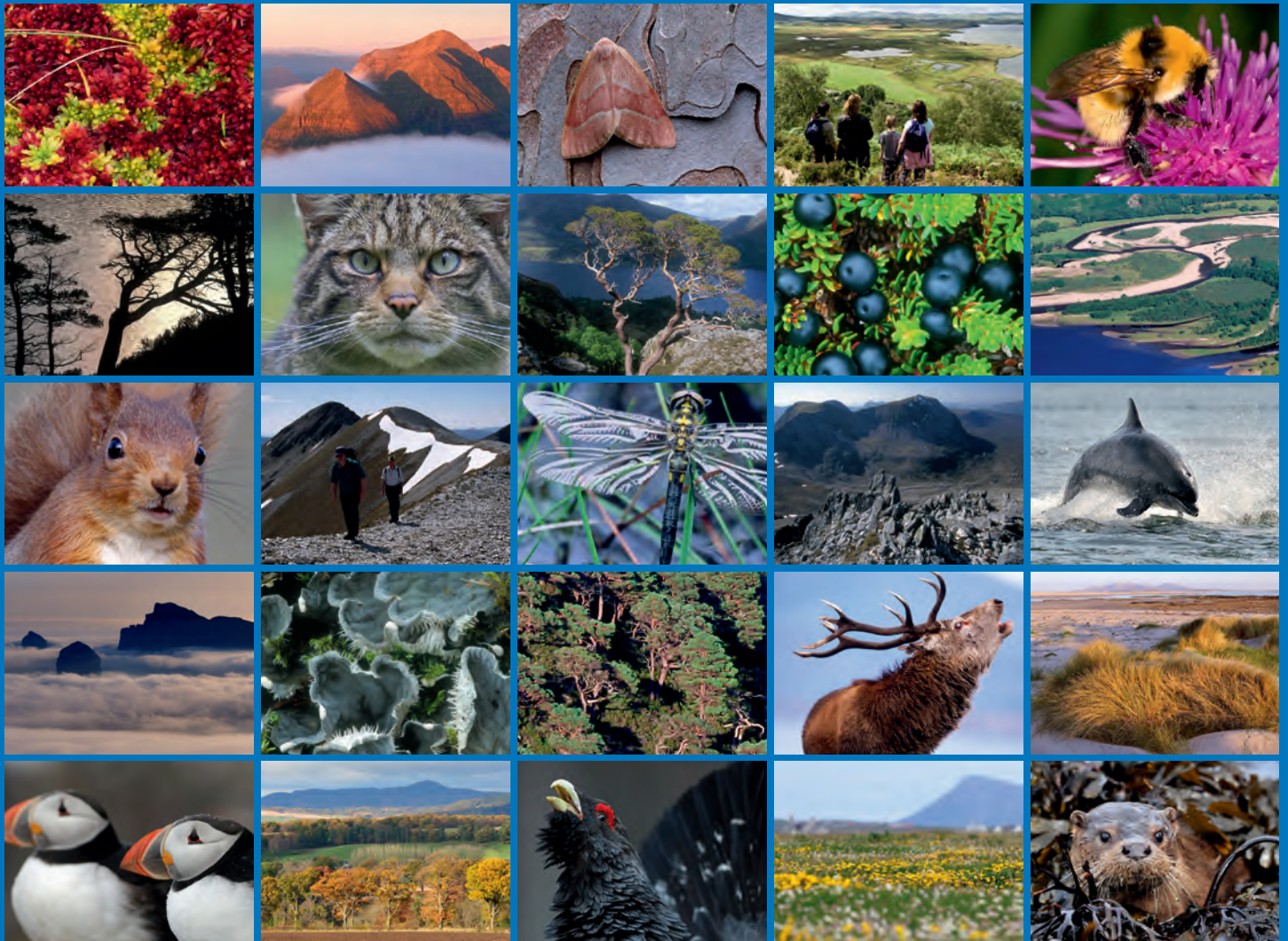


Elaborating the distribution of the great crested newt in Scotland (2010-2011)





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COMMISSIONED REPORT

Commissioned Report No. 793

Elaborating the distribution of the great crested newt in Scotland (2010-2011)

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This report should be quoted as:

Wilkinson, J.W., Arnell, A., Driver, D. & Driver, B. 2014. Elaborating the distribution of the great crested newt in Scotland (2010-2011). *Scottish Natural Heritage Commissioned Report No. 793.*

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COMMISSIONED REPORT

Summary

Elaborating the distribution of the great crested newt in Scotland (2010-2011)

Commissioned Report No. 793

Project no: 12873

Contractor: Amphibian & Reptile Conservation

Year of publication: 2014

Keywords

Great crested newt; *Triturus cristatus*; distribution; modelling; survey; Scotland.

Background

The distribution and status of the great crested newt in Scotland have been elusive. It is known, however, that its numbers have declined due to pond losses and habitat fragmentation. The species is strictly protected by the EC Habitats Directive and the UK has an obligation to report on its status every six years (under Article 17).

The aim of this project was to use species-specific ecological modelling techniques, developed by Amphibian and Reptile Conservation, to predict areas of suitable habitat for the great crested newt in Scotland as a way of targeting surveys to locate new populations.

Main findings

- Modelling can be successfully used to predict areas of habitat suitable for supporting great crested newt populations.
- Scotland contains many fewer potential great crested newt breeding ponds than Wales though the two countries have previously been assigned similar targets under the UK BAP.
- From 272 pond surveys in 135 grid squares examined during this study, only five new great crested newt breeding ponds were located. Though there are undoubtedly other breeding ponds yet to be discovered, much of Scotland is thought to be unsuitable for the species and its distribution is actually much better known than was previously thought. There are other areas of high pond density in Scotland but it is likely that many ponds are too elevated or too acidic to support great crested newts.
- Great crested newts in Scotland occur in three main areas: Borders, Central Belt and the Moray Firth.
- These findings can be used to inform future monitoring and reporting efforts in Scotland.

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Acknowledgements

The authors would like to thank Tony Gent and John McKinnell for advice throughout, plus all the surveyors and landowners taking part in this study.

1. INTRODUCTION

The great crested newt (*Triturus cristatus*) is widely distributed across Europe. The species has suffered from marked declines throughout its European range due to the loss and fragmentation of its habitat, the lack of appropriate pond management leading to pond senescence, and the introduction of fish *inter alia*. Great Britain is a key area for great crested newts in Europe, with significant populations in several localities.

The species is strictly protected through the European Union's 'Habitats Directive' (*Council Directive 92/43/EEC (a) on the Conservation of Natural Habitats and of Wild Fauna and Flora*), where the great crested newt is listed under Annexes II and IV. The Habitats Directive is implemented in Scottish legislation through *The Conservation (Natural Habitats, etc.) Regulations 1994* as amended by *The Conservation (Natural Habitats, etc.) Amendment (Scotland) Regulation 2007*. As a result of this protection, the United Kingdom has a legal requirement to report on the conservation status of the great crested newt every six years, as outlined in Article 17 of the Habitats Directive. Monitoring of the conservation status is also a legal requirement as stated in Article 11 of the Directive, and forms the basis of the reporting obligation highlighted above.

In Britain, the great crested newt is relatively widespread across lowland England, but is absent or rare in parts of Devon, Cornwall and the Pennines. The species is less common in Wales, where it has an uneven distribution which is most likely due to considerable spatial variation in pond density and occupancy. Significant populations exist in the North East of the country, where there are high pond densities, but it is absent from large areas of West Wales. In Scotland, the species has a far more restricted distribution, but key populations have been identified in Dumfries and Galloway, Lothian, the Borders and around Inverness.

In 1994, Scottish Natural Heritage (SNH) commissioned a review of the known great crested newt populations (Langton & Beckett, 1995) as a first step to determining the distribution and status of the great crested newt in Scotland. A large survey was coordinated across Scotland in 1996 (Alexander, 1997) in which sites highlighted in the 1994 review and the adjacent surrounding areas formed the framework for survey activity. The survey results improved significantly the known distribution of the species, identifying the (now) well documented core species range in Scotland.

In the intervening years, additional sites have been recorded through survey work, casual observations and as part of surveys commissioned due to planned development. Many of these new records are outside the areas documented in the 1996 surveys, indicating that we still have an incomplete picture of the distribution of great crested newts in Scotland. It is also evident that there are large tracts of (what appears to be) suitable habitat for the species, with no records.

This project has been developed to build on the earlier SNH commissioned work and is designed to make an assessment of the distribution and status of the great crested newt in Scotland. This is to be undertaken in two ways: first, to develop a predictive model based on current knowledge and, second, to ground truth the model through field surveys. Modelling was developed specifically for this project but has also fed into other, concurrent work in Wales (see for example Amphibian and Reptile Conservation & Cofnod, 2010; Wilkinson & Arnell 2011), England and throughout GB (Wilkinson *et al.*, 2011).

Outcomes from this work will facilitate the refinement of the targets within the great crested newt Species Action Plan, which forms the framework for conservation action for the species. In 2005/6 the UK BAP underwent its first full review and SMART (Specific, Measurable, Achievable, Relevant and Time-bound) targets were set. Four targets have been developed, but the evidence base was inadequate to make precise and accurate

assessments. Knowledge gained from this project (including data from the field survey, but also assessments made from the modelling work) will help to evaluate existing targets as part of the (planned) iterative process of target setting and re-evaluation. The work can also be used to feed into the targeting of agri-environment schemes, and for land-use planning and habitat creation initiatives. Ultimately, only a more comprehensive picture of great crested newt distribution in Scotland will enable the establishment of amended baselines and the re-setting of realistic and achievable targets.

2. METHODS

2.1 Process

Attempts to improve knowledge on the distribution and status of great crested newts in Scotland were made by (1) mapping known great crested newt records from Scotland using as many sources as possible, (2) interrogating the 1 km grid squares within which those records fell as an objective means of assessing habitat and environmental preferences of the species in Scotland, (3) creating a model based on (2) that would identify other grid squares with suitable habitat and environmental characteristics, (4) exploring ways of tightening that model in order to identify squares to be targeted for great crested newt survey and (5) conducting surveys of the targeted squares within temporal and financial constraints. This process is summarized in Fig. 1.



Figure 1. The process used to identify new great crested newt records in Scotland.

2.2 Mapping in Preparation for Modelling

Existing great crested newt records in Scotland were collated using data from (i) the NBN Gateway (<http://www.searchnbn.net/>), (ii) the ARC database, (iii) the National Amphibian and Reptile Recording Scheme (NARRS) surveys 2007 – 2009 and (iv) additional great crested newt records held by SNH (supplied by J. McKinnell). Records were mapped using GIS software (MapInfo) and used as a basis for the modelling described below. In order to avoid spatial bias and bias introduced by duplicate records, modelling was carried out on the basis of “occupied 1 km grid squares” (i.e. several records from one grid square resulted in only one “occupied” square). Collation of records has continued throughout the present project and was ultimately used to generate range-buffer and 10 km square occupancy maps using MapInfo (Fig. 2; see also Fig 11). Range-buffers generate an objective estimate of “total range” using a simple 5 km radius buffer around each known occupied square.

2.3 Modelling Habitat and Targeting Survey Squares

The modelling of 1 km grid squares theoretically suitable for great crested newts in Scotland was carried out using the “ARC Removal Model”. This model predicts the potential distribution of newts using a combination of climatic and land cover parameters. It was developed particularly for the present project but is also being used to effect in projects in England, Wales and covering GB (see Wilkinson *et al.*, 2011). The approach is similar to others being trialled to model habitat suitability (e.g. ARC & Cofnod, 2010) and target survey effort for great crested newts and other species such as adders (e.g. S. Langham, *pers. comm*). The comparability of habitat suitability modelling approaches represents an ongoing challenge in the production of national descriptive status metrics (*sensu* Loiselle *et al.*, 2003), so the use of approaches compatible with related work is beneficial. “Removal Modelling” is also similar to more complex ecological niche modelling approaches described by (e.g.) Hernandez *et al.* (2006) and Phillips & Dudik (2008) but remains relatively simple and objective.

