Quantifying the Status of Great Crested Newts in Wales

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1. Crynodeb Gweithredol

Mae nifer y madfallod dŵr cribog sydd yn y Deyrnas Unedig yn lleihau er bod ganddynt amddiffyniad llawn ar lefel Ewropeaidd. Cyflwynir adroddiadau ar statws y rhywogaeth i'r Undeb Ewropeaidd ar lefel y Deyrnas Unedig ond mae gwarchod natur yn swyddogaeth sydd wedi'i datganoli. O ganlyniad, bydd arolygon a gwybodaeth am statws y fadfall ddŵr gribog yng Nghymru'n rhan o adroddiadau cyfanredol y Deyrnas Unedig yn y dyfodol.

Mae'r adroddiad hwn yn cyfuno allbynnau model GIS o adroddiadau blaenorol (a gomisiynwyd gan y Cyngor Cefn Gwlad) ar gyfer Ynys Môn a Gogledd-ddwyrain Cymru, Powys a Pharc Cenedlaethol Bannau Brycheiniog, a De Cymru (Gŵyr i Sir Fynwy) er mwyn cael metrigau cadarn y gellir eu hailadrodd ar gyfer statws y fadfall ddŵr gribog ym mhob ardal yng Nghymru lle mae'r rhywogaeth i'w chael. Roedd allbynau cyfunol y model yn dda i ragorol (AUC 0.71 i 0.86) ac yn mesur paramedrau "cyrhaeddiad" (7,312 km^2), "poblogaeth" (3,271 o byllau dŵr yn cael eu defnyddio) a "chynefin" (2,2170 km^2) yn llwyddiannus, yn ogystal ag awgrymu meintoliad dirprwyol ar gyfer ansawdd cynefinoedd (810 pwll dŵr o safon uchel).

Trafodir defnyddioldeb y metrigau hyn, awgrymiadau ar gyfer gwella dulliau mesur drwy fodelu ailadroddol a chasglu data er mwyn cadarnhau canfyddiadau, a chymhwyso'r technegau hyn i ranbarthau a gwledydd eraill yn y Deyrnas Unedig.

2.   Executive Summary

The great crested newt is declining in the United Kingdom despite full European-level protection. Reporting on the species' status to the EU is carried out at UK level but nature conservation is a devolved function. Knowledge and quantification of the great crested newt's status in Wales will therefore form part of future aggregated UK-level reports.

This report combines GIS model outputs from previous reports (commissioned by CCW) for Anglesey and North East Wales, Powys and Brecon Beacons National Park, and South Wales (Gower to Monmouthshire) to derive robust, repeatable great crested newt status metrics for the species across its distribution in Wales. Combined model outputs were good to excellent (AUC 0.71 to 0.86) and successfully quantified "range" (7,312 km^2), "population" (3,271 occupied ponds) and "habitat" (2,2170 km^2) parameters, as well as suggesting a proxy quantification for habitat quality (810 high quality ponds).

The utility of these metrics, suggestions for improving quantification through iterative modelling and ground truthing, and the application of these techniques to other regions and countries of the UK are discussed.

3.   Introduction

The great crested newt (*Triturus cristatus*) has undergone substantial declines in the UK and elsewhere in Europe through habitat loss and fragmentation (see Edgar and Bird, 2006). It is protected at European level under the Conservation (Natural Habitats etc.) Regulations 1994 (and as amended) ("the Habitats Directive"), protection which is reflected under UK Law through the Wildlife and Countryside Act (1981 and as amended).

As part of the UK's obligations under the Habitats Directive, great crested newts and other European Protected Species (EPS) must be monitored (both within and outside protected sites series) and their conservation status must be reported on every six years under the Directive's Article 17. This reporting is carried out at UK level but, as nature conservation functions are devolved to the individual countries of the UK, knowledge of the conservation status of great crested newts at Wales level is therefore now an intrinsic constituent part of the reporting process.

In its wider context (i.e. outside protected sites series), Article 17 reporting is based on quantification of four parameters:
- Range
- Population
- Habitat for the species
- Future prospects

Each parameter is assessed as being either "bad", "inadequate", "good" or "unknown", overall conservation status in an EU member state being Favourable only when all four parameters are considered favourable. The concept of Favourable Conservation Status (FCS) depends therefore on having Favourable Reference Values (FRVs) against which to compare each parameter. The UK's first Article 17 report on the great crested newt 2001 -2006 recorded a status of "Inadequate U1" (meaning *somewhat unfavourable*), based on the judgements that (i) the number of populations in the UK is inadequate and deteriorating and (ii) the extent of habitat for the species is unknown (range and future prospects are considered favourable).

The second Article 17 status assessment for the great crested newt in the UK (based on data 2007 – 2012; see http://bd.eionet.europa.eu/article17/reports2012/) is now available and records a status of "Unknown XX", based on uncertainty about population, habitat and future prospects variables (only range is considered favourable in the present report). The next Article 17 report, covering 2013 – 2018, is due in 2019. In order to develop methods to address these uncertainties in Wales, therefore, the Countryside Council for Wales (CCW, now Natural Resources Wales) commissioned a series of Geographical Information Systems (GIS) based studies in order to (i) demonstrate the applicability of GIS techniques to quantification of conservation status parameters and predictive mapping and (ii) produce regional, fine-scale spatial outputs (at 25 m resolution) which could be aggregated to create an objective quantification of spatial metrics for the great crested newt across Wales (see ARC and Cofnod, 2010; Arnell and Wilkinson 2011a, 2011b; Arnell and Wilkinson 2013a, 2013b, and Fletcher *et al.,* 2014). Similar approaches were also trialled by Scottish Natural Heritage (Wilkinson *et al.,* 2014 and one report in press) and Natural England (Wilkinson *et al.,* 2011).

