





Understanding the origins of the ring-necked parakeet in the UK

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Introduction

Biological invasions by alien species can have significant effects on native biota and are widely considered one of the most serious threats to biodiversity at the global level (Simberloff *et al.*, 2013; Hernández-Brito *et al.*, 2018). Indeed, aliens have been associated with almost one-third of known global species extinctions since 1500 AD, more than any other driver (Blackburn, Bellard & Ricciardi, 2019). Alien birds alone have been shown to have substantial negative impacts on native species through such diverse mechanisms as hybridization, predation, competition and spreading disease (Evans, Kumschick & Blackburn, 2016).

According to Shiels, Bukowski & Siers (2018), the ring-necked parakeet *Psittacula krameri* is the world's most successful introduced parrot and has established itself in at least 35 countries on five continents (Butler, 2003). A recent estimate suggested that the UK population numbered 8600 breeding pairs by 2013 (Musgrove *et al.*, 2013), up from 3500 in 1997 (Stone *et al.*, 1997). More recent estimates, covering 90 populations in 10 European countries, can be found in Parau

Abstract

The ring-necked parakeet *Psittacula krameri* is one of the best-known invasive species in the UK. It is also arguably the species whose origins as an invasive have been the subject of the greatest speculation, with explanations ranging from birds escaping from the set of the film 'The African Queen' to animals being released in Carnaby Street in London by Jimi Hendrix in the 1960s. Here, we use geographic profiling – a statistical technique originally developed in criminology to prioritise the large lists of suspects typical in cases of serial crime such as murder, rape and arson, but more recently applied to ecology and conservation biology – to analyse the spatial patterns of the ring-necked parakeet, from the first detailed records in the 1960s to the 21st century and ask whether spatial analysis supports these hypotheses. We show that, despite the undoubted appeal of the different hypotheses concerning their origin, spatial analysis provides no support for any of them, leading us to conclude that the birds' establishment in Britain is more likely to be a consequence of repeated releases and introductions, a view supported by a detailed search of the British Newspaper Archive. More generally, our study shows how geographic profiling can be used to understand the spatial patterns of biological invasions over time.

et al. (2016). The European populations of *P. krameri* largely derive from the Indian subcontinent (Jackson *et al.*, 2015), where they can be found in a range of habitats from semi-desert to light secondary jungle (<https://www.hbw.com/species/rose-ringed-parakeet-psittacula-krameri>). It is also considered a synanthropic species, meaning that individuals benefit from living within close proximity to humans, where they utilize the artificial habitats that humans create, for example, where domestic bird feeders diminish the necessity to seek out food during the winter months (Strubbe & Mattheysen, 2009; Clergeau & Vergnes, 2011).

Menchetti & Mori (2014) provide a comprehensive review of the impacts of alien parrots across the world, identifying a range of negative impacts, including competition with native birds and other animal species, effect on natural plant communities, economic consequences such as damage to crops/orchards or human facilities (e.g. electrical utility structures) and disease transmission, and provide examples of all of these categories for ring-necked parakeets, many in the UK. Other studies have also shown that ring-necked parakeets can have detrimental effects on both native species and socio-economic

activities in their alien range (Kumschick & Nentwig, 2010; Evans *et al.*, 2016). Crop damage – particularly for fruit growers and vineyards – is frequently cited as a problem (see, for example, Ahmad *et al.*, 2011), although there is little evidence of significant crop damage due to parakeets in the UK. A recent study in Belgium revealed a negative correlation between the abundance of ring-necked parakeets and nuthatches (Strubbe & Mattheysen, 2007; Strubbe & Mattheysen, 2009), while a significant reduction in populations of the noctule *Nyctalus lasiopterus* (classified as ‘vulnerable’ on the IUCN Red List of Threatened Species (Alcalde, Juste & Paunović, 2016)) was observed in Seville, Spain between 2003 and 2013, with the suggestion that the shared preferences of the two species for the occupation of tree cavities was the causal factor in the diminishing noctule numbers (Hernández-Brito *et al.*, 2014a, 2018). Examples in Menchetti & Mori (2014) include negative effects of ring-necked parakeets on dormice, bats, red squirrels and honey bees (see Table 2 in the same reference).

At the opposite extreme, Menchetti & Mori (2014) also identify some positive impacts due to alien parrots, for example, enlargement of cavities by *P. krameri* can benefit stock doves (*Columba oenas*) (Czajka, Braun & Wink, 2011), and there have been suggestions that *P. krameri* may be beneficial to smaller birds nesting close by, since the presence of the parakeets offers some protection against predation (Hernández-Brito *et al.*, 2014b). Menchetti & Mori (2014) cite instances of physical intimidation of raptors by ring-necked parakeets (e.g. Cramp, 1985) in the UK.

