# Mapping the distribution of feeding Pink-footed Geese in England

**A report by the Wildfowl & Wetlands Trust**

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# Executive summary

1. This report involved the collation of data and the construction of sensitivity maps to aid location of onshore wind farms in England, based on the feeding distribution of Pink-footed Goose *Anser brachyrhynchus*, with special reference to the Special Protection Area (SPA) network. The maps provide an indication of where wind farm development is most likely to come into conflict with this species; they are an indicative tool that enables the identification of areas where impacts of turbines on geese may be of concern and others where impacts on geese may be minimal. However, the lack of structured surveys means that currently the maps do not replace the requirement for site specific survey to fully assess local levels of feeding activity.

2. No systematic/standardised recording of goose feeding distribution is currently in place. Instead, records of geese were gathered from a variety of sources, including the location of flocks containing colour-marked individuals, flocks of feeding geese observed for breeding success assessment, *BirdTrack* data, county bird records, and *ad hoc* records supplied by goose counters and other birdwatchers.

3. In total, 20,009 Pink-footed Goose records were used to map the feeding distribution in England. These were summarised and plotted in 2,593 1km squares. It should be noted that the maps show patterns of distribution based on the identified data sources only. Some historic and recent data sources have yet to be collated, and the intention is to update distribution data in the future.

4. The primary outputs of the project were an attributes table (in MS Excel) giving distribution data at the 1km square level and Geographical Information System (GIS) layers (shapefiles). Examples of the latter are provided in this report. Raw data were also provided in a separate spreadsheet so that details of records for an individual 1km square can be cross-referenced.

5. Care should be used when interpreting the maps since the distribution of geese in the wider landscape can change over time. In addition, the number of records in particular areas can vary over time which can also affect the apparent distribution. This is particularly true of records of colour marked individuals; as ringing projects stop, the number of records decreases and this can lead to under representation of data.

6. No liability is accepted for the presence or absence of species at particular sites contrary to that indicated on the map.

7. The maps will need to be reviewed and updated as new data become available. The sensitivity criteria should also be reviewed as new research methods for the analysis of non-standardised distribution data are developed.

8. A rolling programme of bespoke standardised surveys in areas used by feeding Pink-footed Geese would provide a more representative picture of their feeding distribution.

9. Promotion of the results of this study will be used to encourage among birdwatchers the value of recording feeding geese. It is suggested that *BirdTrack* provides the most suitable system for collating *ad hoc* records, whilst the Goose & Swan Monitoring Programme network is the most suitable mechanism for the development and coordination of bespoke surveys, which is the ideal way of assessing feeding distributions.

10. This feeding distribution study provides a platform for extending analyses to other important waterfowl species feeding in cropped habitats away from waterbodies.

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# 1 Introduction

A strategic approach to planning the location of wind farms can be of benefit to safe-guarding bird species, many of which are protected under European law. Geese can be affected by wind farms through collision mortality, displacement from feeding sites and disturbance. Displacement from feeding areas can result from avoidance of the turbines by feeding geese (Larsen & Madsen 2000), although there is recent evidence that some geese may habituate to turbines (Madsen & Boertmann 2008). Collision mortality is thought to be low in geese, which appear to be efficient in avoiding turbines (Patterson 2006, Plonczkier & Simms-, 2012-), and current SNH advice is to use a 99% avoidance rate in collision risk calculations, though Natural England advise different rates and are currently reviewing evidence to determine the most appropriate avoidance rate. However, even if the predicted number of collision casualties is low at any given wind farm development, the cumulative impact could become significant if large numbers of turbines were to be built in areas with high densities of feeding geese. This could be especially significant in areas around Special Protection Areas (SPAs) designated for their significant goose roosts.

This report documents the construction of sensitivity maps to aid the location of onshore wind farms in England, based on the distribution of Pink-footed Geese *Anser brachyrhynchus*, with special reference to the SPA network. The maps provide an indication of known areas where wind farm development is most likely to come into contact with this species. However, the nature of the data mean that there is a possibility that other important areas remain undetected, as bespoke surveys have not been carried out. The maps are therefore an indicative tool that aids the identification of areas where impacts of turbines on geese maybe of concern and others where impacts on geese may be minimal helping with smarter planning for future on-shore wind farms. However, it is important to note that the maps may not replace the requirement for site specific survey to fully assess local levels of feeding activity in relation to individual development proposals.

This work builds upon the analysis of feeding distribution data for Pink-footed Goose and Iceland Greylag Goose in Scotland carried out by Mitchell (2012a). It is envisaged that in time a national dataset for all native goose and swan species will be collated, and a rolling programme of structured surveys developed and implemented.

## 1.1 Pink-footed Geese

The Pink-footed Goose breeds primarily in central Iceland and in smaller numbers along the east coast of Greenland (Mitchell *et al.* 1999). In early autumn, the geese migrate to winter exclusively in Britain. The British wintering population is discrete from the Svalbard population wintering in the Low Countries and Denmark (Madsen *et al.* 1999).

Regular autumn counts of Iceland/Greenland Pink-footed Geese started in the early 1950s and were systematic from winter 1960/61. During the early autumn, *c.*90% of the population can be counted on as few as 30 roost sites (Mitchell & Hearn 2004). The census, now known as the Iceland-breeding Goose Census (IGC) continues today and is organised through the Wildfowl & Wetlands Trust (WWT) / Joint Nature Conservation Committee (JNCC) / Scottish Natural Heritage (SNH) Goose & Swan Monitoring Programme. The IGC provides an accurate assessment of abundance (Frederiksen *et al.* 2004) and indicates that the population increased from *c.*60,000 birds in the early 1960s to *c.*225,000 in the mid 1990s and *c.*350,000 by the late 2000s, before declining to *c.*250,000 in 2011 (though some degree of undercount is likely in this most recent estimate; Mitchell 2012b). The winter population is distributed in the east and south of Scotland, and north west and east England. In England, small numbers also formerly wintered on the Severn Estuary and the Cambridgeshire fens and washes (Mitchell & Hearn 2004). Range contraction in the wintering quarters, from the early 1950s to the early 1970s, saw decreases in numbers at these southernmost areas, with increases in numbers in east central Scotland. This was largely reversed from the late 1980s, when increasingly large numbers began using agricultural land in Lancashire and, notably, sugar beet tops in north Norfolk (Gill *et al.* 1996).

Resightings of individually marked birds have shown autumn dispersal from Scotland into Lancashire and then Norfolk. Some birds migrate down the east coast from Scotland directly to Norfolk without visiting Lancashire. Furthermore, resightings, especially those made in early September, also suggest that some birds may arrive directly into Lancashire without having visited Scotland, though lack of satellite telemetry studies means that this cannot currently be confirmed. Return movements northwards start in spring through England and southern Scotland to important staging areas in east and north east Scotland and the Moray Firth (Fox *et al.* 1994).

Since the mid 1990s, numbers have continued to increase up to a maximum of 364,212 in 2008/09. Despite this eight-fold increase in numbers, the early autumn distribution of Pink-footed Geese in Britain is largely congruent with earlier years (Figure 1), as birds are particularly loyal to established roost sites. Thus as the national population has increased, numbers at many individual roost sites have similarly increased. However, a few roosts have seen dramatic decreases in use. For example in Scotland, Dupplin Loch, Perthshire, previously held 62,000 birds in October 1994 (a quarter of the then population), but the five year peak mean for 2004/05 to 2008/09 was only *c.*700 birds. No roosting sites in England have shown such dramatic decreases in roosting numbers.



**Figure 1.** Distribution of Iceland/Greenland Pink-footed Goose population during the non-breeding season (based on autumn IGC counts, five year mean peak counts 2007/08 to 2011/12).

The main winter habitat is thought to have been saltmarsh (Owen 1976) but from the late 19th century, the species moved inland to feed on farmland, taking advantage of reservoirs and, other freshwater bodies for roosting. Pink-footed Geese tend to be faithful in their use of roosts (Owen *et al.* 1986), although these may shift locally in response to disturbance or feeding conditions (Giroux 1991). In north east Scotland, 82% of Pink-footed Geese foraged within 8km (median distance 4km) of traditional roost sites (Bell 1988) though at times they may fly up to 30km from their roost to feeding sites (pers.obs.). Broadly, most studies of habitat use show that Pink-footed Geese prefer stubble fields in autumn gleaning the spilt grain, with grasslands preferred from mid winter onwards (Forshaw 1983, Bell 1988, Gill 1996). Fox *et al.* (1994) put these patterns into a national context, suggesting that Pink-footed Geese feeding mainly on grass in spring (principally *Lolium perenne,* the main constituent of the sown sward) were responding to a gradient of plant growth, particularly the high protein content associated with the onset of growth. The geese moved north within Britain progressively utilising the late occurrence of the 'spring bite' as they move towards their ultimate destination – the breeding grounds of Iceland and Greenland.

# 2 Methods

## 2.1 Data sources

Information on the feeding distribution of Pink-footed Geese is not currently routinely collected for any national recording scheme and so data from a variety of disparate sources were collated. These included;

- sightings of marked geese (collated by WWT);
- counts made when undertaking goose age assessments as part of the Goose & Swan Monitoring Programme (GSMP);
- data from the 2004/05 WWT SPA feeding distribution study – goose counters provided non-numeric information on the distribution of feeding geese relative to SPAs;
- *BirdTrack* data collated by the British Trust for Ornithology (BTO);
- *Ad hoc* bird records supplied by county recorders, goose counters and other birdwatchers.

A full list of data sources is given in Appendix 1.

*BirdTrack* data collated by the BTO offered the potential for a large number of goose records. However, the majority of these records were collected in such a way that it was impossible to determine if the geese were feeding on the ground or flying over the site and so use of them was limited for this study. Nevertheless, sightings of Pink-footed Geese recorded in *BirdTrack* were used in this analysis, since it is likely the majority do refer to feeding birds, and the way the data were treated is explained below (see 2.3.3).

Counts of geese on water bodies were excluded because the aim of this study was to map feeding distributions only; much information already exists on the use of water bodies by roosting and loafing geese through the IGC and Wetland Bird Survey (WeBS). However, in cases where it was not known if a count in a 1km square referred to birds on a water body or feeding nearby, the count was included because it is likely that the majority of such counts are at feeding locations near to roost sites or other water bodies. In some cases, e.g. Holkham, a high proportion of feeding occurs close to the roost, therefore the exclusion of such counts could mean that a significant proportion of the available data were excluded.

Data were collated for the period 1986/87 to 2012/13. Winter seasons were considered to run from September through to April (*i.e.* season 2011/12 refers to records from September 2011 to April 2012 inclusive).

## 2.2 Data precision

All records of Pink-footed Geese were recorded at the 1km square level (*e.g.* NH1234). No records of geese recorded at the 10km level (e.g. NH12) or tetrad level (*e.g.* NH12V) were included in this analysis. Plotting feeding distribution at the field level was beyond the scope of this study, and in any case few data exist at this level of precision.

The 1km square scale for mapping was considered a sufficiently fine resolution to be of use to local planning authorities and other decision makers.

The maximum reliably recorded distance at which geese have been disturbed by wind farms is 600m (Kruckenberg & Jaene 1999). Therefore, as the majority of records were recorded at the 1km level and it was not possible to tell where in the square the geese were located, the 1km square was not buffered in any way.

## 2.3 Data manipulation

### 2.3.1 Manipulation of count data

All counts of less than 10 geese were excluded from the analysis because the majority of these were reported via *BirdTrack* as sick or injured. Duplicate counts were also removed. These occurred, for example, when two or more marked birds were seen in a flock or when a marked bird was seen when undertaking an age count and the flock details were recorded twice. In order to stabilise the variance of the samples, counts of geese were log transformed (natural logarithm).

Prior to mapping data were pooled within each of three time periods: *i.e.* 1986/87 to 2007/08 (old); ii) 2008/09 to 2012/13 (new); and iii) 1986/87 to 2012/13 (all). The 2008/09 to 2012/13 time period represented the most recent five year period of the available data. To remove the possibility of a single year (or count) influencing the analysis, the mean of the natural logarithm of the annual peak counts for each 1km square was calculated for each of the three time periods.

Some records had no quantitative data (*i.e.* no count). These included data from colour ring sightings, which involved at least one bird, but where no flock size had been recorded. These records were allocated a code for 'present' only and were excluded when determining the mean of the annual peak counts. If, after determining the mean of the annual peak count, a 1km square had a mean of zero, but had records of geese being present, the 1km square was allocated a code for 'present only'. For the mapping exercise, such squares were identified separately (as small red dots; see Key in 3.1).

Creating accurate distribution maps based on records that are collected in a non-standardised way is difficult. A lack of standardised surveying, where the absence as well as the presence of geese in defined areas is known, for the vast majority of the wider countryside severely limits the spatial/statistical analyses that can be performed on such data.

### 2.3.2 Frequency of counts

The total number of counts for each 1km square in the three time periods (old, new and all) was calculated. The counts were then ranked (lowest to highest). The number of counts corresponding to various percentiles above zero were then determined. For each time period, each 1km square was allocated a 'Frequency Index' based on the following criteria:

| Percentiles | Number of counts | | | Frequency Index |
|---|---|---|---|---|
| | Old records 1986/87 to 2008/09 | New records 2008/09 to 2012/13 | All records 1986/87 to 2012/13 | |
| 0-25% | 1 | 1 | 1 | 0.7 |
| 25-50% | 2 | 1 | 1-2 | 0.8 |
| 50-75% | 3-4 | 2-3 | 3-4 | 0.9 |
| 75-100% | >4 | >3 | >4 | 1.0 |

## 2.3.3 Quality of count data

Goose feeding distribution records were collected in many ways and from a variety of sources (see Appendix 1). Where the count and location were known to be accurate records were allocated a 'Quality Index' of 1.

*BirdTrack* records, where it was not known if the geese were feeding in or flying over the 1km square, were allocated a Quality Index of 0.9. For any records where no flock size was recorded, but 1 km squares were indicated as supporting feeding geese, records were also allocated a Quality Index of 0.9.

Where several sources contributed count data to a single 1km square, the highest Quality Index was used in preference to all other Quality Indices. That is to say, if a 1km square held count data from six different sources, the presence of a single count with a Quality Index of 1 meant that that index value was allocated to the square.

## 2.3.4 Sensitivity Index

In order to map the distribution of feeding geese for this study, a Sensitivity Index (or score) for each 1km square was calculated. Three sources of information/data contributed to the Sensitivity Index:
  i)       the mean of the natural logarithm of the annual peak counts (see above);
  ii)      a measure of count frequency for each 1km square;
  iii)     an assessment of how accurate individual counts of geese were considered to be (quality of counts).

The derived Sensitivity Index was dependent on the parameters included and the weighting given to those parameters. It was considered that mean flock size should have the greatest weighting, since this was more independent of survey effort (which varied significantly across the country) and therefore considered to most closely reflect goose activity in the 1km squares. Count frequency and count quality were given lower weightings due to their uncertainty (see below). This means that the maps are precautionary. It should be noted that the Sensitivity Index is simply an example of use of the raw data (which have been provided to Natural England). Alternative Sensitivity Indices, or other ways of identifying core feeding areas, could be derived if necessary. The details of how the Sensitivity Index for a 1km square was calculated are given on page 13 in Mitchell (2012a)[1]. The same methodology was followed for the current analysis.