The habitat and environmental variables (from the Land Cover Map 2000, accessed through the Countryside Information System, see <http://www.cis-web.org.uk/home/>) associated with 1 km grid squares where great crested newts were known to occur were interrogated. Maximum and minimum values from the ranges generated for each variable were used to remove “unsuitable” squares from all those available for Scotland. The result of this step (Phase 1) leaves the model with all those squares that match the known distribution characteristics.

In order to improve the model and further target suitable squares for possible survey (Phase 2), more squares were removed by eliminating those where one or more environmental or habitat variable fell outwith the 95% confidence interval (mean \pm SD \times 1.96 assuming normal distribution). Such squares were considered to have a low likelihood of supporting great crested newts. Phase 1 and 2 Removal Models were generated using data (per 1 km grid square) on the extent of (i) horticultural land, (ii) broad-leaved woodland, (iii) built-up land and gardens, (iv) coastal habitat, (v) coniferous woodland, (vi) improved grassland, (vii) open water, (viii) sea, (ix) semi-natural rough grassland and (x) upland, as well as (xi) average annual rainfall, (xii) mean summer temperature, (xiii) mean winter temperature and (xiv) altitude. The efficacy of Phase 1 and 2 models was assessed using a training subset of a random selection of 50% of squares where great crested newt were known to occur to generate a model for all Scotland (as suggested by Liu *et al.*, 2005) and examining the number of *other* great crested newt-positive squares (i.e. those not used for training) that were successfully accounted for.

Phase 3 of this modelling process involved mapping Phase 2 squares in MapInfo, overlaying the locations of squares where great crested newt were known to occur and creating 5 km-radius buffers around each of these squares. Phase 3 squares are therefore those that fall within both the Phase 2 area and within 5 km of a known great crested newt square.

2.4 Surveying and Survey Protocols

Survey protocols were developed based on the NARRS methodology and requirements of the present project (see Annex 1). Surveyors were recruited in areas near the target survey squares and supplied with the protocols, supporting information and survey sheets (Annex 3). Surveyors were allocated an agreed number of survey days.

In 2010, surveyors were asked to spend approximately 70% of their time surveying ponds within the Phase 3 target squares (within 5 km of a known record square), with the remaining survey time spent on Phase 2 squares including the 1 km square with the record as indicated in Annex 1. Maps were provided showing Model square locations, and of those squares containing ponds (extracted by Stuart Ball of JNCC from OS Mastermap under licence agreement to NE). Actual 2010 survey squares were identified by the local surveyors based on combinations of this information provided and their particular knowledge (see Annex 1 for detailed instructions). Additionally, guidance was provided on the four survey methods recommended to maximise amphibian detectability (Sewell *et al.*, 2010): visual search, netting, torchlight survey and bottle trapping. Surveyors were accredited under ARC's SNH great crested newt survey licence if required (and where experienced) in order to carry out the surveys. Surveyors also collected great crested newt habitat suitability index (HSI) data (Oldham *et al.*, 2000) for each survey square.

In 2011, further surveys were carried out using an identical survey protocol, but targeting clusters of survey squares with high pond density – irrespective of whether they were Phase 3 squares, i.e. those within 5 km of known great crested newt squares (see Annex 2). Clustering was determined by assessing the mean distances between high pond density squares using a form of nearest-neighbour analysis performed using MapInfo. Squares were prioritised for survey according to their pond density (e.g. the highest survey priority was given to those with 10 or more ponds) and connectivity (distance to other squares with high pond density).

Resulting survey squares were mapped and the data collected were used for comparison and analyses in conjunction with other concurrent great crested newt projects (see above and References) and available HSI data.

3. RESULTS

The results of the modelling are outlined in Figures 2 – 4 below. Figures 5 – 10 show the locations of survey sites, HIS scores and great crested newt finds for the three areas of Moray Firth, The Central Belt and Borders.

Table 1 summarises the great crested newt distribution and habitat metrics in Scotland, Table 2 summarises the survey results for 2010 and 2011 and Table 3 summarises the great crested newt distribution and habitat metrics in Scotland amended to incorporate the results from the present project.

Figures 11 – 15 illustrate the analysis of these survey results in relation to the pond density data analysis outlined in Wilkinson *et al.*, (2011) and discussed below.

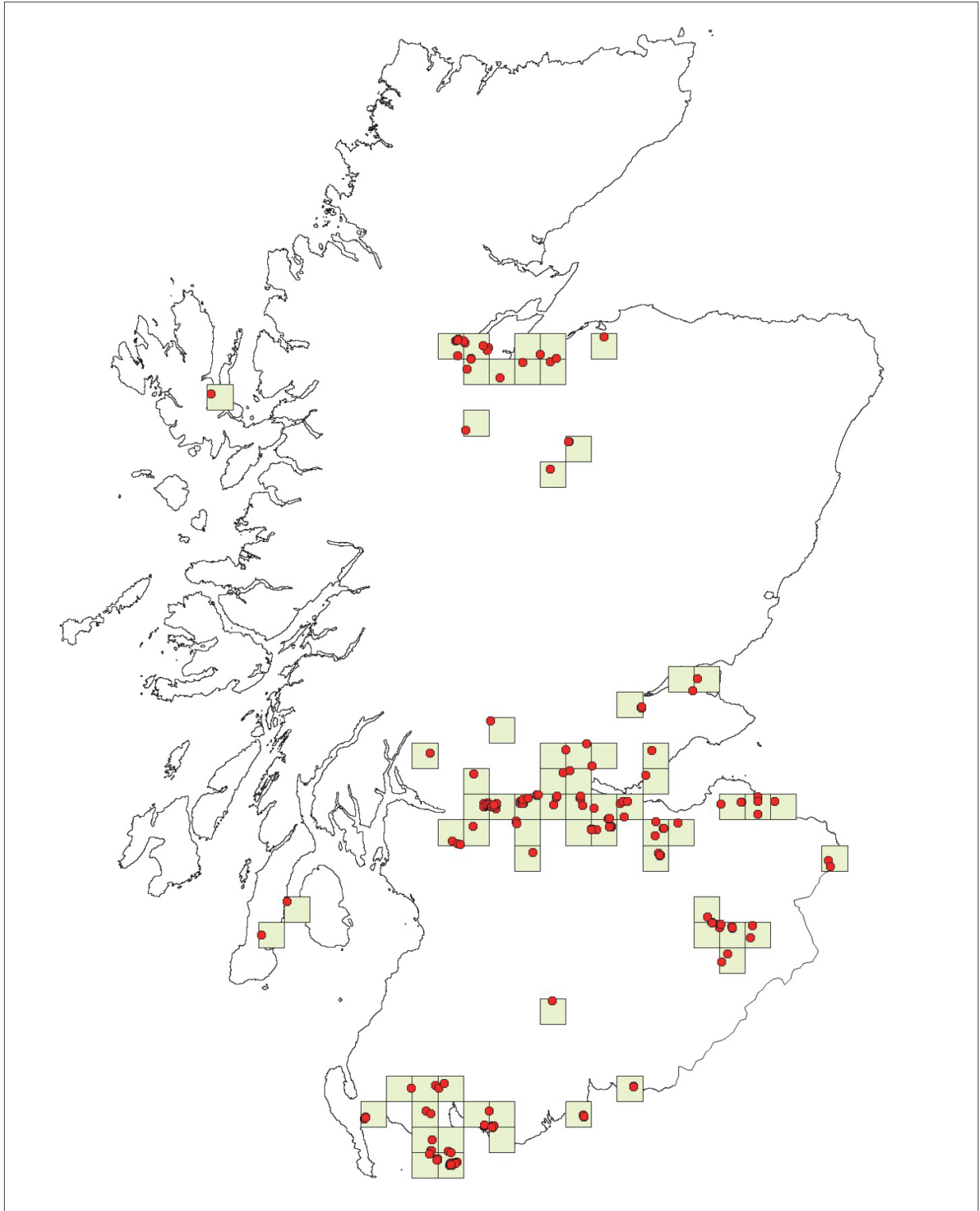


Figure 2. Map showing all unique great crested newt record locations in Scotland identified prior to surveys for the present project (red dots, n=194) and the 10 km grid squares in which they fall (n=70). © Crown copyright and database rights 2014 Ordnance Survey 100017908.



Figure 3. 1 km grid squares matching characteristics of great crested newt habitat in Scotland (from ARC Removal Model Phase 1). © Crown copyright and database rights 2014 Ordnance Survey 100017908.

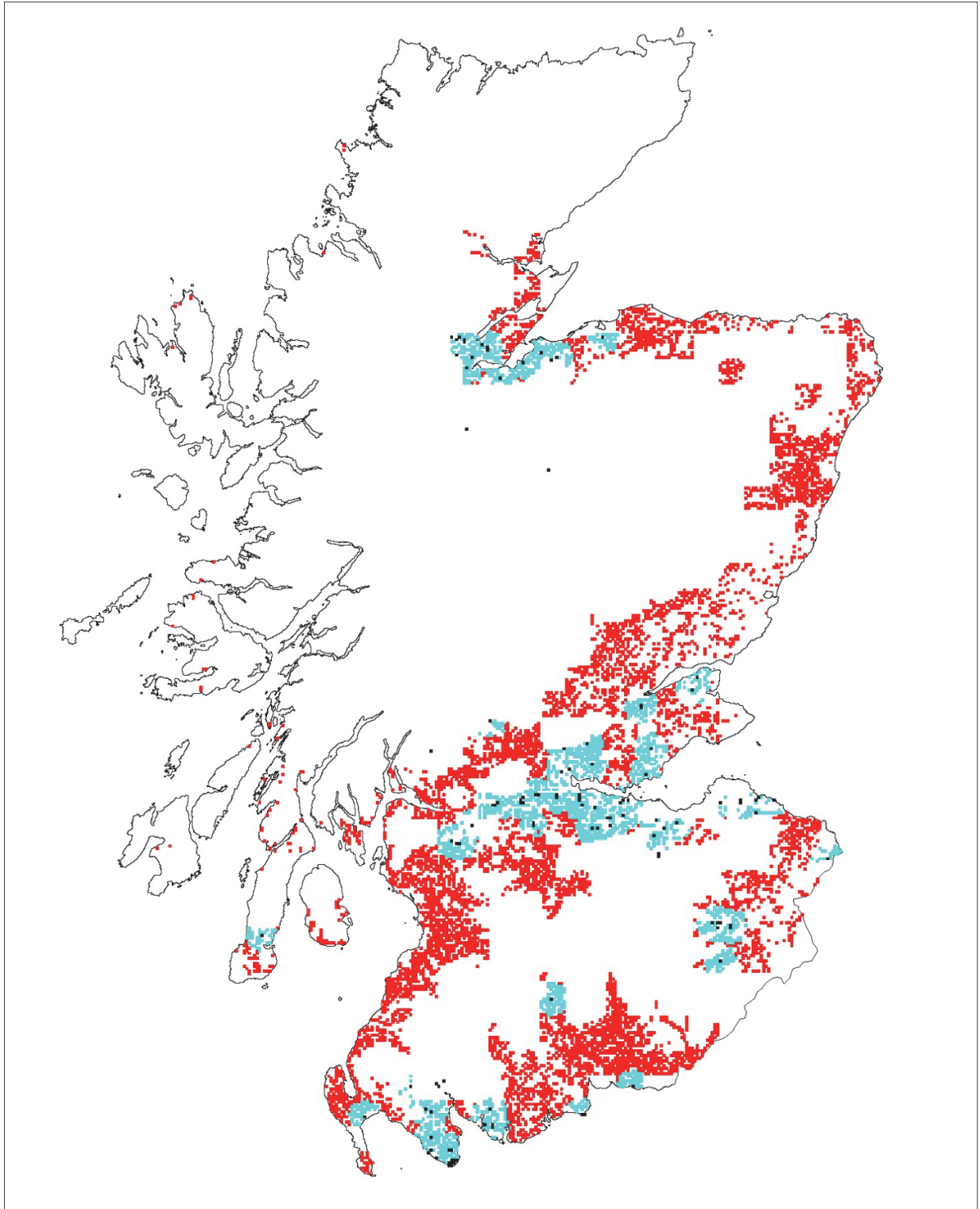


Figure 4. 1 km grid squares of ARC Removal Model Phase 2 (in red) and Phase 3 (in light blue, used to target surveys) in Scotland. See Methods for full explanation. Great crested newt-occupied squares used as model basis are shown by black dots. © Crown copyright and database rights 2014 Ordnance Survey 100017908.