Fine-scale GIS outputs specifically to inform great crested newt status in Wales were generated from Maximum Entropy Modelling (MaxEnt; also known as Multinomial Logistic Regression) for (i) Anglesey ii) North East Wales (Flintshire, Denbighshire and Wrexham), (iii) Powys and Brecon Beacons National Park and (iv) South Wales (Gower Peninsula to Monmouthshire). These four areas, delimited by modern Welsh unitary authority boundaries, encompass the overwhelming majority of the natural range of great crested newts in the country (Fig. 1). The present study describes the aggregation of model outputs, and the generation of accurate and objective all-Wales status metrics which can be repeated to assess possible status *changes* in Wales, and could be applied to other regions and countries of the UK.
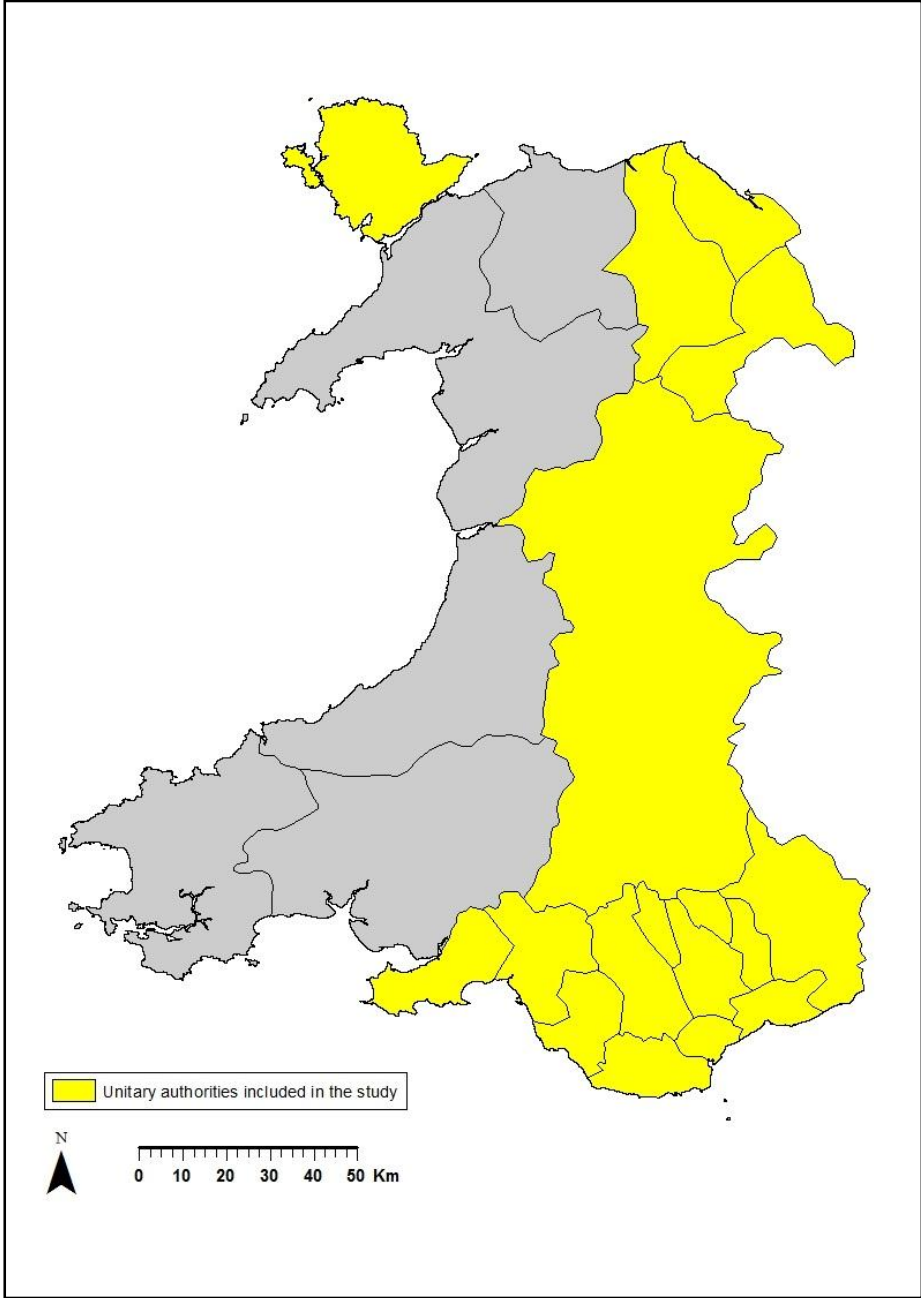

Figure 2. The 17 Welsh unitary authorities encompassing the natural distribution of great crested newts in Wales.

4. Methods

4.1. Combining model outputs

The Equal Training Sensitivity and Specificity (EQSS) threshold was used to delineate areas of suitable GCN habitat. The choice of such threshold values has been the subject of much discussion and remains controversial, though the EQSS has been found to be superior to other commonly used thresholds (Liu *et al.*, 2005) and often provides the most conservative estimate of suitable habitat – appropriate for application of the precautionary principle.

We combined the EQSS results from each model using the merge function in ArcGIS 10.2 (ESRI).These outputs covered the original model regions plus a 5 km buffer around each one, meaning there was overlap between EQSS outputs. Final combined outputs were clipped by the boundary of Wales for display and calculation purposes (i.e. we did not include the 5 km buffer that crosses the English border in quantification of status metrics).