For each of the three time periods a separate Sensitivity Index value for each 1km square was calculated by multiplying together the natural log of the annual peak counts, by the Frequency Index and the Quality Index. One km squares were ranked (lowest to highest) and various percentiles determined. For maximum comparability, equal subdivisions were used. These corresponded to 0-25%, 25-50%, 50-75% and 75-100% percentiles above zero. On the distribution maps, the four subdivisions were allocated a mapping code and represented as dark blue dots of varying size, smallest (1 = 0-25%) to largest (4 = 75-100%).

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[1] Available at http://monitoring.wwt.org.uk/pdf/mitchell_2012b.pdf

For 1km squares that had a mean annual peak count of zero (and hence Sensitivity Index of zero) but had records of geese being present, the 1km square was allocated a code for 'present only' and represented on the maps as small red symbols (dots; see Key in 3.1).

## 2.4 SPAs and goose roosts

There are eight SPAs in England where Pink-footed Goose is cited as an interest feature (Appendix 2). Individual SPAs sometimes contain several roosts sites, for example North Norfolk SPA includes five geographically separate roost sites; three major roosts and two used less frequently. Principal roost sites within SPAs or other sites where the current five year peak mean count (2007/08 – 2011/12) holds more than 1.0% of the population (taken as 3,600; Musgrove *et al.* 2011), are shown on the distribution maps as green symbols (dots; see Key in 3.1).

The SPA boundary is shown on the distribution maps as a red line. A line drawn at 20km around each SPA is shown as a black line (see Key in 3.1). This distance is generally taken to be the normal maximum distance geese fly to and from individual roosts (see Patterson 2011).

The existing suite of SPAs includes a large proportion of the roosting Pink-footed Geese in England. However, the proportion of the population using the suite of SPAs can change (Figure 2), and at several individual SPAs within Scotland this change has been significant, including some where they are largely abandoned (*e.g.* Loch of Kinnordy and Din Moss – Hoselaw Loch). Shifts in distribution (either temporary or permanent) can thus affect the use of land around SPAs by feeding geese.
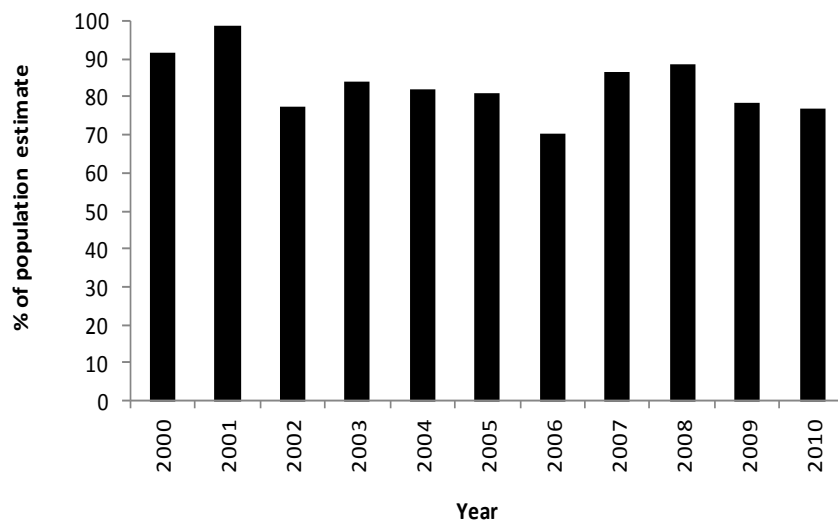


**Figure 2.** The percentage of the Iceland/Greenland Pink-footed Goose population counted on the UK SPA network at the time of the annual population estimate.

## 2.5 Attribute tables and creation of sensitivity maps

The primary output of this study was an attributes table (created in Excel) (Table 1).

**Table 1.** Attributes table (example records for a fictional 1km square TG3611 (east Norfolk), see 2.3.4).

| Attribute | Attribute type | Example | Comment |
|---|---|---|---|
| 1km square | Text | TG3611 | |
| Easting | Text | 636555 | Locates centre of 1km square |
| Northing | Text | 311555 | Locates centre of 1km square |
| 1986/87 to 2007/08 (old) | Integer | 3 | Number of records |
| | Integer | 0.9 | Highest Quality Index |
| | Integer | 4.605 | Mean of natural logarithm of annual peak counts |
| | Integer | 3.730 | Sensitivity Index |
| | Integer | 3 | Mapping code |
| 2008/09 to 2012/13 (new) | Integer | 5 | Number of records |
| | Integer | 1 | Highest Quality Index |
| | Integer | 4.880 | Mean of natural logarithm of annual peak counts |
| | Integer | 4.880 | Sensitivity Index |
| | Integer | 4 | Mapping code |
| 1986/87 to 2012/13 (all) | Integer | 8 | Number of records |
| | Integer | 1 | Highest Quality Index |
| | Integer | 4.825 | Mean of natural logarithm of annual peak counts |
| | Integer | 4.825 | Sensitivity Index |
| | Integer | 4 | Mapping code |

Sensitivity maps were created in QGIS 8.0.1

# 3 Results

In total, there were 20,009 Pink-footed Goose records used to map the feeding distribution of geese in England providing data for a total of 2,593 1km squares (Figure 3).
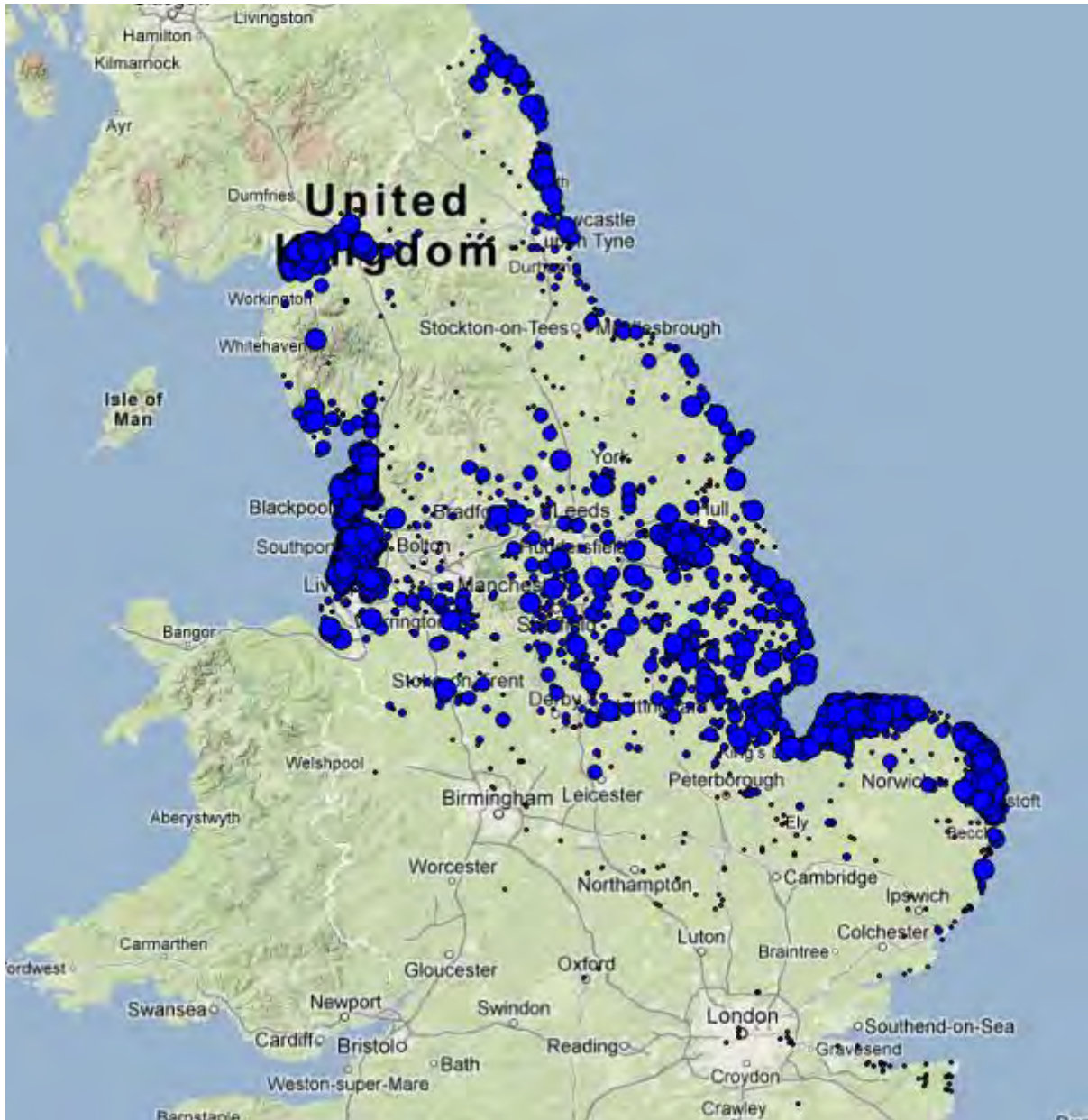


**Figure 3.** The distribution of feeding records of Pink-footed Geese in England. Based on all data (1986/87 to 2012/13). Sensitivity Index represented by four graduated dark blue symbols (dots) (see 2.3.4 above). One km squares for which no quantitative data exists but where geese were known to have been present (see 2.3.1 above) are represented by small red symbols (dots).

Records were not evenly distributed over time (Figure 4). The majority of Pink-footed Goose records were from the early 2000s onwards mainly due to the creation of the BTO's *BirdTrack* recording system which allows birders and members of the public to enter their sightings of geese online. Those records from the mid 1990s to the early 2000s are partly related to the number of colour ring sightings generated by increased ringing in Iceland and the UK at that time. In 2005 WWT undertook a questionnaire-based study to map the distribution (presence / absence only) of feeding geese around SPAs. Records from the most recent five year period (2008/09 to 2012/13) contributed 48% of the total.
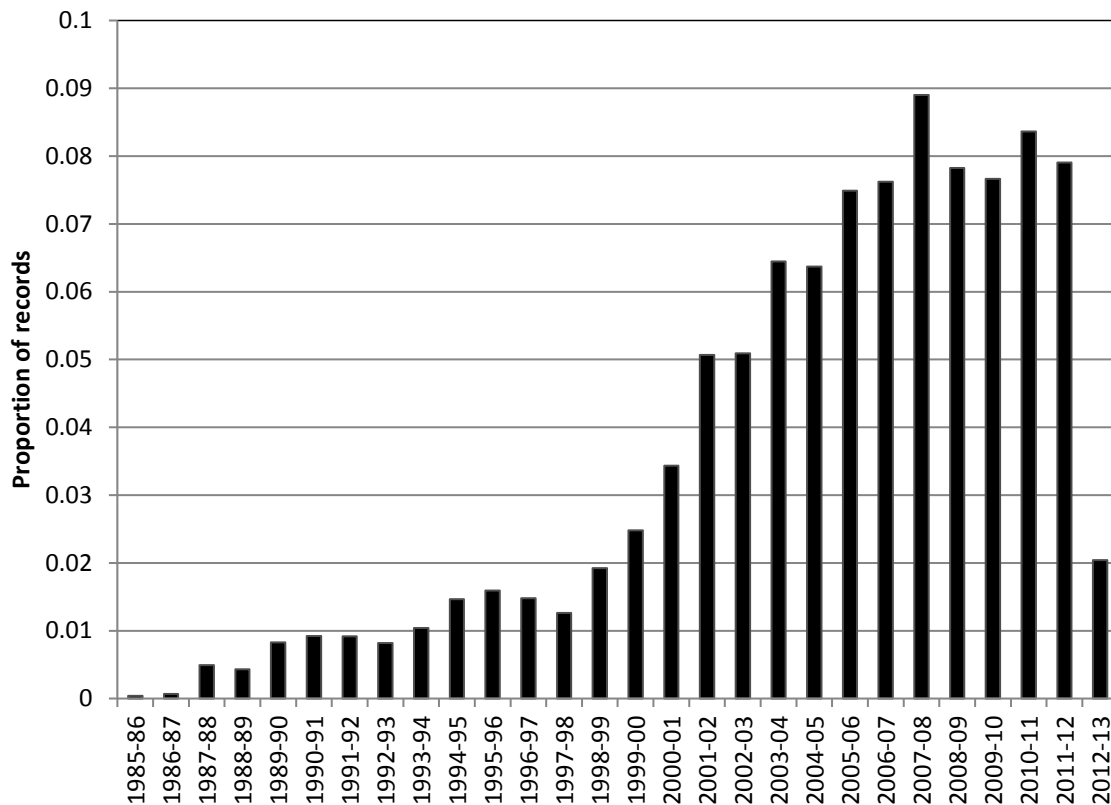


**Figure 4.** Temporal distribution of Pink-footed Goose records in England used in the mapping analysis.

Due to the way the Sensitivity Indices were calculated (see 2.3.4) the indices were positively correlated with the mean of the natural logarithm of annual peak counts for each 1km square. There is less confidence (*i.e.* a lower Sensitivity Index) for data points below the fitted perfect correlation line (indicative only) since lower Frequency and Quality indices have been allocated to some records. In other words, the number of birds is the most important component of the Sensitivity Index and even allocating lower Frequency and Quality indices to some records, although yielding lower Sensitivity Index values, they are still positively related to the number of birds counted.
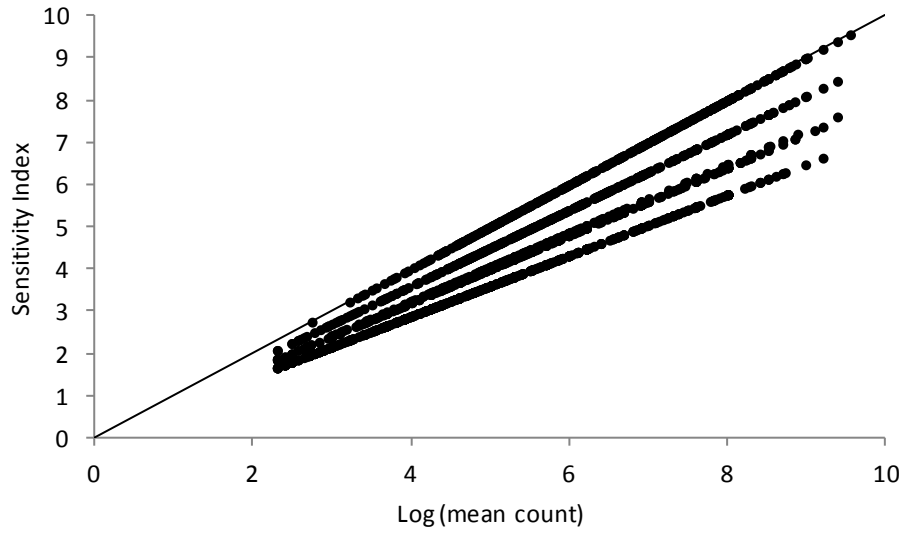
**Figure 5**. Relationship between the mean of the natural logarithm of annual peak counts for a 1km square and the derived Sensitivity Index for that square for records of Pink-footed Geese.