Stories of how *P. krameri* was introduced to the UK are as colourful as the birds themselves. Perhaps the most widely known is the suggestion that they initially escaped from the set of ‘*The African Queen*’, starring Humphrey Bogart and Katharine Hepburn, in 1951. Indeed, this suggestion was popular enough to form the basis of a 2007 BBC radio play by Lynne Truss (<https://www.bbc.co.uk/programmes/b00775bf>). There are numerous accounts of this story, often placing the filming at Shepperton Studios or Ealing Studios, although filming actually took place at Worton Hall Studios (Harris, 2013). An alternative explanation has it that Jimi Hendrix released two parakeets in London in 1968 (Brennan, 2016; Hunt, 2019), but hard evidence of this is difficult to find; another theory is that the birds escaped from a pet shop in Sunbury-on-Thames in the 1970s (Self, 2014). Slightly less glamorously, another theory claims that birds escaped from an aviary at Syon Park when it was damaged by debris falling from an aircraft in the 1970s or from a wide range of unspecified aviaries damaged during the ‘great storm’ of 1987. This storm took place overnight on 15th–16th October, featured winds of up to 160 kph, felled approximately 15 million trees and killed 18 people, causing widespread damage to the southeast of England (<https://www.metoffice.gov.uk/weather/learn-about/weather/case-studies/great-storm>).

Although the earliest record in the NBN Atlas (www.NBNAtlas.org) is from 1968, there are reports of *P. krameri* going back as far as 1855 in Norfolk, with another in Epping Forest in Essex in the 1930s, and the distinction between the origin or founding of the UK population and its later spread is unclear. The 1855 population did not persist, but breeding

populations were evidently established in the 1960s, with a family group of parakeets apparently observed in Kent in 1969. The range seems to have expanded in the 1970s, with the records of nests in Greater Manchester, Surrey, Essex, Kent, Middlesex and Berkshire (Butler, 2005). These dates argue against some of the hypotheses for the origin of the UK ring-necked parakeet population, which was already estimated at between 500 and 1000 birds in 1986 (Lack, 1986). However, the parakeet population grew rapidly between 1986 and 1999 (Python & Dytham, 2002), and it is possible that the introduction of individuals increased genetic diversity contributing to the elevated population growth rate.

Although there are several stories (which we might generously describe as hypotheses) about the founding of the UK ring-necked parakeet population, we are not aware of any evidence that might be useful in distinguishing between them. Here, we use the Dirichlet Process Mixture (DPM) model of geographic profiling (GP) to analyse the spatial distribution of ring-necked parakeets in the UK, with the aim of providing the first evidence in this regard. Geographic profiling was originally developed in criminology to prioritize the large lists of suspects – sometimes running into the hundreds of thousands – that typically arise in investigations of serial crime. In this context, GP uses the spatial locations associated with the crimes (e.g. victim encounter sites, vehicle dump sites, body dump sites) to generate a probability surface that is then overlaid on a map of the area of interest to produce a geoprofile (Rossmo, 2000). More recently, the model has been adapted to fit a Bayesian framework (Verity *et al.*, 2014; Faulkner *et al.*, 2016) and applied to biological data, from such fields as epidemiology (Le Comber *et al.*, 2011; Verity *et al.*, 2014), animal diseases (Smith *et al.*, 2015), conservation biology (Faulkner *et al.*, 2018; Struebig *et al.*, 2018), ecology (Faulkner *et al.*, 2015) and invasion biology (Stevenson *et al.*, 2012; Faulkner *et al.*, 2016).

In this last context, the model uses the current locations of alien species to infer the most likely areas from which they have spread. In a study of UK aliens, ranging from marine invertebrates to woody trees, and in a variety of habitats from marine to man-made, geographic profiling outperformed other models (e.g. spatial mean, spatial median, centre of minimum distance) in identifying locations of introduction for 52 of 53 species (Stevenson *et al.*, 2012). In a more detailed analysis, looking at the giant hogweed *Heracleum mantegazzianum*, GP also outperformed a kernel density model (Stevenson *et al.*, 2012). The significance of using GP lies in the fact that in conservation or invasion biology – just as in criminal investigations – resources will usually preclude exhaustive searches of large areas. Thus, methods that can be used to identify areas of high priority will allow more efficient, targeted interventions and better use of scarce time and resources (Le Comber & Stevenson, 2012).

In this study, we analyse records of ring-necked parakeets in the UK from 1968 to 2014 to ask whether geographic profiling can provide any support for the different hypotheses relating to their origins. Thus, we use records of bird sightings as analogous to crime locations and potential sources of introduction as ‘suspects’. Specifically, we ask whether the main ‘suspect’ sites – Worton Hall Studios, Syon Park and Carnaby Street – correspond to areas of high priority on the resulting

geoprofiles. We also carried out a systematic search of the British Newspaper Archive (<https://www.britishnewspaperarchive.co.uk/>) to try to identify stories relating to these 'suspect sites'.

Materials and methods

Data

Latitude and longitude for all records of ring-necked parakeets from the earliest (1968) to the most recent (2018) were obtained from www.NBNAtlas.org.

The Dirichlet Process Mixture model

The Dirichlet process mixture model was introduced in Verity *et al.* (2014) and extended in Faulkner *et al.* (2016). It provides a mathematically robust way of estimating the locations of an unknown number of sources using as input point pattern data originating from those sources. The model breaks down the difficult problem of estimating the locations of multiple sources into two much simpler problems using a Gibbs sampler (Geman & Geman, 1984), repeating these steps many thousands of times using standard Bayesian Markov Chain Monte Carlo (MCMC) methods until it converges on the posterior distribution of interest. In the first step, the model partitions the observations into clusters, conditional on the locations of the sources. In the second, the model estimates the locations of the sources, conditional on the clustering.

Model implementation

The DPM model described here was implemented in R (R Core Team, 2015) using version 2.1.0 of the package *Rgeoprofile*; this package is available at <https://github.com/bobverity/Rgeoprofile>. Model settings are explained in detail in Verity *et al.* (2014).

