Annual Monitoring of the White-clawed Crayfish Populations within the Wyre Forest

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Background

A baseline White-clawed Crayfish survey of Bell Brook and Forest Lodge stream, both within the Wyre Forest, was undertaken in 2010. Following the 2010 survey a monitoring programme was set-up to record the White-clawed Crayfish and its habitat in Wyre and in 2011 the first monitoring survey of the two watercourses was undertaken. In addition, White-clawed Crayfish surveys were undertaken in 2011 of Kingswood Stream and Longdon Stream which were also found to support White-clawed Crayfish. During 2012 all four watercourses were surveyed as part of the monitoring programme and this article gives a summary of the findings from the survey.

Aim

The aims of the monitoring study are:

- To build up a record of White-clawed Crayfish in watercourses across the Wyre Forest.
- To detect any change in population range, abundance and dynamics.
- To trigger a response if any changes are undesirable.
- To contribute to the knowledge of White-clawed Crayfish population within the Wyre Forest, Worcestershire and the UK.

Method

The 2012 survey replicated (where possible) the same team of surveyors, the same number and location of sample patches (fixed-area sampling) and the same amount of survey effort as surveys undertaken in previous years. The survey work was undertaken by two licensed surveyors and several assistants between 20 August and 18 September 2012 following published guidelines and best practice (Peay 2002). The methods are described in detail in the 2011 Crayfish of Wyre Forest report (Hill 2011). A summary of the methods is given below. All licence conditions were complied with. Table 1 briefly describes the sample patches.

Where terrain and access issues allowed, all surveys were undertaken starting at the downstream end of a reach.

A standard daytime manual search was made of all the watercourses. Areas of habitat considered the most favourable for crayfish were selected within each patch and ten potential refuges were manually searched in each patch. All crayfish caught were recorded for species, sex and size. Carapace length (CL) of all live and dead crayfish was recorded to nearest mm, measured from tip of rostrum to junction of carapace and tail. In addition, signs of disease etc. were noted. Some crayfish escaped capture during the standard daytime manual search. In these instances the escapee was recorded as adult or juvenile based on surveyor judgement. A juvenile is taken as size <25 mm CL.

A qualitative appraisal of likely White-clawed Crayfish habitat was undertaken of the water-bodies at the same time as undertaking the standard daytime manual search and the results recorded on standard crayfish habitat survey cards.

Night-time torching (using a 15-minute timed search) was also undertaken of all four watercourses. Crayfish were identified to species. All active adult and juvenile crayfish were recorded.

Watercourse	Standard Daytime Manual Search	Night-time Torching
Bell Brook	Six patches Patch 1 starts at culvert (downstream) and Patch 5 ends upstream at three silt traps below forest track. Patch 6 starts east of Unclys Farm and finishes upstream below Unclys Pool. Bell Brook pool too deep for manual search.	Eight patches Patch 1 starts at culvert (downstream) and Patch 6 ends upstream at three silt traps. Patch 7 downstream two short reaches separated by single and twin culverts and a small stretch of water below the culverts to the confluence with Dowles Brook. Patch 8 In stream pool within Bell Brook one x 15-mins torching.
Forest Lodge Stream	Five patches Patch 1 starts at the culvert (downstream) and Patch 5 finishes at the Forest Lodge fence line.	Six patches Patch 1 starts at the culvert (downstream) and Patch 4 finishes at the track by gabions (upstream). Patch 5 starts at the track by gabions (upstream) and finishes upstream where the stream divides. Two short stretches either side of stream divide depending on water levels. Patch 6 downstream one short reach below the culverts to the confluence with Dowles Brook.
Kingswood Stream	Six patches Patch 1 starts at forestry track and Patch 6 ends where stream leaves Natural England ownership.	Three patches Patch 1 starts at forestry track and Patch 3 ends where stream leaves Forestry Commission ownership.
Longdon Stream	Six patches Patch 1 starts in alluvial flats just north of public right of way and Patch 6 ends upstream where stream divides.	Three patches Patch 1 starts in alluvial flats just north of public right of way and Patch 3 finishes where stream divides.
Dowles Brook	Too deep for manual search	Three patches Patch 1 starts at confluence with Forest Lodge stream and Patch 3 finishes at confluence with Bell Brook.

Table 1: A summary description of the "fixed-area" sampling patches used during the annual monitoring study of white-clawed crayfish in watercourses of the Wyre Forest.

