact on the populations of the Silver-studded Blue population and distribution.

In addition, the butterfly in Cornwall is at the westerly point of its geographical range and will always be vulnerable to the vagaries of the British weather. The good weather of 1976 and increased butterfly numbers in the UK was quickly followed by poor butterfly years so we must always guard against complacency! And to prove the point:- unfortunately, 2020 transect data now in the process of analysis is demonstrating a substantial drop in numbers at Upton Towans and Gwithian Green transects and a small drop at Roskestal West Cliff transect so highlighting the need to remain vigilant.

The most important task is to continue to work with our partners and protect the sites we have, give legal protection to vulnerable sites and make every effort to provide suitable areas into which the butterfly can expand.

Apart from the continued excellent recording and monitoring the following should be prioritised:

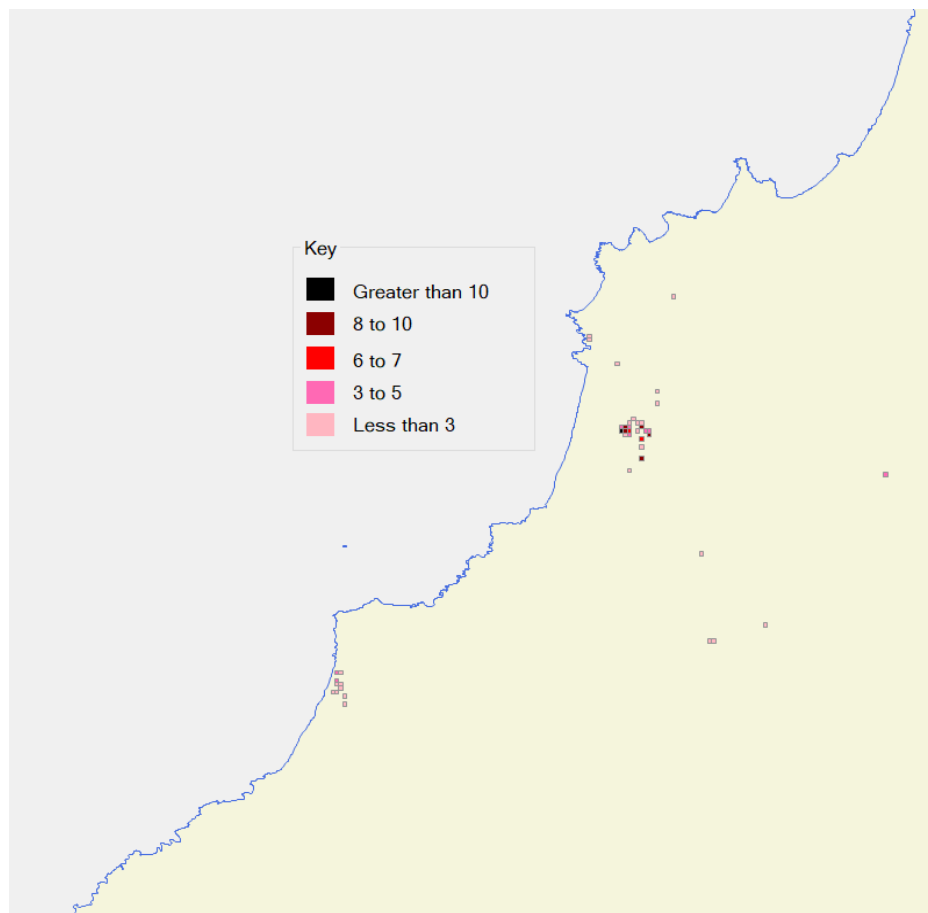
- Population estimates for Cornish colonies and comparison with UK populations. In Cornwall a population estimate could be achieved by a co-ordinated timed count programme throughout all the main sites.
- Research - climate change and phenology. It is very rewarding that all the industriousness of past recorders/naturalist can help provide the foundation which enables scientists to further research the subjects of climate change and phenology. These areas are of real importance for the future of the planet.

- Ant surveys throughout different ecosystems
- Engagement with the Dunescape Project. Penhale- baseline survey, establish a transect and monitor conservation work would all be extremely helpful. Hayle dune system - a baseline survey required and more transects.
- Detailed site management. Target: establish a contiguous landscape in West Penwith and Godrevy to St Agnes.. Some excellent work by National Trust staff has already achieved rewarding results on National Trust land so more of the same can only achieve further good results.
- Protect the three Gwithian LNR's with SSSI status in order that we have a contiguous landscape in the St Ives Bay. Conservation management is required at the landscape-scale in order that this butterfly maintains metapopulations and any local extinction can then be recolonized naturally. It is wholly unacceptable that the Gwithian LNRs are not afforded the same status as the adjacent SSSIs. See maps in Appendix 2.
- Lizard -recent excellent 5 year plan formulated by NE (Lizard staff) will enable better understanding of butterfly populations on the Lizard. It appears that the Lizard heathland populations are the only populations found inland in Cornwall that are not influenced by a mining past. Further research is required to identify larval foodplants and ant species associated with caterpillar.
- In 2017 CBC received funding from the World Heritage Fund for a 'Mining for Butterflies' . This work has been extremely beneficial and it is essential this work continues.

Appendix 1 : Penhale area – North Cornish Coast



Photo: copyright Cornwall wildlife Trust



2019 records

Penhale contains very large metapopulation and combined with the Hayle Dune System supports the largest colonies of the Silver-studded Blue in Cornwall. The sand dune populations are also thought to be a separate ecotype but this requires further research.

Records received from S. Batt and J. Cripps in a 2018 survey indicated very large numbers. This was expected but confirmation was good.



Pony grazing at Penhale

Appendix 2: Hayle to Godrevy Dune Systems and Godrevy Headland - North Cornish Coast

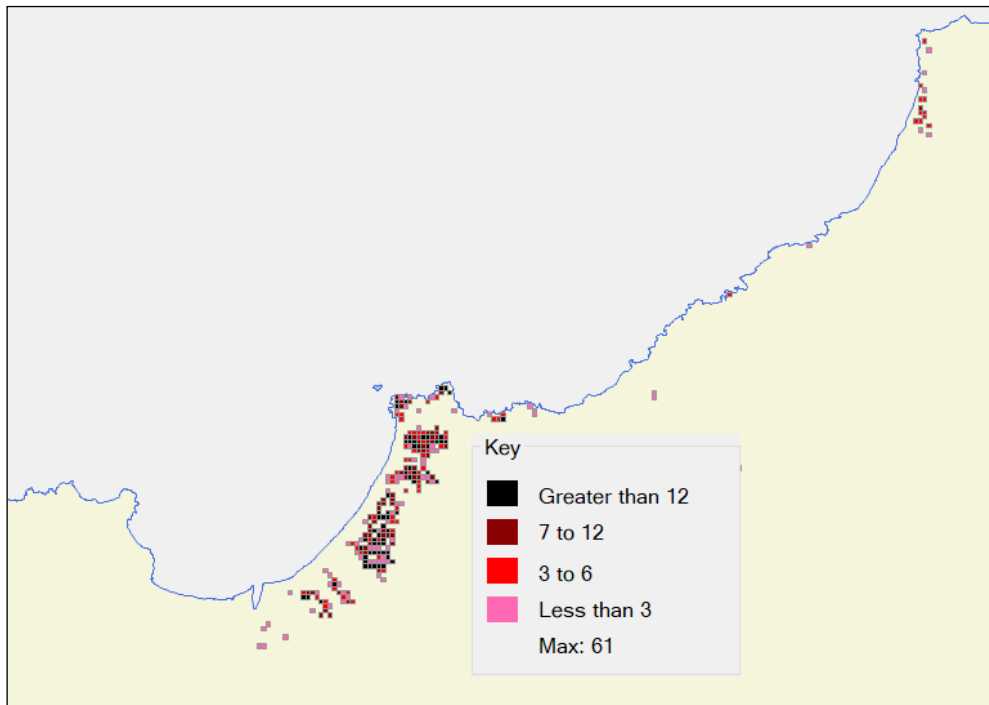
This area contains very large metapopulation and in recent years the butterfly has expanded into the heathland of Godrevy Headland. The sand dune populations are thought to be a separate ecotype but this requires further research. As with Penhale the Hayle Dune System is estimated to be a very significant metapopulation with numbers in the thousands.



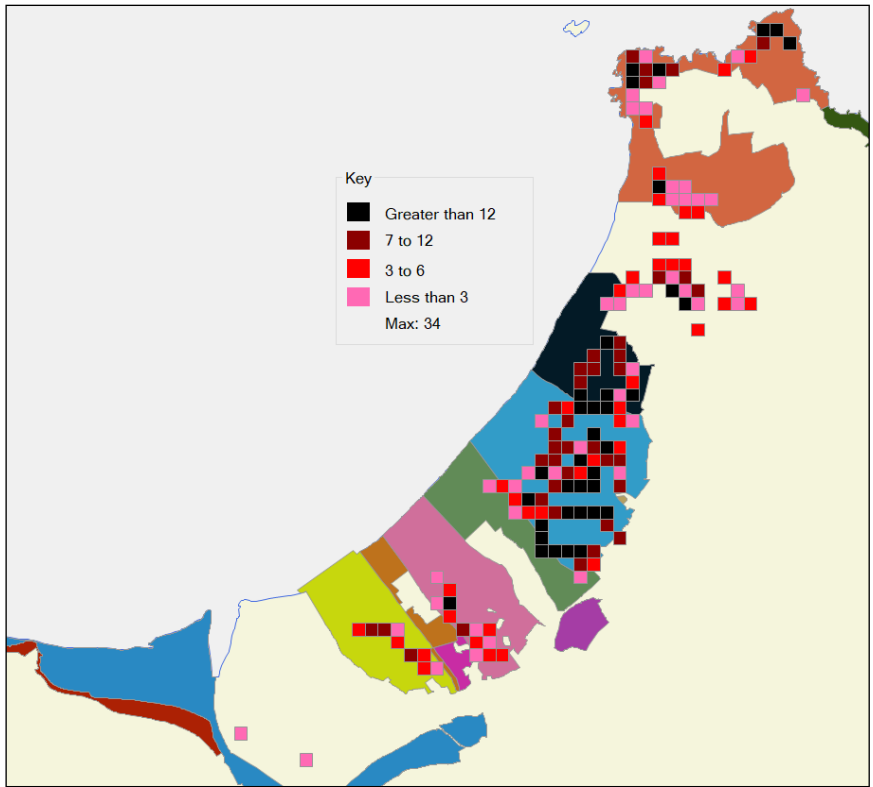
St Ives Bay 2012



Gwithian Green 2012

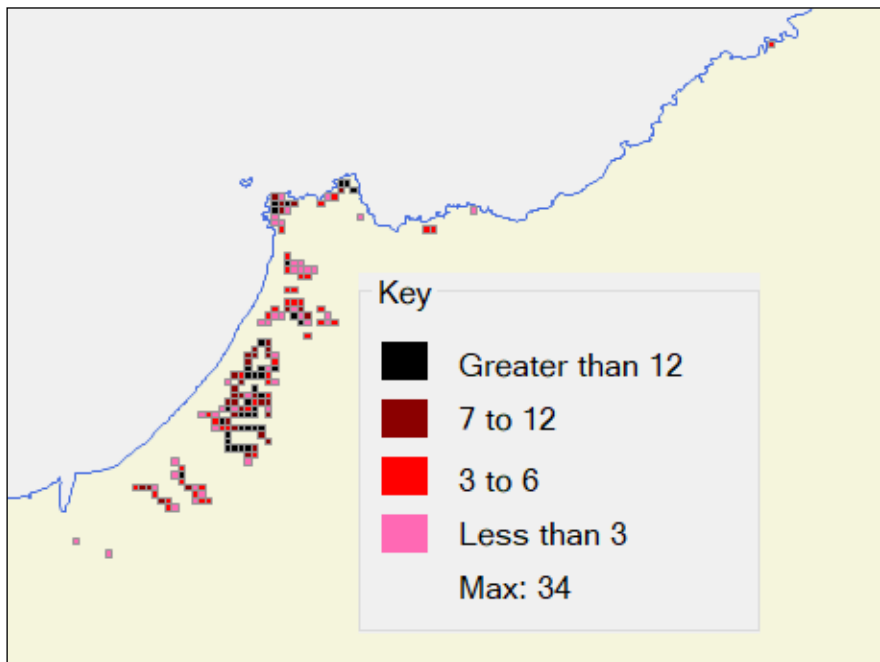


St Ives Bay and North Coast S-s B – 2015-2019 records



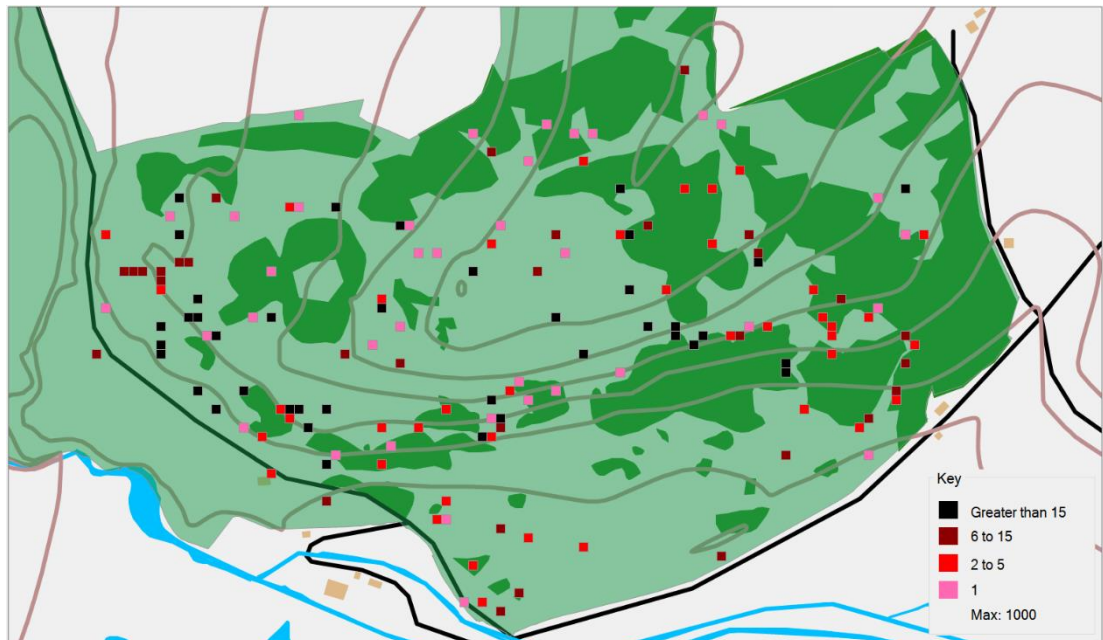
SSSIs in the St Ives Bay – 2019 S-s blue records

St Gothian Sands LNR



Evidence was requested in 2017 by NE to support the application from the Hayle Towans Partnership for the extension of the present SSSI to include St Gothian Sands LNR and part of Gwithian Towans. It is considered this report provides additional evidence to support the SSSI request. The request is supported by NE's national sand dune expert, many other national experts, local experts and most importantly the local community. It is the local community, that after a hard-fought campaign, originally secured the 'high dunes' at Gwithian for the benefit of everyone to enjoy! The criteria for SSSI designation are well fulfilled and the protection of the missing link in the landscape would fulfil Cornwall Council and NE's own targets. Further information available from the following: *Silver-studded Blue Butterfly – Hayle to Godrevy Dune System: Report for Natural England – February 2017*. S. Foster (Biological Surveyor) and PowerPoint Presentation: Request for SSSI status Gwithian Local Nature Reserves – Hayle Towans Partnership.