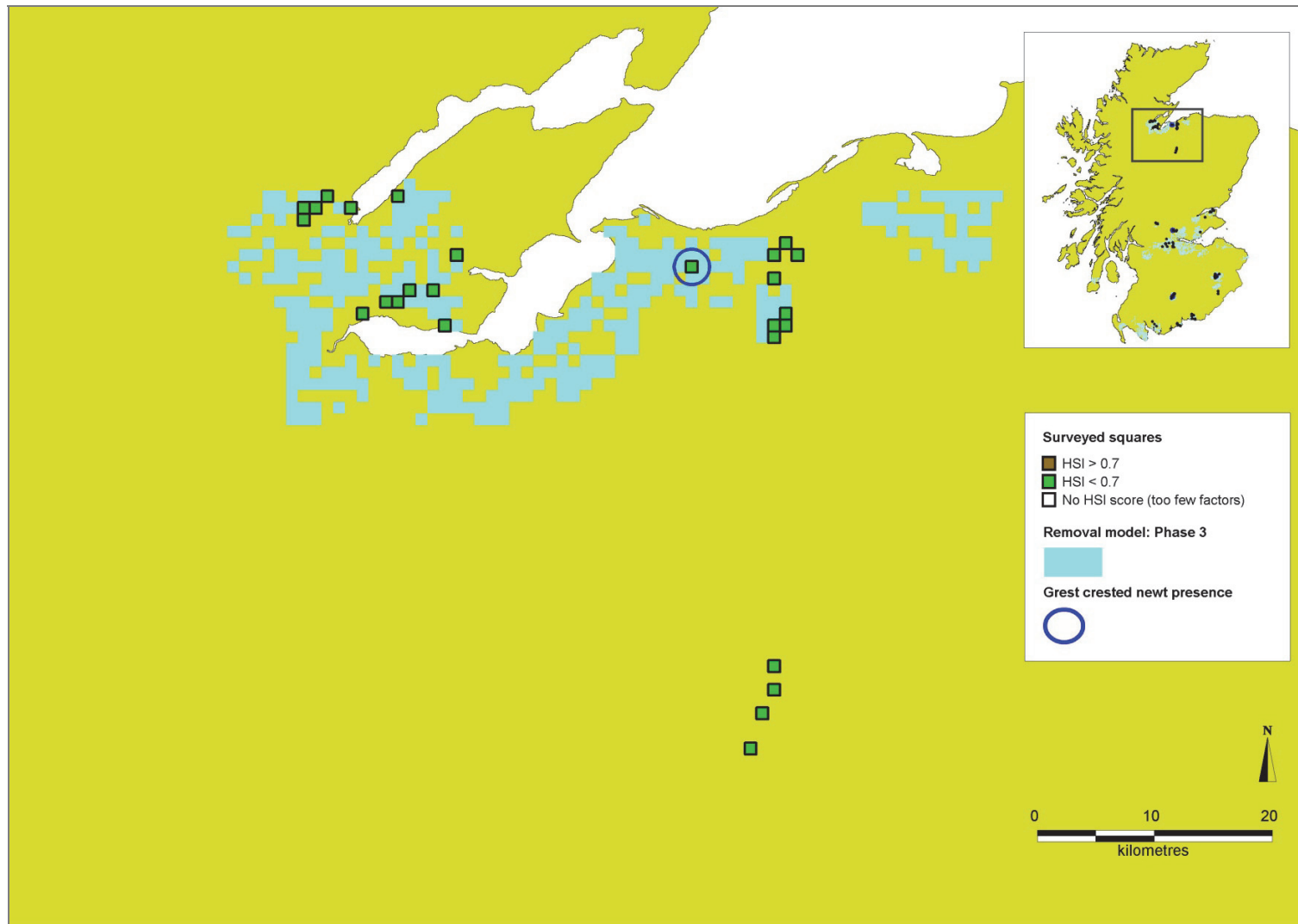


Figure 5. Squares surveyed for the present project in the Moray Firth area of Scotland 2010. HSI scores and a new great crested newt-occupied square are also shown. (Where ponds in the same square had differing HSI scores, the highest is displayed.) © Crown copyright and database rights 2014 Ordnance Survey 100017908.

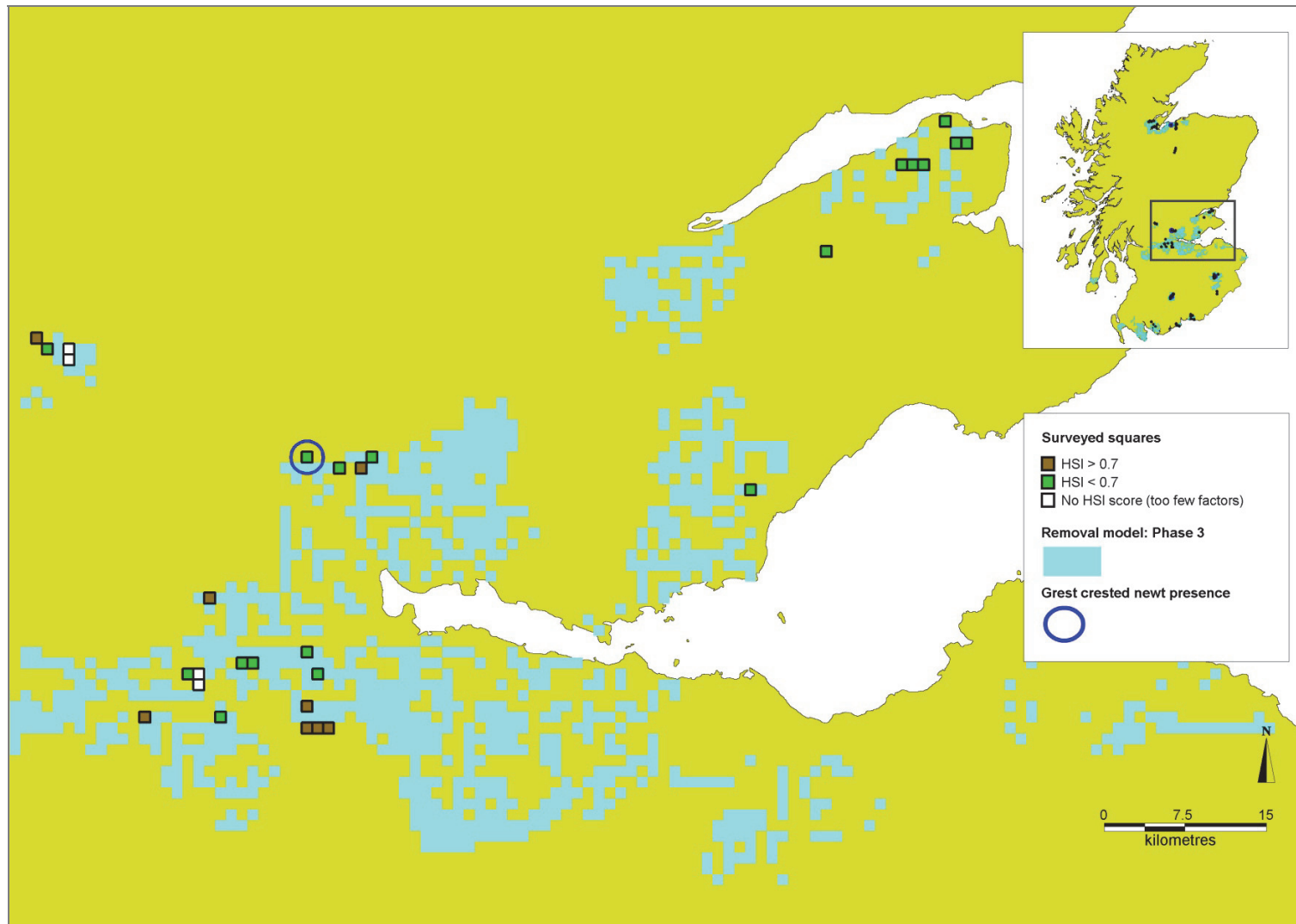


Figure 6. Squares surveyed for the present project in the Central Belt of Scotland in 2010. HSI scores and a new great crested newt-occupied square are also shown. (Where ponds in the same square had differing HSI scores, the highest is displayed.) © Crown copyright and database rights 2014 Ordnance Survey 100017908.

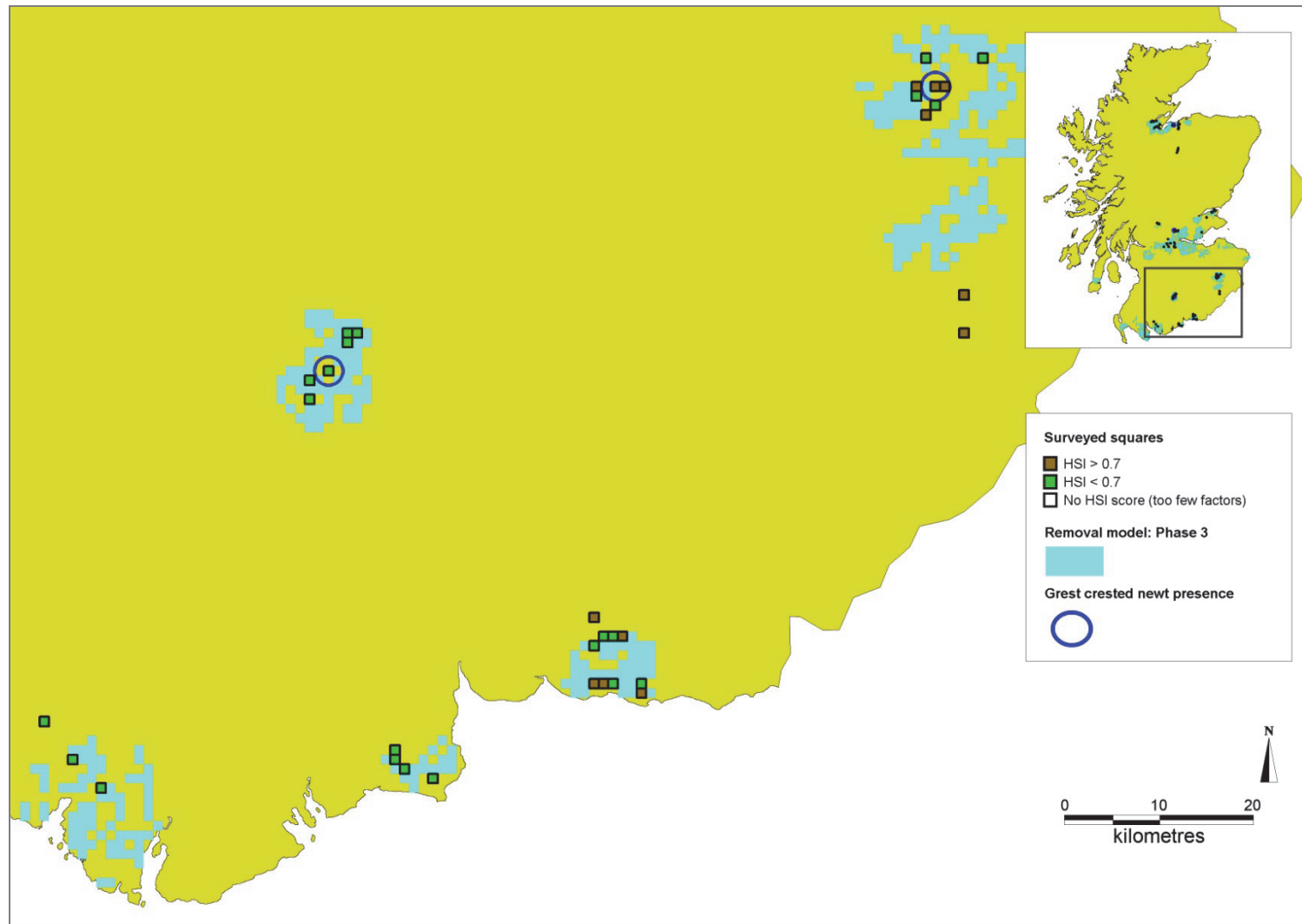


Figure 7. Squares surveyed for the present project in the Borders area of Scotland in 2010. HSI scores and two new great crested newt-occupied squares are also shown. (Where ponds in the same square had differing HSI scores, the highest is displayed.) © Crown copyright and database rights 2014 Ordnance Survey 100017908.