## 3.1 Feeding distribution around individual Special Protection Areas

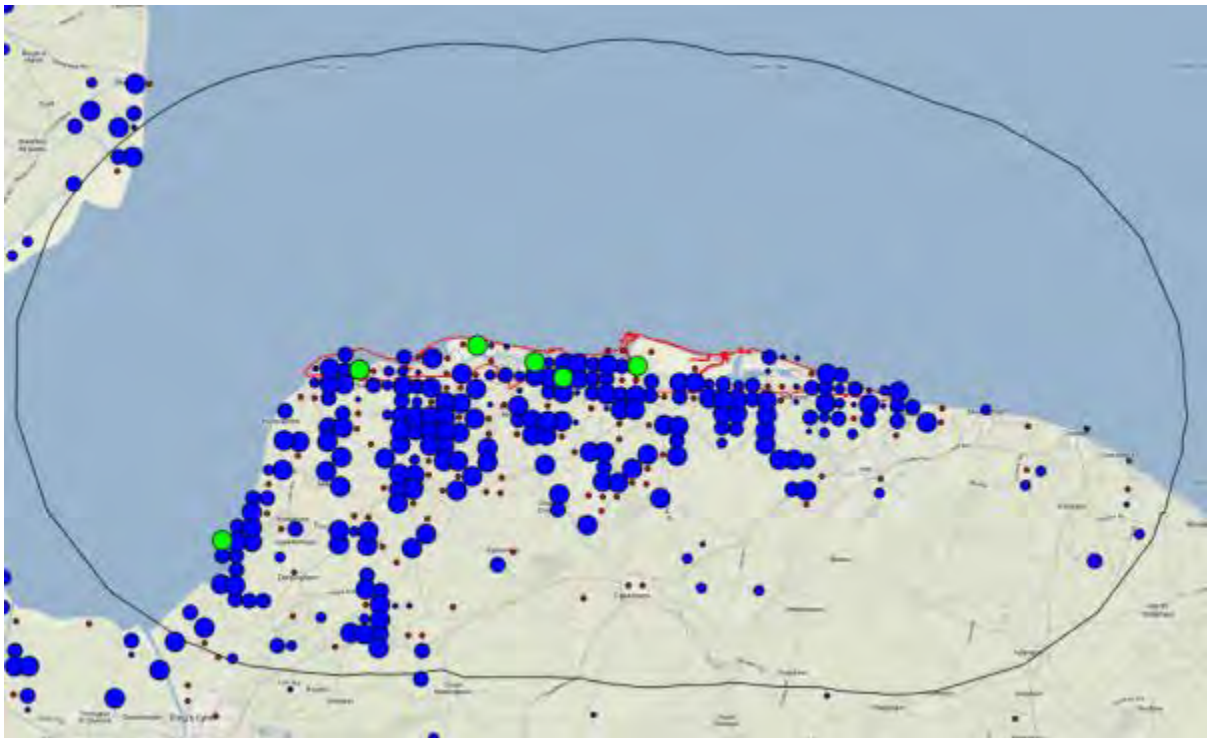ArcView output maps are given for the 8 SPAs in Appendix 2 (example in Figure 6).



**Figure 6.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to the North Norfolk Coast SPA. For key see below.

For each of the maps, the following symbols were used:

1) Sensitivity Index represented by four graduated dark blue symbols (dots) (see 2.3.4 above).
2) 1km squares for which no quantitative data exists but geese were known to have been present (see 2.3.1 above) represented by small red symbols (dots).
3) The SPA boundary (thick red line).
4) Important roosts either within the SPA boundary (if known) or other nearby waterbodies (see 2.4) represented by green symbols (dots).
5) 20km line surrounding the SPA boundary (black line).

# 4 Discussion

## 4.1 Map applications

The rapid increase in the number of wind farms proposed in England has led to the potential for conflict with bird conservation objectives. As of March 2013, England had 141 operational onshore windfarms, 107 consented projects (granted planning approval but have not yet become operational) and 40 currently under construction)[2]. It is important to minimise this conflict as many of the species of concern are specially protected under Annex 1 of the EU Birds Directive or other international agreements to which the UK is Party (such as the Convention on Migratory Species). They are also an important part of England's natural heritage. The maps are intended to provide an overarching strategic view of the areas in England most important to feeding Pink-footed Geese, where there is potentially the greatest risk from onshore wind farm development. They should aid local spatial planning for renewable energy development facilitating more effective location of future wind farms to minimise potential conflict. They also potentially open up opportunities for strategic mitigation through targeted habitat enhancement for displaced or disturbed birds.

The maps are, however, an indicative tool due to the nature of the data available, and do not replace the need for more comprehensive site-specific assessments of the impact of individual wind turbine proposals on geese as part of the normal environmental impact assessment process.

Further, there is a need for important agricultural feeding areas for geese and swans to be identified and protected or managed for the benefit of the internationally important concentrations of birds they support, complementing the protection provided to roosting birds through the existing suite of designated sites for this species. One possible mechanism for this is the extension of existing SPA boundaries to incorporate the most important feeding areas. But targeting of agri-environment and development mitigation will also provide more immediate opportunities. Their identification and management will require a robust data collection and assessment protocol, and whilst this currently does not exist in the UK, and is outwith the focus of this study, the results and methods presented here provide a sound starting point for the further development of a monitoring programme for goose and swan feeding areas that can be extended to other species and regions.

## 4.2 Representativeness of the data

There are currently no standardised surveys being carried out on feeding geese in England. The majority of feeding records were collected in an *ad hoc,* non-standardised or casual manner. Inevitably, feeding records collected in this way may be prone to biases. Casual records may simply reflect the distribution of fields checked by individual observers, and observed flocks may not have been recorded if no age count was carried out or the flock did not contain a marked individual. Consequently, more records may be generated close to key bird watching sites or even the homes of, or regular routes travelled by, observers. Furthermore, records of geese feeding in fields are often not recorded by birdwatchers and, generally, have not been of interest to county bird recorders. In some areas, this has contributed to a lack of detailed knowledge about the feeding areas preferred by geese around roosts.

However, the existence of several systematic surveys in Scotland designed to map goose feeding distribution at local scales meant that Mitchell (2012a) was able to compare the completeness of maps generated using *ad hoc* data with maps generated using data from systematic surveys. This comparison demonstrated an acceptable level of agreement between the two data types. No such comparisons for England were possible, since there have not been any systematic surveys carried out. However, there is no reason to believe that the *ad hoc* data for England would be less comprehensive than that from Scotland; in fact it is likely to be more comprehensive given the greater number of bird watchers. Thus, whilst some gaps in the mapped distributions are likely to exist, it is believed that these are small in number, although this cannot be confirmed without bespoke surveys.

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[2] From http://www.renewableuk.com/en/renewable-energy/wind-energy (accessed on 21/03/2013).

Nevertheless, the following caveats need to be taken into account when using the maps:

- The maps have been developed from available information collected for other purposes. Thus, the lack of standardised survey coverage means that there is no guarantee that feeding Pink-footed Geese do not occur in 1km squares shown here with no presence, *i.e.* an absence of goose records could be because of the absence of geese or the absence of records/recorders.
- The maps were created by collating data that were largely collected for other purposes and thus data collection protocols were not tailored specifically to the requirements of this project. For example, *BirdTrack* records have been included, yet for many of these records it is not known if the geese were flying over or feeding in a 1km square.
- Distribution data collected in a non-standardised way cannot be easily analysed. The Sensitivity Index is not based on modelled spatial analysis, but is simply based on the abundance of geese recorded in 1km squares and takes into account the number of records from that 1km square and the quality of the raw data.
- The maps are not a substitute for site-specific assessments of the impact of individual wind turbines or proposed developments on geese, but are intended as an indicative map of areas of highest likely bird sensitivity to help guide decision-makers in the early stages of the planning process.
- The maps will require updates to add new survey data as they become available (see 4.3.1).

The maps should be interpreted in conjunction with recent roost count data (see Appendix 2), annual IGC reports (e.g. Mitchell 2012a), a review of goose use of SPAs (Mitchell & Hall 2012) and the Waterbird Review Series reports for Pink-footed Goose (Mitchell & Hearn 2004). This is because it is difficult to fully interpret the mapped feeding distribution of Pink-footed Geese without reference to other information (notably about roost use) because a lack of feeding records may be because of a lack of observations or because the birds no longer use the roost and therefore no longer feed in the surrounding area.

## 4.3 Recommendations

### 4.3.1 Updating the sensitivity maps

The maps were created using information currently available. There will be a need to review and update the maps as new *ad hoc* data become available, and as additional historical information is submitted. There are various surveys which may make useful updates or additions to the map, which were not available within the timescale of the current project, for example BTO atlas data. Fieldwork for the most recent Bird Atlas was conducted in 2007-2011, and is due to be published in 2013, after which it may be possible to incorporate these data for wintering Pink-footed Geese, and ideally other species feeding in cropped habitats.

Further, it would be prudent to review the sensitivity criteria as new research methods to analyse non-standardised distribution data are developed.

### 4.3.2 Future recording of feeding geese

The value of recording feeding geese (and other species – see 4.3.3 below) will be emphasised through distribution of this report and summary results in publications such as the *WeBS Newsletter* and *GooseNews*, and through direct communication with the GSMP network and other birdwatchers. Thus attempts will be made to encourage goose watchers to regularly record the location of feeding flocks, and make required improvements in the recording of data, such as confirming that the birds were feeding as opposed to flying or daytime loafing on nearby roost sites. Recording the location of feeding flocks could be accommodated in *BirdTrack* if the recording of whether a bird and/or flock is in flight or on the ground was made mandatory on the *BirdTrack* online recording site.

However, in preference to continued reliance on *ad hoc* data sources, a programme of standardised bespoke surveys of feeding distributions around SPAs and other nationally and internationally important sites should ideally be implemented. The standardised recording of feeding geese (counting birds on fixed survey routes) would be extremely valuable in assessing the true distribution of the birds in the wider landscape. This would overcome existing uncertainties with the completeness of current sensitivity maps and mean that they would provide a more reliable assessment of the location of all key feeding areas. Further, more sophisticated analyses of spatial data, for example the distribution of geese in relation to landscape features, would be possible once data deficiency issues (primarily a lack of nil counts) are addressed.

The 2004/05 WWT SPA feeding distribution study identified areas where goose counters had indicated the presence of feeding geese, but for which no quantitative data exists (identified as small red dots on the maps), thus we know we cannot currently determine the relative importance of some feeding areas. A rolling programme of standardised surveys carried out through the GSMP would address such gaps in knowledge and this could be implemented as a rolling programme of surveys akin to the sampling method used for the WeBS Low Tide Counts (see Holt *et al.* 2011), by surveying several sites each year, but no individual site more than once within a, *e.g.*, five year period.

## 4.3.3 Mapping the feeding distribution of other species in the UK

This feeding distribution mapping study provides a platform for extending analyses to other important wildfowl species feeding in cropped habitats away from waterbodies, particularly those that are protected sites, including other goose species, Whooper Swan *Cygnus cygnus*, Bewick's Swan *Cygnus columbianus bewickii*, and Wigeon *Anas penelope*. These species occur throughout the UK and a joined-up approach to monitoring and mapping their feeding distributions could be developed at a national scale. This could be undertaken in a targeted way, for example, to better understand wildfowl use of non-designated land around specific SPAs to help plan for wind turbine developments.

# 5 Acknowledgements

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Appendix 1.  Data sources.

| Author/contact | Data type | Time period covered | Area covered | Number of records (% of total) |
|---|---|---|---|---|
| WWT | Colour ring sightings of individually marked geese | 1988 to 2013 | Whole of England | 4,127 (20.6%) |
| WWT | Grey goose age counts | 1986 to 2009 | Lancashire and Norfolk, | 185 (0.9%) |
| BTO | *BirdTrack* | 2000 to 2013 | Whole of England | 10,095 (50.4%) |
| RSPB | Counts made at RSPB reserves | 1988 to 2012 | Various parts of England | 3,339 (16.7%) |
| Cumbria Bird Club | Sightings recorded within Cumbria | 2006 to 2011 | NW England Cumbria | 341 (1.7%) |
| Lancashire County Bird Records | Sightings recorded within Lancashire | 2005 to 2012 | NW England Lancashire | 7 (0.03%) |
| Lincolnshire County Bird Records | Sightings recorded within Lincolnshire | 1998 to 2013 | E England Lincolnshire | 1,400 (7.0%) |
| Suffolk County Bird Records | Sightings recorded within Suffolk | 2006 to 2011 | East Anglia England Suffolk | 61 (0.3%) |
| L. Griffin (WWT) | Barnacle Goose surveys around the Solway Estuary | 2007 to 2010 | NW England Cumbria | 19 (0.09%) |
| F. Mawby | Pink-footed Goose distribution around the Solway Firth | 2008 | NW England Cumbria | 108 (0.5%) |
| WWT | SPA feeding study | 2005 to 2006 | NW England Cumbria and Lancashire | 327 (1.6%) |
| **Total** | | | | **20,009** |

# Appendix 2. SPAs in England with Pink-footed Goose as a qualifying species.

The following tables show the mean peak IGC counts (from 2006/07 to 2010/11) for Pink-footed Geese at all SPAs and non SPAs holding nationally important numbers. Further details of these designations can be found in Stroud *et al.* (2001).

| Site Code | | SPA | Mean IGC peak count 2006/07 to 2010/11 (1) |
|---|---|---|---|
| UK9009253 | 1 | Broadland | 6,185 |
| UK9009031 | 2 | North Norfolk Coast | 56,617 |
| UK9008021 | 3 | The Wash | 37,908 |
| UK9006011 | 4 | Lindisfarne | 4,532 |
| UK9005111 | 5 | Martin Mere | 11,383 |
| UK9005103 | 6 | Ribble and Alt Estuaries | 22,214 |
| UK9005081 | 7 | Morecambe Bay | 25,775 |
| UK9005012 | 8 | Upper Solway Flats and Marshes | 19,408 |
| **Other nationally important sites** | | | |
| Breydon Water/Berney Marshes | | | 12,183 |
| Humber Estuary | | | 6,871 |

Notes:
    (1) Mean derived from any IGC count (*i.e.* from any month, October, November or December).

# Appendix 3. Sensitivity maps.

For each SPA for which the site is designated and selected important roost sites, two maps are presented; one showing the distribution of all feeding records (from the period 1986/87 to 2012/13) and one showing the distribution of feeding records from the most recent five years (2008/09 to 2012/13).

**Key:**

For Figures 7 to 26, the following symbols were used:

1) Sensitivity Index represented by four graduated dark blue symbols (dots) (see 2.3.4 above).