4.2. Range

Range metrics for the great crested newt in GB, as determined by JNCC (see e.g. Wilkinson *et al.*, 2011 for discussion), correspond to "Extent of Occupancy" (EOO) – defined by IUCN as range delimited by the shortest line bounding all records for the species. In IUCN Red List assessment, however, it is acknowledged that, for low-vagility organisms such as amphibians, this method may result in the erroneous inclusion of large unoccupied areas. We therefore defined range for the great crested newt in Wales using a convex hull algorithm in the 'R' statistical software environment, 'alphahull' package' (Pateiro-Lopez and Rodriguez-Casal, 2013). The input data consisted of a collection of all known presence locations, dated post-1990, buffered to a distance of 2 km to represent potential maximum dispersal from breeding ponds. The alpha value used was 8,000, arrived at by trialling several values and selecting the one most representative of the observed core distribution in Wales.

4.3. Population

The Article 17 great crested newt reporting metric for Population is "number of populations", equating to "number of occupied ponds". To determine this number for Wales, the EQSS threshold (see above) for each model was used to determine the areas in which "suitable" ponds might be found (i.e. ponds likely to be occupied are found in suitable habitat). The suitable habitat was then clipped to the known range of the species in Wales and subsequently used to clip a UK wide pond dataset, extracted from Mastermap. In order to improve the relevancy of the number of occupied ponds, the results were further filtered to include only ponds within the range 50 – 750 m^2, this range being typical of pond sizes occupied by great crested newts (Oldham *et al.*, 2000). Finally, the total number of ponds deemed suitable (in terms of habitat and size range) was multiplied by 0.47 – the great crested newt's mean local pond occupancy rate calculated for a sample of Welsh ponds, as per the results of Griffiths *et al.* (2010).

Additionally, the likely number of high quality ponds in Wales was derived from the proportion of ponds predicted to have a Habitat Suitability Index (HSI) score of 0.7 or above - 24.75%; from National Amphibian and Reptile Recording Scheme (NARRS) surveys 2007 – 2012 for the Wales and Central region of NARRS (Wilkinson and Arnell, 2013).

4.4.   Habitat for the species

EQSS thresholds (the corresponding ones for each of the individual regional MaxEnt models) were applied to the individual regional model outputs, thus giving a binary (1/0) output representing suitable and unsuitable habitat respectively. The EQSS outputs were converted into polygons, from which total area in km² was derived. This area was then clipped to the known range of GCNs in Wales to provide an estimate of the suitable habitat available to the species within their range.

4.5.   Future Prospects

This metric can be the most poorly defined of the FCS components. It theoretically includes all factors potentially impacting great crested newts at sites and/or larger scales including legislation, climate, site-specific factors etc. The UK's latest Article 17 report for the great crested newt lists Future Prospects as "unknown". With application of the modelling processes described in the present report to Scotland and regions of England, confidence in habitat and population metrics could be improved to allow a UK-wide assessment of Future Prospects.

5.   Results

5.1.   Combined model outputs

All model fits in these studies were very good or excellent, as indicated by their areas under the receiver operating characteristic curves (AUC; Table 1). AUCs of 0.7 to 0.8 are considered to provide acceptable levels of discriminatory power, while values of 0.8 and above are regarded as indicating excellent discriminatory power (Fielding & Bell, 1997). This can be regarded as a way of analysing the model's level of precision for predicting areas of suitable habitat (see above).

Table 1. MaxEnt model results for all regional models.

Metric	Powys	North East	Anglesey	South
AUC	0.77	0.81	0.86	0.71
EQSS threshold	0.3409	0.3146	0.3	0.3932

5.2.   FCS metrics

Numerical outputs for each of the FCS metrics are given in Table 2 and spatial outputs shown in Figs. 2 – 6.

Table 2. FCS metrics for the great crested newt in Wales. Values are based on a total Wales area of 20,761 km^2, a total number of ponds of 30,056, a number of ponds in the typical size range of 19,899 and regional HSI >0.7 of 24.75%.

Metric		Value
RANGE	Total in km^2	**7,312**
	Proportional (to Wales)	35.22%
POPULATION	No. of occupied ponds	**3,271**
	Proportional occupancy (to all ponds in Wales)	11%
	Proportional occupancy (to typical-size ponds in Wales)	16%
	No. high quality ponds (HSI >0.7)*	810*
HABITAT	Total in km^2	**2,170**
	Proportional (to Wales)	10.5%
	Proportional (to range)	29.7%