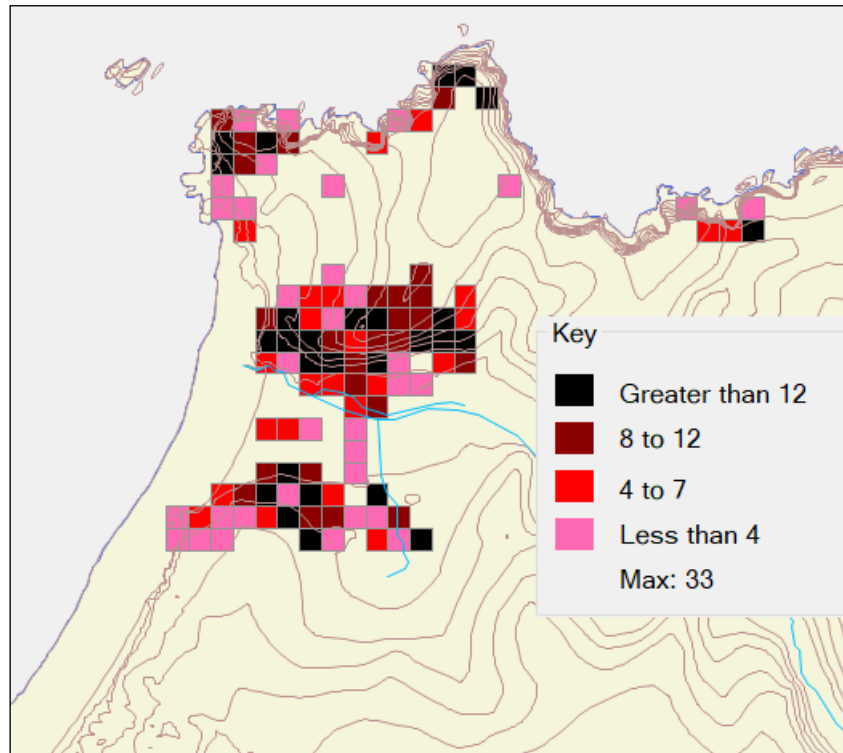
Godrevy Warren



Godrevy Warren – baseline survey carried out in 2018 recorded in excess of 5,400 Silver-studded blue butterflies

With the support of Natural England, in 2019 Godrevy Warren entered a Higher Level Stewardship agreement. It is considered this is one of the best examples of good management practice for both the wildlife and the archaeological interests.

Godrevy Headland



Godrevy Headland- 2018 and 2019 records

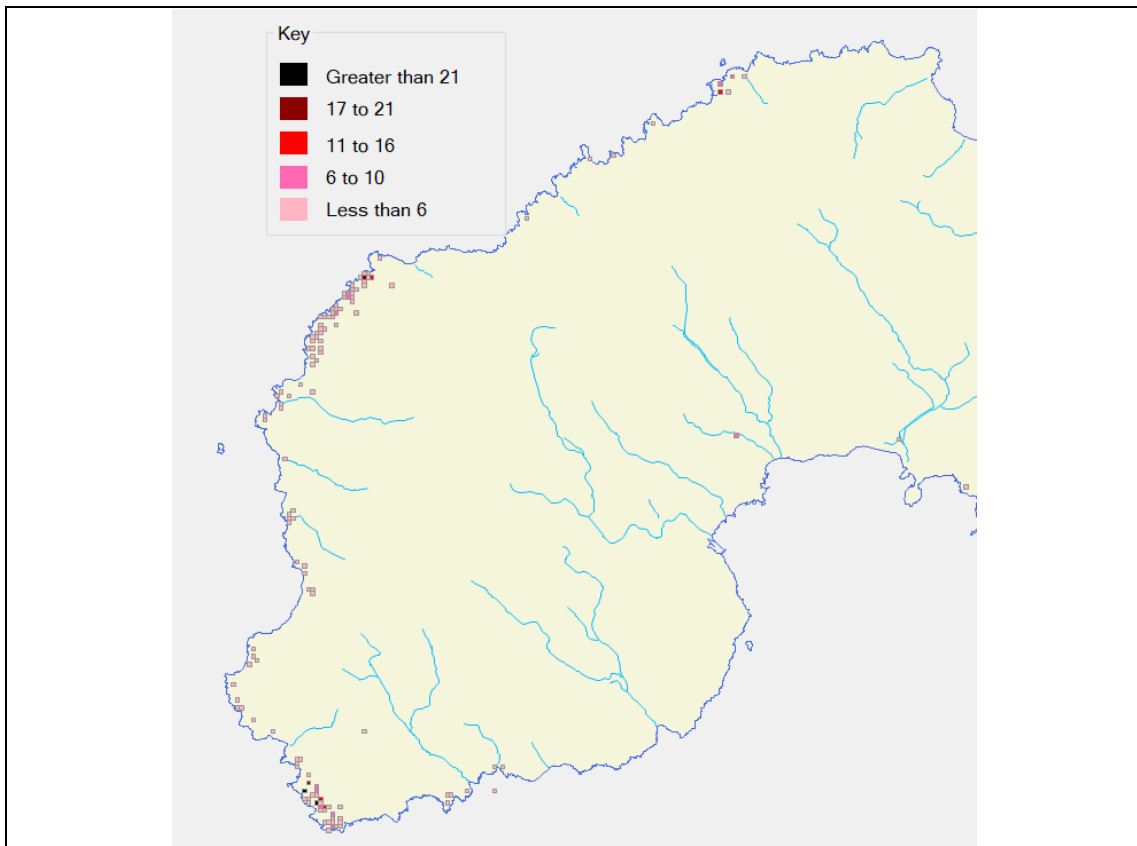
Appendix 3: West Penwith

This area has proved to consistently hold resilient colonies of the butterfly. One of these colonies is estimated to be an important large colony. For instance Enys Zawn –Cliffs close to Pendeen recorded 214 butterflies in a 50 minute timed count in 2014 and 287 in 2015 (R. Symonds).

There is a very strong association with disused mining sites. Geevor Mine pictured below was the last operational mine in the area. It operated from 1911 to 1990 producing about 50,000 tons of black tin. Now a museum and heritage centre and part of the UNESCO World Heritage Site Cornwall and West Devon Mining Landscape



Geevor Mine 2012

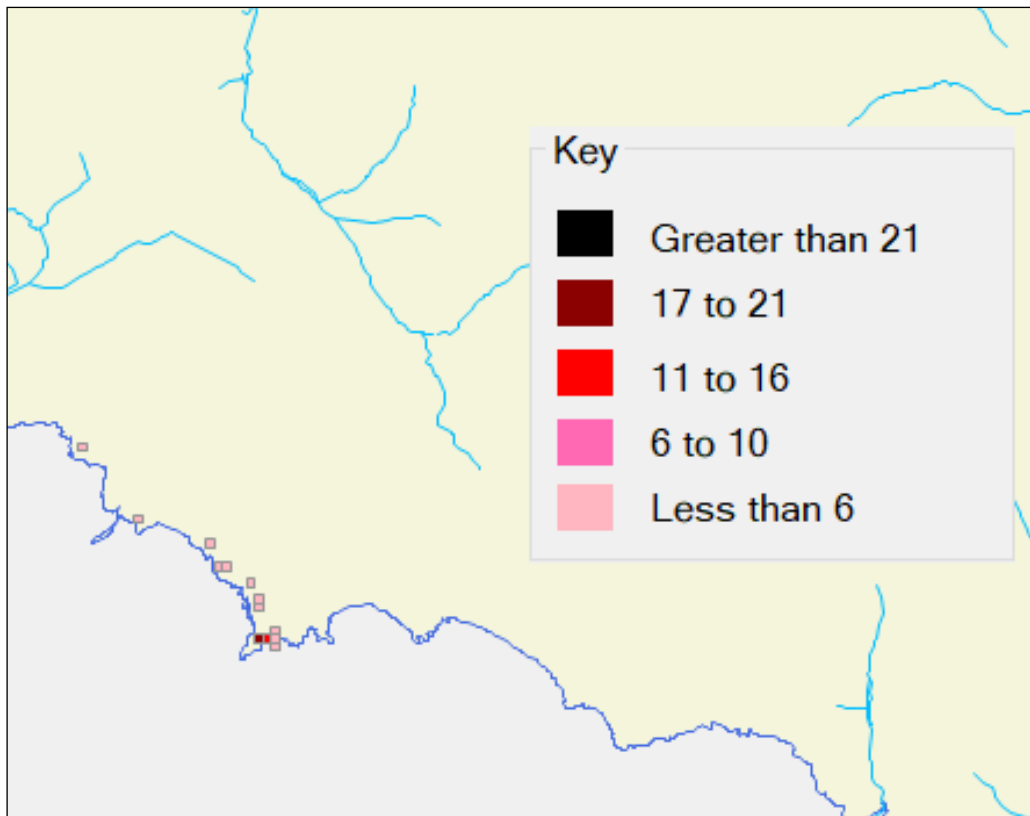


2019 records

Appendix 4: South coast east of Penzance – Porthleven to Cudden Point - Medium-sized colonies

Cudden Point numbers appear to be holding up recently but there has been a significant decrease in numbers since 1999 when surveyed by the late Professor John Wacher and S. Foster. On that visit 500 Silver-studded blues were recorded (SW 551277). Timed count data in Appendix 9.

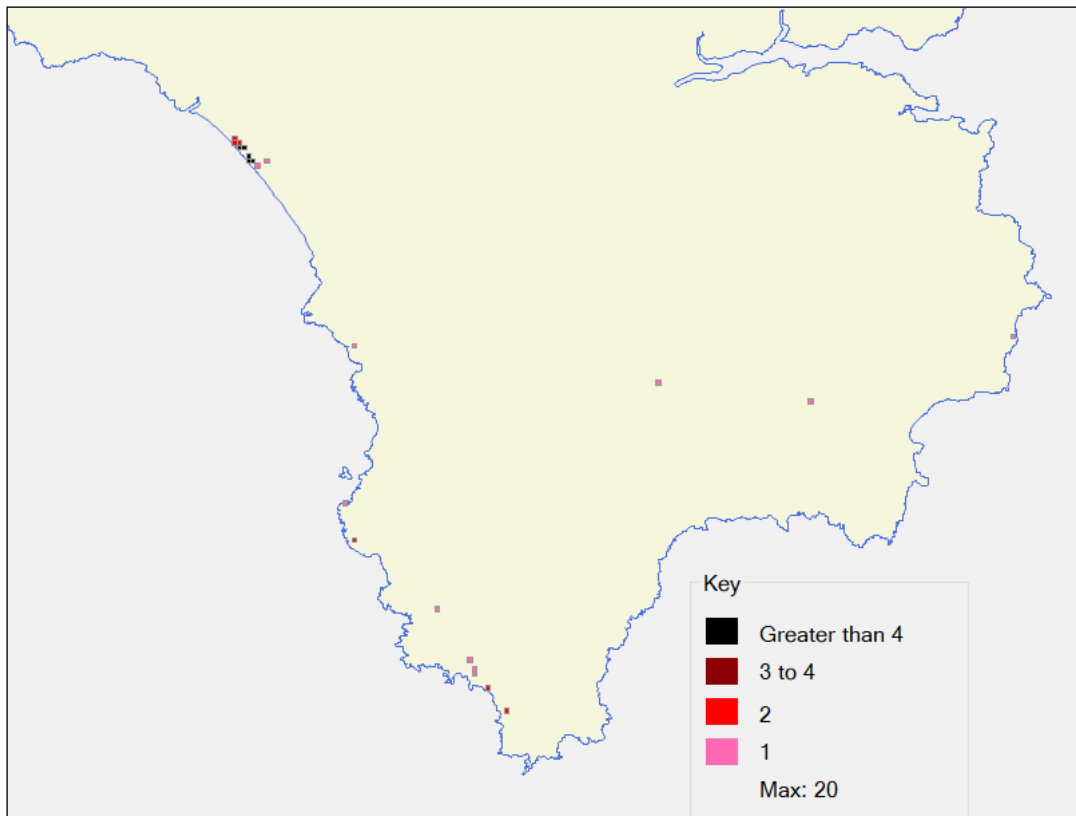
This area requires further investigation. As opposed to the sand dune populations where the larval food plant appears to be mainly Bird's-foot Trefoil, at Cudden Point a female was egg laying on ericaceous plants. It is most likely that this is the preferred larval foodplant.



2019 records

Appendix 5: The Lizard- 2 or 3 small colonies

The Lizard contains several colonies which are mainly small with the colony at Kynance containing the highest numbers (20-30) but this still can only be described as a small colony at present. In 2016 one record from Predannick airfield has been submitted. Significant numbers were recorded in 2019 at Croft Pascoe plantation. As already stated in the main text, the inland Lizard sites are very interesting and more recording effort is required in particular inland sites. These inland heathland sites are of particular interest as it appears that there is no historical mining activity in this area. Particular note needs to be made of the larval foodplant and the ant species associated with the butterfly. As the numbers are very low this is a particularly difficult task.

