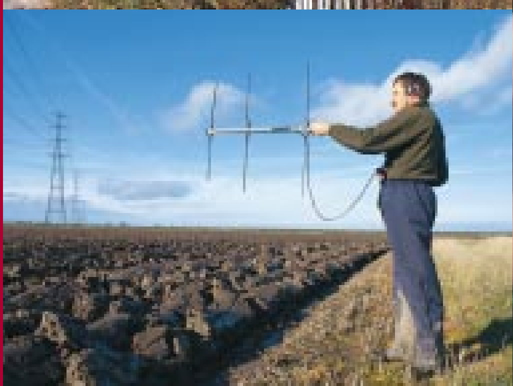
Report Number
584

An investigation of recent declines in the common toad *Bufo bufo*

English Nature Research Reports



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An investigation of recent declines in the common toad *Bufo bufo*

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English Nature cover note

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Summary

- Data obtained from a questionnaire-based survey of common toad *Bufo bufo* and common frog *Rana temporaria* population trends since 1985 were used as the starting point for investigating recent common toad declines in Britain.

- This study, involving detailed assessments of sites reported in the questionnaires, confirmed that toad declines in the past 15 years have been substantial in much of lowland England.

- Toad sites in the area of main decline (eastern, central and southern England) were broadly similar to sites in areas with no overall decline, though the former tended to be situated in more complex landscapes with higher traffic levels on local roads.

- About a quarter of declines were unattributable by correspondents to any specific cause. This percentage was similar in the “main decline” and “no overall decline” regions.

- The remainder (ie most of the declines) were ascribed by respondents to habitat changes of various kinds. Increased traffic during toad migration times was thought important by many respondents.

- No common habitat or landscape features were associated statistically with declining populations.

- Logistic regression provided a best fit model, nevertheless weakly supported, in which the cooperative effects of excess aquatic vegetation, low levels of marginal vegetation and the absence of wildfowl were associated with toad declines.

- The cause(s) of toad declines remain unclear and research concentrating on a set of specific sites is required to address this conservation problem.

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1. Introduction

The status of amphibians in Britain has been relatively well documented over many decades, thanks to a long tradition of study in this country (eg Taylor 1948, 1963; Cooke 1972; Prestt and others 1974; Cooke & Scorgie 1983; Arnold 1996). Substantial declines of most species occurred during the 1950s and 1960s at a time when changes in agricultural practices and increasing urban development lead to widespread loss of habitat (Cooke & Scorgie, 1983). Recognition of this problem resulted in a concerted conservation effort, widespread pond restoration, and varying degrees of statutory protection for amphibians under the Wildlife and Countryside Act (WCA) of 1981. This has proved effective in slowing the decline of some species (Cooke & Scorgie, 1983; Swan & Oldham, 1993; Banks and others 1994). Common toads *Bufo bufo* are one of the species that received only minimal protection under this law, though in some places they have benefited indirectly from the increased protection of habitats afforded by the WCA. Countryside pond losses have continued apace, but were offset to some degree by the creation of garden ponds in recent decades (Cooke & Scorgie, 1983). Because of their preference for large water bodies, common toads have benefited less from this development than have common frogs. Toads are less catholic in their choice of breeding ponds than the other widespread British amphibians, and often migrate long distances between terrestrial and breeding habitats. This may make them particularly vulnerable to habitat change.

Recent evidence has generated cause for concern about renewed declines of common toads. There was some indication by the late 1980s that toads were declining more than other widespread amphibians in parts of lowland England (Hilton-Brown & Oldham, 1991). Anecdotal evidence during the 1990s supported this concern. A particular example was the dramatic decrease in toad population size, from several thousands to low hundreds, at Offham Marshes in East Sussex (Beebee 2000). This site was given SSSI status on the basis of its amphibian assemblage, a significant component of which was the *B. bufo* population. Common toads have a wide distribution (Beebee & Griffiths, 2000) and their status cannot be assessed from national distribution maps since the large scale geographical resolution will not reflect changes in abundance unless they disappear altogether from a wide area (Beebee, 1973). Quantitative studies detailing population sizes of common toads are few, but questionnaires asking recorders to report changes in status of amphibians have become an accepted way of monitoring population trends (eg Cooke 1972; Cooke & Scorgie 1983; Hilton-Brown & Oldham, 1991). In autumn 2001 a questionnaire was sent out by *Froglife* to people involved either directly or indirectly in working with amphibians. Respondents were asked to indicate the status of frog and toad populations monitored for at least five years over the previous 15 (ie since about 1985). There were 101 responses to these questionnaires and preliminary analysis indicated that the status of common frogs seemed stable across Britain. However, in a broad swathe of eastern, southern and central England (but apparently not elsewhere) a high proportion of common toad populations were reported as declining (Carrier & Beebee 2003). Here we outline a further investigation of the questionnaire responses with a view to validating their observations and elucidating the causes of recent toad declines.

2. Methods

The dataset consisted of 101 returned questionnaires giving information on frogs and toads at 240 individual sites plus five wider areas, notably the New Forest, Renfrewshire, Ayrshire, the Isle of Bute and South Holderness. Of these returns, 169 gave details about sites with toads (see Appendix 1). Twenty-four of these were garden ponds and so were excluded from this investigation.

A subset of the toad populations cited in the questionnaire responses was chosen for further investigation. The region in which toads appeared to be suffering excessive decline (hereafter the "main decline" area) was previously defined as counties in eastern, south eastern and east-central England (Beebee 2003). This included Lincolnshire, Nottinghamshire, Derbyshire, Leicestershire, Norfolk, Northamptonshire, Suffolk, Cambridgeshire, Bedfordshire, Buckinghamshire, Oxfordshire, Berkshire, Hertfordshire, Essex, Greater London, Surrey, Sussex, Kent and Eastern Hampshire. From this area of main decline, ten toad populations were selected which respondents had stated were declining or extinct, and a further ten populations which respondents felt were stable or increasing. Twenty populations, similarly divided, were selected from the rest of Britain. This is referred to subsequently as the "non-decline" area, meaning there was no excess of decline relative to stable and increasing populations. There were, of course, some declining populations in the non-decline area. The 40 selected populations are highlighted in Appendix 1. They were chosen to cover a wide geographical spread within the two defined regions, but otherwise arbitrarily. All 20 sites within the main decline area were visited, accompanied by the questionnaire respondent. Various physical and biotic parameters of the sites were recorded. These included the nature of the water body, its size, the percentage of the surface covered by aquatic and emergent plants, the percentage of the shoreline shaded by trees, the presence of fish, and the presence of wildfowl. The immediate terrestrial habitat (within 20 m of the breeding site) was categorised by recording the presence of rough grass, cut grass, pasture, arable, parkland, scrub, occasional trees, woodland, nearby roads, residential and "any other" land use. Habitats of the wider terrestrial landscape up to 1 km from the breeding site were recorded along similar lines. Information was collected concerning the recent history of the site and surrounding area, management of the site (both terrestrial and aquatic), and perceived threats to the toad population.