* Within modelled range area and typical size range. This modelled number of high quality ponds within the total occupied might be a suitable proxy for habitat quality.
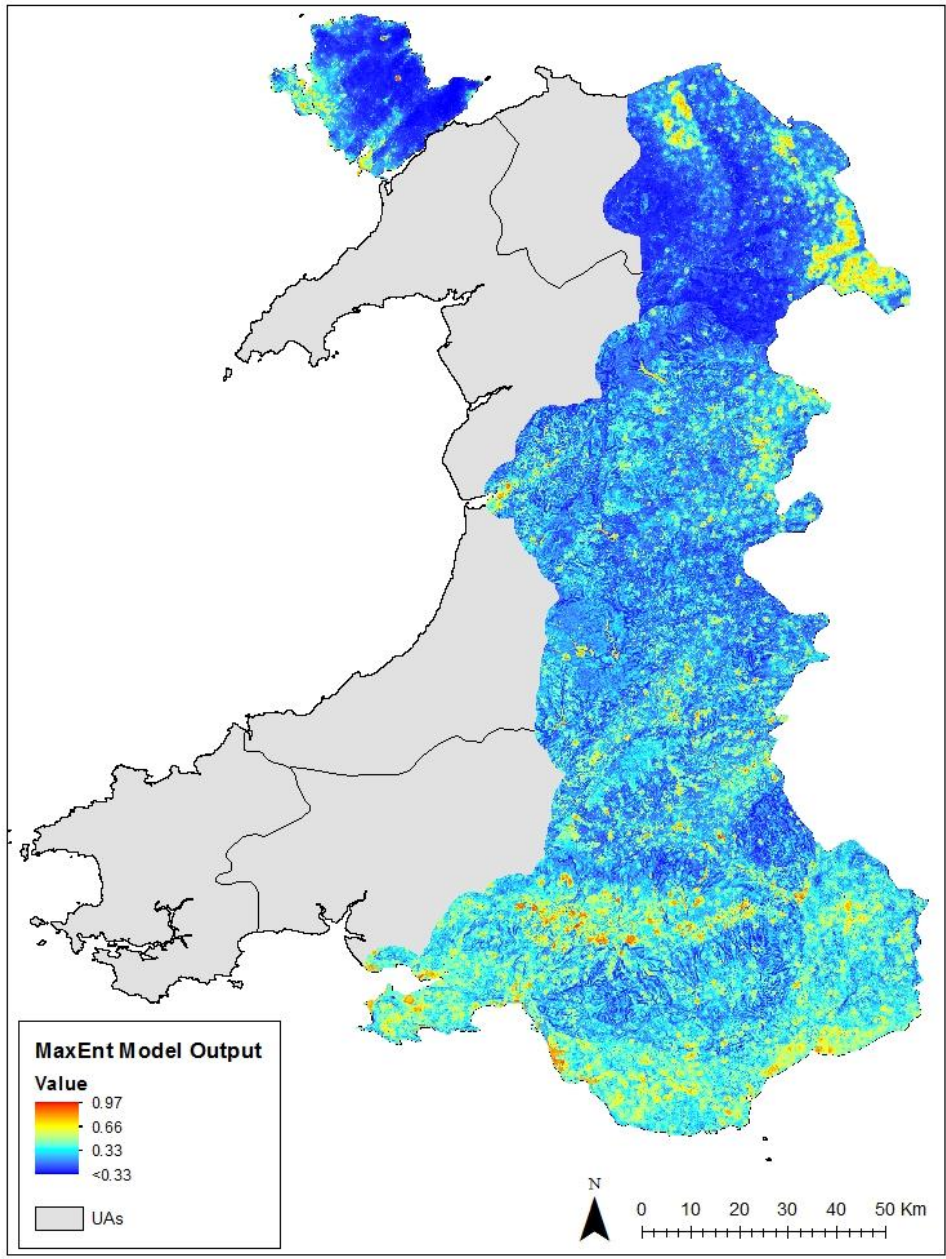
Figure 2. Combined Wales model logistic outputs in MaxEnt. "Hotter" areas indicate a greater likelihood of great crested newt presence (and, conversely, the species should be absent from dark blue "cold" areas).
