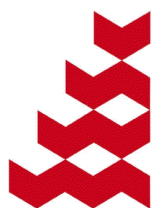


The status and conservation of the silver-spotted skipper *Hesperia comma* in South-East England 2000-2009

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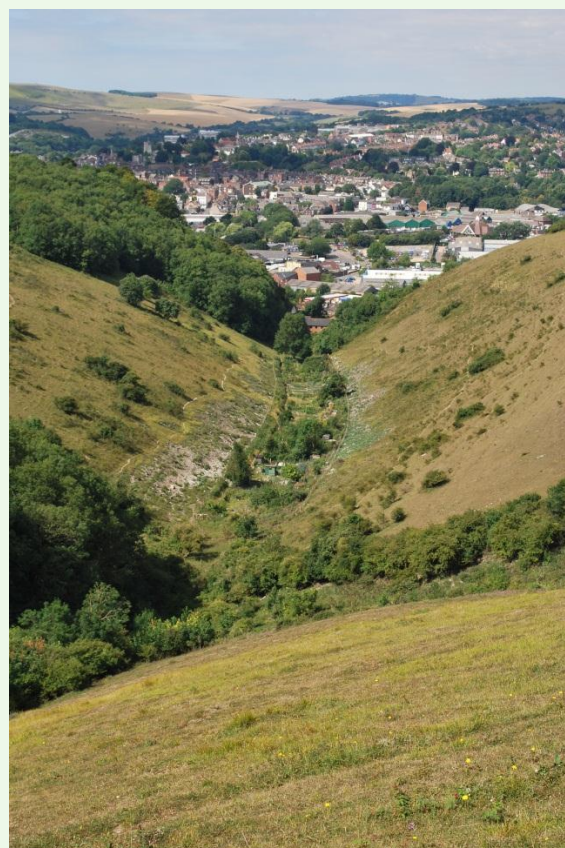
Executive Summary

- The silver-spotted skipper is a rare butterfly restricted to short-turfed chalk grassland in the UK, where it is at the northern limit of its range.
- Following severe declines during the early 20th century, three distribution surveys from the mid 1980s onwards reported signs of recovery, thanks to conservation management of chalk grassland, increases in rabbit grazing, and warmer summer temperatures during the butterfly's flight period. However, most populations remained small, with fewer than 225 individuals at peak emergence.
- In summer 2009, a team from the Universities of Exeter and York conducted the fourth major survey of populations of the silver-spotted skipper across five habitat networks in South-East England.
- From 2000-2009, the number of silver-spotted skipper populations increased from 237 to 316. However, the rate of expansion slowed in all networks except Sussex, with a marked increase in the number of population extinctions, from just two during 1982-2000 to over 50 between 2000 and 2009.
- The majority of populations were smaller in 2009 than in 2000, with the number harbouring more than 225 individuals at peak flight roughly matching that before the butterfly's expansion.
- The decline in size of skipper populations appears to result from a combination of the effects of habitat management, particularly on sites lacking protection from conservation schemes, and the cooler summer temperatures experienced since 2007.
- The pattern of new colonisations reveals that the expansion of the silver-spotted skipper continues to be limited by the availability of suitable habitat, with the majority of new colonies established within 2 km of sites occupied in 2000.
- This latest survey, funded by NERC, carries important messages for the conservation of specialist species in a changing climate. Recommendations to help facilitate the northward expansion of the silver-spotted skipper include grazing management to provide areas of short or broken sward, to protect the species against declines in cooler years; and developing networks of habitat patches that are large enough and close enough together to permit colonisation of sites which become suitable through climate warming or conservation management.

Introduction

The silver-spotted skipper butterfly (*Hesperia comma*) is restricted to chalk grassland in Britain. It lays eggs on a single species of plant, sheep's fescue grass (*Festuca ovina*). The butterfly's flight period takes place between July and September; eggs hatch the following March, and caterpillars feed exclusively on the leaves of sheep's fescue. Females are highly selective about the sites on which they lay eggs, selecting tufts of sheep's fescue less than 10 cm tall and often adjacent to patches of bare ground. This requirement for short turf arises at least partly from the selection of warm microhabitats by egg-laying females. Egg-laying and overall adult activity also increase with temperature. As such, the silver-spotted skipper is constrained to patches of grassland that are both short enough to contain suitable host plants, and have ambient temperatures high enough to fulfil the requirements for egg-laying.

Globally, the butterfly has a circumpolar distribution and can be found as far south as North Africa; in Britain, it is at the northern limit of its range. Although the skipper previously occupied much of southern Britain and was recorded as far north as the Yorkshire Wolds, over the past century its range has contracted considerably: by 1982, fewer than 70 populations remained, encompassing just 11% of the 10 x 10 km grid squares in which it formerly occurred. The primary reason for this decline was a loss of short-turfed grasslands due to reduced grazing, initially because of agricultural intensification and the abandonment of extensive grazing on chalk downland, and then through the devastation of rabbit populations by myxomatosis in the 1950s. The surviving populations, identified by a comprehensive survey in 1982, were concentrated on south-facing chalk hills in the North Downs, South Downs and Chilterns in South-East England, with a few additional populations on the borders of Hampshire, Wiltshire and Dorset. The majority were small, with fewer than 225 individuals estimated at peak emergence.



Above: Silver-spotted skipper habitat at Malling Down near Lewes in East Sussex

Following the decline of the silver-spotted skipper leading up to 1982, two subsequent surveys at nine-year intervals reported more positive news. By 2000, the species had undergone a partial re-expansion in Britain, with more than three times the number of populations present in 1982, occupying a combined area of habitat ten times larger than that in the original survey. A major contributing factor was an increase in the availability of short-turfed calcareous grassland in South-East England, thanks to the recovery of rabbit numbers, and conservation management of chalk grassland through the reintroduction of domestic livestock. Additionally, warmer summers in the UK meant that the silver-spotted skipper was able to colonise north-facing slopes which had previously been too cool to support breeding populations, effectively doubling the area of habitat.

The silver-spotted skipper was listed as "rare" under IUCN criteria in the UK Red List in 1987,



Photographs of the different lifestages of the silver-spotted skipper Hesperia comma. From top to bottom: egg on stem of host plant, sheep's fescue grass Festuca ovina; larva on sheep's fescue grass; pupa nestled amongst the vegetation; adult perching on leaf.

but after its partial recovery it was downgraded in subsequent assessments in 1997 and 2007. In 1999, UK Species Biodiversity Action Plan (BAP) objectives for this species were defined as:

1. To maintain populations throughout the current range, through conservation of large colonies and/or networks of smaller populations.
2. To conduct strategic re-introductions to large sites or a network of small sites.
3. To ensure that a minimum number of colonies are protected within Sites of Special Scientific Interest (SSSIs).
4. To restore populations to the 1970-82 distribution by 2010.

Whilst the status of the silver-spotted skipper had undoubtedly improved by 2000, most populations remained small, and a large proportion of apparently suitable habitat remained unoccupied. With this in mind, the Natural Environment Research Council (NERC) provided funding for the fourth major survey of the silver-spotted skipper in summer 2009, conducted by a team from the Universities of Exeter and York. The objectives of this survey were as follows:

1. To identify all populations of the silver-spotted skipper in South-East England and estimate their size.
2. To identify and map all areas of suitable habitat within 30 km of existing populations.

This report summarises the results of the survey to provide a comprehensive assessment of the current status of the silver-spotted skipper and advise on management actions likely to improve its status in the future.

Methods

Prior to the survey, a desk study was carried out to identify all potential chalk grassland habitat within 30 km of known silver-spotted skipper populations in South-East England. Known populations were identified based on the 2000 survey and subsequent sightings provided by Butterfly Conservation. The 30 km search radius was considered sufficient to detect all new populations, since previous surveys had failed to find colonisations exceeding this distance even over an 18 year period. This study is focused on the five population networks of the species in South-East England: Kent, Surrey, Sussex, Hampshire, and the Chilterns. Further populations exist on the borders of Dorset, Hampshire and Wiltshire; due to constraints of time and personnel these were not covered in 2009.