For logistic reasons it was not possible to visit sites in the non-decline area, so respondents in this region were interviewed by telephone and asked to provide details similar to those collected during site visits in the main decline area. Because many of the respondents were unfamiliar with this type of analysis the quality of the data varied, limiting the detail in which they could be collected. In order to reduce recorder variability effects, classes within the variables measured were kept broad. For example, estimates of past and present population sizes were necessarily very approximate, except in a few scientific surveys, and were simply categorised as "few" (toads observed in tens, or "very few", or under 100 collected at a toad crossing per season); "moderate" (toads observed in hundreds, or up to 1000 collected at a toad crossing per season) or "large" (toads observed in many hundreds, or over 1000 collected at a toad crossing per season).

Many people were unsure of the size of the pond in which the toads bred, and estimates were variously given in yards, metres, acres, hectares, car lengths and the time it took to walk around the pond. Water body sizes were therefore converted into square metres and assigned to one of five categories: "Very small" (less than 100 m^2); "small" (100 – 500 m^2); "medium"

(500 - 2000 m^2); “large” (2000 – 10,000 m^2); and “very large” (over 10,000 m^2). The problem was further complicated where several water bodies existed close together within a site, as the distribution of toad breeding sites within these areas was not necessarily known. Therefore the size of water body in this analysis refers to the area considered to be available for breeding rather than that of a particular breeding site. All other quantitative factors, such as amount of aquatic vegetation, were categorised as low, medium or high as appropriate.

Differences between the breeding sites of declining and stable populations within each of the two areas were analysed using χ^2 tests, comparing the frequencies of all recorded variables in each group. Declining populations from both areas were compared similarly. Due to the high number of comparisons made in each analysis, Bonferroni corrections were applied. As the history of each site differed, most changes associated with the sites could not be analysed individually. Although population declines were in some cases assigned to the effects of such changes, in other cases there was not even a hypothesis for the decline. Declining populations were therefore categorised either as being relatable to habitat degradation or as having no obvious cause. Declining populations within and outside the main area of decline were compared using χ^2 to see if there were more ponds in one area than the other with no obvious cause for decline. We also used logistic regression analysis to investigate whether models combining the effects of multiple factors could explain the patterns of population decline. Statistical tests were carried out using the MINITAB and STATISTIX 7 computer programs.

Following interviews with questionnaire respondents, some sites were subsequently deemed unsuitable for inclusion in the subset of 40 for statistical analysis. This was because only sites with robust data were appropriate in this context. However, information obtained from these interviews was useful in interpreting the questionnaires and some of it is included in the results.

3. Results

3.1 Overview of declines

Some of the questionnaire respondents were not contactable, either because they had not given contact details or because they had moved house. Furthermore, following the site visits and telephone interviews some sites were not considered suitable for inclusion in the statistical analysis. Thus information was gathered about more sites than were eventually compared statistically. Within the area of main decline about 51% of the rural toad sites reported on were considered to be declining or extinct. In the “non-decline” area such sites comprised around 31%. We first compared the 20 sites in the main decline area with the 20 outside it, for which we had reliable data, to see whether there were systematic differences that might account for different decline rates. The sets of sites were statistically indistinguishable with respect to most of the variables we assembled (pond size, past population size, presence or absence of fish, fishing activities, presence or absence of wildfowl, extent of aquatic and marginal vegetation). Figures 1-5 display the data for population size, previous population size, waterbody size, aquatic vegetation and marginal vegetation. There was, however, almost a significant difference in landscape complexity (number of habitats within 1 km of the pond); sites in the non-decline area tended to be in less complex landscapes than those within the main decline area (χ^2 = 3.68, df = 1, P = 0.055; Table 1). A similar trend was seen with nearby traffic, which tended to be lower outside the main decline area (χ^2 = 5.91, df = 2, P = 0.052). With respect to specific habitat features, cut-grass, arable and woodland were all more frequent in the main decline area than outside it. Since land use was diverse at many sites, and listing broad habitat categories would not be particularly informative, a brief habitat description of each site used in the statistical analysis is presented in Appendix 2.

Table 1. Habitat complexity

Population status and location	**Mean habitat complexity index (1-7)**
Declining populations within main decline area	3.2 ± 1.03
Stable populations within main decline area	3.6 ± 1.43
Declining populations outside main decline area	2.4 ± 0.97
Stable populations outside main decline area	2 ± 1.05