Data in the NBN Atlas include some records with precise latitude/longitude and some based just on grid square centroids. Clearly, where there are multiple records from the same grid square, there will be zero distance between these points. This can cause the DPM model to underestimate sigma, the standard deviation of the bivariate normal distribution around the source – essentially, the model's estimate of the cluster size. To avoid this, we followed the approach of Struebig *et al.* (2018), and first ran the model on unique locations only, using the settings $\sigma_mean = 10$, $\sigma_var = \text{NULL}$, $\sigma_squared_shape = 2$, $samples = 100\ 000$, $chains = 10$ and $burnin = 1000$. These settings correspond to a very diffuse prior on sigma, so that the model is free to fit the cluster size from the data. For all subsequent analyses, we used this fitted value of sigma with $\sigma_var = 0$ and $\sigma_squared_shape = \text{NULL}$, ensuring that the model fitted clusters of consistent size for each analysis.

We ran the model on (1) all records prior to 1980 ($n = 18$); (2) all records prior to 1987 ($n = 147$); and (3) 1988 ($n = 100$). Respectively, these correspond to the first reliable records, to data prior to the great storm in 1987 and to data immediately following the storm. We also ran data separately for each year from 1981 to 2003 inclusive, omitting years prior to this (when the number of records is too small to be informative) and also

years after this when records for each year are prohibitively high. For all of these analyses, the geoprofile was restricted to an area from -0.75 to 0.25 degrees longitude and from 51.3 to 51.6 degrees latitude. Records more than 30 km from this area were omitted from the analysis to save computational effort, since the fitted value of sigma of 9.17 km means that they will not affect the geoprofile in the area of interest.

Hit score percentages

The model's performance is assessed by the hit score percentage. A suspect site's hit score percentage is the proportion of the geoprofile that must be searched before that site is located. Thus, the lower the hit score, the higher priority the 'suspect' – in this study, a location likely to be the source of origin for spread. A hit score percentage of 50% is what would be expected from a random search. In criminology, hit score percentages <10% might be considered good.

Newspaper archive

We looked for historic evidence supporting the most well-known ideas concerning the parakeets' origins in the UK using a systematic search of the British Newspaper Archive. The British Newspaper Archive (<https://www.britishnewspaperarchive.co.uk/>) contains 31 230 010 pages and claims to contain most of the runs of newspapers published in the UK since 1800. Digitisation is ongoing, but in its earlier stages the project concentrated on cities plus local titles from London boroughs, so there is good coverage of the area of interest in this study over the critical period from the 1940s to the 1990s. Pages are searchable by word or combinations of words, with results then narrowed down by geographic area and date range. Pages tagged as advertisements (including numerous classifieds for parakeet sales) were not included in the analysis. Manual scanning of the remaining results determined whether a single article mentioned both 'Jimi Hendrix' and 'parakeets', for example, within the same article or whether the page contained two unrelated references in separate articles.

This was followed by extensive searches for stories relating more generally to escaped or released parrots and parakeets. Further searches then focused on several of these incidents. Details are shown in Tables 1 and 2.

The BNA expands by upwards of 100 000 pages per week so search results on a given subject may change rapidly. It is a historic archive: more recent news reporting is not available through the BNA due to copyright restrictions, so we also looked for reporting concerning parakeets' origins in the UK via Google to locate the oldest available online reference to the four most common origin myths.

Search terms are shown in Tables 1 and 2. The archive was accessed on 1 April 2019.

Results

Location data for ring-necked parakeets in the NBN Atlas comprised 107 921 records, from 1968 to 2018, coinciding with the established population in the 1960s (Figs 1 and 2).

Table 1 Search terms and results for search of British Newspaper Archive for each of the most popular accounts of the parakeets' origins in the UK

| Presumed origin | Search terms | Number of hits (number of hits after manual filter) | Notes |
|-----------------|--------------------------------------|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 African Queen | (a) African Queen + parakeet | (a) 0 (0) | na |
| | (b) African Queen + parrot | (b) 5 (0) | |
| | (c) African Queen + Pinewood Studios | (c) 2 (0) | |
| | (d) African Queen + Ealing | (d) 36 (0) | |
| | (e) African Queen + Worton | (e) 2 (0) | |
| | (f) African Queen + Shepperton | (f) 4 (0) | |
| 2 Jimi Hendrix | (a) Hendrix + parakeet | (a) 3 (0) | na |
| | (b) Hendrix + parrot | (b) 10 (0) | |
| | (c) Hendrix + Carnaby Street | (c) 30 (0) | |
| 3 Syon Park | (a) Syon Park + parakeet | (a) 1 (0) | (f) An article in the <i>Liverpool Echo</i> (22 nd October 1987) discusses the escape of two butterflies from the London Butterfly House when a tree fell through the glass roof. There is no mention of parakeets |
| | (b) Syon Park + parrot | (b) 76 (0) | |
| | (c) Syon Park + aeroplane | (c) 4 (0) | |
| | (d) Syon Park + airplane | (d) 0 (0) | |
| | (e) Syon Park + plane | (e) 22 (0) | |
| | (f) Syon Park + damage | (f) 109 (1) | |
| | (g) Syon Park + conservatory | (g) 400 (0) | |
| | (h) Syon Park + aviary | (h) 57 (0) | |
| 4 Great Storm | (a) Great storm + parakeet | (a) 124 (0) | na |
| | (b) Hurricane + parakeet | (b) 16 (0) | |
| | (c) Storm + parakeet | (c) 151 (0) | |
| | (d) Storm + parrot | (d) 6919 (0) | |

Geographic profiling

Restricting the analysis to 5072 unique records to prevent under-estimation of sigma (see Methods), the DPM model fitted a sigma of 9.17 km. Sigma is the standard deviation of the bivariate normal distribution surrounding the source, so 39% of observations would occur within this distance and 99% within a radius of three times this value.