A suitable “habitat patch” was defined as unimproved chalk grassland, containing sheep’s fescue plants less than 10 cm tall. Discrete patches were separated by at least 25 m of unsuitable grassland, or a woodland or scrub barrier. Identification of this habitat was achieved using a combination of the following information sources: digital boundary maps of lowland calcareous grassland and Sites of Special Scientific Interest (SSSIs) and maps of “open country” under the Countryside and Rights of Way Act from Natural England (<http://www.gis.naturalengland.org.uk>);

1:50,000 digital geology maps from the British Geological Society; and records and advice from local contacts and organisations including Butterfly Conservation, county Wildlife Trusts, National Trust and Natural England, as well as visual searches via Google Earth and ground-based searches conducted by field assistants.

Once identified, each habitat patch was visited at least once by one of 14 field researchers, who were trained over a three-day intensive course at the start of the survey to collect data on silver-spotted skipper presence/absence, population size, and the characteristics of the habitat. Detection of the

butterfly could occur either through observing adults, or by conducting an egg-search on favourable-looking host plants. Habitat patches where the butterfly had been recorded in 2000 but was found to be absent after the first visit in 2009, or which were visited in poor weather conditions during the flight season, were revisited on at least one further occasion to confirm absences.

Habitat characteristics that could affect silver-spotted skipper occupancy were recorded: these included aspect and gradient of the slope, shelter and altitude, as well as a vegetation survey which estimated the proportional coverage of turf less than 10 cm tall, sheep’s fescue grass, and bare ground, as well as an assessment of grazing impact on sheep’s fescue plants. Each field researcher used a handheld Global Positioning System (GPS) unit to map the perimeter of the patch; these data were digitised using Geographic Information System (GIS) software, which was used to create maps of suitable habitat and calculate the areas (in ha) of habitat patches.

Population size was estimated for 150 of the 316 populations identified in the survey. Transects were run in conditions of good weather, and a peak population index was calculated as follows:

Peak population index = No. butterflies per 100 m × Patch area (ha) / Proportion of regional peak on date of transect

The proportion of regional peak was estimated by comparison with a site for which weekly transect data was available throughout the flight season. The peak population index was then multiplied by a correction factor of 20 based on previous mark-recapture estimates, to provide an estimate of actual peak population size. Since these calculations provide only very rough estimates of silver-spotted skipper population size, they were used simply to group populations into size classes of small, medium, and large (with less than 225, between 225 and 800, and more than 800 individuals at peak, respectively).

The status of the silver-spotted skipper 2000-2009

The following sections describe the findings of the 2009 survey, beginning with changes in the number and size of populations across South-East England, and concluding with a summary of distribution changes for each network. We then attempt to explain the findings in terms of the distribution and management of habitat, in combination with the effects of climatic changes.

Number and size of populations

The total number of silver-spotted skipper populations in South-East England increased from 237 to 316 between 2000 and 2009. The increase in the number of populations was largely due to the continued expansion of the species in Sussex, where the number of populations almost doubled, from 71 in 2000 to 140 in 2009. In the other networks there was no marked change in the overall number of populations. However, a number of former populations were lost and new locations were colonised (see “Colonisation and Extinction”).

The Sussex network contains by far the largest number of populations of the species, but here as elsewhere most of the populations are small. In fact, most populations in all networks were smaller in 2009 than in 2000 (Table 1). The number of large (peak emergence of more than 800 individuals) and medium (between 225 and 800 individuals) populations dwindled to approximately match those of 1982 (Figure 1), with the vast majority (94%) of populations now likely to be “small”. “Undefined” populations are those where butterflies were not counted on transects, but other evidence of the species’

presence was found (usually eggs). In most cases these may cautiously be interpreted as “small” populations, apart from to the east of the river Ouse in Sussex, where presence was largely determined by egg searches at the end of the flight period, but a number of medium or large populations may exist.

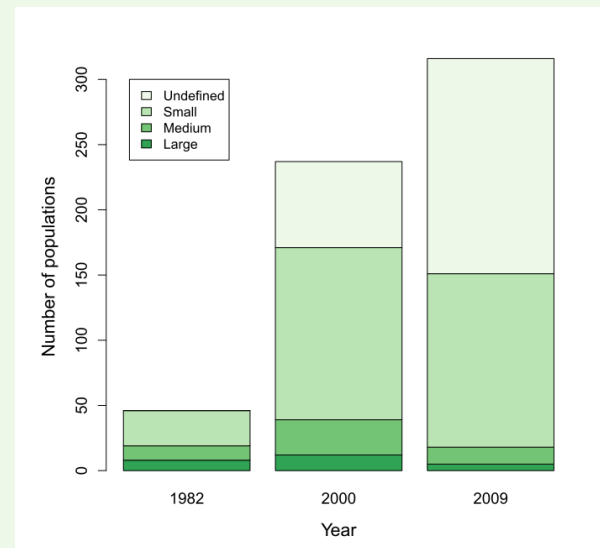


Figure 1: number of populations in each size class as calculated during the three major national surveys

Four out of five large populations were found in the Chilterns, whilst the Hampshire network consisted solely of small colonies (Figure 2). The size of many silver-spotted skipper populations was diminished in 2009 relative to 2000 across the region as a whole, probably related to several relatively cool summers during the butterfly’s flight period since 2007.

Size	Network					
	Chilterns	Hampshire	Kent	Surrey	Sussex	Total
Large (>800)	4 (4)	0 (1)	0 (2)	0 (3)	1 (2)	5 (12)
Medium (225-800)	3 (4)	0 (1)	3 (2)	4 (13)	3 (7)	13 (27)
Small (<225)	19 (24)	8 (5)	13 (14)	57 (60)	36 (29)	133 (132)
Undefined	16 (11)	9 (4)	15 (17)	25 (1)	100 (33)	165 (66)
Total	42 (43)	17 (11)	31 (35)	86 (77)	140 (71)	316 (237)

Table 1. Size classes of silver-spotted skipper populations in 2009, in its five networks in South-East England. The number of populations in the same size classes in 2000 are shown in parentheses.