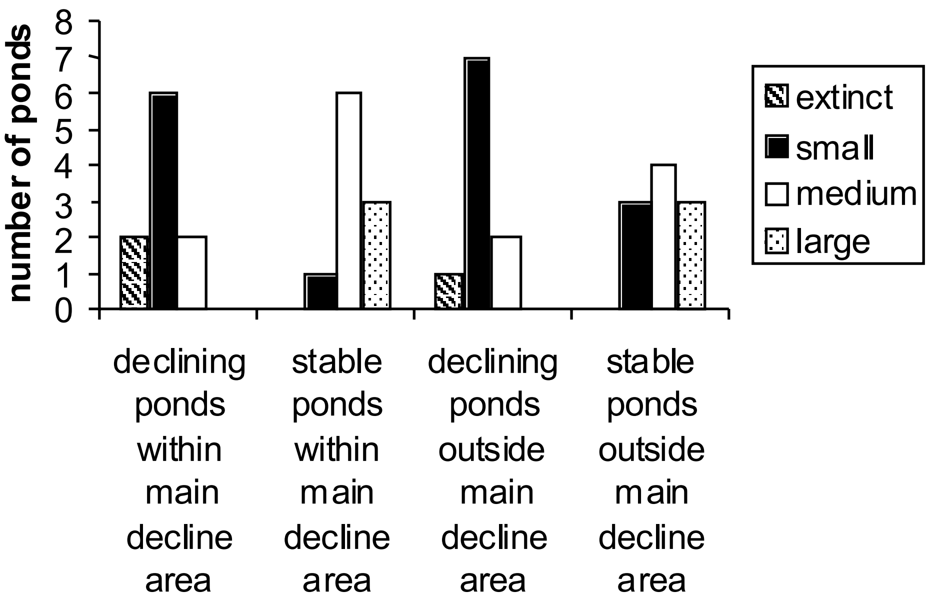


Figure 1. Present population size

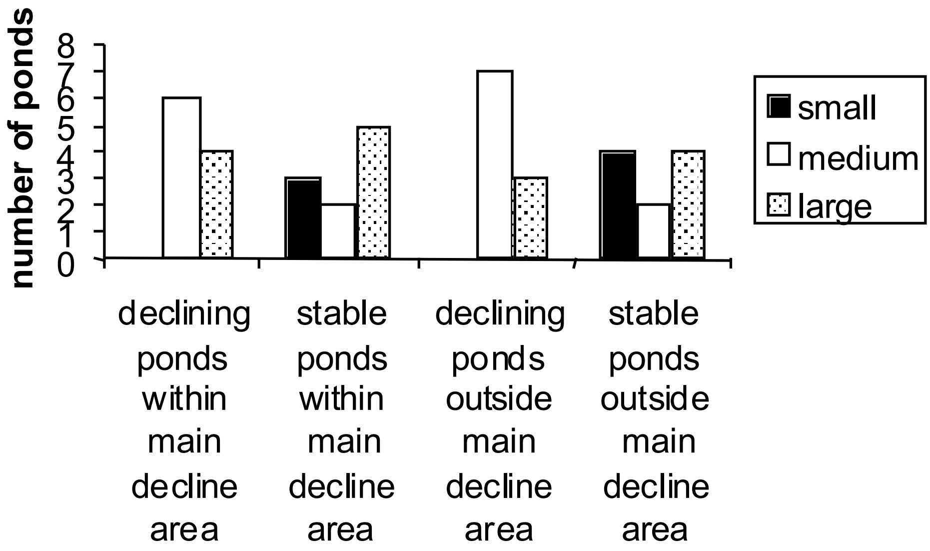


Figure 2. Previous population size

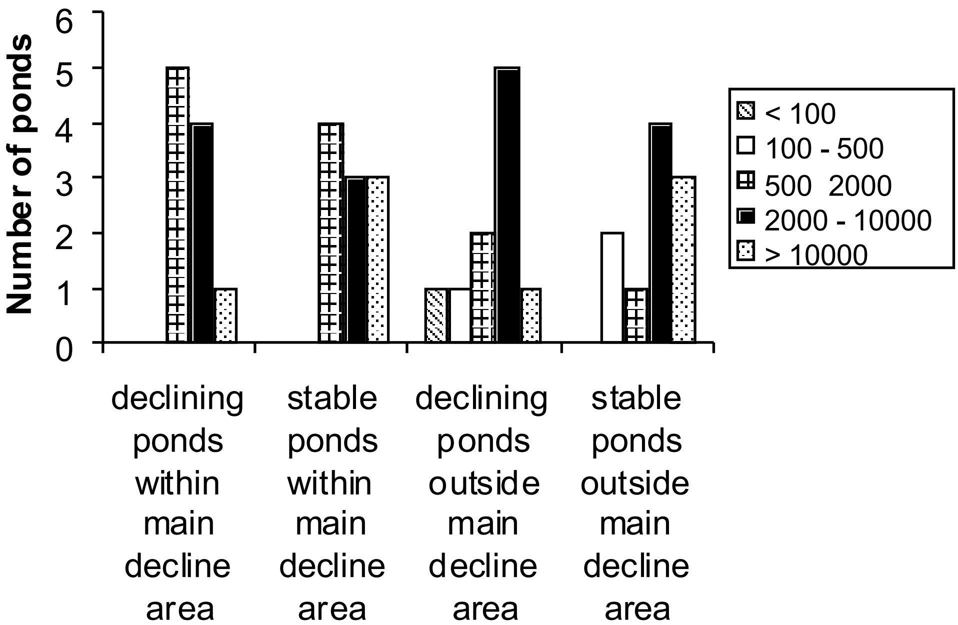


Figure 3. Waterbody size

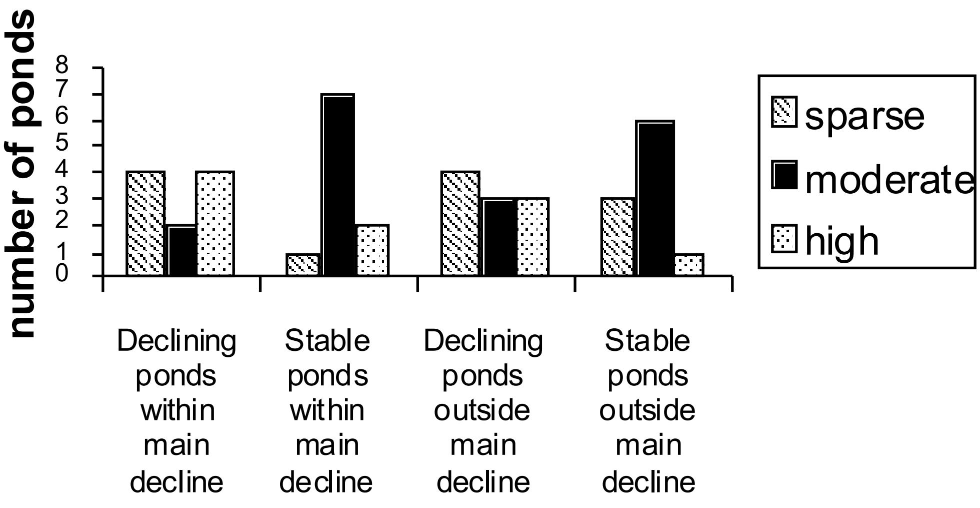


Figure 4. Aquatic vegetation

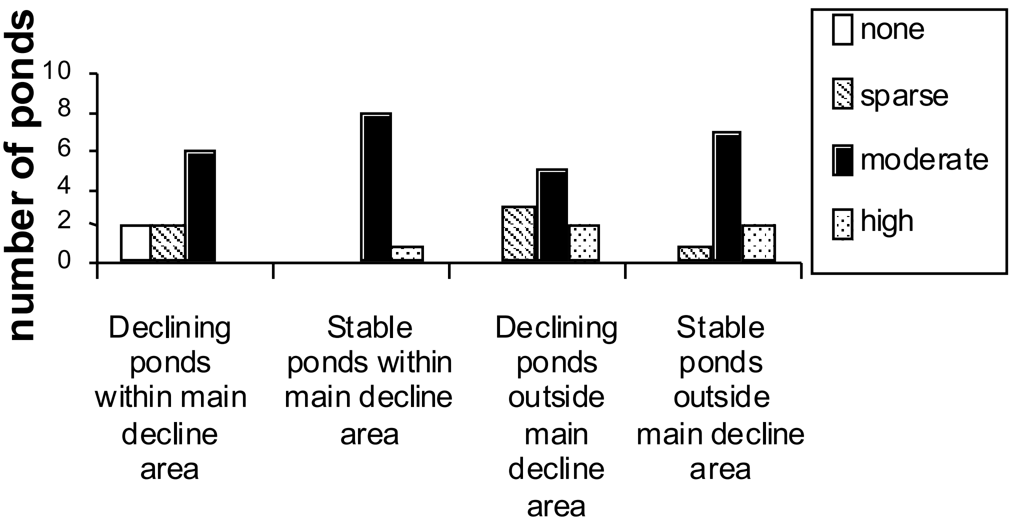


Figure 5. Marginal vegetation

Taken altogether (including sites unsuitable for statistical analysis of habitat features) the data were used to compile a list of possible reasons for toad declines at 39 rural sites across the whole of Britain where toads were reported as declining (Figure 6). The majority of the declines were thought by respondents to relate to habitat degradation. There was no significant difference in the relative number of declines for which no cause could be ascribed within and outside the main area of decline ($\chi^2 = 0.30$, df = 1, P = 0.900). Overall, 23% of declines could not be assigned by respondents to any identifiable cause. However, more than 12% of reported declines could not be confirmed on closer examination of the data. Taking these incorrectly reported declines into account, over 25% of true declines had no obvious cause. It remains unknown as to what proportion of the explanations for decline given by respondents for the other 75% of cases was actually correct.

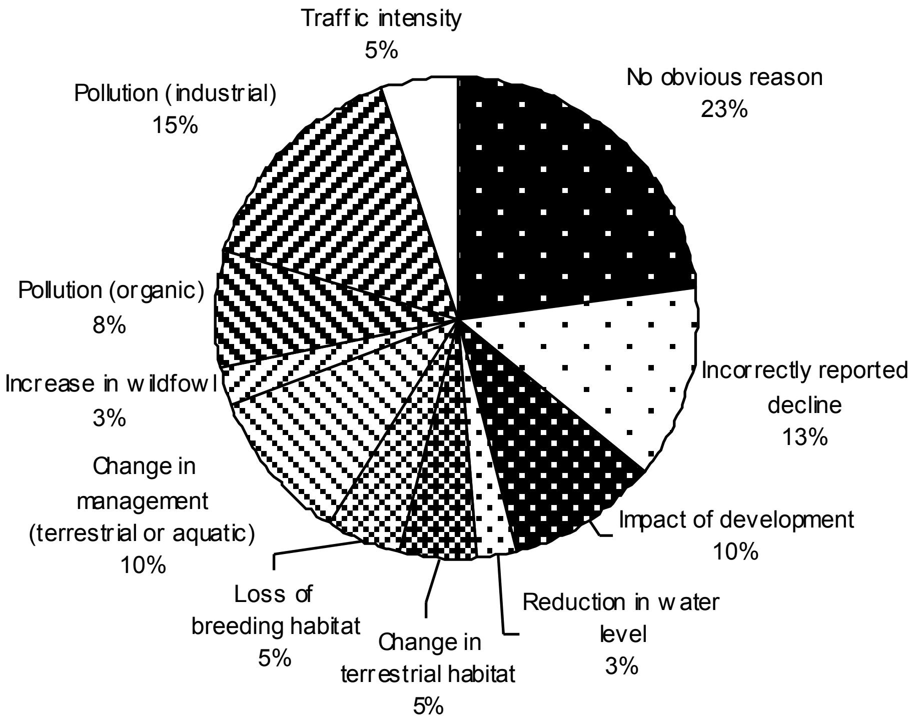


