3.9 Bridge material

Table 10 shows the number of grade fours and grade fives recorded in bridges with a single material in the span. A high percentage (>60%) of all types of stone span bridge were considered suitable for bats, and 33% of limestone bridges were grade fives (Table 10). A lower percentage of brick, concrete, steel, and wood spanned bridges were suitable, but concrete bridges support a significant number of roosts because they are a common bridge type.

Similar data can be produced for abutment material, but most roosts recorded were located in the span, and the abutment data is therefore not considered relevant to this analysis.

866 bridges had spans made of more than one material and 113 (13%) of these were grade five bridges. The roosts in bridges with more than one material in the span could not be analysed by material type.

Table 10: Grading of bridges with a single material in the span

Span Material	Total	No. Suitable (Grade 4 + Grade 5)	No. Grade 5
Brick	36 (2%)	15 (42%)	4 (11%)
Concrete	490 (29%)	120 (24%)	23 (5%)
Granite	31 (2%)	19 (61%)	1 (3%)
Gritstone	4 (<1%)	3 (75%)	0
Limestone	75 (4%)	55 (73%)	25 (33%)
Other	1 (<1%)	1 (100%)	0
Sandstone	792 (47%)	482 (61%)	122 (15%)
Slate	166 (10%)	126 (76%)	27 (16%)
Steel	72 (4%)	28 (39%)	5 (7%)
Wood	22 (1%)	5 (23%)	0
Total	1689	854 (51%)	207 (12%)

NB Not all of these roosts are located in spans *eg.* no roosts were found in steel spans - roosts in steel span bridges were located in the abutments.

3.10 Bridge width

The percentage of grade four and grade five bridges recorded varied little with respect to bridge width (Table 11).

Table 11: Bridge width

Width (Range: 0.5 - 700)	No. Bridges Surveyed	Grade 4	Grade 5
< 2.5	120 (5%)	45 (38%)	12 (10%)
2.5 - 4.9	692 (27%)	294 (42%)	110 (16%)
5 - 9.9	1230 (48%)	507 (41%)	131 (11%)
10 - 19.9	304 (12%)	111 (37%)	36 (12%)
20 - 29.9	80 (3%)	27 (34%)	11 (14%)
30 - 49.9	66 (3%)	29 (44%)	9 (14%)
≥ 50	50 (2%)	22 (44%)	8 (16%)

3.11 Bridge span

The number of roosts recorded appears to be positively correlated with span length (Table 12), but the proportion of bridges with suitable crevices only increased above a span length of 20 metres.

Table 12: Bridge span

Span (Range: 0.4 - 200)	Bridges Surveyed	Grade 4	Grade 5
< 1	58 (2%)	23 (40%)	4 (7%)
1 - 2.9	748 (29%)	282 (38%)	63 (8%)
3 - 4.9	572 (22%)	233 (41%)	49 (9%)
5 - 9.9	765 (30%)	313 (41%)	122 (16%)
10 - 19.9	204 (8%)	84 (41%)	41 (20%)
20 - 39.9	107 (4%)	53 (50%)	18 (17%)
40 - 59.9	54 (2%)	25 (46%)	10 (19%)
≥ 60	37 (1%)	23 (62%)	10 (27%)

3.12 Arch height

Grade fives were recorded across the range of arch heights from less than one metre high up to 50 metres (Table 13). Roosts were less frequent in bridges below two metres high and scarce in bridges less than one metre high.

Table 13: Maximum arch heights

Maximum Arch Height (Range: 0.2 - 50)	Bridges Surveyed	Grade 4	Grade 5
<1	152 (6%)	24 (16%)	2 (1%)
1 - 1.4	452 (18%)	180 (40%)	27 (6%)
1.5 - 1.9	540 (21%)	211 (39%)	54 (10%)
2 - 2.4	339 (13%)	133 (39%)	47 (14%)
2.5 - 2.9	148 (6%)	60 (41%)	20 (14%)
3 - 3.9	273 (11%)	118 (43%)	47 (17%)
4 - 4.9	274 (11%)	116 (42%)	61 (22%)
≥5	363 (14%)	193 (53%)	57 (16%)

3.13 Date of survey

Bridges have been surveyed in Cumbria in every month of the year but survey work for this project was only carried out from June to December. Only the months from July to October have comparable levels of survey effort, and the peak month for bat occupation of bridges during this period was September (Table 14).