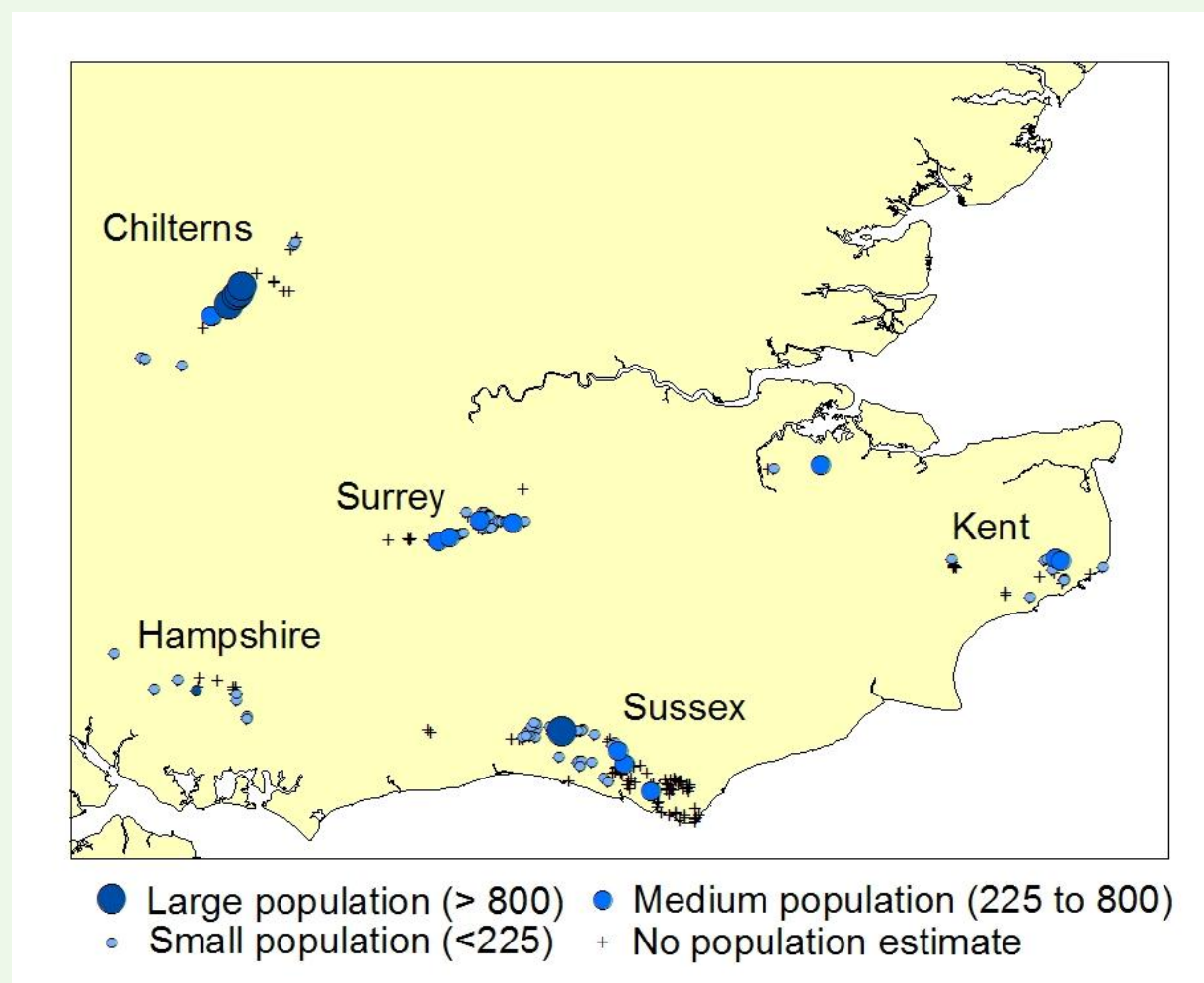
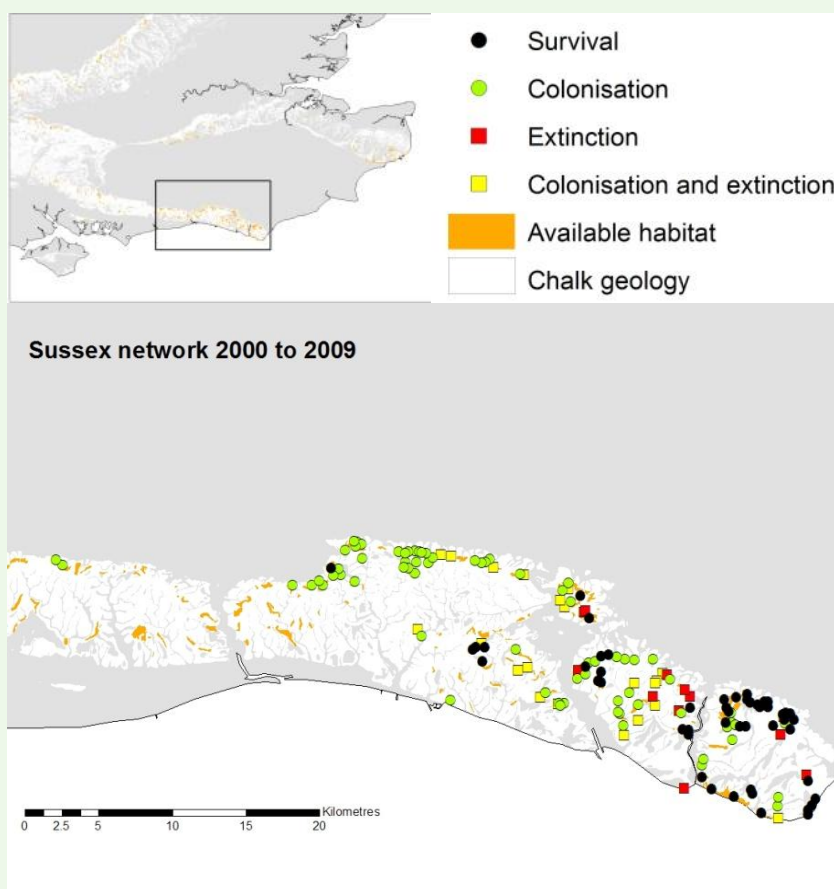


Figure 2: the location of silver-spotted skipper populations in South-East England in 2009, with symbols indicating their size

Changes in distribution



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East Sussex

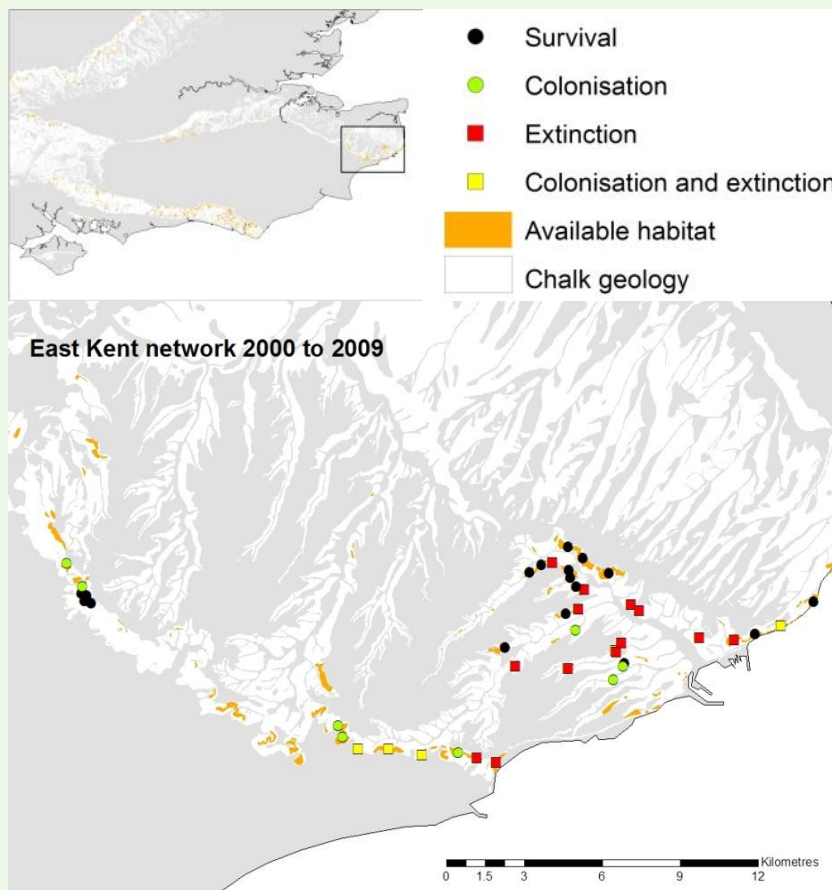
This region contains the densest network of suitable habitat within the species' current British range, and the estimated number of populations increased from 71 to 140 between 2000 and 2009. The species has continued its westward spread along the South Downs at an average rate of two kilometres a year, although this has taken place in a series of jumps, by establishing isolated footholds through long-distance dispersal, from which the surrounding available habitat has been colonised.

Since 2000 the species has consolidated its range between the rivers Ouse and Adur, occupying most of the available habitat in this stretch of the Downs, and has crossed the Adur to establish two populations at Kithurst

Hill, 18 km from the nearest colonised patch in 2000.

In contrast with previous surveys, there were a number of local extinctions in East Sussex, particularly in the core of the species range east of the Ouse, usually from relatively small or low quality areas of habitat, largely in terms of vegetation cover of bare ground and sheep's fescue grass, or topography (with extinctions more likely on cooler, more north-facing slopes).

The rate of spread in Sussex has been favoured by grazing management of chalk grassland in agri-environment schemes. There are still large areas of habitat to the west of the main expanding front of the distribution, and very good prospects that these will be colonised in the near future.