2) 1km squares for which no quantitative data exists but geese were known to be present (see 2.3.1 above) represented by small red symbols (dots).

3) The SPA boundary (thick red line).

4) Important roosts either within the SPA boundary (if known) or other nearby waterbodies (see 2.5 and appendix 2) represented by green symbols (dots).

5) 20km line surrounding the SPA boundary (black line).

**Interpreting the maps**
The maps show the distribution of feeding geese based on available data. There are fewer records from the most recent period (from 2008/09 to 2012/13) partly due to the shorter time period (five years) and partly due to the reduction in the number of geese being ringed in recent years and a subsequent reduction in the number of sightings.

However, at some sites, a reduction in feeding records may also represent an absence, or reduction in number of geese. The maps should therefore be interpreted in conjunction with results from any available local surveys, recent roost count data, annual IGC reports (e.g. Mitchell 2011), a review of goose use of SPAs (Mitchell & Hall 2012) and the Waterbird Review Series reports for Pink-footed Goose (Mitchell & Hearn 2004).

## 1) Broadland (UK9009253):

**Roost locations and feeding distribution**

The two main Pink-footed Goose roosts within Broadland are Horsey Mere and Berney Marshes (Figure 7). Birds from there generally remain close to the roost sites when feeding, moving mainly along the coast rather than inland. The main concentration is around Horsey Mere, though some move as far south as north Suffolk.
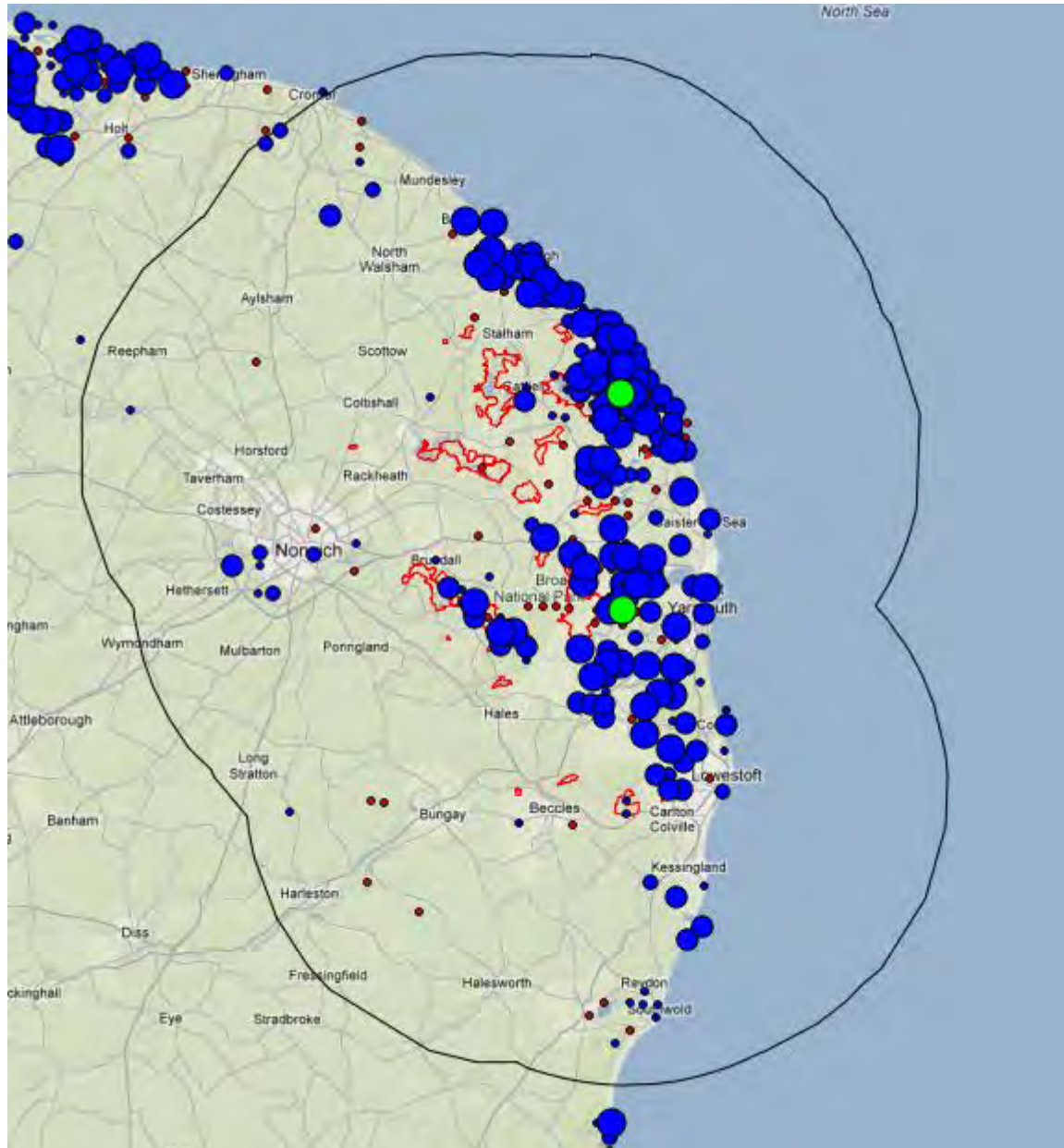


**Figure 7.** Feeding distribution (1986/87 to 2012/13 - all records) of Pink-footed Geese in relation to the Broadland SPA. For key see page 25.

The data for the most recent five years (Figure 8) show that during this period little change has taken place in the main feeding areas of birds roosting within Broadland.
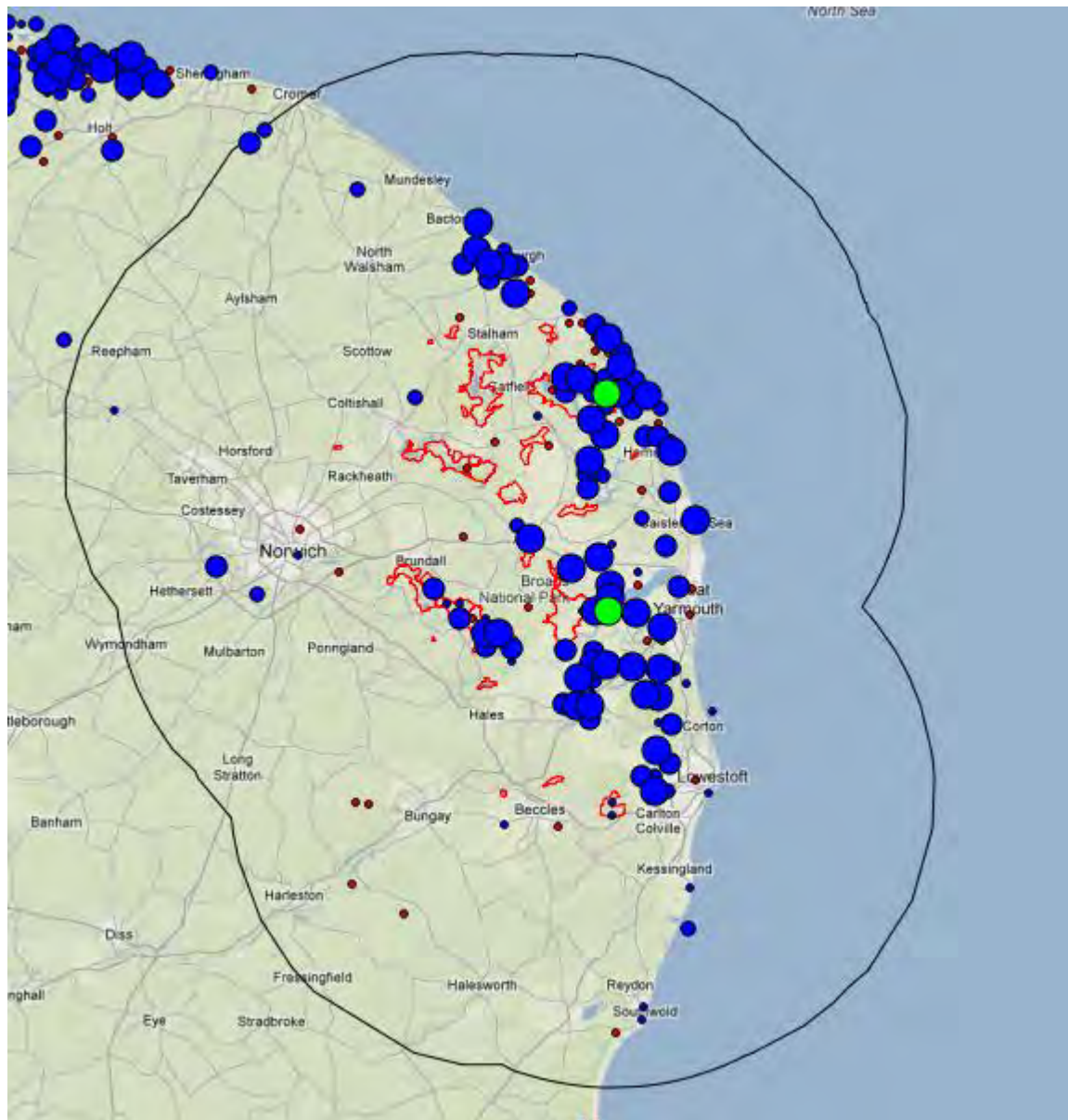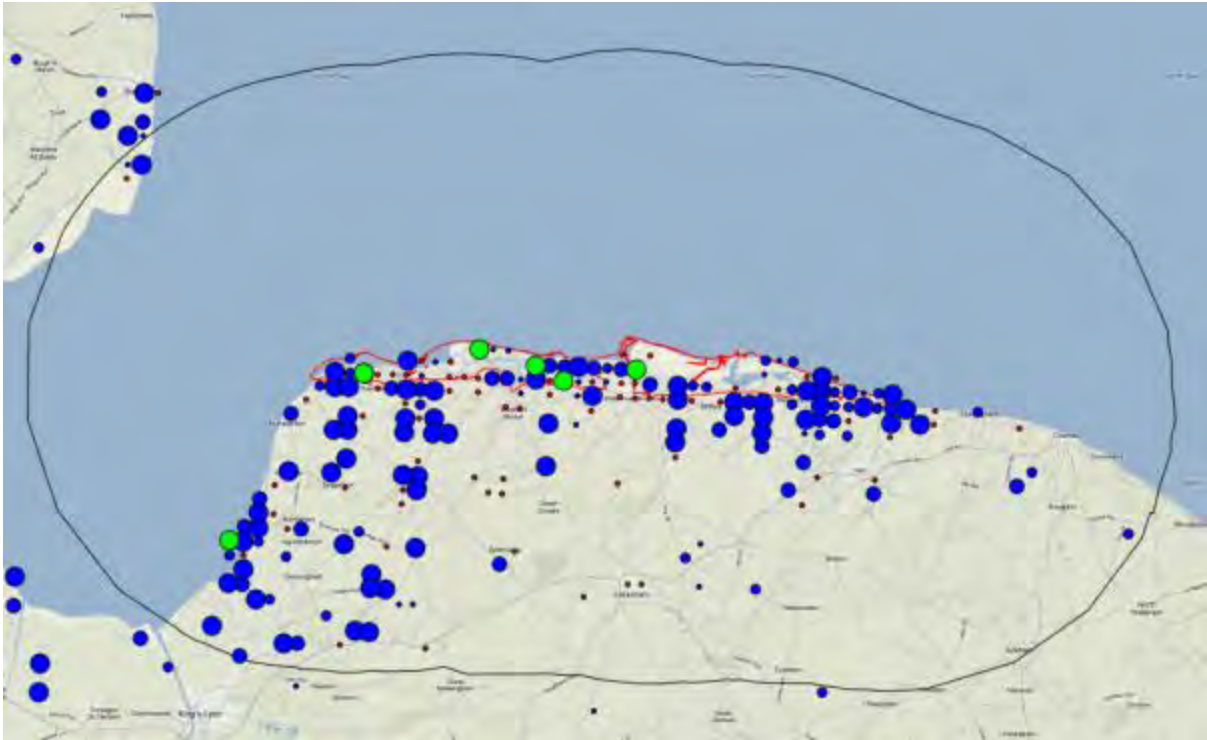
**Figure 8.** Feeding distribution (2008/09 to 2012/13 - new records) of Pink-footed Geese in relation to the Broadland SPA. For key see page 25.