Table 14: Month surveyed for all bridges and grade 5 bridges

Month	Number of Bridges surveyed	Number of grade 5 bridges	Bridges with bats visible	No. bats recorded *	Maximum no. at one bridge *
January	1	1	0	0	0
February	14	1	0	0	0
March	12	2	0	0	0
April	21	6	6	9	3
May	3	1	0	0	0
June	65	9	4	28	15
July	534	46	14	280	100
August	597	61	16	70	40
September	559	98	50	221	57
October	564	67	28	65	12
November	174	26	9	12	4
December	5	1	0	0	0
Total	2549	319	127	685	

* Includes emergence counts

3.14 Other species recorded

A number of non-bat species were recorded during the survey and these records are summarised in Table 15. 141 bridges (5%) had signs of otters, these records coming mainly from the northern half of the county (see Appendix V), and 17 bridges had signs of mink.

A large number of bridges were used as nest sites by birds and ten species were recorded. 90 bridges were used by nesting dippers (see Appendix V) and 132 nests were unidentified.

A number of invertebrate species were also recorded and these are listed in Table 15.

Although not recorded systematically the following plant species were commonly seen growing on bridges: ivy (*Hedera helix*), maidenhair spleenwort (*Asplenium trichomanes*), polypody spp. (*Polypodium spp*), wall rue (*Asplenium ruta-muraria*), and numerous ruderal species. Black spleenwort (*Asplenium adiantum-nigrum*) was recorded on two bridges.

Table 15: Non-bat species recorded

Species	No. of Records	Percentage of Bridges
Mink	17	0.7%
Otter	141	5.5%
Bird sp	132	5.2%
Dipper	90	3.5%
Feral pigeon	1	0.04%
Grey wagtail	4	0.2%
House martin	1	0.04%
House sparrow	1	0.04%
Kestrel	2	0.08%
Pied wagtail	16	0.6%
Raven	1	0.04%
Swallow	31	1.2%
Wren	32	1.3%
Drone fly (a hoverfly)	72	2.8%
Giant lacewing	29	1.1%
Meta spp (spiders)	129	5%
Old lady (a moth)	40	1.6%
Small tortoiseshell (a butterfly)	21	0.8%
The herald (a moth)	26	1%

NB All bird records refer to nests in or on a bridge

4.0 DISCUSSION OF SURVEY RESULTS

4.1 Factors that may affect bridge occupation

4.1.1 The presence of crevices

The presence or absence of suitable crevices was related to a number of factors:

Maintenance often removes suitable crevices and regularly maintained structures had fewer crevices. This is illustrated by a comparison between council maintained road bridges and privately maintained bridges carrying tracks. Only 49% of road bridges were considered to have suitable crevices compared to 71% of track bridges. The ease of maintenance is also important - lower bridges were less likely to contain suitable crevices than higher bridges (Table 13) which can only be maintained with the use of scaffolding. Maintenance includes the removal of thick growths of ivy which could provide potential roost sites.

Material of construction and the design of the bridge both affect the presence of crevices. An examination of span material in bridges with a single material in the span (Table 10) revealed that 64% of stone spanned bridges had suitable crevices compared to 24% of concrete spanned bridges. These figures are much higher than those recorded by Roberts (1989) who stated that 31% of stone bridges and only 2% of concrete bridges provided suitable roost sites in his survey in North Yorkshire. At least 23 concrete bridges were confirmed as roost sites during the COBIB survey, demonstrating the potential importance of these structures. Concrete bridges have been under-estimated as roost sites in the past, and in addition to a significant number of day roosts located the survey has shown that they are also often used as night roosts.