Figure 6. Reasons given by questionnaire respondents for declining toad populations at 39 sites.

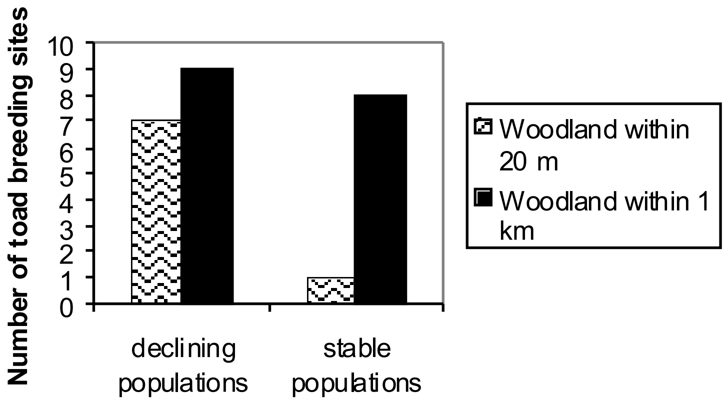
3.2 Statistical comparisons

A comparison of the 40 stable/increasing and declining toad populations selected for data reliability is given in Table 2. Within the main decline area, only two factors approached statistical significance. Firstly, there was a trend for immediate land use around the breeding sites of declining populations to be different from that at sites with stable populations. Secondly, there was a difference between stable and declining populations with regard to the length of time over which the sites had been observed. Nine of the 10 declining populations had been observed for over 10 years, compared to only four of the stable populations. Neither of these factors retained significance after Bonferroni correction for multiple comparisons. With respect to the immediate land use, it appeared that woodland within 20 m of the breeding pond was positively associated with declining sites (Figure 7). However, woodland within 1 km was in general more frequently associated with toad breeding sites in the area of main decline than with those in the non-decline region ($\chi^2 = 7.033$, df = 1, P = 0.008).

Table 2. Comparisons of stable and declining populations within and outside the main area of decline. Individually significant differences are highlighted.