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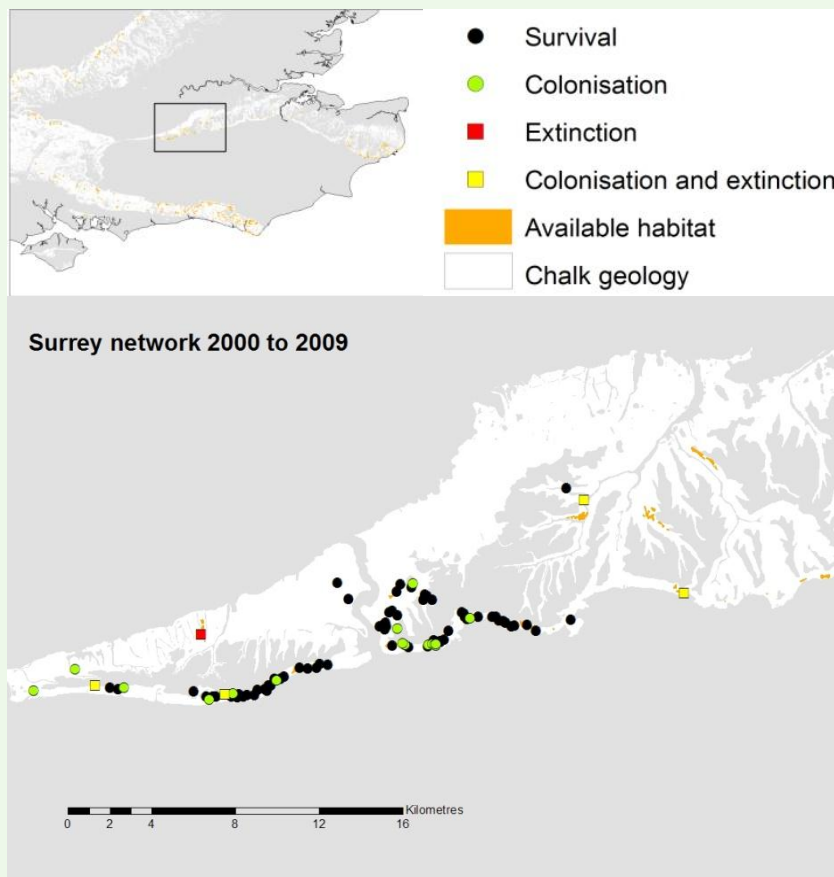
Kent

The total number of populations in Kent showed a slight decrease, from 35 in 2000 to 31 in 2009, but there were a number of colonisations and local extinctions in the network.

Kent Wildlife Trust's Lydden Temple Ewell Nature Reserve continued to hold the largest population of silver spotted skipper in this region. Small outlying populations were found on patches of unimproved downland around Dover, including persistent populations in the Ministry of Defence training areas, and on National Trust land at Fox Hill Down and Lighthouse Down. However, several small populations recorded in 2000 had gone extinct in the Dover area, mostly on marginal and unmanaged sites. Populations were scarce in 2009 on the south-facing escarpment of the Folkestone Downs: a population was found at Wingate Hill, but

previous populations at Dover Hill and at Folkestone Warren were apparently extinct. However, since 2000 a population had established in the Ministry of Defence Arpinge Training area. Large areas of suitably managed habitat exist within this area and, with continued appropriate management, have good potential to be colonised in the future.

The reintroduced populations on the Wye Downs have spread slowly since 2000, with two further small populations becoming established between 2000 and 2009. In west Kent (not shown), further spread is limited by the lack of suitable habitat; the large reintroduced population at Queendown Warren appears to be persistent but isolated. The reintroduced populations at Blue Bell Hill and Burham Down were still present, but apparently in very low numbers in 2009. These two populations exist in very small, isolated habitat patches with little potential to spread at present.

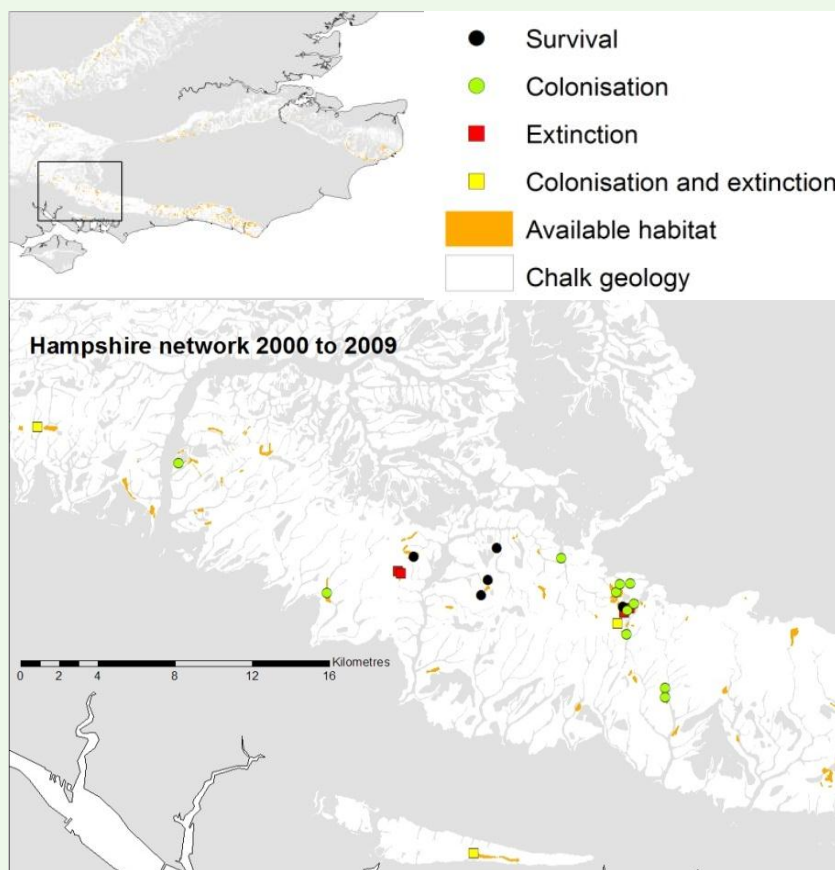


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Surrey

The core of the species range in Surrey, the steep south-facing escarpment of the North Downs between Guildford and Reigate, retained populations in most patches of suitable habitat from 2000 to 2009. The total number of populations increased slightly, from 77 to 86, and it is known that the species colonised, but subsequently went extinct, in at least four additional new sites during this period. This population network is largely managed for conservation by organisations such as the National Trust and Surrey Wildlife Trust, and is expected to be persistent. However, the apparent decline in bare ground cover in many habitat patches should be monitored carefully to ensure that it does not lead to declines in the silver-spotted skipper and other species which are associated with broken or short-turfed grassland.

The few colonisations and extinctions since 2000 have been largely limited to outlying patches of chalk grassland on the periphery of the core distribution, but there is limited suitable habitat for the species to expand further west and east. To the west, there is little habitat beyond the latest colonisation, at Pewley Downs in Guildford. To the east, one small population remains at Park Downs (Banstead), but small colonies which were established since 2000 near Banstead Woods, and at Quarry Hangers (Caterham) had disappeared by 2009. Suitable habitat further to the East, such as at Oxted Downs, is unlikely to be colonised unless the species first regains its foothold at Quarry Hangers, which would probably require several summers of good weather during the butterfly's flight period.