The high percentage of limestone spanned bridges recorded as roosts is almost certainly because the bridges on the Lancaster Canal are built of this material. The large number of roosts is more likely to be related to the bridges' situation and maintenance regime than the material of construction.

A relatively low percentage of steel and wooden spanned bridges were considered suitable for bats, but several wooden bridges had suitable crevices between beams and a number of steel bridges had suitable crevices in stone abutments. No roosts were found in steelwork but these sites should not be discounted as at least one roost has been found between two steel surfaces in a bridge (Briggs, pers. comm.).

There was little difference in the percentage of roosts recorded from bridges with a single material in the span (12%) and the percentage recorded from bridges with more than one material in the span (13%). Bridges with a number of materials in the span might be expected to have more available roost sites because of the joints that are often present between sections (widening joints). 45% of spans with more than one material were grade fours as opposed to 38% for single material spans, but this difference is not necessarily related to the presence of widening joints.

Design was a particularly important factor in concrete bridges where gaps between concrete beams and expansion joints provided suitable crevices, but box designs had no crevices.

4.1.2 Surrounding habitat

The habitat surrounding the bridge was only recorded from a small area when compared to the distances travelled by bats on nightly feeding trips - Richardson (pers. comm.) has recorded Daubenton's bats travelling up to 10km from the roost to preferred feeding habitats. However it is logical to assume that if suitable roost sites exist close to regular feeding areas then bats will choose to use those roosts, and the recording of habitat adjacent to the bridge is therefore valid. The adjacent habitat will also affect the microclimate of the bridge, and any potential roost crevices within the bridge, and may provide commuting routes to and from a bridge roost. Fieldwork during the survey suggested that it would have been preferable to record habitat in blocks along both linear features associated with the bridge rather than just along the bridged feature, as the method used does not record all key habitat features adjacent to the bridge.

The presence and dominance of the habitat types recorded was compared between grade five bridges and grade four bridges (see 3.7) to establish whether the recorded occupation of bridges by bats was related to the surrounding habitat. There was no difference in the occurrence of walls, hedges, fast-flowing water, conifers, or bog/wet ground, between bridges with and without roosts. The remaining habitats displayed significant differences either in the frequency with which they occurred or the frequency with which they dominated the habitat surrounding the bridge.

Broad-leaved trees/woodland Dominant broad-leaved trees and the presence of broad-leaved trees were strongly associated with grade five bridges. Where broad-leaved trees occur adjacent to a bridge roost they can be readily used by bats for feeding, often provide commuting routes, and mature trees may provide alternative roosting sites. Sargent (1991) showed that Daubenton's bats exhibited a preference for feeding over rivers with deciduous woodland on the bank. Trees will also have an ameliorating affect on the microclimate of a bridge providing shelter from wind, and shade. Areas with abundant broad-leaved woods are also likely to have higher bat populations and therefore suitable bridges are more likely to be occupied.

Slow-flowing water/ponds The presence of this habitat was strongly associated with grade five bridges, in contrast with fast-flowing water which showed no association. As the majority of bats identified to species were Daubenton's and slow-flowing and still water is selected by feeding Daubenton's bats (Sargent, 1991), this result is not unexpected. Adjacent water will also increase the humidity of roost sites, but as fast-flowing water did not show any association with roosts it appears that the presence of water as a feeding habitat is more important than its effect on roost microclimate.

Arable This habitat was found at significantly less grade five bridges than grade four bridges. This difference may be explained by the fact that arable land has been shown to be avoided by foraging bats (Walsh *et al.*, 1995), and there are therefore likely to be lower bat populations in areas with a higher proportion of arable land. There were too few bridges with dominant arable to analyse.

Buildings The presence or absence of buildings showed no association with grade four or grade five bridges but there was a positive association between dominant buildings and grade four bridges. This indicates that bridges in urbanised areas are less likely to have roosting bats.