Variable	Differences (stable x declining populations): Within main decline area			Within non-decline area		
	χ^2	df	P	χ^2	df	P
Past population size	3.11	2	0.212	6.79	2	***0.034***
Size of waterbody	1.25	3	0.534	3	3	0.392
Change in size of waterbody	0.27	1	0.606	0	1	1
Presence of fish	0.41	1	0.522	0.83	1	0.362
Fishing at waterbody	0	1	1	0.22	1	0.639
Presence of wildfowl	3.11	2	0.212	2.23	2	0.33
Quantity of aquatic vegetation	5.24	2	0.073	2.14	2	0.343
Quantity of marginal vegetation	2.04	1	0.154	1.33	2	0.514
Immediate land use up to 20 m around pond	13.41	6	***0.038***	2.87	4	0.58
Land use up to 1 km around pond	3.32	6	0.768	3.05	4	0.55
Traffic intensity	1.15	2	0.563	0.68	3	0.877
Time over which sites have been observed	5.50	1	***0.019***	0	1	1

(a) Within main decline area



(b) Outside main decline area

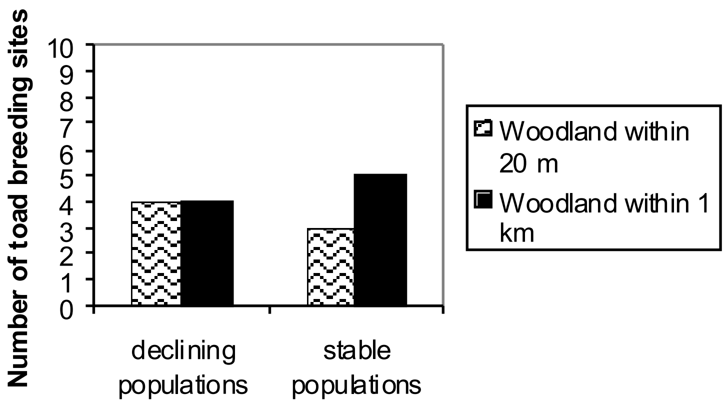


Figure 7. Association of toad sites with woodland

In the non-decline region the only factor approaching significance that differed between stable and declining sites was past population size. Populations that had been larger in the past were more likely to be considered declining now, but again this was not significant after Bonferroni correction.

The majority of the questionnaire responses were from people involved in toad crossings. The number of responses that were cited on the questionnaires as being from toad patrols was analysed separately but this yielded no significant differences from the total data set. There was also no significant difference in the relative numbers of responses from toad crossings, relative to total responses, between the decline and non-decline areas.

We also compared factors associated with declines in the main decline area and outside of it (Table 3). There were no significant differences in the biotic or abiotic variables associated with declining populations inside and outside of the main area of decline. However, declining populations inside the main area of decline had been observed for a longer period than those in the non-decline area. This difference was insignificant after Bonferroni correction.

Table 3. Comparison of variables in declining populations inside and outside the main area of decline.

Variable	χ^2	**df**	**P**
Past population size	0.20	1	0.653
Size of waterbody	2.67	3	0.446
Change in size of waterbody	0.39	1	0.531
Presence of fish	2.81	1	0.094
Fishing at waterbody	0.01	1	0.906
Presence of wildfowl	0.20	1	0.653
Quantity of aquatic vegetation	0.34	2	0.842
Quantity of marginal vegetation	4.29	3	0.232
Immediate land use up to 20 m	7.59	5	0.181
Land use up to 1 km	3.96	5	0.555
Traffic intensity	3.83	3	0.281
Time over which sites have been observed	5.50	1	***0.019***

Finally, we carried out a logistic regression analysis testing a wide range of models with different combinations of independent variables. For this we combined all the 40 sites with adequate data, with the dependent variable annotated as 1 (decline) or 0 (stable/increasing). By far the best model we found is summarised in Table 4. Aquatic vegetation density and past population size were positively correlated with declines, while the presence of wildfowl and density of marginal vegetation were negatively associated with declines. Landscape complexity (on a score of 1-7 based on the number of different elements present) was not quite negatively associated with decline, but was an essential variable in the model. However, the probability associated with this model overall was only 0.455.

Table 4. Results from logistic regression analysis of toad declines

Predictor variables for decline	Coefficient	P
Constant	9.56	***0.039***
Aquatic vegetation	1.78	***0.020***
Wildfowl	-1.77	***0.023***
Marginal vegetation	-3.78	***0.016***
Past population size	2.20	***0.008***
Landscape complexity	-0.66	0.083

4. Discussion

An initial analysis of the questionnaire returns indicated that there were more toad populations declining in the east, eastern central and southeast of England than in the rest of Britain while frogs were faring similarly everywhere (Carrier & Beebee, 2003). This more intensive study confirmed the initial analysis. 51% of rural toad sites reported in the questionnaires from east/east-central and south-east England were declining compared with only 31% of rural toad sites reported from the rest of the country. The only general differences between toad sites in the two regions were that those in the main decline area tended to have greater landscape complexity (unlikely to predispose declines) and more traffic nearby. The apparent difference in landscape complexity may simply reflect the difference in the way this information was collected in the two regions. Sites in the main decline area were visited, enabling more detailed information to be recorded; information about sites in the area of non-decline was given in telephone interviews, relying on the recorder's memory of the site, and may have been more generalised. Statistically, there were no substantive differences in either the breeding sites or their surrounding terrestrial habitat that would account for the difference in rate of decline between the two regions studied. It therefore seems likely that factors causing toad declines are common to both regions but simply occur at higher frequency in the area of main decline than outside it.

From the sample of sites investigated in this study, and from interviews with questionnaire respondents, it certainly seems that toad populations in the main decline area are decreasing over and above what might be considered natural population turnover. Although extinctions are natural occurrences (Blaustein and others 1994), the rate at which they happen has been accelerated by anthropogenic factors (Wilson 1992; Diamond 1994). Loss of habitat and habitat degradation have been the principal factors causing previous amphibian declines in Britain (Cooke & Scorgie, 1983). Is that true of the recent common toad declines?

One important aspect of this study has been the comparison of data reported in the questionnaires with facts emerging from direct contact with the respondents. Thus, the majority of the replies came from people who were involved with toad road crossings and 70% of sites subsequently investigated were toad crossings. This was not immediately apparent from the questionnaires themselves, as people had not always ticked the column headed "Toad Patrol Data". This in turn was often because the toad patrols were no longer active, or because data were not collected when toads were helped across the road. It also became clear (Figure 6) that a significant number of the reported declines could not be substantiated on more critical examination. It is therefore very important not to take questionnaire data at face value. Closer scrutiny is essential for accurate analysis and meaningful conclusions.