## 2) North Norfolk Coast (UK9009031):

**Roost locations and feeding distribution**
The five main roost sites within the North Norfolk Coast SPA are i) Holkham Bay, ii) Holme, iii) Burnham/Norton Marsh, iv) Scolt Head and v) Wells (Figure 9). Birds from these sites feed on farmland inland in a radius of up 10-15 km, feeding on primarily autumn stubbles, post-harvest sugar beet tops and improved / semi-improved grasslands. The nearby roost at Snettisham is within the Wash SPA though birds from here also mostly feed inland in north Norfolk. The interchange with feeding birds from roosts along the north coast is currently unquantified.
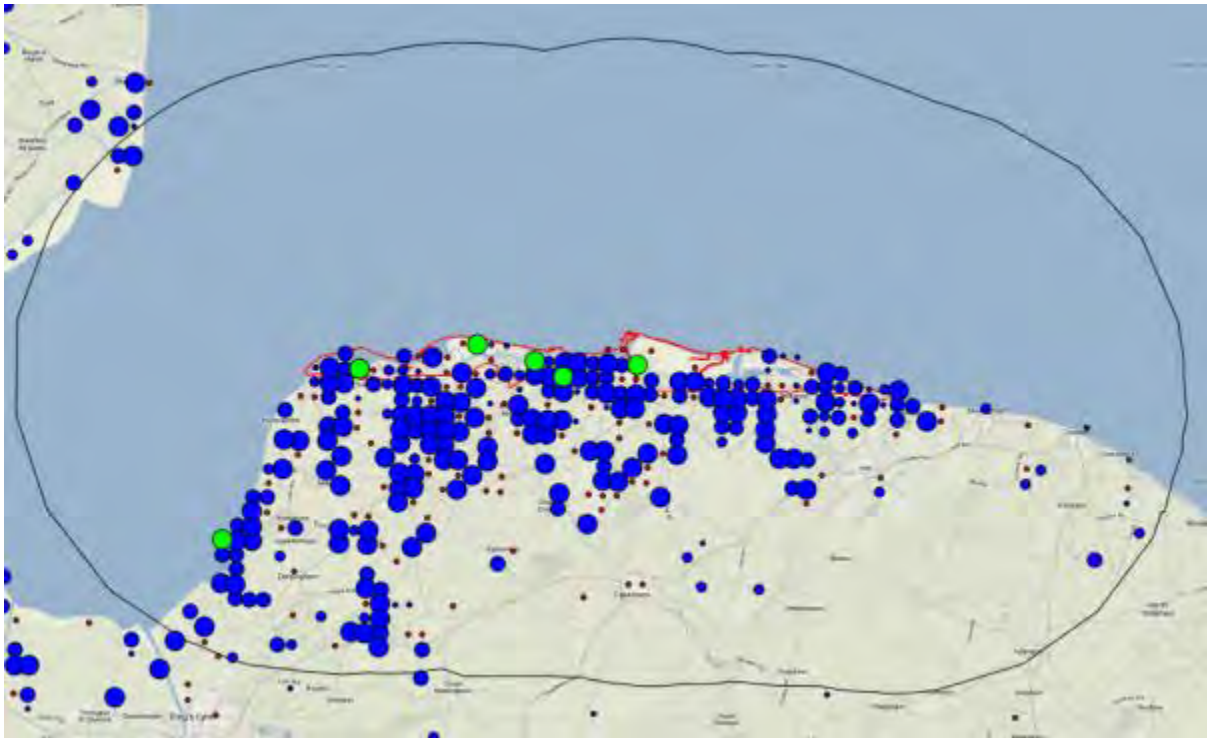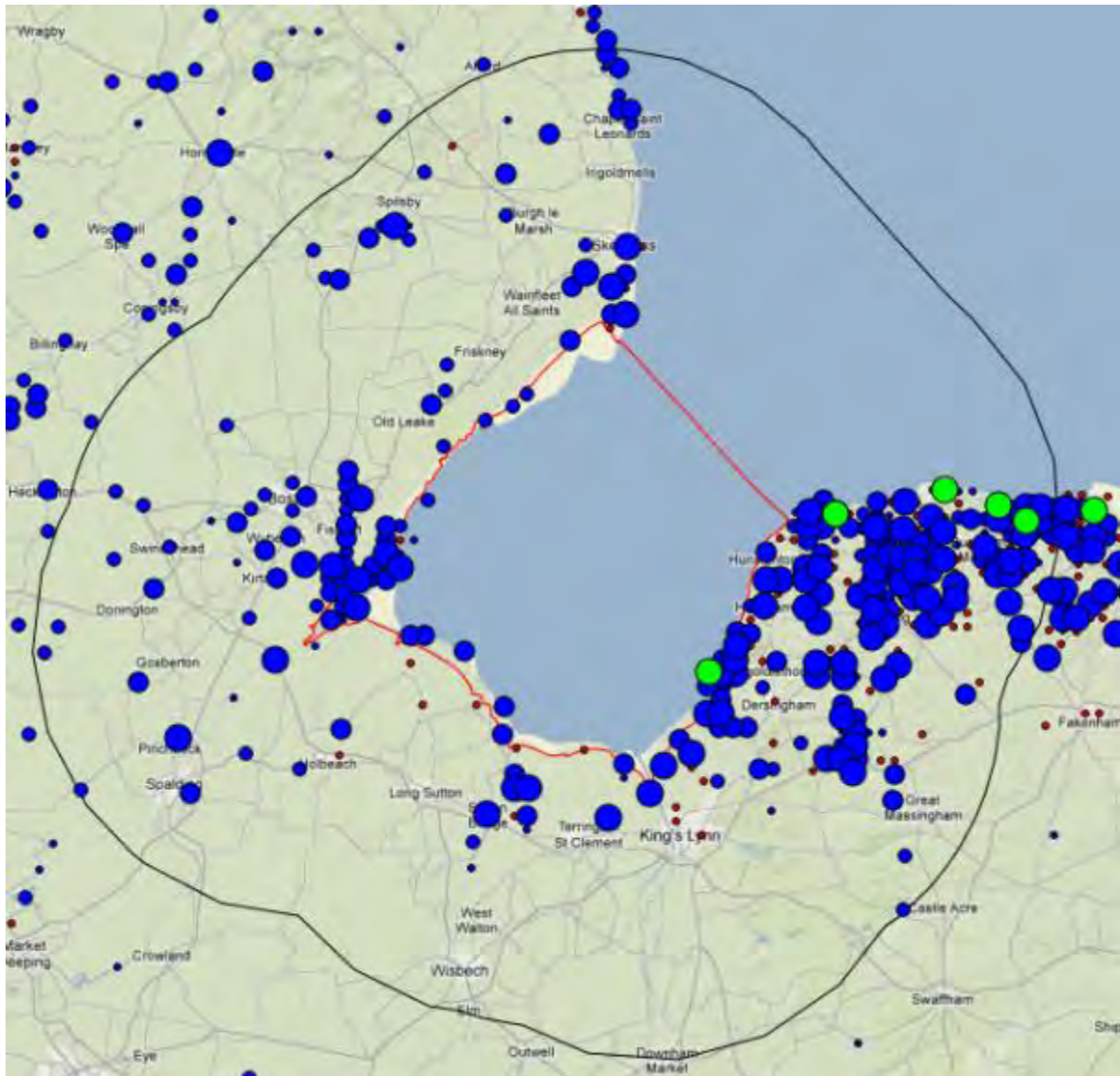


**Figure 9.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to the North Norfolk Coast SPA. For key see page 25.

The data for the most recent five years (Figure 10) show that during this period little change has taken place in the main feeding areas for birds roosting within the North Norfolk Coast SPA.
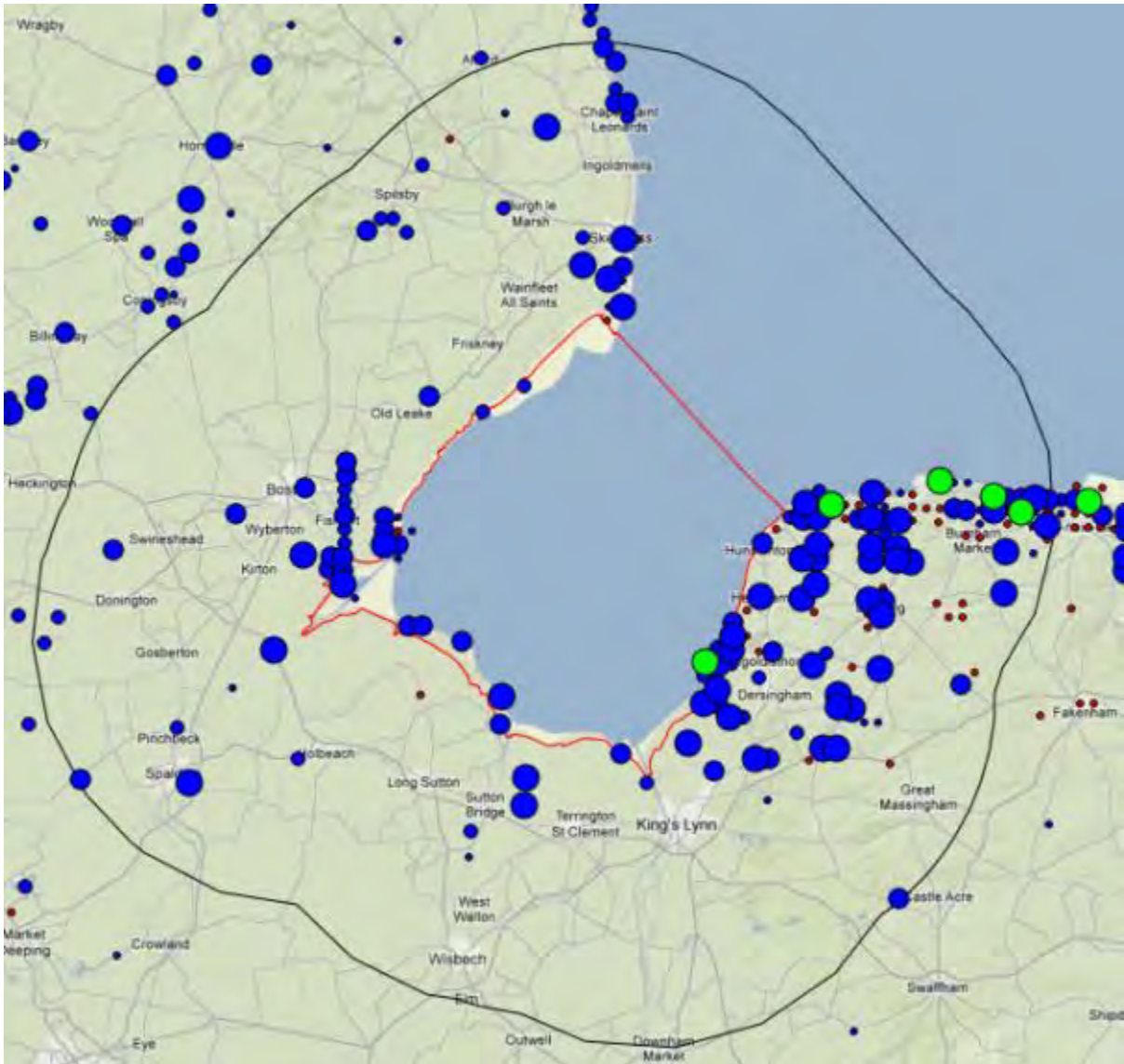
**Figure 10.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to the North Norfolk Coast SPA. For key see page 25.

## 3) The Wash (UK9008021):

**Roost locations and feeding distribution**

The only roosting site in The Wash SPA is at Snettisham which holds large numbers of roosting birds; the five year mean peak is 37,908 geese. Feeding areas from the roost site are primarily inland to the south and east in Norfolk, though some also move across the Wash to south Lincolnshire (Figure 11). Arable fields are the main food source in this area, particularly post-harvest sugar beet tops. However, geese often feed on marshes much closer to the roost, particularly after the shooting season.
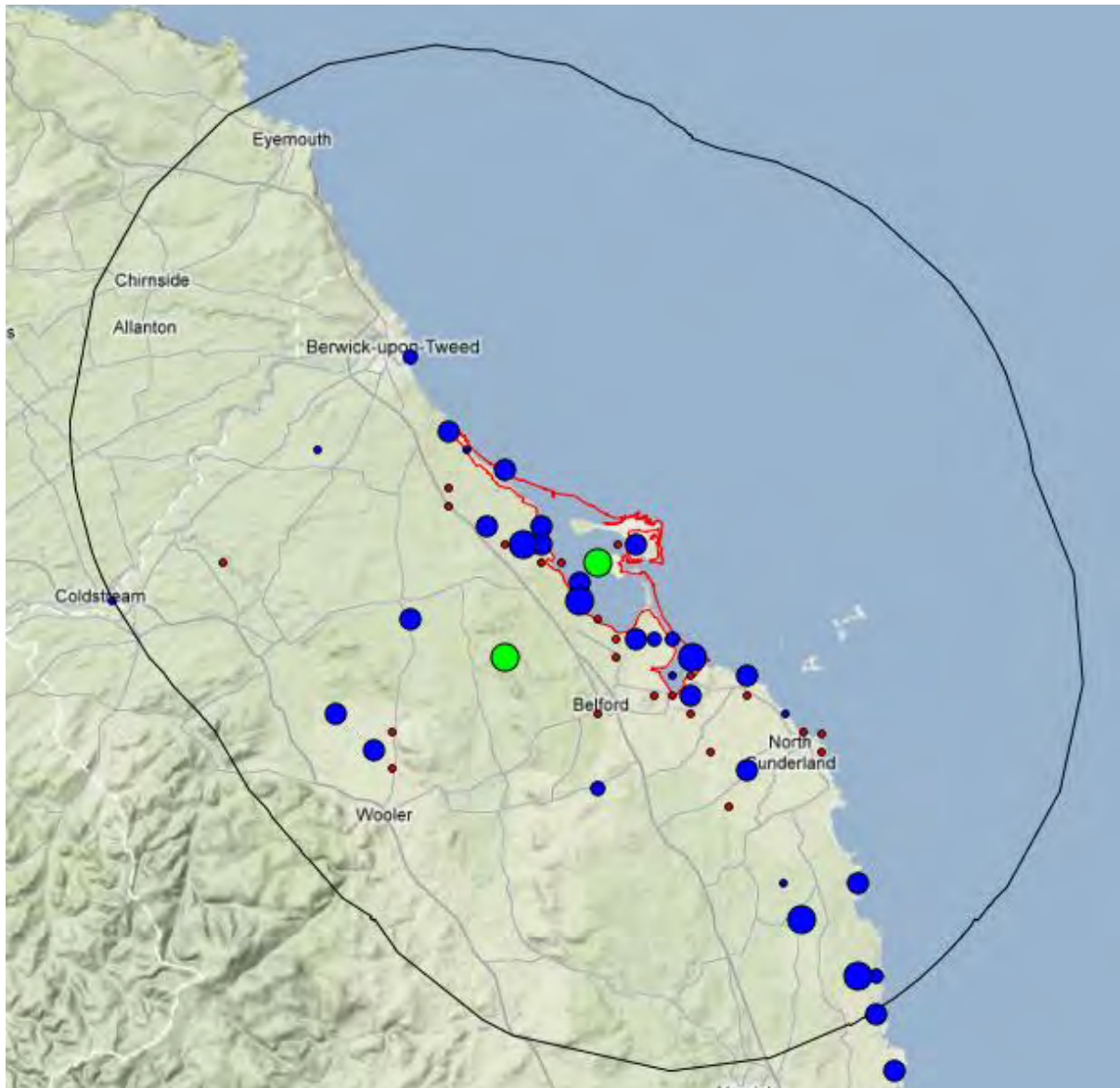


**Figure 11.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to The Wash SPA. For key see page 25.

The data for the most recent five years (Figure 12) show that during this period little change has taken place in the main feeding areas for birds roosting within The Wash SPA.
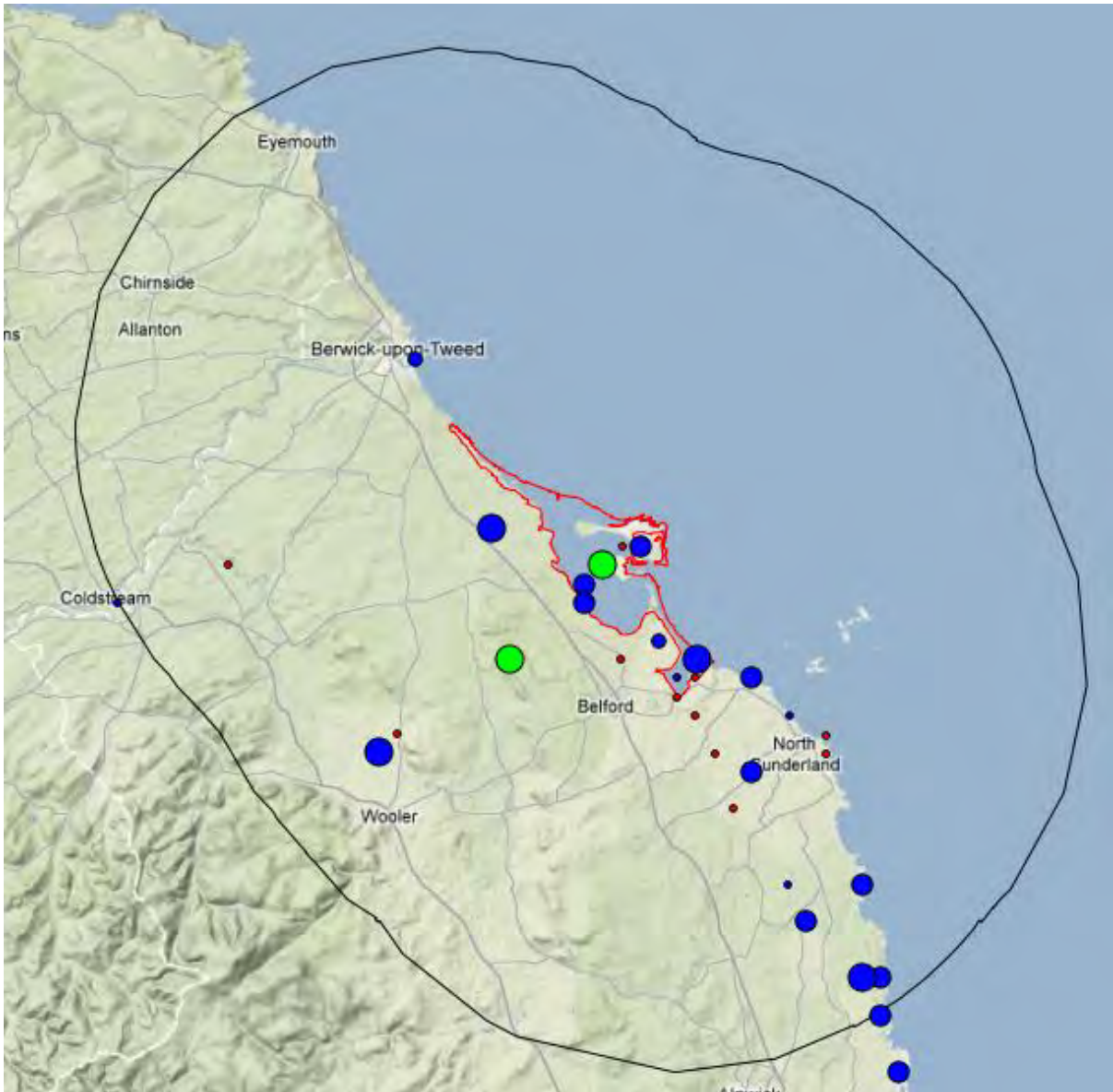
**Figure 12.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to The Wash SPA. For key see page 25.