Scrub Scrub showed a strong association with grade four bridges, indicating that bridges with adjacent scrub habitats are less likely to have a bat roost. No explanation can be offered for this result.

Improved grassland The presence of this habitat showed a significant association with grade five bridges. This result appears anomalous in the light of the avoidance of this habitat by feeding bats (Walsh *et al.*, 1995), and the few roosting or commuting opportunities it offers.

Unimproved grassland This habitat showed a strong association with grade four bridges. Although it is an important foraging habitat for some bat species most species found in Cumbria (and all of those found in bridges) are likely to avoid it for foraging and commuting it as it is too open. It is curious that this habitat shows such a strong association with grade four bridges when improved grassland (which should be less favourable for bats) has a strong association with grade five bridges. One possible explanation could be that unimproved grassland is more likely to occur in more upland areas with fewer bats, but the fact that grade five bridges showed no association with altitude does not support this theory (see 4.1.3).

The results have shown that if broad-leaved trees/woodland and slow-flowing water or ponds are not present then bats are less likely to use a bridge that has suitable crevices. The significance of broad-leaved woodland suggests that efforts to conserve bridge roosting bats could be enhanced by encouraging broad-leaved trees and woodland on river banks adjacent to grade four and grade five bridges.

If the habitats recorded are treated as a sample of the habitats present in the locality of the bridge the observed differences in habitat occurrence may result from the effect of habitat on the size of local bat populations. Alternatively the differences may be due to a more local effect on the selection of bridge roosts by bats.

4.1.3 Altitude

The occupation of bridge roosts might be expected to decline with rising altitude due to the falling temperatures and the scarcity of slow-flowing water. This was not the case however as occupation rates remained more or less constant up to 300m a.s.l., and few bridges were surveyed above this height. Swift (1990) suggested that the low number of bridge roosts in Scotland might be related to the lower ambient temperatures at higher latitudes but this would seem unlikely in the light of these results.

4.1.4 Feature spanned by bridge

13.4% of bridges over watercourses were grade five and only 8.8% of bridges over other features were grade five. This result is probably a consequence of the association between slow-flowing water and roosts (see above). Bridges over wider watercourses were also more frequently recorded as roosts - 22% of bridges over rivers more than 3m wide were roosts, compared to 8% of bridges over rivers less than 3m wide. Wider rivers are more likely to have areas of slow-flowing water, and Daubenton's bats show a preference for wide rivers for feeding (Sargent, 1991). A remarkable 42% of bridges over a disused section of the Lancaster Canal were recorded as roosts. The water of the canal is very slow-flowing but the high occupation rate is probably also related to the bridge maintenance regime on this section of canal.

4.1.5 Size of Bridge

The size of the bridge was measured by four variables: arch height, span, width, and number of arches. Bridge occupation was not investigated in relation to number of arches as this was considered to be a function of span length.

Arch height Bridges less than 2.5 metres high were less likely to have bats but they are also more readily maintained, and this is reflected in the lower number of bridges with suitable crevices below 2.5 metres high (see Table 13). Low arches are more likely to flood than higher arches, and bats may also select higher arches because of the greater space for manoeuvring and easier exit from the roost that they provide.

Span length Large bridges are more likely to provide suitable roost sites (Table 12), and bats appear to select larger bridges for roosting. This may also be related to the ease of bridge repair.

Bridge width Width had little effect on the grading applied to bridges (Table 11).

4.1.6 Date of survey

Bridge surveys were carried out from June to December during the project, but only July to November can be usefully compared as very little surveying was done in June and December. Records from other months originate from the voluntary survey. September appears to be the peak month for numbers of bridges occupied (Table 14), and this is the time of year when nursery colonies are dispersing and males are occupying breeding territories. The numbers of bats in bridges peaks in July with a slightly smaller peak in September. These figures must be interpreted with caution however as they are based on a random selection of emergence counts carried out over a number of years.