The geoprofile based on the earliest records in the data set (1968-1979 inclusive; $n = 18$) is shown in Fig. 3a. Fig. 3b shows the geoprofile for the 147 records from 1968 to 1986 inclusive, that is, before the great storm of 1987. Fig. 3c shows the geoprofile for 1988, the year immediately following the storm, when the number of records jumps from 10 in 1987 to 100. Hit score percentages for each of these analyses are shown in Table 3.

Fig. 4a shows the yearly position of the peak nearest Worton Hall Studios from 1981 to 2004, with the suspect sites shown as blue squares. In Fig. 4b, all peaks in the study area from 1981 to 2004 are shown; note that in some years, there is more than one peak within this area.

Newspaper archive

Search results from the British Newspaper Archive are shown in Tables 1 and 2. A total of 3697 pages on the BNA contain the word 'parakeet' between 1804 and 2008. Search word combinations covered the four main origin myths – Jimi Hendrix, The African Queen, Syon Park and the Great Storm of 1987 – combined with 'parakeet' or 'parrot' among other phrases. This method ultimately did not locate a single item of archived news coverage in national, regional or local

newspapers documenting the escape or release of parakeets in any of these contexts (Tables 1 and 2).

Discussion

Spatial analysis shows no support for any of the popular theories about the introduction of *P. krameri* to the UK. None of the supposed sites of introduction show up prominently in the geoprofiles, with the possible exception of Shepperton Studios when we consider data from 1988. However, contrary to numerous reports, 'The African Queen' was filmed at Worton Hall and not Shepperton (Harris, 2013). This is perhaps not surprising: although the different stories about the parakeets are undoubtedly appealing, we know that the first parakeets in the UK pre-date all of these stories by around a century, and although none of these populations seem to have become established (Butler, 2005), the consensus among ornithologists is that their origins are more likely to be the result of repeated releases of pet birds. This is an important concept and one that should be taken into consideration when controlling invasive species in the UK.

This view is supported by the results of the search of the British Newspaper Archive. There are no accounts relating the parakeets to either 'The African Queen' or Jimi Hendrix until very recently. The oldest reference found to date for these specific stories is via BBC News online in September 2005 (<http://news.bbc.co.uk/1/hi/magazine/4371008.stm>). However, the newspaper archive does contain numerous accounts of accidental releases and escapes from numerous years. There are sightings of wild parakeets in the 1800s, including a breeding pair with five offspring living 'on familiar terms' with sparrows in the trees of Lincoln's Inn Fields, London, reported by *The Essex Herald* on 7th July 1886.

On 23 April 1932, the *Middlesex County Times* reported that parakeets had been spotted in Epping Forest and Loughton Cemetery. The newspaper credited the ‘parrot disease scare’ of 1931 for an increase in pet birds released into the wild. There is indeed a series of sensational accounts of human deaths due to psittacosis infections from parakeets across 1929 and into the early 1930s including ‘INFECTED BY PARROT – Theory of Doctor’s Fatal Illness – A Deadly Disease’ (*Nottingham Evening Post*, 14 December 1929) which highlighted the deaths of 300 parrots and 16 people in Paris in 1892, and the recent illness of a man who purchased a parrot in a London shop. Under the headline ‘RISK RUN BY KEEPING PARROTS’, the *Western Daily Press* (14 December 1929) noted that ‘a risk that may be run by the many people who keep parrots as pets was emphasised yesterday by a medical authority commenting on the death of Dr Daniel L. Thomas, Medical Officer of Health for Stepney’. The *Lancashire Evening Post* (‘PARROT DON’TS, 30 December 1929) relayed reports from Germany that Berlin authorities have ‘recommended people take precautions and not to allow parrots to kiss or bite them’. The articles refer to the psittacosis outbreak of 1929-1930 which became of global concern. Ramsay (2003) notes that it was first reported in England in 1929. Additionally, *The Londonderry Sentinel* on 10 March 1932 published an article about the death of a man and his parakeets in Cologne due to parrot disease. Bird imports were then banned for the next two decades by the Ministry of Health. With the fear of bird to human transmission, we can hypothesize that there may have been an increase in deliberate release of parakeets.