## 4) Lindisfarne (UK9006011):

**Roost locations and feeding distribution**
Lindisfarne and nearby Holburn Lake and Moss SPAs are the two main roosting locations for Pink-footed Geese in this area (Figure 13). Traditionally, Holburn Moss was used by Icelandic Greylag Geese, for which it is designated as a SPA, and only used by Pink-footed Geese as an alternative roost when they were disturbed from Lindisfarne, which is 6km to the northeast. More recently, however, both sites are used regularly as roosts by Pink-footed Geese. Birds feed on the surrounding farmland to the north and south of the roost sites, mainly close to the coast.
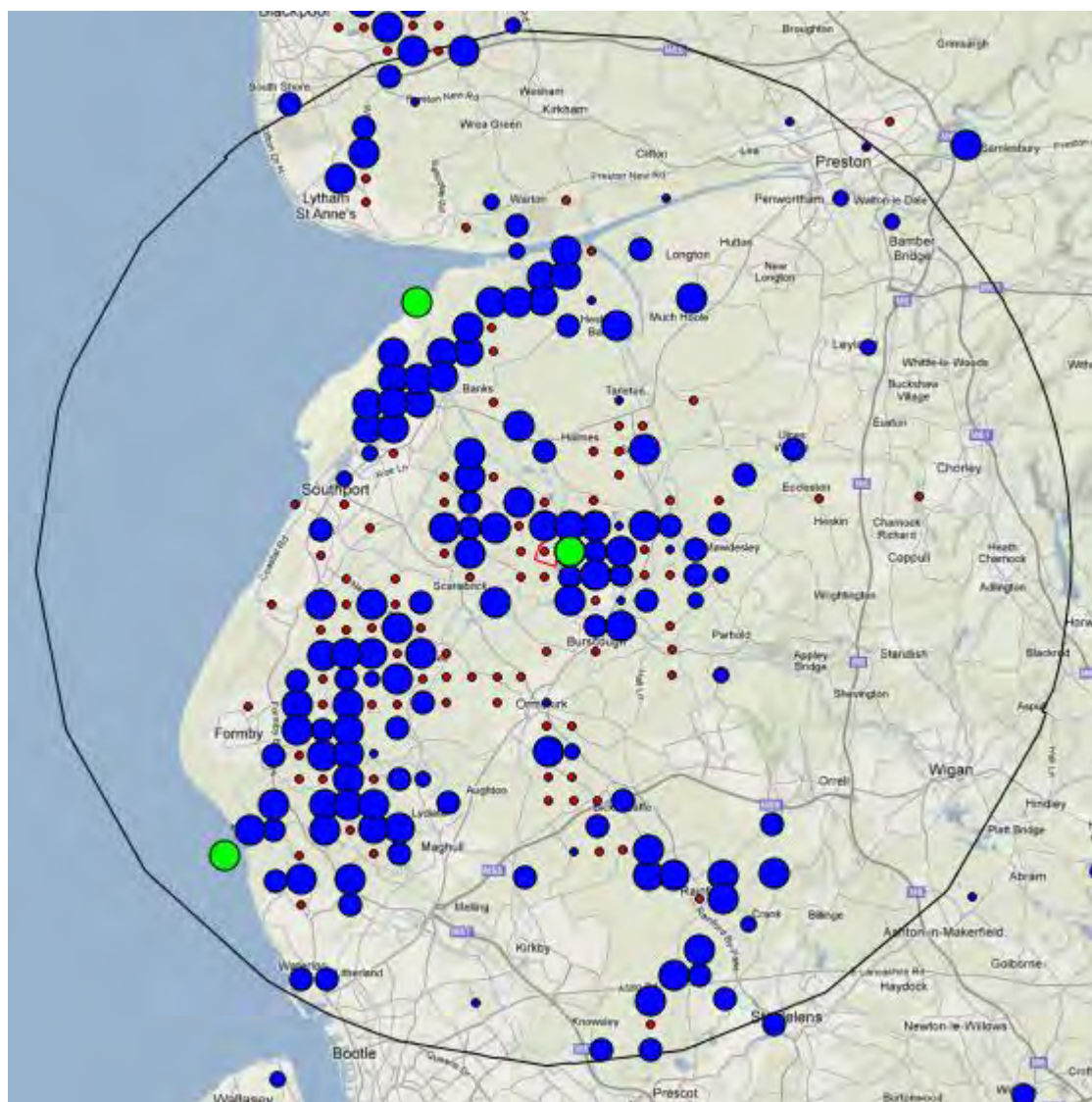


**Figure 13.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to the Lindisfarne SPA. For key see page 25.

The data for the most recent five years (Figure 14) show that during this period little change has taken place in the main feeding areas for birds roosting within Lindisfarne and Holburn Lake and Moss SPAs.

**Figure 14.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to the Lindisfarne SPA. For key see page 25.

## 5) Martin Mere (UK9005111):

**Roost locations and feeding distribution**

WWT Martin Mere is the main roosting site for Pink-footed Goose in Southwest Lancashire, with the 2012/13 maximum count of 18,000 roosting birds in November. Birds feed on the WWT reserve as well as flying out to the surrounding areas towards Southport, Sollom and Burscough Mosses, the Rufford and Crosten area and even as far as Knowsley Park near St Helens, which is 20km to the south (Figure 15). Birds also cross the Ribble Estuary to feed around the Fylde area, though most there probably roost at Morecambe Bay.



**Figure 15.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to the Martin Mere SPA. For key see page 25.

The data for the most recent five years (Figure 16) show that during this period little change has taken place in the main feeding areas for birds roosting within the Martin Mere SPA.
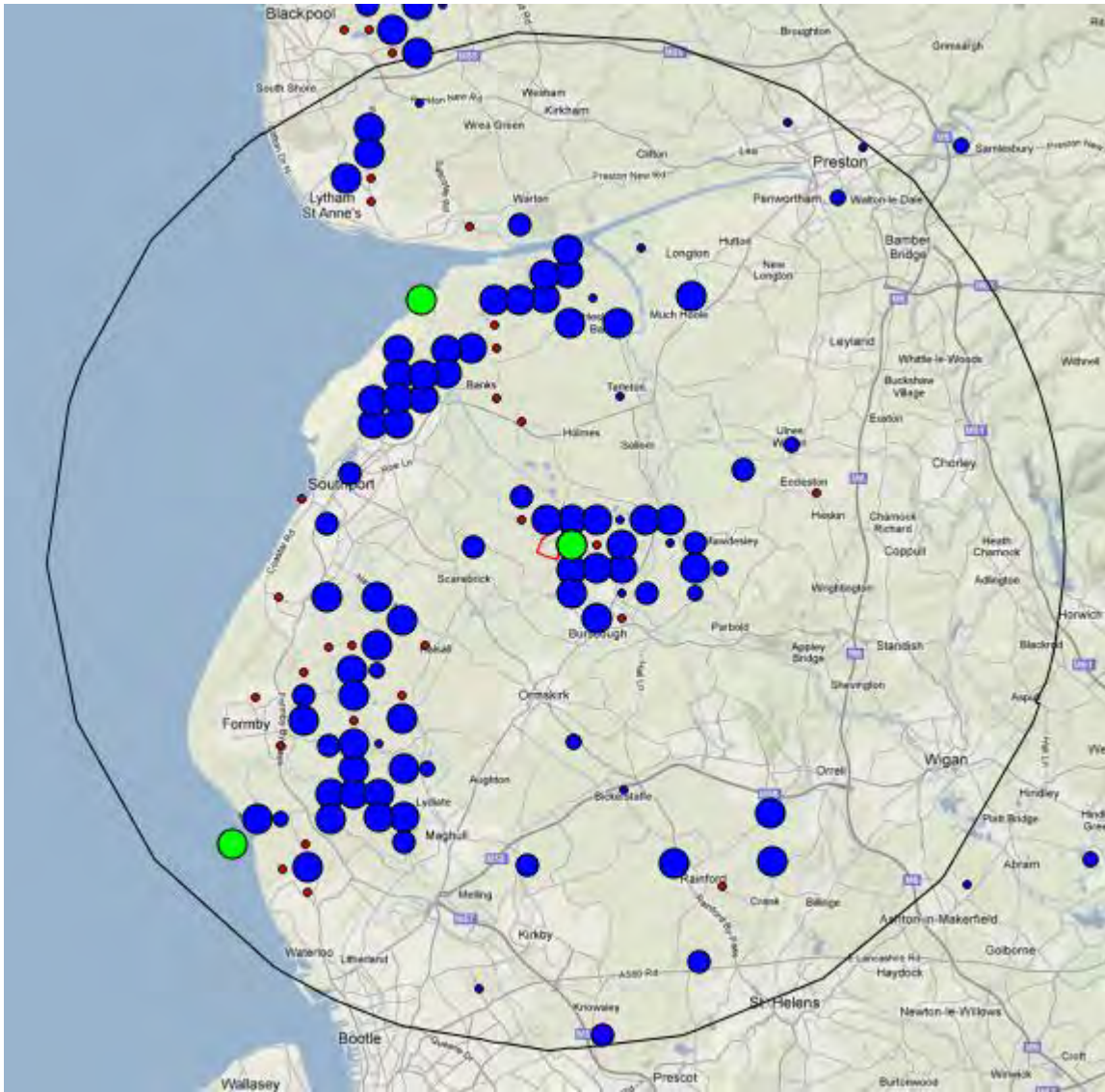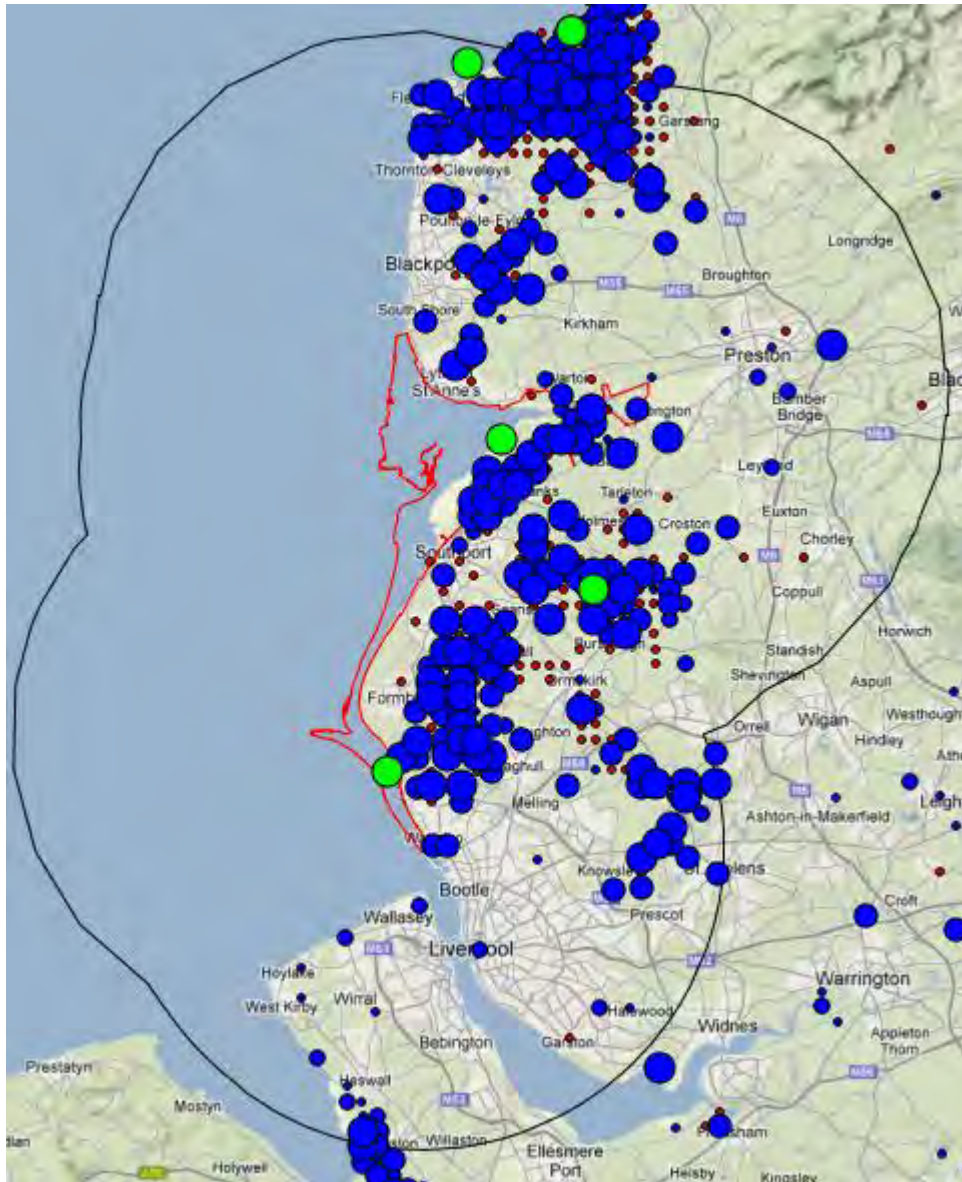
**Figure 16.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to the Martin Mere SPA. For key see page 25.