A Hannah H198129 water meter was used to record water pH, water temperature, conductivity and total dissolved solids in the water (parts per million (ppm) and µS/cm).

Monitoring Targets

The monitoring targets are:

Crayfish Population Range:

- White-clawed Crayfish should be present in all four watercourses.
- Non-native crayfish should be absent from all four watercourses.

Crayfish Population Abundance:

- There should be no statistically significant reduction in the number of White-clawed Crayfish in the watercourse over three or more years in succession.
- The relative abundance of White-clawed Crayfish in the watercourse should remain relatively constant from year to year. The relative abundance of crayfish within each watercourse is calculated as a Catch per Unit Effort (CPUE). Table 2 is used to grade watercourses on the basis of relative abundance of crayfish determined from standard surveys (Peay 2003). There is no similar table for the relative abundance of crayfish determined from night-time surveys.

Average no. of Crayfish per 10 Refuges	Population Abundance
>5	A: Very high
>=3, <=5	B: High
>=1, <3	C: Moderate
>0, <1	D: Low
0	E: Absent or undetected

Table 2: Grading the abundance of crayfish - standard method (Peay 2003)

Crayfish Population Dynamics:

- Juvenile crayfish <25mm carapace length should be present in the watercourse (Peay 2003).
- Using the standard method, the proportion of juveniles (<25 mm carapace length) from a healthy population should be about 40% (Peay 2003).
- Male and female White-clawed Crayfish should be present in a watercourse.

Repeat sampling from one monitoring year to the next will improve the chance of detecting a change if the change is consistent along the watercourse.

Statistical Tests

The Two-way Anova (with replication) and the non-parametric Kuskal-Wallis statistical test were used to test for significant differences between data sets. SPSS Statistics Version 19.0.0 (1995-2010) statistical package was used in the analyses.

Survey Limitations

There were no periods of increasing river flow although high water levels within Far Forest Stream and Dowles Brook reduced survey effort in places.

High water turbidity in London Stream and Kingswood Stream reduced the effectiveness of both the standard daytime manual search and night-time torching effort.

In some watercourses it was difficult to find the start and finish of individual sample patches, especially at night. However, the number of patches within each watercourse was adhered to except where access was difficult or survey effort was impossible due to water levels.

Site

The site and the location of the four watercourses are shown in Figure 1.

Results

Crayfish Habitat

Bell Brook retained excellent in-stream and bankside habitat with frequent undermined, overhanging banks, sections exhibiting heterogeneous flow patterns with refuges, roots of woody vegetation, accumulations of fallen leaves and under water-saturated logs. Water clarity was excellent and there was no significant change in water chemistry from the previous year, Table 3.

Forest Lodge Stream continued to have favourable habitat with excellent in-stream and bankside habitat. The water channel was difficult to access in places due to high water levels caused by heavy rain in the previous 24 hours. There had been some minor geomorphological change in the stream bed since the 2011 survey visit suggesting high discharges during the past twelve months. Water clarity was excellent and there was no significant change in water chemistry from the previous year, Table 4.

Kingswood Stream had excellent in-stream and bankside habitat. The in-stream duck pond has been removed from Kingswood Stream although relatively high numbers of waterfowl were present in the adjacent duck ponds and the outflow from the adjacent ponds flowed into the watercourse. Little aquatic macro-invertebrate activity was seen in the water. Filamentous algae was present downstream