Another ‘parrot flu’ scare in 1952 may also have encouraged the public to release their pets. The BNA has 42 articles from 1952 found using the search term ‘psittacosis’, including ‘PARROT DISEASE SUSPECTED’ (*Biggleswade Chronicle*, 12 December 1952) following the death of a man in Birmingham, ‘STOP IMPORTS OF DANGER PARROTS’ (*Daily Herald*, 19 December 1952) and ‘PETS’ CORNER DEATH: NEW PARROT BAN?’ (*Birmingham Daily Gazette*, 19 December 1952). While only one death was reported, by early 1953 the Ministry of Health announced a new ban on bird imports following the spread of psittacosis to domestic poultry (‘PARROT DISEASE FOUND IN DUCKS’, *Birmingham Daily Gazette*, 10 January 1953). While the Ministry of Health advised only that ‘it is necessary to ensure disposal of infected birds and their contacts, not only to prevent spread of infection among poultry but also because of the possibility that human beings in close contact with infected birds might become infected’ (*Western Mail*, 10 January 1953), it is easy to imagine that these headlines may have led to swift release of pets. The increase in parakeets in the wild would also coincide nicely with the years immediately following the filming of ‘*The African Queen*’, perhaps providing an explanation for the popular idea that the birds had been released from the set. This, however, does not support the theory that the set of the ‘*The African Queen*’ was indeed responsible for the release of parakeets. Certainly, there is ample precedent for newspaper headlines causing strong public reactions; one of the most obvious examples is the autism/MMR scare in the UK in the 1990s and early 2000s (Deer, 2011).

Table 2 Search terms and total number of hits for search of British Newspaper Archive for stories about parakeet escapes or releases and psittacosis

| Search term(s) | 1900-1909 | 1910-1919 | 1920-1929 | 1930-1939 | 1940-1949 | 1950-1959 | 1960-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2009 | 2010-2019 |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Parakeet | 282 | 166 | 235 | 287 | 327 | 270 | 235 | 332 | 183 | 309 | 38 | 0 |
| Parakeet + escape | 15 | 6 | 14 | 16 | 5 | 15 | 11 | 2 | 5 | 4 | 5 | 0 |
| Parakeet + released | 10 | 6 | 7 | 7 | 5 | 16 | 3 | 10 | 8 | 5 | 0 | 0 |
| Parrot + fever | 1690 | 513 | 320 | 432 | 172 | 84 | 35 | 42 | 25 | 99 | 36 | 0 |
| Parrot + disease | 2679 | 1065 | 754 | 1778 | 228 | 296 | 109 | 123 | 55 | 115 | 57 | 0 |
| Parrot + influenza | 871 | 236 | 364 | 241 | 43 | 53 | 8 | 11 | 0 | 1 | 3 | 0 |
| Psittacosis | 5 | 0 | 28 | 933 | 42 | 218 | 39 | 71 | 9 | 11 | 6 | 0 |

As well as disease scares, numerous accounts of accidental escapes have been documented across the country, including the escape of 140 ‘foreign caged birds’ during a gale in Monmouthshire, Wales, with only a few of the ‘budgies, lovebirds and parakeets’ returning after being ‘carried far throughout the country by strong winds’ (*Western Mail*, 28 March 1955). With the ‘parrot flu’ scare now presumably over, *The Daily Herald* reported on 4 October 1961 that birds were by then the most popular pet in Britain, outnumbering dogs and cats put together. They estimated that there were around 11 million in the UK and 1200 caged bird societies, with 1 million budgerigars (*Melopsittacus undulatus*) bred in the UK each year. With such numbers, it seems likely that there would be many more escapes, either intentional or deliberate. On 20 August 1976, an article in the *Middlesex County Times* on exotic birds in Britain argued that most are escapees and parakeets are starting to crop up with increasing frequency due to ‘a succession of about a dozen mild winters’ helping them breed. ‘The ring-necked parakeet has begun to colonize in the London suburbs to the point where there is a population of about 100; indeed with its penchant for pears and plums the parakeet is in danger of becoming regarded as something of a pest’, it reported presciently.

Perhaps the most plausible of the stories of the parakeets’ origins in the UK is that numbers increased when birds escaped from aviaries that were damaged in the 1987 storm. The number of records jumps from 10 in 1987 to 100 in 1988, and it is certainly possible that birds that escaped in this way began to breed. In our view, though, these would have been in addition to other birds that had already been released – accidentally or on purpose – rather than the sole source of the current population. Indeed, as noted above, the UK ring-necked parakeet population was already at least 500 wild birds in 1986 (Lack, 1986), and birdwatchers at the time well knew that areas around Esher rugby club and the village of Wraysbury were reliable sites to find them for listing purposes (T.M.B. pers. obs.).

Although the lack of congruence between areas identified by geographic profiling and the supposed sites of introduction is informative in that it suggests none of the popular theories are correct, it is worth noting in passing that even if geographic profiling did identify – for example – Worton Hall, it is always possible that the legend arose as a consequence of the

high numbers of parakeets in that area potentially indicating the establishment of an ecological niche. In addition, the model used here does not incorporate spatial complexities, but current work is being done to incorporate additional geospatial information and varying dispersal parameters into the DPM model.

Spatial methods, such as GP, can improve the understanding of animal spatial patterns and can play an important role in the conservation of species. As such, novel applications, such as GP, should be attractive to policymakers and conservation managers. The use of GP is transferable, and it is applicable across many diverse jurisdictions and disciplines. It has been shown that it can be used to locate elusive animals, find sources of invasive species and help identify areas of human wildlife conflict and wildlife crime (Faulkner *et al.*, 2015, 2016; Struebig *et al.*, 2018). Other studies also identify its benefit in studies of epidemiology (Le Comber & Stevenson, 2012). All of these disciplines, including criminology, share a similar issue and that is they all cover large areas, and large remits. Given these similarities and the fact that resources and time are often limited, techniques such as GP can provide efficient and targeted strategies to solve conservation problems.