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Hampshire/West Sussex

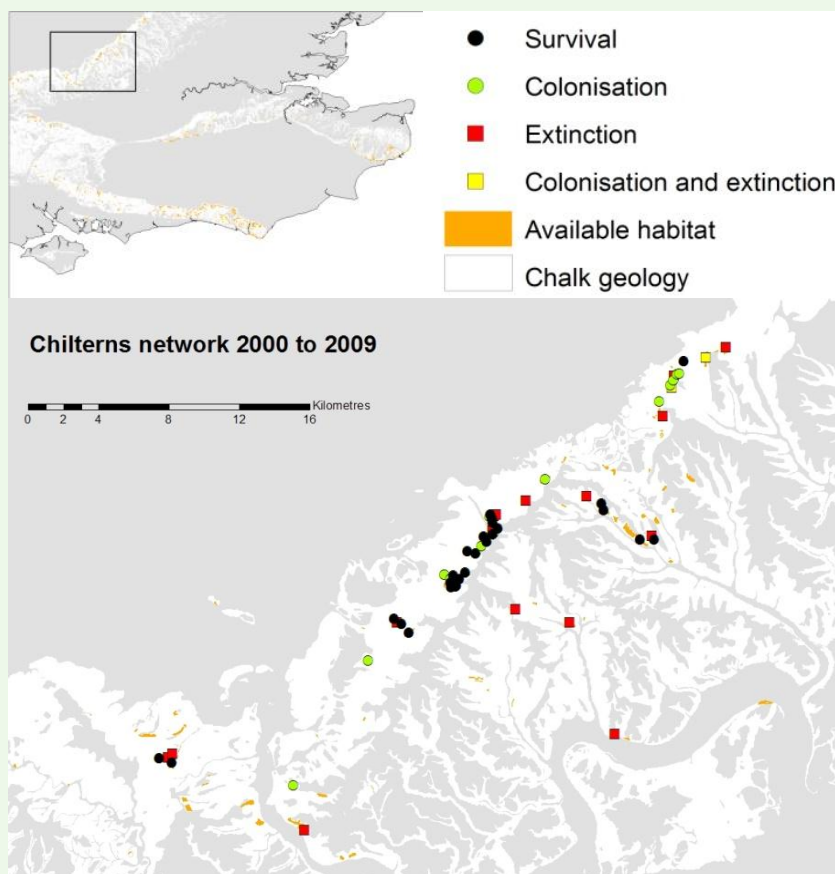
This network showed a slight increase in the number of populations, from 11 in 2000 to 17 in 2009.

Before 2000, the East Hampshire population network was dominated by large populations at the National Nature Reserves of Beacon Hill and Old Winchester Hill, and a few smaller outlying populations. By 2000, these had been augmented by a reintroduction and possible natural colonisation of hills around Queen Elizabeth Country Park / Butser Hill.

In 2009, no populations in the network were estimated to be large. Beacon Hill, which in 2000 was estimated to contain >3000 adults at peak, was estimated to have a peak population size of <100, almost certainly related to reduced grazing intensity, denser

vegetation, and reduced bare ground cover at the site. Populations at Old Winchester Hill remain important, while a few local extinctions but larger numbers of colonisations occurred in small habitat patches around Butser Hill.

Colonisations since 2000 were found at Stephens Castle and St Catherine's Hill in the west, and Charlton Down in the east. The species had been recorded as far west as Farley Mount in 2003, midway between the Hampshire populations and Stockbridge Down, and to the south on the isolated chalk outcrop at Portsdown Hill in 2005 and 2006. These sites may have been colonised during the warm summers in the first half of the decade. However, neither of the sites were found to have a population in 2009, and populations at these sites are assumed to be extinct.



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Chilterns

The number of populations in the Chilterns barely changed, with 43 identified in 2000, and 42 in 2009. However, as in other networks there were several colonisations and extinctions.

The main part of the species' distribution in the Chilterns is still comprised by a string of large populations along the scarp slope from Aston Rowant in the north to Swyncombe Downs in the south. Several of these populations are still large, but population size has declined since 2000, particularly in sub-optimal areas such as north-facing slopes, and on sites which are either grazed too heavily or insufficiently.

No clear expansion has occurred since 2000, despite the availability of habitat to the north in the Chilterns, and to the west of the few small populations around Aston Upthorpe in the Berkshire Downs. No adults or eggs were found in 2009 at Bacombe Hill, previously the most northerly recorded site, or at Hartslock, the most southerly site. Several other small populations on the dip slope of the chalk had also apparently gone extinct, although a number of relatively small and isolated populations do persist, and there have been a few colonisations around the fringes of the distribution since 2000.

Colonisation and extinction

To understand changes in the silver-spotted skipper's distribution, it is useful to consider that populations of the butterfly exist in discrete habitat "islands" separated by a "sea" of uninhabitable land. The silver-spotted skipper conforms well to this framework because its presence is largely determined by the availability of chalk grassland, which occurs in fragmented patches across South-East England. Populations can survive in these habitat patches from one year to the next, or can suffer extinction, for instance if habitat becomes unfavourable, or simply because of poor weather conditions. Favourable habitat patches can be colonised by silver-spotted skippers dispersing from other populations. In each particular region, the set of populations and habitat patches linked by dispersing butterflies can be referred to as a "metapopulation". The future survival of each metapopulation depends on the relative rates of colonisation and extinction, which are influenced by the area, quality and relative isolation of habitat. Occasional extinctions and subsequent re-colonisations of sites are expected to occur over time even in stable, healthy metapopulation networks.

From 2000-2009, 76 habitat patches were colonised, excluding two introductions of the

butterfly at Queendown Warren in Kent. However, in stark contrast to the findings of the 1982-2000 surveys, which saw the loss of just two silver-spotted skipper populations, there were 53 local extinctions from 2000-2009 (note that the true number of colonisation and extinction events will have been greater than those documented in either survey, since populations may be founded and extinguished during the intervening period). New colonies were also found at 52 previously unexamined sites, though these were not classified as colonisations since it is not known whether the butterfly was present in 2000.

The relative numbers of patches which were colonised and populations which suffered extinction between 2000 and 2009 were markedly different for the five networks (Figure 8). The Surrey metapopulation remained relatively stable through the decade, with few colonisations and extinctions; in contrast, the other networks show a high degree of population turnover, with the establishment of new populations in some patches offset by the loss of those elsewhere in the region. In Hampshire and particularly Sussex, colonisations exceeded extinctions and the metapopulations continued to grow. However, there have been slight signs of retraction in both Kent and the Chilterns, with an overall decrease in the

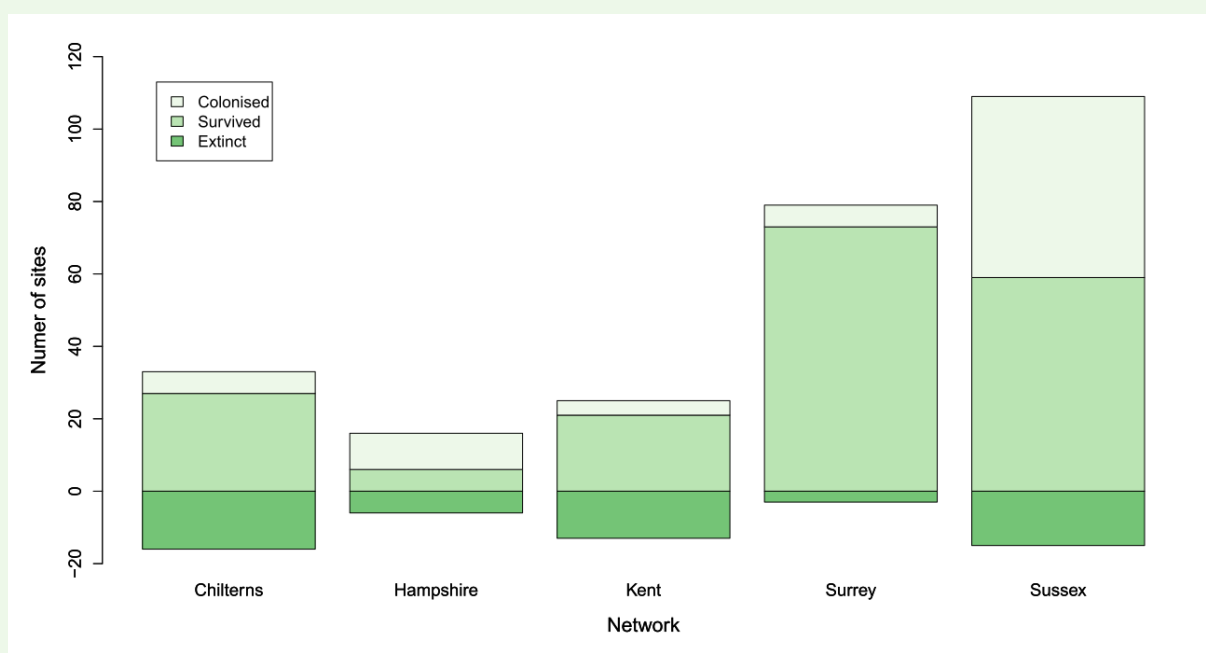


Figure 8: Colonisations, Survivals and Extinctions from 2000-2009 by Network

number of occupied sites.