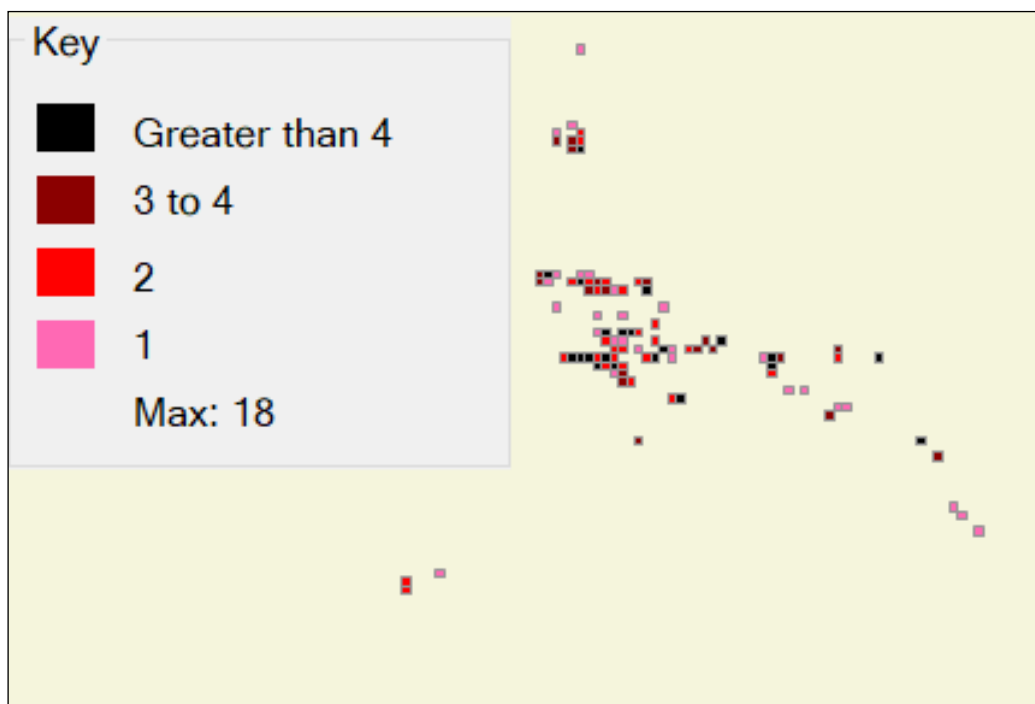


S-s blue records since 2000



Croft Pascoe Plantation - 2020. The rides provide the best habitat for the butterfly.

Appendix 6 : Old mining sites south west of Truro



Funding from the World Heritage Fund for a 'Mining for Butterflies' Project has made a significant contribution to understanding the state of the butterfly on these very important areas. It is important that this excellent work continues.

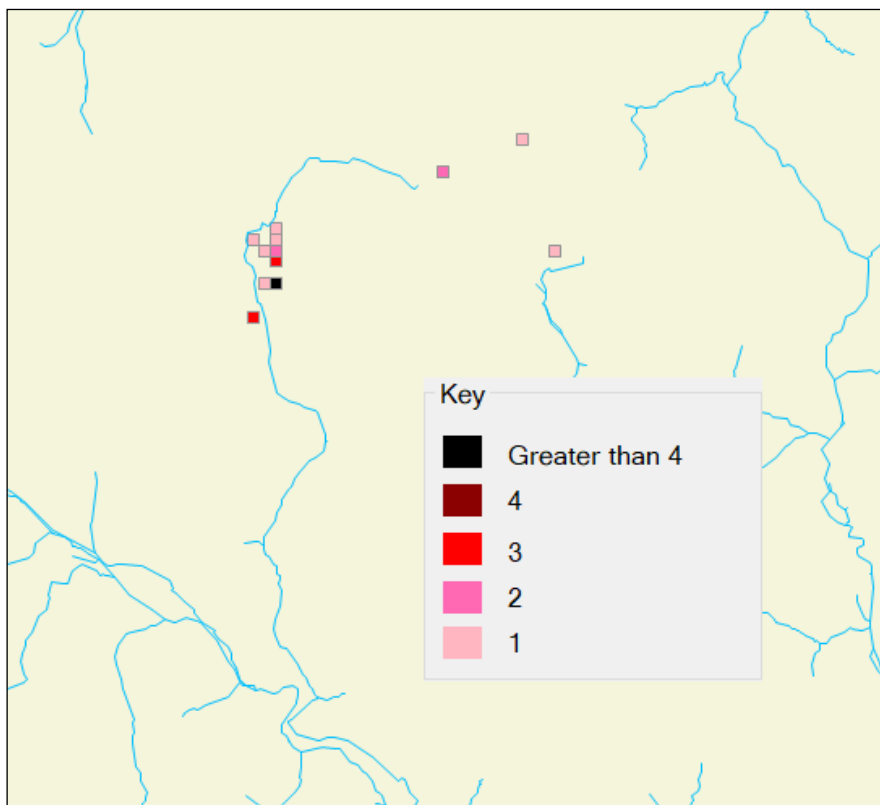
Appendix 7: Mid- Moor Area

There have been no recent records from the Goss Moor area. The most recent record is from 2010. This can be due to under-recording or unsuitability of habitat and it is advised to keep searching. Numbers seen have always been very low so it is easy to miss the butterfly in its short flight period.

Numbers of the butterfly recorded at Breney Common and Red Moor have always been higher than Goss moor but numbers still indicate relatively small colonies. Information supplied from the CWT manager indicates the habitat where the butterfly has been recorded is dry heath, which is unusual for the Breney area. It is gorse dominated with *E cinerea* and *calluna* present and not so much *tetralix*. Birds-foot trefoil is not common in the area.

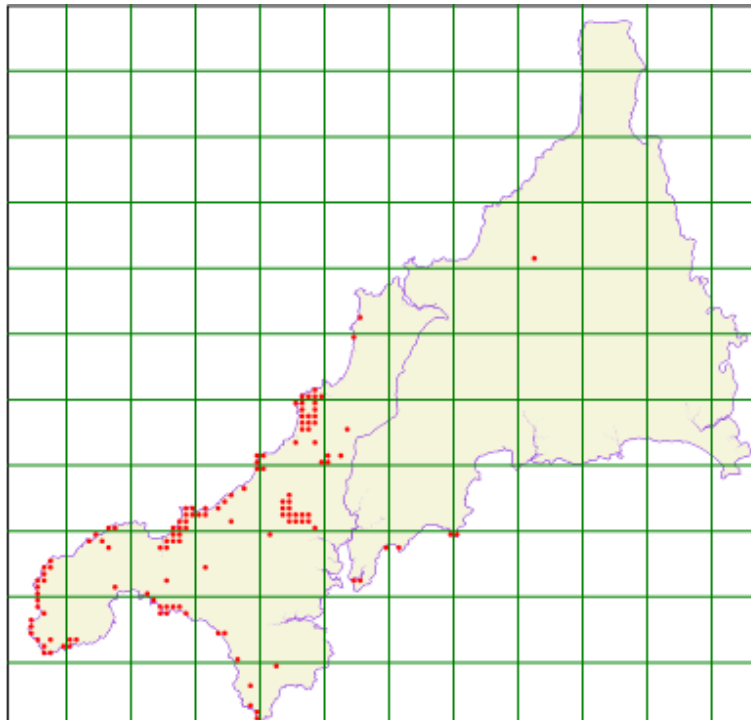
Again it is advised to keep searching.

There are very few records east of this area. One record due east of Red Moor was an unregulated introduction (by a collector) – now believed to be extinct!

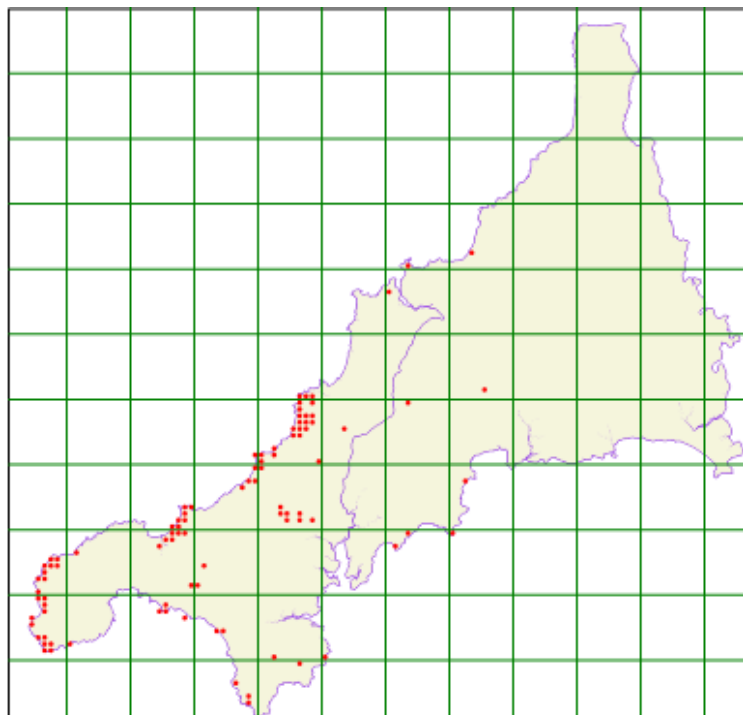


All records from Breney Common and Red moor

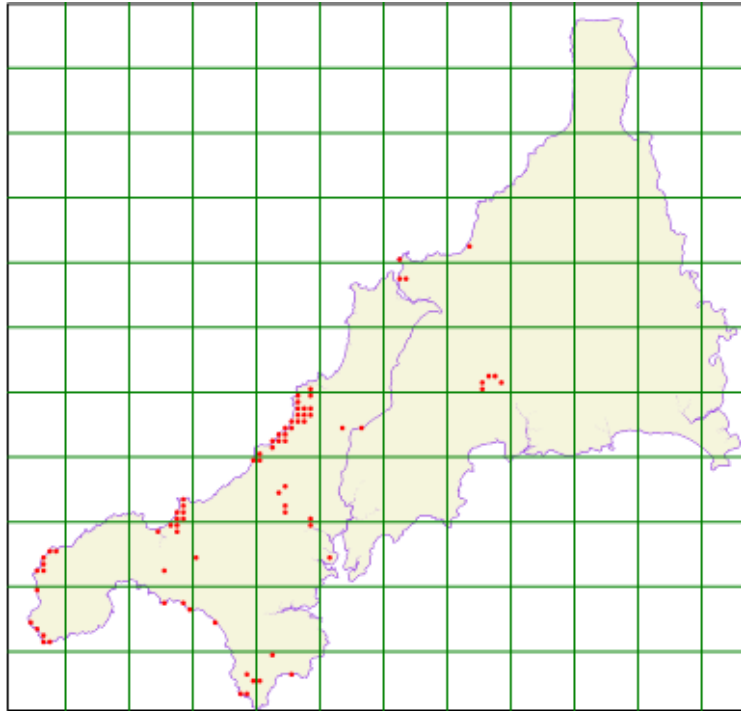
Appendix 8. Maps of the main S-s Blue areas in Cornwall showing historical records



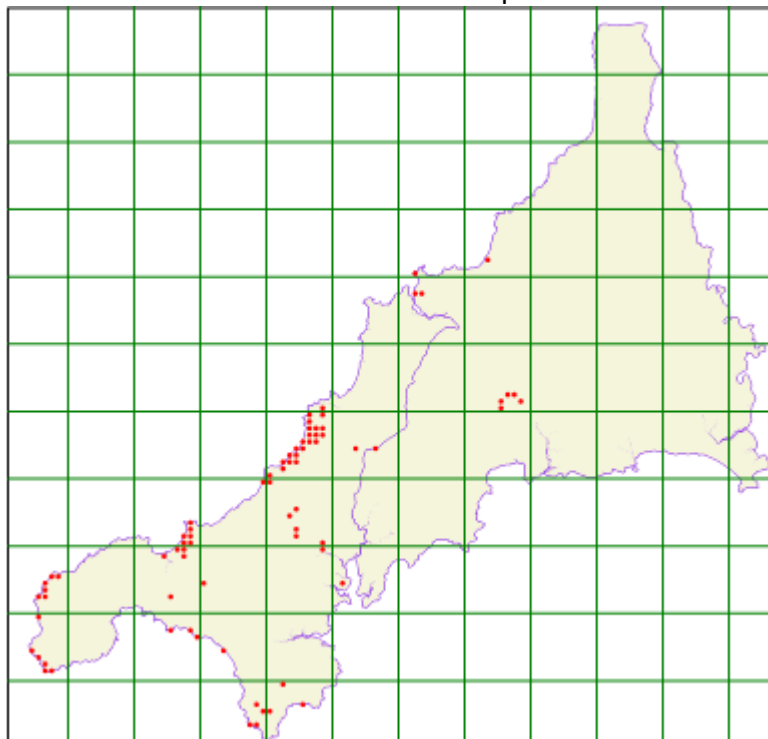
2015-2019
128Km Sq



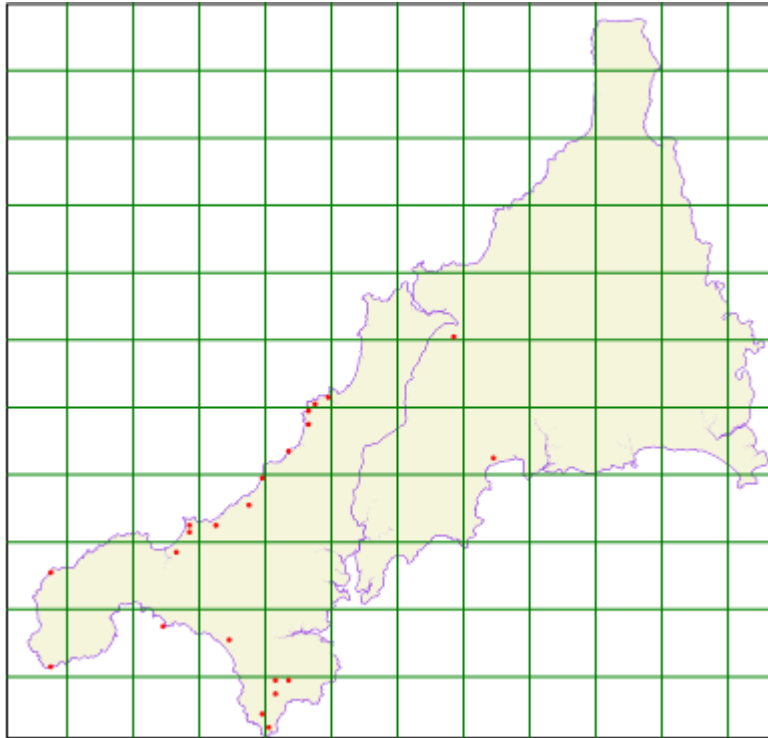
2005-2014
96 km sq.