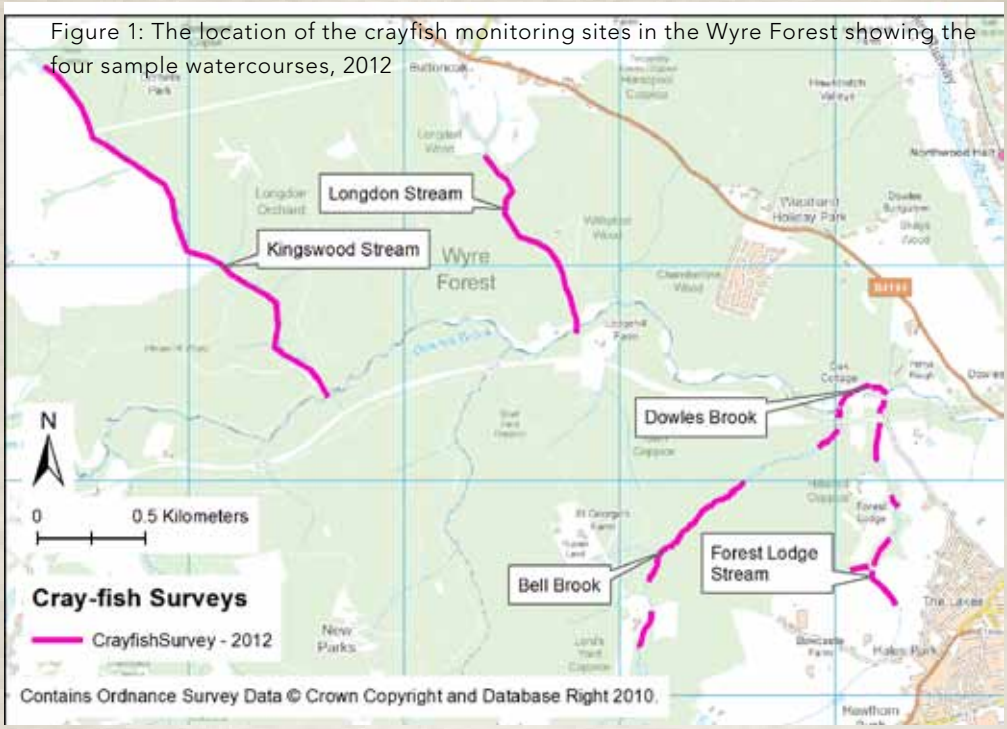

Figure 1: The location of the crayfish monitoring sites in the Wyre Forest showing the four sample watercourses, 2012

Year	Water Variable	N	Minimum	Maximum	Mean	Std. Deviation	Kruskal-Wallis Test Asymp. Sig.	
2011	water pH	7	7.86	8.34	8.07	0.17	0.09	n.s.
2012		11	7.86	8.73	8.24	0.34		
2011	ppm	7	62	247	202.71	64.25	0.06	n.s.
2012		11	62	247	180.91	58.40		
2011	µS/cm	7	134	493	407.86	125.27	0.06	n.s.
2012		11	134	493	363.36	115.32		
2011	water temperature	7	12.00	18.00	15.59	2.30	0.57	n.s.
2012		11	12.00	18.00	15.42	1.81		

Table 3: Water chemistry of Bell Brook, Wyre Forest.

Year	Water Variable	N	Minimum	Maximum	Mean	Std. Deviation	Kruskal-Wallis Test Asymp. Sig.	
2011	water pH	9	7.83	8.28	8.04	0.13	0.23	n.s.
2012		3	7.98	8.42	8.27	0.25		
2011	ppm	9	27	249	167.00	72.74	0.78	n.s.
2012		3	172	176	174.33	2.08		
2011	µS/cm	9	54	498	332.11	145.87	0.78	n.s.
2012		3	343	352	348.00	4.58		
2011	water temperature	9	11.90	19.90	15.72	2.23	0.51	n.s.
2012		3	13.70	15.40	14.83	0.98		

Table 4: Water chemistry of Forest Lodge Stream, Wyre Forest.

of the ford. Hay bales and silage clamps were present in the watercourse. Water clarity was very poor (with a view of less than 30cm) during both the daytime and nocturnal surveys and the habitat had a distinct smell of fertiliser. Water temperature was significantly lower in 2012 compared with measurements taken in 2011, Table 5. There was no significant change in water pH and dissolved solids in the water (ppm and µS/cm) compared with the previous year. However, Kingswood Stream had the highest recording of dissolved solids in the water of all four watercourses and levels had increased on 2011 measurements.

Longdon Stream had excellent in-stream and bankside habitat with submerged refuges in stable, slightly undercut banks with overhanging vegetation, natural crevices in bedrock, large tree roots, slow-flowing glides and pools with refuges. The water was turbid on both survey visits and consequently the water clarity was poor. Longdon Stream had significantly higher water temperature and a significantly lower water pH and concentration of dissolved solids in the water in 2012 compared with measurements taken in 2011, Table 6. Longdon Stream had the second highest recording of dissolved solids in water of all four watercourses but levels were lower than in 2011.