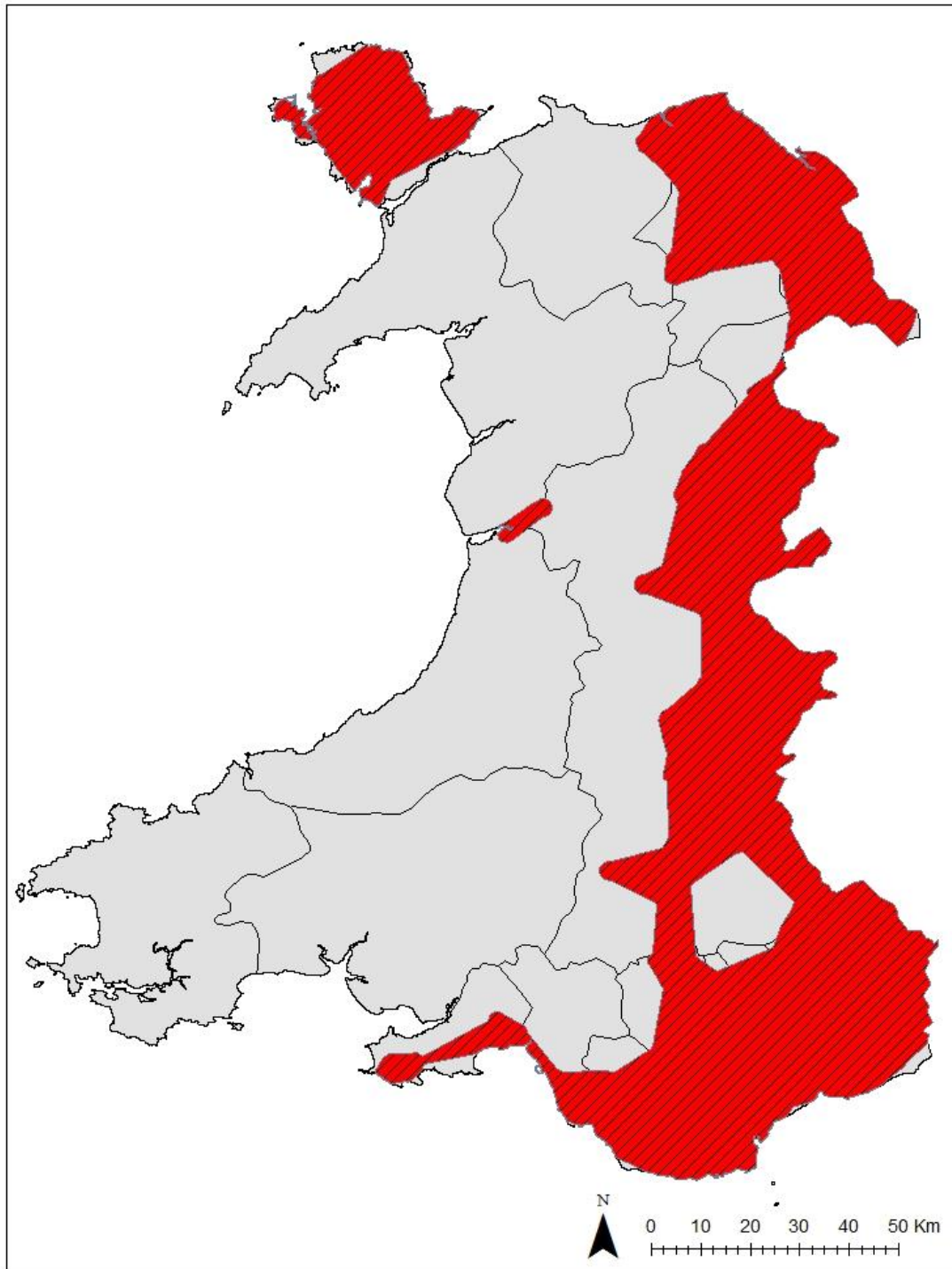
Figure. 3. Range of great crested newt in Wales. Based on concave bounding polygon; (alphahull = 8,000); range = 7,312 km^2.
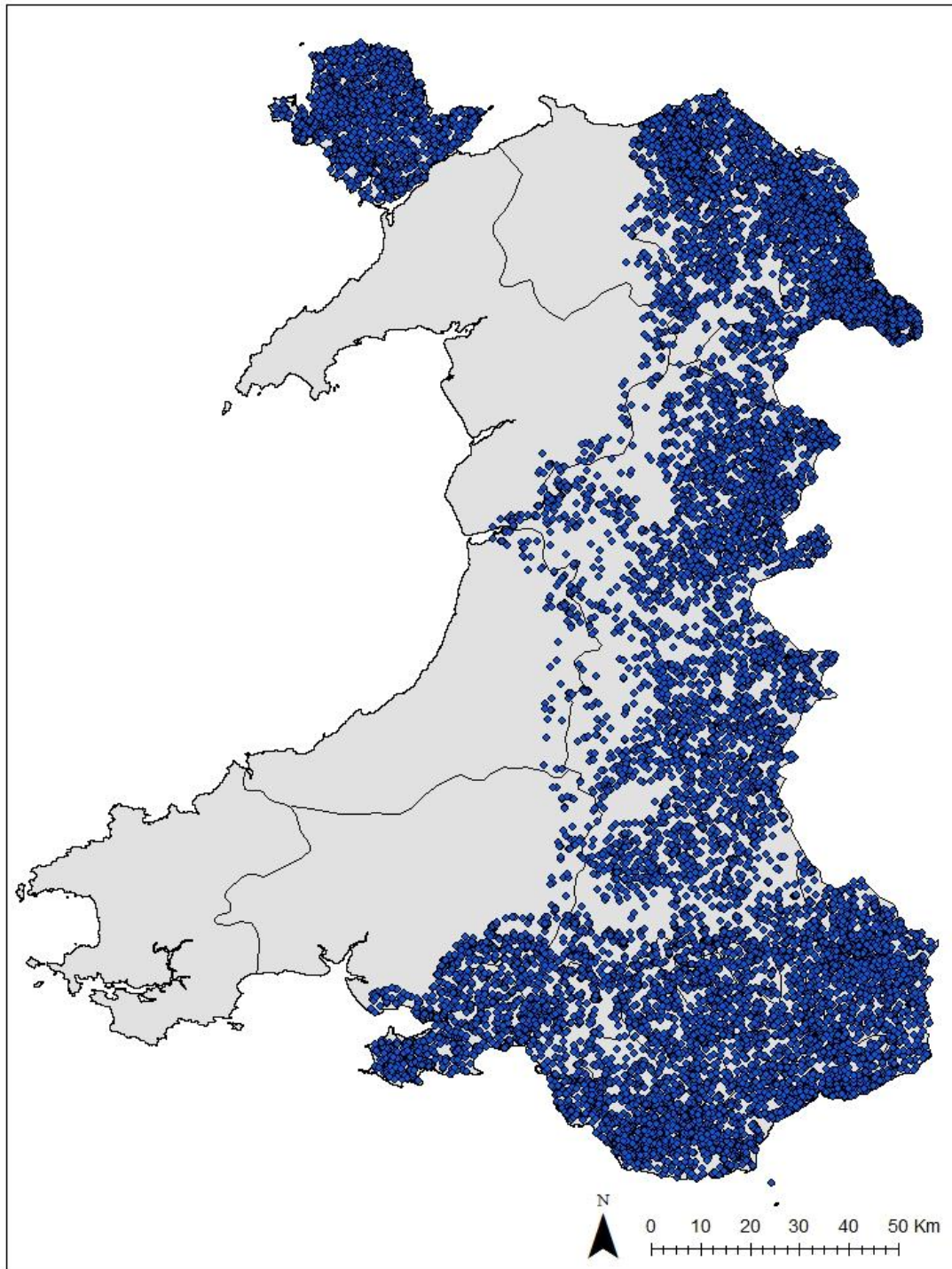
Figure 4. All ponds found within the present study area.
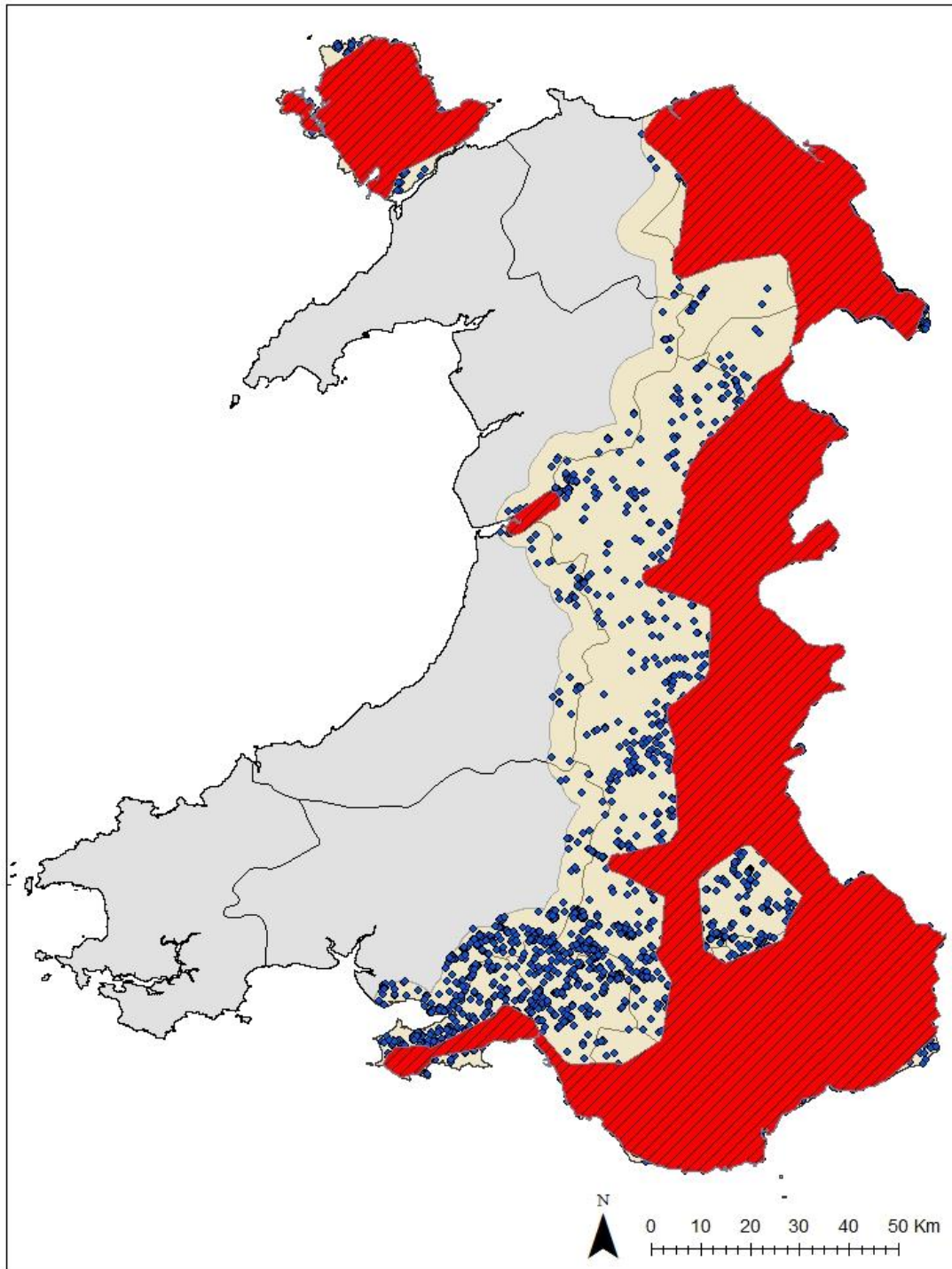
Figure 5. Ponds predicted to be suitable for great crested newts within the current study area overlaid with Wales range. These should