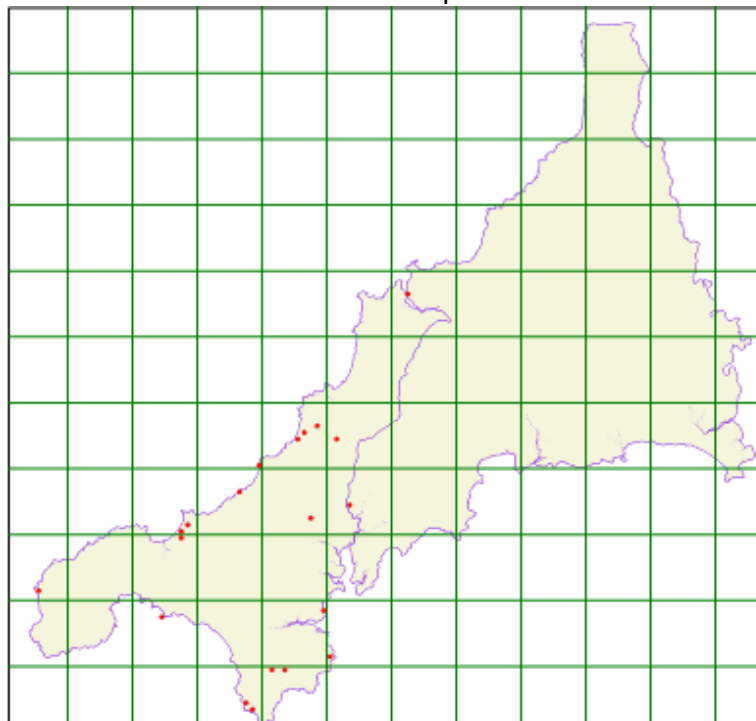
1995 – 2004 77 km squares



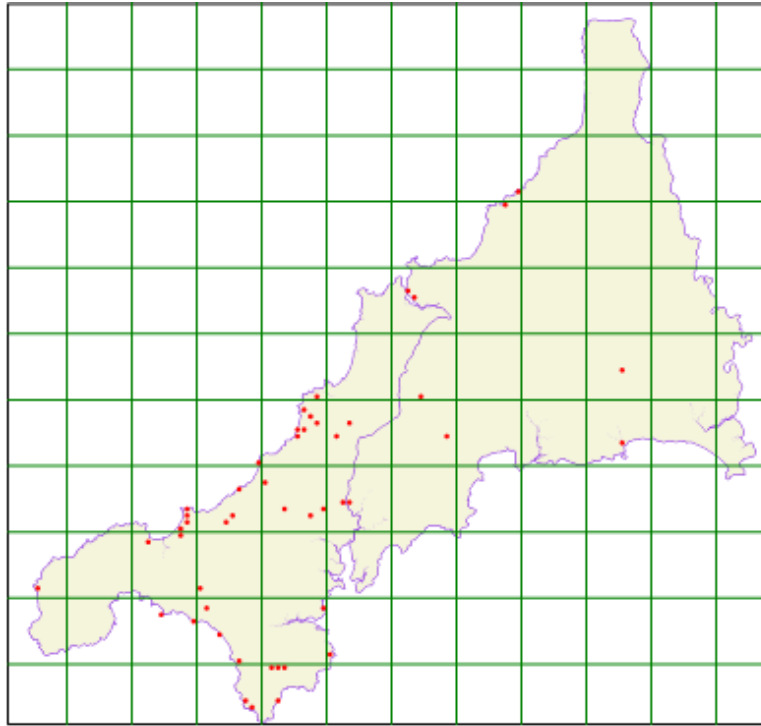
1985-1994
63km 374 records



1975-1984
22 km sq.



1964-1974
20 km sq.



All years up to 1976
48 km sq.

Appendix 9. Transect and timed count data

Cornwall has a proud history of recording and many of the early records have painstakingly been entered into the ERICA database by such people as the late Stella Turk MBE. The Penzance Natural History and Antiquarian Society (1839–1961) is an example of early work. This local society founded in [Penzance](#) was one of the earliest Natural history societies in the UK and their aim was "the cultivation of the science of Natural History, and for the investigation of the Antiquities referring to the early inhabitants." Much is owed to those early naturalists whose work has provided us with so much valuable knowledge to further progress our understanding of the natural world. Unfortunately we also can have an insight to what we have destroyed.

Today, butterflies continue to be collated by CBC's county recorder. Dick Goodere has collated butterfly records from 2011 to April 2020, and this work has provided us with an excellent idea of distribution of our butterflies. Whilst this excellent work of recording provides us with a rough idea of abundance, transects and timed counts are carried out to provide us with a more scientific guide to abundance and trends. The UKBMS is a long-term scheme monitoring butterfly populations across the UK. It has developed from the merger of the long-running Butterfly Monitoring Scheme (BMS) originating at the Centre for Ecology & Hydrology (CEH) in the early 1970s, with Butterfly Conservation's coordination of 'independent' butterfly monitoring transects. By being part of this scheme Cornwall can compare trends with the rest of the UK. See Table 3a and 3b, Page 21.

At present the Cornwall transect co-ordinator oversees 48 transects. Of these 5 record the Silver-studded Blue. Trends have been obtained from two transects. There are only two transects in Cornwall that can provide trends. Of these Upton Towans provides the most long-term data on abundance. This transect, started in 2010, features regularly as one of the top Silver-studded Blue transects in the UK. The Upton Towans data indicates a stable population with a gentle upward trend with a slight dip in 2019 – see Table 1. Page 20. The Gwithian Green transect first recorded the butterfly in 2010 and in the last ten years there has been a steady increase in numbers indicating a small breeding colony has been established – see Table 2 Page 20.

Both Porthgwarra and Treveal are providing numbers which will provide good trends year in the future.

It must be noted that whilst annual changes are interesting, it should be noted that there are naturally year to year fluctuations in butterfly populations, and the 10-year and long term trends are of more relevance from a conservation perspective.

Data provided by Transect co-ordinator Jim Barker

	RP	KE	ML	CC	TV	MT	UT	GG	HD	Te	CP	CU	TRC	NH	DH	SITES
	SW				SW	SW	SW	SW	SW	SW		SW		SW		
Grid OS	32				44	53	53	54				75				
Year																
2010	49						2131	1				82				3
2011							2372									1
2012							1356									1
2013	18						1920	5								4
2014	30						2236	12								4
2015	29						3087	12								5
2016	8				83	90	3107	32								10
2017						248	1912	22	11					4	1	6
2018	165	3			4	375	3196	41	11		53		1	5	1	10
2019	218		19	2	64		2862	54			75				3	8

Roskestal Cliff	SW3642	RP
Porthgwarra	24	
Kenijack	SW3532	KE
Mayon Lookout	SW3426	ML
Cape Cornwall	SW3531	CC
Treveal	SW4724	TV
	00	
Mexico Towans	SW5633	MT
	85	
Upton Towans	SW5793	UT
	96	
Gwithian Green	SW5874	GG
	13	
Hudder Down	SW6042	HD
Tehidy Woods	SW6343	Te
Chapel Porth	SW6949	CP
Cubert	SW7855	CU
	99	
Treluggan Cliffs	SW8937	TRC
Nare Head	SW9137	NH
Dodman Head	SX0039	DH

Timed count data

Cudden Point			
Date	Number seen	Time (mins)	
2016	29	30	
2017	31	33	
2018	83	33	
2019	13	30	
Please note weather in 2019 was very challenging with strong easterly and a longer flight period without a very pronounced peak			
Little Cudden			
Date	Number seen	Time (mins)	
2016	No count		
2017	35	18	
2018	62	18	
2019	20	14	
Please note weather in 2019 was very challenging with strong easterly and a longer flight period without a very pronounced peak			
St Gothian Sands LNR			
Date	Number seen	Time (mins)	
2015	194	60	
2016	243	60	
2017	72	60	
2018			
2019	37	Abandoned	
Please note weather in 2019 was very challenging with strong easterly and a longer flight period without a very pronounced peak			
Godrevy Warren			
Date	Number seen	Time (mins)	
2014	800	60	
2015	600	60	
2016	Route impossible due to scrub encroachment		
2017	340 -past peak	60	Scrub encroachment Altered route
2018	500	60	
2019	Abandoned. Weather in 2019 was very challenging with strong easterly and a longer flight period without a very pronounced peak		

This monitoring method provides additional information on abundance and acts well when time does not allow for a fixed transect. Consistency is essential and it is

dependent on assessing the peak of the flight period. Reliable transect data is extremely beneficial.

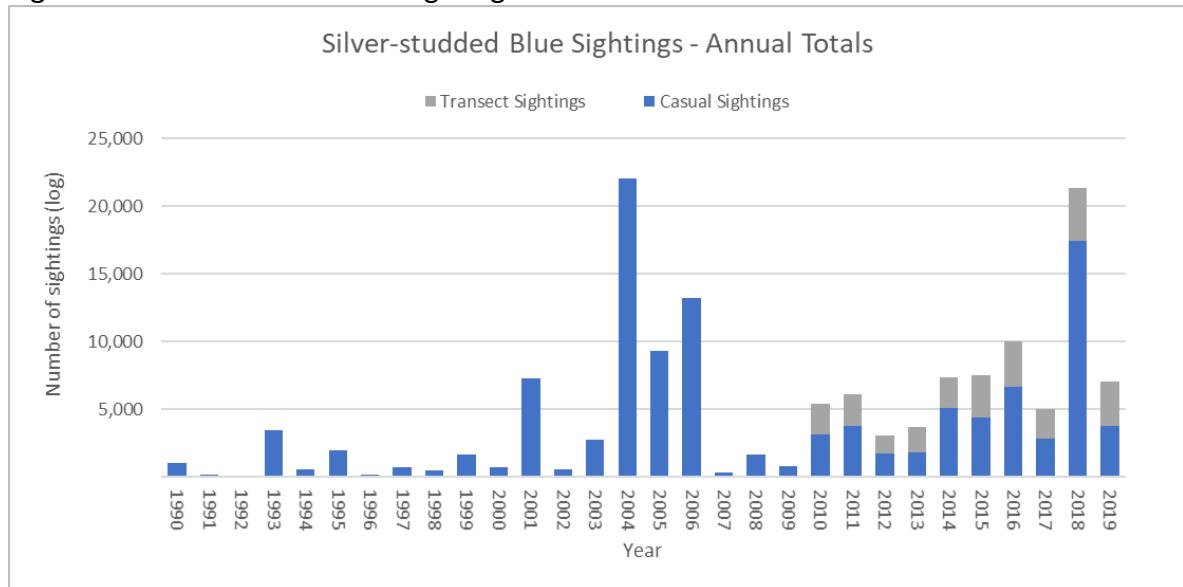
Timed count data in Cornwall provides very useful information for site managers. 2019 proved to be a very difficult year as the weather during the peak proved to be problematic with strong easterly winds. In addition due to the weather there appeared to be an extended flight period with a less definable peak. In 2018 this was much more pronounced.

Supplement: Silver-studded Blue Phenology Analysis Written by Jerry Dennis – Grayling Species Champion

1. Silver-studded Blue Data

Total numbers of Silver-studded Blue seen in each year since 1990 is shown in figure S.1.

Figure S.1 Silver-studded Blue Sightings 1990 – 2019



In 2010, UKBMS transects were established for several sites habited by the butterfly and the number of transect records are shown with grey bars.

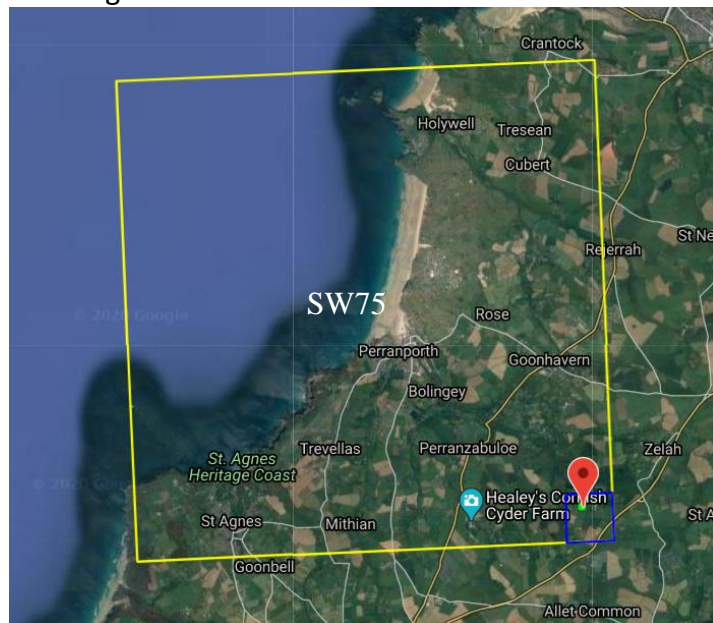
Unfortunately, there is no UKBMS transect or regular surveying for butterflies on the extensive towans at Penhale Sands and environs north of Perranporth, which is a premium site for the Silver-studded Blue in Cornwall and potentially one of the most important in the UK. In some years, individual surveys were undertaken there near peak flying times, particularly in 2001, 2004, 2005 and 2006 and these counts dominate the annual totals in those years. Consequently, the data available in these years is not ideal for phenology studies.

Numbers at the site were estimated in round thousands, for example, on 15th June 2004 10,000 were estimated and further surveys totalled over 22,000 Silver-studded Blues at this amazing site. Getting accurate numbers when so many butterflies emerge on the same day is a major challenge in itself, especially for a single recorder. Table S.1 shows the sightings in the hectad SW75 that covers the Perranporth towans for the last 10 years. Location is shown in figure S.2.

Table S.1. Sightings by week in Hectad SW75, 2010 to 2019

SW75	13-May	20-May	27-May	03-Jun	10-Jun	17-Jun	24-Jun	01-Jul	08-Jul	15-Jul	22-Jul	29-Jul	05-Aug	12-Aug	19-Aug	all year
Year	WK7	WK8	WK9	WK10	WK11	WK12	WK13	WK14	WK15	WK16	WK17	WK18	WK19	WK20	WK21	Total
2010			17	34		1,007	41	2,038	6						1	3,144
2011	5		100	401	1,005	507	338	53	13	1						2,423
2012			1	1	1				50	8	14					75
2013					12		121	400	800	1		2				1,336
2014					50		200	300		12	1					565
2015		2	9			378		252		20		2	1			664
2016		5	81	1,000		215	110		1	50	101					1,563
2017		4				125										129
2018		10	7	8	120	1,220	4,945		145	4					1	6,460
2019		1	4	4	56	100	188	15	13		6					387
Total	5	22	221	1,448	1,244	3,552	5,943	3,058	1,028	96	122	4	1		2	16,746
10 yr ave.	1	2	22	145	124	355	594	306	103	10	12					1,675

Figure S.2 Map showing location of hectad SW75 with towans north of Perranporth



During a period of increasing butterfly recording in the county, there is only one year (2011) with Silver-studded Blue records in each week of the flight period in SW75 and five years with less than 1,000 sightings. With a baseline survey of more than 22,000 sightings in 2004, the recent data recording gives little clue as to the health of the butterfly colonies at this key site. A set of surveys carried out on 29th June 2018 attempted a near-peak estimate of numbers in parts of the site that totalled 4,786, the only such estimate in the 10 years.