4.2 Types of crevice used by roosting bats

Although 257 roosting sites (75%) were located in bridge spans, only 24 of these were found in the joints created by bridge widening. This contrasts strongly with the findings of Roberts (1989) who stated that 76% of roosts found in his study in North Yorkshire were located in widening joints. This difference is unlikely to be explained by the distribution of such widening joints as they are frequently found in Cumbrian bridges. There may however be more crevices of other description available in Cumbria than in North Yorkshire, which the bats are using in preference.

Bats used a wide variety of crevices and their use of drainage holes and pipes was of particular interest. Bats have rarely been looked for in such crevices in the past and bridges with well-pointed arches have been considered unsuitable for bats. Bats are most often found in drainage holes in bridges which are otherwise well pointed.

4.3 The importance of Cumbria's bridges for bats

The large number of roosts recorded on the survey suggests that Cumbria's bridges are of great importance for bats. Bridges appear to be of particular importance for Daubenton's bats and Natterer's bats. If hibernation sites (which hold very few bats) are excluded the 92 Daubenton's roosts in bridges represent around 90% of the total number of known Daubenton's roosts in Cumbria, which confirms the importance attributed to bridges for this species by other authors (Roberts, 1989; McAney, 1992). If the roosts with unidentified species were assumed to be occupied by a similar proportion of each species to the identified roosts, then the number of Daubenton's bat roosts found would be 220.

Very few Natterer's bat roosts are known in the county and the 25 bridge roosts therefore represent a high proportion. Extrapolating the figures from the unidentified bridge roosts would give a total of 60 Natterer's roosts. These figures will exaggerate the relative value of bridges for these species in comparison to other roost types because of the additional effort expended in bridge surveys, and the difficulty of finding roosts in trees, but the importance of bridges to these two species is clear.

Few bridge roosts have had emergence counts but daytime surveys suggest that the majority of bridges support only small numbers of bats. Bridges with counts greater than five bats, or signs suggesting that they are heavily used, were considered to be significant sites. Some of these bridges are probably key sites for the bat colonies that use them. Bridges with particularly high emergence counts are: Bouthray (100 Natterer's), Beckfoot (40 Natterer's), Southwaite (98 Daubenton's), Sandford (44 Daubenton's), and Newbiggin (20 Daubenton's). Southwaite Bridge has been occupied for at least ten years, and one bridge at Isel, near Cockermouth has been used by bats for at least 100 years (McGuffie, pers. comm.).

No bats were netted from bridge roosts during the project and only a small amount of netting has been carried out in Cumbria prior to the project. Thus the sex and age composition of bridge roosting bats in Cumbria is poorly known and this would be a valuable area for future study.

Bridge roosts appear to be less important for the other species recorded because of the small number of roosts recorded and the low numbers of bats using them. One pipistrelle roost (Skygarth Bridge) has had up to 57 bats, and is important in its own right. However the seven pipistrelle bridge roosts recorded represent less than 5% of known roosts in the county, most of which are in dwelling houses.

The survey methods were designed to locate bridges that were suitable for bat use, to prevent possible roosts being destroyed by works. Time limitations prevented more intensive surveys, *i.e.* using ladders and dusk visits, to identify whether bridges were being used and by which species.

The number of roosts recorded is therefore likely to be a significant underestimate of the actual number of bat roosts in bridges in Cumbria.

4.4 Non-bat species recorded on the survey

4.4.1 Invertebrates

Many invertebrate species hibernate during the winter and some seek similar environmental conditions for hibernation to those chosen by bats. Thus many caves and similar sites used by hibernating bats also contain small tortoiseshell butterflies (*Aglais urticae*), herald moths (*Scoliopteryx libatrix*), and drone flies (*Eristalis tenax*). It was hoped that torpid specimens of these species found in bridge crevices during the survey might indicate suitable environmental conditions for bat roosts. Unfortunately all three of these species were regularly found in situations unlikely to be used by bats *i.e.* either too draughty or too light, as a result of their position on the bridge or the shallow crevice depth used. However, in one bridge drone flies and bats could be seen roosting in the same crevice.