Conclusions

The urban legends relating to the origins of the UK’s parakeets will probably not be dispelled quickly, and we do not completely dismiss these theories but this study has made them less likely. The results reported here provide no evidence that the source of the parakeets’ spread is associated with any of Worton Hall Studios, Carnaby Street or Syon Park. In addition, the complete absence of news reporting on any of the four key origin stories is striking. Due to copyright restrictions and agreements with publishers defining the boundaries of what it can publish online, the BNA is not a conclusive archive, and it is impossible to determine that an article does not or did not exist purely because it is not currently available online. Nevertheless, this absence of evidence is at least consistent with the status of these stories as urban myths and also suggests that these stories did not originate in the print media. This is probably not surprising: as noted above, most ornithologists believe the parakeets’ spread in the UK is more likely to be a consequence of repeated releases and introductions, a view supported by our search of the British Newspaper Archive –

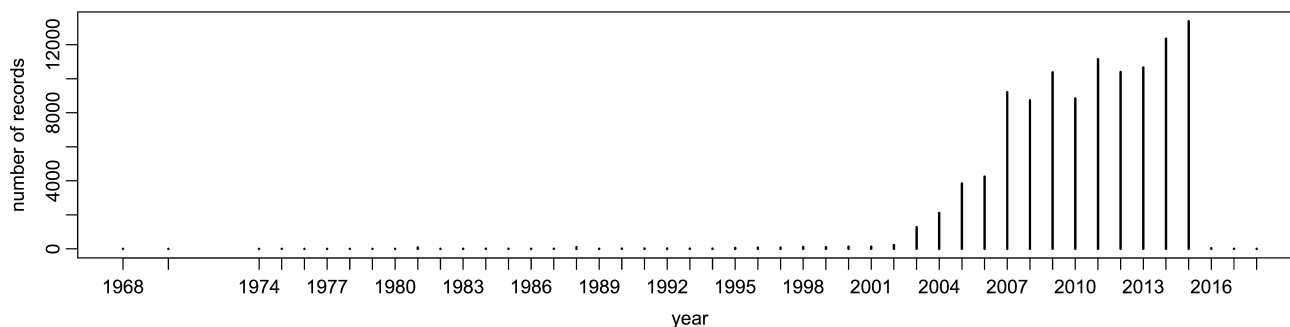


Figure 1 Numbers of records for *Psittacula krameri* per year in the NBN Atlas (NBNAAtlas.org).