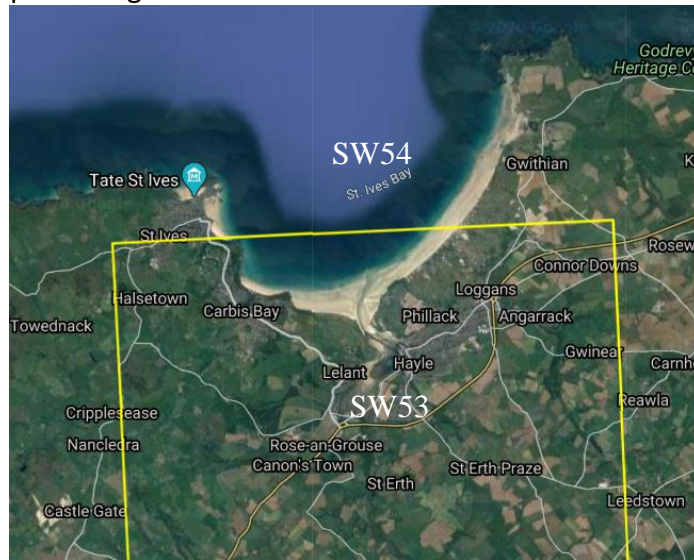
2. Upton Towans Transect

Fortunately, there is a transect at Upton Towans, near Hayle, where there are large colonies of Silver-studded Blue. This is the most significant transect for the butterfly in Cornwall and the best recorded site. It is split between hectads SW53 and SW54 (see figure S.3). The transect records alone provide a complete weekly record of Silver-studded Blue numbers over 10 seasons since 2010 and these are summarised in Table S.2. This dataset is ideal for phenology studies and it is the Cornish reference in this phenology study.

Table S.2. Upton Towans Transect Sightings by week in Hectads SW53 and SW54, 2010 to 2019

Upton Towans	13-May	20-May	27-May	03-Jun	10-Jun	17-Jun	24-Jun	01-Jul	08-Jul	15-Jul	22-Jul	29-Jul	05-Aug	12-Aug	19-Aug	all year
Year	WK7	WK8	WK9	WK10	WK11	WK12	WK13	WK14	WK15	WK16	WK17	WK18	WK19	WK20	WK21	Total
2010				66	259	631	707	207	41	160	39	15	6			2,131
2011		120	279	687	624	303	169	174	12	3	1					2,372
2012			12	30	103	191	284	304	202	150	59		15	6		1,356
2013				13	15	74	241	293	766	389	109	9	8	3		1,920
2014				16	52	825	791	356	120	72	4					2,236
2015			8	47	355	864	700	401	562	136	9	3	2	1		3,088
2016		2	2	43	178	570	807	792	425	180	86	18	10	3		3,116
2017			1	45	386	820	282	190	111	50	15	4	2			1,906
2018				24	477	1,099	777	534	255	21	9					3,196
2019			13	178	450	409	541	620	395	227	9	9	4	5		2,860
Total		122	315	1,149	2,899	5,786	5,299	3,871	2,889	1,388	340	58	47	18		24,181
10 yr ave.		12	32	115	290	579	530	387	289	139	34	6	5	2		2,418

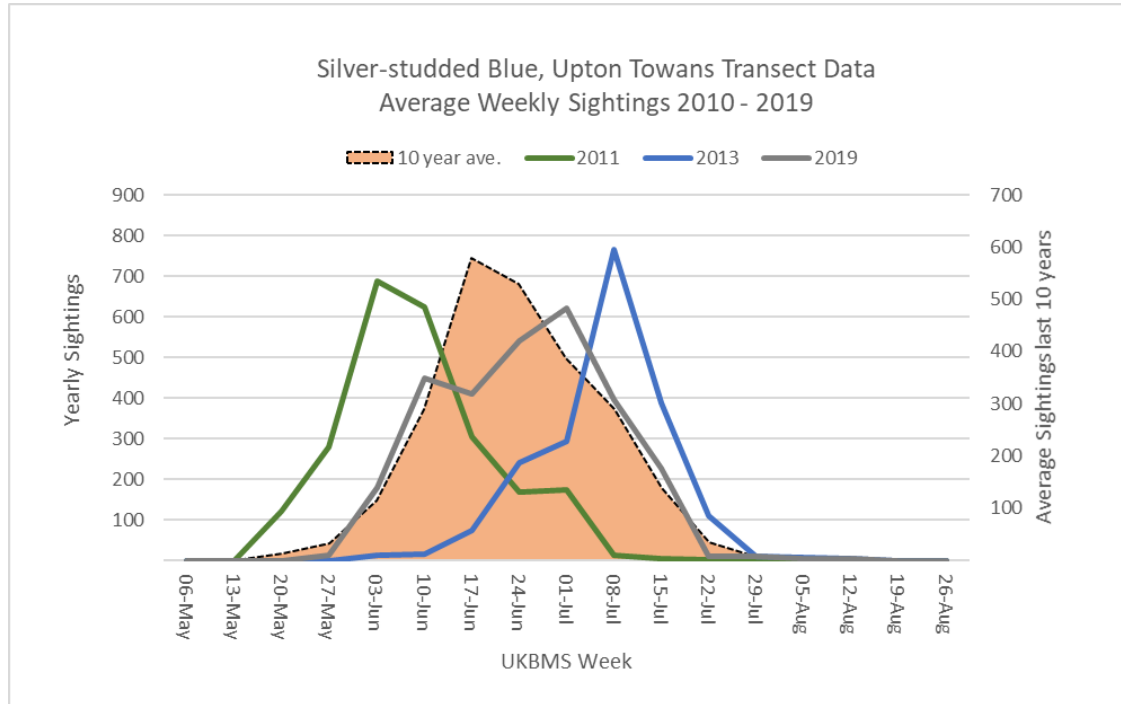
Figure S.3 Map showing location of hectads SW53 and SW54 with Hayle Towans



3. Upton Towans Silver-studded Blue Flight Times

Figure S.4 summarises the flight times of the butterfly at the Upton Towans transect, using the UKBMS week concept where Week 1 commences on 1st April each year. The plot shows the dates of the commencement of those weeks rather than the week numbers. The average of the 10 years at the transect are shown by the orange area. This is a slightly early-skewed almost triangular distribution with a peak in week 12 (w/c 17th June). There are a few late sightings in weeks 19 and 20 from 5th August that may represent a partial second brood in some years. These are numerically insignificant to the overall phenology.

Figure S.4 Silver-studded Blue Weekly Sightings 2010 – 2019, Upton Towans Transect



The population distribution for three individual years at Upton Towans is also shown: 2011 (green line), 2013 (blue line) and 2019 (grey line). Note that all years are shown in the data section at the end of this supplement.

2011 is chosen because as will be seen later, this has the earliest population occurrence in the last 10 years and one of the earliest in the last 30 years. It is the only year with significant numbers in Week 8 (w/c 20th May) and the last sighting exceptionally early in week 17 (w/c 22 July). The distribution is slightly early-skewed. The peak is in week 10 (w/c 3 June).

2013 is chosen as this has the latest population development in the last 10 years and one of the latest in the last 30 years. There were no significant sightings until week 12 (w/c 17th June) and a late-skewed distribution with a peak in week 15 (w/c 8th July) with significant numbers extending to week 17 (w/c 22 July).

2019 is shown as the most recent year. This is close to the average emergence, but with an atypical shape. Numbers in weeks 12 and 13 (17 – 22 June) are lower than the usual trend. As a consequence, the population peak is later than average in week 14 (w/c 1 July).

Overall, the population timing shows a similar duration each year of 10 to 11 weeks, but there is a big range of timing of the peak. From earliest year (2011) to the latest year (2013), this is about 5 weeks.

4. Data Processing and Analysis

In order to characterise the yearly Upton Towans population, the timing of the 10% (P10), 50% (P50 or median) and 90% (P90) of the cumulative population was calculated for the Upton Towans transect sightings. These are shown in figure S.5. The timing of these markers are shown in UKBMS weeks but using the actual days of the threshold surveys. There is a similar trend from year to year, with the earliest

timings in 2011 and the latest timings in 2013 as per the trend of peak flight times in those years shown on figure S.4.

Figure S.5 Silver-Studded Blue Population Markers 2010 to 2019, Upton Towans Transect

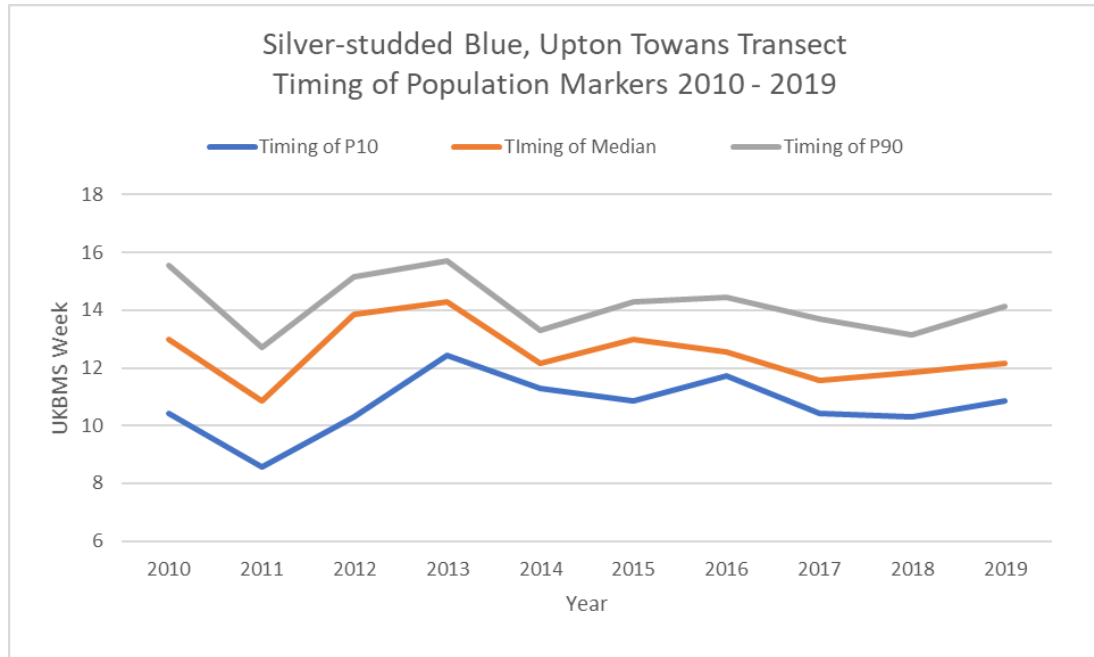
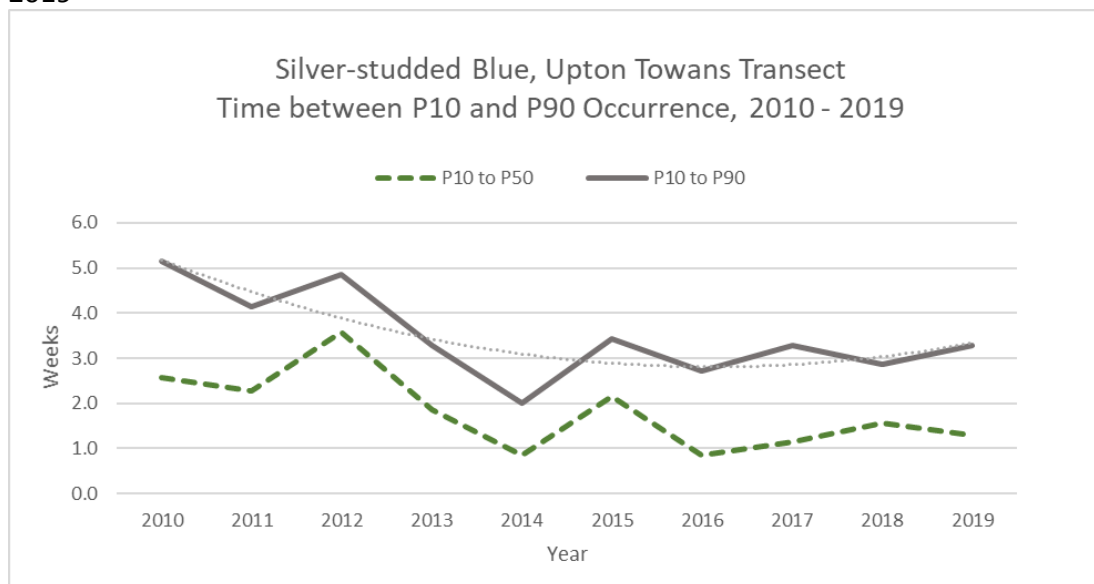


Figure S.6 shows the duration of the period between the P10 and P90 markers in each year as a grey line and also the duration of the period between the P10 and P50 (median) in a dotted green line.

Figure S.6 Duration of P10 to P90 Population Markers for Silver-studded Blue, 2010 – 2019



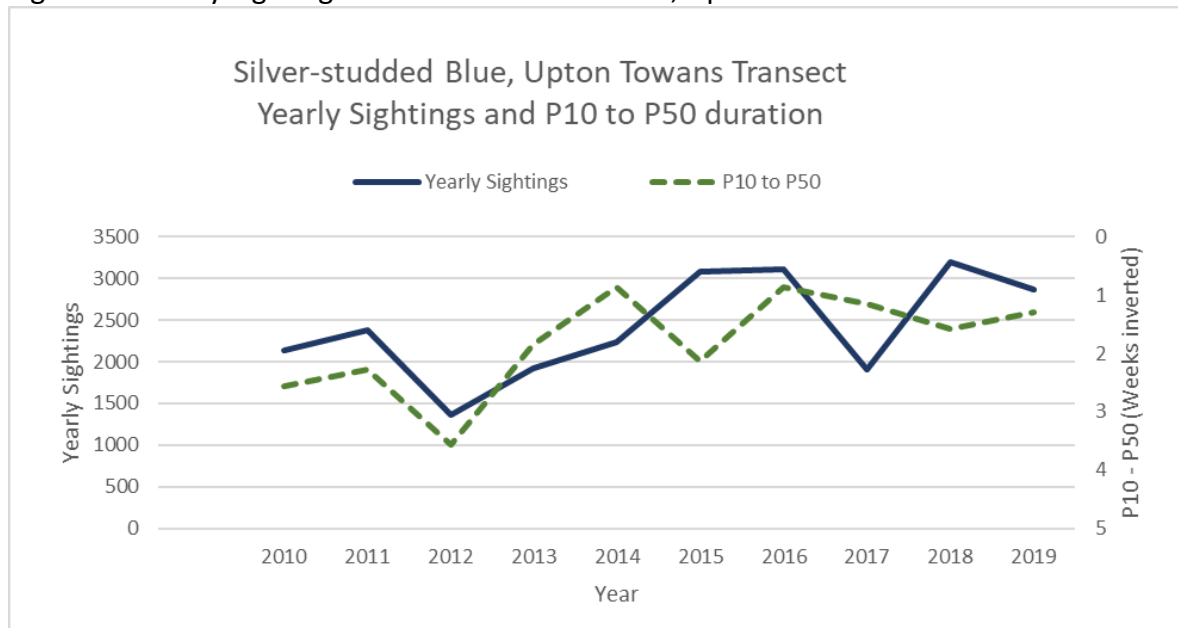
There is a trend of reducing P10 to P90 duration through the 10 years, from 5 to around 3 weeks, and the dotted green curve of the P10 to P50 shows that this

acceleration of the population development is predominantly in the first half of the population.