be regarded as high priority survey targets to improve knowledge of Welsh range for the species and provide additional information for future modelling.
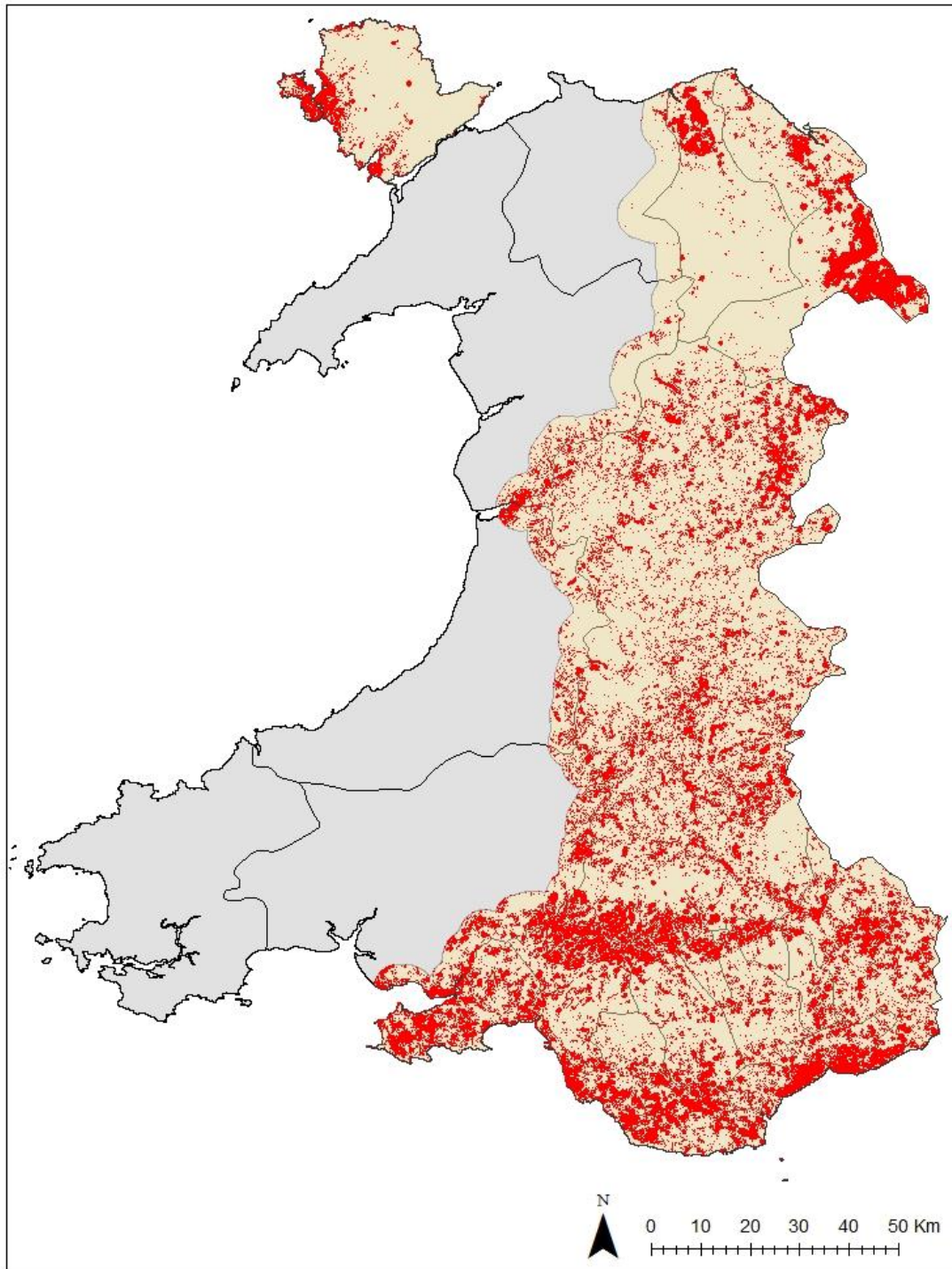
Figure 6. Extent of modelled suitable habitat (red) for great crested newts in Wales (based on 25 x 25 m cells) within the total area of model output (pale orange). Total extent = 4,199 km^2, clipped to known GCN range = 2,664 km^2.