## 6) Ribble and Alt Estuaries (UK9005103):

**Roost locations and feeding distribution**

The Ribble Estuary is a traditional roosting site for Pink-footed Geese in Lancashire; they have occurred there since records began. Birds roosting on the Ribble Estuary regularly fly inland to feed at Martin Mere, Sollom Moss, Tarleton Moss, Halsall and Plex Mosses (Figure 17). Geese roosting on the Alt Estuary feed predominantly on Downholland Moss, Altcar Moss, Altcar Withens and the Ince Blundell and Little Crosby estates.



**Figure 17.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to the Ribble and Alt Estuaries SPA. For key see page 25.

The data for the most recent five years (Figure 18) show that during this period little change has taken place in the main feeding areas for birds roosting within the Ribble and Alt Estuaries SPA.
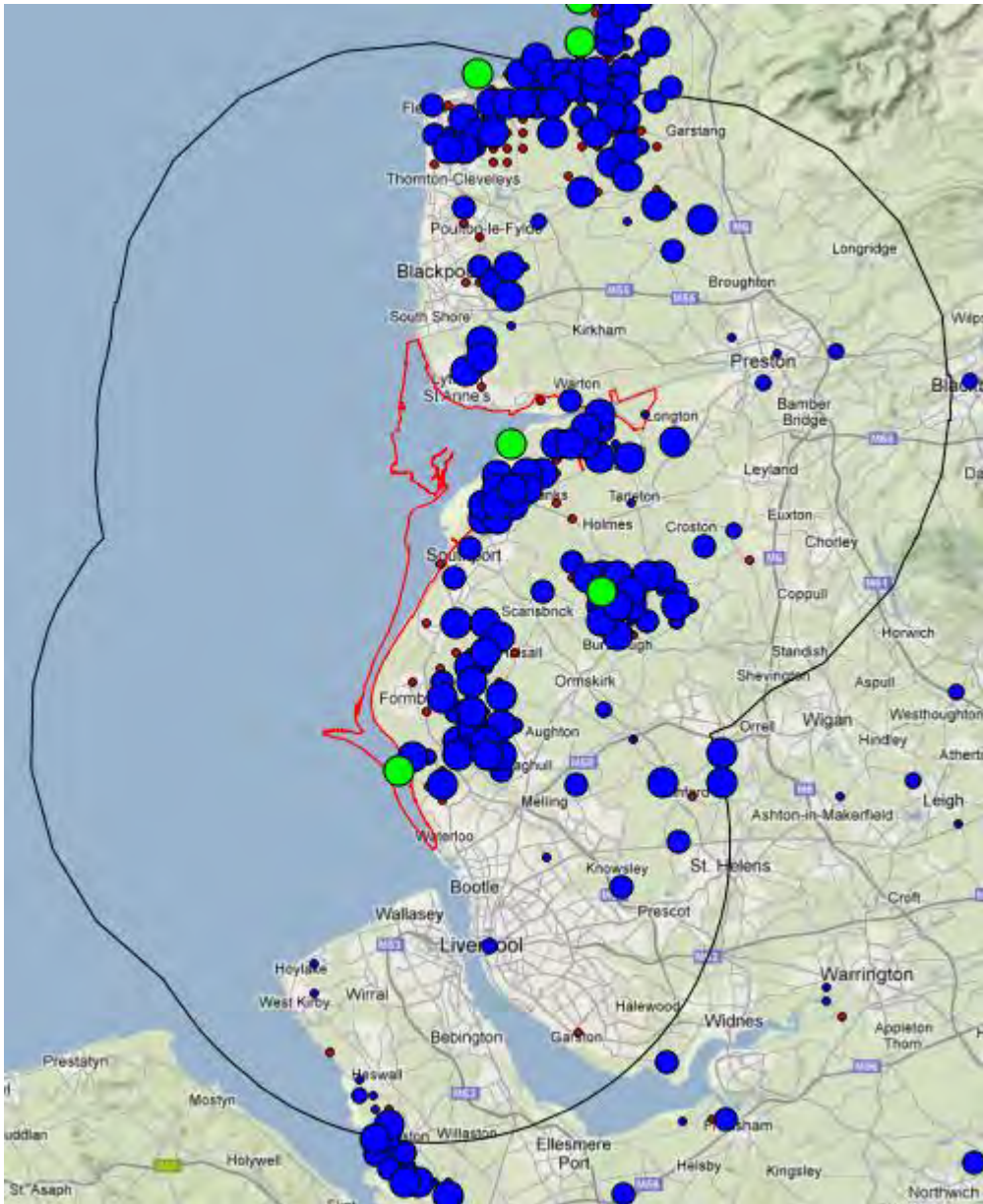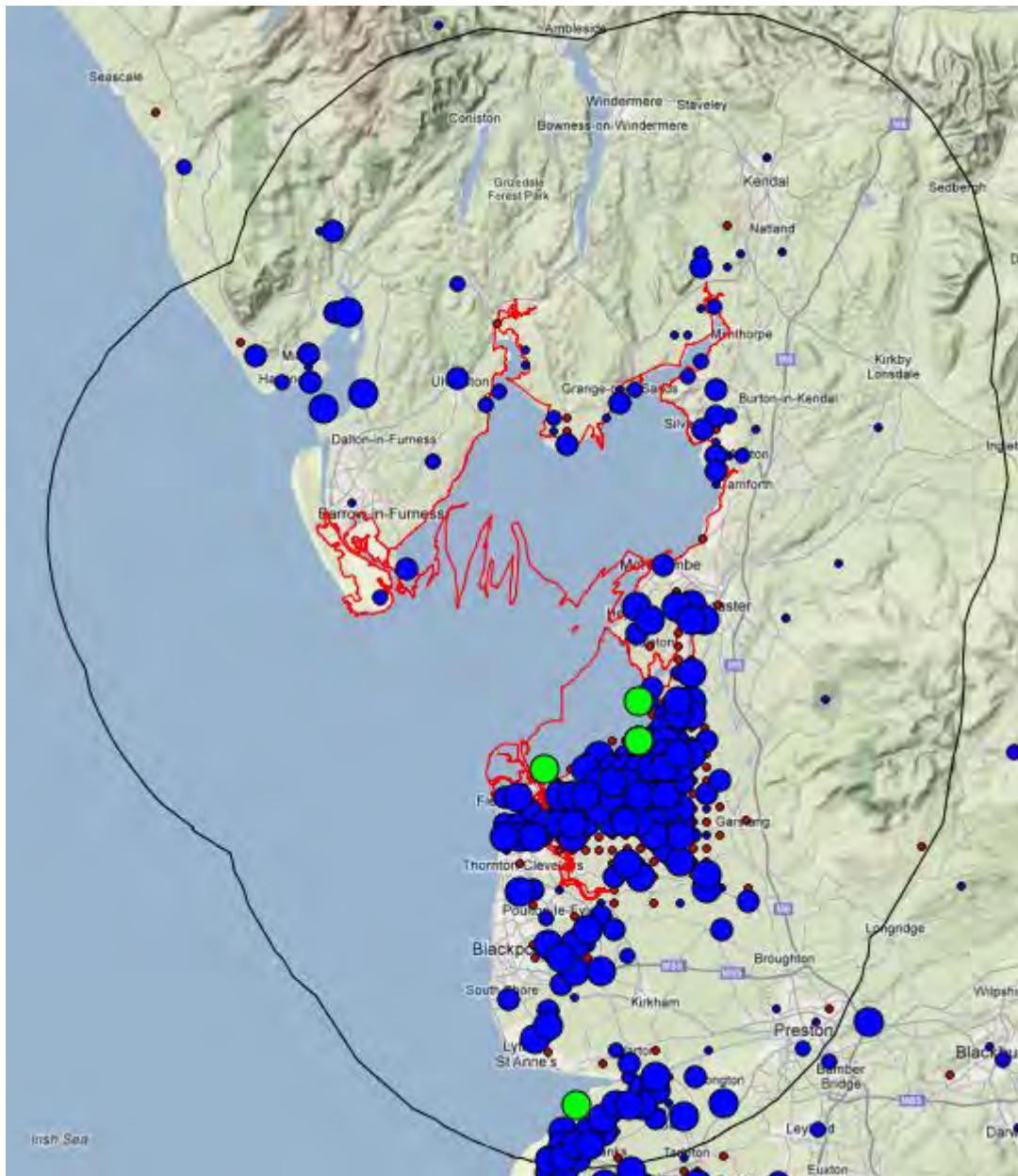
**Figure 18.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to the Ribble and Alt Estuaries SPA. For key see page 25.

## 7) Morecambe Bay (UK9005081):

**Roost locations and feeding distribution**
There has been a considerable increase in the use of the Lune Estuary roost by Pink-footed Geese.
Numbers are much lower in the earlier part of the season, but it is now the most important roost in
Lancashire from January onwards. From the Lune Estuary, geese move to feed over an extensive area of
the Fylde peninsula from Pilling, Cockerham and Glasson in the north, south towards the River Wyre and
including particularly the areas of Pilling, Cockerham and Winmarleigh mosses (Figure 19).



**Figure 19.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation
to the Morecambe Bay SPA. For key see page 25.

The data for the most recent five years (Figure 20) show that during this period little change has taken
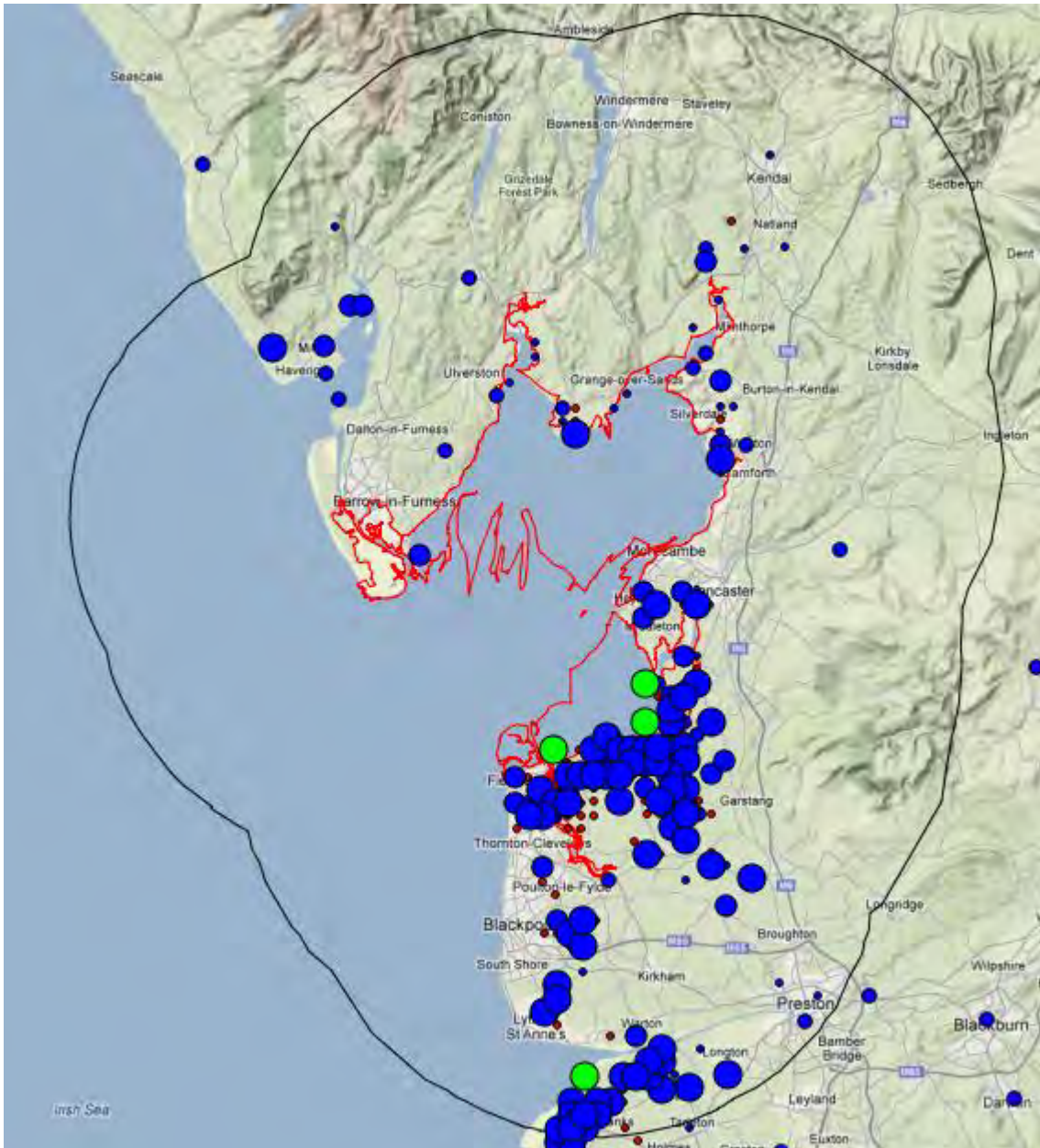place in the main feeding areas for birds roosting within Morecambe Bay SPA.