On further analysis, it can be seen that there is a correspondence between the P10 to P50 duration and the total yearly sightings on the transect and this is shown in figure S.7.

The figure firstly shows that the Silver-studded Blue transect sightings have increased during the 10 years and a linear trend suggests on average by 120 per year or around 5%. The dotted green curve from figure S.4 is re-displayed using the right-hand axis scale that is inverted. A linear trend suggests on average there is a reduction of c. 1.3 days per year in the timing from P10 to P50 population occurrence. This might be explained by population size changes in the different colonies along the transect route, but this level of investigation has not been followed up.

Figure S.7 Yearly Sightings and P10 to P50 Duration, Upton Towans



5. Linear Regression Processing

Firstly, the population timing characteristics were transformed into relative variance using 2019 as a reference year.

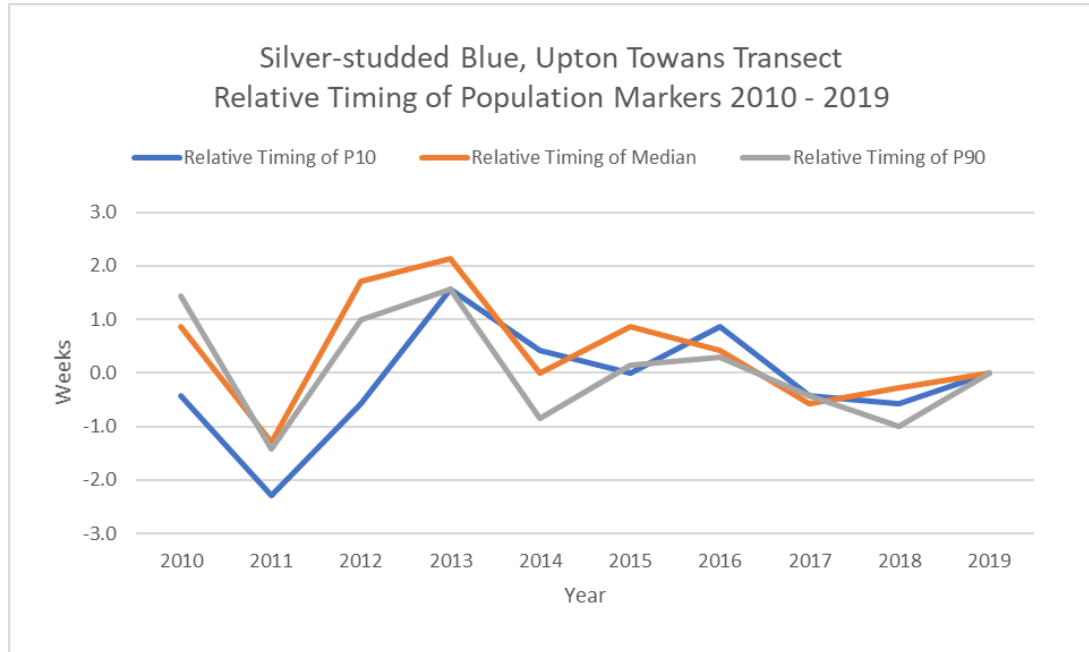
The variance of each P10, median and P90 marker in each year (Pvar) is calculated as follows:

$$Pvar = Pyr - Pref$$

Where Pyr is the timing of the marker in the year and Pref is the timing of the marker in 2019.

The relative timings of the three cumulative population markers are shown in figure S.8. All markers are zero in 2019 by definition.

Figure S.8 Silver-Studded Blue Population Markers relative to 2019



A similar procedure was carried out for weather data used in the linear regression. Historic weather data from the Newquay Weather Station (www.newquayweather.com) is publicly available in monthly averages from August 2007. The monthly temperature data was particularly useful, with average high (daytime), mean and average low (night-time) temperatures used. The monthly averages of each temperature type were converted to variance compared to 2019 as described for the population marker timings.

6. Linear Regression and Analysis

Data for relative population timing and a selection of relative monthly temperature averages were prepared and plotted graphically. Data points for 2019 are always (0,0) by definition as this is the reference year. In the preceding years, data points (t,p) were created, where:

t = selected temperature in year – selected temperature in 2019,

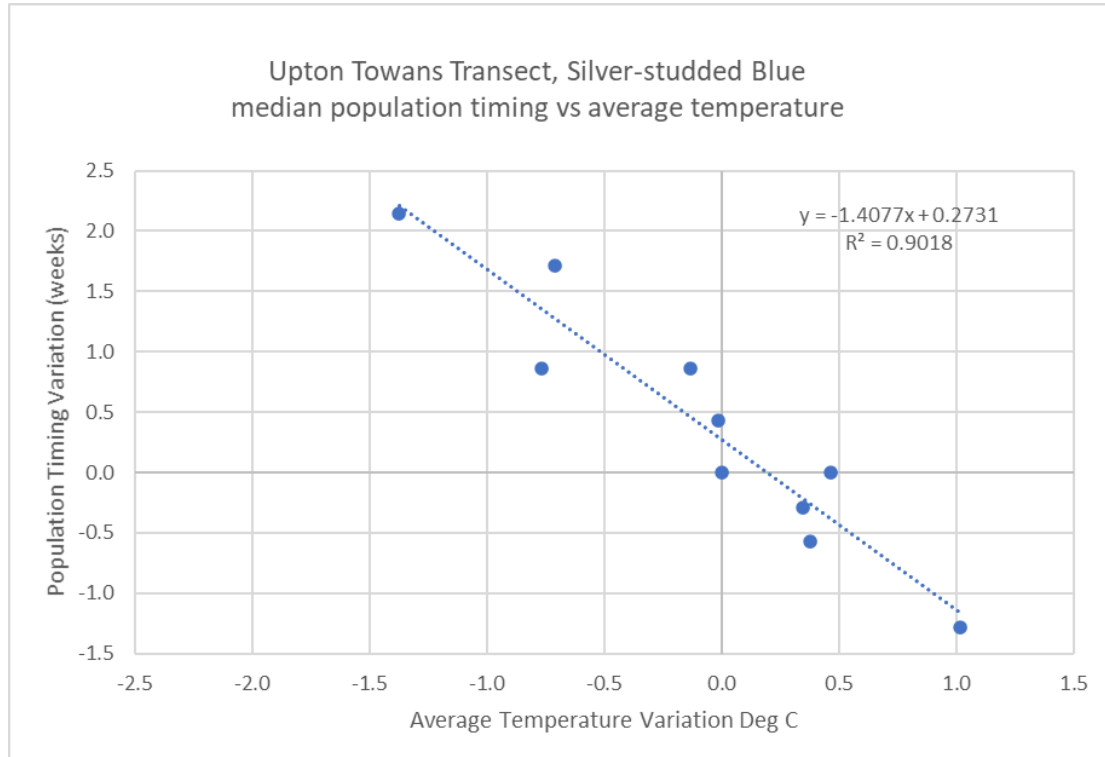
p = population marker timing in year – population marker in 2019

The linear regression technique plots an independent variable (in this case average temperature) on the x-axis against a dependent variable (in this case population marker timing) on the y-axis. A best fit line (using excel's graph utilities in this case) is constructed through the scatter of points to determine the statistical significance of the line fit by comparing the variance from the best-fit line to the variation from the mean of the data and a correlation value R^2 is generated. The closer R^2 is to 1, the better the statistical fit between the independent variable and the dependent variable.

Many iterations were carried out to determine which temperatures produced the most statistically significant relationships and the best realisation is shown in figure

S.9. This is a negative relationship; the timing of the population gets later (positive) as the temperature decreases (negative) and vice versa. The plot shows the best-fit line and its equation, and the negative gradient of the line confirms the negative relationship.

Figure S.9 Cross-plot of Average Temperature and Median Population Timing, Upton Towans



The yearly differential temperature (T) is weighted as follows:

$$T = A + B + C$$

Where: A = April Ave. Low Temp. x 0.6 (year) – April Ave. Low Temp. x 0.6 (2019)

B = May Mean Temp. x 0.15 (year) – May Mean Temp. x 0.15 (2019)

C = June Ave. Low Temp. x 0.25 (year) – June Ave. Low Temp. x 0.25 (2019)

The R^2 at 0.9 signifies a strong statistical correlation between the variance of the temperature average and median population marker in the 10 years. The yearly coordinates are shown in table S.3.

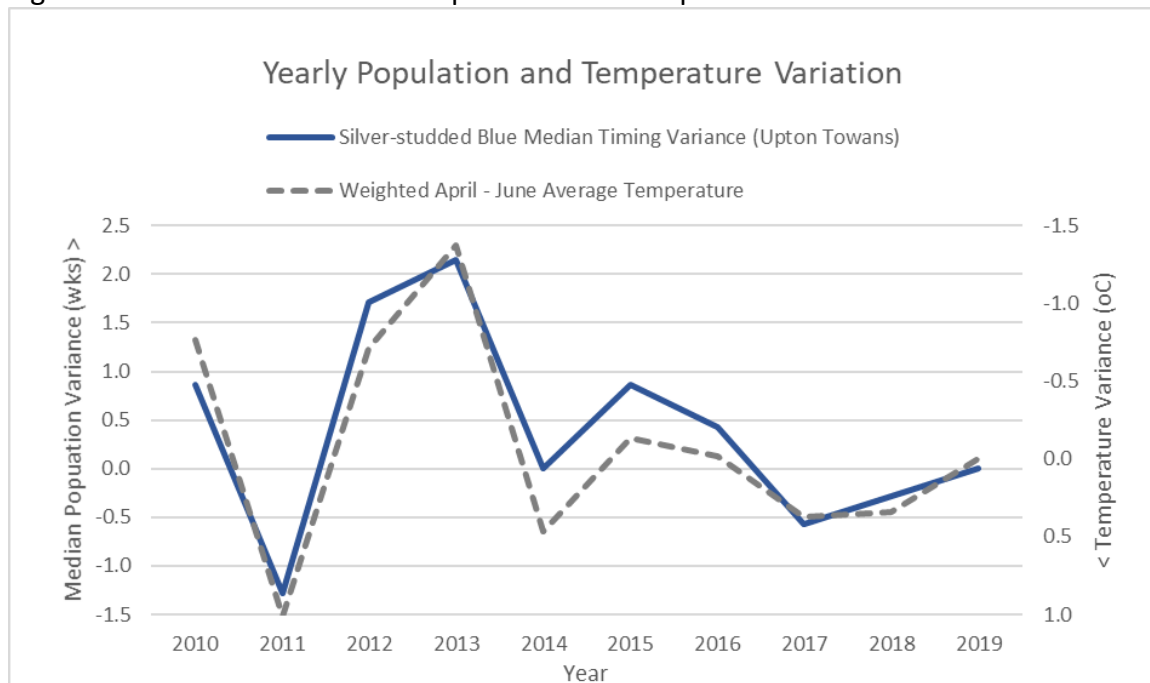
It is worth reporting that other strong correlations are possible, and that they all use combinations of average low temperatures as opposed to mean or high temperatures. The best match was by weighting the average low temperature in April by 60% and the remaining 40% to mean and average low temperature in May and June. The implication is that night-time temperatures through April to June, particularly in April, are influencing the timing of subsequent population emergence as characterised by the median timing. This period includes the late larval stages of the butterfly, perhaps both 3rd and 4th instar, and the pupation stage.

Table S.3 Coordinates used in figure S.9

Year	Temperature Variance	Median Population Variance
2010	-0.77	0.86
2011	1.02	-1.29
2012	-0.71	1.71
2013	-1.38	2.14
2014	0.47	0.00
2015	-0.14	0.86
2016	-0.02	0.43
2017	0.38	-0.57
2018	0.35	-0.29
2019	0.00	0.00

Another potent method of showing the correlation is on figure S.10 below where both population timing and temperature are shown together graphically. The temperature data scale (right-hand y-axis) is inverted to align the trends in both datasets, given the negative relationship.

Figure S.10 Silver-studded Blue Population and Temperature variance 2010 - 2019



The yearly matches are acceptably close for most years. Years 2014 and 2015 show the most variance.

The gradient of the best-fit line on figure S.9 is -1.41 and this signifies that one degree of warmer weighted-average April to June temperature is correlating with 1.41 weeks earlier development of the median population, or c. 10 days. As will be seen later, the sensitivity of the Silver-studded Blue emergence in response to late

larval and pupation temperatures is particularly high in comparison to other species that have been studied. This makes the butterfly a particularly good species with which to study the long-term dynamic effects of climate change.

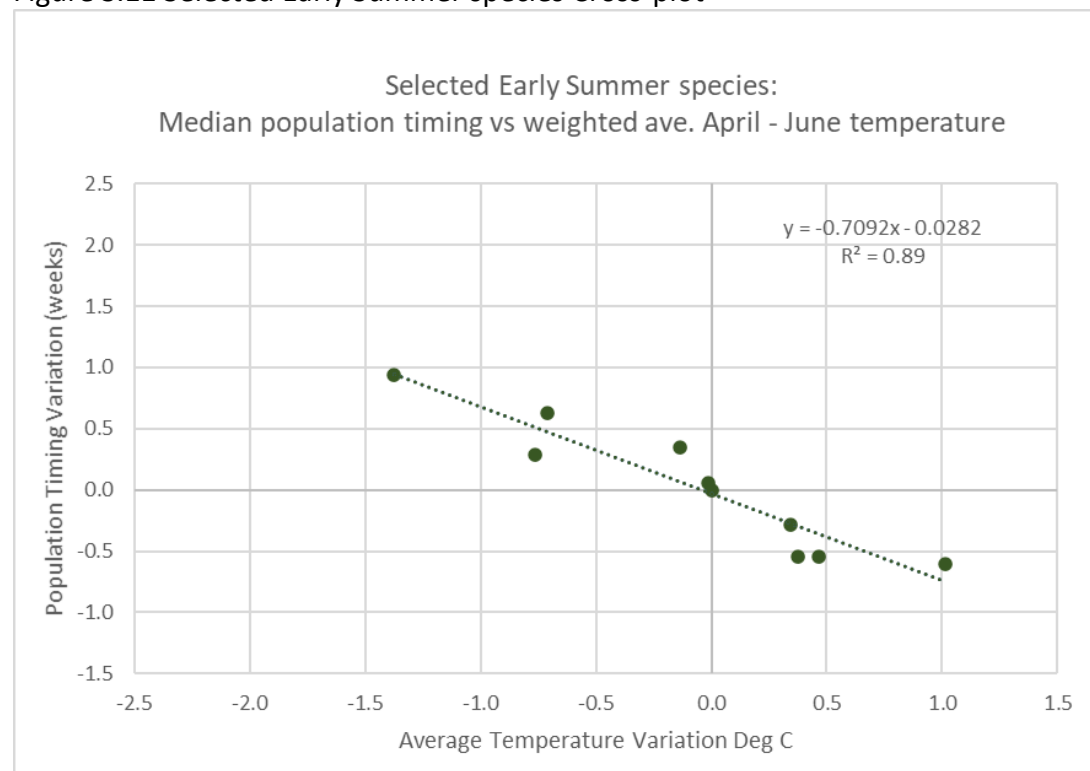
7. Comparison to Other Early Summer Butterfly Species