Year	Water Variable	N	Minimum	Maximum	Mean	Std. Deviation	Kruskal-Wallis Test Asymp. Sig.	
2011	water pH	9	7.60	8.50	8.10	0.26	0.21	n.s.
2012		15	6.99	8.30	7.92	0.35		
2011	ppm	9	74	305	176.00	73.65	0.07	n.s.
2012		15	184	253	221.40	20.78		
2011	µS/cm	9	146	611	353.00	147.02	0.08	n.s.
2012		15	367	504	443.80	41.68		
2011	water temperature	9	13.70	17.50	15.09	1.35	0.00	****
2012		15	10.80	12.90	11.69	0.76		

Table 5: Water chemistry of Kingswood Stream, Wyre Forest.

Year	Water Variable	N	Minimum	Maximum	Mean	Std. Deviation	Kruskal-Wallis Test Asymp. Sig.	
2011	water pH	3	8.15	8.27	8.21	0.06	0.05	*
2012		3	8.05	8.10	8.07	0.03		
2011	ppm	3	259	307	285.33	24.34	0.05	*
2012		3	186	187	186.67	0.58		
2011	µS/cm	3	518	615	571.00	49.12	0.05	*
2012		3	375	376	375.33	0.58		
2011	water temperature	3	12.80	15.40	14.43	1.42	0.05	*
2012		3	16.10	16.20	16.17	0.06		

Table 6: Water chemistry of Longdon Stream, Wyre Forest.

Crayfish Population Range

White-clawed Crayfish continued to be present in all 4 watercourses in 2012, Fig. 2. No non-native crayfish were found in any of the watercourses surveyed.

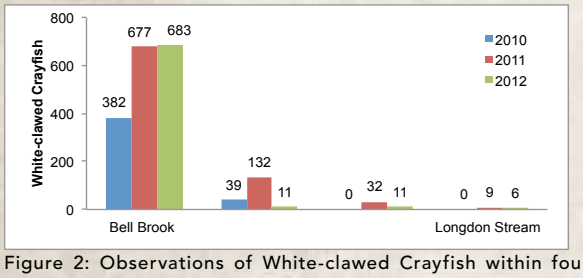

Figure 2: Observations of White-clawed Crayfish within four watercourses in the Wyre Forest, Worcestershire between 2010 and 2012.

Crayfish Population Abundance

Bell Brook had a statistically significant increase in standard daytime manual observations in 2012 compared with observations in 2010 and 2011 (Kruskal-Wallis test, P-value 0.01), Figure 3. There was no significant increase in night-time torching observations (Kruskal-Wallis test, total observations P-value 0.125).

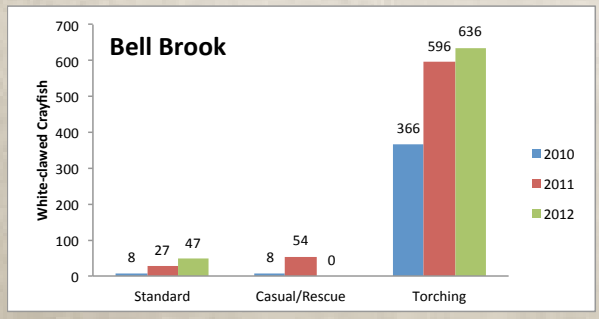

Figure 3: Observations of White-clawed Crayfish within Bell Brook, Wyre Forest between 2010 and 2012.

Forest Lodge Stream observations across the three recording years have been very variable because of the influence of flow conditions, Figure 4. The increase of crayfish observation in 2011 was the result of drought conditions concentrating the White-clawed Crayfish into a smaller area and which also provided surveyors with greater access to the stream bed for recording. However, in 2012 the opposite was true and the high water levels limited surveyor access to the stream bed for recording and thereby reduced the survey efficiency. In addition, standard survey effort in 2011 was replaced by a rescue operation. Therefore the results should be interpreted with caution. There was a non-significant increase in standard daytime manual observations compared with observations in 2010 and 2011 (Kruskal-Wallis test, P-value 0.737). However, this result has to be tempered by the fact that there no standard survey in 2011.

There was a statistically significant decrease in night-time torching observations in 2012 compared with 2011 observations (Kruskal-Wallis test, P-value 0.042). Nonetheless, when compared with observations over the longer time period, from when the monitoring study began, there was a non-significant decrease in night-time torching observations in 2012 compared with observations made in 2010 and 2011 (Kruskal-Wallis test, P-value 0.148). The results confirm the variability and vulnerability of the Forest Lodge Stream and its associated crayfish population.