Some spiders of the genus *Meta* (*Meta menardi* and *Meta bourneti*) also seek similar environmental conditions to bats but live in the same place year-round. It was considered that a link might exist between the presence of such spiders and bats, particularly in the light of a suggestion that bats may help to disperse tiny specimens of *Meta menardi* (Parker, 1990). However, problems with the identification of these spiders made it impossible to analyse the data.

Several unidentified moth species were recorded on one or two occasions but the old lady moth (*Mormo maura*) was recorded at 40 bridges. This is a common and widespread species which flies during July and August (Skinner, 1984). It does not hibernate as an adult, and during its flight season the adults can be found roosting in shallow crevices and on open, but well shaded, bridge surfaces.

The giant lacewing (*Osmylus fulvicephalus*) is a local and under-recorded species that is occasionally found resting on the underside of bridge arches. The 29 records gathered during the survey have almost doubled the number of records, and trebled the number of known sites of the species in Cumbria (Hewitt, pers. comm.)

4.4.2 Mammals

Otters (*Lutra lutra*) and mink (*Mustela vison*) both use ledges, rocks, and banks of sediment under bridges to mark their territories by leaving spraints (otters) and scats (mink). Using these signs (and tracks), 141 otter records and 17 mink records were gathered during the project. Hollows in bridge abutments, or culverts and drains, may also be used as lying-up sites or holts, and one otter holt was found in the abutment of a small bridge. The vast majority of otter records were in the north of the county reflecting known otter distribution (Hewitt, 1996(b)), but records from the survey in the southern half of the county have helped to record its spread southwards (Appendix V). In the vice-county of Cumberland, which lies predominantly in the north of

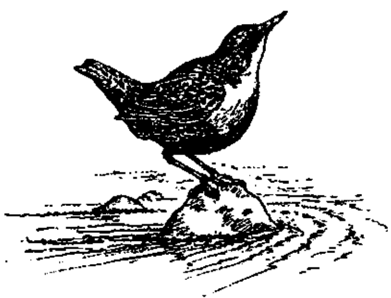
Cumbria, 10% of bridges had otter signs. It is important to be aware of otters during bridge works as their holts, which are protected by law, can easily be damaged if they are present in the bridge structure or adjacent river banks (see Appendix I, section 3).

4.4.3 Birds

Many bird nests were found in bridge structures during the course of the survey. 132 nest sites were not identified to species but of the remaining sites the most common species involved was the dipper (*Cinclus cinclus*). Cumbria does have a large amount of suitable natural nesting habitat for dippers but in a similar area in Wales Tyler and Ormerod (1994) recorded 44.4% of nests in bridges. They also stated that bridges are often used in preference to natural sites, and may be important in allowing dippers to nest in lowland areas with few natural nest sites. The bridge nests located in the survey are therefore likely to represent a significant proportion of the dipper nest sites in the county. Tyler and Ormerod (*op. cit.*) also state that many traditional nesting and roosting sites have been lost through bridge improvements and it is important that dippers are accounted for in any bridge works (see Appendix I, section 3).

Although the other bird species recorded add significantly to the conservation value of the structure in which they occur, records of nests in bridges are too few in number for bridges to represent a significant nesting habitat for them in the county. All birds nests are protected (see Appendix I, section 3) and the large number of nesting sites recorded during this survey suggest that full account should be taken of the possible effects of bridge works on nesting birds.

Several bird species also use bridges as night-time roosts. These were not recorded during the survey as it was rarely possible to say with certainty that birds were roosting in a bridge without dusk visits, and it was often impossible to identify the species involved from signs. The most common species found in bridge crevices during night-time bat surveys are blue tits (*Parus caeruleus*) and dippers. Up to ten dippers have been recorded roosting communally under bridges in autumn and winter, and they are believed to be attracted to bridges because they are warmer than nearby open roost sites (Tyler & Ormerod, 1994).



Dipper