One major reason why silver-spotted skipper metapopulations have fared so differently among networks is the relative availability of suitable habitat in close proximity to existing populations. New populations may only be founded if dispersing adult butterflies are able to reach new habitats, breed, and lay eggs in them. If the nearest empty patch of habitat is too far away, the chances of successful colonisation will be small. Virtually all (95%) of the habitat patches which were colonised between 2000 and 2009 were within 6 km of habitat where the species was already present in 2000, with the majority (55%) closer than 2 km to a population in 2000 (Figure 9).

The findings that habitat within 2 km of silver-spotted skipper populations stands a good chance of colonisation, and that habitat beyond 5-10 km is unlikely to be colonised, correspond well to the range expansion of the species between earlier surveys in 1982, 1991, and 2000. Generally, this species and other relatively sedentary insects will only be able to spread their distributions through networks in which there is a succession of suitable habitat patches within about 2 km of each other. As a result, the silver-spotted skipper has been able to spread more rapidly along the South Downs in Sussex than in the other networks. However, occasional long-distance colonisations, such as Kithurst Hill in Sussex,

18.5 km away from the nearest population in 2000, can be important for the spread of the species (Figure 9). The colonisation of Newtimber Hill in Sussex in 2000 was one such long-distance event, and has acted as a focus for many additional shorter-distance colonisations between 2000 and 2009.

In Surrey, most habitat patches are occupied, and although there remains some suitable empty habitat at the periphery of the present distribution, it is largely too far away from current populations for expansion to take place. This explains why relatively few colonisations took place in Surrey over the nine years between the two surveys. In the other networks, the skipper has sometimes failed to colonise apparently suitable habitat even when it is relatively close to existing populations. Moreover, local extinctions have been observed in all metapopulations. Both the failure to colonise suitable habitats and the extinction of some populations could result from low population sizes, and our estimates suggest that population size decreased for the species in most sites. In contrast, between 1982 and 2000 population size increased on most sites, and there were many more colonisations than extinctions. For the silver-spotted skipper, there are two potentially important drivers of these changes in population size: habitat management and climate change. The impacts of these factors are discussed in the following sections.

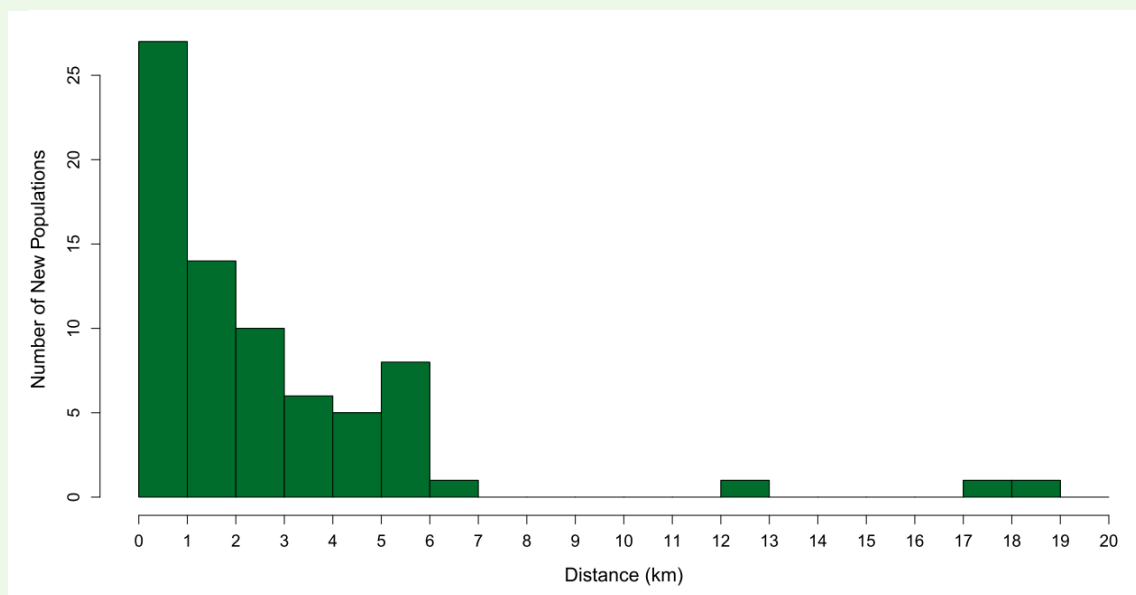


Figure 9: Distance of Colonisations between 2000-2009 from the Nearest Occupied Site in 2000

Habitat management

The silver-spotted skipper requires calcareous grassland with sheep's fescue grass growing in a short broken sward. Without an appropriate level of grazing, such habitat becomes unsuitable: too little, and vegetation becomes too tall and dominated by coarse grasses or scrub; too much, and sheep's fescue plants become unfavourable for egg-laying. For this reason, management of chalk grassland has a pivotal influence on the size and persistence of silver-spotted skipper populations.

In the 1980s-90s, the vast majority of sites with silver-spotted skipper populations were actively managed for conservation, by organisations such as Natural England (formerly English Nature / NCC), the National Trust, and the Wildlife Trusts. Sites managed by these organisations still represent 43% of silver-spotted skipper populations in South-East England, and a further 12% of populations are also managed by local councils, other statutory bodies, and the Ministry of Defence (MoD).

Since the expansion of the species, a larger proportion of colonies occur on privately-owned and managed land (44% in 2009). Populations are usually restricted to unimproved chalk grassland, so most of these sites (59%) are designated either as Sites of Special Scientific Interest (SSSIs); while a further 20% of private sites are managed under voluntary schemes (the Countryside Stewardship Scheme and Environmentally Sensitive Areas, which have now been superseded by the Environmental Stewardship Scheme). These schemes have played an important role in enabling the continuing range expansion of the species in parts of its British range, particularly on the South Downs in Sussex.

The approximately 10% of populations on land managed by conservation organisations which suffered extinction had usually been small populations in 2000 found on relatively unfavourable sites, such as north-facing slopes. There was a greater risk of extinction (29%) from sites under private ownership and

management (Figure 11). Encouragingly, however, the risk of extinction was lower on private sites included in obligatory conservation management schemes than on those with no formal management (Figure 12). There were too few sites on voluntary schemes to show clear evidence of a positive effect on chances of population survival, but many colonisations were observed in such locations.

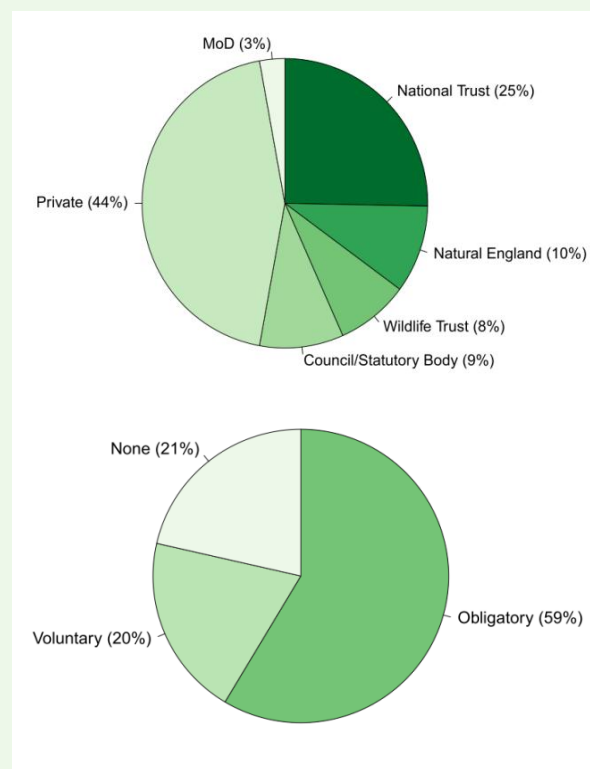


Figure 10: Top: Proportion of silver-spotted skipper populations on land owned by each manager; Bottom: proportion of populations on private land under each conservation scheme category. Obligatory – SSSIs; Voluntary – agri-environment schemes.