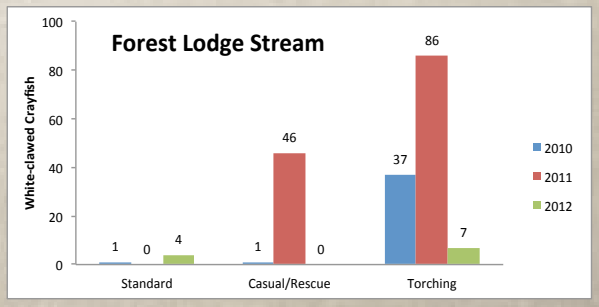

Figure 4: Observations of White-clawed Crayfish within Forest Lodge Stream, Wyre Forest between 2010 and 2012.

Kingswood Stream had a non-significant decrease in both standard daytime manual observations (Kruskal-Wallis test, P-value 0.494) and in night-time torching observations (Kruskal-Wallis test, P-value 0.246) in 2012 compared with observations made in 2011, Figure 5. In addition, Kingswood Stream was the only watercourse where night-time torching observations exceeded the standard daytime manual observations.

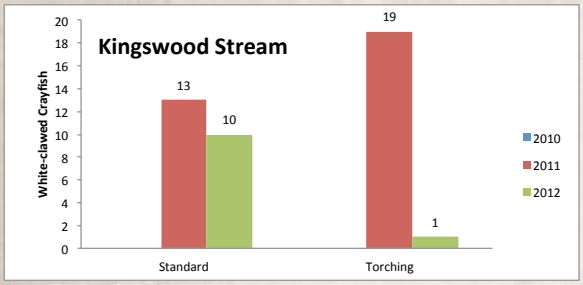

Figure 5: Observations of White-clawed Crayfish within Kingswood Stream, Wyre Forest between 2010 and 2012.

Longdon Stream had a non-significant decrease in night-time torching observations (Kruskal-Wallis test, total observations P-value 0.658; adult observations P-value 1.000; juvenile observations P-value 0.114), Figure 6. White-clawed Crayfish were undetected using the standard daytime manual observations in 2012 in Longdon Stream.

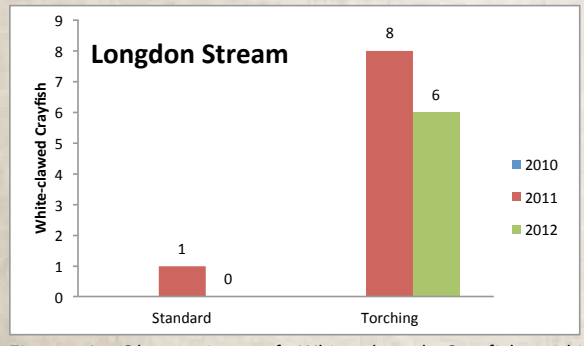

Figure 6: Observations of White-clawed Crayfish within Longdon Stream, Wyre Forest between 2010 and 2012.

Relative abundance of crayfish was calculated as the number of crayfish per ten refuges searched (Catch per Unit Effort, CPUE) or fifteen-minutes timed night-view, Figures 7 and 8. The CPUE in Bell Brook increased and the population remained in the *very high* category. Forest Lodge Stream increased in CPUE using the standard method but decreased using the fifteen-minutes timed night-view method: overall the Forest Lodge crayfish population remained in the *low to moderate* population abundance category. Kingswood Stream had a decrease in CPUE but remained in the *moderate* population abundance category. Longdon Stream had a decrease in CPUE and had a negative change in population abundance category from *low abundance* to *none* or an *undetected* population.

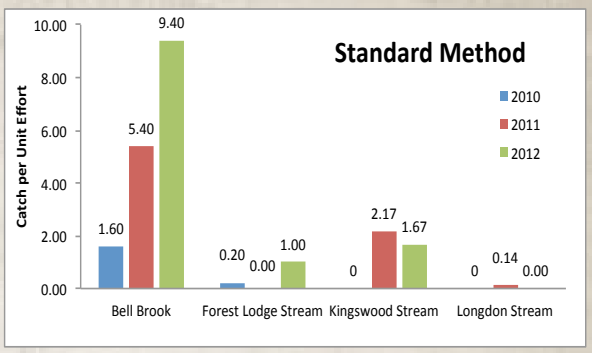

Figure 7: Comparison of relative abundance of White-clawed Crayfish recorded per unit effort searched (ten refugia) between 2010, 2011 and 2012 in four streams within the Wyre Forest.