Many different reasons were proposed to account for toad declines, but no consistent pattern emerged following statistical analysis. The trend for the presence of woodland within 20 metres of a breeding pond to be associated with declining toad populations in the main area of decline was probably an artefact. Woodland is generally a positive habitat feature for toads (Swan & Oldham, 1993) and there was no evidence that ponds with declining populations experienced more shade than those not associated with declines. The fact that decreasing populations within the main area of decline were more likely to have been observed for longer than non-decreasing ones may be more interesting. One explanation for this could be that populations considered to be stable had already declined prior to the start of observations. Outside the main area of decline this difference was not found, but stable populations in the non-decline zone tended to have been smaller than declining populations when observations started. Thus the small toad population at Drimpton Road, Dorset (outside the main decline area) was reported as stable. However, before data returns were started, the population was apparently a lot higher with toads on the road collected "by the bucket-load". Many of the declines seem to have occurred gradually over the past decade, although several people said that their population had declined suddenly about 5 years ago. This type of information was not sufficiently detailed to be analysed statistically. Overall, though, this pattern suggests that the extent of recent declines may actually be greater than indicated in the questionnaires because some major decreases occurred a little more than 15 years ago.

A factor that was not statistically significant but which was mentioned repeatedly by respondents was an increase in road casualties, corresponding with an increase in traffic over the years. Traffic was cited as the main cause of decline at only two sites, but at many sites where there was no obvious cause of decline respondents were concerned about heavy traffic. This was particularly noticeable on smaller roads that were used as "rat runs" during rush hour in order to avoid traffic congestion on main roads. This was considered an important change in conditions over recent years, because the peak time of toad migration during the evening often coincided with peak traffic flow. Many people commented on the fact that toad migration seems to be starting earlier in the season. However, the data from toad crossings was conflicting, with some long term datasets showing no obvious trend. Climate change has affected the spawning times of the natterjack toad, *B. calamita*, and the edible frog, *Rana kl. esculenta*, in Britain (Beebee, 1995) but there is no evidence of significantly increasing earliness for the common frog or the common toad (Reading 1998).

At some sites the reasons for toad declines may involve several factors. For example, at one lake the immediate habitat had been managed intensively for many years with the grass cut short and the banks kept fairly clear of vegetation. Only a few scrubby areas were retained, probably insufficient for the needs of the toad population, but years ago the toads could migrate across pasture to nearby woodland. At that time the toad population was high. However, 15 years ago the pasture was converted to arable. Some years later, lorry traffic on a very narrow road across which the toads migrate increased dramatically. Despite the cessation of this traffic after two years, the population declined and is now reportedly extinct. Thus it may be that a population already stressed by habitat degradation was unable to survive the high mortality rates imposed over two years by the increased traffic. At one of the stable sites, numbers of toads at the breeding site as monitored by torch counts had not declined but numbers crossing a nearby road had. This suggests that toads were no longer using terrestrial habitat that was only accessible by crossing the road. It is possible that constant mortality on roads may create a selection pressure on toads to reduce the distance they migrate from their breeding sites. This would be an interesting question to investigate.

In conclusion, there is cause for concern about the high number of declining toad populations recorded in this survey. Many of these populations were thought to be declining because of habitat change, but no individual factor showed statistical significance across populations. Moreover, it was impossible to determine which (if any) of the reasons for decline proposed by correspondents were correct because most were inevitably based on casual observations. For around a quarter of the declines it was not possible even to surmise what the cause(s) might be. There could be a lot of individual causes, or a single main cause not yet recognised (ie not one of the variables thus far investigated, such as climate change, or a known variable such as traffic for which current data are inadequate). Evidently a mixture of factors may interact to drive a population into decline and ultimately to extinction, but an important clue is that the declines seem specific for toads. Whether one or more factors are involved, they must be ones to which *B. bufo* is particularly vulnerable. Mortality rates from traffic during the breeding migration may be increasing, due to the increase in traffic intensity during peak times on smaller roads. Several factors might predispose toad populations (relative to frog populations) to traffic mortality impacts: the timing of immigration often coincides with high traffic volumes; their behaviour makes them more prone to being killed on the carriageway (slow speed, males' preference to seek open areas to intercept females); use of relatively low proportion of available ponds within a given area, and consequent long migration routes. Logistic regression analysis also highlighted some credible causes of decline that might act cooperatively. Increasing density of aquatic vegetation has been identified as a correlate of low toad tadpole survival rates at Offham (Beebee 2000), and at that site was a consequence of changed management of the breeding ditches. Reduced amounts of marginal vegetation might reduce toadlet survival. It is difficult to see why wildfowl should be negatively associated with declines, unless perhaps they play a role in the control of aquatic vegetation. Evidently broad comparisons across multiple sites have limited scope for resolving the causes of toad declines, and detailed investigations of particular populations will be needed to resolve this potentially serious problem. We recommend that serious consideration be given to a research programme in which a set of declining and non-declining sites are compared in detail with respect to toad population dynamics.

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Appendix 1: Site list

Table of all sites named in questionnaire returns for which information on toads was available. *: Sites selected for statistical comparisons.

Common toad	Common frog	Site name	County	Garden
increased	increased	Haynes West End	Bedfordshire	Yes
declined	declined	Cople Pits NR*	Bedfordshire	No
stable	stable	Studham Hall Farm*	Bedfordshire	No
stable	none	Sandhurst Mem Park	Berkshire	No
increased	increased	Deerswood*	Berkshire	No
new	none	Westmoreland Park	Berkshire	No
declined	uncertain	Braybrooke Rec	Berkshire	No
declined	stable	Popes Meadow	Berkshire	No
stable	stable	Chaucer Woods	Berkshire	No
stable	none	Priest Hill*	Berkshire	No
stable	none	Heath Lake	Berkshire	No
stable	stable	Faircross Farm*	Berkshire	No
stable	stable	Common Rd	Buckinghamshire	Yes
declined	stable	Cawdor Quarry	Derbyshire	No
declined	declined	Newboundmill Lane	Derbyshire	No
increased	none	Wingerworth	Derbyshire	No
declined	increased	Dimple Lane	Derbyshire	No
declined	none	Whatstandwell*	Derbyshire	No
stable	none	Terrel Hayes	Derbyshire	No
increased	none	Tapton Grove	Derbyshire	No
stable	stable	Tapton Grove	Derbyshire	No
declined	none	Repton Shrubs	Derbyshire	No
declined	none	Lea Bridge*	Derbyshire	No
stable	none	Kinder	Derbyshire	No
stable	none	Grangemill*	Derbyshire	No
declined	none	Dimple Lane Crick	Derbyshire	No
stable	stable	Whitworth Park	Derbyshire	Yes
declined	declined	Winster Mere	Derbyshire	No
declined	declined	Flash Dam	Derbyshire	No
uncertain	declined	Hopton Clay Pit	Derbyshire	No
stable	declined	Marystones Quarry Pond	Derbyshire	No
new	stable	Shothouse Spring	Derbyshire	No
declined	declined	Plachet Plantation	Derbyshire	No
declined	declined	Carr ponds	Derbyshire	No
stable	none	Church Broughton	Derbyshire	No
increased	increased	Carsington*	Derbyshire	No
stable	none	Buxworth Basin	Derbyshire	No
declined	declined	Meden Dam	Derbyshire	No
stable	none	Birch Vale	Derbyshire	No
declined	uncertain	Burton Closes	Derbyshire	No
declined	declined	Stockly pond	Derbyshire	No
declined	none	Foremark	Derbyshire	No
stable	increased	Brookvale	Derbyshire	Yes