6. Discussion

6.1. Combined model outputs

Combined MaxEnt model logistic outputs (Fig. 2) show that the main hotspots for great crested newt occurrence in Wales are north Denbighshire, Flintshire and northern Wrexham, parts of central eastern Powys, northern Rhondda, Merthyr Tydfil and neighbouring authorities, southern Bridgend, the whole of the Vale of Glamorgan, parts of Cardiff and Newport and in Monmouthshire. Smaller but significant suitable patches also occur in Anglesey (especially Holy Island), Gower and patchily throughout the eastern half of Powys (as well as one isolated patch near Machynlleth). The south-western half of Denbighshire and most of western Powys are apparently unsuitable for the species, most likely as a result of inimical altitude acting as an historic and current barrier to dispersal. Indeed, earlier coarse-scale modelling by Wilkinson *et al.* (2011) showed suitable habitat in (for example) Pembrokeshire which is unavailable due to altitudinal and riverine barriers. Further surveys (recording efforts) are needed particularly in the Brecon Beacons to better understand Welsh great crested newt distribution and inform future status modelling (Fig. 5). Such "ground truthing" of model outputs, targeting ponds and areas with predicted suitability for great crested newts, could be carried out relatively simply following the recent development of a robust protocol for detecting great crested newts through environmental DNA (eDNA) in pondwater samples (see Biggs *et al.,* 2014).

6.2. Range

The present range estimate of 7,312 km^2 is the finest-resolution estimate for great crested newt range in Wales to date. Nevertheless, it is compatible with the coarser previous estimate of Wilkinson *et al.* (2011) of 8,373 km^2. The latter may be expected to exceed present values as it was carried out at only 1 km resolution (as opposed to 25 m), therefore encompassing some unsuitable areas.

The present range estimate is easily updatable and comparable, if and when new survey data comes to light (e.g. from the Brecon Beacons, see above), and/or if a narrower date range was selected for model input data. Notwithstanding that, the approach is repeatable in order to assess changes over time and we suggest the use of a rolling 20 year date range to input to future models intended to detect change. Though it is currently unclear whether the Welsh range of great crested newts has changed substantially in (say) the last two centuries with variable and sometimes dramatic rates of pond loss, it may be true that the great crested newt's Welsh range remains favourable (as reported at UK level). We also suggest, however, that the FRV for Welsh range (currently not established) is set as an area range which would help account for variability in the generation of, and access to, records over any rolling 20 year period.