Figure 8. Squares surveyed for the present project in the Moray Firth area of Scotland 2011. HSI scores and a new great crested newt-occupied square are also shown. (Where ponds in the same square had differing HSI scores, the highest is displayed.) © Crown copyright and database rights 2014 Ordnance Survey 100017908.



Figure 9. Squares surveyed for the present project in the Central Belt of Scotland in 2011. HSI scores are also shown. (Where ponds in the same square had differing HSI scores, the highest is displayed.) © Crown copyright and database rights 2014 Ordnance Survey 100017908.

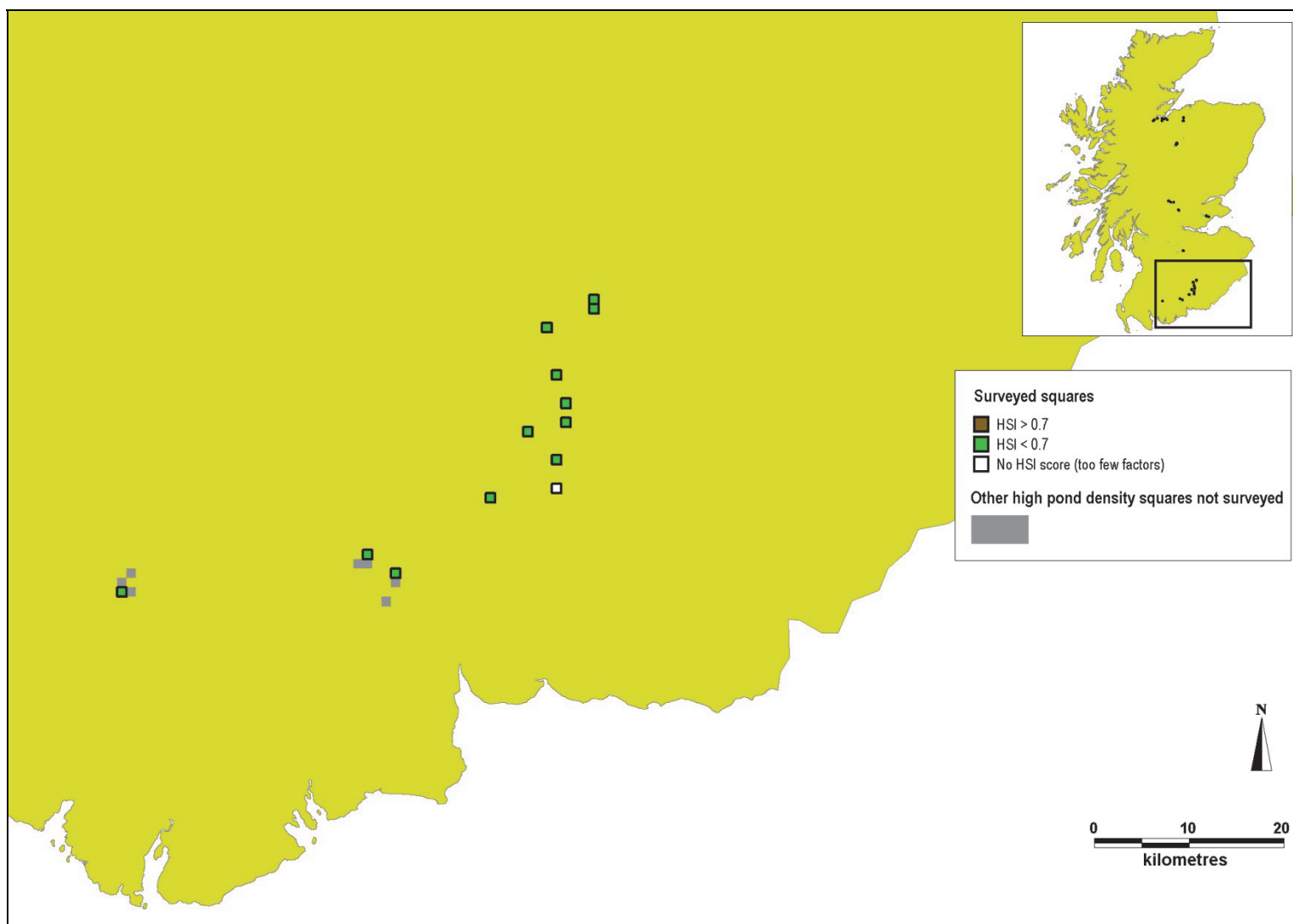


Figure 10. Squares surveyed for the present project in the Borders area of Scotland in 2011. HSI scores are also shown. (Where ponds in the same square had differing HSI scores, the highest is displayed.) © Crown copyright and database rights 2014 Ordnance Survey 100017908.

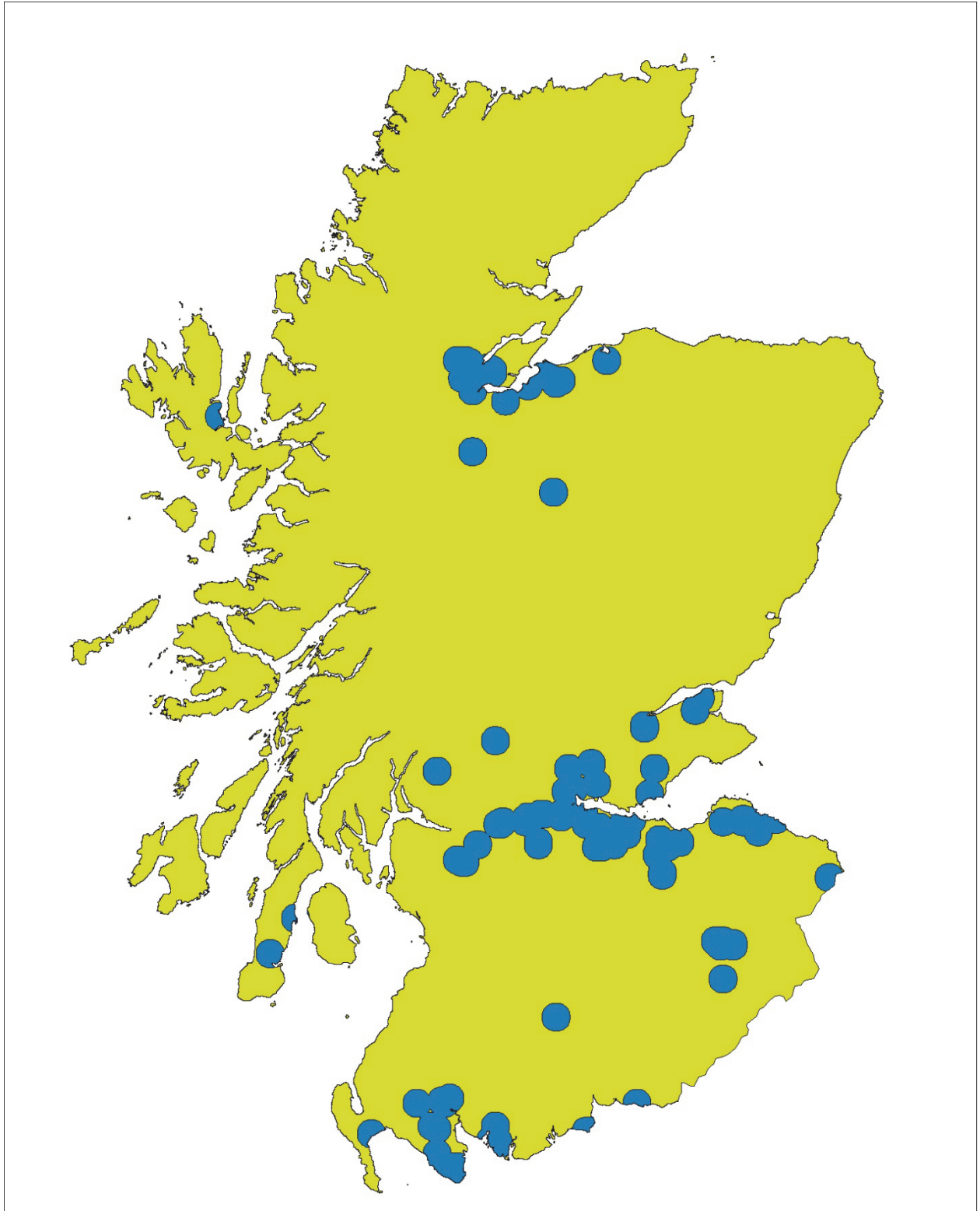


Figure 11. Range-buffer map showing objective total range of great crested newts in Scotland (see section 2.2). © Crown copyright and database rights 2014 Ordnance Survey 100017908.

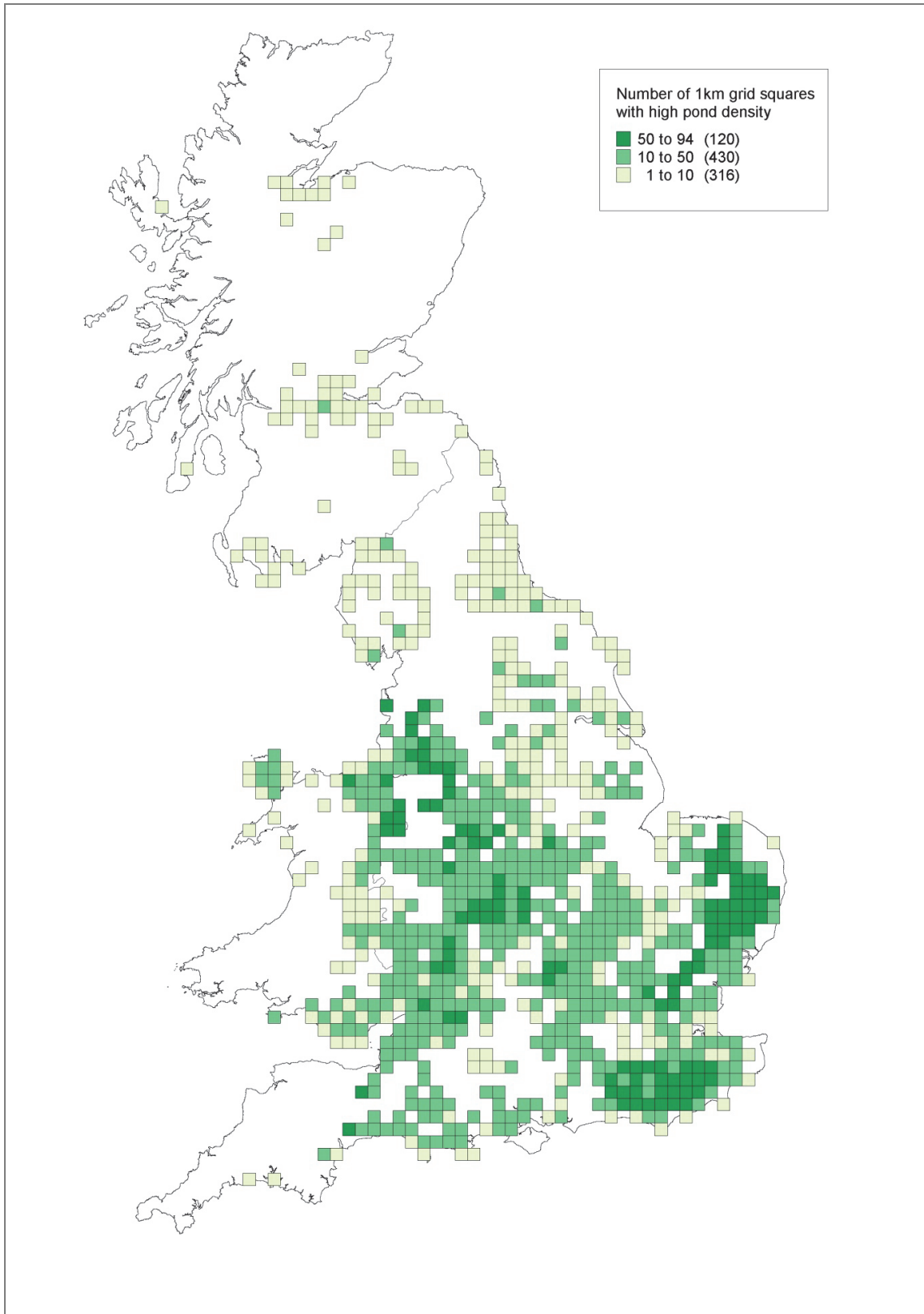


Figure 12. Thematic map showing great crested newt-occupied 10 km grid squares in GB plus the number of high pond-density 1 km squares within them, from Wilkinson et al., (2011). See also Figure 13. © Crown copyright and database rights 2014 Ordnance Survey 100017908.