**Figure 20.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to the Morecambe Bay SPA. For key see page 25.

## 8) Upper Solway Flats and Marshes (UK9005012):

**Roost locations and feeding distribution**

The main roosts are at Moricambe Bay at the confluence of the Rivers Waver and Wampool and on the extensive sandflats off the Rockcliffe saltmarsh (Figure 21). Counts show a very consistent pattern from September to October of birds using the estuary as a brief stop-over en route to Lancashire. Although most birds feed on the Scottish side of the Solway, feeding locations are also used on the English side, including along the Eden Valley, the Esk Valley and the lowlands around Abbeytown and the Rivers Wampool and Waver.
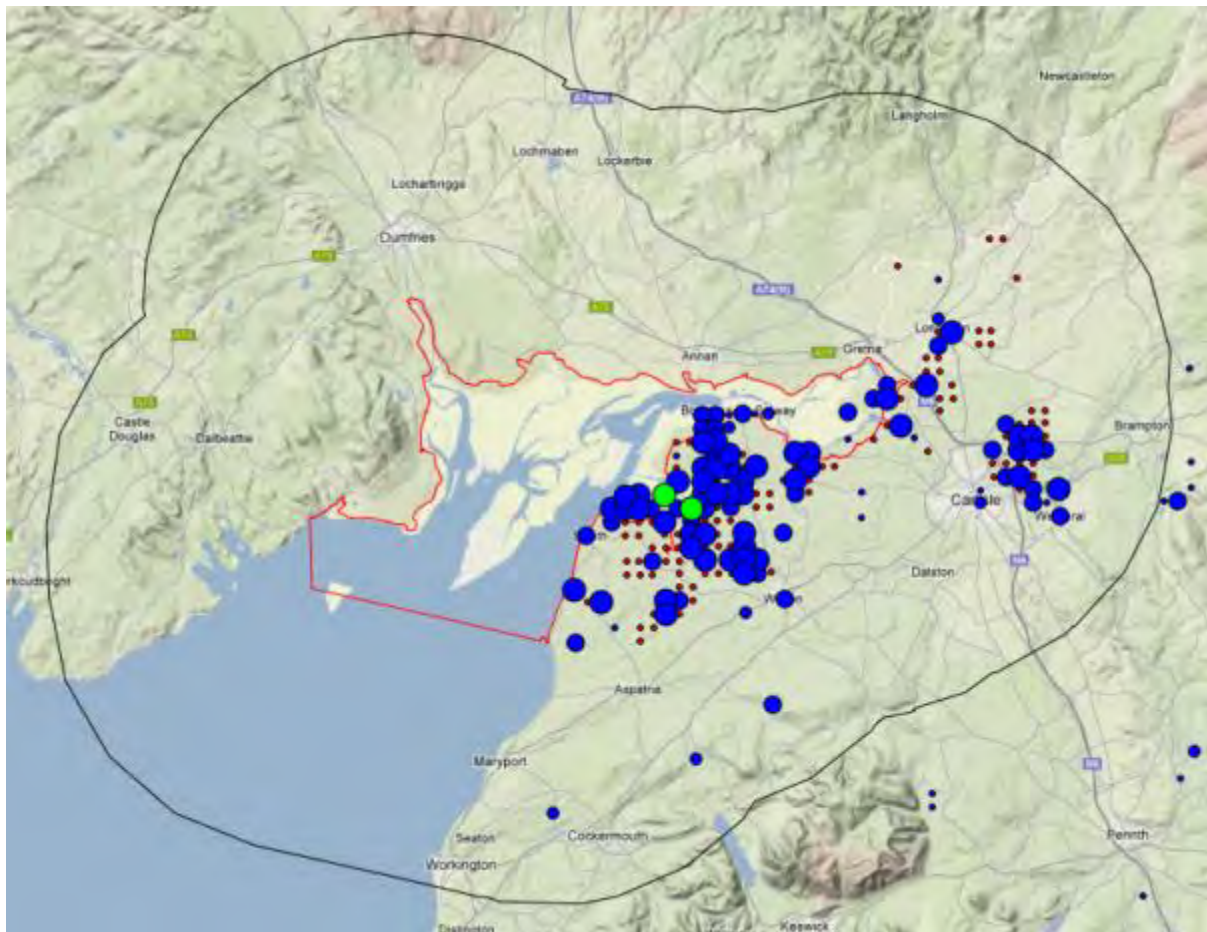


**Figure 21.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to the Upper Solway Flats and Marshes SPA. For key see page 25.

The data for the most recent five years (Figure 22) show that during this period little change has taken place in the main feeding areas for birds roosting within the Upper Solway Flats and Marshes SPA.
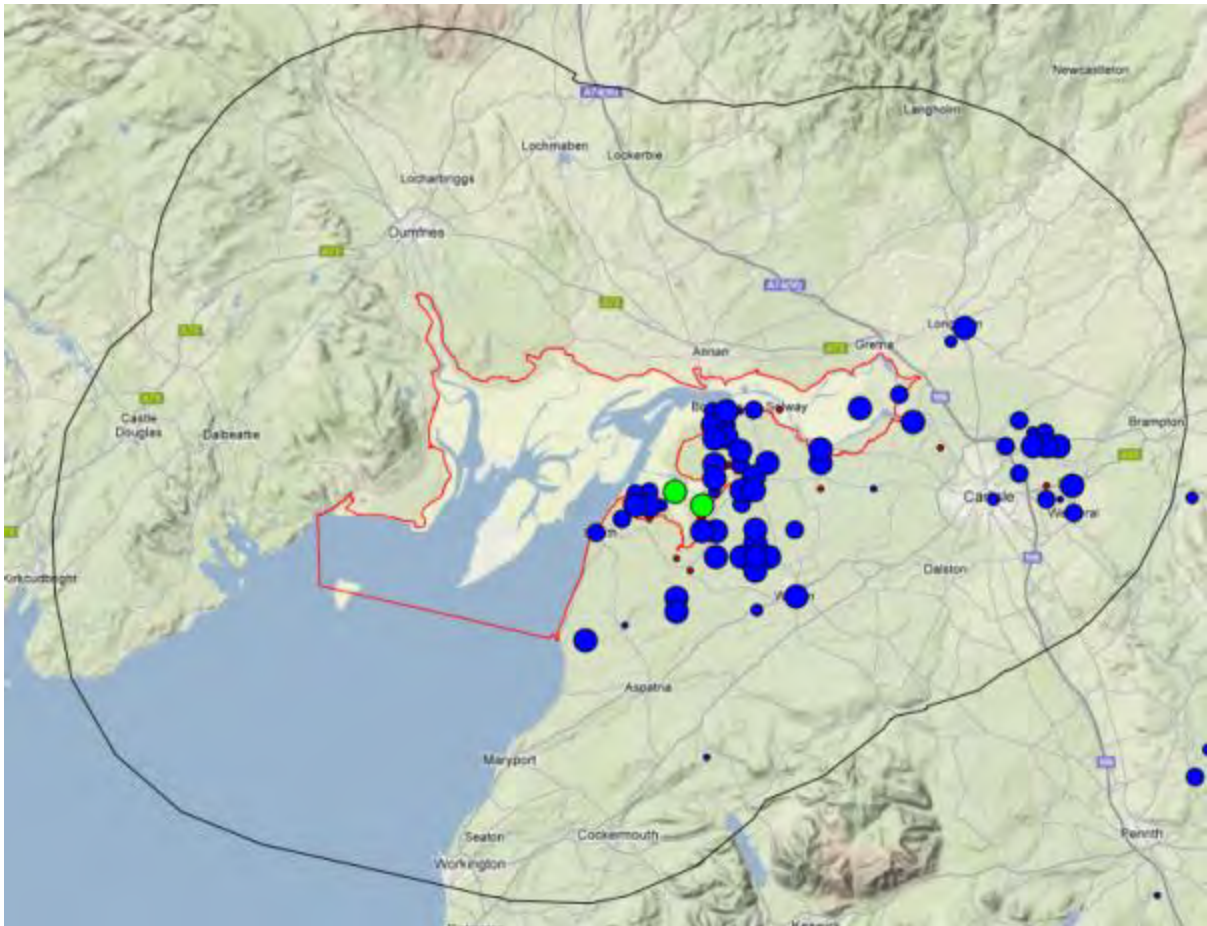
**Figure 22.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to the Upper Solway Flats and Marshes SPA. For key see page 25.

## 9) Humber Estuary (Read's Island and Whitton Sands)

**Roost locations and feeding distribution**

Although the Humber Estuary is not designated as an SPA for Pink-footed Geese, it is of international importance for the species. There are two main roosts at Read's Island and Whitton Sands (Figure 23). The five year mean (2006/07 – 2010/10) for Read's Island is 4,118 and for Whitton Sands 2,753. From the roosting sites birds mainly feed south of the Humber Estuary.
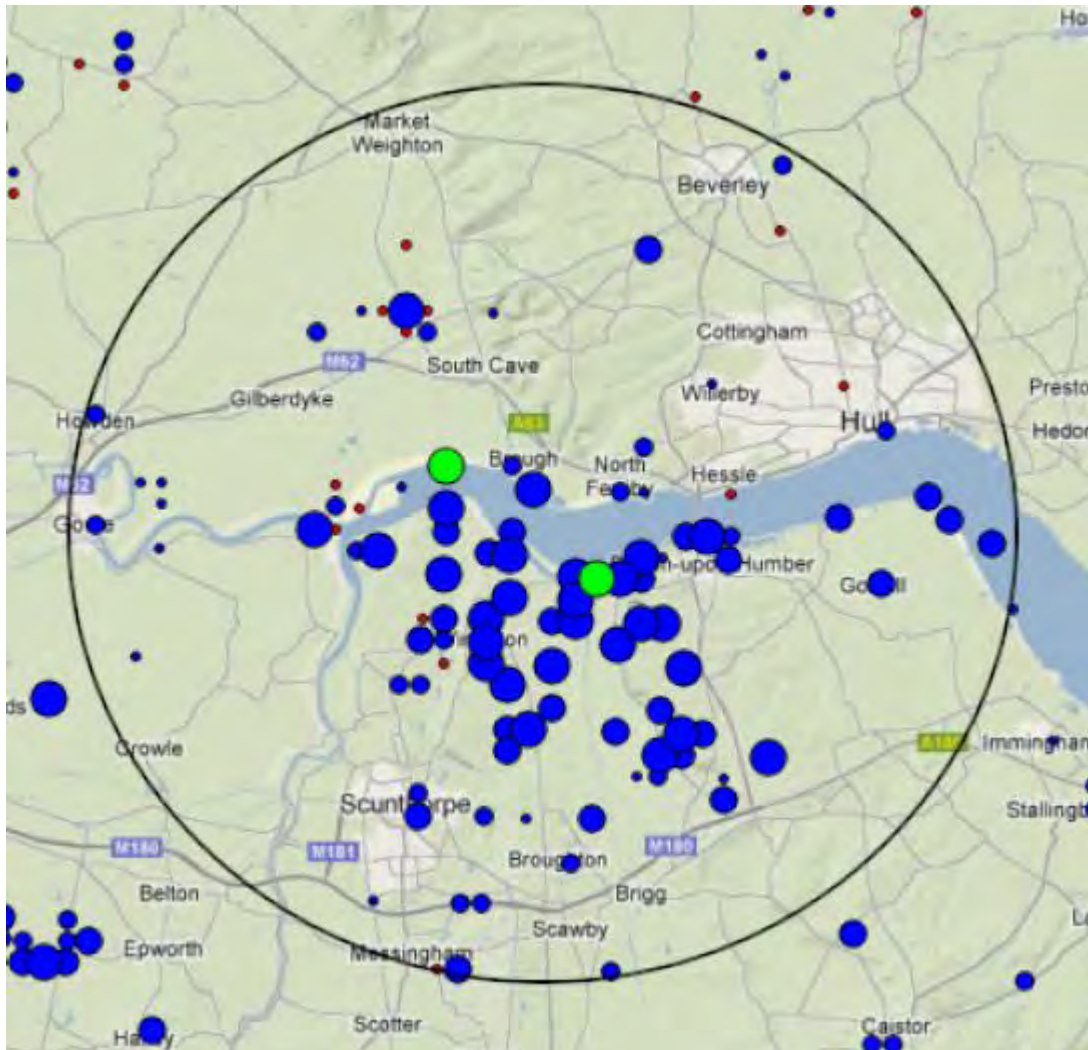


**Figure 23.** Feeding distribution (1986/87 to 2012/13 – all records) of Pink-footed Geese in relation to Humber Estuary (Read's Island and Whitton Sands). For key see page 25.

The data for the most recent five years (Figure 24) show that during this period little change has taken place in the main feeding areas for birds roosting at the Humber Estuary.
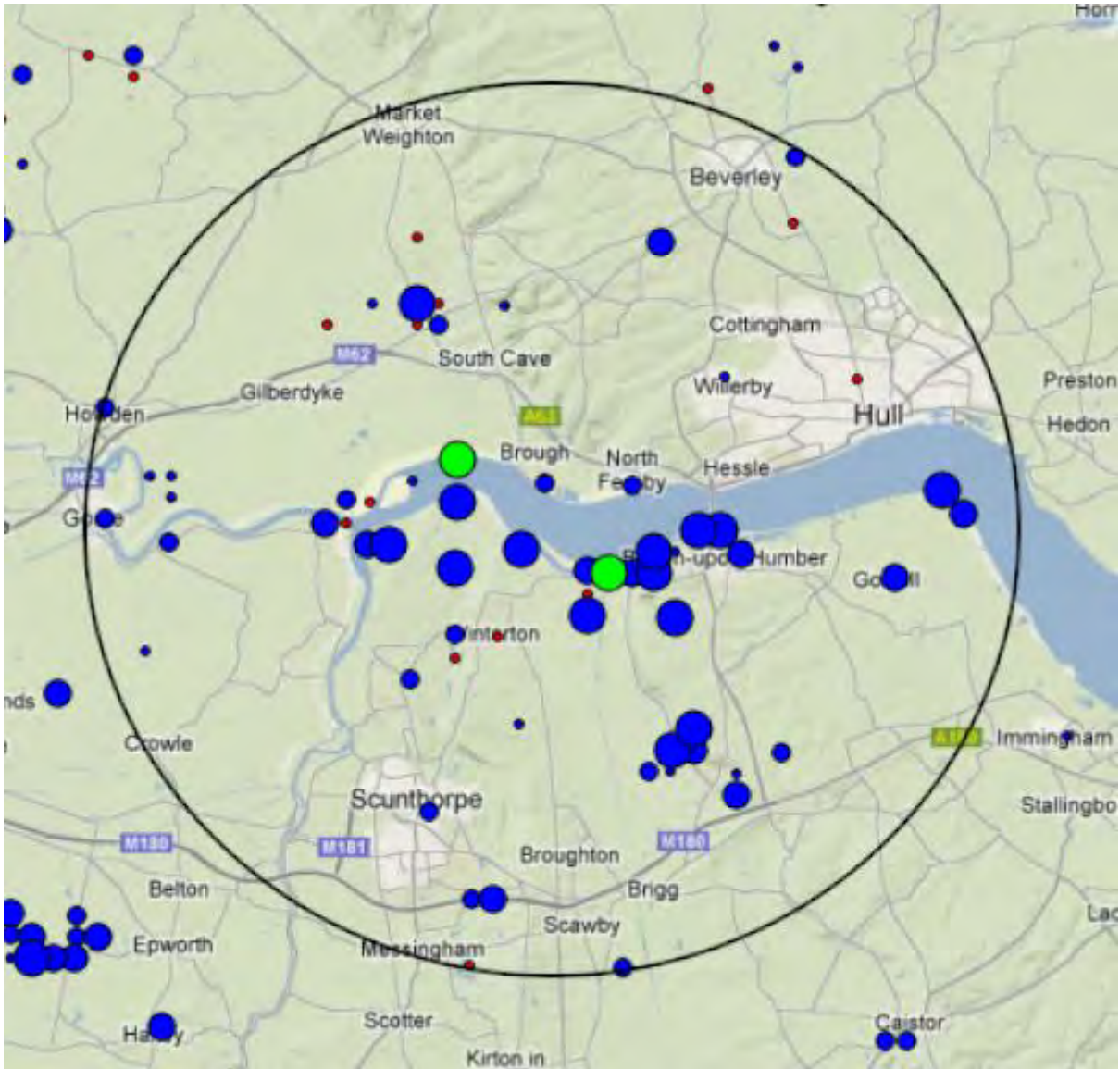
**Figure 24.** Feeding distribution (2008/09 to 2012/13 – new records) of Pink-footed Geese in relation to Humber Estuary (Read's Island and Whitton Sands). For key see page 25.