Common toad	Common frog	Site name	County	Garden
declined	declined	Litlington	E. Sussex	No
declined	stable	Offham Marshes*	E. Sussex	No
extinct	increased	Brighton Crematorium	E. Sussex	No
extinct	stable	St Annes Well gardens	E. Sussex	No
stable	stable	Withdean Park	E. Sussex	No
new	none	Stanmer Heights	E. Sussex	No
extinct	stable	Rottindean Pond	E. Sussex	No
increased	stable	Whitelands	E. Sussex	No
extinct	increased	Hargleton	E. Sussex	Yes
increased	increased	Harlands Farm*	E. Sussex	No
declined	declined	Newhaven	E. Sussex	No
declined	none	Jarvis Brook*	E. Sussex	No
stable	stable	Churchill Gardens	Essex	Yes
declined	declined	Surbiton road	Essex	Yes
increased	increased	The Avenue	Essex	No
declined	declined	S Fairbridge newt pond	Essex	No
declined	declined	S Fairbridge dyke pond	Essex	No
declined	declined	Magnolia LNR	Essex	No
stable	declined	47, Wedgewood Way	Essex	Yes
declined	declined	Anglian Water Reservoir	Essex	No
declined	increased	Poulner	Hampshire	No
stable	stable	Wildmoor	Hampshire	No
stable	stable	various, New Forest	Hampshire	No
stable	stable	Herne Bay boating lake	Kent	Yes
declined	declined	Archbishops School	Kent	Yes
increased	stable	Fleets Lane	Kent	No
stable	none	Doddington Place	Kent	No
declined	none	Stockerstone	Leicestershire	No
declined	none	Cawston Heath	Norfolk	No
new	new	Park Farm	Norfolk	Yes
increased	stable	Svanton Abbot	Norfolk	No
declined	declined	Upgate Common*	Norfolk	No
stable	stable	Broad Fen	Norfolk	No
stable	stable	How Hill	Norfolk	No
stable	none	Tunstead Chrch Farm	Norfolk	No
increased	increased	Mown and Kings Fens	Norfolk	No
increased	increased	Sulby gardens	Northamptonshire	Yes
stable	increased	ST Margarets Ave	Northamptonshire	No
declined	declined	Lakeside	Northamptonshire	No
stable	increased	Rowan Way	Nottinghamshire	No
declined	declined	L Lake, Rainworth	Nottinghamshire	No
declined	declined	Spa Ponds	Nottinghamshire	No
declined	declined	Souldern	Oxfordshire	Yes
increased	stable	Church Way	Oxfordshire	No
declined	uncertain	Berrick Salome	Oxfordshire	No
declined	none	Mill St*	Oxfordshire	No
declined	uncertain	Rokemarsh	Oxfordshire	No
increased	increased	Vincents Farmhouse	Suffolk	Yes

Common toad	Common frog	Site name	County	Garden
stable	increased	Steeplechase	Suffolk	No
declined	none	Morenton Hall	Suffolk	No
declined	uncertain	Hill Farm	Suffolk	No
stable	stable	Church Road*	Suffolk	No
declined	none	Wonham Mill	Surrey	No
stable	stable	The Fisheries	Surrey	No
stable	stable	Oast Rd	Surrey	Yes
declined	declined	Pennypot	Surrey	No
declined	increased	79 Sandy Lane	Surrey	Yes
declined	declined	Homewood	Surrey	Yes
declined	none	Prune Hill*	Surrey	No
declined	declined	Balchins Lane	Surrey	No
increased	stable	Earlswood Lakes*	Surrey	No
declined	declined	none given	Surrey	No
stable	declined	Farnham Park	Surrey	No
uncertain	none	Littleton	Surrey	No
declined	none	Hollow Lane*	Surrey	No
stable	stable	The Drift	Surrey	No
stable	stable	Tintern Rd	Surrey	Yes
stable	increased	Long Gore	Surrey	Yes
declined	uncertain	Holmby St Mary	Surrey	No
extinct	uncertain	Newells Pond*	West Sussex	No
declined	declined	Bristol Road*	Avon	No
stable	stable	entire county	Ayrshire	No
new	new	Bryntirion Pond	Carmarthenshire	No
stable	declined	Reservoir	Carmarthenshire	No
declined	uncertain	Pantllyn Turlough*	Carmarthenshire	No
increased	increased	Holmes Chapel	Cheshire	Yes
stable	none	Hatch Mere*	Cheshire	No
declined	uncertain	Timbersbrook Mill Pool*	Cheshire	No
increased	none	Welsh Mountain Zoo*	Conwy	No
stable	stable	Bowness on Solway Gravel Pits*	Cumbria	No
increased	increased	Townstal Post Office	Devon	Yes
stable	increased	Powerstock Common*	Dorset	No
increased	stable	Drimpton Rd*	Dorset	No
increased	increased	CED NNR	Durham	No
declined	declined	Newty pond CED*	Durham	No
declined	declined	South Holderness	E. Yorkshire	No
stable	stable	Old Brick Pool	Gloucestershire	No
stable	increased	Smithills	Gtr. Manchester	No
increased	declined	Barracks Lodge*	Lancashire	No
increased	declined	Haig Rd	Lancashire	No
new	none	Sudbury Rd	N. Somerset	No
declined	none	The Pit Pond*	N. Somerset	No
declined	uncertain	Stanley Rd	N. Somerset	No
increased	stable	Burton Riggs*	N. Yorkshire	No
stable	stable	Throxenby Mere	N. Yorkshire	No
increased	declined	Croyde	North Devon	No