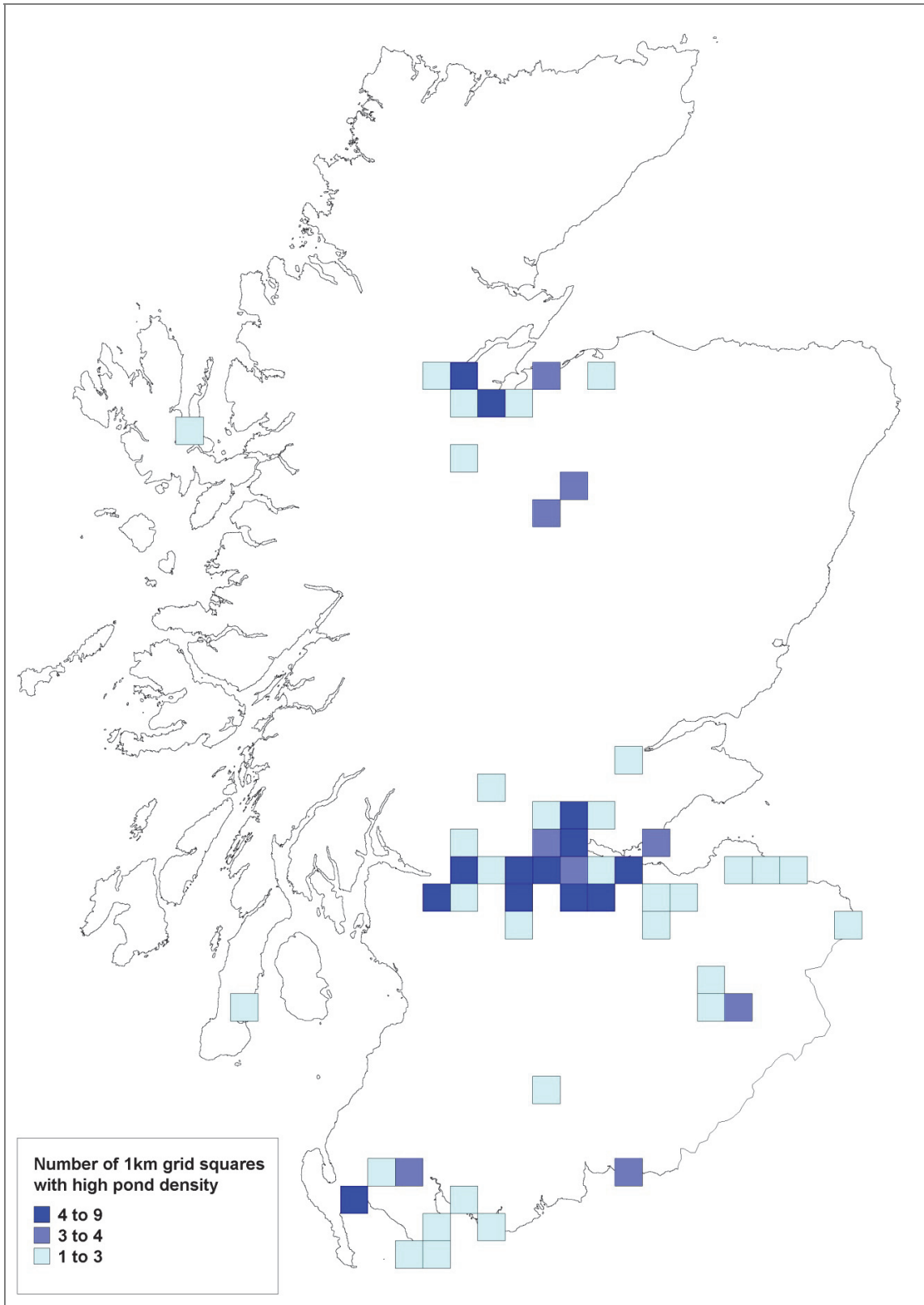


Figure 13. Thematic map showing great crested newt-occupied 10 km grid squares in Scotland plus the number of high pond-density 1 km squares within them, modified after Wilkinson et al., (2011). See also Figure 12. © Crown copyright and database rights 2014 Ordnance Survey 100017908.

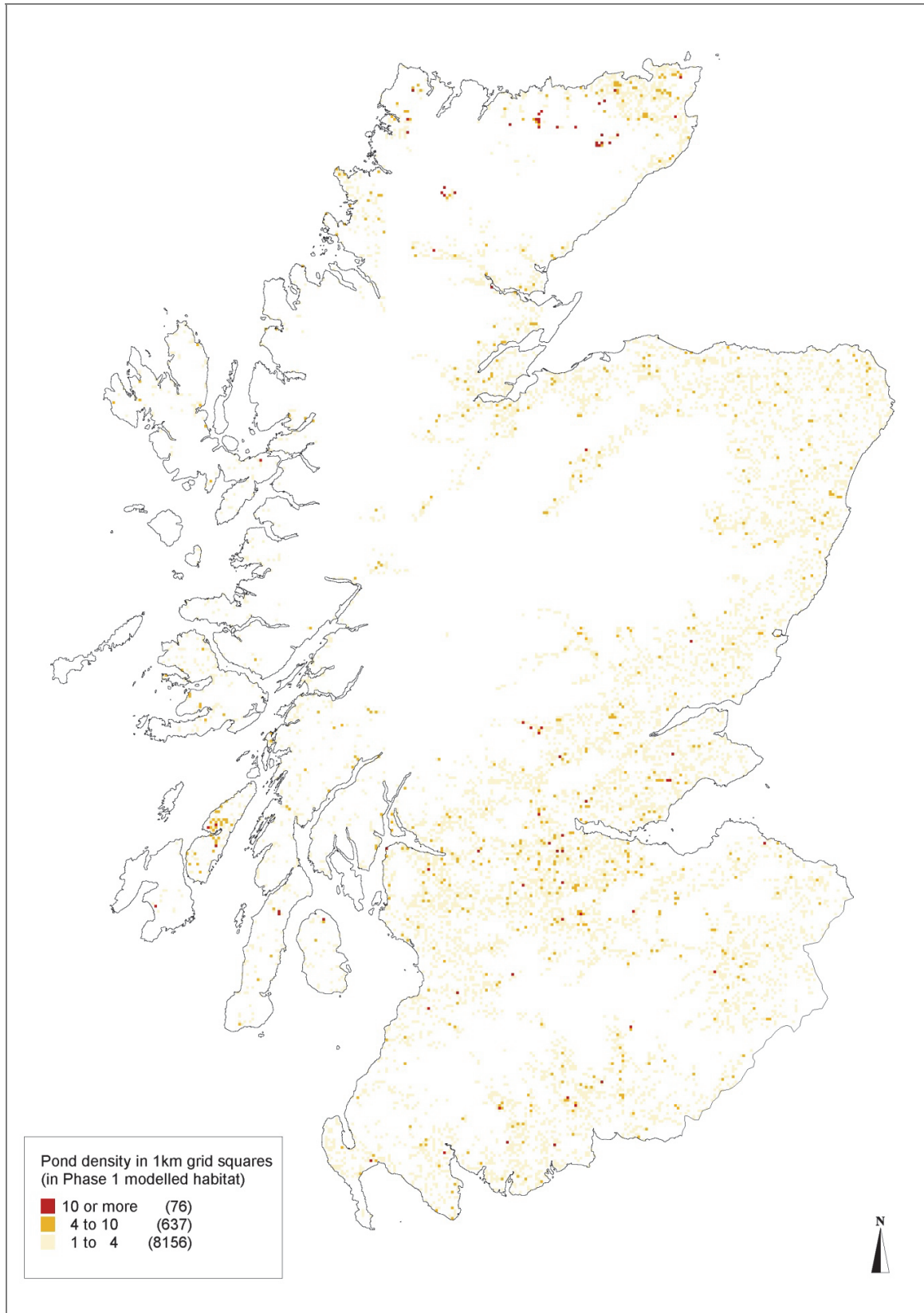


Figure 14. Predictive thematic map of modelled (Phase 1) 1 km squares with habitat suitable for great crested newts in Scotland. Darker squares contain more ponds, modified after Wilkinson et al., (2011). See also Figure 15 and Table 4. © Crown copyright and database rights 2014 Ordnance Survey 100017908.