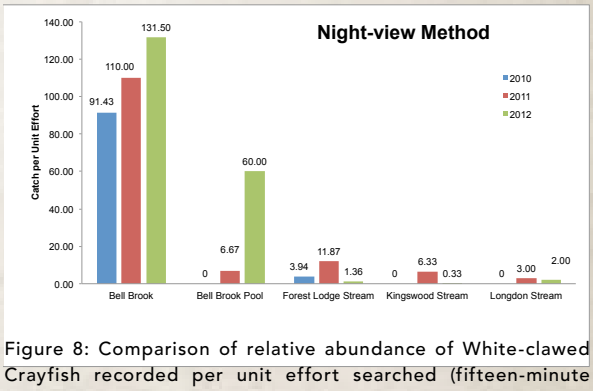

Figure 8: Comparison of relative abundance of White-clawed Crayfish recorded per unit effort searched (fifteen-minute timed search) between 2010, 2011 and 2012 in four watercourses within the Wyre Forest.

Crayfish Population Dynamics

Using the standard method, juvenile White-clawed Crayfish (<25mm carapace length) were caught and measured in Bell Brook, Forest Lodge Stream and Kingswood Stream, Figure 9. Using the standard method, the proportion of juveniles in Bell Brook, Forest Lodge Stream and Kingswood Stream was 57%, 50% and 78% respectively. No juvenile White-clawed Crayfish (or adults) were caught and measured in Longdon Stream.

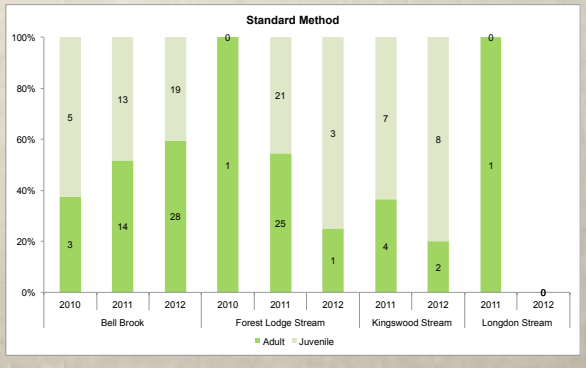

Figure 9: Comparison of adult and juvenile White-clawed Crayfish caught and measured in four watercourses of the Wyre Forest during three years.

Juveniles were recorded in Bell Brook, Forest Lodge Stream and Longdon Stream using the night-time torching method, although the proportion of juvenile observations was reduced to 45%, 29% and 17% respectively, Figure 10.

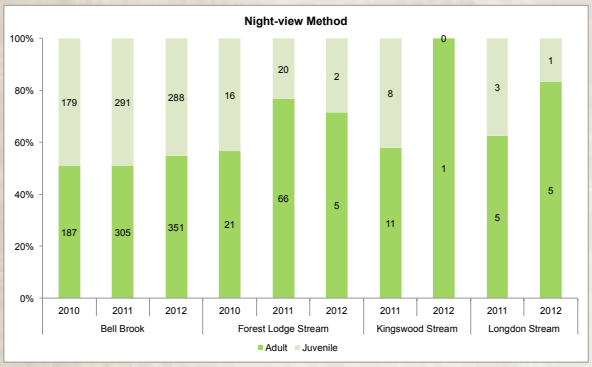

Figure 10: Comparison of adult and juvenile records recorded in four watercourses of the Wyre Forest during three years using night-view survey method.

Carapace size was also used to measure population structure. There was no significant difference between the White-clawed Cwrayfish carapace length of individuals caught and measured over the three years in Bell Brook, Forest Lodge Stream and Kingswood Stream (Bell Brook: Kruskal-Wallis test, sig. = 0.592, p = n.s., n = 2; Forest Lodge Stream: Kruskal-Wallis test, sig. = 0.793, p = n.s., n = 2; Kingswood Stream: Kruskal-Wallis test, sig. = 0.178, p = n.s., n = 1), Figure 11. Neither was there any significant difference between year (2010, 2011 and 2012), watercourse (Bell Brook, Forest Lodge Stream, Kingswood Stream and Longdon Stream) and white-clawed crayfish carapace length (Two-way Anova (with replication) year P-value = .337; watercourse P-value = .278; year*watercourse P-value = .420).