6.3. Population

Ponds are very abundant in parts of Wales and, though the effects of this are visually amplified in Fig. 4, it can be seen that the best areas for great crested newts in Wales correspond to regions with high pond density (particularly the far north east and Vale

of Glamorgan). In the absence of a complete and constantly-updated dataset of survey data from across the whole of Wales, it is reasonable to assume we will never have absolute knowledge of pond occupancy for the species. The application of modelling approaches as described here, based on presence-only data, a theoretically typical range of pond sizes occupied and an estimated pond occupancy rate for Wales (from Sewell *et al.*, 2010) is probably therefore the best and most objective way of estimating pond occupancy to assess change in status over time.

The total number of occupied ponds generated here (3,271) is again similar to Wilkinson *et al.*'s (2011) estimate of 4,512 (remarkable considering the latter estimate was arrived at by completely different methods). Moreover, our Wales occupancy rate estimate of 11% is extremely close to the UK NARRS estimation of 12% (Wilkinson and Arnell, 2013) and the occupancy rate in Welsh ponds within the typical size range of 16% is compatible with both Wilkinson *et al.* (2011) (16%; modelled for Wales) and Wilkinson and Arnell (2013) (15%; based on survey data from the NARRS Wales and Central region 2007 – 2012). We would again suggest that the FRV for Welsh populations is set at a range, though this needs particularly careful consideration, taking account of the possibility of substantial pond and/or population losses on a local or regional scale.

The inclusion of an estimate for the number of high quality occupied ponds within the area and typical size range for the great crested newt is probably also a useful metric that could be used to examine changes (e.g. with pond senescence) but the present proportion used (24.75%) would ideally be based on a great deal more survey data from across Wales in order to better assess changes over time. The number of high quality ponds within the total occupied within Wales can also be used as a proxy for overall habitat quality (i.e. the more high quality ponds, the higher the habitat quality). This would likely require the establishment of a further FRV that would feed into metrication of both Population and Habitat FCS components. As things stand, the projected figure of 810 high-HSI ponds across Wales may seem inadequate.

6.4. Habitat for the species

We have used the EQSS threshold to generate the extent of suitable habitat for great crested newts in Wales (see above). Suitability of habitat (or otherwise) can be a very subjective measure, dependent on field survey and surveyor expertise (though the HSI; Oldham *et al.*, 2000, can be informative). Probably most important for this metric is that habitat extent is quantified in a repeatable and objective way in order to assess any changes. The MaxEnt approaches demonstrated here would again appear suitable. Moreover, there is remarkable concordance between the present value (2,170 km^2) and the comparable value from the coarse modelling conducted by Wilkinson *et al.* (2011; phase 1 removal model with pond density filter) of 1,989 km^2.

The extent of predicted suitable habitat is also used to model the number of occupied ponds which, when compared to range, is a useful tool to inform survey targets (as described above; Fig. 4).

The present approach may be especially valuable and, as with the other spatial metrics quantified here, useful for application to other countries and areas of the UK, as the current Article 17 report lists "Habitat for the species" as "unknown". Presence-only

modelling using MaxEnt can clearly deliver repeatable metrication of habitat extent that is usable for status reporting. Additionally, the quantification of suitable habitat extent as a proportion of range (29.7%) may be a further useful metric by which to assess change in status (e.g. if the proportion of suitable habitat shrinks within a stable range area). We would again recommend a carefully-determined area range to set the FRV, bearing in mind that this metric is derived directly from the MaxEnt output and its long-term variability when based on a rolling 20 year dataset is currently unknown.

6.5. Summary

The quantification of FCS metrics is essential to repeatable and objective assessments of status, including applications such as Habitats Directive Article 17 reporting obligations at UK level. The present report demonstrates that the derivation of spatial metrics is possible for all-Wales, based on the aggregation of outputs from relevant regional models. The approach could also be used for the disjunct areas of great crested newt distribution in Scotland, and for regions or counties of England (though some calculation as to the optimal number of models used to cover England and the Borders would be beneficial). Background samples, and therefore the scale of individual models, should be chosen to reflect local environmental conditions based on the spatial scale of the ecological questions of interest (Saupe *et al.,* 2012), hence the use of several regional models combined to produce all-Wales metrics. Most importantly, this approach is repeatable and has no basis in subjectivity, being reliant mainly on the availability of sufficient presence records (filtered for spatial-autocorrelation and within an appropriate date range) from the study areas of interest.

A summary of FCS spatial metrics is given in Table 3. The process of objective status assessment and reporting based on incomplete knowledge and variable survey data still, however, requires agreement on FRVs in order to determine whether the status of great crested newts in Wales (and elsewhere) can be quantified as "favourable" or otherwise. Additionally, an objective process for determining "Future Prospects" is required (possibly based on a matrix of elements including trajectories of the three spatial metrics).

Ground truthing of model outputs, including the use of volunteer and contractor data, and eDNA techniques, should be carried out in order to contribute to the iterative process of model improvement – leading to more accurate metrication of status over time. We also anticipate that surveillance of population sizes, and changes thereof, at key sites across Wales, will also contribute to status assessment in the country and be key to detecting countrywide or regional trends.

Table 3. Summary of FCS metrics for great crested newts in Wales, from the present study.

Metric	Value
Range	7,312 km^2
Population	3,271 occupied ponds
Habitat for the species	2,2170 km^2
Habitat quality measure	810 high quality ponds

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8.   ACKNOWLEDGEMENTS

Data Archive Appendix

Data outputs associated with this project are archived within the report, and raw datasets are held by the ARC Trust.

The data archive contains:
The final report in Microsoft Word and Adobe PDF formats.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://194.83.155.90/olibcgi by searching 'Dataset Titles'. The metadata is held as record no. 115877.

Further copies of this report are available from:

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