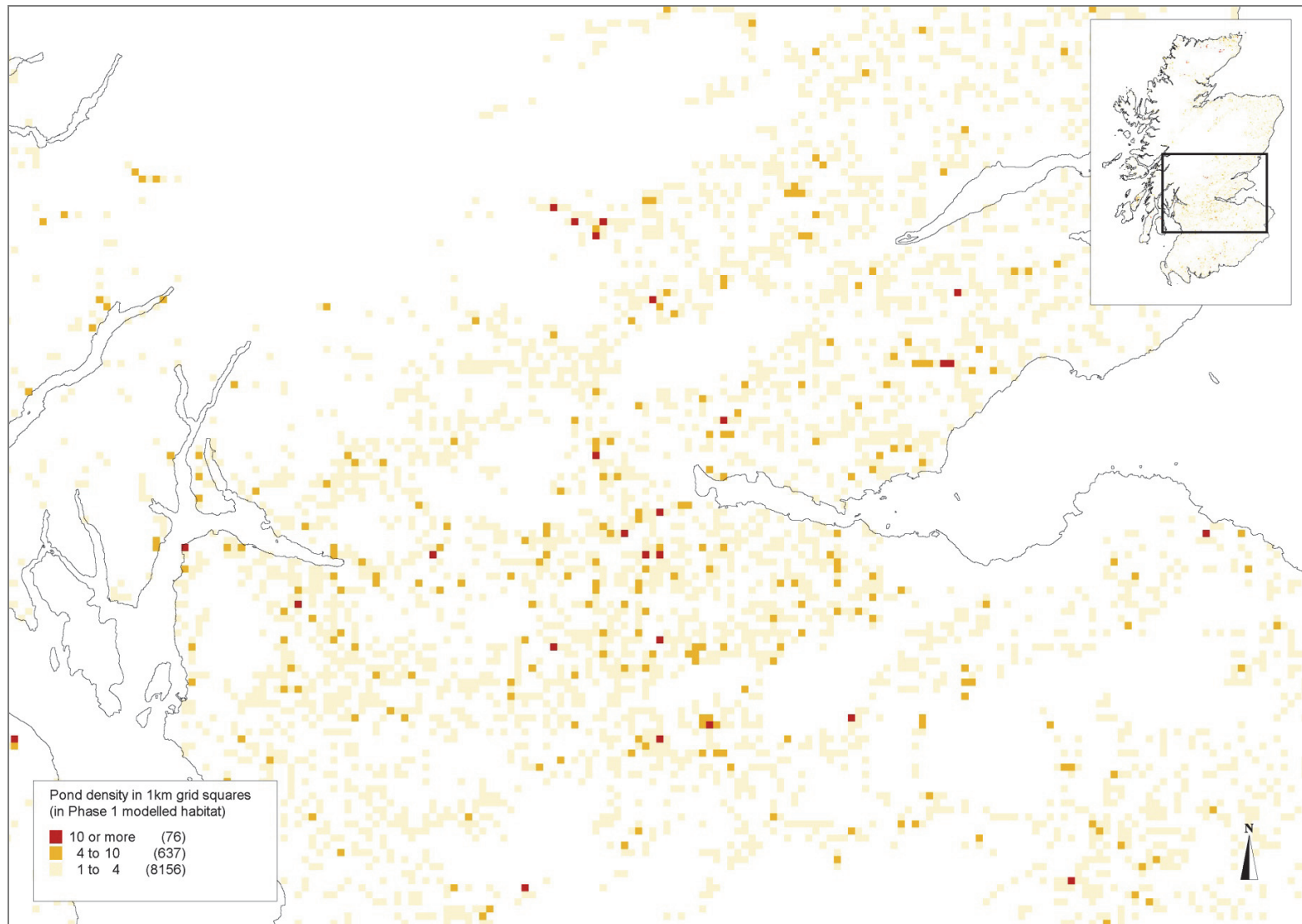


Figure 15. Central Scotland detail of Figure 14 showing dispersal of high pond density squares.© Crown copyright and database rights 2014 Ordnance Survey 100017908.

Table 1. Summary of great crested newt distribution and habitat metrics in Scotland.

Metric	Unit measure
Total number of post-1970 great crested newt records from Scotland prior to the present project	317
Total number of post-1970 unique record locations for great crested newts in Scotland (≡ populations) prior to the present project	194
Total number of great crested newt-occupied 1 km grid squares in Scotland prior to the present project	133
Total range of great crested newts in Scotland (range-buffer estimation method) prior to the present project	5,238 km ²
Total number of great-crested newt-occupied 10 km grid squares in Scotland prior to the present project	70
Area of habitat matching characteristics of great crested newt-occupied 1km grid squares in Scotland (ARC Removal Model Phase 1; includes areas of some islands which have no great crested newts)	30,203 km ²
Model fit, Phase 1	65%
Area of habitat included in ARC Removal Model Phase 2 in Scotland (includes small areas of some islands which have no great crested newts)	8,466 km ²
Model fit, Phase 2	30%

Table 2. Summary of results of surveys for this project.

Metric	2010	2011
Number of surveyors (including Borders ARG as one surveyor)	13	7
Number of 1km grid squares in which surveys were conducted	89	36
Number of ponds surveyed	164	108
Number of new great crested newt records	4	1
Number of common frog records	66	40
Number of common toad records	33	18
Number of unidentified frog/toad tadpole records	0	5
Number of palmate newt records	38	24
Number of smooth newt records	12	4
Number of palmate/smooth newt records*	22	11
Number of ponds from which no amphibians were recorded	68	39
Average pond HSI score	0.50	0.48
Number of ponds with HSI score >0.7 (out of those for which HSI could be calculated)	23 (16.55%)	15 (15.63%)
Average number of visits to each pond	1.50	1.73
Number of survey visits employing "visual survey"	121	156
Number of survey visits employing "netting"	120	129
Number of survey visits employing "torching"	85	77
Number of survey visits employing "bottle trapping"	7	26
Number of survey visits with method unspecified	13	36
Average number of methods used per survey	2.36	2.04

*mostly or wholly due to presence of small eggs, from which ID to species cannot be made

Table 3. Amended summary of great crested newt distribution and habitat metrics in Scotland, incorporating results from the present project.

Metric	Unit measure
Total number of post-1970 great crested newt records from Scotland	322
Total number of post-1970 unique record locations for great crested newts in Scotland (≡ populations)	199
Total number of great crested newt-occupied 1 km grid squares in Scotland	138
Total range of great crested newts in Scotland (range-buffer estimation method, see section 2.2)*	5,327 km ²
Total number of great-crested newt-occupied 10 km grid squares in Scotland*	70 (no change)

* amended maps not shown

4. DISCUSSION

The Removal Modelling approach developed for the present project has been successfully used elsewhere (see Wilkinson *et al.*, 2011) to model great crested newt habitat in England and Wales. Model fit was as good as 97% for Phase 1 and 65% for Phase 2, according to testing of the model in Wales (Wilkinson *et al.*, 2011.). Other work (e.g. Rebelo & Jones, 2010) has also demonstrated the usefulness of presence-only modelling in successfully predicting species occurrence outside their current known range. Wilkinson *et al.*, (2011.) also predicted that only 0.54% (425 km²) of the total area of Scotland is suitable for great crested newts compared to over 8% and over 11% for Wales and England respectively. Despite these figures, this work suggested that there may be as many as 1,500 ponds occupied by great crested newts in Scotland out of a total of some 60,000 occupied ponds in GB and compared with more than 3,000 in Wales. The modelling of potentially-occupied ponds and squares was carried out using NBN Gateway data to generate theoretical square and pond occupancy rates on a region-specific basis. Though it seems that there is a much lower potential for great crested newts in Scotland than predicted by the GB report, there may well be more undiscovered populations to be found.

Just five new great crested newt ponds were identified during the present project (Figs. 5 - 8): four in 2010 and one in 2011. This brings the total known populations in Scotland to 199 unique record locations in 138 1 km grid squares, or 70 populations in 10 km grid squares (Table 3). The number of occupied 10 km grid squares therefore remains the same as previously assessed. Many other records for other amphibian species were also generated (Table 2), which will be added to the ARC database and ultimately to the NBN.

Though our Scottish model testing shows that the Phase 1 Removal Model is quite successful (65% fit) at describing suitable great crested newt habitat (Fig. 3 and Table 1), the Phase 2 model falls below an acceptable success threshold (i.e. <50% fit). This may be an indication that Scottish great crested newt populations can and do persist in suboptimal habitat. The present model may not be sophisticated enough to fully describe the niche of the species in Scotland, in contrast to the very good model fit found by Wilkinson *et al.* (2011; see above) in other areas. It is not clear why more new newt populations were not identified during the 2010 surveys unless there were only a few to find. Great crested newts are most likely to be found in metapopulations (see Langton *et al.*, 2001) and the targeting of ponds in suitable habitat near existing known populations was therefore a sensible initial approach.

It was because of the low detection success in 2010 that 2011 surveys were targeted irrespective of distance to known great crested newt populations and concentrated on clusters of 1 km grid squares with high pond density. The presence of four or more ponds per km² ("high pond density") was shown to be a good predictor of great crested newt presence in Oldham *et al.*'s (2000) study. In Scotland, however, the generally relatively lower suitability of the landscape for great crested newts (as compared to parts of England and Wales; see above and Figs 12 - 15) may mean that populations exist singly or in small clusters which are effectively disconnected from other areas of suitable habitat (and thence from other metapopulations). Figures 14 and 15 show the highly dispersed distribution pattern of high pond density squares in suitable (Phase 1) habitat in Scotland. Fig. 13 shows the same information as Fig. 12 for Scotland only and with the ranges amended to be relatively more revealing in the Scottish context. Scattered areas of higher pond density are found around the Moray Firth and in the Borders, with a contiguous spread of relatively high pond density in 10 km grid squares being found only in the Central Belt of Scotland. Some areas of Scotland, of course, do have large areas with a high density of ponds, but it is likely these are too elevated or too acidic to support great crested newt populations and/or act as connecting habitat. Elevation was the most important variable in predicting newt distribution in the study by Ćirović *et al.* (2008) on the distribution of newts in Montenegro.

It may be, that few new populations were discovered in the present surveys because of the relatively few number of squares on which the model was based. It may also be that crested newts in Scotland are really as rare as they appear to be, with few new populations to be found, that some populations were not detected by the surveys or a combination of these factors. If there really are few new great crested newt populations to be discovered in Scotland, the range-buffer estimate of total range in Scotland (Fig. 11) may be an overestimate, despite being based on a fairly conservative and objective method.

The average HSI score of ponds surveyed for the present project was 0.5 in 2010 and 0.48 in 2011 (i.e. they were of medium quality on average), with 16.55% and 15.63% of ponds respectively having a high HSI score of >0.7. The average HSI scores in each year are comparable to the average HSI score in Scotland generated from NARRS surveys during 2007 – 2009 (0.47; Wilkinson & Arnell, 2011) whereas only 9.84% of NARRS pond surveys in Scotland scored >0.7 (*ibid.*). This shows that more of the ponds in the present study were of higher quality than the randomly-allocated and untargeted NARRS survey ponds, and therefore theoretically more likely to support great crested newt populations. It may be that surveys involving more survey visits, and particularly more visits employing bottle trapping (where possible and licensed for; see Table 2) would yield more new Scottish great crested newt records. The low number of survey visits employing bottle-trapping may have biased the surveys against detection of new great crested newt records. Nevertheless, the surveyors used for this project were experienced so these effects should not be over-estimated.

In summary, the surveys conducted for the present study were, on average, carried out in high quality ponds and in theoretically suitable habitat but they had low success in detecting new great crested newt populations. Surveyors performed well and generated records for all other expected amphibians. It seems logical to conclude, therefore, that great crested newts really are a relatively rare animal in Scotland with restricted distribution in small areas containing both suitable breeding ponds and appropriate terrestrial habitat. Though there are undoubtedly new populations to be discovered, these will likely be many less than the 1500 initially predicted by other predictive mapping (Wilkinson *et al.*, 2011). Indeed, there may currently be no better way of detecting new great crested newt populations in Scotland than by ensuring that all new records are collected and collated, and that ongoing monitoring is instigated to add to our knowledge of Scottish great crested newt population dynamics and habitat preferences. These data can then be incorporated into other, newer and more sophisticated modelling techniques (such as Maximum Entropy [MaxEnt] and graph theory approaches to modelling metapopulation connectivity) currently being developed for use with great crested newt status assessment at ARC.

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ANNEX 1: 2010 SCOTTISH GCN SURVEY PROTOCOL

Aim of the survey

This survey aims to enhance our understanding of the status and knowledge of distribution of great crested newts (gcns) in Scotland.

A predictive model of gcn distribution has been developed based on the characteristics of squares from which gcns have been recorded. The model identifies 1km squares to be targeted for survey which share characteristics with these known gcn squares.

The surveyor will collect information about the pond habitat (Habitat Suitability Index, or HSI), record all amphibians seen, and record other variables. The survey forms and protocol are based loosely on the National Amphibian and Reptile Recording Scheme (NARRS). You may find it useful to refer to some of the documents on the NARRS website (www.narrs.org.uk), which can be found under "National Amphibian Survey".

Pond selection

Surveyors will be given a print-out of a map(s) from the model showing target squares in the area they are able to survey (to be discussed with surveyors). This will show:

- **Filled black squares** = known gcn squares
- **Hollow red squares** = squares sharing similar characteristics to known gcn squares
- **Filled light blue squares** = squares sharing similar characteristics to gcn squares AND which are within 5km of a known gcn square – **these are our main target squares for survey**
- **Dark blue hatched squares** = ponds are likely to occur in these squares.
- **Empty areas** = gcns not predicted to occur here (please tell us of any records from these areas!).