There are four other common Early Summer species that emerge at similar time to the Silver-studded Blue. These butterflies are summarised below with the average timing of their median population development using Cornish transect data in UKBMS weeks:

Silver-studded Blue	12.6
Common Blue	9.0
Large Skipper	12.7
Small Heath	13.5
Ringlet	14.4

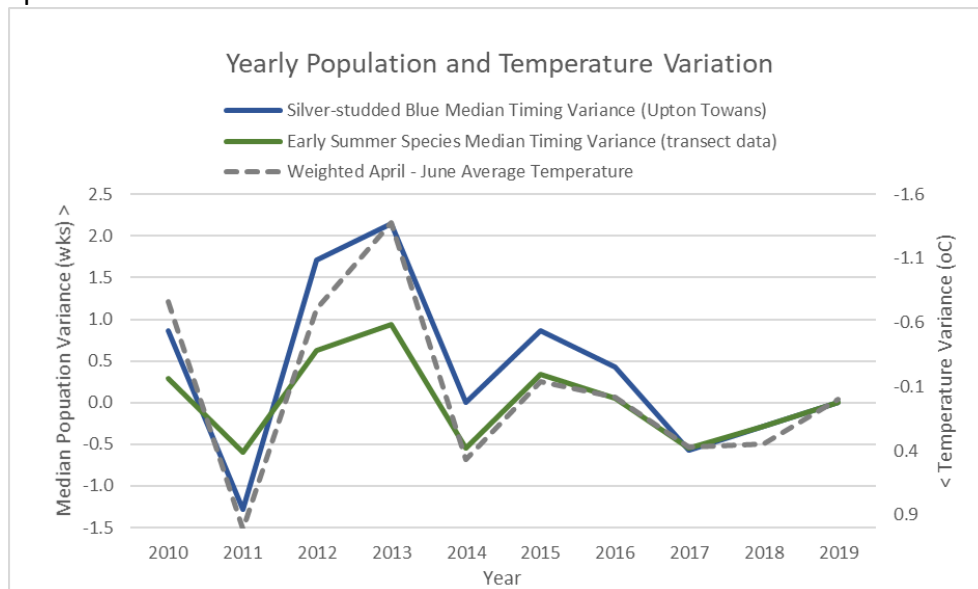
There are sufficient transect sightings for these butterflies from 2010 to 2019 from the Cornish transects and these were processed in the same manner as for the Silver-studded Blue to create relative median timing variance compared to 2019. The data for the Upton Towans transect only for Silver-studded Blue was combined with the other species and the average yearly median timing compared to 2019 was generated for the group. These variances are plotted against the same weighted-average temperature as described for the Silver-studded Blue in Figure S.11.

Figure S.11 Selected Early Summer species Cross-plot



A similar degree of statistical correlation is seen for the average response for the group as for the Silver-studded Blue data alone (R^2 of 0.89) but the slope of the line is much reduced at -0.71 weeks per degree. This shows that on average these species as a group show half of the variance of the Silver-studded Blue with one degree of relative warming corresponding with 0.71 weeks earlier population development, or c. 5 days. Figure S.12 shows the Early Summer group variance with the two curves shown in figure A.8 and the muted response to temperature variation is evident comparing the blue and green lines.

Figure S.12 Yearly population timing and temperature variation for Early Summer Species



8. Long-term Trends using all historic Silver-studded Blue Sightings

The wealth of casual sightings from the early 1990s onwards can be used to give estimates of Silver-studded Blue population timings for the best part of 30 years. As discussed, there is no transect data before 2010 and some of the years between 2001 and 2006 have overall sightings dominated by a small number of large counts from Perranporth towans.

The total Silver-studded Blue sightings were processed in the same fashion as the transect data from 1990 to 2019. Year 1990 to 1992 do not have sufficient numbers of sightings to be particularly useful.

Figure S.13 is a twin to figure S.4 and shows the average sightings per UKBMS week for the Silver-studded Blue based on all Cornish sightings and shows the same individual years 2011, 2013 and 2019.

There are some differences. Overall, the 10-year average peaks a week later than the Upton Towans transect data and the population is slightly late-skewed. The pattern in the three example years are similar, although 2019 much more closely resembles the 2013 year which is particularly late and late-skewed. Field trips and one-off

surveys at Penhale Sands are factors in the differences to the standard represented by the Upton Towans transect.

Figure S.13 Silver-studded Blue Weekly Sightings 2010 – 2019, all sightings

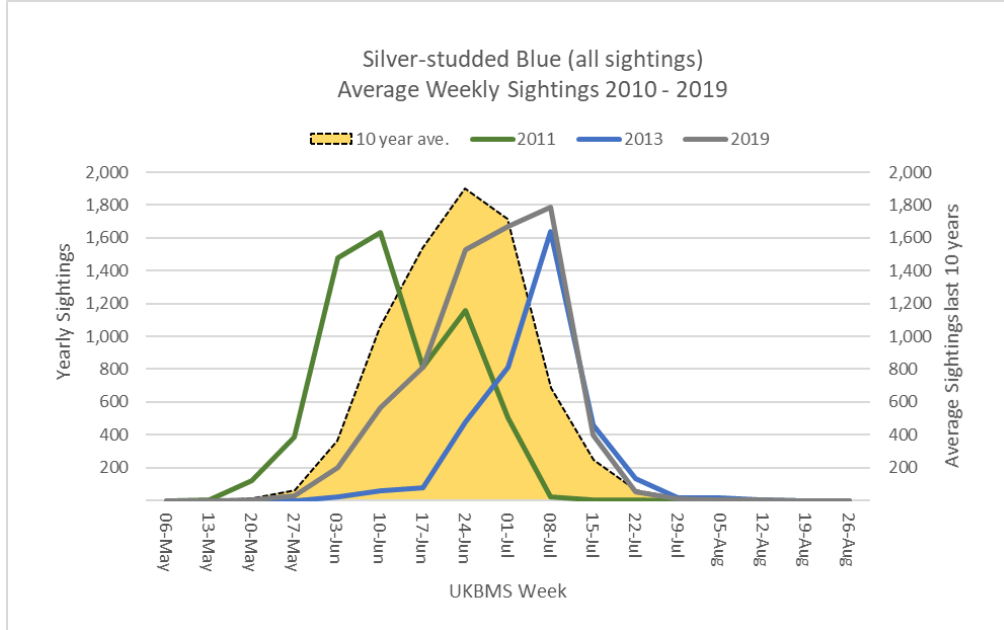
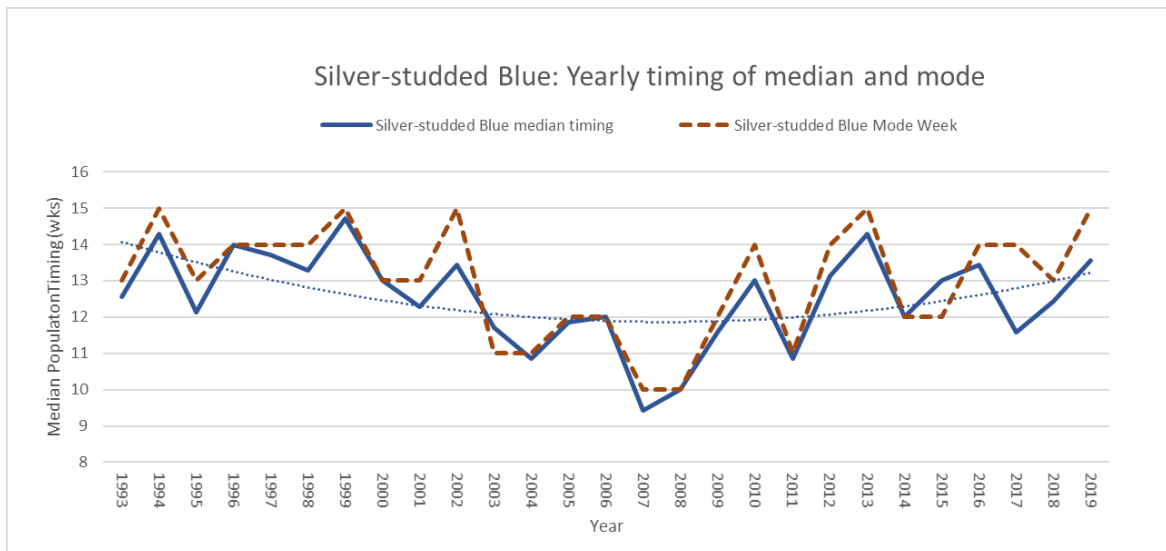


Figure S.14 shows the yearly timing of both median (blue line) and modal or peak week (dotted brown line) for all years of the processed data. There are insufficient sightings for years before 1993 and these are not displayed.

These two attributes are in quite close agreement for most years and where dissimilar, the modal week tends to be later than the median date. This would imply late-skewed populations in those years, although also can be caused by recorders trying to achieve maximum counts at prolific sites.

Figure S.14 Yearly Silver-studded Blue median and modal population timing, 1993 - 2019

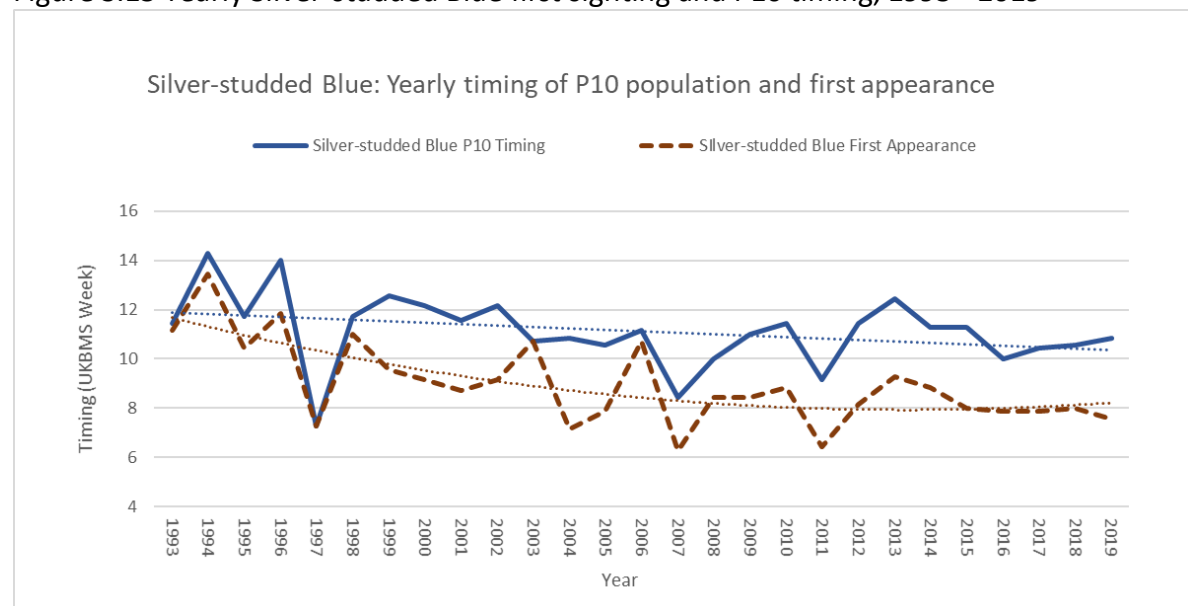


A long-term trend line (2 order polynomial) is fitted in acknowledgement that there is no single linear trend in the data. Instead, there is a clear period between the mid-1990s to 2011 of progressive ‘earlying’ of the population by more than two weeks. The data for 2007, only 321 sightings, is not sufficient to characterise the yearly population and so it should be treated with caution.

After 2011, the pattern changes, with the population timing becoming later and with one of the latest years occurring in 2013. Overall, a linear trend from 1993 to 2019 (not illustrated) suggests an overall ‘earlying’ of 5 days through the period.

In terms of the early parts of the population, figure S.15 shows the dates (in UKBMS weeks) of the first sightings and the P10 in each year between 1993 and 2019.

Figure S.15 Yearly Silver-studded Blue first sighting and P10 timing, 1993 - 2019



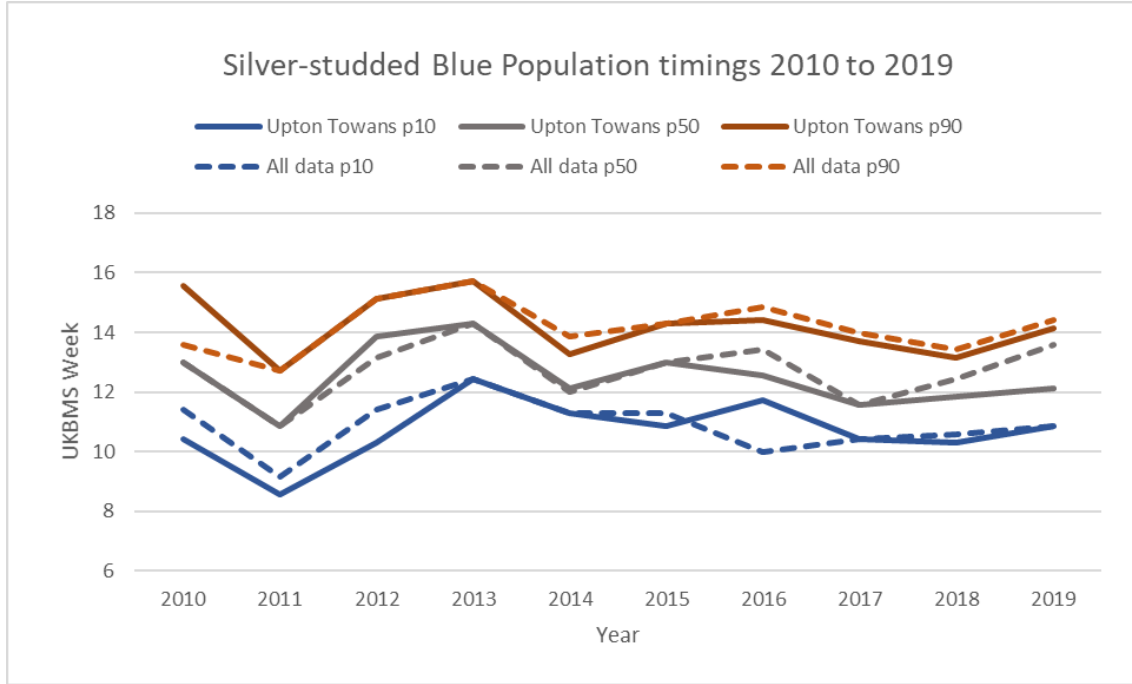
Obvious ‘earlying’ trends are seen in both attributes. The earliest first sightings were in 2007 and 2011 and were on 14th and 15th May respectively. After early concordance between first sightings and P10 population emergence, in subsequent years the two trends have diverged, with first sightings becoming earlier more quickly. This may be in part a recording phenomenon, with a keen interest shown in the trophy for the first one of the season. In the last five years, all first sightings have been between 23rd and 26th May at Penhale sands or Upton Towans. The trends in P10 timing show a more linear progression and the trend line suggests that this timing has occurred 11 days earlier through 1993 to 2019.