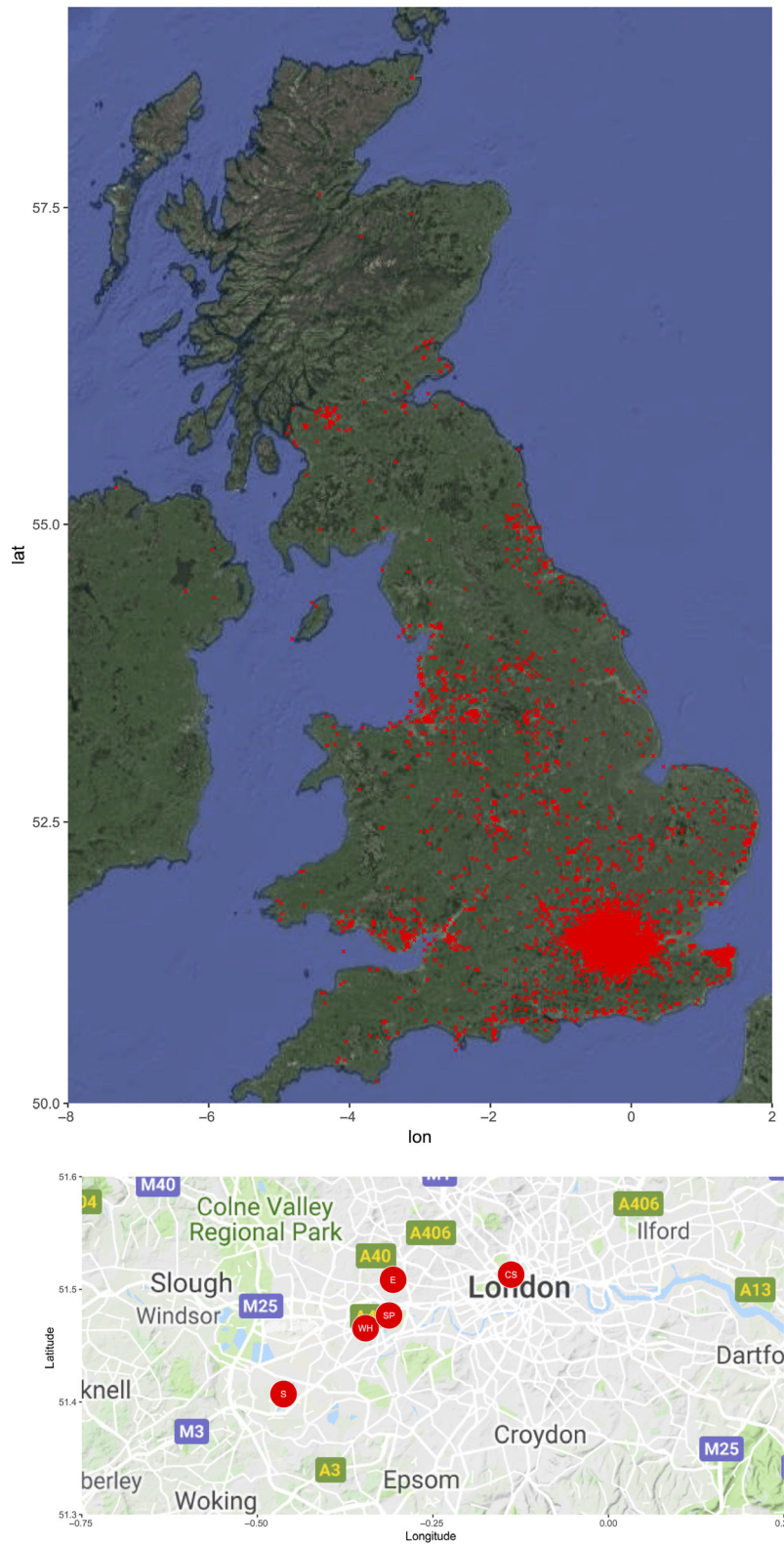


Figure 2 (a) Locations of all records for *Psittacula krameri* in the UK. (b) The supposed sites of introduction: S = Shepperton Studios; WH = Worton Hall Studios; SP = Syon Park; E = Ealing Studios; CS = Carnaby Street.

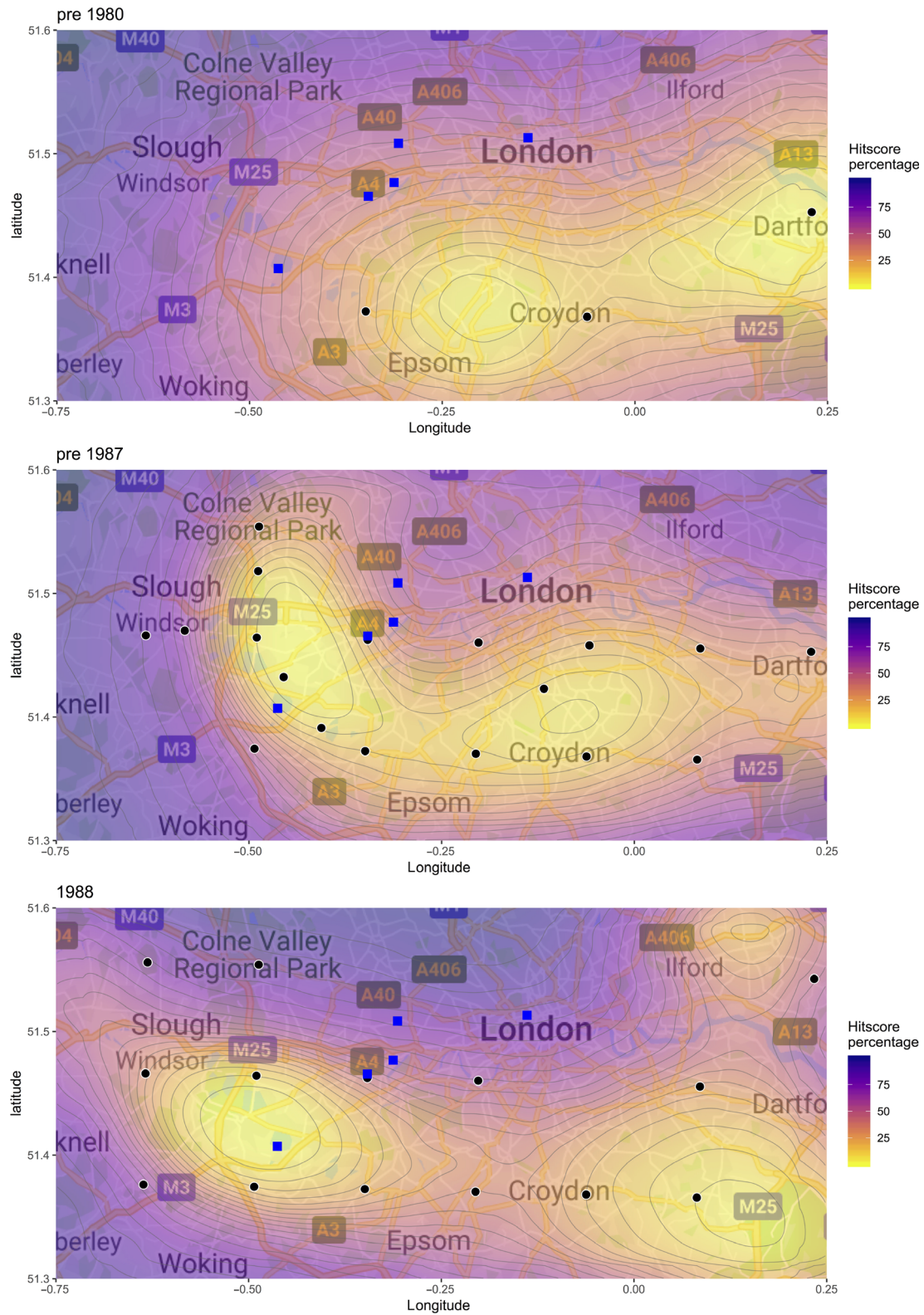


Figure 3 Geoprofiles for (a) all records prior to 1980; (b) all records prior to 1987; and (c) records for 1988. Blue squares plot the locations of the supposed sites of origin. Black circles show locations of parakeet sightings.