Each surveyor will be allocated a set number of survey days/ nights. We would like roughly 70% of survey days spent on targeting **filled light blue** squares and 30% of survey days on targeting **hollow red** squares. Please use the dark blue hatched squares to help guide you to areas that are likely to contain ponds. However, some ponds will occur in areas outside blue hatched squares, so please don't limit surveys to just blue hatched squares. We hope you will use your local expertise and/or on-line maps and aerial photos to help identify squares with likely-looking ponds and pond clusters (gcns are often found in areas with most ponds).

- Surveyors are left to choose their own squares from their survey area/ list of 1km squares (see above).
- Please try to visit each suitable pond within a square (gcns may only occur in the last one you visit!) BUT move on to another square as soon as you do find gcns.
- If crested newts are found during a daytime survey and a torch survey is planned for the evening, then this should still be carried out, but the pond should not be visited again another day.
- Identify each pond by a detailed OS grid reference and/or unique code (e.g. NT1234-1, NT1234-2, NT1234-3, NT1234-4 if four ponds are surveyed in square NT1234 – see survey form).
- Fill out a new form for each water body (though your HSI scores may be the same for ponds in the same square, in which case just note this).

A pond is defined as a water body between one square metre and two hectares (100x200m). Try the following websites for this exercise, as they can show boundaries of 1km squares and display OS maps and aerial photographs:

<http://www.surrey-arg.org.uk/SARG/02000-Activities/SurveyAndMonitoring/SRS2008/SARG2NARRS.shtml>

<http://homepage.ntlworld.com/keith.balmer/BNHS/focuson/getagridref/html/index.htm>

Other useful websites include:

<http://www.bing.com/maps/>

<http://maps.google.co.uk>

<http://www.ordnancesurvey.co.uk/oswebsite/getamap/>

Access permission

We strongly recommend that you identify the landowner/tenant and ask permission to survey the pond. Simple verbal permission can often be achieved after knocking on doors locally. You will be given a copy of the NARRS advice sheet and a landowner letter which can be shown to landowners if needed. Also ask the landowner about access points, safety issues, and the pond and its wildlife. If access is denied, identify the next nearest pond in the same square, or move to another square.

GCN habitat suitability index (HSI)

This comprises ten questions about the pond used to help predict its suitability for great crested newts. You will be provided with a copy of the HSI guidance.

Survey visits

Only survey during suitable weather conditions if possible and between April and mid-June. Do a maximum of four survey visits to each pond, ideally using three different techniques: egg search/ visual survey, netting and torchlight survey. Bottle trapping can be used but only if trained, licensed and very confident to do so. Torching must be done after dark, so should only be carried out if you feel it is safe. You can wait for nightfall after a visual/netting visit (a good time for a pub meal) or you can make a separate visit. Torching also needs clear water, so if the water is muddy after netting, it will need to settle for an hour or two. Record dates, times, survey conditions and amphibians seen, using the survey form.

1. **Visual search** - Walk around the pond edge as far as you can, looking for amphibians and their spawn/eggs. Look especially for submerged aquatic plants with folded leaves where newts have laid their eggs. Carefully unfold a few leaves to see if they contain a white/yellowish egg (great crested newt) or grey/brownish egg (smooth or palmate newt).
2. **Netting** – Newts tend to hide in aquatic vegetation by day. If the pond has submerged vegetation, work your way around the edge with a strong net, making vigorous sweeps through the vegetation at roughly two-metre intervals. You may catch newts (especially the smaller species) or tadpoles. Inspect your catch, take care not to harm anything, then release them and continue around the pond.
3. **Torchlight survey** – Newts become very active after dark, and a powerful torch is very effective for spotting them in open water. Circumnavigate the pond, stopping every two metres or so to make torch sweeps outwards and back again. Work your way around the bank and keep note of the amphibians you see. Great crested newts are much larger than the other two species, and males are easily recognizable by the white tail flash. Smooth and palmate newts are harder to distinguish, but you might be able to separate them by presence/absence of webbed feet, tail filament and jagged crest in the males. The torchlight survey is optional, as safety allows.
4. **Bottle-trapping** – a way to increase the “detectability” of newts in your survey pond but only for use if fully trained, licensed and very confident of the method. Please note the number of bottle traps used on the survey form. We recommend that you create a map of bottle trap locations for your own use, to help you recover all traps the morning after they are set out.

If you have access to a camera, we would like you to take a photograph of the pond and label the photo/ image file by 1km grid square (or, if more than two ponds are surveyed per 1km square, label photographs of ponds sequentially e.g. NT1234-1, NT1234-2 etc– see survey form). This would be a useful additional piece of information to collect, if possible.

It is thought that, on average, surveyors will be able to visit three different ponds per day/ night, ideally using three methods comprising both daytime (net, egg search or retrieve bottle traps) and night time visits (torch survey or set out bottle trap) to the three ponds. Torch survey alone, or just daytime visits (in some cases it might be, for safety reasons, some ponds can only be visited during the day) are also acceptable. If ponds are remote then perhaps only 1 pond survey can be achieved per day, whereas if ponds are in clusters, perhaps 4 or more could be visited per day/ night. This flexibility is ok.

Other points

- **Health & safety** – Take care and refer to our risk assessment and lone working advice.
- **Amphibian disease** - Chytrid fungus is present in the UK. As a precautionary measure, disinfect footwear and equipment thoroughly between sites with bleach spray or agricultural Virkon solution. Please refer to the ARG-UK Biosecurity note we've provided.
- **Licensing** – Where great crested newts might be present, you will need your own licence or an accreditation letter from ARC. Always carry this with you.
- **Results** – please submit using the recording form/s. We request records are sent to us by the end of July 2010.

Please also refer to/ use other documents provided:

- S11 -HSI guidance
- S12 - Health and safety documentation, including lone working form
- S13 - NARRS landowner liaison advice sheet
- S14 - Landowner letter
- S15 - ARG-UK Biosecurity note.

Good luck with your surveys and please get in touch with Ben Driver data.officer@arc-trust.org / Dorothy Wright dorothy.wright@arc-trust.org / John Wilkinson johnw.wilkinson@arc-trust.org at Amphibian and Reptile Conservation if you have any queries. Telephone 01202 391319.

ANNEX 2: 2011 SCOTTISH GCN SURVEY PROTOCOL

Aim of the survey

This survey aims to enhance our understanding of the status and knowledge of distribution of great crested newts (gcns) in Scotland.

A predictive model of gcn distribution has been developed based on the characteristics of squares from which gcns have been recorded. The model identifies 1km squares to be targeted for survey which share characteristics with these known gcn squares. Since the previous SNH survey in 2010 we have further filtered these squares by the number of ponds contained and their mean distance to other similar squares. This technique also allows us to inform the survey square priority shown below.

The surveyor will collect information about the pond habitat (Habitat Suitability Index, or HSI), record all amphibians seen, and record other variables. The survey forms and protocol are based loosely on the National Amphibian and Reptile Recording Scheme (NARRS). You may find it useful to refer to some of the documents on the NARRS website (www.narrs.org.uk), which can be found under "National Amphibian Survey".

Pond selection

Surveyors will be given a print-out of a map(s) and an excel sheet showing target squares in the area they are able to survey (to be discussed with surveyors). This will show:

- **Red squares** = *Primary target squares* (marked A1, A2 etc.) Please aim to target these first and foremost.
- **Green squares** = *Secondary target squares* (marked as B1, B2 etc.). These are for targeting when it makes most sense - such as while you are in the area, you have the time or if there is a problem with surveying the primary squares.
- **Empty areas** = gcns not predicted to occur here (but please do tell us of any records from these areas!).

The order of importance for the primary target squares is denoted with A1 being highest, A2 a little lower, and A3 being lower still. However, this has to be weighed up by travel time and costs etc. If two squares are about the same distance to travel to (eg. A1 and A4) and you have to choose between them due to time constraints, then it would be preferred to target the one that is highest priority (in this example A1). The same goes for choosing between the secondary squares (the highest importance being B1, then B2, and then B3 etc.).

We hope you will use your local expertise and/or on-line maps and aerial photos to help identify ponds and pond clusters within these squares. Surveyors are left to plan their route but please take into account the priority and order of importance (see above).

- Please try to visit each suitable pond within a square (gcns may only occur in the last one you visit!) BUT move on to another square as soon as you do find gcns.
- If crested newts are found during a daytime survey and a torch survey is planned for the evening, then this should still be carried out, but the pond should not be visited again another day.
- Identify each pond by a detailed OS grid reference and/or unique code (e.g. NT1234-1, NT1234-2, NT1234-3, NT1234-4 if four ponds are surveyed in square NT1234 – see survey form).
- Fill out a new form for each water body (though your HSI scores may be the same for ponds in the same square, in which case just note this).

A pond is defined as a water body between one square metre and two hectares (100x200m). Try the following websites for this exercise, as they can show boundaries of 1km squares and display OS maps and aerial photographs:

<http://www.surrey-arg.org.uk/SARG/02000-Activities/SurveyAndMonitoring/SRS2008/SARG2NARRS.shtml>

<http://homepage.ntlworld.com/keith.balmer/BNHS/focuson/getagridref/html/index.htm>

Other useful websites include:

<http://www.bing.com/maps/>

<http://maps.google.co.uk>

<http://www.ordnancesurvey.co.uk/oswebsite/getamap/>

Access permission

We strongly recommend that you identify the landowner/tenant and ask permission to survey the pond. Simple verbal permission can often be achieved after knocking on doors locally. You will be given a copy of the NARRS advice sheet and a landowner letter which can be shown to landowners if needed. Also ask the landowner about access points, safety issues, and the pond and its wildlife. If access is denied, identify the next nearest pond in the same square, or move to another square.

GCN habitat suitability index (HSI)

This comprises ten questions about the pond used to help predict its suitability for great crested newts. You will be provided with a copy of the HSI guidance.

Survey visits

Only survey during suitable weather conditions if possible and between April and mid-June. Do a maximum of four survey visits to each pond, ideally using three different techniques: egg search/ visual survey, netting and torchlight survey. Bottle trapping can be used but only if trained, licensed and very confident to do so. Torching must be done after dark, so should only be carried out if you feel it is safe. You can wait for nightfall after a visual/netting visit (a good time for a pub meal) or you can make a separate visit. Torching also needs clear water, so if the water is muddy after netting, it will need to settle for an hour or two. Record dates, times, survey conditions and amphibians seen, using the survey form.

5. **Visual search** - Walk around the pond edge as far as you can, looking for amphibians and their spawn/eggs. Look especially for submerged aquatic plants with folded leaves where newts have laid their eggs. Carefully unfold a few leaves to see if they contain a white/yellowish egg (great crested newt) or grey/brownish egg (smooth or palmate newt).
6. **Netting** – Newts tend to hide in aquatic vegetation by day. If the pond has submerged vegetation, work your way around the edge with a strong net, making vigorous sweeps through the vegetation at roughly two-metre intervals. You may catch newts (especially the smaller species) or tadpoles. Inspect your catch, take care not to harm anything, then release them and continue around the pond.
7. **Torchlight survey** – Newts become very active after dark, and a powerful torch is very effective for spotting them in open water. Circumnavigate the pond, stopping every two metres or so to make torch sweeps outwards and back again. Work your way around the bank and keep note of the amphibians you see. Great crested newts are much larger than the other two species, and males are easily recognizable by the white tail flash. Smooth and palmate newts are harder to distinguish, but you might be able to separate them by presence/absence of webbed feet, tail filament and jagged crest in the males. The torchlight survey is optional, as safety allows.
8. **Bottle-trapping** – a way to increase the “detectability” of newts in your survey pond but only for use if fully trained, licensed and very confident of the method. Please note the number of bottle traps used on the survey form. We recommend that you create a map of bottle trap locations for your own use, to help you recover all traps the morning after they are set out.

If you have access to a camera, we would like you to take a photograph of the pond and label the photo/ image file by 1km grid square (or, if more than two ponds are surveyed per 1km square, label photographs of ponds sequentially e.g. NT1234-1, NT1234-2 etc– see survey form). This would be a useful additional piece of information to collect, if possible.