9. Comparison between all sightings and Upton Towans transect trends

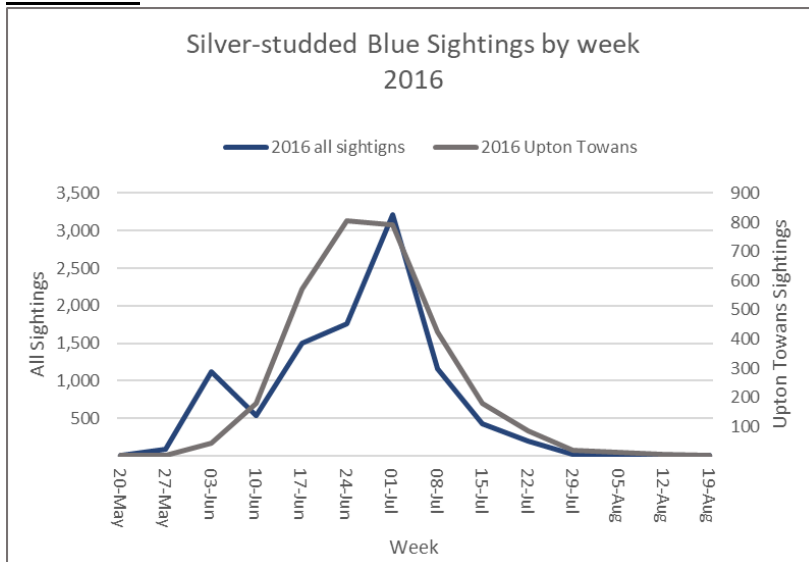
The timing of P10, median and P90 trends for the Silver-studded Blue for last 10 years are presented on figure S.16 for both all sightings and the Upton Towans transect data.

For most years, there is general agreement between the two datasets. Some detail on the comparison in the last four years is given.

Figure S.16 Silver-studded Blue Population Timings 2010 to 2019

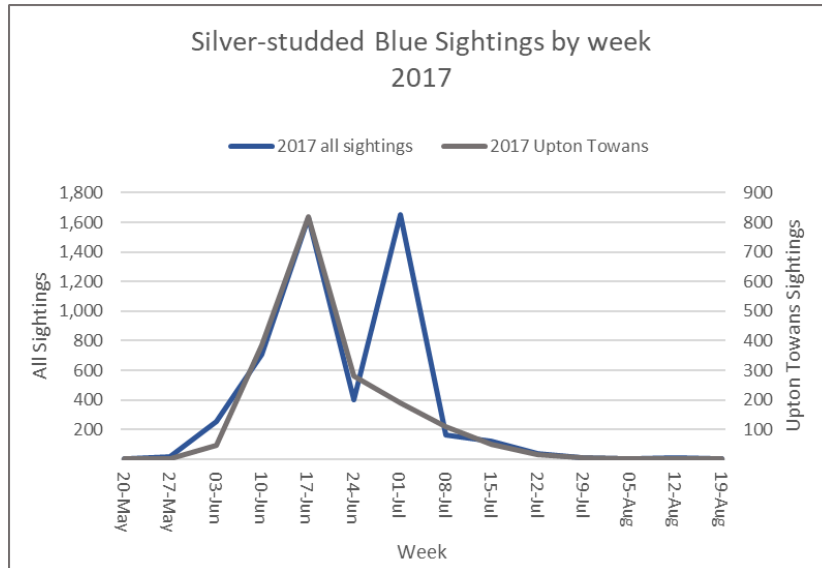


2016 Data



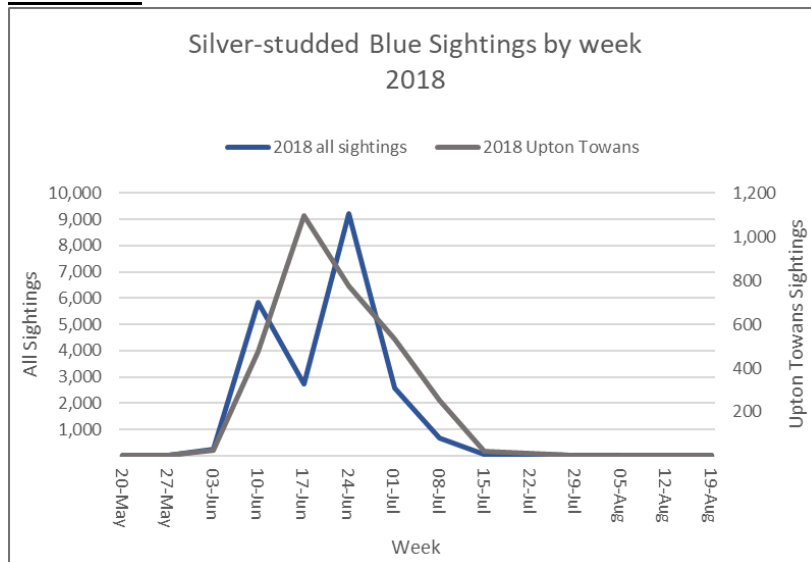
The graph above shows two curves for 2016: all sightings (blue curve) and Upton Towans only (grey curve). The all sightings data includes significant peaks on 9th June when 1,000 were estimated at Penhale Sands and 1,818 sightings on a field trip at Upton Towans on 5th July. The latter were in addition to 792 recorded on the Upton Towan transect that week.

2017 Data



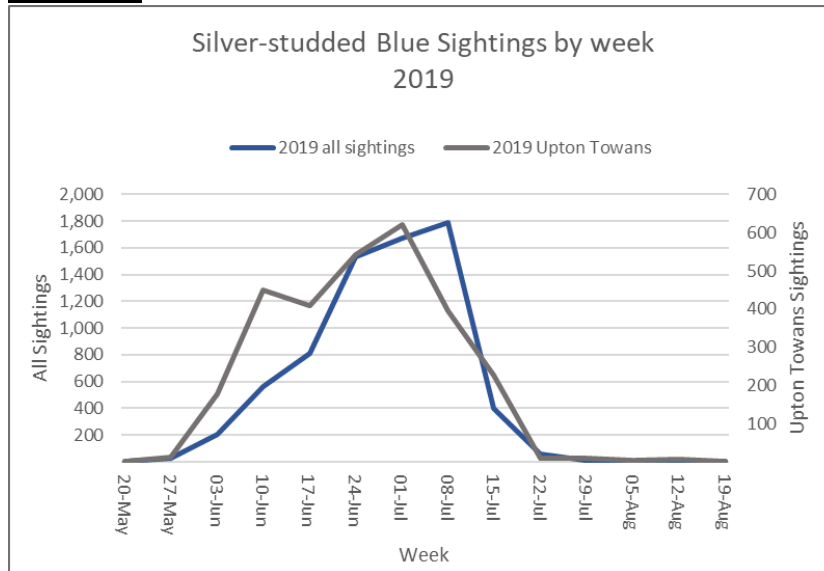
Casual sightings were boosted by one-off surveys at Upton and Godrevy Towans in w/c 1st July.

2018 Data



Surveys at Penhale Sands and the annual CBC field trip to Upton Towans accounts for the peaks in all sightings for weeks of 10th and 24th June. The latter surveys cause the discrepancy in P50.

2019 Data



All sightings data includes extensive surveys in week 15 (w/c 8th July) that produce the discrepancy in P50 timing.

10. Conclusions

It has been possible to determine some details of the phenology of the Silver-studded Blue from the wealth of Cornish data recorded in the ERICA database. Most insights, however, have been deduced from the data gathered on the Upton Towans UKBMS transect with 10 years of uninterrupted weekly sightings of the butterfly. This transect contains major colonies of the Silver-studded Blue and has sufficient sightings each year to detail meaningful populations and population characteristics.

Using yearly cumulative population markers and publicly available historic Cornish weather data, linear regression techniques have shown a strong correlation between average night-time temperatures in April to June each year and the timing of the median (P50) population. One degree of relative warming is seen to correspond to 10 days earlier emergence as characterised by the median population timing. This period coincides with the late larval and pupation stages of the butterfly.

The analysis suggests that the emergence of the Silver-studded Blue is particularly sensitive to the temperature in this period. A relative increase of one degree in the weighted average night-time temperature between April and June correlates with the median population development occurring 10 days earlier. Studies on other butterfly species with brood emergence at a similar time to the Silver-studded Blue have found that they on average show half of the timing sensitivity, with a one degree relative rise related to about 5 days average earlier emergence. This makes the Silver-studded Blue an ideal butterfly to use for future phenology studies into the effects of climate change.

Longer term trends are deduced from the casual sightings before 2010 and a mixture of transect and casual sightings from then onwards. The analysis suggests that population timing, as characterised by the median timing, advanced markedly between 1993 and 2011 but that since then this trend has stalled and since 2012 timing has become slightly later. Overall, some five days of advancement is seen over the 27 year period.

The earlier parts of the population as characterised by first sightings and P10 emergence, exhibit 'earlying' trends through the period 1993 to 2019, with the P10 showing 11 days of advancement over the period.

Silver-studded Blue Phenology: Data Section
 Summary of yearly sightings used in analysis

Transect Sightings	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Silver-studded Blue	830	2,263	2,390	1,356	1,948	2,291	3,130	3,343	2,195	3,956	3,296	26,998
Common Blue 1st	74	226	338	131	40	155	175	196	237	770	303	2,645
Large Skipper	43	252	212	94	328	764	438	337	232	714	597	4,011
Small Heath 1st	36	283	168	59	307	318	174	235	122	545	553	2,800
Ringlet	532	933	1,032	293	795	1,807	1,534	1,269	1,687	3,395	4,353	17,630
Yearly Total	1,515	3,957	4,140	1,933	3,418	5,335	5,451	5,380	4,473	9,380	9,102	54,084

All Data Sightings	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Silver-studded Blue	830	5,394	6,136	3,072	3,719	7,357	7,524	10,038	4,996	21,382	7,074	77,522
Common Blue 1st	406	1,105	1,985	398	331	1,046	1,354	780	784	2,619	1,062	11,870
Large Skipper	268	635	612	268	1,060	1,734	1,221	839	569	1,319	1,079	9,604
Small Heath 1st	530	705	1,043	209	820	1,115	743	565	325	1,928	1,327	9,310
Ringlet	2,476	3,032	2,681	1,557	3,872	4,034	3,803	2,617	3,242	5,964	6,555	39,833
Yearly Total	4,510	10,871	12,457	5,504	9,802	15,286	14,645	14,839	9,916	33,212	17,097	148,139

All Data Sightings	1990	1991	1992	1993	1994	1995	1996	1997	1998
Silver-studded Blue	1,032	159	78	3,423	557	1,994	148	723	464
Common Blue 1st	403	243	169	478	408	584	253	860	415
Large Skipper	178	83	84	198	433	614	220	269	560
Small Heath 1st	850	124	85	799	428	556	275	665	1,278
Ringlet	1,067	857	443	768	972	960	771	831	3,704
Yearly Total	3,530	1,466	859	5,666	2,798	4,708	1,667	3,348	6,421

All Data Sightings	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Silver-studded Blue	1,627	710	7,264	555	2,746	22,030	9,339	13,226	321	1,635
Common Blue 1st	572	790	649	547	1,161	2,872	1,106	2,264	1,373	634
Large Skipper	363	473	505	162	380	387	131	394	313	191
Small Heath 1st	1,832	1,049	1,073	445	1,050	1,681	2,492	1,831	1,103	360
Ringlet	5,760	6,240	2,325	2,266	3,507	1,487	937	1,766	2,035	1,935
Yearly Total	10,154	9,262	11,816	3,975	8,844	28,457	14,005	19,481	5,145	4,755

Summary of calculated P10, Median and P90 timings, transect records

Transect Records P10 Timings	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Ave
Common Blue 1st	8.9	7.3	5.9	7.1	5.9	7.0	7.6	3.4	5.7	7.4	6.6	6.6
Silver-studded Blue	11.0	10.4	8.6	10.3	12.4	11.3	10.9	11.7	10.4	10.3	10.9	10.7
Large Skipper	9.4	11.1	10.7	10.3	11.4	10.1	10.1	10.3	10.0	10.3	9.6	10.3
Small Heath 1st	9.1	11.6	7.9	8.9	13.1	10.4	12.0	9.4	11.1	9.3	9.6	10.2
Ringlet	12.6	13.6	13.0	13.9	14.4	13.0	13.0	13.4	12.3	12.7	13.3	13.2
Early Summer Species Average	10.2	10.8	9.2	10.1	11.5	10.4	10.7	9.7	9.9	10.0	10.0	10.2

Transect Records Median Timings	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Ave
Common Blue 1st	9.4	9.3	7.9	8.9	8.7	8.9	9.6	8.7	8.9	9.3	9.6	9.0
Silver-studded Blue	11.6	13.0	10.9	13.9	14.3	12.1	13.0	13.4	11.6	12.3	12.3	12.6
Large Skipper	12.4	13.7	13.4	12.7	13.1	12.1	12.6	12.6	11.6	12.6	12.6	12.7
Small Heath 1st	11.9	13.0	13.4	14.1	15.6	12.9	14.3	13.4	13.6	12.9	13.3	13.5
Ringlet	14.3	14.6	13.6	15.7	15.1	13.4	14.4	15.1	13.9	14.1	14.6	14.4
Early Summer Species Average	11.9	12.7	11.8	13.1	13.4	11.9	12.8	12.7	11.9	12.2	12.5	12.4

Transect Records P90 Timings	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Ave
Common Blue 1st	12.1	11.6	11.7	14.3	10.6	12.9	12.6	13.4	12.9	12.9	14.0	12.6
Silver-studded Blue	11.6	15.4	12.7	15.1	15.7	13.3	14.3	15.0	14.1	14.1	14.4	14.2
Large Skipper	15.1	16.4	16.4	16.1	15.6	15.6	15.4	15.6	14.7	14.7	15.3	15.5
Small Heath 1st	13.7	19.6	16.9	17.7	18.4	16.0	16.6	18.0	16.3	17.3	18.0	17.1
Ringlet	15.3	16.4	16.0	17.7	17.3	16.0	16.6	17.3	15.4	15.7	16.3	16.4
Early Summer Species Average	13.6	15.9	14.7	16.2	15.5	14.7	15.1	15.9	14.7	14.9	15.6	15.2

Summary of Upton Towans Transect Yearly Sightings by Week