Common toad	**Common frog**	**Site name**	**County**	**Garden**
stable	declined	Darracott	North Devon	No
uncertain	uncertain	Putborough	North Devon	No
stable	stable	South Tyne	Northumbria	No
declined	uncertain	Llandrindod Wells Lake*	Powys	No
stable	stable	entire county	Renfrewshire	No
stable	stable	Bute	Renfrewshire	No
declined	increased	Burrington*	Shropshire	No
stable	none	Underton Lane	Shropshire	No
declined	none	Fyne Court	Somerset	No
stable	stable	Priddy	Somerset	No
increased	declined	Hawkridge Reservoir*	Somerset	No
stable	declined	Weacombe	Somerset	Yes
increased	declined	Porlock Vale	Somerset	No
declined	stable	Ynys Farm	Swansea	No
increased	stable	Dog Lane millpond	W. Yorkshire	No
stable	declined	Walled Garden	Warwickshire	No
stable	declined	Church Ra Covert*	Warwickshire	No
increased	stable	Welches Meadow	Warwickshire	No
stable	increased	Ashlawn rail cutting	Warwickshire	No
increased	stable	Sych Wood	Warwickshire	No
stable	increased	220 Alwyn Rd	Warwickshire	Yes
declined	none	Dunchurch College*	Warwickshire	No
declined	none	Crackley Lane*	Warwickshire	No
new	new	90 Station Road	West Midlands	Yes
extinct	declined	Barrow Hill*	West Midlands	No
uncertain	declined	Smithy Lane	West Midlands	No
declined	increased	Cotwall End	West Midlands	No
increased	increased	86 Farington Rd	West Midlands	Yes
increased	increased	Fens Ponds*	West Midlands	No
stable	increased	Severn Bank	Worcestershire	No

Appendix 2: Brief habitat descriptions of sites used in statistical comparisons

Within decline area	
Declining populations:	
Jarvis Brooks	pond in a wood within a suburban area
Prune Hill	pond in small area of woodland, grazing land beyond on one side, Proctor and Gamble industrial site on other
Mill St	river with weir, arable and pasture, village
Cople Pits	gravel pits in LNR, woodland, scrub, rough grassland
Upgate Common	field pond on common land, scrub, rough grassland, woodland
Hollow Lane	chain pond, on large estate, mainly woodland
Whatstandswell	canal, woodland and residential
Lea Bridge Canal	small reservoir above factory, woodland and pasture
Newells Pond	fishing lake within arable fields, some trees
Offam Dyke	drainage ditches in permanent pasture
Stable populations:	
Priest Hill	field pond in pasture
Earlswood Lakes	clay pit pond and duck pond, on common with golf course adjacent, within suburban area
Church Rd	field pond on arable land
Harlands Rd	ex farm pond, now in amenity grassland within housing estate
Grangemill	millpond, rural area, mainly pasture
Carsington	very large reservoir, rural area, village and woodland nearby
Studham Hall Farm	farm pond, within farmyard, mixed arable & pasture, woodland
Whitelands	farm pond, within pasture
Deerswood	gravel pit lake in urban area, mainly residential, small area of rough grassland
Beechwood Farm	farm pond, mixed arable and grazing, woodland nearby

Outside decline area	
Declining populations:	
Llandrindrod Wells Lake	upland lake, woodland, upland grassland
Dunchurch Management College	ornamental lake in college grounds, parkland
Pantllyn Turlough	shallow lake, pasture, woodland, scrub
The Pit Pond	rural in LNR - rough grassland; farm yard and permanent pasture on other side
Crackley Lane	field pond in arable fields
Newty Pond	old farm pond, woodland one side, recent development (previously meadow) other side
Burrington	pond in wet woodland, beyond that mixed farming
Borrow Hill	fishing lake, scrub and rough pasture
Timbersbrook Mill Pond	mill pond, pasture
Bristol Rd	fishing lake, some pasture and scrub, mainly arable

Stable populations:	
Hatch Mere	fishing lake, forest and peat bog
Welsh Mountain Zoo	ornamental, in wooded zoo grounds
Powerstock Common	rural, woodland and managed grassland
Barracks Lodge	urban, residential
Bowness on Solway	gravel pits, nature reserve, rough grassland, scrub, trees
Church Pool Covert	ancient woodland
Fens Pools	on common, rough pasture, but within urban area
Drimpton Rd	field pond, light grazing
Hawkridge Reservoir	reservoir, rough grazing, woodland
Burton Riggs	disused quarry, ex landfill site adjacent, industrial estate, arable farmland

Appendix 3: Sites for further study

Many of the sites investigated during the course of this study warrant further investigation, particularly those with declining toad populations for which no cause could even be hypothesised. It would be impractical to carry out studies on widely separated sites, because of the necessity of visiting sites during the breeding migration. Sites within the same county or neighbouring counties would therefore be a practical choice for further study, for example the four sites in Derbyshire. A few particularly interesting sites are summarised below.

Sussex

Jarvis Brook: Woodland pond on land earmarked for LNR status. No negative impacts, yet previously high toad population disappeared two years ago.
Harlands Farm: Increasing toad population breeding in a pond in a residential area. Limited terrestrial habitat. Fish recently removed. It would be interesting to monitor the impact of this change.

Surrey

Prune Hill: Used to be a toad crossing but no longer patrolled, therefore could assess the impact of traffic. Change in local drainage may have led toads to change breeding site, status unclear.
Hollow Lane: No negative impacts except traffic at this woodland site, all other variables unchanged for many years. Population slowly declining
Earlswood Lakes: A large stable population with apparently very limited terrestrial habitat. Interesting to see if this can support the toad population in the long term.

Berkshire

Deerswood: Very large population, increasing perhaps due to the efforts of a toad patrol. 75% of surrounding land use is residential, and new development is planned which will isolate terrestrial habitat from breeding lake.

Oxfordshire

Mill St: Could be a variety of factors at work here. Although EA say water quality is acceptable, very high turbidity has led to loss of aquatic and marginal vegetation. There is a very high population of American crayfish. Huge decline in toad population.

Bedfordshire

Cople Pits: Recent decline in this LNR population, but complex pond landscape in the wider area. Following improvement of terrestrial habitat, toads may have colonised different ponds.

Haynes West End: There was a toad crossing here which had been operating for 6 to 7 years, but the only known breeding site is a garden pond dug 5 years ago which was immediately colonised by 70 toads. It was thought there were no other ponds nearby, but this needs confirmation.

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Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
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