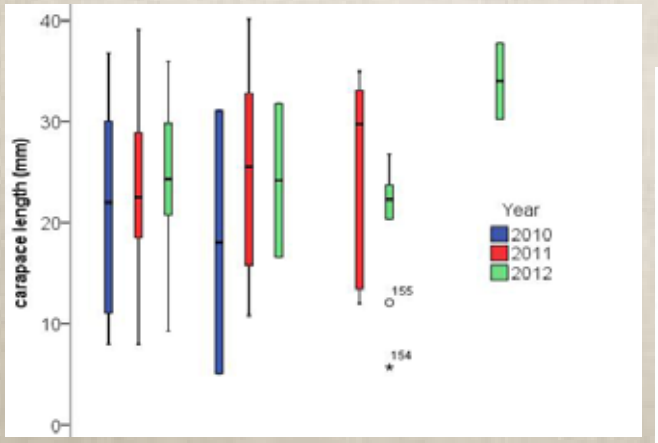

Figure 11: Comparison of White-clawed Crayfish carapace length of individuals caught and measured over the three years (2010, 2011 and 2012) in Bell Brook, Forest Lodge Stream, Kingswood Stream and Longdon Stream, Wyre Forest.

The carapace size distribution of the population of White-clawed Crayfish indicated that after two relatively stable years the crayfish population in Bell Brook is showing an increase in average carapace size, indicating the possibility of an older population (skewness -0.161), Figure 12. Fewer individuals were caught and measured in Kingswood Stream but those measured exhibited the same increase in average carapace length suggesting that Kingswood Stream may also have an ageing population (skewness -1.451), Figure 13. The smallest measurement in 2012 was a juvenile White-clawed Crayfish with a carapace length of 5.7mm caught in Kingswood Stream. There were too few observations to comment on population status in Forest Lodge Steam (Figure 14) and Longdon Stream.

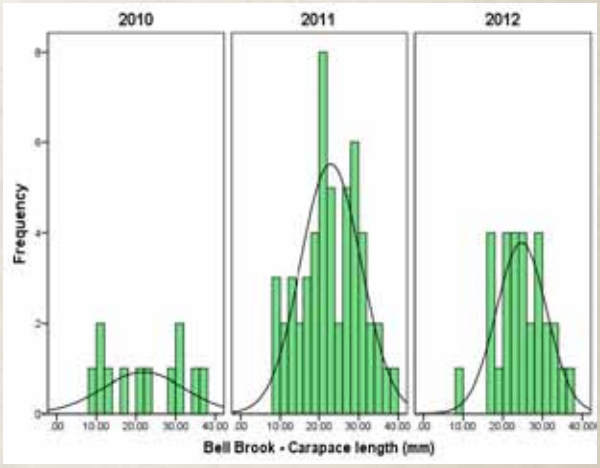

Figure 12: Histogram showing size distribution (carapace length mm) of White-clawed Crayfish population in Bell Brook, Wyre Forest in three survey years.

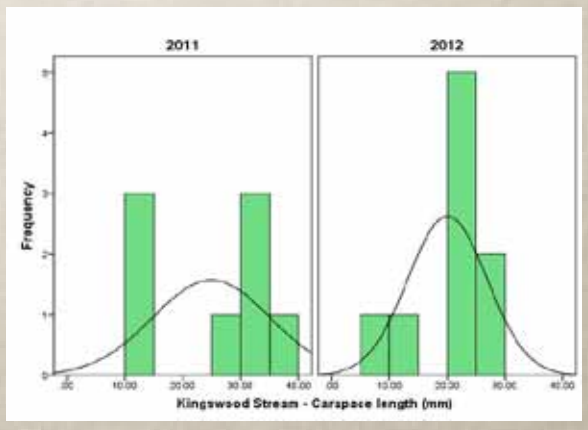

Figure 13: Histogram showing size distribution (carapace length mm) of White-clawed Crayfish population in Kingswood Stream, Wyre Forest in three survey years.