It is thought that, on average, surveyors will be able to visit three different ponds per day/ night, ideally using three methods comprising both daytime (net, egg search or retrieve bottle traps) and night time visits (torch survey or set out bottle trap) to the three ponds. Torch survey alone, or just daytime visits (in some cases it might be, for safety reasons, some ponds can only be visited during the day) are also acceptable. If ponds are remote then perhaps only 1 pond survey can be achieved per day, whereas if ponds are in clusters, perhaps 4 or more could be visited per day/ night. This flexibility is ok.

Other points

- **Health & safety** – Take care and refer to our risk assessment and lone working advice.
- **Amphibian disease** - Chytrid fungus is present in the UK. As a precautionary measure, disinfect footwear and equipment thoroughly between sites with bleach spray or agricultural Virkon solution. Please refer to the ARG-UK Biosecurity note we've provided.
- **Licensing** – Where great crested newts might be present, you will need your own licence or an accreditation letter from ARC. Always carry this with you.
- **Results – please submit using the recording form/s.** We request records are sent to us by the 15th July 2011.

Please also refer to/ use other documents provided:

- S11 -HSI guidance
- S12 - Health and safety documentation, including lone working form
- S13 - NARRS landowner liaison advice sheet
- S14 - Landowner letter
- S15 - ARG-UK Biosecurity note.

Good luck with your surveys and please get in touch with Andy Arnell data.officer@arc-trust.org / Dorothy Wright dorothy.wright@arc-trust.org / John Wilkinson johnw.wilkinson@arc-trust.org at Amphibian and Reptile Conservation if you have any queries. Telephone 01202 391319.

ANNEX 3: SCOTLAND GCN 2010/11 SURVEY FORM

Surveyor details

Name of surveyor(s)	1.	2.
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Pond location details

Location name (taken from nearby hamlet/ farm/house/ woodland etc)	
Pond full grid reference (6, 8 or 10 figure)	
1km square. If surveying 2+ ponds in same square number sequentially (eg. NT1234-1, NT1234-2 etc) and use a separate form for each pond	
Photo taken? (yes/no). Use 1km square ref to label photo/ image file	

Landowner details *If the pond is on private land you must have the landowner/manager's permission to visit the site. If the pond is in a public access area it is still useful to know who owns the land.*

Name	
Address	
Telephone	
Willing to be contacted?	

Habitat suitability factors (refer to HSI guidance and summary notes below)

	Score (fill out in field/ at home)	SI value (read off graph)
1. Map Location. Score: A (optimal), B (marginal) or C (unsuitable).		
2. Pond area in m ² . Estimate.		
3. Number of years in ten pond dries up. Estimate or ask landowner.		
4. Water quality. Score: 1 = bad, 2 = poor, 3 = moderate, 4 = good.		
5. Percentage perimeter shaded (to at least 1 m from shore). Estimate.		
6. Waterfowl impact. Score: 1 = major, 2 = minor, 3 = none.		
7. Fish presence. Score: 1 = major, 2 = minor, 3 = possible, 4 = absent.		
8. Number of ponds within 1 km (1: 25 0000 maps) not separated by barriers to dispersal.		
9. Terrestrial habitat. Score: 1 = none, 2 = poor, 3 = moderate, 4 = good.		
10. Percentage of pond surface occupied by aquatic vegetation (March-May). Estimate.		

Water quality Bad = clearly polluted, only pollution-tolerant invertebrates, no submerged plants; Poor = low invertebrate diversity, few submerged plants; Moderate = moderate invertebrate diversity; Good = abundant and diverse invertebrate community.

Waterfowl impact Major = severe impact of waterfowl i.e. little or no evidence of submerged plants, water turbid, pond banks showing patches where vegetation removed, evidence of provisioning waterfowl; Minor = waterfowl present, but little indication of

impact on pond vegetation, pond still supports submerged plants and banks are not denuded of vegetation; None = no evidence of waterfowl impact (moorhens may be present).

Fish presence Major = dense populations of fish known to be present; Minor = small numbers of crucian carp, goldfish or stickleback known to be present; Possible = no evidence of fish, but local conditions suggest that they may be present; Absent = no records of fish stocking and no fish revealed during survey(s).

Terrestrial habitat None = clearly no suitable habitat within immediate pond locale; Poor = habitat with poor structure that offers limited opportunities for foraging and shelter (e.g. amenity grassland); Moderate = offers opportunities for foraging and shelter, but may not be extensive; Good = extensive habitat that offers good opportunities for foraging and shelter completely surrounds pond e.g. rough grassland, scrub or woodland.

Please complete a maximum of **FOUR** visits to the pond and aim to use **THREE** survey methods. If great crested newts are found, **do not** carry out further visits and move to your next 1km square.

To complete the form overleaf please record:

- Species: Rt = common frog, Bb = common toad, Tc = great crested newt, Lv = smooth newt, Lh = palmate newt, Lv/h = smaller newt species, other (please specify)
- Survey method: VS = visual, N = netting, T = torching, BT = bottle trapping (only bottle-trap if trained and licensed to do so)
- Life stage: Adu = adult, Imm = frog/toadlet or young newt, Larva = newt tadpole or frog/toad tadpole, Egg = newt egg/ frogspawn clump/ toadspawn strings
- Provide counts of adults, immatures and spawn clumps/ strings but indicate detection of eggs and larvae with a tick
- Water clarity 1 = good, pond bottom visible, 2 = intermediate, bottom visible in shallows, 3 = turbid, bottom not visible
- Rainfall 0 = none, 1 = yesterday, 2 = immediately prior, 3 = during daytime survey, 4 = during night survey (i.e. torch survey).

Visit 1					Date (dd/mm/yy)		
Species (Rt, Bb, Tc, Lv, Lh, Lv/h, other)	Method (VS,N,T,BT)	Number / life stage				Day survey time (24h)	to
		Adu	Imm	Larva	Egg	Day air temp (°C)	
						Day water clarity (1-3)	
						Night survey time (24h)	to
						Night air temp (°C)	
						Rainfall (0, 1, 2, 3,4)	
						Wind disturbing water (tick)	
						Bright moonlight (tick)	
						% shoreline searched	%
						Number of traps used	
						Notes:	

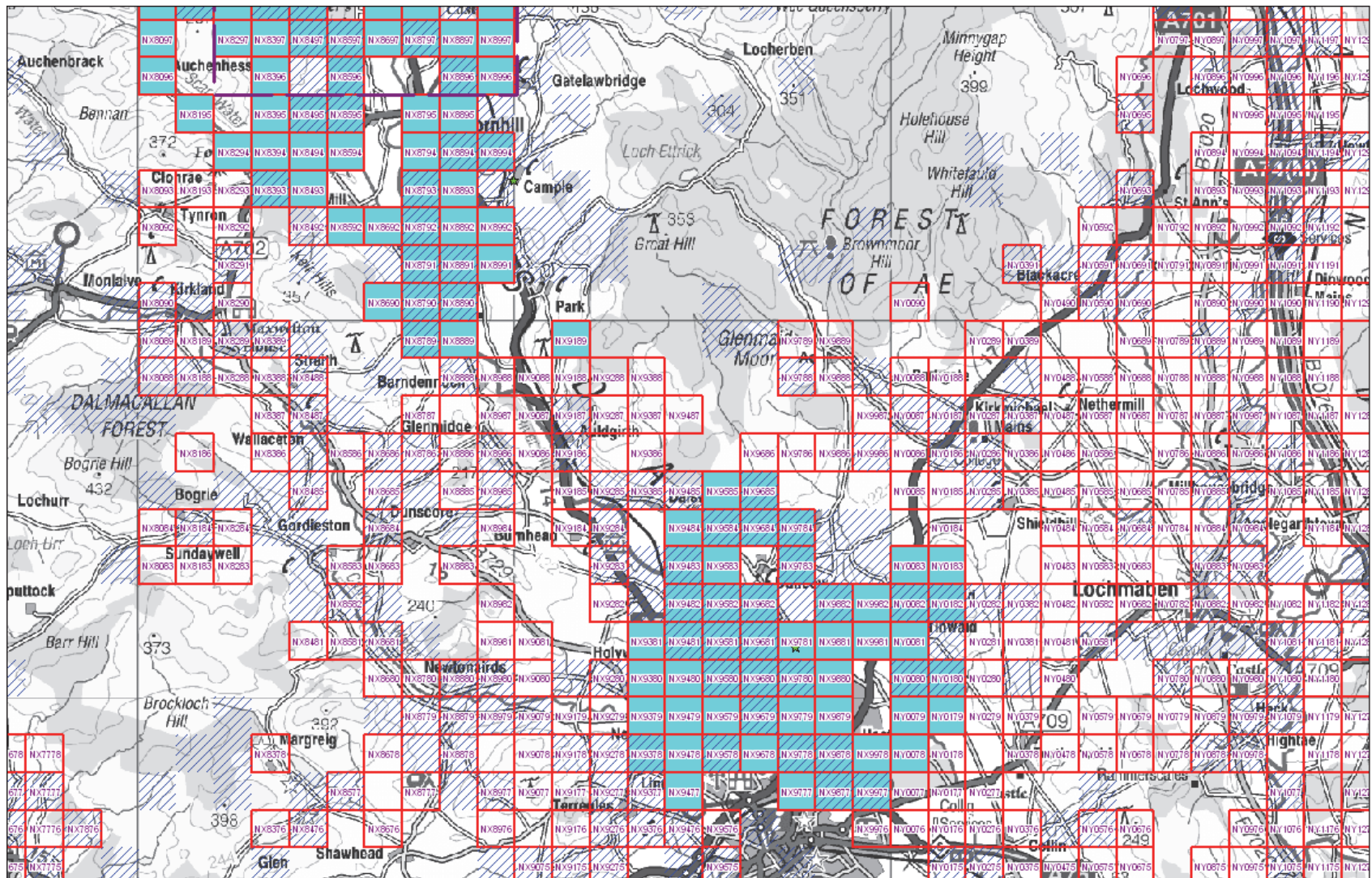
Visit 2					Date (dd/mm/yy)		
Species (Rt, Bb, Tc, Lv, Lh, Lv/h, other)	Method (VS,N,T,BT)	Number / life stage				Day survey time (24h)	to
		Adu	Imm	Larva	Egg	Day air temp (°C)	
						Day water clarity (1-3)	
						Night survey time (24h)	to
						Night air temp (°C)	
						Rainfall (0, 1, 2, 3,4)	
						Wind disturbing water (tick)	
						Bright moonlight (tick)	
						% shoreline searched	%

						Number of traps used	
						Notes:	

Visit 3						Date (dd/mm/yy)	
Species (Rt, Bb, Tc, Lv, Lh, Lv/h, other)	Method (VS,N,T,BT)	Number / life stage				Day survey time (24h)	to
		Adu	Imm	Larva	Egg	Day air temp (°C)	
						Day water clarity (1-3)	
						Night survey time (24h)	to
						Night air temp (°C)	
						Rainfall (0, 1, 2, 3,4)	
						Wind disturbing water (tick)	
						Bright moonlight (tick)	
						% shoreline searched	%
						Number of traps used	
						Notes:	

Visit 4						Date (dd/mm/yy)	
Species (Rt, Bb, Tc, Lv, Lh, Lv/h, other)	Method (VS,N,T,BT)	Number / life stage				Day survey time (24h)	to
		Adu	Imm	Larva	Egg	Day air temp (°C)	
						Day water clarity (1-3)	
						Night survey time (24h)	to
						Night air temp (°C)	
						Rainfall (0, 1, 2, 3,4)	
						Wind disturbing water (tick)	
						Bright moonlight (tick)	
						% shoreline searched	%
						Number of traps used	
						Notes:	

ANNEX 4: EXAMPLE OF MAPS SENT TO SURVEYORS. Shows Phase 3 squares (light blue), Phase 2 squares (red border) and squares with ponds (diagonal stripes). © Crown copyright and database rights 2014 Ordnance Survey 100017908.



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ISBN: 978-1-78391-191-2

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