Overall, active management by conservation bodies, combined with the prevention of habitat destruction conferred by SSSI designation, has considerably increased the rate at which *H. comma* has been able to colonise new habitat patches. A more detailed analysis of how conservation actions have influenced the range expansion of *H. comma* in Britain, which statistically controls for other determinants of population presence, can be found in Lawson *et al.* (in review – see References).

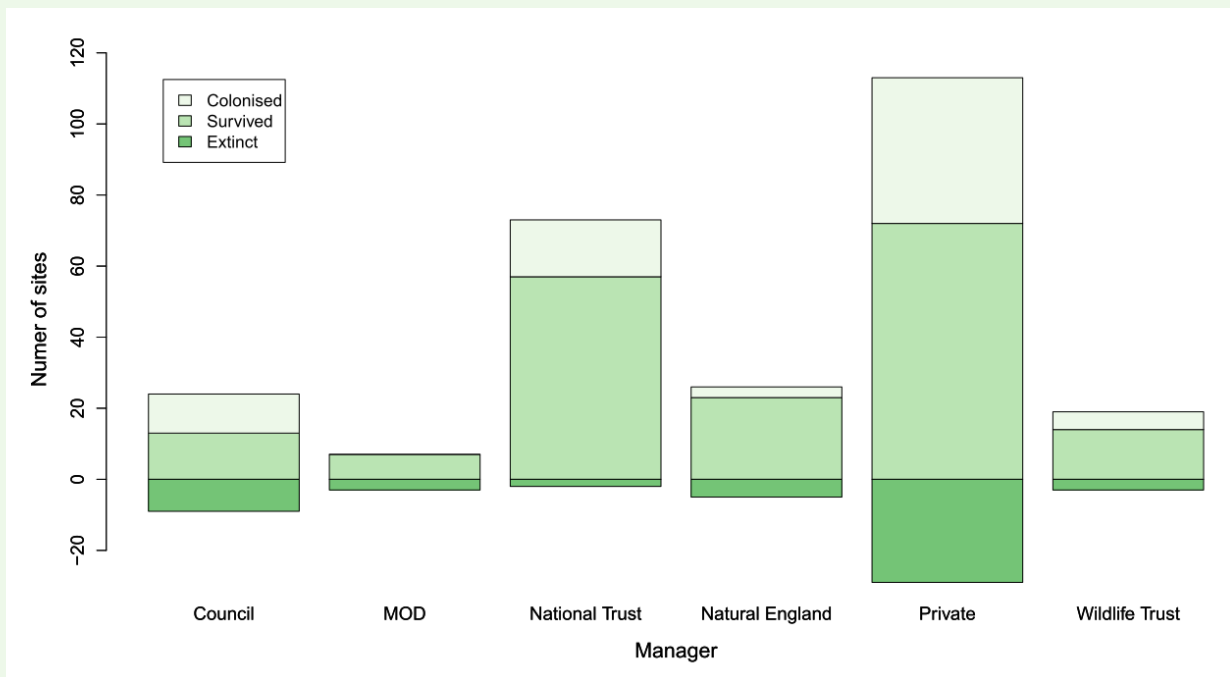


Figure 11: Colonisations, survivals and extinctions 2000-2009 on land with different managers

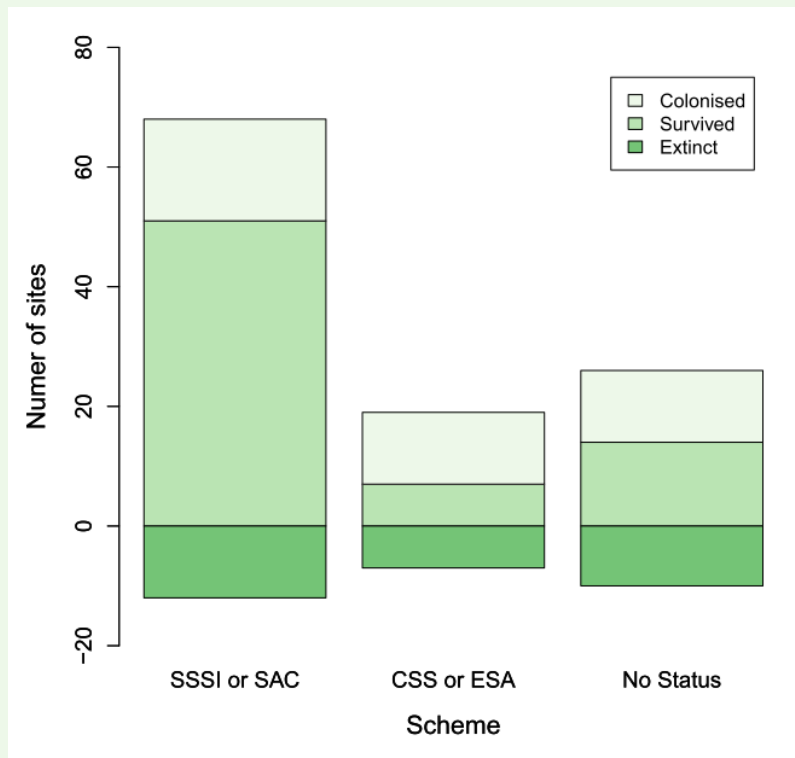


Figure 12: Colonisations, survivals and extinctions 2000-2009 on private land under different management schemes

Climate change

Research on the silver-spotted skipper over the last decade has revealed climate warming to be a key factor favouring the range expansion of the species. Since 1976, local and national trends in butterfly populations have been measured by the UK Butterfly Monitoring Scheme. Trends in the national silver-spotted skipper population are closely linked to temperature during the flight period, with increasing numbers observed in years when August is relatively warm (Figure 13). The trend towards increasing summer temperatures from the 1970s to around 2006 was accompanied by increases in the size of silver-spotted skipper populations. During this time, the skipper was able to colonise North-facing slopes that had previously remained unoccupied despite their close proximity to existing colonies. Furthermore, females were able to broaden their range of egg-laying sites: in 1982, eggs were laid predominantly on sheep's fescue plants growing next to bare ground, which heat up more quickly than

plants in denser swards, but by 2000, egg-laying was less restricted to such warm microsites. It is thought that warmer ambient temperatures catalysed the re-expansion of the silver-spotted skipper in Britain by broadening both the number of suitable habitat patches as a whole and the amount of suitable microhabitat for egg-laying within those patches.

Summer temperatures in 2007, 2008 and 2009 were comparatively cool, and the national index for the silver-spotted skipper declined over this period. Population sizes in the 2009 survey were lower than those in 2000, almost across the board, leading to the observed decrease in the number of medium and large populations at individual sites documented in this report. This decline in population size coincides with an increased number of local extinctions across all networks. In a reversal of the colonisation patterns observed from 1982-2000, extinction tended to occur on cooler North-facing sites, implying that temperature changes have indeed played a role.