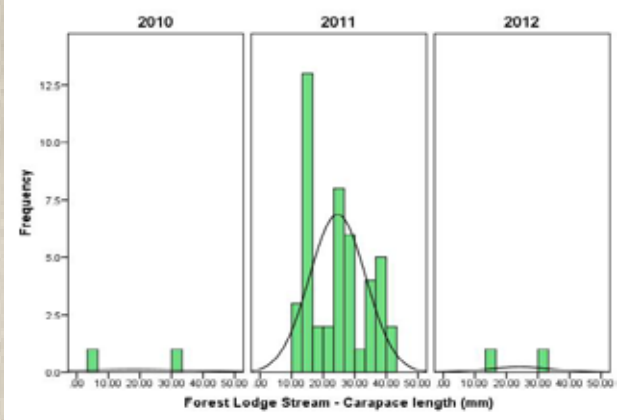

Figure 14: Histogram showing size distribution (carapace length mm) of White-clawed Crayfish population in Forest Lodge Stream, Wyre Forest in three survey years.

All crayfish that were caught were sexed, Figure 15.

Figure 15: Comparison of male and female records recorded in four watercourses of the Wyre Forest during three years using standard survey method.

Female and male White-clawed Crayfish were recorded in Bell Brook and Kingswood Stream in 2012. However, only female White-clawed Crayfish were recorded in Forest Lodge Stream and Longdon Stream.

Crayfish Health

Parts of a few dismembered crayfish were found along and within all watercourses.

All White-clawed Crayfish caught and recorded in Bell Brook, Forest Lodge Stream and London Stream appeared healthy with no evidence of crayfish-plague. Three of the caught and measured White-clawed Crayfish in Kingswood Stream appeared to be covered in a white fungus/algae growth.

Discussion

There was no change in the geographical range of the White-clawed Crayfish in Wyre Forest although there was an overall reduction in White-clawed Crayfish observations across the Wyre Forest.

The excellent in-stream and bankside habitat within Bell Brook continued to support a very high population of White-clawed Crayfish and there was a statistically significant increase in standard daytime manual observations in 2012 when compared with the previous two years. There was a mix of adults, both male and female, and juveniles indicating a healthy population structure although it may be slightly ageing. The results were likely due to favourable environmental conditions in the past twelve months and/or underlying natural population cycles (currently unknown).

Forest Lodge Stream has a small catchment that responds quickly to rainfall but with little storage capacity and as a consequence the White-clawed Crayfish population is vulnerable to the peculiarities of the weather. Notwithstanding the weather, the white-clawed crayfish population was recovering from the drought conditions of 2011 and had a low to moderate population abundance. Juveniles made up at least 40% of the White-clawed Crayfish population in Forest Lodge Stream so whilst no male crayfish were caught and recorded the varied size range indicated that Forest Lodge Stream continued to have a healthy but small population of White-clawed Crayfish.

There was no significant change in the White-clawed Crayfish population in Kingswood Stream and the presence of juveniles and a varied size range of adults (both male and female) was indicative of a breeding population. Catch per Unit Effort decreased although Kingswood Stream continued to have a moderate population abundance category for White-clawed Crayfish. The in-stream duck pond has been removed during the past twelve months, which should have improved the water quality. However, Kingswood Stream had the highest recording of dissolved solids in the water of all four watercourses and levels had increased on 2011 measurements. Therefore, water quality remained an issue for the survival of the Kingswood Stream White-clawed Crayfish population.

There is negative change in the population condition of White-clawed Crayfish in Longdon Stream. No White-clawed Crayfish were detected during the standard daytime survey and only six crayfish were recorded at night-time (eight were recorded in 2011). The two crayfish that were caught and measured were both female. No juveniles were recorded. The overall conclusion is that the breeding success and population structure is poor and that there

is a problem with recruitment. Longdon Stream had excellent in-stream and bankside habitat but the water clarity was poor with the second highest recording of dissolved solids in water of all four watercourses. Water quality is likely to be the critical issue for the survival of this population of white-clawed crayfish.

In conclusion, after three years of study there is still only limited information about the way the White-clawed Crayfish of the Wyre Forest vary in abundance and spatially over time. The trends will need to be compared over many years and information on long-term variation will only gradually be obtained from continuing the monitoring of crayfish populations in Wyre Forest.

Acknowledgements

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White-clawed Crayfish with abnormal claw, 27 August 2012
Rosemary Winnall

Crayfish recorders from left: Ann Hill, Jane Scott, Graham Hill, Mike Averill, 21 August 2012 Rosemary Winnall