Table 3 Hit score percentages for each of the sites associated with stories of the parakeets' origins in the UK, for (a) all records before 1980; (b) all records before 1987; and (c) 1988

| Geoprofile | Carnaby Street | Ealing Studios | Shepperton Studios | Syon Park | Worton Hall Studios |
|--------------|----------------|----------------|--------------------|-----------|---------------------|
| (a) Pre-1980 | 53.0 | 53.8 | 45.5 | 40.1 | 40.9 |
| (b) Pre-1987 | 53.2 | 54.4 | 6.9 | 42.8 | 24.3 |
| (c) 1988 | 82.0 | 77.1 | 0.7 | 62.8 | 46.6 |

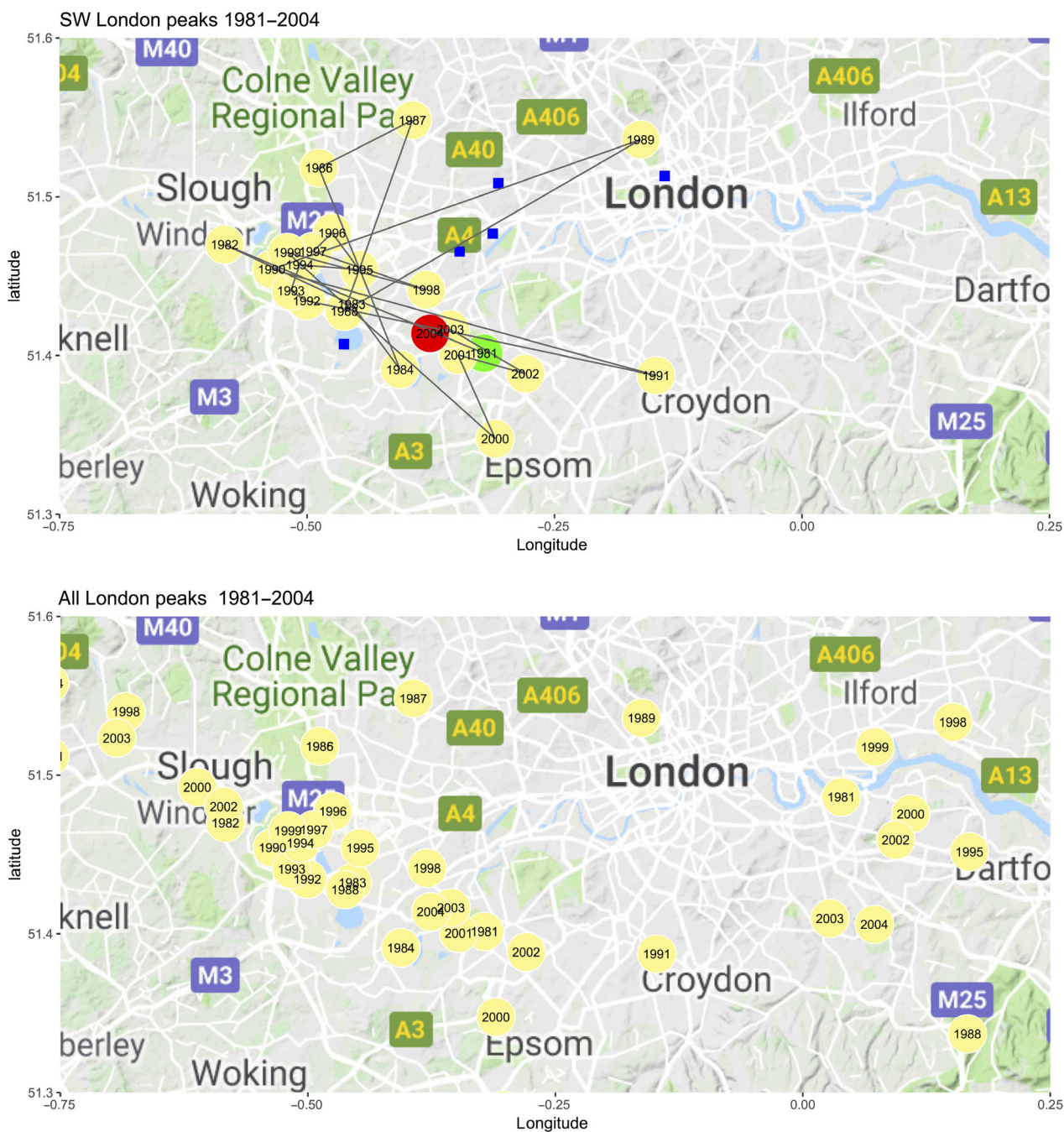


Figure 4 (a) Yearly position of the peak nearest Worton Hall Studios from 1981 to 2004, with the suspect sites shown as blue squares. Green and red circles mark the peaks in 1981 and 2004 at the start and end of the analysis, respectively. (b) All peaks in the study area from 1981 to 2004. Note that in some years there is more than one peak within this area.

perhaps aided by escapes from aviaries during the 1987 storm. Certainly, in the other 34 countries on five continents in which *P. krameri* has been recorded as an invasive (Butler, 2003), it has not needed the help of either rock stars or movie stars to become established.

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