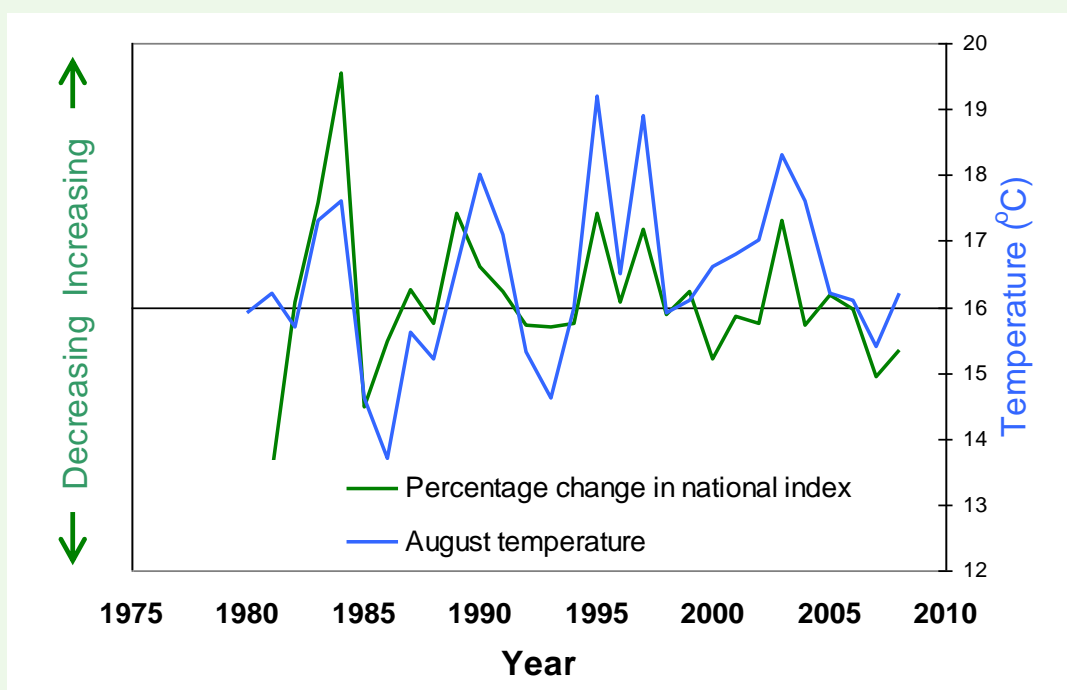


Figure 13: Changes in national population index of the silver-spotted skipper and mean August temperature for central England 1980-2008. National index data compiled using UK Butterfly Monitoring Scheme data are presented with permission from Butterfly Conservation and the NERC Centre for Ecology and Hydrology.

Conservation recommendations

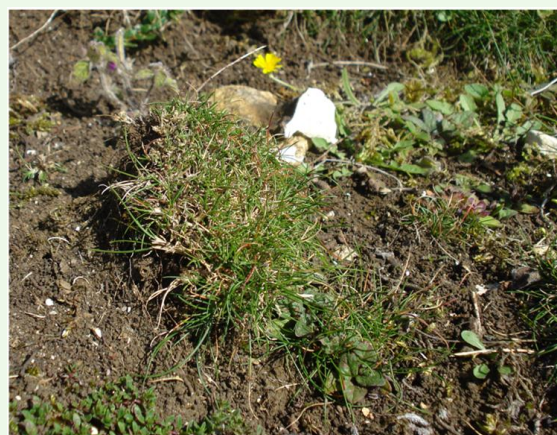
In the long term, summer conditions in South-East England are expected to become warmer, but with considerable interannual variation in temperature. What can be done to alleviate the impacts of these fluctuations on silver-spotted skipper numbers and reduce rates of local extinctions in cooler years?

Sensitive management through grazing of existing sites remains critical to sustaining viable populations of the species. The probability of population survival may be improved by providing a variety of microhabitats for egg-laying. If temperatures during the flight season are lower, it is likely that a higher proportion of bare ground next to sheep's fescue plants will be required for oviposition. This makes it important to maintain a mosaic of both sparse and denser sward, to cater for egg-laying in cooler and warmer years respectively. However, habitat assessments during the 2009 survey provide indications that the proportional area of bare ground had decreased in some networks, particularly Surrey, since 2000. Though this pattern itself may partly be climatically driven, grazing management to maintain relatively short swards at least in parts of sites could ease the severity of population declines in cooler years.



Above: Silver-spotted skipper habitat at Aston Rowant in the Chilterns. Maintaining well-grazed patches of chalk grassland containing the host plant, sheep's fescue grass, will be integral to the butterfly's continued recovery.

Due to the important impacts of grazing, local management of individual patches of calcareous grassland by respective owners is key to successfully managing the range expansion of the silver-spotted skipper. As temperatures rise, continued colonisation of unoccupied habitat networks will bring the silver-spotted skipper within reach of many new habitat patches, in which habitat management for this species may not have been considered. Continued monitoring of the British distribution of silver-spotted skipper will help to inform landowners when they are likely to see silver-spotted skippers colonising the habitats under their management.



Above: Example of an "ideal" host plant for the egg-laying by the silver-spotted skipper. Short tufts of sheep's fescue grass, surrounded by bare ground, provide warm microclimates which are important for egg-laying in Britain.

At the landscape scale, the creation and restoration of new habitat between isolated patches can facilitate the range expansion of the skipper when August temperatures are high. These "stepping stone" patches allow the intervening distance to be traversed in smaller, multi-generational jumps within the butterfly's usual dispersal range. Special consideration should be given to potential habitat patches within 6 km of existing sites. Conversely, any further fragmentation of short-turfed chalk grassland is likely to exacerbate the damage done in cooler years, because local extinction will leave suitable habitat isolated and devoid of nearby populations to permit recolonisation. A full

consideration of the roles of conservation at local (within habitat patches) and landscape-scales (among networks of habitats) is presented for the silver-spotted skipper in Lawson *et al.* (2012; see reference list).

The designation of areas of semi-improved grassland as Sites of Special Scientific Interest (SSSIs), and the uptake of Environmental Stewardship Schemes will remain important tools in maintaining appropriate management across many sites, aiding individual populations at local scales and ultimately facilitating the spread of the silver-spotted skipper throughout chalk grassland landscapes in Britain. However, active management of SSSIs remains an important component of their success in improving the colonisation of new habitat. Consideration of the important roles of protected areas and active habitat management is presented in Lawson *et al.* (in review; see reference list).

Artificial introductions may allow the butterfly to gain a foothold in networks too remote to be colonised naturally, and aid the restoration of the species to its former range. Here, evidence from introductions since the 1990s suggests that the choice of site is critically important. The population at Queendown Warren in Kent is faring well, but currently has little neighbouring habitat to expand into; in contrast, the introductions on the Wye Downs in Kent and Queen Elizabeth Country Park in Hampshire are close to networks of habitat and have led to a number of subsequent colonisations and consolidation of the species in the respective regions (although it is possible that both locations could have been colonised naturally during the period of expansion by the butterfly since the 1980s). If introductions are to take place, the location selected should be well connected to empty habitat networks, of sufficient size and quality to make the established population durable, and (conversely) isolated enough to make the expenditure on reintroduction a greater priority than management of land separating the site from current populations of the species. Given the silver-spotted skipper's

continuing expansion, introductions are not a priority for the species at present.



Above: two mating silver-spotted skipper butterflies. Courtship and mating primarily occur at high temperatures – one of the many reasons that climate change is likely to provide continued opportunities for the expansion of the silver-spotted skipper's distribution in Britain.

Climate change represents both an opportunity and an urgency to promote range expansions for species, especially given that many habitat specialist butterflies have failed to shift their distributions northwards despite recent warming. Work on the silver-spotted skipper demonstrates how habitat fragmentation is an important constraint on rates of range expansion, but also shows how good management of networks of habitat (such as in Sussex) helps to facilitate range shifts. Conservation managers can provide a mosaic of suitable microhabitats within patches to reduce the extent of declines in cooler years. In addition, the maintenance of large, good quality areas of habitats that are relatively close to each other can increase the landscape-level “connectivity” among habitat patches and populations of the species, to enhance expansions in warmer years. By combining these approaches it is hoped that the distributions of species like the silver-spotted skipper will be able to track suitable climatic conditions and recover from the declines due to habitat loss in the last century.

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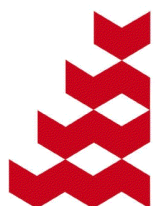
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